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COSTS OF INTRODUCTION OF THE FOREST COMPONENT FOR THE IMPLEMENTATION OF LIVESTOCK-FOREST INTEGRATION SYSTEMS IN PORTO VELHO, RONDÔNIA

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ABSTRACT
The Crop-Livestock-Forest Integration system is a technology that combines the use of agricultural, livestock, and forestry activities in the same area. The system is being applied to improve land use by diversifying production outputs, restoring the quality of the soil and pastures, and contributing to cattle management by offering thermal comfort to the animals. Although farmers recognize the importance of trees on pastures, especially to provide shade for livestock, in general, they are concerned about the negative effects of trees on pasture growth and pasture carrying capacity. Furthermore, it is likely that ranch farmers are still not convinced regarding the costs of planting trees on pastures, because they are unsure about the economic benefits that can result from this practice. The costs of implementing a livestock-forest integration system should be used as a basis for technicians and ranchers in their decision to adopt this technology for the management of dairy herds. For the calculation of the total cost, expenses with inputs, labor, in addition to fixed costs, and opportunity costs for the period of planting and maintenance of the tree component were considered, as well as the prices practiced in the local market. The total cost for Integrated Livestock-Forest system implementation was similar regardless of the tree species, *Eucalyptus pellita* and *Samanea tubulosa* (US$ 70.31 and US$ 67.40, respectively). In conclusion, decision making should be based on the main objective of the introduction of the forest component in the system; producing wood products, or supplying multiple services.
Key words: Pasture; Natural Shading; Integrated Livestock

INTRODUCTION

The possibility of integrating the animal and forest components in the same area is an alternative for shading pastures, especially in local areas with high environmental temperatures, solar *radiation,* and relative humidity. These climatic conditions are common in the municipality of Porto Velho (RO) during almost the entire year, which leaves animals to be subject to heat stress conditions, especially during the hottest hours of the day (SOUZA et al., 2019).

The Integrated Crop-Livestock-Forest system (ICLF) is a technology that combines the use of agricultural, livestock, and forestry activities in the same area and is being applied to better take advantage of the soil, diversify agricultural production, recover the quality of soil and pastures, and contribute to cattle management by offering thermal comfort to animals. Integrated Livestock-Forest (ILF) or silvopastoral system is a modality of ICLF that can be implemented with a focus on pasture shading to mitigate heat stress in animals (OLIVEIRA et al., 2012).

Despite acknowledging the importance of trees in pastures, especially in providing shade for livestock, cattle ranchers are still not convinced that tree shade may not negatively affect pasture growth and animal support capacity. In addition, they are not willing to bear the costs of planting trees in pastures, probably because they are not convinced of the economic benefits that can arise from this practice (ANDRADE et al., 2012).

With the objective of supporting technicians and ranchers, this study provides information on the implementation costs of silvopastoral systems in the first two years using two tree species, *Eucalyptus pellita* and *Samanea tubulosa*, for afforestation of pastures for dairy herds in the municipality of Porto Velho, Rondônia.

MATERIAL AND METHODS

A technological reference unit (TRU) in Integrated Livestock-Forest (ILF) located at the Experimental Field of Embrapa Rondônia (8°48’26.61” S 63º51’01.68” O) was established using two tree species to shade pasture for Girolando dairy herd. An area of approximately 14 ha of pasture cultivated with marandu grass (*Urochloa brizantha* ‘Marandu’ *syn. Brachiaria brizantha* ‘Marandu’) was divided into two areas. The trees were planted in January 2018 in double lines with 6 m distance within rows of 300 m × 10 m aligned in the NE-SW direction (azimuth of 140º). The space between plants was 3.5 m. At the planting stage, 156 seedlings of *S. tubulosa* and 172 seedlings of *E. pellita* were used.

The area for planting the forest essences was prepared by desiccation of the grass on the planting line with the herbicide glyphosate (5.0 L/ha) followed by a subsoil at 60 cm depth. One day after planting, 4.0 L/ha of pre-emergent oxifluorfen-based herbicide was applied. Soil correction was undertaken using limestone filler in the pit (200 g/plant). Based on the results of the analysis of the chemical attributes of the soil, the area received planting fertilization with 200 g/plant of natural phosphate in the pit and 300 g/plant of NPK 04-30-16 + 6% Ca + 2% S + 0.05% B + 0.05% Cu + 0.2% Mn + 0.3% Zn, in lateral small pits. Two topdressing fertilizers were applied with 350 g/plant of NPK 20-05-20 + 0.5%B, 0.5% Zn, 0.5% Cu, at 6 and 12 months after planting. Weed control on the planting line was undertaken by mechanical removal every six months. Ant infestation was systematically monitored during the implantation period, and the necessity for control was observed at 6 and 12 months after planting in both areas. It was undertaken with an ant bait.

At the tree planting stage, the marandu grass pasture was in a moderate stage of degradation according to the evaluation criteria proposed by Dias-Filho (2017), i.e., the presence of invasive plants and the support capacity of the pasture was reduced by 30%–50% in relation to the non-degraded pasture. Therefore, it was necessary to remove animals from the pasture area for six months to restore the productivity of marandu grass. After this period, electrical fences were installed to protect the tree planting line.

For the calculation of the total cost, we considered the expenses with inputs and labor, in addition to the fixed costs and the opportunity cost for the period of planting and maintenance of the tree component considering the prices practiced in the local market. In the case of *S. tubulosa*, there were no commercial nurseries for seedling acquisition. Thus, the seedlings were produced in the nursery of the Experimental Field of Embrapa Rondônia, and the total cost for the production of 10 seedlings was US$ 3.02.

To calculate the expenses with electric fence and production costs per liter of milk, it was considered that in both systems, the pastures were managed with an average stocking rate of 2 AU (animal unit, 450 kg of live weight) per ha with a rotation cycle in six paddocks with five days of occupation and 30 days of rest periods. Further, it was considered that the Girolando dairy herd was composed of 80% of cows, with 60% in lactation with an average daily production of 10 L, and lactation period of 280 days.

The costs of implantation of *E. pellita* and *S. tubulosa* trees in the pasture areas are shown in Table 1. The period from January 2018 to December 2019 was considered for the composition of the costs for system implementation.

Table 1. Components of the total cost for implementation of integrated livestock forest (ILF) system with *E. pellita* and *S. tubulosa*.

		Unit	Unit Value (R$)	Total Amount	Total Value (R$)	R$/ha	US$/ha	% TC
E. pellita	**A – Variable Cost**							
	Operation with Machine + Implement	HMi	180.00	2.0	360.00	51.43	9.35	13.30
	Labor	day	80.00	10.5	840.00	120.00	21.82	31.03
	Seedlings	unit	2.50	212.0	530.00	75.71	13.77	19.58
	Soil correctives	kg	0.64	34.4	22.02	3.15	0.57	0.81
	Natural Rock Phosphate	kg	1.98	34.4	68.11	9.73	1.77	2.52
	Macronutrients 04-30-16 NPK	kg	3.00	60.2	180.60	25.80	4.69	6.67
	Macronutrients 20-05-20 NPK	kg	3.40	51.6	175.44	25.06	4.56	6.48
	Herbicide (Pre-planting)	L	28.20	1.0	28.20	4.03	0.73	1.04
	Herbicide (Post-planting)	L	28.20	1.0	28.20	4.03	0.73	1.04
	Ant trap	kg	15.00	1.0	15.00	2.14	0.39	0.55
	B – FIXED COST/ Depreciation Improvements	year	25,60	1.0	25.60	3.66	0.66	0.95
	C – OPERACIONAL COST							
	Expected Remuneration on Capital	year	133,72	1.0	133.72	19.10	3.47	4.94
	Land	year	300,00	1.0	300.00	42.86	7.79	11.08
	D – TOTAL COST (TC)					**386.70**	**70.31**	**100.00**
S. tubulosa	**A – Variable Cost**							
	Operation with Machine + Implement	HMi	180.00	2.0	360.00	51.43	9.35	13.87
	Labor	day	80.00	12.5	1000.00	142.86	25.97	38.54
	Seedlings	unit	1.66	159.0	263.30	37.61	6.84	10.15
	Soil correctives	kg	0.64	34.4	22.02	3.15	0.57	0.85
	Natural Rock Phosphate	kg	1.98	34.4	68.11	9.73	1.77	2.62
	Macronutrients 04-30-16 NPK	kg	3.00	60.2	180.60	25.80	4.69	6.96
	Macronutrients 20-05-20 NPK	kg	3.40	51.6	175.44	25.06	4.56	6.76
	Herbicide (Pre-planting)	L	28.20	1.0	28.20	4.03	0.73	1.09
	Herbicide (Post-planting)	L	28.20	1.0	28.20	4.03	0.73	1.09
	Ant bait	kg	15.00	1.0	15.00	2.14	0.39	0.58
	B – FIXED COST Depreciação Benfeitorias	year	25.60	1.0	25.60	3.66	0.66	0.99
	C – OPERATIONAL COST							
	Expected Remuneration on Capital	year	128.45	1.0	128.45	18.35	3.34	4.95
	Land	year	300.00	1.0	300.00	42.86	7.79	11.56
	D – TOTAL COST (TC)					**370.70**	**67.40**	**100.00**

RESULTS AND DISCUSSIONS

The total cost for the implementation of one ha of the ILF system with *E. pellita* or with *S. tubulosa* were estimated as US$ 70.31 and US$ 67.40, respectively (Table 1). These costs represent 83% and 82.5% of the income of the factors considered for *E. pellita* and *S. tubulosa,* respectively, and the combined fixed costs represent 16% and 16.5%, respectively, for a period of two years.

Decomposing the total cost for the implementation of both systems (Figure 1A and Figure 1C), it was verified that current expenditure required more financial resources, and within these, labor had a significant impact on the variable costs (37.4% and 46.7% in the ILF with *E. pellita* and *S. tubulosa*, respectively). In the implementation of the system with *S. tubulosa*, the labor costs were higher because of the lack of availability of seedlings from commercial nurseries. Thus, it was necessary to purchase the seeds and supplies necessary to produce seedlings in the nursery of the Experimental Field of Embrapa Rondônia, and it is necessary to consider the expenses associated with labor.

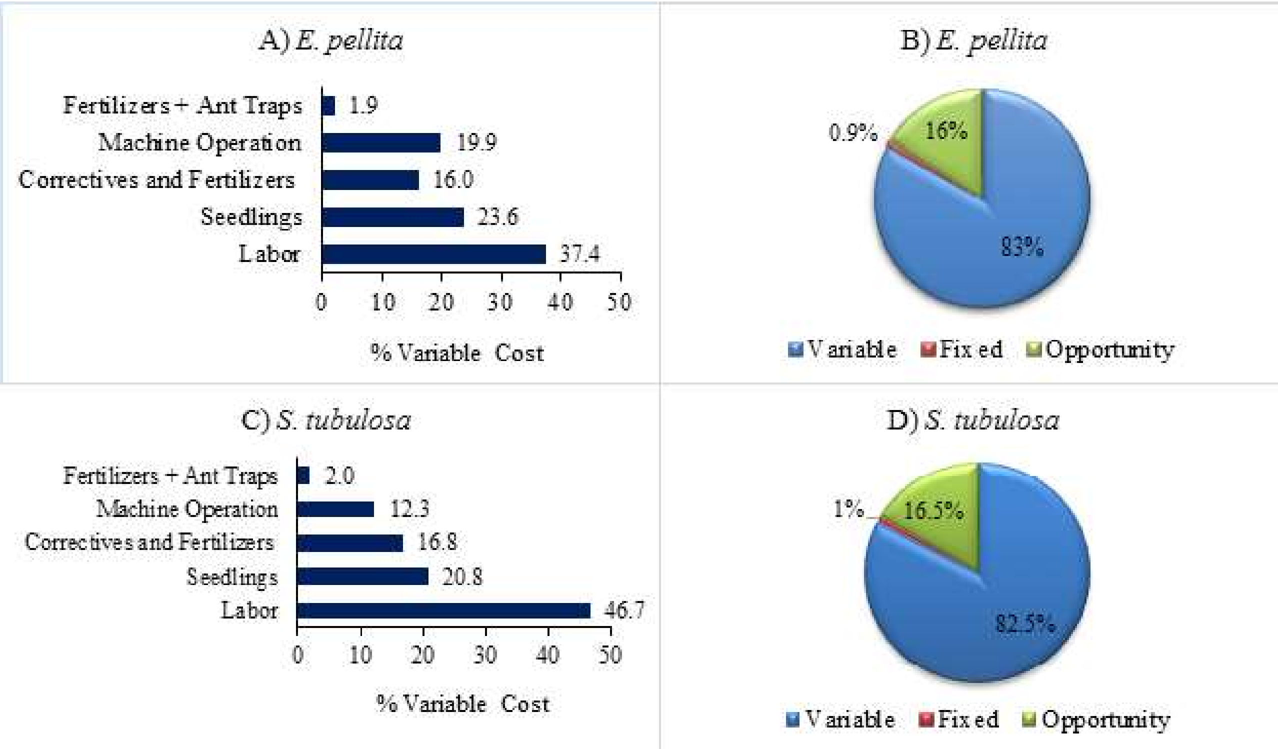

Figure 1. Proportion of costs (variable = A and C; and total = B and D) for implementation of Integrated Livestock-Forest (ILF) system with E. pellita and S. tubulosa in the municipality of Porto Velho, Rondônia, Brazil.

The total cost for ILF implementation was similar between the tree species, *E. pellita* and *S. tubulosa*. Thus, the choice of a tree species should be based on the main objective of the forest component, i.e., to produce wood products, or to supply multiple services. The main features of each tree species should be considered.

The advantages of eucalyptus as the forest component in the ICLF system are related to the availability of technical information for management (VALE et al., 2014) and to the advanced genetic improvement, which is responsible for the easy access to seedlings with excellent quality and affordable price, and a range of species for the various desired purposes. These factors place eucalyptus in a prominent position as a forestry essence and as an important component of silvopastoral systems (MELOTTO et al., 2012). In general, eucalyptus species have good growth and coppicing properties, resistance to *leaf disease*, adaptability to a variety of environmental conditions, and are useful as multipurpose timber. In the specific case of *E. pellita*, this species is recommended to the Amazon region because of its relative tolerance to leaf diseases related to tropical climate (FERREIRA and SILVA, 2004) and its adequate timber productivity in acidic soils with low fertility levels (AMEZQUITA et al., 2018). Other advantages of eucalyptus as a tree component in ICLF systems are: considerable wood productivity, cultivation at a high technological stage in some Brazilian regions and the potential to capitalize on agroforestry systems, as it works as "green savings". Despite the wide possibility of using eucalyptus wood in ICLF, farmers must focus on more noble forms of use, such as poles, sawn wood, and laminates for the production of furniture, thus obtaining greater profitability in the system (MELOTTO et al., 2012).

The use of native trees in the composition of integrated systems has been a trend of scientific research, as an alternative for increasing the biodiversity of the systems and for the conservation of natural resources. According to Andrade et al. (2012), there are 51 Amazon native tree species with the potential to be integrated with pastures, including the *S. tubulosa* tree. The main feature of this species is that it is a tree legume with the capacity to fix nitrogen from air, one of the most desirable multiple services in the afforestation of pastures. The other traits of *S. tubulosa* are: 1) the adequate canopy architecture characterized by a flabeliform form with low density that allows the radiation passage through it and does not negatively affect forage productivity, 2) the production of fruits with adequate nutritional value for animal feeding, 3) the absence of negative interference on the soil covering, the adequate natural regeneration in pastures, 4) a relative high growth rate (mean of 1.64 m per year), and 5) the facility for seedling production. In addition, *S. tubulosa* produces honey flowers.

CONCLUSIONS

The total cost for ILF implementation was similar regardless of the tree species, *Eucalyptus pellita* or *Samanea tubulosa* (US$ 70.31 and US$ 67.40, respectively). Thus, the choice of the tree species to be introduced in the system should be based on the main objective of the forest component, for producing wood products, or for supplying multiple services.

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