TROPICAL TREE SPECIES FROM DIFFERENT ECOLOGICAL GROUPS GROWTH UNDER DIFFERENT MANAGEMENT IN AGROSILVOPASTORAL SYSTEM IN BRAZIL

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INTRODUCTION

The restoration of degraded areas should lead the process of natural succession, restoring the structure and composition of the forest through natural regeneration. Agroforestry systems (AFS) and silvopastoral systems are alternatives in these situations as they include the agricultural production using different crops, trees and animals ensuring biodiversity and ecosystem and optimizing land use. These systems are strategies to minimize the intensive use of land with monoculture, besides serving as a strategy to make forest restoration and interaction between agriculture forest and animal. Native vegetation and mixed reforestation also reduce the impact activities and generate income and food production. The crop diversification leads to a significant improvement of the physical, chemical and biological soil through nutrient cycling and erosion control. The success of these projects depends on the right choice of species to be planted and their interactions. The separation of tree species in ecological groups is a way to allow the handling of the large number of tree species of tropical forest by grouping for similar functions and requirements. The growth and the way that the species from different ecological groups respond to different management during planting and then over time under these systems are very important as they led us to information about their success and efficiency .
This work evaluated tropical forest tree species from different ecological groups interspersed with annatto (B*ixa orellana), rubber tree* (*Hevea brasiliensis L.) and Malpighia that were planted in silvopastoral system planted in February 2011 under four different management.*

OBJECTIVE

This work aimed to evaluated the trees that were planted under a silvopastoral system after four years. Were evaluated mortality rate of trees, biomass, and carbon stock of the different species within the different ecological groups (pioneer and non pioneer) under four different management adopted .

METHODS

In 1998, a project stabilized a gully erosion process in the Polo Centro Norte- APTA, Pindorama, Brazil with the construction of four dams to minimize erosion caused by runoff of rainwater (Abdo et al., 2013).

Figure 1. Gully erosion stabilization before plantation (1998)

In february 2011 an agroforestry system (AFS) with native tropical forest species interspersed with annatto (*Bixa orellana),* rubber tree (*Hevea brasiliensis* L.*)* and *Malpighia punicifolia* was planted in the edges of the four dams under different managements. The intension was then to convert it in to a silvopastoral system introducing animals after the trees were grown. The revegetation after the dams construction was part of the recovery project to established the gully erosion process. In that time 33 species of native trees from different species and different sucessional groups were planted and 24 species were classified as pioneer, 6 species as climax and 3 species were commercial species: annatto, rubber tree and *Malpighia.* In figure 2 the pattern of plantation can be seen :

Syzygium malaccense	*Guazuma crinita*	*Chorisia glaziovii*	*Albizia haslerii*	*Psidium acutangulum*	*Cecropia pachystachya*	*Anadenanthera macrocarpa*
Joannesia princeps	**Rubber tree** *Hevea brasiliensis*	*Dilodendron bipinnarum*	*Inga edulis*	*Anadenanthera macrocarpa*	**Rubber tree** *Hevea brasiliensis*	*Psidium acutangulum*
Ceiba samauma	*Hymenaea Courbaril*	*Malpighia emarginata*	**Annatto** *Bixa orellana*	*Malpighia emarginata*	*Cariniana Legalis*	*Schinus terebinthifolia*
Anadenanthera macrocarpa	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	**Rubber tree** *Hevea brasiliensis*	*Acacia polyphylla*
Jaracatia spinosa	**Annatto** *Bixa orellana*	*Malpighia emarginata*	*Tabebuia heptaphylla*	*Malpighia emarginata*	**Annatto** *Bixa orellana*	*Mabea fistulifera*
Psidium guajava	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	**Rubber tree** *Hevea brasiliensis*	*Gallesia integrifolia*
Malpighia emarginata	*Casearia gossypiosperma*	*Malpighia emarginata*	**Annatto** *Bixa orellana*	*Malpighia emarginata*	*Casearia gossypiosperma*	*Malpighia emarginata*
Albizia haslerii	*Guazuma crinita*	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	**Rubber tree** *Hevea brasiliensis*	**Annatto** *Bixa orellana*	*Caesalpinia ferrea*
Peltophorum dubium	Malpighia emarginata	*Gustavia Augista*	*Malpighia emarginata*	*Cariniana estrellensis*	*Malpighia emarginata*	*Myrciaria dubia*
Cecropia pachystachya	*Rapanea guianensis*	*Inga laurina*	*Cecropia pachystachya*	*Inga edulis*	*Triplaris americana*	*Croton floribundus*

LEGEND: Pioneer; Climax; Malpighia; Rubber tree; Annatto

Figure 2. Sequential Organization of tree species in each plot SAF deployed at the North Pole-APTA Center in 2011 .

On February 17th, 2011, was implemented for each dam, 8 plots, 4 on each dam edge with 10 rows and 7 columns, spacing 3 m x 2 m in Dam 1 (T1) and 3.5 m x 2 m in Dam 2(T2), Dam 3(T3) and Dam 4(T4).
In order to evaluate the influence of management on plant development and erosion it was adopted the following treatments (T) during the Agroforestry System (AFS) plantation:

T1 : Native species and *Malpighia* planted in hollows without soil disturbance and spacing 3 x 2m, with mechanical control of weeds by mowing.
T2: Native species and *Malpighia* planted in hollows without soil disturbance and spacing 3.5 x 2m, weed control with herbicide and corn planting between rows of trees under no-tillage system.
T3: Native species and *Malpighia* planted in furrows with soil disturbance with disc plows, for weed control. Spacing of 3.5 x 2m and corn cultivation under conventional system between rows of trees.
T4: Native species and *Malpighia* planted in furrows with soil tillage for weed control, spacing of 3.5 x 2m and with no culture between rows.

Methodology of living tree biomass determination using indirect methods:
To estimate tree biomass in tons/hectare (TC/ha) an indirect method developed by ICRAF (Arevalo *et al.* 2002) was applied using the trees' survey data.

Living tree biomass: First a survey of height (m) and the diameter at breast height (DBH) (cm) of all trees > 2.5cm was done (Figure 3.)

Figure 3. Trees' survey

Calculation of the living tree biomass (BA) (kg / tree) forest areas :
Biomass of alive or dead standing tree was calculated with the following equation:

$$BT(kg/tree) = 0{,}1184\ DBH^{2.53}$$

Where: BT = biomass of live and standing dead trees; 0.1184 = constant; DBH = diameter at breast height (cm); 2.53 = constant
(Biomass per hectare: adding the biomass of all trees and the area of each parcel: treatment 1 the parcels are 420 m^2 and treatments 2, 3 and 4 the area of each parcel is 490 m^2.)

Calculating total carbon: According to AREVALO et al.(2002) the total carbon stock in plant biomass of each parcel (t/ ha) was:

$$CPB\ (t/ha) = BTP * 0{,}45$$

Where: CPB (t/ ha) = carbon in plant biomass; BPB = Total plant biomass and 0.45 = constant

RESULTS AND DISCUSSION

Table 1. Number of living trees (native species, rubber, annatto and *malpighia*) in the Agroforestry System after four years of planting (January 2015).

Variation Analysis	Pioneer	Non Pioneers				
		Climax	Rubber tree	*Annatto*	*Malpighia*	Total
DF	28	28	28	28	28	28
F treatments	1,19 ns	3,51*	4,59**	5,36**	1,19 ns	6,66**
GM	13,72	1,84	2,41	6,66	1,44	12,34
SD	2,25	0,94	2,12	2,65	1,53	4,60
DMS (5%)	3,08	1,29	2,89	3,62	2,09	6,28
CV (%)	16,44	51,12	88,12	39,79	106,40	37,27
Tukey test 5%						
T1	13,25 a	2,50 a	4,75 a	7,75 a	1,88 a	16,88 a
T2	13,13 a	1,38 a	1,13 b	6,38 ab	0,63 a	9,50 bc
T3	15,00 a	2,25 a	2,00 ab	8,75 a	1,88 a	14,88 ab
T4	13,50 a	1,25 a	1,75 b	3,75 b	1,38 a	8,13 c

Significance levels: * P < 0.05. ***P < 0.001. ns = not significant. Values followed by the same letters in each column area not significant (P < 0.05). a > b > ….Level of significance: **: 1%; *: 5%.

DF:degrees of freedom; LSD: least significant difference; CV: coefficient of variation, SD: standart deviation.

Table 2. Biomass and Carbon (T/ha) of pioneer species and non pioneer species in the Agroforestry System after four years of planting (January 2015).

Variance analysis	Pioneers Biomass	Pioneer Carbon	Non Pioneer Biomass	Non Pioneer Carbon
DF	28	28	28	28
F treatments	2,59	2,59	1,59	1,59
GM	2,48	1,11	0,78	0,35
SD	1,11	0,50	0,79	0,35
DMS (5%)	1,51	0,68	1,08	0,48
CV (%)	44,72	44,72	101,35	101,35
Tukey test 5%				
T1	2,59 a	1,17 a	0,71 a	0,32 a
T2	3,32 a	1,49 a	1,28 a	0,57 a
T3	2,02 a	0,91 a	0,67 a	0,30 a
T4	1,97 a	0,89 a	0,45 a	0,20 a

Significance levels: * P < 0.05. ***P < 0.001. ns = not significant. Values followed by the same letters in each column area not significant (P < 0.05). a > b > ….Level of significance: **: 1%; *: 5%.

DF:degrees of freedom; LSD: least significant difference; CV: coefficient of variation, SD: standart deviation.

In January 2015 mortality of all trees was 68%.There was no significance difference for pioneer trees survival rates under the treatments but the the survival rates of living trees from all ecological groups were higher in T1 and T3 during the four years evaluated. T4 with intensive soil management and without culture between rows had the lowest values for survival trees and carbon stock (0.2 T/ha). There was no significant statistic difference for rates of biomass and carbon stock for all live trees in all ecological groups. The different management influenced the trees mortality but not trees biomass rates.

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