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Initial Growth of *Eremanthus erythropappus* in Recovery of a Gravel Pit in Diamantina, Brazil

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ABSTRACT

The mining activity causes intense degradations to the environment, because it needs the vegetable suppression and the removal of the surface soil layer, leaving the mother-rock or saprolites exposed. The recovery of this areas is possible, however it is a slow and difficult procedure, in which the choice of species with peculiar characteristics of success in the survival and development in adverse conditions. The objective of this study was to evaluate the effect of six different planting densities on growth and survival of a candeia (*Eremanthus erythropappus (DC.) MacLeish*) in order to recover degraded areas. For recovery practices were collected from surface soil layers and then transported to the area of the gravel pit. Three were selected points where the material was deposited in stacks and spread in layers of about 20 cm of topsoil. The experimental design was randomized blocks with six treatments (1667, 2000, 2500, 3333, 5,000 and 10,000 plants per hectare) and three replications. Quarterly evaluated the overall height of the plants, stem diameter, canopy cover and survival until 12 months after the first evaluation. It was found that different planting densities did not differ statistically as height, diameter and crown cover. The average survival rate was 99.86% at 150 days, 97.72% at 240 days, 330 days to 72.12% and 56.72% and 52.13% at 420 and 510 days respectively. The denser treatments were those with longer survival. Thus, the candeia is a species with a high potential for use in ecological restoration programs in degraded areas.

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INTRODUCTION

The "Cerrado" owns a high flower diversity and endemism richness, however, that diversity has been threatened by the development of activities such as agriculture, urbanization and, mainly, mining. Such activities are strong landscape modifiers and extensive degraded areas generators, causing impacts which are most of the times irreversible or difficult to recover.

According to Pinheiro (2008), the mining activity cause intense degradations to the environment, because it needs the vegetable suppression and the removal of the surface soil layer, leaving the mother-rock or saprolites exposed. The removal of the soil profile to perform civil and road constructions cause changes in the local environment and around it.

The borrowed areas are defined as a place where some mineral properties of immediate and *in natura* usage, such as sand, gravel, earth and others, which are used in civil constructions, are extracted from. Surfaces of borrowed areas consist in degraded landscapes caused by the vegetable recovery difficulty with its forms and functions in the landscape, which is worsened by the usage intensity and anthropic intervention rate that cause a disorder in the hydrological network and generate environmental impacts (Grant, 2006).

The recovery of these areas is possible, however it is a slow and difficult procedure, in which the choice of species with peculiar characteristics of success in the survival and development in adverse conditions (Alves *et al*., 2007).

The degraded areas recovery acceleration can be achieved through the planting of arboreal species, being the most popular technique in recovery projects. The planting of species to be reintroduced needs maintenance

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and protection during its establishment, which may increase the costs for its implementation (Pierson *et al*., 2007). Although it is a hard and expensive procedure, it is potentially efficient (Bruel *et al*., 2010).

Eremanthus erythropappus (DC.) MacLeish is a forest species of multiple usages, being widely used as fence posts for its high durability and, also, in the essential oil extraction, whose main active principle is the "alpha-bisabolol", used in the manufacture of medicine, because it owns antiseptic, anti-inflammatory and healing properties, and also used in manufacturing of cosmetics (Scoloforo *et al*., 2002). Since the species is adapted to places where I would be difficult to implement other forest species or agriculture, one of the reasons that justify its handling is that it can contribute as a financial source to the farmer (Perez *et al*., 2004). Then, because of its high ecological potential in the recovery of degraded areas, it becomes an alternative to mitigation of environmental impacts and generation of income in small properties at "Alto Jequitinhonha".

In front of the exposed, the work had as object to evaluate the survival and the growth in height, diameter and crown area of the seedlings of *E. erythropappus* in a gravel pit area, submitted to different densities of planting, aiming to generate acknowledges capable to support the recovery of degraded ecosystems.

MATERIAL AND METHODS

The experiment was implanted and conducted in a gravel area with about 10 ha, situated in the "Parque Estadual do Biribiri" (PEB), Diamantina-MG, "Alto do Jequitinhonha" region, in the complex of "Serra do Espinhaço" in coordinates 0649511.86 and 649640.24 m longitude and 798711.81 and 7987250.62 m latitude (UTM) and average altitude 1412 m. the gravel degradation occurred because of the gravel mining for the construction of the highway "BR-367" in the middle of the 50's. After that period the extraction of gravel was still used for civil works through the town of Diamantina. There aren't records about the year when that removal in the area has begun neither when it stopped, so ever it is believed that it has been ceased with the creation of the Park in 1998.

In the surrounding of the gravel, the occurrence of rock field typical vegetation, rural "Cerrado" and Semi-decidual and "candeal" seasonal Forest is verified. The predominant soils in the studied area before the gravel extraction were characterized as "Plintossolos", according to Embrapa (2009), composed by mineral material, presenting a Plinthic or litoplinthic or concretionary horizon getting started in 40cm or in 200cm when immediately below the horizon A or E, or other horizon that presents pale, variegated or mottled colors in abundant amount.

The fertile soil layer was removed because of the mining advance, without windrow stock, contrarily to the technical recommendation for future replacement, having only one more substratum left, very compacted with presence of rough rock fragments.

The local substratum before the implantation of the experiment was totally uncovered from vegetation and with great compaction, being basically composed by rocks and with deep erosion grooves, low index of organic matter and low capacity of water storage.

The climatic regime of the region is typically temperate, Cwb in the Koppen classification, characterized by a soft wet summers (October-April) and fresher and drier winters (June-August). The annual average precipitation vary from 1,250 to 1,550 mm and the annual average temperature is about 18° C to 19° C, being predominantly nice during all the year, due to the highest surfaces of that saw. The air relative humidity mostly high, revealing annual averages of 75.6% (Neves *et al*., 2005).

Before the planting a layer of nearly 20cm of topsoil from a bordering area of the park was applied, denominated "Campus Juscelino Kubitschek da Universidade Federal dos Vales do Jequitinhonha e Mucuri" (UFVJM). The soil of the given area was classified as "Neossolo Quartsarênico", presenting sand or plain sand texture until at least 150 cm deep from the surface or until the lithic contact, with clay index under 15% (Embrapa, 2006).

Three places (blocks) were selected in the gravel, totally without any vegetable coverage, where it was held, firstly, the land remodeling, and then, the application of the topsoil. The seedlings planting was performed in February 2010, where 30x30x30 cm holes were dug and fertilized with 150g in each hole of simple superphosphate. The experimental design with randomized blocks was used, using time subdivided portions, with three repetitions (blocks), being the treatments represented by six planting densities (T1=1.667, T2=2.000, T3=2.500, T4=3.333, T5=5.000 e T6=10.000 plants per hectare). Each block consists of six portions of 10x25 m (250m²), so the number of planted seedlings in each treatment was T1=42, T2=50, T3=63, T4=83, T5=125 e T6=250, being a total of 613 seedlings per block.

The mortality of the seedlings was evaluated at 90 days after the planting and afterwards, the replanting was done. All the seedlings were labeled with aluminum plaques.

The field plants development was evaluated using trimestral measurement up to 12 months after the first measurement, which was done in July 2010. The following variables were evaluated: total height (cm), measure from the soil level to the last yolk insertion, stalk diameter (mm) at the soil level, area/top cover (m²) and survival (%).

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For the measure of the total height and the stalk diameter a measuring tape and a digital caliper were used, respectively. The top area (AC) was calculated using the ellipse formula "AC=a.b.π/4" (Souza *et al.,* 2001) getting two orthogonal measures with the measure tape, in order to verify the consistence of the top in its development, the survival was evaluated from the number of dead individuals along the measurements, which was based in the absence of leaves and dry stalks.

The average month increment was also calculated, for each evaluated time, "$IMM_{height,diameter,leaf\ area} = \frac{average}{age\ (months)}$ in order to verify, in which treatment have the best development occurred.

In July 2010, six months after the topsoil deposition, 15 portions of 1 m² were randomly established in the three places, to verify if the coverage provided by the herbaceous stratum would compete with the seedlings of "candeia". The coverage of the plants inside the portions was evaluated in July 2010 and July 2011, where a subjective measure that visually estimates the coverage in percentage was estimated using the Braun-Blanquet scale. In February 2011, the seedlings of *E. erythropappus* were crowned, in order to decrease the weed competition.

To the analysis of the area, a sample consisted of soil layer of 0-5 cm and 5-10 cm was collected, each composed sample (300cm³) consisted of five simple samples. The chemical and physical analyses were made at "Laboratório de Fertilidade e Física do Solo da UFVJM" according to the Embrapa (1999), being analyzed the soil chemical parameters: pH in water, percentages of P, K, Ca, Mg and Al; sorption complex (potential acidity (H+Al), base saturation (V%), base total (SB), CTC to pH 7 (T), effective CTC (t) and aluminum saturation (m%)) and organic matter (MO). The Evaluated physical parameters were: soil gradation (% of clay, % of silt and % of sand).

The daily meteorological data of precipitation in the period of January 2010 to October 2011 were provided by "Estação Climatológica Principal de Diamantina" obtained with the "5° Distrito de Meteorologia (5° DISME)" which belongs to the "Instituto Nacional de Meteorologia – INMET". To correlate the total survival index and the six treatments in each one of the five evaluations, the precipitation data from the three months before each measurement were collected. The Spearman correlation coefficient was used (rs) employing the BioEstat 5.0 software.

The total height, stem diameter, crown coverage, daily average increment and survival data, were submitted to variance analysis and, when needed, the Turkey average test was performed at 95% probability and, the time (quantitative character), the regression by the ordinary least square method was done in which the time was the independent variable and the dependent variable was the total height, the stem diameter, the crown coverage and the survival. The statistical analysis was performed with the help of the Statistica 10.0 software (Statsoft, 2010).
The results to the chemical analyses for the 0-5cm and 5-10 cm layers indicate that the substrates present low natural fertility, with base saturation (V %) under 50% (dystrophic) and, in its majority, medium to high acidity (Table 1). The texture was frank sandy, which has low capacity to retain water. The organic matter percentage for the six treatments in the two depths, varied from low to very low. The pH percentages in water increased in depth and varied from very low to low. The phosphorus (P), potassium (K), aluminum (Al), magnesium (Mg), calcium (Ca) percentages, base sum (SB) and effective CTC (t), varied from low to very low.

Table 1: Results of the soils analyses in 0-5 and 5-10 cm, in the gravel, situated in Parque Estadual do Biribiri in Diamantina, MG.

Block 1												
Treatments	T1		T2		T3		T4		T5		T6	
Variables / Layers	0-5 cm	5-10 cm	0-5 cm	5-10 cm	0-5 cm	5-10 cm	0-5 cm	5-10 cm	0-5 cm	5-10 cm	0-5 cm	5-10 cm
pH (H_2O)	5.80	6.00	5.30	4.90	5.00	6.10	6.10	6.10	5.60	6.50	7.00	7.10
P (mg/dm^3)	0.42	0.08	0.38	0.93	1.05	1.89	0.46	12.56	0.17	0.17	0.21	0.17
K (mg/dm^3)	28.50	31.35	37.05	33.96	25.47	59.85	34.20	25.65	14.25	19.95	8.55	8.55
Ca^{2+} ($cmol_c/dm^3$)	0.30	0.30	0.40	0.30	0.30	0.30	0.40	0.40	0.30	0.20	0.20	0.20
Mg^{2+} ($cmol_c/dm^3$)	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.20	0.10	0.20	0.10	0.10
Al^{3+} ($cmol_c/dm_3$)	0.20	0.18	0.42	0.44	0.44	0.56	0.44	0.54	0.06	0.10	0.04	0.02
H + Al ($cmol_c/dm^3$)	4.20	4.70	4.70	5.20	5.20	4.20	4.20	4.20	2.40	2.70	1.50	1.40
SB ($cmol_c/dm^3$)	0.57	0.58	0.70	0.59	0.57	0.65	0.79	0.67	0.44	0.45	0.32	0.32
t ($cmol_c/dm^3$)	0.77	0.76	1.12	1.03	1.01	1.21	1.23	1.21	0.50	0.55	0.36	0.34
T ($cmol_c/dm^3$)	4.77	5.28	5.40	5.79	5.77	4.85	4.99	4.87	2.84	3.15	1.82	1.72
m (%)	25.87	23.67	37.67	42.84	43.77	46.15	35.84	44.78	12.08	18.14	11.05	5.85
V (%)	12.01	10.99	12.88	10.14	9.81	13.46	15.79	13.68	15.39	14.32	17.67	18.70
M.O (dag/kg)	1.00	1.50	1.00	0.60	0.60	0.60	0.80	0.90	0.20	0.20	0.10	0.10
Sand (%)	72.47	73.38	81.32	81.00	77.22	72.27	80.60	78.04	62.14	62.86	32.41	29.55
Clay (%)	15.50	18.00	13.00	13.50	14.00	9.00	12.00	12.50	14.00	19.00	22.50	24.00
Silt (%)	12.03	8.62	5.68	4.58	8.78	18.73	6.90	9.46	23.86	18.14	45.09	45.95
Block 2												
pH (H_2O)	5.30	5.60	5.20	5.20	6.20	5.00	5.00	5.00	5.10	5.30	4.60	4.90
P (mg/dm^3)	0.52	0.52	0.81	0.48	0.38	0.81	0.65	0.61	0.65	0.89	0.56	0.73
K (mg/dm^3)	22.64	22.64	28.30	22.64	17.10	11.32	19.81	16.98	33.96	25.47	31.13	22.64

Ca^{2+} ($cmol_c/dm^3$)	0.90	0.90	0.70	0.60	0.80	0.30	0.50	0.40	0.30	0.30	0.20	0.20
Mg^{2+} ($cmol_c/dm^3$)	0.40	0.30	0.30	0.30	0.40	0.10	0.10	0.30	0.20	0.10	0.20	0.10
Al^{3+} ($cmol_c/dm_3$)	0.08	0.06	0.14	0.12	0.10	0.06	0.10	0.12	0.20	0.10	0.38	0.30
H + Al ($cmol_c/dm^3$)	4.70	3.30	5.80	5.20	3.70	4.70	4.70	4.20	5.80	5.20	7.30	6.50
SB ($cmol_c/dm^3$)	1.36	1.26	1.07	0.96	1.24	0.43	0.65	0.74	0.59	0.47	0.48	0.36
t ($cmol_c/dm^3$)	1.44	1.32	1.21	1.08	1.34	0.49	0.75	0.86	0.79	0.57	0.86	0.66
T ($cmol_c/dm^3$)	6.06	4.56	6.87	6.16	4.94	5.13	5.35	4.94	6.39	5.67	7.78	6.86
m (%)	5.56	4.55	11.55	11.13	7.44	12.27	13.32	13.90	25.41	17.69	44.20	45.59
V (%)	22.42	27.60	15.61	15.56	25.16	8.36	12.16	15.04	9.19	8.21	6.17	5.22
M.O (dag/kg)	0.60	0.70	0.60	0.90	0.10	1.10	1.00	0.90	0.80	0.30	0.90	1.50
Sand (%)	73.77	67.47	72.60	66.28	62.31	51.33	64.76	55.84	61.05	48.47	58.09	60.69
Clay (%)	17.00	16.00	13.00	18.50	19.00	26.50	17.00	20.50	20.00	26.50	35.00	19.00
Silt (%)	9.23	16.53	14.40	15.22	18.69	22.17	18.24	23.66	19.45	25.03	6.91	20.3
Block 3												
pH (H_2O)	5.40	5.40	5.40	6.60	5.30	5.30	6.50	5.30	5.60	6.40	6.20	6.10
P (mg/dm^3)	0.04	0.25	2.06	0.13	0.20	0.12	0.13	0.04	0.04	0.25	0.46	0.25
K (mg/dm^3)	37.05	37.05	17.10	17.10	11.32	14.15	22.80	19.95	37.05	37.05	34.20	34.20
Ca^{2+} ($cmol_c/dm^3$)	0.50	0.30	0.30	0.30	0.20	0.20	0.50	0.50	0.30	0.50	0.30	0.40
Mg^{2+} ($cmol_c/dm^3$)	0.30	0.30	0.30	0.30	0.10	0.10	0.30	0.40	0.20	0.30	0.30	0.20
Al^{3+} ($cmol_c/dm_3$)	0.18	0.20	0.08	0.04	0.04	0.02	0.08	0.10	0.10	0.12	0.30	0.34
H + Al ($cmol_c/dm^3$)	3.70	3.30	2.70	2.40	2.70	2.10	2.70	3.00	2.70	3.00	3.70	4.20
SB ($cmol_c/dm^3$)	0.90	0.70	0.64	0.64	0.33	0.34	0.86	0.95	0.60	0.90	0.69	0.69
t ($cmol_c/dm^3$)	1.08	0.90	0.72	0.68	0.37	0.36	0.94	1.05	0.70	1.02	0.99	1.03
T ($cmol_c/dm^3$)	4.60	4.00	3.34	3.04	3.03	2.44	3.56	3.95	3.30	3.90	4.39	4.89
m (%)	16.74	22.35	11.05	5.85	10.84	5.61	8.52	9.51	14.39	11.82	30.37	33.08
V (%)	19.48	17.40	19.25	21.15	10.86	13.80	24.12	24.07	18.06	22.98	15.67	14.07
M.O (dag/kg)	0.70	0.50	0.50	0.60	0.30	1.10	0.10	0.90	0.80	0.30	0.10	0.10
Sand (%)	49.00	51.99	49.11	65.74	43.24	42.02	67.66	72.60	42.18	52.65	65.96	75.98
Clay (%)	17.50	17.00	17.00	13.50	41.00	43.00	16.50	17.50	17.00	17.00	13.00	12.00
Silt (%)	33.50	31.01	34.39	20.76	15.76	14.98	15.84	9.90	40.82	30.35	21.04	12.02

It can be verified that to the height and diameter characteristics there was significant difference ($p<0.05$) for the block and time, while to the crown coverage the significance ($p<0.05$) has occurred only for the time (Table 2).

Table 2: Summary of the variance analysis for the total height, stem diameter and crown coverage of the seedlings of *Eremanthus erythropappus*, in the gravel, situated in "Parque Estadual do Biribiri, in Diamantina, MG.

Variation source	Total height	Stem diameter	Crown coverage
	QM	QM	QM
Block	2543.63*	121.49*	0.027^{ns}
Treatment	513.14^{ns}	13.12^{ns}	0.007^{ns}
Residue. a	373.72	16.68	0.013
CV_{exp}	49.74	47.33	158.78
Time	2388.14*	93.83*	0.028*
Treat. x time	26.42^{ns}	0.99^{ns}	0.002^{ns}
Residue b	37.73	1.98	0.003
CV_{exp}	15.80	16.29	81.71

^{ns} Non-significant. * Significant at 5% probability by the F test. QM median Square. CV experimental variation coefficient.

Adjustment with the simple linear model for the height, stem diameter and crown area according to the time. A constant linear and positive growth was noticed, evidencing that the species has adapted to the planting place (Figure 1). The "candeia", 540 days after the planting, had average values of height, diameter and crown coverage 65.31cm, 13.64mm and 0.24m², respectively.

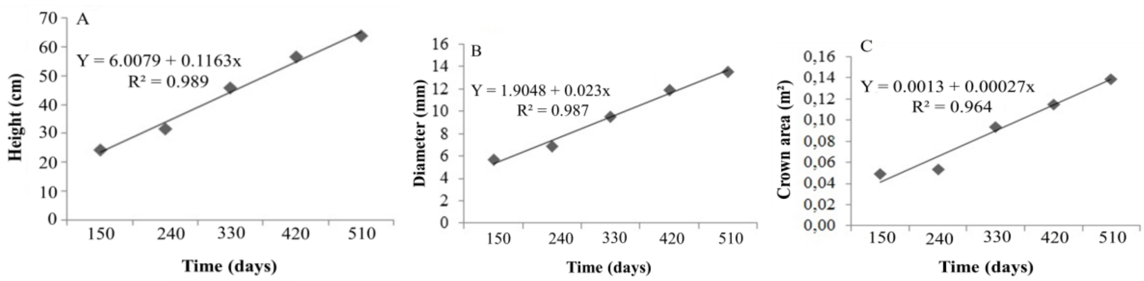

Fig. 1: The average estimate of the growth in height (A), diameter (B) and crown area (C) of seedlings of *Eremanthus erythropappus*, in function of the time, in the gravel, situated in "Parque Estadual do Biribiri, in Diamantina, MG. where: * Significant at 5% probability by the F test.

It was verified that there wasn't significant correlation between the survival at the end of the five evaluation with the precipitation (rs= 0.200; p= 0.7471), and the six treatments (T1, T2, T3, T4 and T6 –rs = 0.200; p= 0.7471 and T5 –rs = 0.1539; p = 0.8048) what indicates that the rain was not the main factor for the survival (Figure 2).

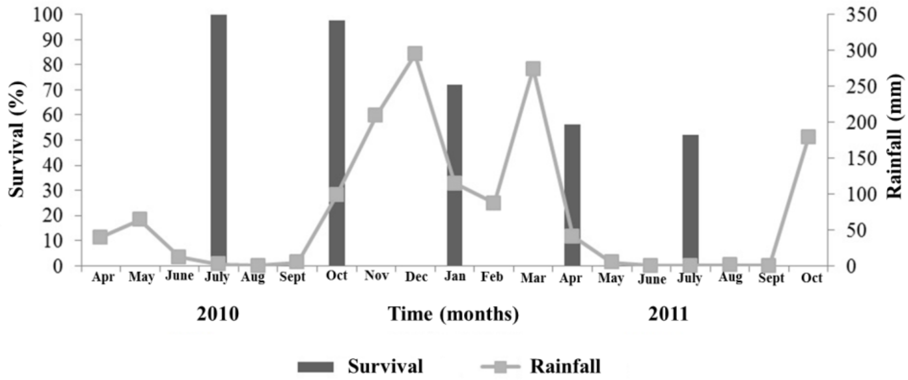

Fig. 2: Monthly variation of the rainfall and total survival of the plants of *Eremanthus erythropappus* in the gravel, situated in "Parque Estadual do Biribiri, in Diamantina, MG, during the period of April 2010 to October 2011.

To the survival, the significant statistical effect was observed to the interaction treatment x time. It noticed that, up to 330 days after the planting, there was no significant difference among the treatments, that is, different planting intensities, did not affect the survival (Figure 3). However after 420 days, it was verified that the denser treatments (T5 and T6), were statistically equal and superior to the others, presenting a major survival.

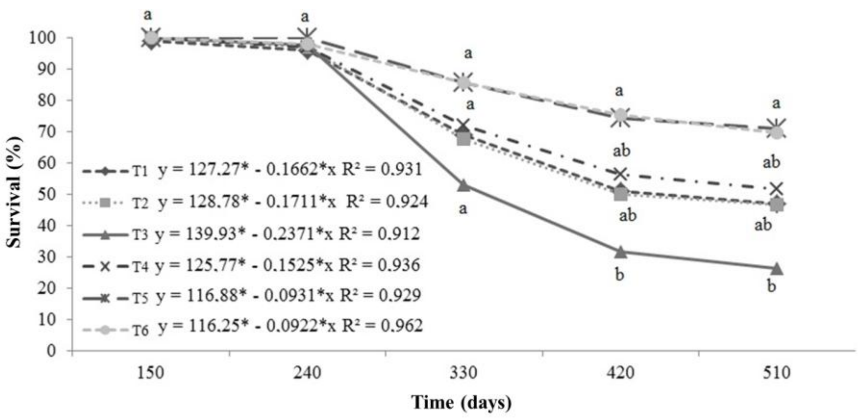

Fig. 3: Average results of the survival of seedlings of *Eremanthus erythropappus*, in function of time, in the Gravel, situated in "Parque Estadual do Biribiri, in Diamamantina, MG. where: * Significant at 5% probability by the F test. Averages followed by the same letter do not statistically differ among themselves by the Turkey test at 95%probability.

The monthly average increment in diameter, coverage area of the plants of "candeia", did not differ in the treatments, being noticed some statistical difference (p<0.050) just in the time, however, it was not possible to obtain a regression model that explained the data behavior.

Although the six planting densities did not show difference in relation to the gain of increment, it can be noticed that the less dense treatments (T1, T2 and T3) were the ones that presented less gain in month average increment, noticing, again, that the weed competition might have influenced in this variable success (Figure 4).

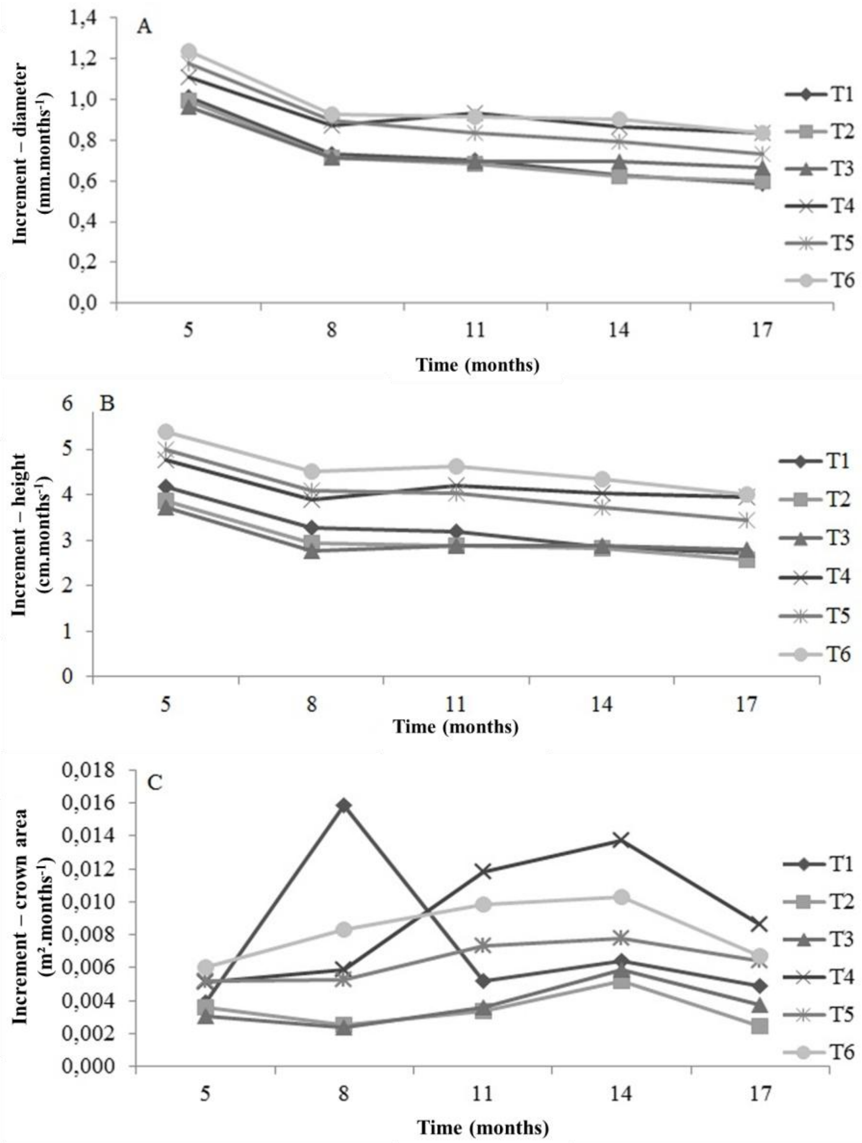

Fig. 4: Month average increment in diameter, (A), height (B) and crown area (C), in function of time, of seedlings of *Eremanthus erythropappus*, in the gravel situated in "Parque Estadual do Biribiri, in Diamantina, MG.

Discussion:

The low organic matter percentages that were found minimized the availability of nutrients for the plants, so hampering their establishment in the area. These data confirm studies made by Silva *et al*. (2004) in a gold mining area in the State of Minas Gerais and Costa and Zocche (2009) in a coal mining area, in the region of Santa Catarina. However, it is worth to highlight that the "candeia" occurs, predominantly, in soils with low fertility.

As well as in this work, very low values of pH were found by Costa and Zocche (2009), however, these authors highlight that in nutritional terms the ideal range of pH for the plants is between 5.6 and 6.2, since most of the nutrients are found in the soluble form and are passible of being absorbed by them. However, the "candeia" is a species ecologically adapted to acid soils conditions, this way it's not expected that these variations have influenced the growth of the same. According to Corá *et al*. (2004), values of pH, were lower in the surface layer, probably due to the acidification which occurs in the soil over time.

Generally, in mined areas the percentages nutrients in the analysis of soils is low. Silva *et al*. (2004), very low values of Al, P H+Al and K; low values of CTC to pH 7.0 (T), effective CTC (t), organic matter (MO) and aluminum saturation (m), median percentages of Mg, Ca and SB and a very good level of base saturation (V). But Silva *et al*. (2006) in a study about four materials from the iron mining has found low levels of Ca, Mg and T.

The Calcium, potassium and magnesium elements, in tropical and subtropical soils, in its majority acids, are normally found in low concentrations, what is natural, since the base wastes are characteristics of the soils acidification process (Luchese *et al.*, 2002). So, the chemical correction becomes necessary so that it can permit a satisfactory development of the plants that are not adapted to those conditions. According to Scivittaro and Pillon (2006), soils that presented very low, low or median levels of potassium and phosphorus, as in the case of the topsoil of the gravel, need correction fertilization, in order to elevate these nutrients levels in the soil up to the sufficiency level.

Unghire *et al*. (2011) when the soil properties are quantified, using pre and post-restoration, it was verified that the activities normally used to restore the ecosystem structure might have negative impacts, because of that, a pre and post restoration study would be important to examine the differences in those soil properties.

The percentage of replanted dead seedlings was 29.10%, being 13.88% to Block 1, 41.76% to Block 2 and 31.66% to Block 3, totalizing 534 seedlings. That mortality rate might have been due to the dry period, which occurred from January until middle of February 2010, decreasing the water availability for the plants and increasing the weed competition effect. Ignácio *et al*. (2007) when riparian forests restoration planting monitoring was done, initial mortality rate of up to 30% was verified, result similar to the one found in this work.

It was found in this study that the height, diameter and crown coverage values were not affected by the different densities of planting, corroborating the studies performed by Silva (2009), when he evaluated the growing and production of “candeia” in plantings subject to different spacing (t01-1.5x1.5m, T02-1.5x2.0m, T03-1.5x2.5m and T04-1.5x3.0m), in which it was verified that these ones have not, statistically, influenced in the diameter at 1.3m height, in the total height, in the volume per stash and the volume per hectare.

The models adjusted to height, stem diameter and crown area in function of time show that a constant, linear and positive growth, evidencing that the species has adapted to the planting place. Pérez *et al.* (2004), described, in studies about handling system of “candeia”, that after the application of treatments that reduce its competition, it may come to present median growths in diameter superior to 1 cm/year, mainly because it is a species the demands a lot of light, corroborating the verified in this work.

In relation to the growth the “candeia” has presented similar values of height found to the *Lithraea molleoides* (aroeira), *Schizolobium parahyba* (guapuruvu), *Bauhinia forficata* (unha-de-vaca), *Tabebuia chrysotricha* (ipê-tabaco), *Caesalpinia ferrea* (pau-ferro), *Anadenanthera macrocarpa* (angico-vermelho) e *Colvillea racemosa* (couvilha) species, for diameter of *Hymenaea courbaril* (jatobá), couvilha, pau-ferro, ipê-tabaco, *Stenolobium stans* (ipê-mirim), angico-vermelho e *Calophyllum brasiliensis* (guanandi), species, and crown area for the *Lithraea molleoides, Stenolobium stans, Anadenanthera macrocarpa,”pau-ferro”, Bauhinia forficata and Calophyllum brasiliensis* species, in studies made by Souza *et al.* (2001), when indicate forest species for the restoration of an area degrade by the sand extraction.

The short survival evaluation period might not have been enough for the effect of precipitation to express itself, suggesting the necessity of a longer series of data in that type of evaluation.

Those data corroborate the studies made by Sano and Fonseca (2003), when survival and fructification rates of species native from the “cerrado” are evaluated, where it is verified that the monthly rainfall has been little related to the death of the “pequi” (souari nut) during the first year of planting. While Silva and Corrêa (2008), have verified, in studies about the survival and growth of six arboreal species in mined area of the “cerrado”, that at the end of the second rainy season the survival of planted individuals reached 77.8%, however, of all the dead seedling, 71.8% were of a unique species, *Kielmeyera lathrophytum* (pau-santo). The other five ones presented survival superior to 90%.

The behavior found for the survival can be explained, due to the decreasing of the weed competition, because of the faster closing of the canopy, not allowing that the weed plant take advantage in relation to the planting of *E. erythropappus*. So, there is a tendency for the greater plant coverage area the less weed competition, mainly because the herbaceous species in the topsoil present, in its majority, photosynthetic metabolism type C_4, being adapted to colonize open and sunny areas, thus under the crown of the arboreal plants they became sensible to the shading. The weed competition becomes more expressive in soils with low capacity of water storage, which is the case of the soil in the current study.

The coverage provided by trees crowns decrease the radiation incident in the soil and control the weed competition (Guilherme, 2000), besides promoting the rains interception, reducing the direct impact over the soil (Melo *et al.*, 2007) and reduce the evaporation of soil water.

The treatment T3, has presented more mortality than the other treatments, possibly because the Block 3 referring to this treatment is an inclined area, for this the topsoil was totally taken by the rain water, remaining only a compact and with very low levels of macronutrients substratum (P, K, Ca, and Mg), of base saturation (SB), effective CTC (t), bases saturation (V%) and aluminum saturation (m%), thus hampering the establishment of the seedlings of *E. erythropappus* in the area.

The average coverage rate provided by the herbaceous stratum was 64% and 83% at the first and second evaluation, respectively. It is noticed that the weeds, coming from the seeds bank of the topsoil, might have competed with the plants of *E. erythropappus*. Because it is a pioneer species, the “candeia” becomes more sensible to the shading caused by the coverage provided by the grass in the area, thus, the larger spaces become more susceptible to be affected by the competition.

Aparício *et al*. (2010), when studying the weed competition in planting of two clones of *E. urograndis*, it was noticed that the growth in diameter and height was minor in the treatments without the weeds control, evidencing major sensibility to the competition. In a similar way, Costa *et al*. (2004) aiming to determine the effects of familiarity and control periods of the *Commelina benghalensis* in the initial growth of seedlings of *Eucalyptus grandis*, it was verified that after 40 days, in areas without competition, the height and the diameter presented tendency to be larger, with increase of 21% and 27% respectively.

Klionsky *et al*. (2011), when evaluating the impact caused by *Rhamnus cathartica* bush over four species native from the forests of the east and central-west North America, it was verified that this bush launch a dense shadow, alter the conditions of the soil and may be allelopathic, what has reduced the development of the native plants, affecting the growth, survival and flowering. This way, the coverage provided by the crowns is decisive in the inner micro-habitat of the forest, because it affects the survival and growth of the seedlings, determines the floristic composition of the community, controls the erosive processes and affects the floristic composition of the community (Melo *et al.*, 2007).

Leite *et al.* (2006), when evaluating the spacing and age effects about pinus populations variables, found that the spacings have influenced the growth tendency in total height and diameter, and that after 14 years, the larger spacings provided greater estimates of square diameter, survival and tree volume.

It is worth to highlight, that the greatest number of individuals per area, in general, implies in major IMM, until the stagnating phase of the growth. Mendonça *et al.* (2008) when studying the development of four species of Eucalyptus spp in pure or intercropped with legume (*Mimosa caesalpiniaefolia*) in mining digging clay, it was verified that the monthly average increment in height and diameter at the soil level were not influenced by the planting system, indicating that in the intercropped planting the Eucalyptus plants delay longer to be influenced by the competition.

Although the survival has suffered variations in relation to the planting densities, maintenance measures and/or replanting are indicated in the gravel area. However the surviving seedlings adapt very well to the place, presenting an accelerated growth and helping in the restoration process of the degraded area, being noticed the return of the avifauna, with the presence of several birds' nests in the seedlings of "candeia".

Conclusions:

The different densities of planting of *Eremanthus erythropappus* do not influence, in total height, stem diameter and crown coverage;

The denser spacings are the ones which present greater survival and monthly average increment, suggesting greater potential of establishment in the gravel;

The *Eremanthus erythropappus* is a species with a high ecological potential for the use in degraded areas restoration programs, being advisable a denser planting.

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