Original Research Article

How do ~~Establishment of~~ native trees~~s~~ establish on degraded Caatinga sites?

ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

This study evaluated tree establishment by seeding in manure-enriched substrate or by seedling planting in manure-enriched holes in two experiments carried out in Patos (PB), Brazil, in degraded Caatinga sites. Experiment one evaluated the effects of the joint seeding (absence and presence of it) of four tree species (Mimosa tenuiflora, Poincianela pyramidalis, Anadenanthera macrocarpa and Tabebuia aurea), and singular or lone seeding […of any one particular species; explain properly; …where joint and singular or lone seedings are independent factors] at two levels of cattle manure (absence and presence) in a site protected from grazing. The 2x2 factorial experiment was used with four treatments groups in two replicates to which five completely randomised blocks were assigned[…across or along a gradient (eg. soil or fertility or erosion slope); always state clearly; 2 x2 meaning two factors each with two levels]. Data from six other similar[how similar??, indicate] blocks submitted to previous and current overgrazing [is a difference in sheep and goats grazing envisioned?, if yes or no, clearly indicate assumption] were analysed independently. Experiment two, located in an overgrazed site currently protected from grazing, evaluated tree seedling establishment (natural and that resulting from planted Mimosa tenuiflora and Poincianela pyramidalis seedlings in manure-enriched holes according to a randomised completely blocked design with four treatments in two replicates (four controls: when no tree seedling planting occurred, and when seedling planting of one of the two tree species occurred) to which six blocks were assigned […across or along a gradient (eg. soil or fertility or erosion slope)]. Tree seedling establishment, natural or resulting from seeding, in plots enriched or not with manure and protected or not from grazing, was not observed during three years. Planting of M. tenuiflora accelerated the process of tree establishment, resulting in 36% survival rate and 177.5 cm length growth at the end of the third year[was this observed for all species or just for M. tenuiflora]. Observations should continue to determine the period suitable for making degraded Caatinga sites once again available for production.

Keywords: jurema preta, catingueira, angico, craibeira, land reclamation, tropical dry forest.

1. INTRODUCTION

Caatinga vegetation predominates in the semiarid region of northeastern Brazil, ~~characterized~~characterised by annual precipitation in the range of 500 to 700 mm, high insolation, low cloud cover, and high temperatures and evapotranspiration [1]. Firewood and charcoal from the Caatinga forest supply a~~one~~ third of the energy consumed in the region, mainly for cooking and burning of bricks and gypsum ore [2, 3]. The~~is~~ demand for energy, the expansion of agricultural and cattle raising areas, and~~ the~~ harsh climate cause environmental impacts, such as widespread deforestation. There are reports of $11x10^3$ hectares of deforestation occurring~~ed~~ each year in the region of Araripe-PE, where many gypsum industries have~~generate~~ a high demand of firewood [3].

Forest recovery in these sites is slow and uncertain, and data on natural regeneration and forestry practices are lacking for most of the happenings~~situations~~ in the Caatinga Biome. Natural regeneration is the cheapest way to recover forest cover [4], however recovery~~it~~ may take~~ demand~~ a long time, as it depends on seed dispersion and dispersers, seed banking, seedling establishment, trunk and root sprouting of formerly established trees [5] among~~nd~~ other factors. There are alternatives, such as litter (100 m^3/ha) and manure (30m^3/ha) additions to improve~~amend~~ the regenerative conditions of degraded Caatinga sites [6], a measure not practical on~~ to apply on~~ larger scale~~areas~~.

Planting~~ of trees~~, especially of native tree species, is supposed to accelerate site recovery by attracting agents of seed dispersal, such as birds and rodents, accumulating organic matter and ameliorating site conditions for seed germination and seedling establishment [7]. Batista et al [8] reported these effects of~~ for~~ a site degraded by clay extraction after *Eucalyptus* spp. and *Mimosa caesalpiniaefolia* planting.

Comment [1]: which?? specifcy

Although reports on regeneration of degraded Caatinga sites are uncommon [9], *Mimosa tenuiflora* (Willd.) Poiret), *Caesalpinia pyramidalis* Tul., *Anadenanthera macrocarpa* (Benth.) Brenan.) and *Tabebuia aurea* (Manso) Benth. & Hook. are native trees regularly seen~~observed~~ in primary and secondary stages of revegetation of Caatinga sites [10, 11]. Reintroduction of these species may be viable by direct seeding or seedling planting, especially after~~when~~ the soil is physically amended and enriched with manure. The expectations are that these measures can increase the rate of seed germination and seedling establishment compared to natural tree regeneration, especially in degraded sites [12].

This study ~~had the objective to ~~evaluated~~, in degraded Caatinga sites protected or not from grazing, ~~the effects of manure and seed addition on natural tree seedling establishment or that resulting from joint seeding of four tree species, according to seed germination and seedling survival of *Mimosa tenuiflora* (Willd.) Poiret), *Poincianella pyramidalis* Tul., *Anadenanthera macrocarpa* (Benth.) Brenan.) and *Tabebuia aurea* (Manso) Benth. & Hook in degraded Caatinga sites protected or not from grazing. Also, it evaluated~~, in a degraded overgrazed Caatinga site where no further grazing was allowed,~~ natural tree seedling establishment or that from *Mimosa tenuiflora* and *Poincianella pyramidalis* seedling planting into manure-enriched~~planting~~ holes enriched with manure in a degraded overgrazed Caatinga site where no further grazing was allowed.

2. MATERIAL AND METHODS

Experiments were carried out at the NUPEARIDO Experimental Station/UFCG, in Patos-PB, Brazil, in a deforested site (07º05'10"S and 37º15'43"W) overgrazed~~ by sheep and goat~~ in the last 30 years~~,~~ with scattered adult and no juvenile trees, and shrub stratum dominated by *Sida cordifolia* L., and incipient soil cover dominated by herbs. Monthly rainfall data (mm) were collected for~~during~~ four years (2005, 2006, 2007 and 2008) according to *Embrapa Algodão Meteorological Station — Patos – PB, Brazil* (Table 1).

Comment [2]: If there were any differences in sheep and goat grazing, please indicate or state any needed assumptions.

TABLE 1. Monthly precipitation (mm) in four years: 2005, 2006, 2007 and 2008.

Month	Year

	2005	2006	2007	2008
January	43.6	0.0	16.6	27.4
February	79.8	168.8	264.7	227.1
March	237.9	244.1	50.1	491.6
April	103.9	202.4	112.5	216.9
May	58.8	128.8	43.1	187.4
June	31.8	23.4	8.3	14.0
July	0.0	0.2	2.9	15.6
August	0.0	0.0	1.2	2.2
September	0.0	0.0	0.0	-
October	0.0	15.3	0.0	-
November	0.0	1.3	0.0	-
December	78.0	83.2	94.8	-
TOTAL	**633.8**	**867.5**	**594.2**	**1182.2**

Source: Embrapa Algodão Meteorological Station — Patos – PB, Brazil.

Tree seeds were collected in late 2004 and 2005, and remained stored (5ºC) until they were sown in the field in~~,~~ March 2006 [Experiment one: joint seeding of *Mimosa tenuiflora* (Willd.) Poiret), *Poincianella pyramidalis* Tul., *Anadenanthera macrocarpa* (Benth.) Brenan.) and *Tabebuia aurea* (Manso) Benth. & Hook], or used, in December 2004, one to three months after collection, to produce seedlings in the UFCG nursery facilities. These seedlings were planted in the field in March 2005 (Experiment two: planting of *M. tenuiflora* and *Poincianella pyramidalis* seedlings).

Experiment one evaluated the effects of two levels (absence and presence) of cattle manure ~~(absence and presence)~~ and two levels (absence and presence) of joint seeding ~~(absence and presence)~~ of four native trees (*Mimosa tenuiflora*, *Poincianela pyramidalis*, *Anadenanthera macrocarpa* and *Tabebuia aurea*) on tree seedling establishment (natural or that resulting from joint seeding of the four native trees), based on percentage of seed germination and seedling survival with two replicates, according to a randomised completely~~ randomized~~ blocked design in ~~with~~ 2x2 factorial ~~treatments~~ and in five blocks ~~of two replications of treatments~~ (10 ~~replications/~~treatment groups) in an area protected from grazing. The 0.5m^2 square plots were subdivided in time (May 6, July 15 and, November 18 2006, March 18 2007 and March 22 2008) and data were collected in the 0.25 m^2 ~~x 0.5 m~~ inner area of each plot. There were six other blocks (i.e: ~~12 replications/~~treatment groups) located in an adjacent grazed area ~~grazed by sheep and goat~~, in which the 2x2 factorial design is also employed with~~treatments and~~ the date introduces as a sub-plot~~factor were~~ similarly ~~randomized~~randomised ~~in plots and sub-plots,~~ respectively. Data sets from the grazed and non-grazed plots were ~~analyzed~~analysed independently, and no formal comparisons were made~~performed~~, but their differences stricken~~were cited in the Discussion section~~.

Comment [3]: Explain why rainfall is missing for the months sept-oct, 2008 in footnote.

Comment [4]: Why were seedlings for Adenanthera macrocarpa (Benth.) Brenan.) and Tabebuia aurea (Manso) Benth. & Hook not also plnated?

Comment [5]: If statistical comparisons were not made between grazed and non-grazed plots, how then do you arrive at differences?

Although zero averages for some factor levels were cited~~ in the Discussion section~~, such levels were not formally included in the statistical analysis, and the number of the degrees of freedom for plot factors was reduced to one, and only the ANOVA's F test (P<0.05) was employed in drawing conclusions~~performed~~. For the sub-plot date factor, no further test or statistical procedure other than the ANOVA's F test (P<0.05) was carried out. Values of the number of seedlings were transformed (square root) prior to ANOVA.

Just prior to seed deposition, top soil (top 10 cm) was~~ revolved and~~ mixed with the equivalent ~~t~~of 120 m^3 of cattle manure (i.e.: 6 L of cattle manure/plot) and applied according to experimental setup~~treatments~~. Seeding occurred between March 18 and 28, 2006 in the plots where seed addition treatment was assigned. In these plots, *M. tenuiflora* (400seed/plot), *P. pyramidalis* (100seed/plot), *A. macrocarpa* (100seed/plot) and *T. aurea* (100seed/plot) seeds were jointly placed and slightly pressed on the soil surface, half of them in the 0.25m^2 outer-~~border~~ area and half in the 0.25 m^2 inner area~~square~~ of each plot. Data on the number of seedling in the square of each plot were collected in May 6, July 15 and November 18, 2006, March 18, 2007 and March 22, 2008.

Comment [6]: Why did you use different number of seeds per plot? Don't you think higher seed numbers would offer more reliable percentages/viability?

Experiment two considered the effects of *M. tenuiflora* and *P. pyramidalis* seedling planting into manure~~-~~ enriched ~~planting~~ holes on tree revegetation of degraded Caatinga sites. Tree seedlings were grown at the UFCG Seedling Nursery facilities in Patos-PB, Brazil, from mid-December 2004 to mid-March 2005. Seedling planting in the field occurred in March 19 and 20, 2005. At this moment, mean height and basal diameter (mean±SE) of the 108 *M. tenuiflora* seedlings were (72.70+0.97) cm and (6.90+0.08) mm, respectively. For the *P. pyramidalis* seedlings the respective values were (24.40+0.62) cm and (4.08+0.05) mm. In April 16 and June 12, 2005, seedlings that remained developing in nursery replaced the dead seedlings.

This experiment consisted of four treatments (T0=control 1, T1=control T2=opening of 30 cm x 30 cm x 30 cm planting holes enriched with 5 L of manure but no tree seedling planting, T2= the same as T1 and planting of *M. tenuiflora* seedlings in mid March 2005, one month after hole preparation, and T3=the same as T1 and planting of *P. pyramidalis* seedlings in mid March 2005, one month after hole preparation) and six blocks with two treatment replications. Experimental plots measured 9 m x 9 m, with three lines of three plants. Plots were sub-divided in time (April 1, July 12, and November 25, 2005), and sub-plot consisted of one three-plant line randomly chosen for each date. Blocks were located in a fenced area not grazed by domestic ruminants.

Once a year, weeding was performed in a 50 cm radius area around each planted seedling to reduce herb competition. Herbs growing in T0 and T1 and between plants in T2 and T3 plots remained intact to ensure soil protection and organic matter accumulation.

Comment [7]: You believe herbs can only compete from without and not within? Varying density of herbs plays a role.

The statistical procedures, tests and significance levels used in the first experiment were similar in this experiment. Collected data considered seedling survival, length (cm) taken with a graduated rod, and basal diameter (mm) measured with a digital ~~caliper~~calliper~~ ruler~~ 5 cm above soil surface.

Comment [8]: State specific similarities. In any case, what is the use of their similarity?

3. RESULTS AND DISCUSSION

Herbs were present in all plots, but no established tree seedling was observed in 2006, 2007 and 2008 in plots that received no seeds of tree species. Lack of natural tree regeneration may indicate poor or no-~~in~~existent tree seed bank or deteriorated environmental conditions.

Comment [9]: such as...?

No effect of manure addition was detected on tree seedling emergence or persistence in seeded plots, whether grazing was allowed or not. Under both conditions, seedlings of the four native trees germinated in all plots in which seeds were sown, but the mean number of tree seedling decreased for all species from May to December 2006 (Table 2). *Tabebuia aurea* was ~~characterized~~characterised by its relatively high initial number of germinated seeds (half or more of the observed tree seedlings per plot), although the number of its seeds sown per plot was a quarter of *M. tenuiflora's*. *Mimosa tenuiflora* strategy was unique because some of its seeds were left to germinate in the moist season of the following year, while no seed of the other three tree species remained in the soil or showed to be able to germinate after the first few months they were sown. This all-in-one-event strategy was reported for *T. aurea* by [13], while that of parceling germination in two or more years, now observed for *Mimosa tenuiflora,* ~~characterizes~~characterises legume species with seeds with hard tegument, and results in longer persistence of propagules in seed bank [14].

Comment [10]: Which?

Comment [11]: why for just T. aurea and not other species as well. This does not make a strong support literature. Consider replacing.

The number of observed seedlings of the four tree species tended to be higher in non-grazed than in grazed plots. No seedling that germinated during the first moist season (2006) after seeding survived to the following year, and all observed seedlings in the following year (March, 2007) were only new *M. tenuiflora*, but none survived to the third year (2008). This indicates the high level of difficulty for the establishment of tree seedlings in degraded Caatinga sites, even for ones receiving the equivalent ~~t~~of 14 million tree seeds/ha and 120 m^3 of manure/ha~~,~~ in years when annual rainfall showed to be close or superior to the expected average of….

Comment [12]: specify

Estimated average number of *M. tenuiflora* seedling per plot corresponded to 3% or less of the seeds of this species deposited on the soil surface of each plot, 20% or less for *P. pyramidalis*, 22% or less for *A. macrocarpa*, and 59% or less for *T. aurea* (Table 2). *Poincianela pyramidalis* and *A. macrocarpa* seeds germinated less than reported elsewhere [11, 14, 15], probably a result of the poor site conditions.

TABLE 2: Mean number of seedlings (total and on a species basis) in 0.25 m^2 plots sown with four tree species*, according to the level of manure addition to the soil (absence and the equivalent to 120 m^3/ha) and sheep and goat grazing (absence and presence) between two months and 2 years after sowing.

Manure	
Absence	
Presence	
Manure	
Absence	

Comment [13]: Is this a date?

Comment [14]: Is this a comma or a dot?

Comment [15]: Is this a date?

Presence	

**Mimosa tenuiflora, Poincianela pyramidalis, Anadenanthera macrocarpa and Tabebuia aurea.*
***Means in the columns corresponding to the manure levels in the "No sheep and goat grazing" level, followed by the same letter, do not differ by the ANOVA F test (P>5%). The same is true for the other grazing level.*

The lowest average value for the number of *M. tenuiflora* seedlings in May 2006 (4.4 seedlings/0.25 m^2) (Table 2) corresponds to 176 x 10^3 seedlings/ha. Bakke et al [9] reported a minimum and a maximum of 3.7 x 10^3 and 58 x 10^3 seedlings of this species per hectare during the dry and the raining seasons, respectively~~,~~ in *M. tenuiflora*-rich Caatinga sites. The high seedling number reported in the present study may result from the high number of *M. tenuiflora* seeds present in the soil after the addition of the equivalent to 8 x 10^6 seeds of *M. tenuiflora*/ha. However, this high initial number of seedlings did not assure seedling establishment, certainly due to the poor conditions of the degraded experimental site despite~~ of~~ the addition of the equivalent ~~t~~of 120 m^3 of cattle manure to the~~ revolved~~ top soil. It~~Time~~ should be~~ spent to~~ tested if too many tree seeds were added to each plot, and thus, resulted in high levels of competition and total failure in seedling establishment, or if an even higher number of seeds has to be added to assure survival of tree seedlings in degraded Caatinga sites.

Data collected in Experiment one and two showed that natural regeneration of native trees in degraded Caatinga sites does not begin at least during the first three years after site protection from grazing. However, 93.9, 40.0 and 36.2% of the planted *M. tenuiflora* seedlings survived, respectively to November 2006, March 2007 and June 2008 (8, 12 and 27 months after planting, respectively). For *P. pyramidalis* this~~ese~~ number was~~ere~~ 75.2% in November 2008 and close to zero in the last two dates.

The growth of *M. tenuiflora* planted seedlings was significantly faster than that~~e~~ observed for planted *P. pyramidalis*~~,~~ in the formally ~~analyzed~~analysed dates (April 01, July 12 and November 25, 2005). *Mimosa tenuiflora* was longer than 100 cm/plant and *P. pyramidalis* reached a third of this value in November 2005 (Table 3). For basal diameter the respective values were 11.1 and 5.0 mm/plant. Sampaio et al[16] consider that the low initial growth profile adopted by *P. pyramidalis* a~~i~~s a strategy to increase survival in dry sites. Although this strategy may be advantageous in some Caatinga sites, it did not show success~~ful~~ in the experimental degraded site considering the very low seedling survival rate.

TABLE 3: Mean length and basal diameter of the surviving *Mimosa tenuiflora* and *Poincianela pyramidalis* planted seedlings in five dates between April 2005 and June 2008.

	Length (cm/plant)		Basal diameter (mm/plant)	
Date	***M. tenuiflora***	***P. pyramidalis***	***M. tenuiflora***	***P. pyramidalis***
01/04/2005	71.1 a*	25.0 b	6.8 a	4.2 b

12/07/2005	109.3 a	31.7 b	11.6 a	5.0 b
25/11/2005	104.6 a	35.7 b	11.1 a	5.0 b
03/03/2007	69.3		10.3	-
30/06/2008	177.5		24.8	-

**Mean values in the same line and for the same variable followed by different letters differ by the ANOVA F test (P<5%).*

Almost every *P. pyramidalis* seedling showed dried stems or were dead in March 2007 and June 2008, and no ANOVA could be run ~~t~~on the date subplot~~factor~~ data. However, average mean values of *M. tenuiflora* length and basal diameter for these dates were included in Table 3. Its average length and basal diameter increased from 104 cm and 35.7 mm, in November 2005, to 177.5 cm and 24.8 mm~~,~~ in June 2008, showing the growth potential of this species in degraded Caatinga sites. The decrease in averages values observed in March 2007 resulted from the accidental grazing event that occurred in August 2006. This showed that *M. tenuiflora* tolerates heavy grazing 17 months after planting in degraded Caatinga sites and resumes growth even though an average of 35 cm was removed from its longest branch (and all the branches in general). The lower~~decrease in~~ average basal diameter ~~average~~ results from the nutrient reserve depletion and the high stress level that certainly occurred to the plants due to sprouting in the dry season after the grazing event in August 2006.

Three years after planting, height and diameter showed to be below the values reported by APNE [17] for *M. tenuiflora* of similar age and planted in similar spacing, in a non-degraded Caatinga site in Limoeiro do Norte (CE): 350 cm high/plant and 38 mm of basal diameter/plant (see data from plots CMP01 and CMP06 of that study).

Although not formally considered in statistically analyses, there were more branches in *M. tenuiflora* than in *P. pyramidalis* plants. This resulted in a well-developed canopy of *M. tenuiflora*~~,~~ : what is important for soil protection (erosion and solar radiation) and for~~to~~ foraginge and firewood production. Altogether, seedling survival, growth and canopy development support the use of *M. tenuiflora* in the recovery of degraded Caatinga sites.

No naturally regenerating tree seedling was observed in any plot of Experiment one and Experiment two. It was reasonable to expect a few of them because no animals were allowed to graze in the area and the ~~seedbank~~seed bank certainly had some *M. tenuiflora* seeds from the two adult trees of this species in the area that produced fruits and seeds during the experimental period. However, 10 naturally regenerating *M. tenuiflora* plants developed in the fenced area outside the plots of Experiment one and Experiment two. Certainly, these plants are as old as or younger than the planted seedlings because the site had no regenerating *M. tenuiflora* in the beginning of the experiments.

In June 2008, the height and diameter of these plants averaged (151±20) cm and (15±2) mm, respectively. These are similar to the June 2008 values observed on planted *M. tenuiflora* of Experiment two (Table 3). This is unexpected, due to the presumably better conditions (e.g.: seedling x seed, manure~~-~~enriched ~~planting~~ holes x degraded soil, weeding x high competition) available to the planted than to the naturally regenerating *M. tenuiflora* individu-

Comment [16]: if not why was it subdivided in the first place?

Comment [17]: how accidental? I thought the area was protected?

Comment [18]: Diameter once set is set, there is no way it can decrease.

Comment [19]: how do you mean? I thought caatinga sites were all generally degraded and left to fallow?

Comment [20]: if not statistically tested it amounts to causal observation which cannot be reliably admitted. Speculation are beteer avoided.

Comment [21]: This introduces biases which future experiments may better avoid or take care of by effective blocking.

Comment [22]: Outliers had better remain so for the soundness of experimental data.

als. This is supportive to the natural regeneration as a forest management tool and deserves further studies to detect the microsite characteristics that allowed~~ freely developed~~ plants to freely develop in degraded sites ~~to grow as ~~much as the plants originated from two-month old seedlings planted in planting holes enriched with manure. Replication of these microsite characteristic in planting holes certainly has the potential to further improve the performance of planted *M. tenuiflora* seedlings.

~~The advantage of seedling planting resides in the quantity of plants per area established in a certain period of time. ~~Considering the 60 m x 70 m protected area in which experiments were carried out, the 10 naturally regenerating *M. tenuiflora* are equivalent to less than 24 plant/ha, while the 64 *M. tenuiflora* surviving planted seedlings in the twelve 9 m x 9 m experimental plots are equivalent to 658 plants/ha. However, these values are well below those reported by Bakke et al [9] and~~,~~ Araújo & Carvalho [18], and show how difficult seedling establishment is ~~happens to be ~~in degraded Caatinga sites.

The initial herb soil cover of the experimental area by Sida species (*Sida cordifolia* and *Sida sp.*) was almost non-~~in~~existent~~, mainly from two Sida species (*Sida cordifolia* and *Sida sp.*)~~. The predominance of these species would suggest~~s~~ that the plant succession process was regressive [18] (i.e.: probably, the climax would be different from that observed before the area was degraded by deforestation and overgrazing), had the pressure on the area remained unchanged. During the experimental period, when grazing was not allowed, other species of herbs developed as much as the two *Sida* species. Certainly, the relative value of the two *Sida* species regarding soil cover diminished and tends to further do so~~decrease~~ in the future.~~,~~ This suggest~~sing~~ that factors, such as time, animal deferment and planting of *M. tenuiflora* seedlings, are appropriate to reestablish plant cover and diversity of degrade Caatinga sites.

Comment [23]: such as???

4. CONCLUSION

Natural regeneration of native trees in degraded Caatinga sites does not occur or seems to happen slowly whether or not the soil is ameliorated physically or enriched with manure, and grazing~~ is~~ is controlled.

Tree ~~revegetaion~~revegetation of degraded Caatinga site is unsuccessful after sowing *Mimosa tenuiflora*, *Poincianella pyramidalis*, *Anadenanthera macrocarpa* and *Tabebuia aurea* whether or not the seedbed is ameliorated physically or by manure addition, and grazing is controlled.

The prospects of t~~T~~ree revegetation of degraded Caatinga sites are enhanced~~increases~~ by planting *Mimosa tenuiflora* seedlings into manure-enriched~~ planting~~ holes~~ enriched with manure~~.

REFERENCES

1. Oliveira MBL, Santos AJB, Manzi AO, Alvalá RCS, Correia MF, Moura MSB. Trocas de energia e fluxo de carbono entre a vegetação de caatinga e atmosfera no nordeste brasileiro. Revista Brasileira de Meteorologia. 2006; 21(3b): 378-386. (Português)
2. Superintendência de Administração do Meio Ambiente. Atualização do diagnóstico florestal do Estado da Paraíba, João Pessoa: SUDEMA, 2004.
3. Toniolo ER, Paupitz J, Campello FB. Polo gesseiro de Pernambuco: diagnósticos e perspectivas de utilização dos energéticos florestais na região do Araripe. Em: Küster

A, Marti JF, Melchers I., Organizadores. Tecnologias Apropriadas para Terras Secas – Manejo sustentável de recursos naturais em regiões semi-áridas no Nordeste do Brasil. Brasil: Fundação Konrad Adenauer/Gesselshaft für Technische Zusammenarbeit(GTZ), 2006.

4. Alvarenga AP, Botelho SA, Pereira IM. 2006. Avaliação da regeneração natural na recomposição de matas ciliares na região sul de Minas Gerais. Cerne. 2006; 12(4): 360-372. (Português)
5. Martins AM, Engel VL. Soil seed banks in tropical forest fragments with different disturbance histories in southeastern Brazil. Ecological Engineering. 2007; 31(3):165-174.
6. Mendes BV. Recuperação de áreas degradadas pela “técnica do inóculo”. Mossoró: Fundação Vingt-um Rosado, 2002.
7. Parrotta JA, Knowles OH, Wunderle JR JM. Development of floristic diversity in 10-year-old restoration forest on a bauxite mined site in Amazonia. Forest Ecology and Management. 1997; 99(1-2):21-42.
8. Batista QR, Freitas MSM, Martins MA, Silva CF. Bioqualidade da área degradada pela extração de argila, revegetada com *Eucalyptus* spp e sabiá. Revista Caatinga. 2008; 21(1):169-178. (Português)
9. Bakke IA, Bakke OA, Andrade AP, Salcedo IH. Regeneração natural da jurema preta em áreas sob pastejo de bovinos. Revista Caatinga. 2006; 19(3): 228-235. (Português)
10. Lorenzi H. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 4ed. Nova Odessa: Instituto Plantarum. 2002.
11. Maia GN. Caatinga: árvores e arbustos e suas utilidades. São Paulo: D&Z. 2004.
12. Mattei VL, Rosenthal MD. Semeadura direta de canafístula (*Peltophorum dubium* (Spreng.) Taub. no enriquecimento de capoeiras. Revista Árvore. 2002; 26(6): 649-654. (Português)
13. Pacheco MV, Matos VP, Feliciano ALP, Ferreira RLC. Germinação de sementes e crescimento inicial de plântulas de *Tabebuia aurea* (Silva Manso) Benth. & Hook f. ex S. Moore. Ciência Florestal. 2008; 18(2): 143-150. (Português)
14. Nascimento MPSCB, Oliveira MEA. Quebra da dormência de sementes de quatro leguminosas arbóreas. Acta Botânica Brasílica. 1999; 13(2): 129-137. (Português)
15. Paiva AV, Poggiani F. Crescimento de mudas de espécies arbóreas nativas plantadas no sub-bosque de um fragmento florestal. Scientia Forestalis. 2000; 57: 141-151. (Português)
16. Sampaio EVSB, Araújo EL, Salcedo IH, Tiessen H. Regeneração da vegetação de caatinga após corte e queima, em Serra Talhada, PE. Pesquisa Agropecuária Brasileira. 1998; 33(5): 621-632. (Português)
17. Associação Plantas do Nordeste. Avaliação dos plantios de jurema preta (*Mimosa tenuiflora* (Mart.) Benth) da empresa Carbomil Química S.A. Limoeiro do Norte-CE. Recife: APNE. 2008.
18. Araújo Filho JA, Carvalho FC. Desenvolvimento sustentado da Caatinga. Em: Alvarez V.H.; Fontes LEF, Fontes MP. Editores. O solo nos grandes domínios morfoclimáticos do Brasil e o desenvolvimento sustentado. Viçosa: Jard, 1996.

Comment [24]: Ensure that all citation follow the Harvard format of citation. Referencing softwares are a big help.