

## Original Research Article

# Nitrogen Nutrition in Dry Tropical Forest at Different Times of Regeneration

### ABSTRACT

The management of forest species requires the quantification of various nutrients flows in the ecosystem. Specifically for N this aspect is even more important because many species in dry forests, as Brazilian Caatinga, are legumes and in symbiotic association with diazotrophic bacteria, fix  $N_2$  from the atmosphere. This study aimed to evaluate the N nutrition of forest species in Caatinga fragments with different regeneration times in the semi-arid region of Brazil. The study areas had different historical uses: the first one (53 ha) had no exploitation in the last 44 years; the second (32 ha) was in regeneration for 25 years; and the third (25 ha) had been in regeneration for five years. Four common tree species were evaluated in the three evaluated areas. Leaves were collected from each species to determine N contents. The legume species in the preserved area presented higher N content, decreasing with the regeneration time. [The results showed is may be a related to the](#) greater ecological balance in the most preserved sites, favoring the biological N fixation. N acquisition by legumes was not influenced by the disturbance of the site, suggesting the recommendation of these species as restorers of degraded areas.

*Keywords: Caatinga, forest nutrition, N cycling, leguminous forest species.*

### 1. INTRODUCTION

The mineralization of vegetal residues is the main route of nutrients supply to maintain soil fertility in forest ecosystems. Leaf compartment has already been shown to have greater contribution to the biomass supply in the soil and to the highest concentration of nutrients, particularly N, in different forest ecosystems [1-2].

In dry forest environments, such as Caatinga, a high number of deciduous species occurs, which confirms the high potential for nutrient cycling via foliar deposition. In general, the soils of the semi-arid region present low levels of N, and the mineralization of organic matter is the main source of this nutrient for the vegetation [3]. This condition is increased by vegetation degradation, in which most semi-arid environments are subject to [4].

Nutrient content in leaves of trees may be influenced by internal and external factors, as site conditions, physiological age of leaves, position of leaves in the canopy, time of year [5]. In soils deficient in some nutrients there is a greater demand for these, making the internal cycling inside the plants more active, as for N in soils from Brazilian semi-arid region.

Native leguminous species, adapted to the conditions of high temperatures and low water availability in semi-arid, may represent potential species to recover these adverse environments, mainly due to the biological N fixing capacity and high production of litter [6].

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36 The management of forest species requires the quantification of various nutrients flows in  
37 the ecosystem. According to Bündchen [7], nutrient mobility and conservation in the forest  
38 ecosystem may be an important attribute and related, in part, to the ability of trees to occupy  
39 low fertility soils.

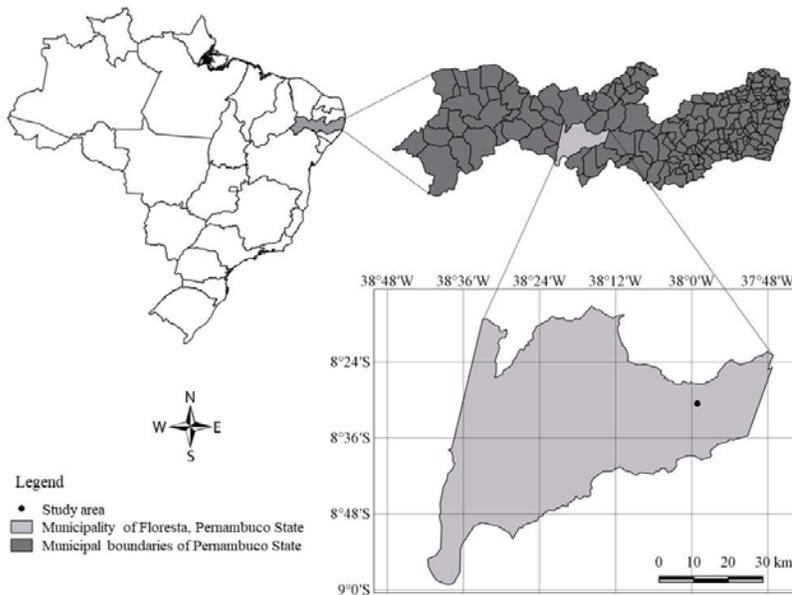
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41 In the recovery of degraded soils with native forest species, the greatest difficulty has been  
42 the lack of studies involving the acquisition of nutrients and the nutritional requirements of  
43 these species, mainly for environments such as the semi-arid region [3]. Studies of this  
44 nature in disturbed ecosystems are important as a basis for understanding changes in the  
45 nutrient cycling process caused by anthropogenic interference and as a basis for assessing  
46 its recovery.

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48 Thus, the objective of this study was to evaluate the N nutrition of forest species in three  
49 fragments of hyperxerophilic Caatinga with different times of regeneration after cutting for  
50 wood exploitation.

## 51 52 2. MATERIAL AND METHODS

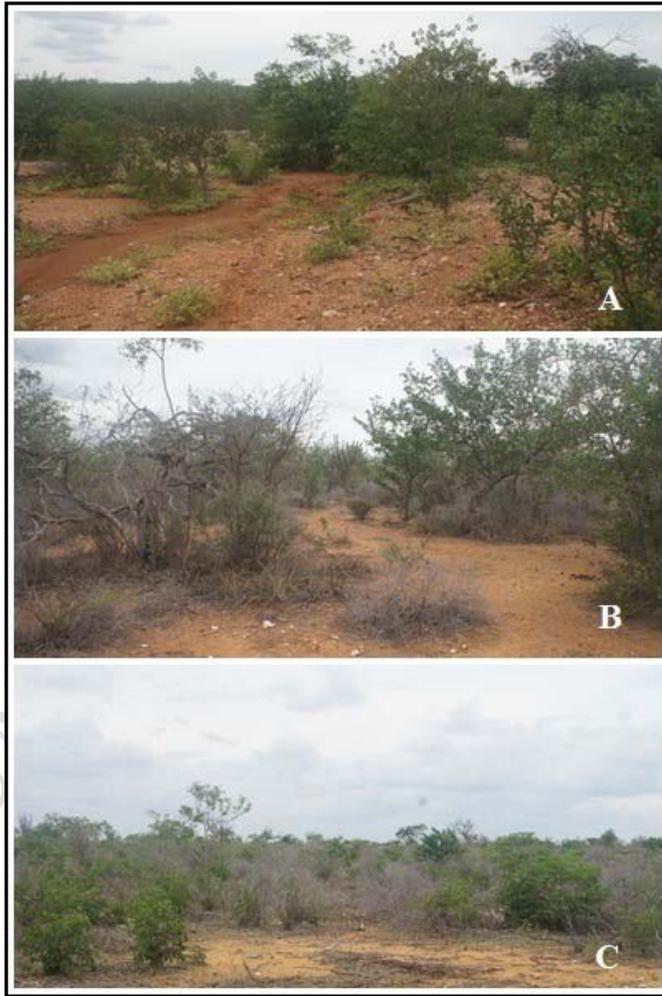
### 53 54 2.1 Study area

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56 The study was carried out on Caatinga fragments located in the municipality of Floresta,  
57 Pernambuco, Brazil (Fig. 1).



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61 Fig. 1. Geographic location of the study area, Brazil.  
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63 Three areas presenting different use histories and were selected to the study. The first one  
64 (Preserved), with 53 ha, had not been explored in the last 44 years; the second [place](#) had  
65 been in regeneration for 25 years after the cutting, and it is approximately 32 ha  
66 (Regeneration 25 years); and the third [site](#) was cut five years ago (Regeneration 5 years)  
67 and it is 25 ha extension (Fig. 2). Currently the regeneration areas have been managed for  
68 the exploitation of firewood for charcoal and/or wood. The areas in regeneration for five and  
69 25 years are distanced by about 200 m and are distant from the preserved area at about  
70 2,000 m.  
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115 **Fig. 2. Fragments of Caatinga where the studies were carried out. Preserved Caatinga**  
116 **area (A); Caatinga area in regeneration 25 years (B); and the regenerating Caatinga**  
117 **Area 5 years (C).**

119 According to Köppen's classification, the climate in this municipality is BSh ' semi-arid, with  
120 well-defined dry season, and the rainfall is concentrated mainly in the summer. The annual  
121 average rainfall is 431.8 mm and the annual temperature is between 24 and 26 °C, providing  
122 high evaporation rate and low relative humidity [8].

123 The vegetation is deciduous thorny woodland [9], characterized by shrub-tree vegetation.  
124 The soil is classified as Chromic Luvisol, shallow and sandy to medium texture in the surface  
125 [10].

126 Four tree species common in these three studied areas were evaluated. These species were  
127 defined as having the highest importance value (IV) in the forest fragments in a floristic and  
128 structural study carried out by Alves Júnior [11] (Table 1).

129  
130 **Table 1. Forest species of natural regeneration of higher value importance (HVI) and**  
131 **botanical family in fragments of the Caatinga, Brazil**

Species	Botanical family
<i>Poincianella bracteosa</i> (Tul.) L. P. Queiroz	Caesalpinioideae
<i>Mimosa ophtalmocentra</i> Mart. ex Benth	Fabaceae Mimosoidae
<i>Cnidocolus quercifolius</i> Pohl	Euphorbiaceae
<i>Mimosa tenuiflora</i> (Willd.) Poir	Fabaceae Mimosoideae

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## 134 **2.2 Species sampling and chemical analysis**

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136 A sampling of leaves was performed to estimate the N content. Four individuals of each  
137 species were sampled, having as criterion of selection the similarity in the size, vegetative  
138 development and phytosanitary status of the individuals sampled. There were collected  
139 randomly 25 newly mature leaves at the four cardinal points in a total of 100 leaves in each  
140 plant (400 leaves by plot).

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142 The sampled leaves were packed in paper bags and stored in coolers containing ice.  
143 Subsequently, the samples were placed in an oven with forced air ventilation and maintained  
144 at 65 ° C until constant weight. They were then crushed and stored in previously cleaned  
145 and dried flasks for N analysis [12]. For N-total determination, the samples were digested in  
146 sulfur solution and analyzed by the Kjeldahl method [13].

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## 148 **2.3 Statistical procedures**

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150 The statistical procedure for the study of N content data was the analysis of variance  
151 (ANOVA) and averages comparison by Scott-Knott test ( $p < 0.05$ ), when the main effects  
152 and/or interactions were significant by F-test ( $p < 0.05$ ).

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154 The orthogonal contrast technique was used to analyze differences of the averages between  
155 legume and non-legume species groups and for the groups of preserved versus in  
156 regeneration areas. The difference between the means of contrast was evaluated by the t-  
157 test ( $p < 0.05$ ).

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### 3. RESULTS AND DISCUSSION

N contents of the plant leaves in the hyperoxerophilic Caatinga fragment differed between regeneration times only for the species *Cnidoscolus quercifolius* and *Mimosa tenuiflora*. *Cnidoscolus quercifolius* had the highest N content in the area at 25 years of regeneration, while *Mimosa tenuiflora* showed the highest content in the area in 5 years under regeneration (Table 2).

**Table 2.** N content in leaves of forest species in Caatinga fragments at different times of regeneration, Pernambuco, Brazil

Forest species	Time of regeneration (years)			Average
	Preserved	5	25	
	g kg <sup>-1</sup>			
<i>Cnidoscolus quercifolius</i>	29.96 aB	34.30 aB	43.65 aA	35.97
<i>Mimosa ophthalmocentra</i>	20.27 bA	17.36 bA	16.54 cA	18.05
<i>Mimosa tenuiflora</i>	24.82 aA	18.73 bB	27.34 bA	23.63
<i>Poincianella bracteosa</i>	17.87 bA	16.01 bA	17.22 cA	17.03
Average	23.23	21.60	26.18	
	F test			
Species	37.220*			
Time	3.547*			
Species x Time	2.823*			
CV (%) <sup>1</sup>	20.86			

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<sup>1</sup>Coefficient of variation = standard deviation/Average x 100. Averages followed by the same letter, uppercase in the row and lowercase in the column, do not differ statistically by the Scott-Knott test (p<0.05). \*Significant by F test (p<0.05).

Although *Poincianella bracteosa* and *Mimosa ophthalmocentra* had no difference in N content in the area of higher equilibrium (preserved) or in regenerating environments, these species presented higher N levels in the preserved area. The acquisition of N by these legumes is higher because they are associated with N-fixing bacteria. On the other hand, the legume *Mimosa tenuiflora* showed to be more demanding in this nutrient presenting higher contents in the areas in regeneration (Table 2).

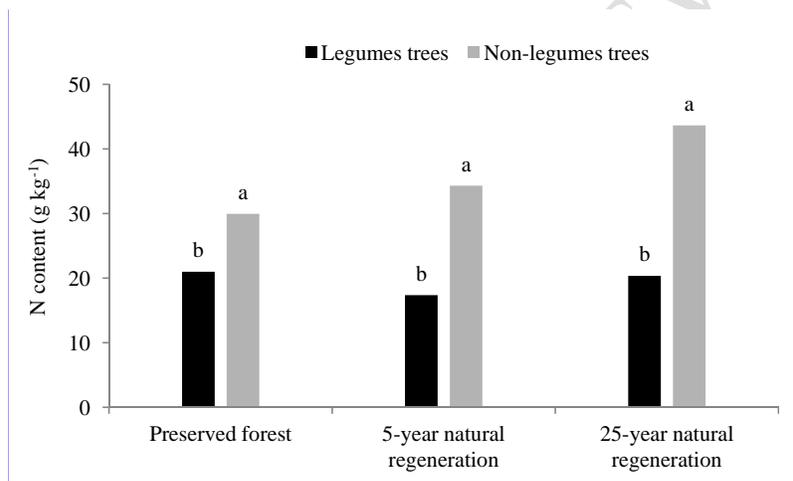
*Cnidoscolus quercifolius* presented high levels of N in relation to legume species regardless of the regeneration time, which shows a high requirement in N, since this species is the only non-legume. All this strategy of survival can cause this species to regenerate much more

185 slowly than the others. This may indicate that regeneration of leguminous species is faster  
186 and more balanced.

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188 The results obtained showed that the evaluated species had N contents similar to those  
189 found in studies in other forests in Brazil. Bündchen [7] obtained N levels between 23.85 and  
190 35.56 g kg<sup>-1</sup> in a study with five species in subtropical forest in southern Brazil. In decidual  
191 seasonal forest in Rio Grande do Sul, Vogel [14] found average N contents in the leaves of  
192 24.20 g kg<sup>-1</sup>. Mendes [15], evaluating ten native species in Central Amazonia observed N  
193 contents in leaves varying between 15.70 and 22.40 g kg<sup>-1</sup>. In Atlantic Forest, Cunha [2],  
194 studying two fragments of Montana Forest in Rio de Janeiro observed average N contents in  
195 leaves of 25.80 and 26.66 g kg<sup>-1</sup>. In area of Caatinga in regeneration, Alves [3] obtained  
196 average N contents in the leaves of five species ranging from 18.00 to 23.10 g kg<sup>-1</sup>.

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198 N contents in leaves of legume species were lower than that of non-legume species in all  
199 evaluated environments (Figure 3). These results demonstrated the highest N requirement  
200 for the only non-leguminous species (*Cnidoscopus quercifolius*) and especially it was verified  
201 that there was an increase of this species occurrence in less balanced areas, with shorter  
202 times of regeneration.

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205 Figure 3. Orthogonal contrast of N content in leaves of legumes versus non-legumes forest  
206 species, separately for each time of regeneration in the Caatinga fragments, Pernambuco,  
207 Brazil. Means followed by different lowercase letters at each regeneration time differ  
208 statistically by the t test (p<0.05).

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210

211 There was certain homogeneity of the average content of N in the leaves of legume species  
212 in the different studied sites, varying between 17.36 and 20.98 g kg<sup>-1</sup> in the regenerating  
213 area for five years and the preserved area, respectively (Figure 3). It was also verified that in  
214 the preserved area, the leguminous species presented higher N content in the leaves,  
215 decreasing with the reduction of the regeneration time of the areas. This may be related to  
216 the greater ecological balance in the most preserved sites and with a longer regeneration  
217 time, favoring the biological N fixation.

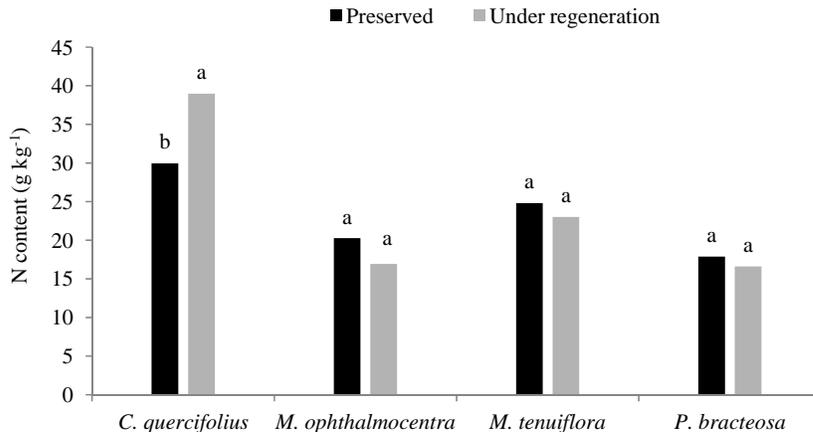
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219 Concerning the contrast between the N levels in the leaves of the species and the  
220 regenerated and preserved environments, it was verified that the legume species presented

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221 similar results in these environments (Figure 4). It emphasizes the advantage of N biological  
222 fixation for the recovery of degraded environments, legume species can be used in the  
223 recovery of degraded areas, since the acquisition of N was not influenced by the disturbance  
224 of the site.



225 Figure 4. Orthogonal contrast of the N content in leaves of forest species in the preserved  
226 versus regenerated areas, separately for each forest species in the Caatinga fragments,  
227 Pernambuco, Brazil. Means followed by different lowercase letters in each forest species  
228 differ statistically by the t test ( $p < 0.05$ ).  
229

230 Regarding to *Cnidocolus quercifolius*, the levels of N in the regenerated and preserved  
231 environments were inversely related to what occurred with the leguminous species, with  
232 higher levels in the regeneration sites. This may indicate that in less balanced environments  
233 *Cnidocolus quercifolius* tends to store more N and favor its internal cycling, because there  
234 is higher demand for N by plants in these places, greater soil limitation and there is no  
235 competitive advantage such as biological N fixation.  
236

237 Moreover *Cnidocolus quercifolius* showed higher average N contents in the evaluated  
238 environments than legume species.  
239

#### 240 4. CONCLUSION

241 The legume species in the preserved area showed higher N content decreasing with the  
242 regeneration time, which ~~it may could be be~~ related to greater ecological balance in the most  
243 preserved sites, favoring biological N<sub>2</sub> fixation. The acquisition of N by legumes was not  
244 influenced by the disturbance of the site, suggesting the recommendation of these species  
245 as restorers of degraded areas.  
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#### 247 4. CONCLUSION

248 Authors have declared that no competing interests exist.  
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