Spatial Distribution, Regeneration, Growth and Thicket Formation of Thornless *Mimosa tenuiflora* in a Caatinga Site of Northeast Brazil

Maria Beatriz Ferreira*, Olaf Andreas Bakke, Geovana Gomes de Sousa, Ivonete Alves Bakke, Sebastiana Renata Vilela Azevedo, and Wesley Costa Ferreira

1Universidade Federal de Campina Grande, Av. Universitária s/n - Bairro Santa Cecília, Patos-PB, 58708-110, Brazil.

2Universidade Federal Rural de Pernambuco, Rua Dom Manuel de Medeiros, s/n – Bairro Dois Irmãos, Recife - PE, 52171-900, Brazil.

Authors’ contributions

This work was carried out in collaboration among all authors. Author MBF designed the study, carried out field work, data manipulation and literature research, wrote the first draft and contributed diligently to the final version of the manuscript. Author OAB supervised the study, wrote the protocol, advised on data analyses, helped in field work and literature research, and translated the manuscript into English. Author GGS carried out field work and literature research. Author IAB designed the study, wrote the protocol, carried out literature review and contributed to the final version of the manuscript. Authors SRVA and WCF carried out field work. All authors read and approved the final manuscript.

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ABSTRACT

**Aims:** Percentage of native thorny and thornless *Mimosa tenuiflora* (Willd.) Poiret trees, and their growth, height and/or diameter class distribution and clustering pattern were determined in a pure stand of this species.

**Study Design:** A survey of the adult and juvenile plants was carried out in a 50 m x 50 m site after 10 years of tree cover regeneration.
1. INTRODUCTION

The Brazilian semiarid region presents a heterogeneous landscape that extends for approximately 969,589 km² where the average annual rainfall is less than 800 mm and daily water deficit is higher than 60% [1]. The predominant vegetation of this region is known as caatinga (a type of tropical dry forest), used also to refer to the regional Brazilian biome (Caatinga Biome) that covers 844,453 km² equivalent to 11% of the Brazilian territory [2]. It is considered the main biome of the Northeast Brazilian region covering most of the territory of the states of the northeast region, and small areas in northern Minas Gerais and eastern Maranhão [2].

It is classified as the most heterogeneous Brazilian biome, with diversified vegetation ranging from dense forests to sparse shrubby formations in which many woody species are twisted, branched and thorny, accompanied by succulent species, such as cacti, and herbs that develop during the short rainy season [3].

According to Araújo [4], limitations of soil and climate favor the development of deciduous and xerophilous plants, such as *Mimosa tenuiflora* (Wild.) Poiret, a tree of the Fabaceae family, widely and abundantly distributed in most states of Northeast Brazil [5]. This pioneer tree forms pure forest stands in many degraded areas with eroded soil exposed to climate adversities [6]. A characteristic of *M. tenuiflora* is the presence of thorns, which represent a defense against herbivores. These thorns can cause injuries to men and domestic animals, making it difficult to manage and exploit the forage and firewood produced by these plants. However, thornless plants of this species have already been identified [7], as well as of other thorny trees, as reported for *Cnidoscolus phyllacanthus* (Mart.) Pax et K. Hoffm. [8], *Piptadenia stipulacea* (Benth.) Ducke [9] and *Mimosa caesalpinifolia* Bent. [10]. Percentage of thornless *M. tenuiflora* plants in native stands in Patos-PB, Brazil ranges from 14 to 21% [11]. Certainly, this genetic trait is linked to more than one pair of highly inheritable recessive genes [7]. According to Arriel et al. [7], spontaneous adult thornless plants are randomly distributed in anthropized caatinga sites in which they usually predominate, with most of the thornless juvenile plants growing close to adult thornless trees.

The selective exploitation of the thorny plants would leave the thornless plants free to grow and produce seeds with the potential to generate thornless progenies. In the long run, this would result in the establishment of stands of thornless plants, with no need to spend on production and planting of thornless seedlings in this biome. This study determined the percentage of thorny and thornless plants and their respective growth, distribution in classes of height and / or diameter, and clustering pattern of adult and juvenile *M. tenuiflora* plants observed in a pure stand of this

### Place and Duration of Study:

The study site was located at Fazenda Nupearido, Patos-PB, Brazil and data collection occurred in September 2017.

### Methodology:

Adult plants with trunk circumference at breast height (1.3 m from the soil) > 6 cm (CBH > 6 cm) were measured for height and CBH, and located within the study area. Juvenile plants (i.e.: CBH ≤ 6 cm) were divided into 4 height classes. The position of only the thornless individuals within the study area was determined.

### Results:

Among the 170 adult plants documented in the area, 95.3% and 4.7% were thorny and thornless, respectively. Height and diameter at breast height averaged higher for thornless than for thorny adult plants (4.13 m and 9.28 cm vs. 3.61 m and 5.90 cm). In contrast, thornless juvenile plants averaged lower for height and basal diameter than the thorny ones. The number of juvenile *M. tenuiflora* totaled 897 plants, including 58 thornless ones, but percentage of thornless juveniles peaked at 17.6% for 10-50 cm high plants. In general, thorny plants showed a clustering pattern of distribution while the thornless plants were randomly distributed.

### Conclusion:

The density, random distribution and growth of the thornless plants suggest the possibility to form thickets of thornless plants in caatinga sites where this tree predominates. Also, these data show that in forested sites with thorny trees that generate thornless mutants, as observed in the Caatinga Biome for *M. tenuiflora* and other tree species, it is possible to increase the frequency and abundance of the naturally regenerating thornless plants, making easier the exploitation of forest resources, an approach that may be applied in other types of vegetation.

**Keywords:** Tropical dry forest; jurema preta; thorny plants; manipulation of woody vegetation.
species to have an idea of the possibility of the formation of thickets of thornless \textit{M. tenuiflora} plants based on spontaneous adult and juvenile plants with this phenotype. These data will certainly contribute to improve the management and exploitation of the caatinga forest and other types of vegetation in which the high abundance of thorny plants hinders animal browsing and the manual harvest of firewood, stakes and other forest products frequently used by rural populations living in underdeveloped regions.

2. MATERIALS AND METHODS

2.1 Localization and Characterization of the Study Site

This study was carried out in September 2017, at Fazenda Nupearido, Experimental Station of the Universidade Federal de Campina Grande/Centro de Saúde e Tecnologia Rural (UFCG/CSTR), in Patos – PB, Brazil. In the study site, a native 50 m x 50 m caatinga stand was divided into 100 5 m x 5 m plots. \textit{Sida cordifolia} L. and \textit{Mimosa tenuiflora} predominated in the herb and tree strata, respectively, and the establishment of shrubs and trees occurred under a continuous cattle browsing regimen of varied intensity. This area received a selective cut of the thorny \textit{M. tenuiflora} plants in late October of 2007, but some of these plants successfully re-sprouted and survived after the selective cut and continued grazing.

Annual precipitation from 2008 (first year after the selective cut) to 2017 (data of data collection regarding plant distribution in the study site) ranged from 169.8 mm, in 2012, to 1595 mm, in 2009 (Fig. 1). In contrast, temperatures showed to be rather stable, ranging from an annual mean monthly minimum of 21°C to an annual mean monthly maximum of 38°C.

The soil of the study site shows reasonable fertility levels although pH indicates soil acidity and high level of sand (Table 1). High sand content may result in deficit in water availability especially in areas where annual rainfall can be as low as 169.8 mm.

![Annual rainfall and mean monthly maximum and minimum temperatures, at Fazenda Nupearido, Patos- PB, Brazil, from 2008 to 2017](image-url)

\textit{Source: INMET [12] and Fernandez [13]}

---

\begin{table}
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Year} & \textbf{Annual accumulated rainfall} & \textbf{Annual mean monthly maximum temperature} & \textbf{Annual mean monthly minimum temperature} \\
\hline

---
\end{tabular}
\end{table}
Table 1. Chemical and physical attributes of the soil from the study site at Fazenda Nupearido, Patos-PB, Brazil

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<th>Chemical attributes</th>
<th>pH</th>
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<th>P</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
<th>H⁺Al</th>
<th>T*</th>
<th>V*</th>
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<tr>
<td></td>
<td>5.63</td>
<td>12.48</td>
<td>3.46</td>
<td>2.06</td>
<td>0.26</td>
<td>1.52</td>
<td>2.18</td>
<td>9.48</td>
<td>78.16</td>
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<table>
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<th>Physical attributes</th>
<th>Soil fraction</th>
<th>USDA Textural class</th>
<th>FWC*</th>
<th>PWP*</th>
<th>Density</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td></td>
<td>%</td>
<td>(%)</td>
<td>g/cm³</td>
</tr>
<tr>
<td>Sand</td>
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<td>Loamy sand</td>
<td>13.33</td>
<td>6.06</td>
<td>1.40</td>
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<tr>
<td>Silt</td>
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<td></td>
<td></td>
<td></td>
<td>2.52</td>
</tr>
<tr>
<td>Clay</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*T=cation exchange capacity, V=base saturation, FWC=field water capacity, PWP=permanent wilting point.

Source: Figueiredo [14] (adapted)

2.2 Inventory of Adult and Juveniles Plants in the Study Site

Each tree with trunk circumference at breast height (1.3 m high) of more than 6 cm (CBH > 6 cm) was considered an adult plant, measured for height (H) and CBH [15] and classified as thorny or thornless plants, and had its coordinates recorded within the study site. Thorny and thornless juvenile *M. tenuiflora* plants (i.e.: plants with CBH < 6 cm) were counted in each 5 m x 5m plot and classified into four height classes: C0 (10 to 50 cm high), C1 (51 to 100 cm high), C2 (101 to 150 cm high) and C3 (> 151 cm high and CBH < 6 cm). However, only the thornless juvenile plants had their coordinates determined to localize them precisely in the study site. Coordinates of the numerous thorny juvenile plants were not necessary as their exact location in the study site was not the focus of this study and their clustering pattern could be determined by plant counting in each 5 m x 5 m plot.

Height and CBH of adult plants were determined using, respectively, a 5 m graduated ruler and a measuring tape (the diameter at breast height - DBH - was obtained by dividing CBH value by \( \pi = 3.1416 \)). Average height of juvenile plants resulted from data manipulation based on the 3 frequency and 3 middle point values of height classes C1, C2 and C3 (C0 was not considered because thorny and thornless plants in this class could not be reliably differentiated).

Adult plants with more than one trunk had all CBH > 6 cm measured and converted to the respective DBH, and these DBH values of each plant were considered together to calculate the equivalent diameter (\( d_{eq} \)) of the plant using Equation 1:

\[
d_{eq} = \sqrt{\frac{\sum DBH^2}{n}}
\]

2.3 Statistical Analyses

The percentage of thornless plants was estimated among adult plants, among juvenile plants classified in each height class (C1, C2 and C3), and among adult and juvenile plants considered altogether. Average height and/or diameter values of thorny and thornless adult and juvenile plants were determined. Height and/or diameter distribution of adult and juvenile *M. tenuiflora* plants were represented separately in histograms. The joint spatial distribution of thorny and thornless adult *M. tenuiflora* plants was represented in a scatter plot. The joint spatial distribution of thornless adult and juvenile plants was represented in scatter plots for height classes C1, C2 and C3. Data manipulation was carried out using Excel for Windows’ 7 Starter.

The aggregation pattern of the plants of the i-th group (group 1: Thorny plants, and group 2: Thornless plants), according to the recommendations of [16] and [17], was estimated by the Payandeh index (\( P_i \)), considering the number of plants of each group in the 100 5 m x 5 m plots using Equation 2:

\[
P_i = \frac{S_i^2}{M_i}
\]

and;

\[
S_i^2 = i-th\ group\ variance\ of\ the\ number\ of\ plants/plot;
M_i = i-th\ group\ average\ of\ the\ number\ of\ plants/plot.
\]

According to these authors [16,17], when the Payandeh index value \( P_i < 1.0 \), there is no clustering and the plants are randomly distributed in the field, for \( 1.0 \leq P_i < 1.5 \), there is a clustering trend of plants, and when \( P_i \geq 1.5 \) indicates plant clustering.
3. RESULTS AND DISCUSSION

3.1 Diversity

Except for one Prosopis juliflora (Sw.) DC, all trees were either adult (n=170) or juvenile (n=897) plants of M. tenuiflora. This indicates the ability and adaptation of this species to colonize inhospitable degraded sites in the Caatinga Biome, ameliorating site conditions to ecologically more demanding trees [6,18].

Among the adult M. tenuiflora, 95.3% and 4.7% were thorny and thornless plants, respectively. This low percentage (4.7%) of thornless plants is significantly lower than the values reported in native stands of this tree in Patos-PB, Brazil from the year 1995 [11]. In addition to a possible effect of climate change observed from 1995 to 2017, this difference may result from genetic variability among populations, the high browsing pressure on thornless plants such that reported by [19], or from the successional stage of the M. tenuiflora stand in which the Hardy-Weinberg equilibrium between thorny and thornless plants was not reached so far. This last issue will be further discussed in this paper.

3.2 Height and Diameter at Breast Height

Height and DBH average values were, respectively, 3.61 m (Fig. 2A) and 5.9 cm (Fig. 2B) for thorny plants, and, respectively, 4.13 m and 9.28 cm for thornless plants. These differences was already considered elsewhere. In a 2005 study, Bakke [20] found thornless M. tenuiflora plants averaged shorter height than thorny M. tenuiflora plants. However, a subsequent analysis [19] in 2007 raised the possibility that the reported inferiority of thornless plants reported by Bakke [20] may have had resulted from browsing, when the thornless plants suffered greater damage than the thorny plants. In a more recent study carried out in 2012, in which there was no grazing, Nunes [21] observed that thorny and thornless M. tenuiflora show similar height and diameter up to 30 months after planting. Certainly, the observed height and diameter average values were affected by the selective cutting of the thorny plants practiced approximately 10 years ago in a previous attempt to increase the participation of the thornless phenotype in the community. This may explain the reason why at least four of the eight thornless plants were included in the higher height or diameter classes and increased the mean values for this phenotype.

3.3 Height by Height Classes

The average height of the 170 adult M. tenuiflora was 3.34 m, and individual values ranged from 2 to 5 m, with many (68) plants in the last (> 3.8 m) and few (19) in the first (2.0 to 2.6 m) height classes (Fig. 3). Similar results were reported by [12], who found an average height of 3.8 m for 30-year-old M. tenuiflora, most of them in the height classes 3.1 - 4.0 and 4.1- 5.0 m.

![Fig. 2. Mean height (A) and DBH (B) values of adult thornless and thorny Mimosa tenuiflora plants in a 50 m x 50 m caatinga site located at Fazenda Nupearido, Patos, Paraíba, Brazil](image-url)
Fig. 3. Height distribution of 170 adult Mimosa tenuiflora plants in a 50 m x 50 m caatinga site at Fazenda Nupearido, Patos, Paraíba, Brazil

The high frequency of the last class probably should consider that some of the M. tenuiflora that suffered the selective cut sprouted and, together with the thornless uncut plants, grew and surpassed 3.8 m high. The establishment of new plants was made increasingly difficult with time as the sprouted and uncut plants together with the early recruited seedlings developed, crowded and shadowed the soil, what could explain the reverse negative trend observed in the frequency of the four height classes. This hypotheses is further supported by the fact that M. tenuiflora is heliophyte, and tends to etiolate to receive direct sunlight when it grows in dense stands (the 170 adult M. tenuiflora in the area are equivalent to 680 plants/ha) and there is competition for light. This resulted in the right deviated height distribution composed of many tall plants (and of reduced diameter: see next paragraph).

The DBH of adult M. tenuiflora ranged from 1.91 to 18.65 cm and averaged 6.06 cm, mostly in the first diameter classes: 55 plants were observed in the first class (1.91 to 3.77 cm) and 37 in the second class (3.77 to 5.63 cm), representing 54.12% of the 170 adult sampled plants. As a result, the diameter distribution resembles an inverted ‘J’ (Fig. 4), characteristic of stands in initial stages of succession. However, the diametric distribution in inverted J may come from the great number of plants per unit area, referred too earlier, and may have resulted in the height distribution deviated to the right and the diametric distribution deviated to the left (etiolation and thin diameter). Both interpretations lead to the confirmation of the successful colonization of the area by M. tenuiflora and its adaptation to anthropized sites.

3.4 Population Structure

Probably the eight thornless adult M. tenuiflora trees currently (September 2017) observed in the experimental site may generate seeds to guarantee the establishment of new individuals with this phenotype. According to Arriel et al. [22], seeds collected from thornless plants in native stands with 80% or more of thorny M. tenuiflora result in 50% of thornless progenies. Reported densities for M. tenuiflora reach 3.7 x 10² surviving seedling/ha in the initial stages of regeneration [23], decline to 1000 plants/ha in the late adult phase of pure stand [24], to be gradually replaced by trees of later successional stages toward the forest climax stage [25]. Considering this perspective, some of these progenies should succeed and develop together with the already established thornless M. tenuiflora juvenile plants. Preserving this type of
progeny, and cutting recurrently the thorny plants for firewood production, would probably allow the formation of a thicket of thornless plants, easy to manage an exploit, within a few years. This seems highly reasonable, considering the number of naturally regenerating thornless *M. tenuiflora*, as reported in the following paragraphs.

Juvenile *M. tenuiflora* totaled 897 plants in 2500 m² (i.e. 3588 individuals/ha), divided into four classes (C0, C1, C2 and C3). Height class C0 (from 10 to 50 cm high) had 279 plants whose differentiation between thorny and thornless plants was considered unreliable. However, these data can be of value when compared to published data regarding regeneration of *M. tenuiflora* in general. Empirically, these 279 seedlings are at least two-years old and are equivalent to 1116 individuals/ha (i.e.: 1.116 x 10³ plants). These values are far below the minimum of 3.7 x 10³ surviving seedlings/ha at the end of the first dry period after seed germination, reported by [23]. Equivalently, 7.4 x 10³ seedlings could be established/ha in two years before being included in this class, but only 1.116 x 10³ managed to survive, 6 to 7 times less than previously reported [23]. This gives an idea of the self-thinning processes inherent to *M. tenuiflora* acting on the study site, especially on the progenies classified at C0 height class.

Classes C1, C2 and C3 showed, respectively 142, 103, 373 *M. tenuiflora* plants, totaling 618 juvenile plants (Fig. 5). Probably, the numerous C3 plants grew and hindered the establishment of new plants afterwards, a plausible hypothesis considering the heliophile character of this species. Also, although 58 out of 618 plants in C1, C2 and C3 were thornless (i.e.: 9.4% of thornless plants) the proportion of thornless plants in the C1-to-C3 gradient decreased from 17.6% (25 out of 142), to 12.6% (13 out of 103 plants) to 5.4% (20 out of 373 plants), respectively. It continuously decreases until the adult class when 4.7% (8 out of 170) plants showed to be thornless. It is possible that the 17.6% C1 value approximates the participation of thornless *M. tenuiflora* in natural populations (Hardy-Weinberg equilibrium), as Bakke et al. [11] reported 14 to 21% of thornless *M. tenuiflora* in four natural populations of this species under similar environmental pressure, meaning that 100% of thornless plants would not be expected naturally under such conditions.

This class gradient may be explained as follow: Plants in class 3 established themselves when there were less established thornless adult plants, resulting in a low proportion of thornless plants. In contrast, C1 plants established in the area recently, when more thornless *M. tenuiflora* were already established and producing seeds, resulting in higher proportion of thornless progenies than in C3 (as well as in C2).

Mean height values of the 560 thorny and 58 thornless juvenile plants in C1, C2 and C3 classes were 1.47 and 1.21 m, respectively. Low thornless plants may result from their

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**Fig. 4. Diameter distribution of 170 adult *Mimosa tenuiflora* plants in a 50 m x 50 m caatinga site at Fazenda Nuepearido, Patos, Paraíba, Brazil**
vulnerability to browsing, especially when the above ground parts of the plant are accessible to the animals without the physical protection of the piercing thorns [19]. However, the presence of juvenile thornless plants in height classes C1, C2 and C3 (25, 13 and 20 juvenile plants, respectively) (Fig. 5) indicates the potential of the thornless plants to form pure thornless thicket stands even under a cattle browsing that certainly reduces indirectly or directly the quantity of juvenile plants, resulting from trampling or injuries and partial or total consumption of the above ground parts of the plants.

Despite the predominance of thorny plants, the 58 thornless *M. tenuiflora* juvenile plants in addition to the eight adult thornless plants (i.e.; 66 thornless plants in the 50 m x 50 m = 2500 m² site) represent the possibility of the formation of the *M. tenuiflora* thicket of thornless plants. If the thorny plants are cut for firewood production, the 66 thornless plants could grow in the site with a density equivalent to 264 plants/ha, approximately an average of 40 m² for each plant considering a regular 6.3 m x 6.3 m grid. Depending on the development of the canopy, it is possible to eliminate undesirable trees and/or allow the establishment of more thornless *M. tenuiflora* or other desirable trees to provide a 30-to-40% soil cover. This soil cover, according to Araújo Filho [26] and Pereira Filho et al. [27], is ideal in the Caatinga Biome by improving the thermal comfort for the animals and maximizing the production of forage, wood and other items by herbs and trees.

*Mimosa tenuiflora* plants concentrated in parts of the study area, while others had little or no tree cover (Fig. 6). Five out of the eight adult thornless *M. tenuiflora* plants (circled in Fig. 6) were observed in these parts, as to indicate the capability of thornless plants to establish themselves isolated and or under the conditions observed at these points. The average height and DBH values of these 5 thornless plants were 4.4 m and 12.47 cm, respectively, greater than the average height and DBH of the 162 adult thorny *M. tenuiflora* plants (3.34 m and 6.06 cm, respectively) or greater than the average of the other 3 non-isolated thornless *M. tenuiflora* plants (3.67 m and 3.96 cm, respectively).

As visual field inspection indicated that these points were unfavorable (exposed soil showing no herb cover), it is difficult to explain why these thornless *M. tenuiflora* successfully established and developed so well in such conditions. Further studies should be carried out to check if there is any genetic factor inducing a greater resistance to biotic and abiotic adversities of thornless than thorny *M. tenuiflora* plants, as if compensating for the decreased physical protection resulting from the absence of thorns.

![Fig. 5. Number of juvenile Mimosa tenuiflora plants in three classes of regeneration (C1, C2 and C3), according to height and CBH criteria, in a 50 m x 50 m caatinga site at Fazenda Nupearido, Patos, Paraíba, Brazil.](image)
Inspection of Figs. 7A-D suggests roughly that the thornless juvenile *M. tenuiflora* plants established themselves close to the adult thornless trees, a pattern already described by Bakke et al. [11]. This is expected to occur because 50% of the progenies from such trees are thornless plants [7] and most of the seed-bearing fruits are primarily dispersed in a 5-to-8 m radius around the mother tree, although long distance dispersion may occur actively by man, when transporting stakes and firewood, and by runoff water, depending on rain intensity [28].

According to the Payandeh classification, adult *M. tenuiflora* plants showed a general clustering pattern of spatial distribution (Table 2). This can be visualized by the spaces with few or no established tress and patches with many established plants in Fig. 6. Adult thorny *M. tenuiflora* plants showed a clustering pattern, similar to the general pattern of distribution of this species reported by Calixto et al. [16] and Santana et al. [29]. However, the thornless adult plants showed to be randomly distributed in the area as a result of the few ones that managed to establish in each cluster of thorny plants combined with those ones established somewhat isolated in unfavorable points of the study area (circled trees in Fig. 6), filling the gaps between clusters of thorny plants. This certainly contributes to the wide dispersion of seeds capable to generate thornless progenies throughout the area and to the formation of the desired thicket of thornless plants.

Juvenile thornless *M. tenuiflora* plants tended to follow the same distribution of their adult counterpart, although randomness was less evident. This results from the trend of these plants to establish and grow close to adult thornless trees [9]. However, intra-species competition (between mother and daughter plants) for resources would negatively affect juvenile numbers in the long run.
Fig. 7. Spatial distribution of thornless adult *Mimosa tenuiflora* plants with thornless juvenile plants C1 (A), C2 (B), C3 (C) and with all thornless juvenile plants (D), in a 50 m x 50 m caatinga site at Fazenda Nupearido, Patos, Paraíba, Brazil

Table 2. Values of the Payandeh index and respective clustering classification for adult and juvenile *Mimosa tenuiflora* plants in a 50 m x 50 m caatinga site at Fazenda Nupearido, Patos, Paraíba, Brazil

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<th>Adult plants</th>
<th>Payandeh index</th>
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<table>
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<th>Juveniles plants</th>
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<td>Clustering</td>
</tr>
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<td>Thornless*</td>
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<td>Thorny&amp;Thornless plants**</td>
<td>6,47</td>
<td>Clustering</td>
</tr>
</tbody>
</table>

* Except C0 juvenile plants ** C0, C1, C2 and C3 juvenile plants

The findings reported from our study should be checked in large caatinga sites, and include other thorny trees, that produce forage or firewood, that developed thornless mutants, such as *Piptadenea stipulacea* (Benth.) Ducke, *Cnidoscolus quercifolius* (Mart.) Pax et K. Hoffm. and *Mimosa caesalpinifolia* Benth if the objective is to increase the frequency and abundance of thornless useful trees. Here, the immediate objective is facilitating the manual collection of
Acknowledgements

Forest products practiced by local workers of underdeveloped regions. In a wider view, sustainable management of the caatinga or other types of forests should be based on sound ecological data and consider a variety of native herbs and trees that produce forage, firewood, timber or protect the soil from solar radiation and running water and wind erosion, considering always the economic and ecological perspectives in a crescent complex of plants, imitating as much as possible the native caatinga flora.

4. Conclusions

Density (264 plants/ha), spatial distribution (random) and growth average (4.13 m high plants and 9.28 cm thick trunks) of thornless Mimosa tenuiflora plants are considered adequate to form, in few years and at low cost, thickets based on spontaneous thornless plants of this species that produces forage and firewood. Additional studies should investigate the applicability of these findings in large areas of the Caatinga Biome in order to make easier the manual exploitation of forage and firewood of this and other trees practiced by rural people of underdeveloped regions of the biome. Other opportunities to improve forest management, facilitate exploitation or increase income of rural people, such as tannin extraction from the bark of various trees currently burned with firewood, exist in the Caatinga Biome (and certainly in other biomes). These opportunities should be investigated in all places and occasions for the sake of the efficient use of the natural resources and human welfare. Considering the Caatinga Biome, it is possible to form thickets of thornless Mimosa tenuiflora. At least three other useful thorny trees with thornless mutants should be considered. Sustainable management of the caatinga forest, and certainly of other types of vegetation, should be based on sound ecological data involving a significant variety of native herbs and trees that produce forage, firewood, timber, or protect the soil from solar radiation and water and wind erosion, considering the economic and ecological perspectives in a crescent complex of plants, imitating as much as possible the regional flora.

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Competing Interests

Authors have declared that no competing interests exist.

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