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MANIPULATION OF NATURAL GRASSLAND IN SEMIARID REGION: A REVIEW

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ABSTRACT: Because the Caatinga is one of the most densely populated areas in the world and having agriculture and livestock farming as its main activities, it has been suffering a process of desertification over the years, reflecting on losses in biodiversity and animal productivity, especially as agricultural practices are based on deforestation and burning of native vegetation. Thus, it becomes necessary and fundamental, a searching for management practices that intensify the use of caatinga's resources without degrading them. This review aims to highlight the use of manipulation techniques of the woody stratum of the Caatinga vegetation, as thinning and enrichment, which aim to increase the support capacity of the native and cultivated pasture, through the increase in herbaceous forage biomass and biodiversity.
Keywords: Caatinga, thinning, enrichment, botanical composition, sustainability.

MANIPULAÇÃO DA PASTAGEM NATURAL EM REGIÃO SEMIÁRIDO: UMA REVISÃO.

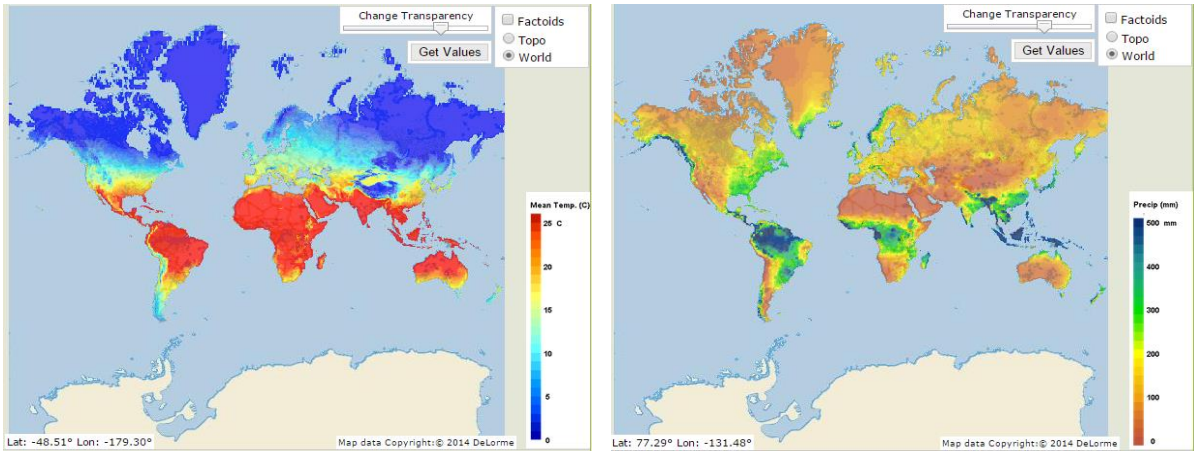
RESUMO: Por se tratar de uma região como uma das mais densamente populosas do mundo, e tendo como atividades principais a agricultura e a pecuária, a Caatinga vem ao longo dos anos entrando em processo de desertificação, refletindo na perca da biodiversidade e da produtividade animal, muito em função das práticas agropecuárias serem pautadas apenas no desmatamento e na queima da vegetação nativa. Deste modo, torna-se necessária e fundamental, a busca por práticas de manejo que intensifiquem o seu uso sem degradá-las. Esta revisão teve como função destacar o uso de técnicas de manipulação do estrato lenhoso da vegetação da

Caatinga, caso do raleamento e do enriquecimento, que visam, aumentar a capacidade de suporte do pasto nativo e cultivado, através do incremento de biomassa de forragem herbácea e também da sua biodiversidade.

Palavras-chave: Caatinga, raleamento, enriquecimento, composição botânica, sustentabilidade.

INTRODUCTION

Most of the semiarid regions of the earth are located between the tropics of Cancer and Capricorn and are characterized mainly by having an average precipitation of 800 mm year^{-1} with irregular distribution. It also has an average insolation of 2.800 h year^{-1}, with average annual temperatures between 23 to 27 °C and soils in most of them with sandy-clay characteristics, with low organic matter (Figure 1). These regions, however, comprise approximately 5.0 billion hectares, housing around 1.0 billion people, who are responsible for generating approximately 22% of the earth's food production (FAO, 1998).



(A) (B)

Figure 1. Mean representation the variables temperature (A) and precipitation (B) on the globe
Source: http://www.climatewizard.org/

In Brazil, semiarid occupies approximately 912,000km², and covers the states of Ceará and Rio Grande do Norte, part of Paraíba, Pernambuco and Piauí, west of Alagoas and Sergipe, center of Bahia, and a strip that extends through the state of Minas Gerais (Figure 2). The tropical dry forest, know as the Caatinga is within a semiarid region, being the largest semiarid ecoregion in the south america (ANDRADE et al., 2020).

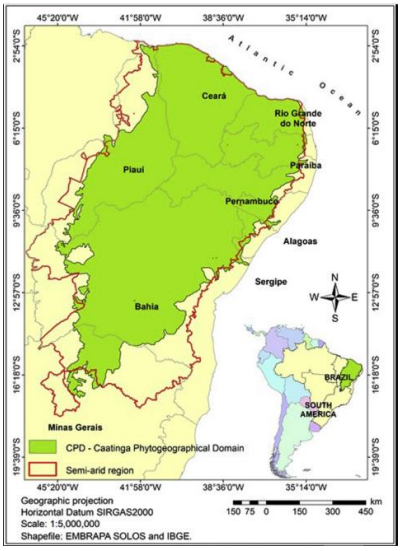


Figure 2. Delimitation of the Brazilian semiarid region
Source: Andrade et al. (2020)

The Caatinga is one of the most important pasture biomes in Brazil, especially because it occupies 70% of the northeastern region and 11% of the Brazilian territory, with a total of approximately 844,453 km^2 (ALVES et al., 2009). It is characterized as a region of high rainfall variability, with periodic drought periods. Because it is a biome located in one of the most densely inhabited semiarid areas of the world and responsible for generating countless jobs (LEAL et al., 2005).

Most people have agriculture as their main activity for the support of their families, however, because these areas have very diverse soil-climatic characteristics, they usually become inappropriate for this activity. According to Conrado et al. (2019a) these areas have significant soil and climatic characteristics, which frequently makes them inappropriate and limiting for agriculture. The livestock farming has become the main activity to be exploited, due to its greater resilience to the oscillations of the climate and soil.

The farm properties follow a mixed farming model, where 90% raise cattle, goats and sheep simultaneously, with a distribution in the national herd of cattle (14.7%), sheep (56.9%) and goats (90.6%).Sheep and goats are the most productive and adapted species in this region, besides the fact that they are animals that do not require much to serve as food base and a product of exchange between families, thus generating an extra income. Livestock farming is therefore fundamental for the development of the region, especially when it comes to the production of small ruminants (CONRADO et al., 2019a), besides having high relevance in the social and economic context (SILVA et al., 2020).

However, it has been observed in researches and reported by farmers, that in the last thirty years livestock has been identified as one of the main motivators to the Caatinga degradation, among the reasons are the low production of biomass and the overgrazing, which has increased deforestation (SILVA et al., 2018), especially in the dry period of the year (SALEM, 2010).

The objective was to discuss the Caatinga biome, relating its characteristics to the productive, social and environmental aspects, so that it was possible to present manipulation mechanisms, aiming at its sustainability and that of the production system.

DEGRADATION AND IMPORTANCE OF THE CAATINGA'S WOODY STRATUM TO THE PRODUCTION SYSTEM

The caatinga is different from other pastoral landscape units, as it has some unique characteristics, such as the high density of shrubs and trees, being very populated by species of the Fabaceae family, which have a high nutritional value, therefore having a relevant role in the feeding of ruminants (ALVES et al., 2009).

This biome also has great biodiversity, with more than 3,500 plant species cataloged, characterized in general by having smaller trees and shrubs that usually lose their leaves (deciduous species) in the dry season, as well as cacti and species ephemeral herbaceous, of which approximately 932 are vascular species, and also endemic. (ALVES et al., 2009). In addition, it has 275 species of ants, 386 of fish, 548 of birds and 183 of mammals (Silva et al., 2018).

In addition to its great diversity of botanical species, the Caatinga has considerable capacity for self-recovery, when it is subjected to some disorders, and this reconstitution is called resilience. However, the constant actions of people, without allowing a minimum recovery period for the area, have contributed to this resilience becoming less and less efficient (SILVA et al., 2014).

The intensive use of agriculture in semiarid regions has been causing loss of local biodiversity and production of forage biomass over the years. According to Rodrigues et al (2013) the anthropogenic action of men, causes deterioration, reflecting on the productivity of the area. In addition, there is reduction in fertilization, caused by deforestation, fire and soil contamination by pesticides, as well as the inadequate use of irrigation, which leads to salinization. According to Freitas et al (2013) studying an area of manipulated Caatinga, they observed that the productivity

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of the herbaceous biomass produced in a deforested and burned area reduced between 45 and 73.6% of its total.

According to Sousa et al. (2010), deforestation is the main starting point for the desertification process in an area and cited that 20% of the Caatinga biome is already in the process of desertification. According Araújo Filho (2013) the deforestation in the Caatinga already reaches 46% of the entire biome, and this number has increased on average by 2.7% per year, reflecting in the botanical composition. Amorim et al. (2014), point out that in most cases the degradation process begins with agriculture, and when it is no longer satisfactory, the area is abandoned and others are deforested.

What has been seen is a greater frequency of studies and research carried out for other biomes, while for the Caatinga these numbers are insufficient, making it the least protected biome in Brazil, with only 2% of the conservation units in the semiarid territory, generating thus having a great impact on the region's economy and on the income generation of rural families (Ribeiro Filho et al. (2015). In a study Rodrigues et al (2013) noted that the loss of biodiversity represents the greatest threat to the biome, and these are mainly associated with the emergence of invasive species, which was initiated due to low fertility and water infiltration in the soil, caused by deforestation.

Some studies (COSTA et al., 2010; SCORIZA et al., 2012; OLIVEIRA et al., 2007) demonstrate how important the minimal presence of trees is in the process of maintaining nutrient cycles in the soil, besides enabling the increase in biomass production, contributes to improve the microclimate, the animal welfare, soil and water conservation, regularization of the water cycle, biodiversity and carbon sequestration. The stability of this biome over time is based on the energy flow and nutrient cycling, as well as on the regulation of the population of animals and plants (AGUIAR et al, 2014). In 2002, the "Center for Vegetable Information of the Northeast" (CNIP), concluded that 40% of the species found in the Caatinga were from the Fabaceae family, with the majority of these species having the capacity to fix N_2 (Santos et al., 2010), amongst them Freitas et al (2010) stressed that in environments natural regeneration, fixation can reach 130 kg N ha^{-1} $year^{-1}$.

MANIPULATION OF THE CAATINGA FOR PASTORAL AND CONSERVATION PURPOSES

As an attempt to minimize future problems, Embrapa (Brazilian Agricultural Research Company) developed in Brazil, in the 1980s, a series of techniques to manipulate the Caatinga in order to increase the support capacity and to allow its use

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for grazing, as well as to guarantee its conservation (SCHACHT; MALECHEK, 1989). Some authors still feel the need for research that promotes the best use of dry tropical forests (VEGA et al., 2017).

There are in the literature some ways of manipulating forests in semiarid regions, for the Caatinga for example, the thinning is presented as a technique capable of maintaining the botanical composition and improve the biomass production, with increases greater than 76% (ARAÚJO FILHO et al 2002). According to Smith et al (2008) heterogeneous areas are more productive and resilient than areas with only one crop, this is due to improved efficiency in the use of natural resources, mainly nutrients and soil water.

The purpose of the manipulation is to enhance the production of biomass, considering all the woody stratum, is around 6 tons per hectare, distributed in the following way: 2 tons of wood and 4 tons of leaves, flowers and fruits, but only 10% becomes available to animals (ARAÚJO FILHO, 2013).

With this, the objective is to use the benefits that trees can promote to the herbaceous layer. According Oliveira et al. (2007) in semiarid environments contributes to improve the microclimate, the animal welfare, soil and water conservation, regularization of the water cycle, biodiversity, carbon sequestration and favor of the scenic beauty of rural landscapes.

Reducing the effects on seasonality of forage production, therefore, in the rainy season this forage is abundant and presents good quality, however, it is inaccessible to the animals mainly due to the height of the canopy of the trees and shrubs, whereas in the dry season, the forage becomes available but presents low nutritive value. Thus, some managements through the manipulation of the woody stratum, has stood out and gained increasing importance in the scenario of sustainability and intensification of the use of Caatinga (SANTOS et al., 2010).

Currently, there are three main ways to manipulate the Caatinga woody layer, they are: Demotion, thinning and enrichment. With more emphasis being placed on the thinning and enrichment.

THINNING OF THE CAATINGA

Thinning is a technique of manipulation of the arboreal stratum that aims to propose the substitution of non-forage biomass, by herbaceous forage biomass that can be grazed by ruminants, by the via reduction of the density of trees and shrubs of low potential for timber and forage, without causing biodiversity loss in the area

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(SCHACHT; MALECHEK, 1989). Different thinning arrangements can be found: forest, savanna and strip thinning, and among the three, savanna thinning is the most used by the producers (ARAÚJO FILHO 2013).

The thinning is done mainly to increase the production of herbaceous biomass in the understory, since the Caatinga can present different densities. Albuquerque et al (2008) found 3.38 plants / m² with height <0.5 m in the Caatinga under different stocking intensities. While Andrade et al (2009) found approximately 3,190 individuals / m², the most recommended species for thinning are: marmeleiro (*Croton suderianus*), velame (*Croton campestris*) and mofumbo (*Combretum leprosum*), mainly because they present low acceptance by the animals.

With this, this practice allows the incidence of light within the understory, contributing to the greater appearance of short-cycle herbaceous species, so abundant in the Caatinga (ASAYE; ZEWDIE, 2013).

Solar radiation is a very important factor for the good development of plants, being directly related to the photosynthetic activities. Garcia-Ruiz et al. (2008) studying a microbasin in the semiarid region of Spain compared a thinned area and a non-thinned area and observed that the presence of thinning promoted an increase in the moisture content of the soil, which was also a consequence of the increase in the presence of the herbaceous layer that reduced the runoff of the water and favored its infiltration.

With this new distribution of shrub species, herbaceous plants appear more accessible to ruminants, especially in the rainy season. Araújo Filho (1992) identified the presence of herbaceous plants in up to 80% of the ruminant diet in the semiarid during the rainy season. In the dry season, forage consumption has a greater share of the woody layer. Aquino et al (2017) observed benefits from thinning in the rainy season via dry matter production, reaching approximately 3,000 kg ha^{-1}, with no significant drop in the same period. In a research, Conrado et al (2019b), observed that the handling of Caatinga increased at least 100% of the herbaceous species considered of forage potential.

The most common model for thinning is the savanna type, which consists of the selective cutting of isolated trees, so that the landscape resembles an African savanna, maintaining a coverage of 30 to 40% of the area (Araújo Filho, 2013). However, it has some disadvantages, such as the high maintenance cost and the high dependence of labor, because of the uniqueness of the architecture that should be maintained, the low survival of native shrubby tree species and the low adaptability of grasses used to

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enrich the area (ASAYE; ZEWDIE, 2013). This type differs from the forest type, as it consists of leaving small groups of trees that occur naturally in the area.

Thus, some other forms of selective thinning of trees and shrubs have emerged, always seeking to maintain biodiversity and reduce competition for water, light and nutrients, thus opening space for herbaceous species to develop (AQUINO et al., 2017).

There is some resistance from adepts of the manipulation of the Caatinga because they believe that thinning in strips degrades biodiversity, since an entire strip area is cleared. However, this aspect can be circumvented by the proper sizing of the strip. Within the range, the remains of plants should be chopped into mounds not exceeding 1.5 m, perpendicular to the ground.

Adequate coverages, triggered by the presence of the tree component in the semiarid region, do not harm herbaceous plants, but maintain or even increase production (kg ha^{-1}) similar to cultivation with full sun exposure (PACIULLO et al., 2008).

Some recommendations can be found in other regions of Brazil for planting in bands with cultivated trees. CORDEIRO et al. (2018) observed that systems containing 10 x 4 m spacing are adopted mainly in crops intercropped with rice. Others in double or triple strips (1.5 m between plants and 3.0 m between strips), with 10, 20 or 40 mb 6 between the tree lines, which besides allowing the production of herbaceous biomass also presents a good wood production, generating an increased income for the producer.

The thinning also allows the use of native or exotic species to be cultivated in consortium with the woody stratum. This technique is called enrichment.

ENRICHMENT OF CAATINGA.

The technique of implantation of exotic and or native species in thinned Caatinga areas is called enrichment (SILVA et al., 2001).

Due to its low support capacity, from 10 to 12 ha / animal for cattle and 2 to 3 ha / animal for sheep and goats, the Caatinga presents some limitations for the intensification of use of the area, However, with the enrichment in the area, it is possible to intensify its use even more, going to 1.1 cattle / ha and 10 sheep and goats / ha, with biomass production of 8,000 kg ha^{-1}, and availability reaching 6,400 kg ha^{-1}, reflection on the animal performance that becomes 172 kg ha^{-1} for bovine and 120 kg

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ha^{-1} for sheep and goats (SILVA et al., 2001). According Carvalho et al. (2018) the increase in animal performance is often related to the availability of forage biomass.

Over the years the most used grasses to enrich the herbaceous stratum of the Caatinga were the buffel grass (*Pennisetum ciliare* syn*. Cenchrus ciliaris*), corrente grass (*Urochloa mosambicensis*) and gramão grass (*Cynodon dactylon*), which are capable of increasing in up to 6,400 kg ha^{-1} the forage supply, thus reflecting on the increase of the support capacity of the area (ARAÚJO FILHO, 1992).

The buffel grass (*Pennisetum ciliare*) is one of the most used exotic species to enrich semiarid regions. This forage species originated in Africa but spread to the Asian (Indonesia and India) and American continents (United States of America, Mexico and Argentina). Its resistance originates from its root system, that can reach 1.5 m depth, and may vary from cultivar and rhizomes. These characteristics favor the reduction of the process of dehydration of the plant, thus promoting the maintenance of its humidity for a longer period of time (MARSHALL et al., 2012). Conrado et al. (2019) working with buffel grass achieved a production of 5.0 ton ha^{-1} with a water blade of 373 mm over 88 days, demonstrating the efficiency in the use of water by this plant.

Some other species belonging to the genus Panicum, such as *Panicum maximum* syn*. Megathyrsus maximus*, have been gaining space in livestock production, especially in semiarid and arid regions, due to the vast supply of species, and because they produce a large amount of biomass, besides the rapid germination, reaching 70% of the seeds and easy harvesting. Among these grasses the massai grass (*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs cv. Massai) (JANK et al., 2011). Cavalcante et al*.* (2014) evaluating the massai grass in dry conditions for deferred use, observed a production of 2,000 kg of total forage biomass at 90 days, which presented only 10% of stem, being a good alternative for systems integrated with trees.

In an area enriched with gramão grass, Araujo Filho et al. (2002) observed a strong increase in support capacity, which for cattle was 1.1 head / ha / year and 10 head / ha / year for sheep. Evaluating animal performance, Silva (2001), observed a gain of 0.406 kg/animal/day, in the most intense level of manipulation, for the cattle. Santana et al. (2010), evaluating the performance of crossbred heifers Gir x Holsteins and Guzerá heifers, observed an average gain of 412 g / animal / day, in the rainy season in an area enriched with buffel grass and corrente grass. Voltolini et al. (2011) reported gains of 0.064 kg animal^{-1} in sheep, with lambs kept in exclusive areas with buffel grass.

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FINAL CONSIDERATIONS

The information contained in this review demonstrates the importance manipulation of the Caatinga. Thinning and enrichment in Caatinga areas are feasible and sustainable alternatives, aiming to contribute significantly to the performance of forage plants, reflecting the increase in the supply and quality of herbaceous forage biomass, whether native or cultivated, causing increase in ruminant production and plant biodiversity.

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