

## **Review Article**

# **Mycorrhizal fungi and their importance in the conservation of the Caatinga**

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### **ABSTRACT**

The suppression of native vegetation due to inadequate practices has contributed to the non-survival of many plant species, resulting in the loss of the genetic heritage of the Caatinga flora. However, their growth and establishment can be improved by the presence of arbuscular mycorrhizal fungi (AMF), a symbiotic association formed by plant roots and soil fungi that helps seedlings to increase nutrition and tolerance to water deficit, a common situation in stressful environments such as the Caatinga. This review aimed to discuss the importance of mycorrhizal fungi in the development and conservation of native species of the Caatinga that live under water stress, highlighting the effects caused by arbuscular mycorrhiza, its importance for conservation and mechanisms of plant adaptation to stress. The research sought to gather data from articles and journals with the help of key words indexed in Science Direct, Scientific Eletronic Library Online (SciELO), on the Google Academic platform and in the Catalog of Theses and Dissertations of the Coordination for the Improvement of Higher-Level Person (Capes). The results indicate that the inoculation of arbuscular mycorrhizal fungi through root growth can increase the absorption of water and nutrients, assisting in the development of local plants of the Caatinga that live under stress, contributing to the structure of the plant community and the functioning of the natural ecosystem. As research on this subject is still scarce, it is necessary to disseminate research on this subject in order to obtain a wider range of information.

*Keywords: Arbuscular mycorrhiza; symbiosis; water stress.*

# 1. INTRODUCTION

Corresponding to 10.1% of the national territory, the Caatinga, a unique Brazilian biome, represents one of the largest semiarid areas in the world rich in biodiversity, endowed with flora and fauna with a high degree of heterogeneity [1,2].

Despite its importance, the removal of native vegetation caused by inappropriate anthropic activities such as logging, mineral and vegetal extraction, livestock and extensive agriculture has resulted in the loss of the genetic heritage of the biome's flora, delaying fundamental ecological processes for the functioning of the ecosystem and may lead to irreversible degradation.

Besides the strong anthropic pressure, the edaphoclimatic factors existing in the natural environmental conditions of the semiarid, such as water deficit and nutritional deficit, hinder the vegetal replacement of pioneer species, which protect the soil and prepare for the climax species. Thus, to tolerate the adverse conditions, plants can make mutualistic associations that promote plant growth and nutritional cycling in this biological community [3].

Arbuscular mycorrhizal fungi (AMFs), an association between fungi of the phylum Glomeromycota and pioneer seedlings, can stimulate their growth since the association is essential for the development and nutrition of the plant providing a greater reach of the roots and, therefore, a greater area of contact with their substrate making the seedlings more tolerant in stressful environments [4].

Despite its relevance, studies on this association are scarce, especially with tree species established in semiarid soils, where water availability is a limiting factor for plant growth and production [5].

Thus, information that supports the use of this biotechnology with native species of the Caatinga would help to improve and use techniques of low environmental impact in the management and conservation of the vegetation of this biome, thus collaborating to curb the problems caused by the advancement of populations inserted in vulnerable areas, seeking a more sustainable and long-term development.

This review aims to discuss the importance of mycorrhizal fungi in the development and conservation of native species of Caatinga living under water stress, highlighting the effects caused by arbuscular mycorrhizae, their importance for conservation and mechanisms of plant adaptation to stress.

## 2. MATERIAL AND METHODS

This research constitutes a literature review of a qualitative nature [6] seeking to gather data from articles and journals indexed in Science Direct, Scientific Eletronic Library Online (SciELO), on the Google Academic platform and in the Catalog of Theses and Dissertations of the Coordination for the Improvement of Higher Level Person (Capes). We used several scientific productions related to the effect of arbuscular mycorrhizal fungi on tolerance to hydric stress in native Caatinga forest species and its implication on conservation.

Data collection took place between the months of June and August 2020. Searches were performed with the help of key words such as: mycorrhizae, water stress, Caatinga, conservation. Twenty-seven articles were selected according to the areas of interest and after analyzing the title, abstract and key words.

## 3. RESULTS AND DISCUSSION

### 3.1 Caatinga

The Caatinga is the main biome existing in the Northeast region, with highly heterogeneous flora and fauna that cannot be found anywhere else on the planet. The biome presents a semiarid climate, with an average temperature of 25°C to 30°C, besides an average precipitation of 800 mm.year<sup>-1</sup> that occurs in a short period of time varying from three to five months in the first semester, with torrential and irregular rains [7]. According to [8], the term Caatinga originates from Tupi-Guarani and means "mata-branca" (white forest), a name referring to the appearance of its vegetation during the dry season.

Much of the biome presents vegetation with high tolerance to drought, presenting anatomo-physiological adaptations such as: deciduous, short life cycle, xylopodia, modified leaves with spines, seeds in dormancy stage, special mechanisms of opening and closing of stomata, chlorophyllated succulent stems and great abundance of cactaceae that perform the absorption of carbon dioxide (CO<sub>2</sub>) during the night [9].

According to [10], the Caatinga has an important meaning for the inhabitants of the Northeast region, because it is through it that a large part of the residents obtain income for the maintenance of their families and their subsistence. However, the inappropriate and exacerbated use of natural resources for the consumption of timber and non-timber products, as well as the inappropriate exploitation of areas for livestock and agriculture compromise the seed bank, hindering natural regeneration, leading to the desertification process and triggering the loss of the genetic heritage of the Caatinga flora [11].

Thus, it is necessary to conduct research aimed at the restoration of this Biome, taking into account aspects of social, environmental and economic character [12].

### **3.2 Arbuscular Mycorrhizal Fungi**

Arbuscular mycorrhizal fungi are obligate symbionts and their existence dates back more than 460 million years [13]. They belong to the Phylum Glomeromycota that are divided into four orders, nine families, and about 200 species. Their life cycle begins with the synthesis of spores and, after the development of the germ tube, some hyphae start the establishment of the arbuscular mycorrhiza symbiosis (AM), resulting from a complex sequence of chemical stimuli that contribute in the germination and direction of intra- and extra-radicular hyphae, capable of absorbing mineral elements from the soil and transferring them to the roots [14]. AMFs form one of the most common associations in nature, in which about 80% of terrestrial plants form the arbuscular mycorrhiza, thus the non-mycorrhizal situation is rare [4].

Mycorrhizal associations are initiated by the "exchange of favors" between the symbionts, since fungi are beings that do not perform photosynthesis, and therefore depend on organic bonds from other living things on which they feed [15]. In return, these provide several contributions to plants, such as increased uptake of water and key nutrients such as nitrogen and phosphorus, as well as contributing to increased resistance to salt, water, and high temperature stresses. In addition, they filter heavy metals that harm the roots and are essential components in recovery programs for degraded areas, being associated with the establishment of plant communities [16].

#### **3.2.1 Implications of mycorrhizae for conservation**

Arbuscular mycorrhizal fungi have significant ecological importance, making it essential to distinguish between species for applicability of their potential. According to [17], mycorrhizae are useful to nature and man, as they play a significant role in the establishment, development, and conservation of ecosystems, whether natural or managed.

In addition, they help in the adaptation of plants to biotic and abiotic soil stresses and in contributing to the structuring of plant communities. AMFs are essential for the recovery of polluted soils and degraded areas and are considered drainage channels of carbon from the atmosphere to the soil, because of their direct access to plant carbon sources and are also involved in the storage and cycling of nutrients in forest ecosystems [4].

### **3.3 Effects of water stress on seedlings with AMF**

Water stress is defined as an irregularity in the normal conditions for plant life, thus causing changes in the organism. In principle, these changes may be reversible, however, in some cases they may become permanent [18].

Water is fundamental in seedling metabolism and a reduction in its availability in the soil can affect the growth, development and productivity of crops [19], causing anatomical, morphological, physiological and biochemical changes [20].

According to [21], the reduction in the availability of water in the soil causes a reduction in cell turgescence, reducing its leaf area. In addition, there is a reduction in the dry mass content of plants, due to its influence on CO<sub>2</sub> gas exchange and on the carbon balance.

The dry season is the period in which water deficit in seedlings can be observed most commonly, because the water present in the soil is not available for short or long periods, causing a reduction in the physiological activities of the plant [22]. In drier regions, many plants use organisms to avoid water loss, such as: decrease in leaf area, deciduousness, change in leaf thickness, reduction in transpiration rate and stomatal conductance [23]. Plants that suffer water stress present higher concentrations of solutes in the tissues and lower osmotic potentials than plants adequately supplied with water [24].

[21] showed that under water deficit conditions in the plant, there is a dehydration of the protoplasm, which results in a decrease in cell volume and an increase in the concentration of solutes, where the growth process is the first to be affected. On the other hand, these authors demonstrated benefits of mycorrhizae on the growth and nutrition of seedlings. They also showed that due to the increase and greater exploration of the soil volume by the root system of the seedlings promoted by the presence of mycorrhizal fungi, there is a greater absorption of water and nutrients [25]. [4] showed that the association is responsible for the adaptation and greater tolerance of seedlings to stress. Therefore, these benefits are amplified, providing better adaptability to seedlings, especially in adverse edaphoclimatic conditions.

Mycorrhization benefited passion-fruit (*Passiflora edulis* Sims.) seedlings, promoting growth, even under water stress [26]. In addition, [27] demonstrated that inoculation with mycorrhiza in Sabiá (*Mimosa caesalpiniaefolia* Benth) seedlings stimulated symbiosis with N<sub>2</sub>-fixing bacteria, providing an increase in N content and the accumulation of N, K, Mg, Cu, Mn, and Fe.

However, studies show the absence of benefits from mycorrhizae. An example of this is the work carried out by [28], where it was observed that there was no contribution of the arbuscular mycorrhizal fungus on the growth and development of the seedlings of tamboril (*Enterolobium contortisiliquum* Vell.) and jatobá (*Hymenaea courbaril* L.). Thus, the diversity of plant responses to this symbiosis can be attributed to the functional diversity of the arbuscular mycorrhizae, as a function of the interaction between AMF-plant and soil and climate conditions.

#### 4. CONCLUSION

The inoculation of arbuscular mycorrhizal fungi, by means of root growth, can increase the absorption of water and nutrients, helping in the development of local plants of the Caatinga that live under stress, contributing to the structure of the vegetal community and the functioning of the natural ecosystem.

As research on this subject is still scarce, it is necessary to disseminate research on this subject in order to obtain a wider range of information.

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UNDER PEER REVIEW