

Effects of slash and burn practices on a soil seed bank of caatinga vegetation in Northeastern Brazil

M. de A. Mamede^{a,*}, F.S. de Araújo^b

^aCNPq/CGCTM, COGEC/Ecologia, SEPN 509, bl. A, Ed. Nazir I, sl. 304, Brasília 70.750-501, DF, Brazil

^bDepartamento de Biologia, Bloco 906, Centro de Ciências, Universidade Federal do Ceará, Campus do Pici, Fortaleza 60455-760, CE, Brazil

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Abstract

The semiarid tropical zone covers 20% of Brazil and is dominated by caatinga, a thorny deciduous savanna well adapted to seasonal water shortage and periodic drought years. This study was focused on effects of slash and burn agriculture on the soil seed bank in a Caatinga area, in Sobral, CE, Brazil. Caatinga is rich in species, called therophytes, which remain as seeds in the soil during unfavorable seasons and rely on regeneration from the soil seed bank for persistence in the environment. Although slash and burn agriculture has been intensified in the region for the past three centuries, its effects on the soil seed bank are not well known. A seedling emergence greenhouse experiment was conducted to evaluate differences in seed bank density and diversity among soil samples collected before and after an experimental burning. Soil samples were previously submitted to sequential sieving to assess fire effects on different-sized seeds. Fire significantly reduced overall seed bank density, with smaller sieving fractions being most strongly affected. Shannon's diversity index was also lowered by fire. Combined, these results show that agricultural practices represent a serious threat to plant biodiversity conservation in the Caatinga biome.

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1. Introduction

The Brazilian semiarid tropical zone (SAT) occupies approximately 20% of the country (Reddy, 1983). This author revised SAT climatic classification and proposed a modified Thornthwaite's approach (Thornthwaite, 1933) as more appropriate to define SAT's boundaries. The SAT is characterized by low mean annual rainfall, representing between 25% and 75% of mean annual potential evapotranspiration, which results in an important hydric deficit. Also, rainfall is erratic and concentrated in a short rainy season (Reddy, 1983).

The drier portion of the Brazilian SAT zone, which periodically experiences drought years, has long been known as the Drought Polygon (Markham, 1967). The Drought Polygon has been the object of special federal legislation since 1936, due to the magnitude of the impact on human population of periodic droughts

*Corresponding author. Tel.: +55 61 3368 1739; fax: +55 61 2108 9391

E-mail addresses: mmamede@cnpq.br (M.deA. Mamede), tchesca@ufc.br (F.S. de Araújo).

occurring in the region. It includes over a thousand municipalities located in 8 of 9 states of the Northeastern region and the Northern region of Minas Gerais state.

Ab'Saber (1974) described morfo-climatic characteristics of the Brazilian semiarid zone, defining as the typical landscape of the region the lowland areas over crystalline basement dated from the pre-Cambrian. Soils on the crystalline basement tend to be shallow, clayey and rocky, usually classified as Leptosols (Lithosols), Regosols and Luvisols (non-calcic brown) (see Sampaio, 1995). The dominant vegetation type, locally known as *caatinga* (Andrade-Lima, 1981), is a thorny deciduous savanna well adapted to seasonal hydric shortage (Cole, 1960).

According to Raunkiaer (1934) system of plant life form classification, one important feature reflecting the dependence of plants upon climate is their adaptation to survive the unfavorable season. The *caatinga* vegetation is rich in therophyte species, which remain as seeds in the soil during the unfavorable season (Costa et al., 2007), vegetating only in the rainy period. This life form represents an avoidance strategy for coping with seasonal drought. The woody species, classified as phanerophytes and chamaephytes, typically shed their leaves during the dry season (Andrade-Lima, 1981; Araújo et al., 2005; Costa et al., 2007).

The *caatinga* vegetation has a high spatial variability, both floristically and physiognomically (Andrade-Lima, 1981). However, it is hard to know to what extent the variation is due to differences in local physical conditions—for example, soil type—or to human interference (Sampaio, 1995). The available data about environmental characteristics and land use history are scarce (Barbosa et al., 2005). The semiarid zone of Brazil has been inhabited for more than 10,000 years (Sampaio, 1995), but population remained low until the 18th century, when Europeans initiated colonization of the inner and drier areas of the country. Nowadays, the population inhabiting the semiarid zone of Brazil is over 18 millions (Melo, 2004).

Livestock soon became the main economic activity of the Brazilian SAT zone. Historical records reveal that the activity was prosperous in the beginning (Brasil, 1863). Since the late 19th century, cattle raising has declined and social conditions have deteriorated with an ever increasing population pressure. Only recently, concerns about the sustainability of human activities in the Brazilian semiarid domain have arisen.

One important aspect to be considered is the loss of plant species biodiversity. Traditional agricultural practices involve slash-and-burn and shifting cultivation, and few studies have dealt with the environmental effects of cutting and burning of *caatinga* vegetation (Kauffman et al., 1993; Sampaio et al., 1993; Pereira et al., 2003).

In *caatinga* vegetation, the soil seed bank plays a crucial role in the maintenance of the herbaceous species populations (therophytes, cryptophytes and hemicryptophytes). As most of the herbaceous species of the *caatinga* are therophytes (Costa et al., 2007), they depend exclusively on the soil seed bank and must complete their life cycles within the short rainy season to maintain viable populations.

Considering that the annual herbaceous species account for the greatest part of *caatinga*'s floristic richness (Araújo et al., 2005; Costa et al., 2007; Rodal et al., 2005), the potential impact of fire on the soil seed bank may represent a serious threat to native plant species conservation. We do not know of any previous studies dealing with effects of burning practices on the soil seed bank of *caatinga* vegetation.

In this study, we hypothesized that slash and burn practices may cause a significant reduction on *caatinga* soil seed bank density and diversity. Additionally, we searched for differential fire effects on different-sized seeds. We hypothesized that small-seeded species, which have fewer protective tissues around the embryo, would be more susceptible to damage by fire.

2. Materials and methods

2.1. Study area

The fieldwork was conducted in an experimental area of the *Centro Nacional de Pesquisa em Caprinos* (EMBRAPA-CNPC), in Sobral municipality, Ceará state, Brazil. The study area, *Fazenda Crioula*, is located at 3°44'56" S and 38°34'27" W and 145 m above sea level. Mean annual precipitation is 822 mm, with 82% of it occurring between February and May. Estimated mean temperature is 27.5 °C, oscillating between 26.3 °C in the coldest and 28.4 °C in the hottest month. Climatic data—rainfall and temperature—were obtained from the Ceará Foundation of Meteorology and Water Resources (FUNCEME).

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