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Arbuscular mycorrhizal fungal communities in buffelgrass pasture under intercropping and shading systems in Brazilian semiarid conditions

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ABSTRACT

The intercropping of grasses and legumes has been suggested as an alternative for ensuring pasture sustainability. However, few studies have focused on the impact of intercropping and shading on the soil microbiota in semi-arid regions. The goal of this study was to evaluate the effects of intercropping a grass, *Cenchrus ciliaris*, with a legume, *Clitoria ternatea*, under different levels of shading, on the *C. ciliaris* carbohydrate concentration and the arbuscular mycorrhizal fungal (AMF) community over time. Soil samples were collected at four sampling times: before intercropping (BI) and after 120, 165 and 210 days cultivation. Four levels of shading were tested: 0 (full sunlight), 26, 39 and 55%. In the intercropped system, mycorrhizal colonization was higher under lower shading levels after 120 and 165 days cultivation, but the number of glomerospores was higher under higher shading levels. After 165 days cultivation, the carbohydrate concentrations were higher under full sunlight. After 210 days cultivation, the reducing carbohydrate concentrations were higher in the intercropped system. Thirty-one AMF species were detected; *Acaulospora* and *Glomus* species were predominant compared with the remaining genera. This study showed that AMF community composition was relatively similar between shading and intercropping by multidimensional scaling (MDS) and PERMANOVA analysis, and it was observed only sampling time effect on the AMF community. The Shannon diversity index showed a reduction in AMF diversity from 210 days of cultivation and an increase in the AMF species richness over time. It was concluded that pastures of *C. ciliaris* under shading and intercropping with *C. ternatea* did not modify the AMF community composition. However, the results suggest that intercropping of these plant species may result in AMF species selection over time.

1. Introduction

Animal production in semiarid regions is limited by variations in the supply and forage quality of plants throughout the year due to the irregular distribution of rainfall, which is concentrated in three months of the year (Gariglio et al., 2010). Forage pastures are of great importance because they supply 90% of the nutrients required by ruminants (Euclides et al., 2010). However, during the dry season, the food supply decreases, and the forage generally has lower digestibility and acceptance, resulting in low zootechnical performance (Silva and Saliba, 2007). In addition to drought effects, the soils of semiarid regions have low fertility, with low availability of essential nutrients such as phosphorus and nitrogen, which results in low pasture regeneration (Sampaio et al., 1995).

Straw deposited over the soil and roots is the main N input into tropical pastures (Cadisch et al., 1994). Due to the high C/N ratio of grass straw, N immobilization is higher for monocropped grass than for grass that is intercropped with legumes, decreasing the availability of N to soil micro-organisms (Calvo et al., 2010). Integrated forage grass-legume systems may promote pasture sustainability and longevity. This type of integration has the direct advantage of supplying N fixed by legume-associated bacteria to grasses, which increases productivity, indirectly decreases the costs associated with nitrogen fertilizer application and increases the pasture useful life compared with conventional systems (Barcellos et al., 2008). This system promotes shading, resulting in

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microclimatic changes (Menezes et al., 2002) and improvements in the forage quality, as higher concentration of carbohydrates, protein and nutrients (Ribaski and Menezes, 2002; Mirsha et al., 2010), promoting animal welfare. However, decreased photosynthetic rates caused by shading result in decreased production of carbohydrates, especially soluble carbohydrates. A study performed in the U.S.A. showed decreased plant soluble carbohydrate concentrations in *Dactylis glomerata* under increasing shading (Belesky et al., 2006).

A disadvantage of the intercropping system is the possibility to promote higher plant competition for nutrients, water and light, which can cause a direct impact on the soil microbiota (Bainard et al., 2011). One of the most important group of microbial soil community are the arbuscular mycorrhizal fungi (AMF) that have beneficial effects on plants and can be affected by crop management practices. AMF supply nutrients, especially N and P, to host plants; in return, the plants supply carbon and energy to the fungi (Smith and Read, 2008). AMF interconnect the roots of neighboring plants through common mycelial networks, allowing the transfer of C and other nutrients between plants in intercropping systems (Walder et al., 2012) and consequently, a more efficient exploration of soil nutrients in semiarid ecosystems (Barea et al., 2011). In addition, intercropping may decrease the impact caused by conventional cropping systems on the fungal community composition, abundance and diversity (Bainard et al., 2011). Several studies have shown that the inclusion of additional plant species into agricultural systems promotes increased AMF sporulation and richness (Burrown and Pfleger, 2002; Bainard et al., 2012; Hiiesalu et al., 2014), which can result in higher plant productivity (van der Heijden et al., 1998).

Studies show that shading negatively affect the AMF community, and may cause reduction in carbon allocation from the plant to the fungus, depending on the fungal species (Zheng et al., 2015), and this can result in less diversity and efficiency of community in the plant establishment in the field, affecting fungal abundance and sporulation (Muleta et al., 2007; Shi et al., 2014). In addition, shading interferes with mycorrhizal colonization (MC). In plants of *Tabebuia avellanedae*, the MC was higher under 30% than under 96% shading (Moratelli et al., 2007). However, *Zea mays* plants shaded by intercropping with *Albizia gummifera* and *Croton macrostachyus* had higher MC compared with plants grown under full sunlight. The effects of shading may therefore vary according to the plant studied, the intensity of shading, and the regional climate (Hailemariam et al., 2013). Although intercropping and shading have been observed to affect mycorrhizal associations and their occurrence, their effects, recommended levels, and possible impacts on AMF in Brazilian semiarid regions have not been studied. The present study tested the hypothesis that AMF communities and the production of AMF infective propagules are affected by shading and intercropping, and that these systems can select AMF species over time. The goal of the present study was to investigate the effects of different levels of shading on the AMF communities in the rhizosphere of intercropped and monocropped plants. Intercropping of buffelgrass (*C. ciliaris*) with an herbaceous legume, also used as pasture, (*C. ternatea*) was tested in the field under four levels of shading (full sunlight, 26, 39 and 55%), aiming to determine the better level of shading for herbaceous vegetation to be applied in agroforestry systems.

2. Material and methods

2.1. Study site

The study was performed in an experimental area in the 'Campus de Ciências Agrárias' of the 'Universidade Federal do Vale do São Francisco', located in Petrolina municipality, semiarid of Pernambuco (Brazilian Northeastern) (09°19′20.70″S, 40°33′36.17″W). The air temperature and average annual precipitation of the region is 27.1 °C and 431.8 mm/year, respectively. The climate of the region is Bswh according to Köppen classification, presenting two distinct seasons: dry (May to October) and wet (November to April). Precipitation and temperature data for the collected periods are presented in Fig. 1, the meteorological station is located in the Univasf *Campus*, near to the experimental field (09°19′20.0″S, 40°33′36.0W).

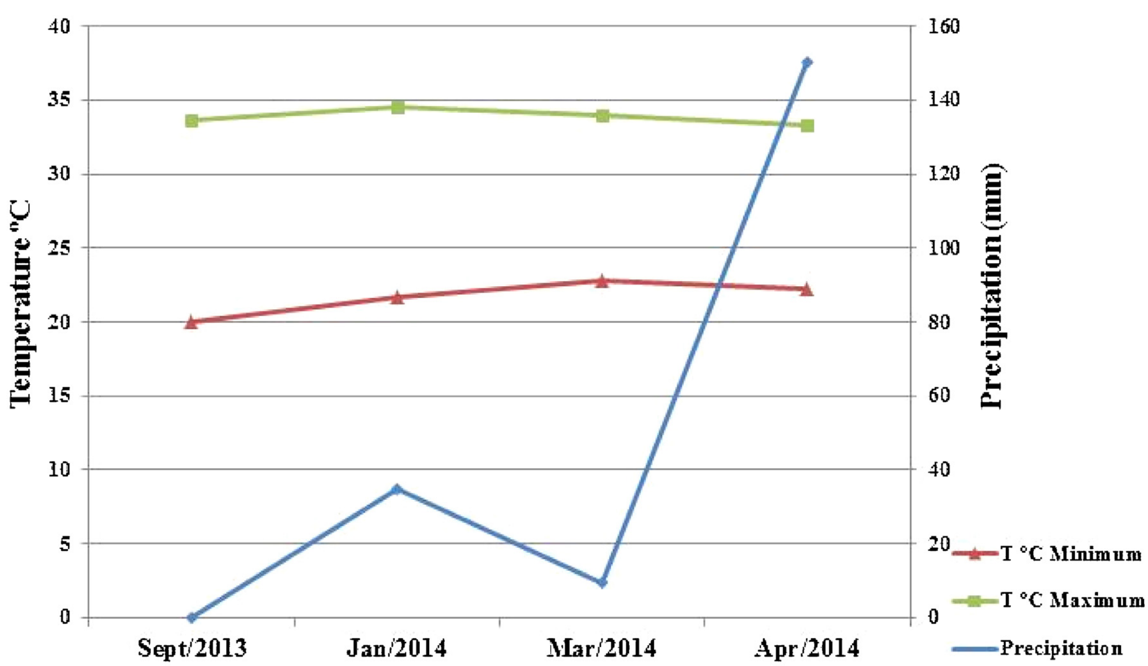

Fig. 1. Average rainfall and temperatures (minimum and maximum) from September 2013 to April 2014, Petrolina-PE.
Source: Automatic Weather Station from the Experimental Field – Univasf.