Succession in AMF Communities from Early to Late Season in Grassland National Park

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Abstract

Change of AMF (arbuscular mycorrhizal fungi) community between two seasons in Grassland National Park had been studied in this article. We used FAMEs analysis and PCR-DGGE analysis tested soil samples collected from 3 different ecosystems at two sampling seasons. Based on our study, we found that AMF activity was significantly higher in early (wet) than late (dry) seasons, and in early season, the amount of AMF also showed significant positive linear relationship with amount of P and N in plant tissue. During late season we didn't find significant result among these variables, which may suggest that seasonal changes could change the activity of AMF and affect relationship between AMF and their host plant nutrient metabolism. Also, AMF species composition differed in early and late season. Most AMF taxa found in the dry season in our study were unknown to the scientific community. This suggests that AMF biodiversity had difference between seasons and these uncommon AMF taxa are adapted to dry conditions. Besides, crested wheatgrass, the dominant species in the park, although didn't show significantly directly relationship with AMF activity, it may improve soil organic carbon, soil soluble P, and increase the amount of soil bacteria, which are also three important factors that could further affect AMF activity. However, the absence of activity of crested wheatgrass combined with the low biodiversity in the stand and low association with AMF in the dry season, suggests that a prolonged drought period detrimental to crested wheatgrass would leave a prairie of crested wheatgrass vulnerable and depleted.

Introduction

Arbuscular mycorrhizal fungi (AMF) form mutualistic associations with the roots of most plant species (Van Der Heijden et al. 1998), and influence many important ecosystem functions, such as N cycling and P uptake (Olsson, P.A. et al. 1997; Marler, M.J. et al. 1999; Grime, J.P. et al. 1988). In natural ecosystems, seasonal variations in soil resources may affect AMF and plant growth. We hypothesized that seasonal variations in water resources change AMF community structure and biodiversity, and the relationship between AMF and plants in the mixed grass prairie ecozone. We examined AMF symbioses during the warm & dry, and the cool & wet periods of summer, in crested wheatgrass and native plant stands.

Methods

Four sets (blocks) of adjacent ecosystems, i.e. (1) native vegetation, (2) crested wheatgrass, or (3) restored native vegetation, were sampled during the warm & dry (24 August 2006), and the cool & wet (4 June 2007) seasons of the mixed grass prairie ecozone, at Grassland National Park.

Plant dry shoots (1.25 m^2) were cut, dried, ground, digested with H_2SO_4/Se/Na_2SO_4 and analyzed for tissue N and P on an autoanalyzer (AAII system). AMF and bacterial biomasses were determined using phospholipid fatty acid 16:1ω5 (Clapperton, M.J. et al. 2005) and Supelco BAME (Sigma-Aldrich) biomarkers, respectively, and soil moisture content was determined by gravimetry.

AMF biodiversity was analyzed by PCR (polymerase chain reaction) - DGGE (denaturing gradient gel electrophoresis). DNA extracted from soil (UltraClean Soil DNA Isolation Kit, MO BIO Lab. Inc) was amplified with general primers GeoA2/Geo11 and AMF specific primers AM1/NS31-GC and Glo1/NS31-GC, in nested protocols.

A clone library was constructed based on the 18S rDNA fragments using AM1 / NS31 and Glo1 / NS3 (Renker, C. et al. 2006). Clones were sequenced (PBI-NRC, Saskatoono) and identified by comparisons to known sequences in public databases using BLAST. The clones were used in a ladder to identify AMF ribotypes on DGGE gels. PCR products were analysed by DGGE using a Dcode Universal Mutation Detection system (Bio-Rad Laboratories) at a constant temperature of 60 □, gel were stained with SYBR Safe DNA gel stain. Statistical analyses were done using SYSTAT 12.0 and R program (*www.**r**-project.org/)*.

Results

The amount of AMF biomass in soil during the cool & wet season was related with the amount of P (P = 0.007) and N (P = 0.009) in plant tissue (Fig. 1). Such relationship did not exist during the warm & dry season (data not shown). Soil moisture and AMF biomass in soil were correlated (Pearson, R^2 = 0.491, P = 0.005).

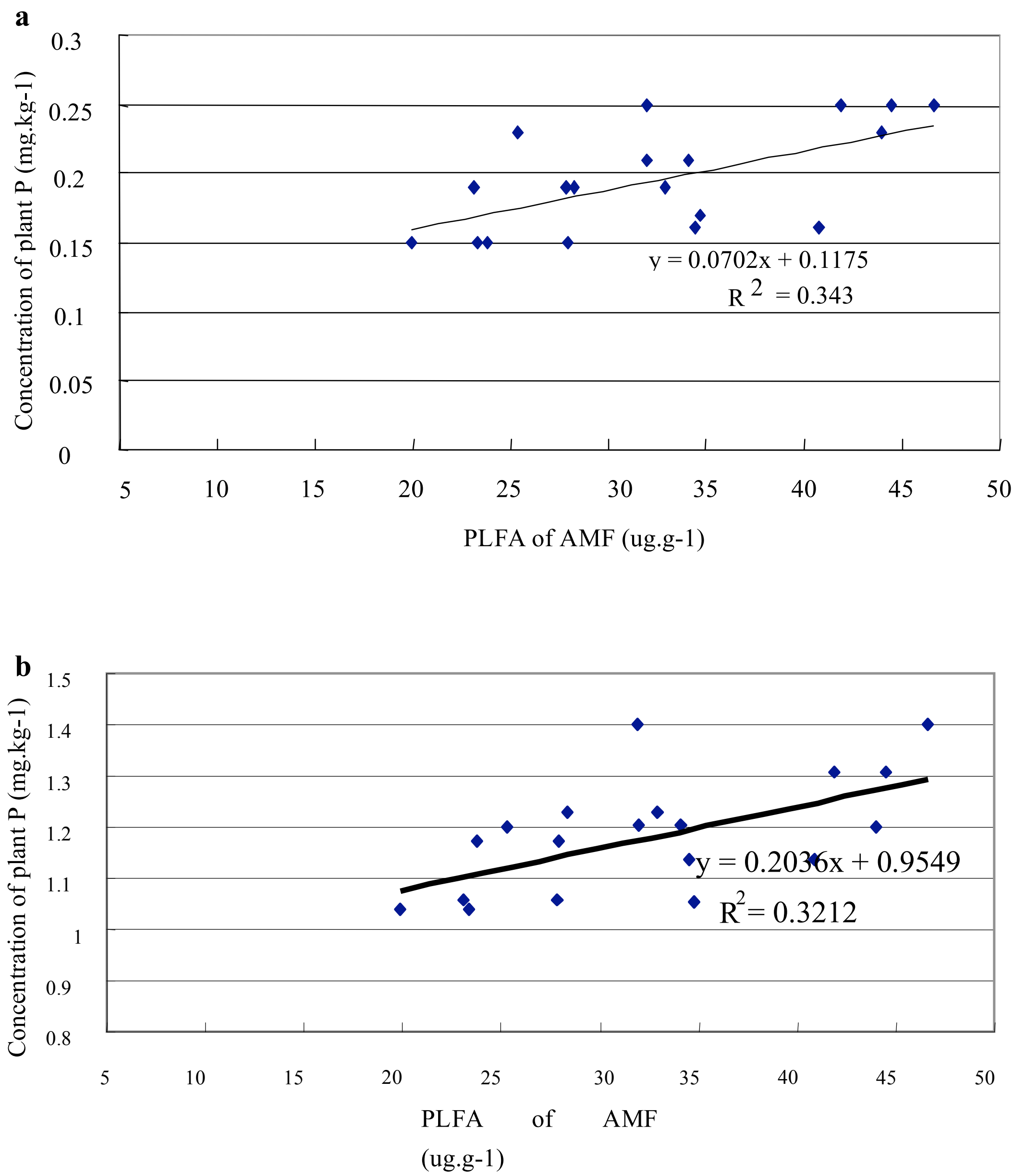

Figure 1. Relationship between AMF biomass and plant phosphorous (a) and nitrogen (b)

Correspondence analysis showed that the AMF communities found in cool & wet and in warm & dry seasons were different (Fig. 2). The four AMF species that could be identified using the public data base were found in cool & wet season. Most of the AMF species found in the warm & dry season were not yet documented. Crested wheatgrass was associated with the AMF prevailing in the cool & wet season (Fig. 2).

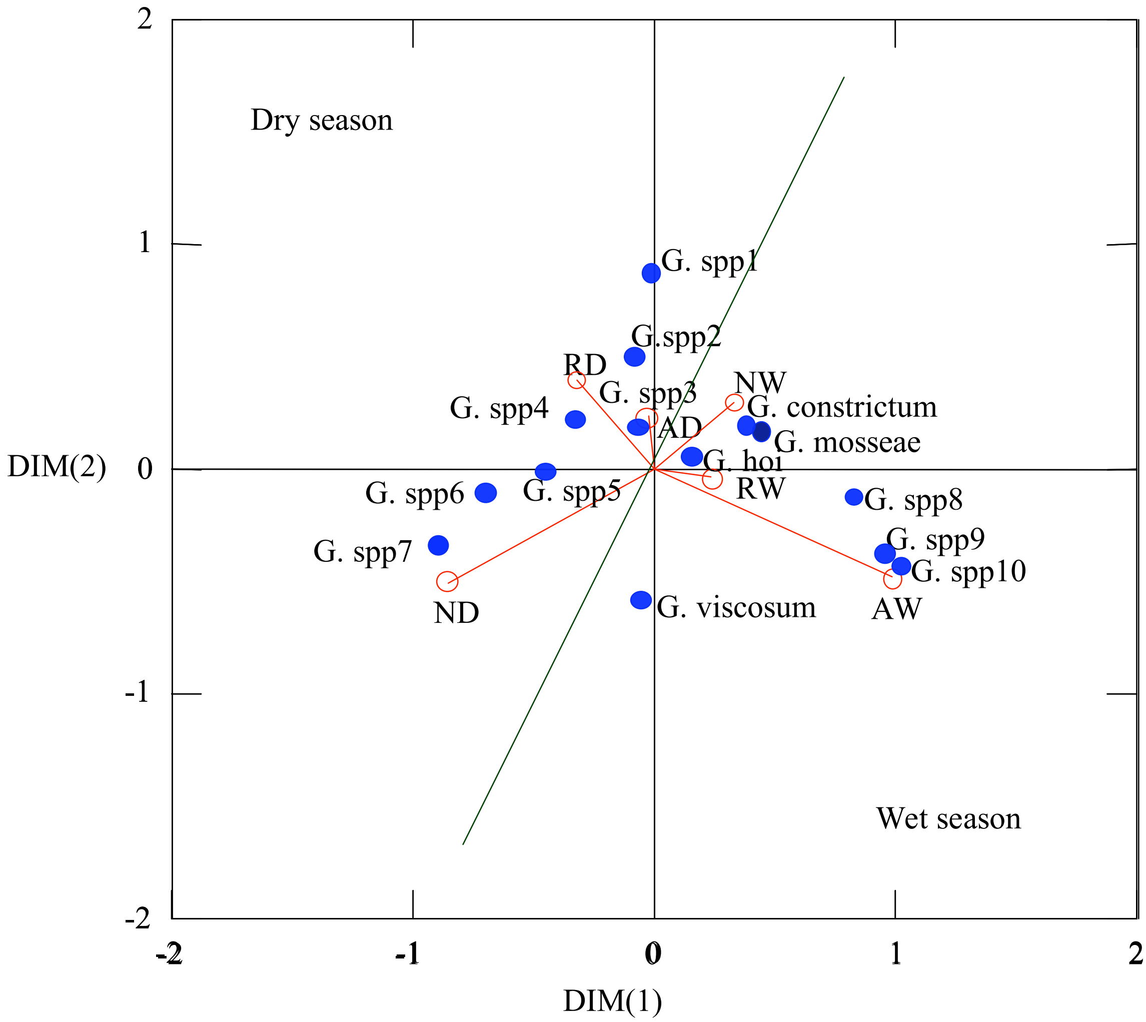

Figure 2. Relationship between AMF spp., seasons, and ecosystems. AD is crested wheatgrass in warm & dry season, AW is crested wheatgrass in cool & wet season, ND is native plant stand in warm & dry season, NW is native stand in cool & wet season, RD is stand restored to native plants in warm & dry season, RW is restored stand in cool & wet season. n = 4.

Crested wheatgrass can significantly affect the amount of soil bacteria, soil organic carbon, and soil soluble phosphorous (Figure 3). For these three variables, significant differences were found (ANOVA test) between crested wheatgrass dominated ecosystem (agriculture) and non-dominant ecosystem (native) as shown above (soil bacteria PLFA (P=0.01), soil organic carbon (P=0.022) and soil soluble phosphorous (P<0.0001).

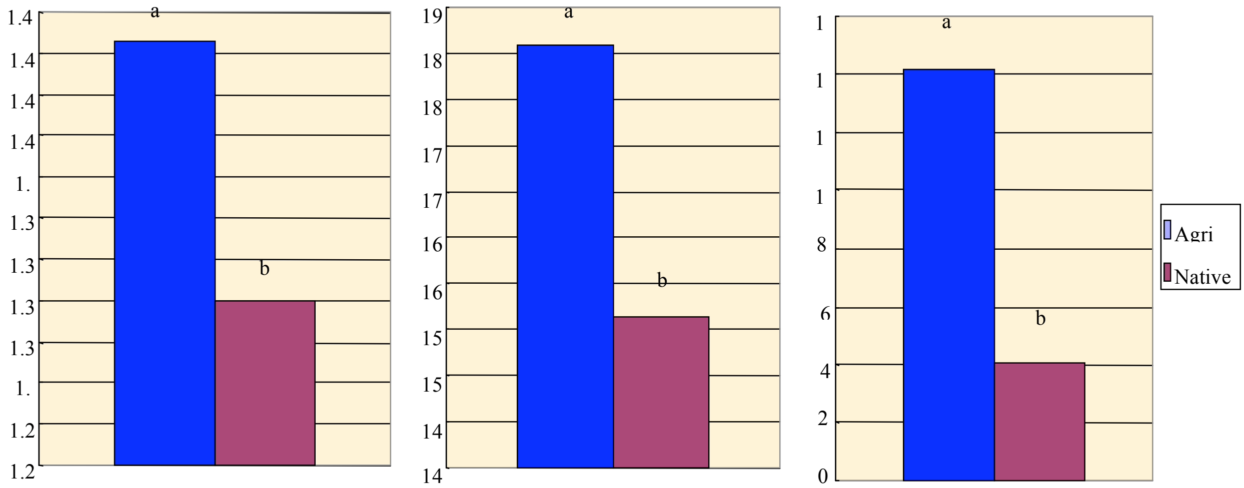

Figure 3. (left) Soil bacterial biomass, (middle) organic C, and (left) soluble P under crested wheatgrass and in the undisturbed native ecosystem. Bars associated with different letters are significantly different (ANOVA, $P < 0.025$, $n = 4$).

Conclusion

In the mixed grass prairie ecozone, a succession of AMF species occurs from the cool & wet part of the growing season to the warm & dry period that follows.
Correlation between AMF biomass and plant P and N concentrations, which were observed in the cool & wet season, suggests that the AMF species dominant at that time improve plant N and P uptake.

Most AMF taxa found in the dry season in our study were unknown to the scientific community suggesting that they are rare and specialized. Such AMF taxa may be adapted to dry environments or periods. The lack of correlation between AMF biomass and plant nutrient content in the warm & dry season may indicate that these AMF species contribute to plant growth in ways other than soil nutrient provision.

Crested wheatgrass improved soil quality indicators as compared to native plant stands, but its lack of activity in the warm & dry season and its lack of association with warm & dry season AMF taxa suggests that crested wheatgrass dominated ecosystems would be more vulnerable under a dryer environment.

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