Influence of Mycorrhizae on Soil Carbon Accumulation, Soil Aggregation and Water Infiltration along a Management Intensity Gradient

MICHIGAN STATE UNIVERSITY

KBS LTER KELLOGG BIOLOGICAL STATION | LONG-TERM ECOLOGICAL RESEARCH

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ABSTRACT

Terrestrial ecosystems appear to remove substantial portion of the anthropogenic CO_2 from the atmosphere (Treseder and Allen, 2000). The restoration of soil carbon pools through the reduction of landuse intensity is a potentially high impact, rapidly deployable strategy for offsetting atmospheric CO_2 increases (Grandy and Robertson, 2007). Increased soil carbon storage has also been linked to improved soil health and agricultural productivity through amelioration of many important soil properties. However mechanisms behind this carbon accumulation and storage are not well understood, although such knowledge is vital in prediction and interpretation of the ecosystem responses to global climatic change and strategizing for sustainable agriculture. Previous studies have shown that arbuscular mycorrhizal fungi (AMF) provide a number of beneficial ecosysytem services including improvement of soil structure and influencing major element cycles including the carbon cycle. Our main goal in this study is to examine the influence of mycorrhizae on soil carbon accumulation, soil aggregation and water infiltration along a management intensity gradient at the KBS-LTER, SW Michigan where the ecosystems lie on the similar or same soil type.

INTRODUCTION

AM fungi are symbiotic partners of a majority of crop species making them an important component of the soil microbial community in both managed and natural ecosystems. There is growing evidence that AM fungi play a crucial role in carbon accumulation in agricultural soils (Rillig et al., 2001) in addition to many other beneficial ecosysyem services. However, the impact of cropping systems and management practices on the community structure and diversity of AM fungi on the same soil series and the functional consequences of different AM fungal communities to ecosystem processes such as carbon sequestration and other changes in soil properties has rarely been investigated. Seasonal dynamics of AMF communities and their implications on soil properties has not been well studied. Exploring the role of AMF and underlying mechanisms behind Carbon accumulation rates, water infiltration and soil aggregation for a range of managed and successional ecosystems on the same soil series is important in advancing our understanding global C cycle and sustainable ways for terrestrial ecosystems management.

OBJECTIVES

Our study proposes to investigate the role of AM fungi and the underlying mechanisms behind differences in carbon accumulation rates and soil aggregation for a range of managed and successional ecosystems on the same soil series.

SPECIFIC OBJECTIVES

Study objectives: The objectives of this study are to:

- Determine the effects of cropping system management (conventional, low input, no till, and perennial) and ecological succession on AM fungal community composition.
- Determine the relationship between soil organic carbon, water stable aggregates in different size classes, water infiltration and AM fungal abundance
- Evaluate temporal variation of AMF during the growing season in the managed ecosystems

MATERIALS AND METHODS

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Experimental Site

The experiment will be conducted across a series of ecosystems that differ in management intensities but located closely to each other on very similar soil series at the Kellogg Biological Station (KBS) Long-Term Ecological Research (LTER) site in SW Michigan. Experimental ecosystems shall include four annual cropping systems, two perennial cropping systems and four successional communities.

AMF abundance and Diversity

Abundance and diversity of AM will be measured using microscopy and terminal restriction fragment length polymorphism (T-RFLP) analyses of the FLR3/FLR4 fragments of the large subunit RNA gene according to Golotte et al 2004. Roots from a C4 grass in successional ecosystems or corn from all other treatments will be monitored. Seven plants per replicate treatment plot will be sampled to quantify VAM colonization of the roots using the magnified gridline intersect method. Spore communities in the soil will be analysed using methods described by Johnson et al., 1999. Soil organic matter dynamics and aggregation will be conducted according to Grandy and Robertson (2007).

Water-Stable Aggregate Distribution

Aggregate distribution will be determined on four replicate 100 g air dried soil samples by wet-sieving in water through a series of 2,000, 250, and 53 μm sieves (Elliott 1986). Previously sieved soil (<8 mm) shall be submerged for 5 min on 2,000 μm sieve surface that will be moved up and down for over 2 min with a stroke length of 3 cm for 50 strokes (Grandy and Robertson 2007). Sieving will be repeated on the 250 μm (50 strokes) and 53 μm (30 strokes) sieves using the soil plus water that passes through the next larger sieve. Aggregates remaining on each sieve shall be dried at 60°C. Sand content shall be determined on an aggregate subsample after dispersing soil in sodium hexametaphosphate (0.5%) for 48 h on a rotary shaker at 190 rpm. Water infiltration will be measured at multiple, key points during the growing season using the double core infiltration method, in situ at field sites, and related to soil moisture holding capacity as shown in historical LTER data and the new measurements that will be taken.

RESULTS

Figure 1 below shows hypothetical temporal variation of AM fungal communities across four sampling periods in the year

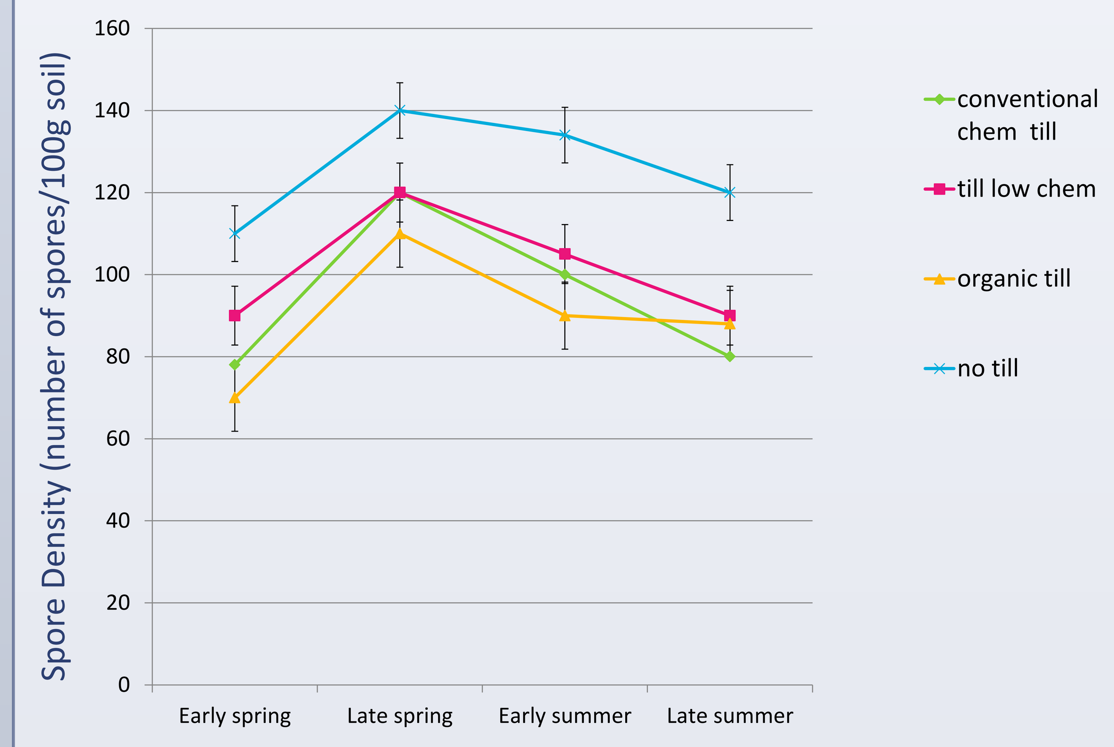

Fig.1 Hypothetical spore density in soil collected from conventional chemical management with tillage, tillage & low chemical, organic till and no till treatments at KBS-LTER.

Strong seasonal trends are expected in AMF spore density. In addition it is expected that tillage will be an important factor on the abundance of AMF. Previous studies have shown that tillage is an important factor in AMF abundance through the destruction of fungal hyphae. Furthermore perennial cropping systems and ecological succession are likely support richer AMF communities than conventional monoculture systems (Bainard et al.,2012)

Influence of management practices on proportion s of aggregates in different aggregate size classes .

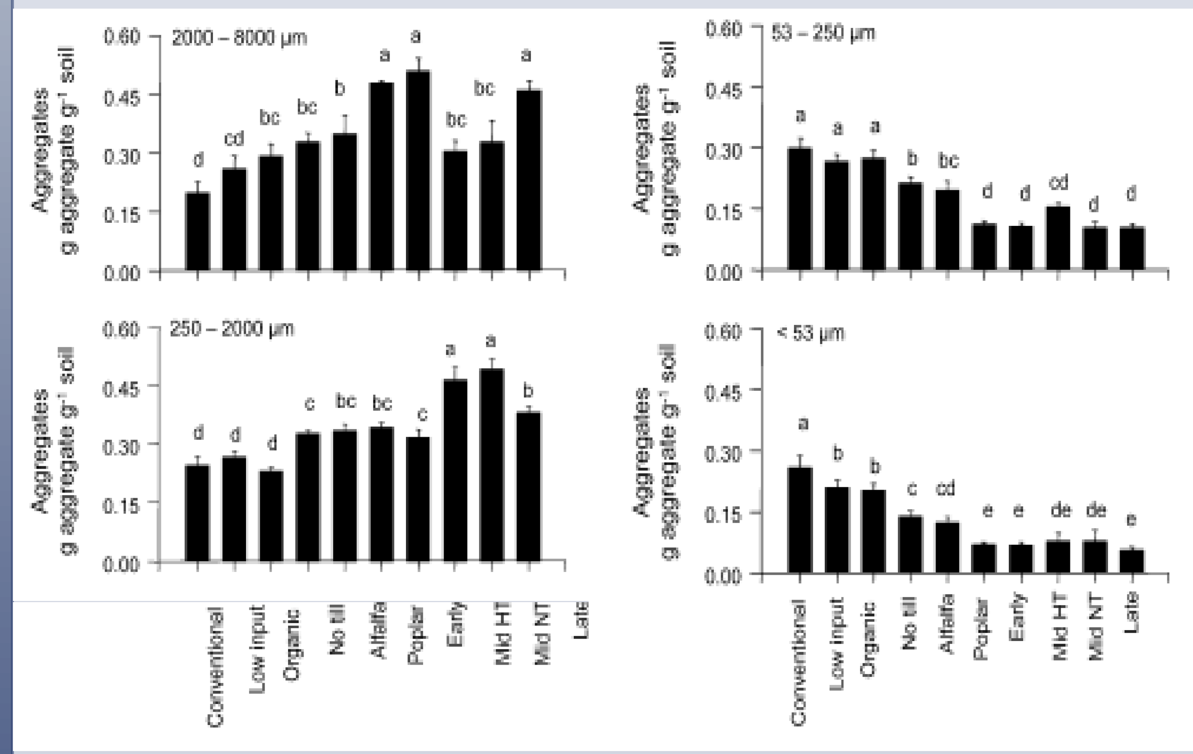

Fig.2 (a-d) Ecosystem effects on proportion of wet sieved soil in different aggregate size fractions at KBS (Data from: Grandy and Robertson, 2007). Ecosystems with different lower case letters within an aggregate size class are significantly different ($p<0.05$)

Previous studies at KBS-LTER have demonstrated that highest C accumulation rates occur in perennial cropping systems and Early successional ecosystems. Across the ecosystems (data not shown). With the exception of the low input treatment in the past, the mass of the 2000-8000 μm size class aggregates Increased compared to that of the conventional system. The no till system had the an increase in the 250 -2000 μm Aggregate class. The smaller size fractions decreased proportionately compared to the conventional management (Figure 2, Grandy and Robertson 2007).

CONCLUSION

The impact of commonly applied management practices on Carbon accumulation has been demonstrated in previous studies. However, the drivers and mechanisms behind carbon storage have not been well characterized. Examination of the role of symbiotic AMF in C accumulation and concomitant modifications of the soil matrix properties could be one possible starting point in elucidating some of the mechanisms.

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