Soil fungal community response to nitrogen rate in a long-term, minimum-till continuous corn and corn/soybean rotation

Liz Jeske, Hui Tian, Rhae Drijber, Dan Walters
Department of Agronomy & Horticulture
University of Nebraska Lincoln

Introduction

Over 40% of the world's maize supply is produced in temperate, rain-fed areas of the North American plains (Cassman, 1999). Understanding the dynamics of the soil microbial community gives insight into soil function and leads to practices that maintain this vital resource.

Fungi are important decomposer organisms in soil and can comprise up to two thirds of the soil microbial biomass. They also promote soil aggregation thereby enhancing soil tilth. Specialized fungi, called arbuscular mycorrhizae (AMF), are plant symbionts that improve nutrient uptake by the host plant in exchange for C.

Fungi are sensitive to agricultural management practices such as tillage and fertilization, particularly N and P (AMF specifically). In natural ecosystems, anthropogenic N reduces the biomass of both saprophytic and mycorrhizal fungi (Bradley et al., 2006); however, the relevance of this trend for agricultural systems is unknown.

Here we determine the impact of N rate on fungal biomass in maize grown continuously or in rotation with soybean.

Materials and Methods

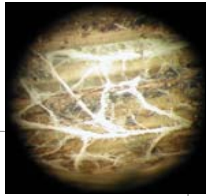
Hui Tian 2009

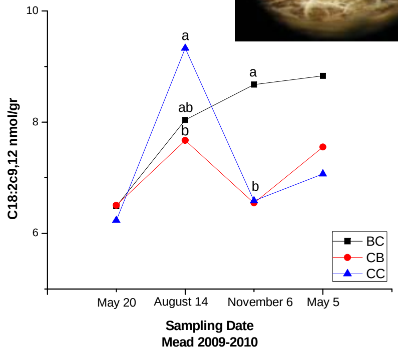
- Fillmore/Sharpsburg silty clay loam, eastern NE
- 3 crop rotations.
  - Continuous corn (CC)
  - Corn following soybeans (CB)
  - Soybeans following corn (BC).
- 5 N rates (urea) 0,50,100,150,300 kg N ha^{-1}
  - N rates in place on these plots since 1997
  - Soil disked after fertilizer application
- Soil Samples: 10 cores 2 cm wide x20 cm deep, composited by plot
- FAME biomarkers (Grigera et al., 2007):
  - AMF (C16:1c11)
  - Saprophytic fungi (C18:2c9,12)
- DGGE analysis (Liang et al., 2009)

Saprophytic Fungi

During the growing season, the concentration of C18:2c9,12 in soil was highest for CC reflecting high residue inputs. For CC and SC, this marker had declined sharply in soil by harvest.

During soybean growth, the C18:2c9,12 increased in soil well past harvest and remained high into the following spring.





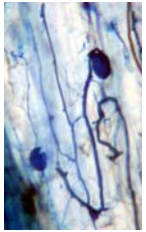
AMF

Roots

C16:1c11 in maize roots showed no response to N rate or crop rotation.

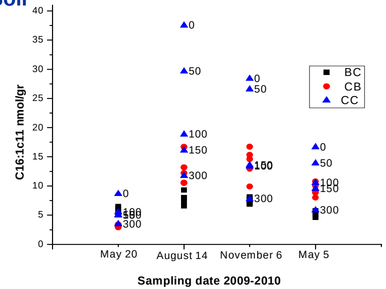
AMF diversity and richness as measured by DGGE declined at 300kg N ha^{-1}.

26 phylotypes of AMF were measured in maize roots and the distribution of phyolotypes differed among N rates.



Hui Tian

Soil



In contrast to root colonization, extraradical AMF was highly responsive to N rate, crop rotation and sampling date.

In CC, AMF biomass declined with increasing N rate.

In CB, 0 kg N ha^{-1}, the concentration of AMF marker in soil was not different from that of CC 100 and 150 kg N ha^{-1}.

Conclusions

Over the growing season, saprophytic fungi in soil responded differently to the presence of corn versus soybeans. In spite of the larger amount of residue provided by the corn crop, C18:2c9,12 was not significantly higher under CC compared to CB. This supports the work of Martens (2000, 2002) suggesting that residue chemistry plays an important role.

The promotion of saprophytic fungal growth following soybeans may also explain why some of the N credit comes at the expense of native soil N (Mwale and Walters 1994). This is also supported by the similar extradical AMF biomass under 0 kg N ha^{-1} CB and higher fertility CC.

The colonization of maize roots by AMF was not influenced by N rate or crop rotation but the diversity of the AMF community declined at the highest N rate. A significant decline in soil pH, changes in the levels of soil innoculum after many years of high N input, or changes in root C exudation may select for AMF phylotypes adapted to these conditions.

Crop rotation and N rate had no significant influence on total C or total N in this system even after 13 years of corn grown with no N. The large AMF hyphal production in soil under corn receiving little or no N may be a prominent C sink (Godbold et al. 2006).

Bibliography

Bradley, K., R.A. Drijber, and J. Knops. 2006. Soil Boil. Biochem. 38:1583-1595.
Cassman. K.G. 1999. Proc. Natl. Acad. Sci. USA. 96:5952-5959.
Egerton-Warburton, L.M., N. C. Johnson and E.B. Allen. 2007. Ecol.Monog. 77:527-544.
Grigera, M.S., R.A. Drijber and B.J. Wienhold. 2007. Soil Biol. Biochem. 39:1401-1409.
Godbold, D.L., M.R. Hoosbeek, M. Lukac, M.F. Cotrufo, I.A. Janssens, R. Ceulemans, A. Polle, E.J. Velthorst, G. Scarascia-Mugnozza, P. De Angelis, F. Miglietta and A. Peressotti. 2006. Plant and Soil. 281:15-24.
Liang, Z., R.A. Drijber, D.J. Lee, I.M. Dwiekat, S.D. Harris and D.A. Wedin. 2008. Soil Biol. Biochem. 40:956-966.
Martens, D.A. 2000. J. Environ. Qual. 29:723-727.
Martens, D.A. 2002. Soil Sci. Soc. Am. J. 66:1857-1867.
Mwale, M. and D.T. Walters. 1994. p. 283. *In* 1994 Agronomy abstracts. ASA. Madison, WI.