Arbuscular Mycorrhizal Fungi have Positive and Negative Impacts on Wheat Grown in Organic and Conventional Fields on the Canadian Prairies

Arbuscular mycorrhizal fungi (AMF) form a symbiotic association on the roots of most crop plants: AMF improve the ability of plants to take up nutrients and the plant provides AMF with carbon. This may be especially important for organic crops on the Canadian prairies due to limited sources of P. Low inputs of P may increase AMF populations and effectiveness. However, tillage used to reduce weed populations in organic systems can rupture the fungal network, leading to a reduced nutrient absorption area. A better understanding of AMF communities may support increased productivity and nutrient efficiency in both organic and conventional farming systems.

In a study published in Soil Biology and Biochemistry in 2014, a group of Canadian researchers from across the Prairies determined the structure of AMF communities in 78 conventional and 72 organic wheat fields and related this to wheat growth and nutrient uptake efficiency (Figure 1). The AMF communities were described by 454 pyrosequencing. Plant Root Simulator (PRS^{TM}) probes were used to determine soil nutrient supply rates of N, P, K, S, Ca, Mg, Cu, Zn, Fe, Mn and B in soil samples obtained after seeding (early June). Samples were wetted to field capacity and PRS probes were installed for one day at room temperature. Wheat biomass and nutrient concentrations were determined at anthesis and maturity. Plant roots were examined to determine the colonization by mycorrhizae.

Figure 1. Field site in the gray-black soil transition zone. Photograph courtesy Chantal Hamel

Soil nutrient supply rates were significantly different between organic and conventional fields, reflecting management practices. Organic fields depended largely on soil tillage for weed control and green manure plowdown, whereas most conventional fields were not tilled. Organic fields had a greater diversity of crops and greater use of fallow than conventional fields, and did not receive chemical fertilizers or herbicides. Compared to conventional fields, organic fields had lower N and P supply rates due to lower inputs and lower Fe, Mn, Zn and Cu supply rates due to higher soil pH associated with the avoidance of chemical fertilizers and to mixing of higher pH soil from deeper layers with tillage.

Organic fields had higher indices of AMF diversity, however taxa proportions in both communities were similar, with the exception of *Claroideoglomus*, which had a higher relative abundance in organic field. Organic fields also had a higher percentage of root colonization by AMF (Figure 2). The efficiency of uptake relative to soil nutrient supply rates was 2.3 and 1.8 times higher in organic than conventional fields. Organic fields had lower wheat biomass but higher nutrient concentrations than conventional fields, thus wheat uptake of N and P was similar. Plant growth and nutrient uptake were positively related to *Paraglomus* populations in conventional fields, but were negatively related to AMF related to *Dominikia iranica (syn. G. iranicum)*, *G. indicum*, and *Funneliformis geosporum* (*syn. G. macrocarpum*) populations in organic systems.

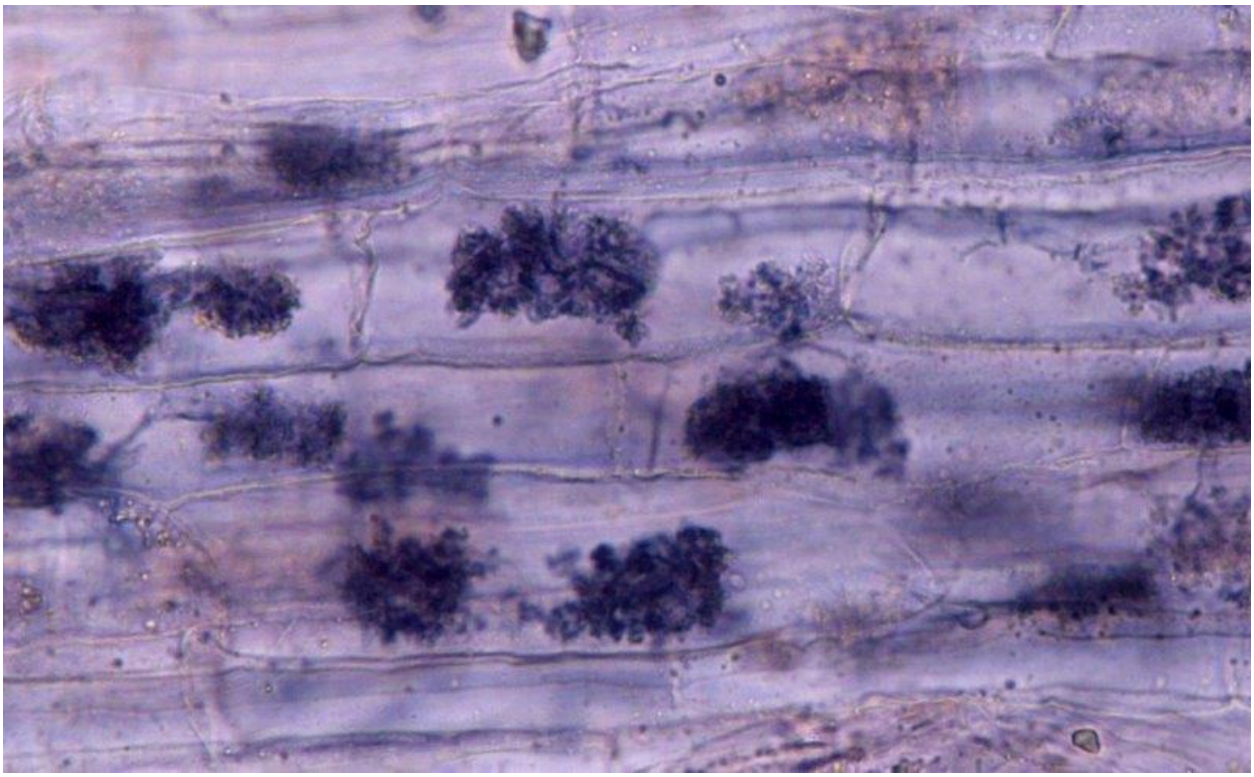

Figure 2. Colonization of a wheat root by arbuscular mycorrhizal fungi. Photograph courtesy Chantal Hamel

The authors conclude that *Claroideoglomus*, *Diversispora*, and *Paraglomus* all appear to be beneficial species for wheat on the Canadian prairies, whereas AMF related to *Dominikia iranica (syn. G. iranicum)*, *G. indicum*, and *Funneliformis geosporum* (*syn. G. macrocarpum*) seem to stunt growth.

Adapted from Dai, M., C. Hamel, L.D. Bainard, M.S. Arnaud, C.A. Grant, N.Z. Lupwayi, S.S. Malhi, and R. Lemke. 2014. Negative and positive contributions of arbuscular mycorrhizal fungal taxa to wheat production and nutrient uptake efficiency in organic and conventional systems in the Canadian prairie. Soil Biology and Biochemistry 74:156-166. View the full article at http://dx.doi.org/10.1016/j.soilbio.2014.03.016.