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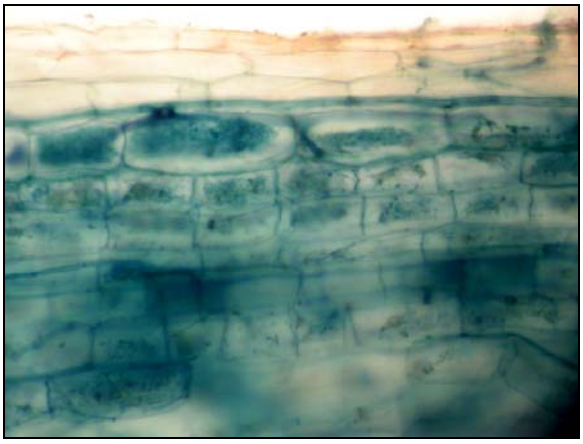
PHOSPHORUS AVAILABILITY ON ORGANIC DAIRY FARMS: A CLOSER LOOK AT THE ROLE OF SOIL MICROORGANISMS

Interim Research Report E2010-58

BACKGROUND

Recent studies exploring soil fertility on Canadian organic dairy and grain farms have reported low soil test phosphorus (P) levels, which is an index of plant-available phosphorus (Martin et al. 2007). To support this finding, field data collected on 10 organic dairy farms in southwestern Ontario during the 2007-2009 growing seasons showed low soil test P values (<10 ppm). These soil test P values were not found to significantly correlate with yield data, with some farms showing good yields despite what should indicate low P availability (Lynch, unpublished data). It has been suggested that increased soil biological activity in organically-managed systems is involved in providing the crop with P not measured by the conventional soil P test (Martin et al. 2007).

Arbuscular mycorrhizal fungi (AMF) development has been shown to be greater under conditions of low soil P (Hamel and Strullu, 2006). AMF development may be further enhanced in organic farming systems because they do not use synthetic fertilizers or pesticides. Organic farmers employ diverse crop rotations, which would encourage a more diverse AMF population.



A plant root showing arbuscular mycorrhizal fungal colonization (stained blue) as viewed under the microscope (K. Schneider)

Graduate student Kim Schneider in the middle of one of the Ontario forage fields under study (I. Bystron)

AMF diversity has been positively correlated with ecosystem productivity and total P uptake in natural systems (Van der Heijden et al. 1998), and AMF diversity could also contribute to greater P uptake in low-input agricultural systems.

Organic sources of phosphorus may become the dominant source of P nutrition for plants when available soil inorganic P (as indicated by the standard soil test P) is limiting (Quiquampoix and Mousain 2005). Mineralization of microbial biomass and the action of extracellular soil enzymes are the main pathways that organic P becomes available for plant uptake. Organic farming systems are managed according to principles that promote soil biological activity and as such, these biological mechanisms of P cycling may be enhanced (Oberson et al. 1996).

The objective of this research is to explore the relationships between AMF diversity, biological activity and productivity of organic farming systems. To better understand unique occurrences on organic dairy farm soils, three conventional dairy farm fields (with relatively high soil test P) in close proximity to the sites of interest were included in the study to enable a comparison.

WHAT WAS DONE

Three long-term organically managed dairy farms in Ontario were selected from initial screening done on 10 farms. These farms showed low soil test P values, but relatively high yields and adequate P uptake. From each farm, one second or third year forage field was selected having a relatively flat topography and consistent management. Conventional dairy farmers with farms located in close proximity to the organic sites were selected according to the following criteria: a long term (20+ years) history of inorganic P fertilizer application, having a second or third year forage field, similar soil characteristics to its organic comparison, and a relatively flat topography.

A directed sampling approach was used to select four 20 x 20 m sampling plots that represented average areas of the field. Within these plots, three 1 x 1 m subplots were randomly chosen for soil and plant sampling.

Just prior to farmers harvesting the first cut of hay, root, plant, and composite soil samples were collected from each field. Specific parameters measured included:

- Sodium bicarbonate extractable Pi, and other soil parameters: texture, pH, potassium (K), organic matter
- Forage yield, % legume content and P uptake (% tissue P x yield)
- Arbuscular mycorrhizal fungi (AMF) root colonization
- AMF species diversity using PCR and DGGE
- Acid and alkaline phosphatase activity
- Microbial phosphorus

Additional plant samples were collected at each subsequent cut of hay to obtain an adequate measure of total forage yield and plant P uptake. Remaining lab work from last field season, along with data analyses, are currently underway.

Once the data are available, further experimentation will be designed and carried out to better elucidate the role that arbuscular mycorrhizal fungi and soil microbial activity play in plant phosphorus availability on these organic forage fields. It is anticipated that this research will assist in the understanding of organic P cycling in low-input agricultural systems.

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CREDITS

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