Latest Research Results

organic SCIENCE CLUSTER 3

Soil Health in Organic Tillage-based Systems

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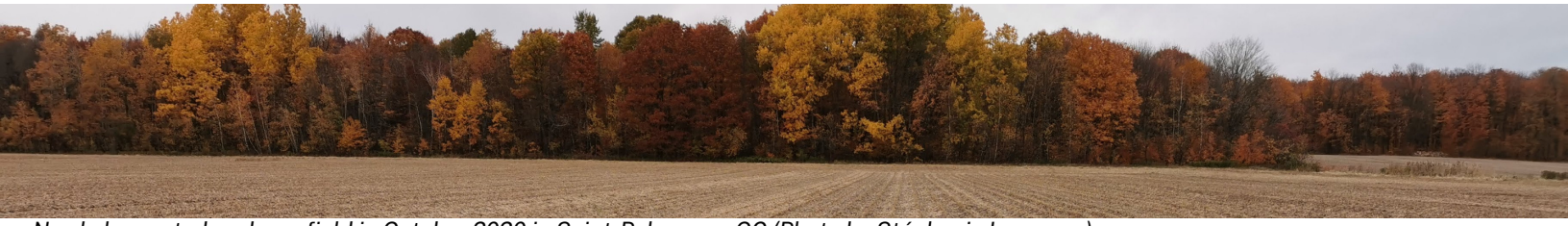

Newly harvested soybean field in October 2020 in Saint-Polycarpe, QC (Photo by Stéphanie Lavergne)

The primary focus of this research project was to examine the status of, and how to improve, soil health under intensive or tillage-based organic cropping systems. Specifically, the objective was to compare the relative impacts on cash crop yield, N supply, soil carbon and soil health of organic grain cropping systems, and to examine the relative impacts of different best management practices (BMPs), (manure/compost application, fall cover crops, modified tillage regime) in sustaining soil carbon and soil health.

Methods:

A common practice amongst the participating organic grain producers in Quebec is a shorter (three year), and relatively intensive, rotation comprised of corn-soybean/winter cereals-green manure (GMr). A common GMr used is forage pea or clover underseeded in the winter cereals, although these farms have no livestock, animal manure is typically applied prior to the corn phase. We hypothesized that under these three-year grain rotations, soil health will be low except where compost is applied, and/or where soil organic matter (SOM) is above threshold levels (>3% OM), i.e. the one year GMr phase will be insufficient to rebuild many of the key components/attributes linked to soil health, while the specific management component of compost utilization (tested at the CETAB+ two-year research trial site) will sufficiently offset negative impacts of tillage on soil health.

On all 11 participating farms, commencing in 2019 and continuing to fall 2021, soil samples were collected each fall from each corn-soybean-wheat rotation phase (n=3), using a stratified random sampling plan consisting of four 20 m x 20 m quadrats per field. Composite surface (0-30 cm) soil samples (n=4) from each field consisted of four random soil cores from each quadrat collected using a 4.8 cm (i.d.) soil corer (n=248 samples from all farms and rotation phases). Samples were analyzed for selected soil physical, chemical and biological parameters at the Atlantic Soil Health lab located at Dalhousie University. These included soil pH, active C (POXc) and water stable aggregates, soil total C and N, soil texture, respiration and water holding capacity, postharvest soil mineral N, plus ACE soil protein. Earthworm abundance and biomass was determined in spring over two years (2019, 2021) from four quadrats (0.25 m x 0.25 m) randomly selected per field excavated to a depth of 20 cm and immediately hand-sorted for earthworms through a mesh (11 mm) screen. Identification of all earthworm species (n=14) was also completed. This research on soil health and earthworm dynamics under intensive organic grain rotations on commercial farms is the focus of Dalhousie PhD candidate (and NSERC scholarship holder) Stephanie Lavergne.

At CÉTAB+ in Victoriaville, QC a three-year experiment examined the impact on soil health of different agronomic strategies for transitioning a farm to certified organic production. Experimental design was a Randomized Complete Block Design (RCBD) with 4 blocks applied to the same three-year rotation (corn-soybean-cereals) as found on commercial farms. The 4 different management regimes included (i) spring tillage, (ii) fall tillage (iii) without animal manure applied (only green manures), and (iv) minimum tillage. Soil health analyses of the 2018 and 2019 season samples from the CETAB trial were completed at Dalhousie University's soil health lab. This included water stable aggregates, active carbon (POXc and POMc), ACE protein, soil texture, respiration, total carbon and total N, for both the 0-15 cm depth and 15-30 cm depth samples. In addition, soil mineral N was extracted, and crop plant tissue analyzed for protein content. The crop and soil response to the transition treatments study comprised the Univ. Laval, M.Sc thesis of Kadidia Moussa Traoré who graduated in April 2020.

Fall soil sampling in 2020 (Photo by Sébastien Angers)

Results and Conclusions:

The results of the two year cropping trial at CETAB+ (comprising the M.Sc thesis at Laval University of K. Traoré) indicated that there was no effect of the four different transitional agronomic management treatments (spring plowing, fall plowing, fall plowing without manure, or minimum tillage) on overall soil health. However, the minimum tillage treatment resulted in substantially reduced grain (corn) yields and lower grain protein and crop N removal, compared to three inversion-tilled treatments which averaged greater than 8 Mg ha-1. This was attributable to a lack of soil N supply for corn under the no-till treatment, having had only composted manure, and no fresh poultry manure applied. In the following year 2019, management systems had no significant effect on soybean yield (P = 0.737) which averaged 2.9 Mg ha-1 or grain protein.

The on-farm research, conducted on 11 commercial organic grain farms over three years, examined the sustainability, with respect to both soil health and earthworm diversity and abundance, of the intensive short (3-year corn-soybean-wheat) rotations practiced on these farms. The results to date indicate that, in spite of these short rotations, and even during very intensive crop phases such as the soybean phase (characterized in this crop phase by extra tillage, low soil cover and low crop residue), with the exception of water stable aggregates, most soil health physical, chemical and biological parameters were sustained through the three-year rotation. This was also true for the earthworm populations, as earthworm total abundance, biomass, and species richness were found to not be influenced by the crop in place at the time of sampling. These results show that the combined practices (BMPs) undertaken by these farms were effective with respect to soil sustainability in general. Ongoing data analysis by PhD candidate Stephanie Lavergne is examining in more detail which of these field management practices (tillage regime, manure utilization, cover cropping, fall wheat planting integration) are most beneficial with respect to maintaining soil health. From the dataset one of the practices that appears promising is the inclusion of fall cereals in the rotation, as it reduces tillage and mechanical weeding frequency and intensity, allows the benefit from manure amendment use (mostly in the fall), covers the soil, and creates a longer period of cover crop at the end of the season.

Future Research Needed:

The beneficial effect on soil health and earthworm populations of integration of fall cereals in intensive rotations as examined here could be studied further in an experimental design that provides greater statistical power to (i) examine and confirm this specific BMP benefit on soil health of integration of fall cereals in intensive organic grain rotations across different provinces and soils; and (ii) elaborates the primary mechanism of this benefit of fall cereals among the combined effects of reduced tillage and mechanical weeding frequency and intensity, benefit from manure use (mostly in the fall), soil cover, and allowing for a longer cover crop period at the end of the season. The transition strategy research at the CETAB+, Victoriaville, suggested there was no effect of spring plowing, fall plowing, fall plowing without manure, or minimum tillage on overall soil health, and a reduction in corn but not soybean yields under minimum tillage management. However, this was a relatively short (two-year) trial conducted on fine textured soil. Longer term transitional agronomic studies would be of benefit, and in keeping with the on-farm trial results, examine a range of combined BMPs and spectrums of intensity of organic field crop management. Notably, for some aspects of the farm research results (earthworm juvenile abundance and biomass), the time since conversion to organic farming had a positive effect. It would be interesting to examine this influence of time since conversion to organic farming for soil health further and whether it holds true irrespective of farm size and intensity of management.

Soil samples drying before soil health analysis, 2020 (Photo by Caroline Halde)

Researchers, Co-investigators, & Co-authors:

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Collaborating Partners:

This research is part of Organic Science Cluster 3, led by the Organic Federation of Canada in collaboration with the Organic Agriculture Centre of Canada at Dalhousie University, supported by Agriculture and Agri-Food Canada's Canadian Agricultural Partnership - AgriScience Program. On-farm trial collaborators included 11 primary producers from Quebec. Collaborators at CETAB+, Victoriaville, Quebec for the two-year transitional agronomic strategy trial included Julie Anne Wilkinson; Gilles Gagné; Noémie Gagnon Lupien and François Gendreau-Martineau.

For more information visit the OSC3 Activity 27 webpage and/or DAL.CA/OACC/OSCIII & https://organicfederation.ca/organic-science-clusters/

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