Latest Research Results

organic SCIENCE CLUSTER 3

The right balance: management strategies for plugging organic soil health constraints and moving forward.

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The Prairie region produces most of Canada's organic grain and pulse crops, and the growing market demand for these products is bringing new farms into organic production. Some Prairie organic farms are highly productive, but others are experiencing yield declines. Reasons for the declines are not well understood, although soil phosphorus (P) deficiency is one well-documented issue. Recent research has shown that insufficient soil carbon (C) inputs may be another significant limitation. Understanding what makes organic farming systems productive or unproductive is important to their long-term sustainability and growth in Prairie Canada.

This project used a systematic, multi- and transdisciplinary approach to characterize positive aspects as well as challenges in high functioning organic systems, with a view to identify solutions that can be adapted for low functioning organic systems. A high functioning organic farm in southern Alberta underwent investigation and was used for comparison to a low functioning organic system in Scott, Saskatchewan. Assessments included biological (soil, insect, weed populations) assessments, soil biophysical analysis, and economic considerations.

The work consisted of three distinct activities:

1) To understand the pros and cons of cover cropping on an established high functioning organic farm at Coaldale, AB;

2) To restore soil fertility in the long-term organic system Alternative Cropping Study (ACS) at Scott, SK by targeted strategies for increasing photosynthetic C inputs and improving N and P fertility via compost as a soil amendment; and,

3) To improve the "Whole farm nutrient management tool" (WFNMT) to include C as an element in the farm/field budgeting process using Prairie-specific information on C dynamics in agricultural systems

The pros and cons of cover crops in a high functioning organic system, Coaldale, AB

The following seven cover crop treatments were evaluated during three cycles of the cover crop–carrot rotation phases of the farm's 5-yr rotation:

1) 15 species blend;
2) 15 species blend plus fall-seeded barley;
3) 15 species blend plus fall seeded wheat;
4) two-species brassica blend;
5) buckwheat;
6) faba bean;
7) fallow.

In all three years, above-ground biomass (AGB) yield of the blend treatment was higher or comparable to the buckwheat treatment, and was significantly higher than brassica and faba bean. Biomass production was similar for brassica and faba bean in all three years. With a few minor exceptions, cover crop C and N mostly mirrored biomass production. Thus, if the main target for use of a cover crop is highest biomass production, then the blend or buckwheat would be the top choice, however N inputs from the Blend tended to be higher than buckwheat, so the Blend might be the best choice overall.

In general, faba bean did not suppress weeds well, although it did have some impact on redroot pigweed. Blend, brassica and buckwheat suppressed lambsquarters, and blend and brassica suppressed cleavers. Buckwheat appeared particularly good at suppressing redroot pigweed, and showed modest effect on sowthistle. In general, adding a fall seeded cover crop strongly reduced the weed biomass measured before seeding carrot the following spring.

Cover crop treatment had minimal observable effect on soil properties measured prior to cover crop incorporation in this study. Although significant differences were noted in some years, there was no consistent pattern discernable, and no firm conclusions could be drawn. Similarly, there were limited differences noted in the measurements associated with soil microbial and nematode metrics. As with the other soil metrics, the response pattern was complex and varied with year and timing. This may be, in part, a result of the similar C and N inputs returned to the soil when C and N inputs from weeds were factored in. Cover crops with lower biomass production (e.g. faba bean) tended to have higher weed biomass production and thus, final C and N inputs to the soil were not greatly dissimilar. Similarly, although some significant differences were noted in the soil health metrics that were measured, no clear or consistent pattern could be discerned. However, this data set will serve as an excellent reference for comparison to other data sets already available and for future studies.

Metrics for the carrots collected were not affected by cover crop treatment, but varied strongly with year. The total yield by mass of carrots and damage by wireworms did not vary by treatment in any year. Percent by mass of Grade A carrots was approximately 90% in all treatments in 2019, around 60% in 2020 and 40% in 2022, and did not vary by treatment. Correspondingly, percent by mass of Juicers showed the opposite trend in differences in magnitude mostly due to carrots being misshapen (e.g. forked, crooked). When the economic value of Grade A, Juicer and Discard carrots were calculated as an “economic yield”, no treatment effects were detected.

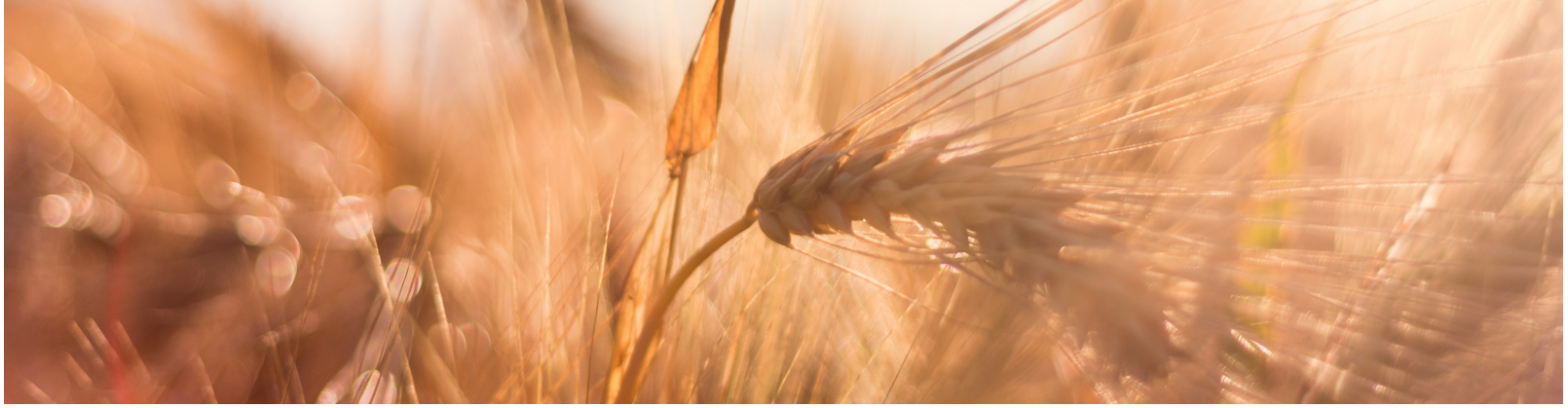
Restoring lost productivity in the long-term Alternative Cropping Systems Study (ACS) organically managed annual grains system.

A long-term experiment at Scott, SK was utilized as the basis of this sub-activity. Previous work has demonstrated consistently lower yields in the organic vs. conventional annual grains system and recent evidence points to C in addition to N and P deficiency as limitations to productivity in this system. A subset of paired, organic (ORG) vs. conventional (CONV), treatments remaining from the long-term study were selected. Crop rotation on the main plots included a 4-year rotation (barley – canola/mustard – green manure/wheat – field pea) with all phases all years. For this study, the existing green-manure pea crop was changed to an oat/hairy vetch mixture in order to maximize photosynthetic C inputs. In the fall of 2018, the plots were split to create 3 sub-treatments as follows: **1)** Check; **2)** compost: 1X rate applied annually; **3)** compost: 4 X rate applied once at beginning of study.

In the first year of the study the application of compost at a 4X recommended rate resulted in straw yields that were significantly higher compared to the control, and a similar trend was observed for seed yield but differences were not significant. Comparing the seed yields of barley (common crop) on the ORG and CONV check plots showed that seed yields were about 30% lower on the ORG compared to CONV – a result consistent with the historical yield differential observed at this site. However, seed yield on the ORG plots receiving the 4x compost rate was only about 5% lower than the CONV check treatment.

In year two, seed yield on the ORG system was again significantly higher on the 4x compost rate compared to the check, but there was no significant impact on straw yield. Barley seed yields on the ORG check plots were only about 56% of those on the CONV check, and seed yields on the ORG 4X compost treatment were only about 60% of those on the CONV check. Similar patterns were observed for straw yields. Thus, while the 4X compost application appeared to improve yields compared to the check on the ORG system, the yield disparity between the organic and the conventional system was much wider than the first year suggesting a diminishing response to the 4X application rate.

By year three (2021) of the study, there was no significant seed or straw yield response to compost application on the organic system. However, barley seed



yields were actually about 25% higher on the ORG compared to the CONV check treatments, while seed yields on the ORG plots receiving the 1X and 4X compost rates were about 86% and 94% of the yields on the CONV check. Precipitation levels during the 2021 growing season were about 30% lower than the 30-year mean. Most notable was the particularly hot July conditions that were coupled with extremely low precipitation (10 mm). Thus moisture was, by far, the most limiting factor in this growing season and yields on the two systems were strongly constrained by moisture limitations. However, it appears that yields were most strongly impacted on the CONV system resulting in similar or even lower grain yields compared to the ORG system.

On the ORG system, seed N, seed P and straw P were all significantly higher on the 4x compared to the 1x compost application and the check in the first year, while seed N and seed P were also significantly higher on the 4x compost treatment compared to the check plots in year two. By year three there was no significant difference in seed N or seed P, suggesting that increased availability of N and particularly P were in part associated with the increased yields on the 4X compost application in the first two years of the study.

In the first year, C-cycling enzyme Beta-glucosidase activity was significantly higher in the 4X rate compared to the control for the organic managed soils. In year two there was no significant difference in enzyme activities on the ORG system, but in year three Beta-glucosidase activity was again higher on the 4X compost rate compared to check. Generally, higher beta-glucosidase activity indicates higher microbial activity either because of a larger overall microbial biomass, or because of a more suitable suite of environmental conditions. This would suggest that a positive effect of the one-time compost application at the 4X rate could still be evidenced in the third year of the study. Compost application appears to have good potential in terms of restoring soil productivity on a degraded soil, but relatively high application rates are required to achieve observable improvements.

Incorporating C into the Whole Farm Nutrient Balance Model

The University of Manitoba developed a nutrient budgeting tool for use by organic farmers. A future goal is to add a C component to the tool, so that the flows of C can be estimated for organic farms. To this end, the long-term biomass production data for the past 30 years of the Glenlea study was carefully organized and utilized to develop a detailed accounting of the total aboveground biomass production (crop and weed biomass) for three, four-year rotation cycles (2011-2022).

Results indicate that organic production systems produce less total biomass than conventional systems. For example, the most productive organic system (Forage-grain rotation with manure added to replace exported P) resulted in 13% less biomass than the annual grain-based rotation under conventional management. It was also observed that when organic systems experienced low levels of soil P, for example, the forage-grain organic rotation with no manure added, the biomass production was 38% lower than

where manure was added to the organic rotation. Taken together, these results show that even the best organic systems at Glenlea could not match the biomass production of the conventional grain-based system, and without P replacement the forage-grain organic systems performed very poorly in terms of biomass production. It is important to note that the forage-grain organic system also results in greater biomass offtake from the field, since two of the four crops in the rotation are alfalfa hay crops. However, C is also added through manure additions. Our future work will be to complete these C budgets for the Glenlea study.

For more information visit the OSC3 Activity 8 webpage and/or DAL.CA/OACC/OSCIII & https://organicfederation.ca/organic-science-clusters/

Left to right: Charles Geddes (Weed Ecology & Cropping Systems, AAFC-Lethbridge); Howard Leffers (farmer-collaborator, Coaldale, AB); and James Hawkins (visiting Nuffield scholar, Neuarpurr, Victoria, Australia) in the 15-species cover crop, August 7, 2018. (Photo by Frank Larney)

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