LEGUME COVER CROP PERFORMANCE IN A SOUTHWEST ONTARIO ORGANIC GRAIN ROTATION

PUBLISHED MARCH, 2023.

STUDY HIGHLIGHTS

- Legume-based cover crops were tested in a corn-soybean-winter wheat rotation in Harrow, ON for the potential to increase productivity and growers' incomes, and to maintain soil health.
- Overall, profit margins doubled due to relatively high crop yield and organic grain price especially for corn and soybean premiums.
- All three legumes tested, crimson clover, hairy vetch, and red clover, can be summer-seeded after winter wheat harvest as winter-hardy cover crop in Southwestern Ontario. They become well established, continue to grow into winter, re-grow vigorously the following spring and are easy to terminate.
- Incorporating the legume biomass into soil, soon after termination, provides sufficient nitrogen to the following corn crop. Termination with a moldboard plow resulted in better incorporation, reduced weeds, and increased yields compared with chisel plow.
- Summer-sown crimson clover, hairy vetch or red clover after winter wheat harvest can be used as a primary nitrogen source in organic corn-soybean-winter wheat rotation.
- Frost-sown red clover into winter wheat works as a steady nitrogen source for the following corn, however some decline in winter wheat yield of about 10-15% was observed and would benefit from additional organic nitrogen sources.
- Dr. Yang's legume-corn–soybean–winter wheat rotation could provide a feasible pathway to increase large scale organic grain production in Southwestern Ontario.

BACKGROUND

Organic farmers often rely on manures, composts, and/or leguminous crops to meet the main crop nitrogen (N) requirements. When composts and manures are not available, there are many benefits to using legume cover crops, including the potential to prevent crop nutrients run-off. The best cover crop management options to maximize N for a following crop while maintaining or enhancing soil health remain largely unknown, especially for organic corn, soybean, and winter wheat production.

In corn-soybean-winter wheat rotations, red clover is typically frost-planted during the winter wheat phase, to benefit from non-crop period between winter wheat harvest in July and corn planting the following May. However, acreage under frost-sown red clover has steadily declined with time in Ontario because the challenges of maintaining adequate red clover stands.

The purpose of this study is to provide the replicated field trials to determine whether two seasons of winter-hardy leguminous cover crops are profitable and sustainable in an organically managed soybean-winter wheat-corn rotation, in SW Ontario.

THE EXPERIMENT

Dr. Xueming Yang and his research team at the Agriculture Agri-Food Canada Harrow Research and Development Centre conducted a five-year study on a sandy loam in Southwestern Ontario, to develop and evaluate the incorporation of red clover, crimson clover and hairy vetch into organically managed soybean–winter wheat–corn rotation systems in Southwestern Ontario, as illustrated in Figure 1.

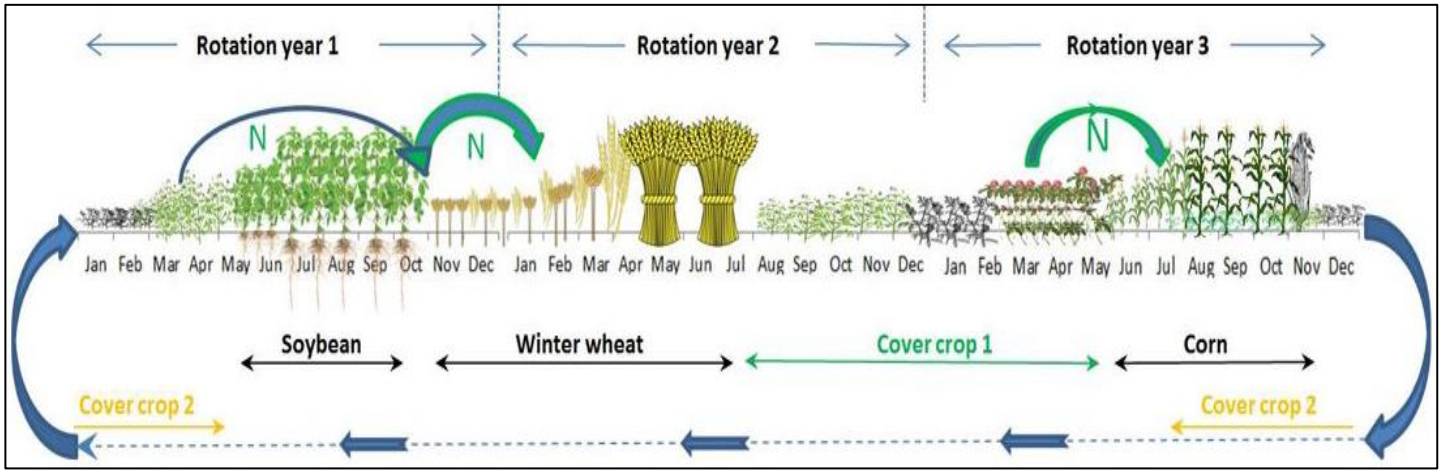

Figure 1: Organically managed, three year, five crop year round rotation: winter wheat - cover crop 1 – corn - cover crop 2 – soybean rotation.

The research team also evaluated the impacts of cover crop type, termination and incorporation method. They tested moldboard (MP) and chisel plow (CP) termination of the cover crops on main crop yield, as well as the effect of winter-hardy leguminous cover crops, planted after winter wheat harvest, on soil mineral N levels during the corn-growing season.

Forty research plots were laid out in a randomized complete block design, including ten treatments with four replications (Table 1). A mechanical drill was used to seed cover crops after the wheat harvest into standing stubble, and inter-seeded in corn at the five to seven leaf stage (Figure 1). The research began with a three-year organic transition period from 2015 to 2017. After which plots were certified organic from 2018 to 2022 (aside from a conventional check).

The main test plots were managed using organic methods, without synthetic fertilizer, and no chemicals were used for weed and disease/pest control. A conventional control plot was included for comparison with standard conventional management practices and no cover crops planted.

Table 1: Overview of test plots, cover crops, termination methods used and planting time.

Plot #	Termination Method	Cover Crop	Plot name	Notes
1	Moldboard Plow	Organic control	CK-O-MP	Frost-sown RC
2		Conventional control	CK-C-MP	No cover crop
3		Crimson clover	CC-MP	Summer-sown
4		Hairy vetch	HV-MP	Summer-sown
5		Red clover (RC)	RC-MP	Summer-sown
6	Chisel Plow	Organic control	CK-O-CP	Frost-sown RC
7		Conventional control	CK-C-CP	No cover crop
8		Crimson clover	CC-CP	Summer-sown
9		Hairy vetch	HV-CP	Summer-sown
10		Red clover	RC-CP	Summer-sown

The study measured main cover biomass and biomass N, N status of corn, grain yield, protein content, and soil organic matter level. Above ground cover crop biomass and biomass N were evaluated in the spring before termination by harvesting two representative 0.7 m × 0.25 m quadrats per plot. All living cover crop plant material was clipped at the ground level, bagged and dried, then weighed and analyzed for N and C contents.

Soil samples were collected monthly after corn planting until maturity to determine soil mineral N levels. The N levels of corn were evaluated using chlorophyll levels of corn leaves at R1 growth stage, once corn silk emerged from corn husks.

RESULTS

Cover Crop Performance

The conventionally managed control (CK-C) was used as a comparison with the frost-sown red clover (CK-O) and summer-sown cover crop treatments.

Frost-sown red clover and summer-sown crimson clover, hairy vetch, and red clover all performed well (Figure 2). On average, these cover crops accumulated 6.1 to 7.1 t/ha of aboveground biomass and 162 to 210 kg N/ha before corn planting (Table 2). The study confirmed that both summer-sown and frost-sown legume cover crops can be used as a primary N source for corn in rotation.

Soil analysis demonstrated that rotations with cover crops at least maintained (and may have slightly improved) soil organic matter levels. However, there also appeared to be a slight drawdown in the soil's content of extractable nutrients, which should be monitored.

Table 2: Cover Crop Performance, legume seeding rates, above-ground biomass N and biomass in May before plow-down incorporation in kilograms per hectare.

2015-2022 Average yield during 3 yr Transition and 5 yr Organic Production Period	Crimson clover	Hairy vetch	Red clover	
			Summer sown	Frost sown
Seeding rate (kg/ha)	25	25	12.5	12.5
Aboveground biomass N (kg N/ha)	162	210	171	190
Biomass before plow down (kg/ha)	6800	7100	6700	6100

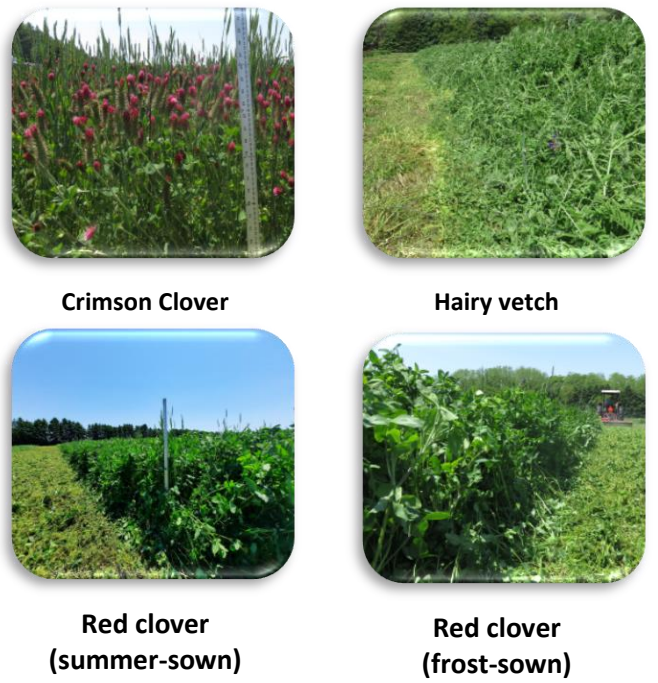

Figure 2: Organic legume cover crops tested and their performance.

Main Crop Performance: Organic Corn

Organic corn grain yield varied across the years of the study, mainly in response to cover crop biomass N accumulation and weed severity (Table 3).

Extremely low corn yield in CK-O was observed during the transition period as expected, due to no red clover sown prior to the corn crop. Low corn yields during the first two years of organic production were due to low biomass N in cover crop in 2018, 43% less than the average of other four years, and heavy weeds in 2019 of organic production.

Corn yield was about 12% lower with chisel plow than moldboard plow termination, and about 6-12% lower in red clover than in other cover crop treatments. Although the corn yields were generally lower in organic plots than in the conventional control plot, the organic corn had similar yields as the conventional corn in the moldboard plow terminiation, during the last three years of organic production between 2020-2022.

Figure 3: Organic corn second cover crop in rotation: CC, HV, RC mix, seeded at the 5-6 corn leaf stage. Clockwise from top left, photos are taken upon seeding in late June 2021, Aug 2021, Nov 2021 (cover crop after corn harvest) and Oct 2021.

Table 3: Organic corn yield five year average in bushels/acre. Corn following summer-seeded crimson/white clover (CC), hairy vetch (HV), or red clover (RC) compared with organic (O) or conventional (C) check plots with frost-seeded red clover. Cover crops were terminated using a moldboard plow (MP) or chisel plow (CP) prior to corn planting. Treatment means followed by the same letter are not statistically different.

	MP	CP	Mean*
CK-C	199	196	197 a
CK-O	171	152	162 b
CC	167	136	151 bc
HV	172	143	158 b
RC	155	129	142 c
Mean	173 A	151 B	

Main Crop Performance: Organic Soybean

Organic soybean yield varied across years. Weed control is one of the most important management practices for organic soybean production, and weeds, particularly tall weeds were often evident in late summer and early fall (Figure 4).

Mean soybean yields in the experiment ranged from approximately 47 to 51 bu/ac but there were no statistical differences among any treatments.

Figure 4: Organic soybean performance in July 2022. Certified organic seed HS13C38/B138CO since 2018, 30'' rows, 180000-243000 seeds/ac. P and K were applied based on soil tests. No N for both CK-C and cover crop treatments, weed control; herbicide spray for CK-C; rotary tiller for cover crop treatments and tall grasses trimmed.

Main Crop Performance: Organic Winter Wheat

Fall sown winter wheat was especially effective at competing with spring germinating annual weeds, and did not require spring weed control (Figure 5). Nitrogen was a yield-limiting factor for organic winter wheat across the study period with some yellowing chlorosis at highest growing period. Organic winter wheat yield (63 bu/ac, summer-sown cover crop plot) was about 27% lower than the wheat yield of CK-C (87 bu/ac). It was noted that the winter wheat yield was 10 - 15% lower in CK-O (53 bu/ac, frost-sown red clover) and in other cover crop treatments (no frost-sown red clover). The low wheat yield in CK-O plots may be due to frost-sown red clover competition.

Figure 5: Organic winter wheat performance June, 2022. Organic Soft Red Winter Wheat seeded at 172-180 lbs/ac Thompson DSS72SRW/SRWBIN11PROFSS17, P and K based on soil testing; 110 kg N/ha was applied to CK-C, No N for cover crop treatments, weed control: herbicide spray for CK-C; none for cover crop treatments.

ECONOMIC PERFORMANCE

All input costs of cash and cover crops were gathered including cost of seed, fertilizers (both synthetic and organic), weed control, tractor and machinery use, organic certification fees, soil analysis and processing. Revenue was calculated from experimental yield data and published organic and conventional grain prices for each year.

The chisel and moldboard plow treatments costs were similar, the chisel plow treatment resulted in lower corn yields and less profit. During the period of organic transition, the organic premiums could not be applied. This coupled with low yields in the organic corn and winter wheat resulted in significantly lower profits in the organic treatments compared with the conventional check during transition.

However, yields improved, particularly in the moldboard plow treatment after the transition period, because the cover crop was better incorporated into the soil, providing more N for main crops. The combination of similar input costs for organic and conventional production, improved organic corn and wheat yields, and organic premiums, resulted in organic margins that were twice that of the conventional check as in Figure 6.

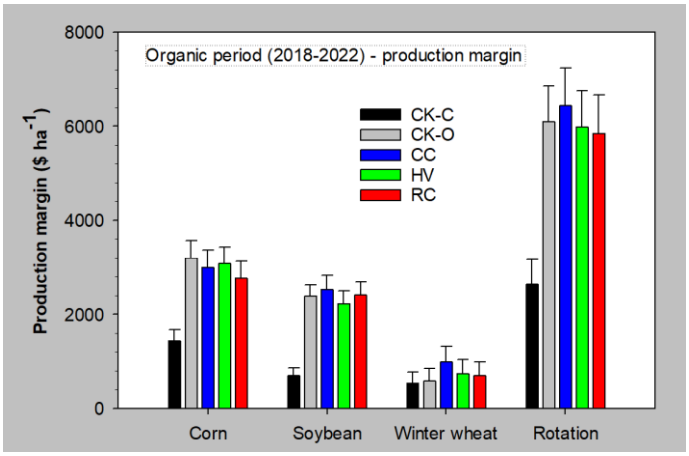

Figure 6: Average annual margins organic production period. Average organic price premium for corn was 125%, soybean 160% and winter wheat 110%. Pricing Sources: http://www.omafra.gov.on.ca/english/stats/crops/ and https://organicbiz.ca/

This bulletin may be cited as:
Belanger, A. & Yang, X.M. 2023. Legume Cover Crop Performance and in a Soutwest Ontario Grain Rotation. Organic Agriculture Center of Canada, Dalhousie University, Truro, NS. 4pp. https://www.dal.ca/faculty/agriculture/oacc/en-home/organic-science-cluster/OSCIII/field-crops/activity-4-a-.html

CONCLUSIONS

Dr. Yang and his team have successfully tested a new organic cover crop best management practice to maintain cash crop production with leguminous cover crops and without the use of costly nitrogen inputs, compost or manure.

This leguminous rotation is twice as profitable as conventional rotations and improves environmental performance of field-crop production with year-round ground cover. There are many benefits of maintaining year-round land cover in Southwestern Ontario, including the reduction of rapid off-field movement of water, sediments and nutrients, as well as nutrient and pesticide pollution in the lower Great Lakes, which are critically important sources of water, fish and recreation for both Canada and the United States.

Seeding legume cover crops (i.e. crimson clover, hairy vetch, and red clover) after winter wheat harvest is feasible for organic corn-soy-winter wheat production in Southwestern, Ontario. The cover crops accumulate additional biomass C and N in the spring regrowth period before termination and provide sufficient N for subsequent corn growth.

Further research is needed to assess the impact of cover crops on weed populations, plant diseases, pests, and weed competition with the main crops for N.

Read the complete results, including references for this study at: https://doi.org/10.2134/agronj2018.10.0652.

This research activity was led by Dr. Xueming Yang and his team under The Organic Science Cluster 3, Activity 4.

ABOUT THE ORGANIC SCIENCE CLUSTER

organic SCIENCE CLUSTER 3

This factsheet reports research results from the Organic Science Cluster program which is led by the Organic Federation of Canada in collaboration with the Organic Agriculture Centre of Canada at Dalhousie University. Organic Science Cluster 3 is supported by funding from the AgriScience Program under Agriculture and Agri-Food Canada's Canadian Agricultural Partnership (an investment by federal, provincial, and territorial governments) and over 70 partners from the agricultural community. More information about the Organic Science Cluster Program can be found at www.dal.ca/oacc.