Diverse Rotations and Crop Resilience – Soil Health at Work

Bill Deen
November 28, 2017
OMAFRA Soil Heath Research Forum
Guelph, Ontario
Production roundup
Everybody’s talking ‘bout: soil health

And not only agriculturists, but land owners and the public as well. A discussion about soil health and its importance in a climate-changing world is spreading far and wide.

There are numerous ways to achieve the benefits of healthy soil, but most agree that soil health is a critical component of climate adaptation. As a result, there have been numerous efforts to improve soil health, and the cycling of carbon and nutrients is central to this goal.

Carbon sequestration in soils is a particularly important benefit of healthy soil. Not only does it help to mitigate climate change, but it also improves the overall productivity and health of agricultural systems. It’s a win-win strategy that everyone can benefit from.

In Ontario, soil health is a major focus of research and policy. The government has invested in soil health research and has developed programs to support soil health initiatives. These efforts are paying off, as soil health is improving across the province.

Still, there is much work to be done. Soil health is a complex issue, and improving it requires a multi-faceted approach. Farmers need to be aware of the benefits of healthy soil, and they need to have the tools and resources to implement the changes needed to achieve those benefits.

The goal is to create a more resilient agricultural system that can withstand the challenges of a changing climate. This will require a long-term commitment to soil health, and it will require the support of all stakeholders. But the benefits are clear, and they are worth pursuing.

References

2016
“Soil health improvements don’t always show up in the weigh wagon” Peter Johnson

“There’s the challenge of taking a long-term view in an industry that demands short term decisions” Chris Brown

“It’s the long game....” Anne Verhallen

“I personally struggle with losing money for today to benefit tomorrow” Clare Kinlin

“A healthy soil may not be a profitable soil” Pat Lynch
Production/profit of soil health BMPs

Tillage system: frequent intensive ← no-till

Rotation: simple ← complex

Cover crops: no cover ← single species ← complex mixes

Inputs: intensive use of synthetic inputs ← organic

Amendments: residue removal ← manure/compost addition

Soil compaction avoidance: none ← extensive
Impact of BMPs on soil health

Tillage system: frequent intensive → no-till

Rotation: simple → complex
- Enables reduced/no-till
- Provides cover crop niche
- Reduces residue removal impact
- Reduces risk of compaction
- Reduces input use

Cover crops: no cover → single species → complex mixes

Inputs: intensive use of synthetic inputs → organic

Amendments: residue removal → manure/compost addition

Soil compaction avoidance: none → extensive
“I may not be able to define exactly what soil health should be, but I can tell you what it is not. It is not found on farms, that for the last 25 years have had a history of 50% or more soybeans grown in the rotation. But these farms have been profitable for the owners. Who am I to say this is wrong? But when I walk on these fields in the spring I get an uneasy feeling. They are hard and crunchy compared to farms with a more diversified rotation, which are softer and mellower. We can make a seedbed in these parts out of hard and crunchy. It takes brute force and steel to do it and it is done. At the end of the day, the steel and brute force is the part that bothers me. Soils are chock full of living beings. Is it right to use brute force to mold them into a definition that is based on economics alone. Some would argue yes. I can respect that opinion. I just don’t agree with it.” Russ Barker (St Mary’s area CCA and Dupont Pioneer Seed Dealer).
% harvested area, Ontario, 1981-2013
(Ontario Ministry of Agriculture, Food and Rural Affairs, Field statistics 2014)

Gaudin A et al., PLOS one (2014) DOI 10.1371/journal.pone.0113261
Corn/soybean rotation is associated with

- Reduced yield and greater yield instability
- Lowest soil organic matter/poorest soil structure
- Increased nitrogen requirement
- Reduced input use efficiency
- Increased GHG emission
- Reduced success of no-till/reduced till
- Reduced opportunity to incorporate cover crops
- Reduced opportunity for sustainable biomass removal

Rotation complexity effect on corn and soybean yield: Elora 1982-2012

Mean corn yields (kg ha\(^{-1}\))

- **CC**: a
- **CS**: a
- **CSW**: a
- **COB**: a
- **CSWrc**: a
- **COrcBrc**: a
- **CA**: a

Soybean yields (Kg ha\(^{-1}\))

- **CS**: b
- **CSW**: b
- **CSWrc**: b

Legend:
- □ Tillage
- ■ No Tillage

Significance:
- a
- ab
- b
- *
Rotation complexity effect on corn and soybean yield: Ridgetown 2010-2013

Gaudin A et al., Agriculture, Ecosystem and Environment (2015), 210:1-10
Cropping sequence diversification provides a systems approach to reduce yield variations and improve resilience to multiple environmental stresses. Yield advantages of more diverse crop rotations and their synergistic effects with reduced tillage are well documented, but few studies have quantified the impact of these management practices on yields and their stability when soil moisture is limiting or in excess. Using yield and weather data obtained from a 31-year long term rotation and tillage trial in Ontario, we tested whether crop rotation diversity is associated with greater yield stability when abnormal weather conditions occur. We used parametric and non-parametric approaches to quantify the impact of rotation diversity (monocrop, 2-crops, 3-crops without or with one or two legume cover crops) and tillage (conventional or reduced till- age) on yield probabilities and the benefits of crop diversity under different soil moisture and temperature scenarios. Although the magnitude of rotation benefits varied with crops, weather patterns and tillage, yield stability significantly increased when corn and soybean were integrated into more diverse rotations. Introducing small grains into short corn-soybean rotation was enough to provide substantial benefits on long-term soybean yields and their stability while the effects on corn were mostly associated with the temporal niche provided by small grains for underseeded red clover or alfalfa. Crop diversification strategies increased the probability of harnessing favorable growing conditions while decreasing the risk of crop failure. In hot and dry years, diversification of corn-soybean rotations and reduced tillage increased yield by 7% and 22% for corn and soybean respectively. Given the additional advantages associated with cropping system diversification, such a strategy provides a more comprehensive approach to lowering yield variability and improving the resilience of cropping systems to multiple environmental stresses.
2016 precipitation
May - 42 mm
June – 36 mm
July 1-13 – 11mm
July 14-24 – 23mm
July 25-31 – 37 mm
August - 146mm
Sept – 64 mm
Elora Long-term Rotation
Drought Resilience trial - 2016

• 3 rotations selected
  Corn – Corn – Soy - Soy
  Corn – Corn – Soy - Wheat
  Corn – Corn - Oats(red clover) –Barley(red clover)

• Tillage

• Water treatments (Summer 2016)
  Simulated drought, ambient rainfall (control), irrigated (control)

• Objectives: Quantify rotation interaction with moisture and study the mechanisms underlying drought resilience
Drought yield loss decreased with rotation diversity

Yield loss under drought relative to irrigated (%)

Rotation

CCSS  CCSW  CCOrcBrc

Rotation  CCSS  CCSW  CCOrcBrc
Economic Justification for Wheat in Rotation

• 4 % increase in corn yield: 7 bu/ac @ $4.50/bu = $32/ac
• 12 % increase in soy yield: 5.5 bu/ac @ $12.50/bu = $69/ac
• Increased drought tolerance/yield stability = ??
• Reduction in N requirement: 26.4 lb/ac @$0.55/lb = $14/ac
• Cover crop N (eg red clover): 50 lb/ac @$0.55/lb = $27/ac
• Reduced tillage requirement = ??
• Ability to sustainably sell crop residue = ??
• Other eg. herbicide resistance management = ??
• Added profit attributed to wheat >$143/ac

• Wheat straw sale (1.2 t/ac net value in winrow $.03/lb) $79/ac
• Double crop forage (2-3 t/ac net value in winrow $??/lb) ??
Benefit of BMP’s for production/profit

Tillage system: frequent intensive ▸ no-till

Rotation: simple ▸ complex

Cover crops: no cover ▸ single species ▸ complex mixes

Inputs: intensive use of synthetic inputs ▸ organic

Amendments: residue removal ▸ manure/compost addition

Soil compaction avoidance: none ▸ extensive
Benefit of BMP’s for soil health in a corn/soybean system

Tillage system: frequent intensive → no-till

Rotation: simple → complex
  - Enables reduced/no-till
  - Provides cover crop niche
  - Reduces residue removal impact
  - Reduces risk of compaction
  - Reduces input use

Cover crops: no cover → single species → complex mixes

Inputs: intensive use of synthetic inputs → organic

Amendments: Residue removal → manure/compost addition

Soil compaction avoidance: none → extensive