Cover crops versus good rotation

vs no-till

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CHANGING LIVES IMPROVING LIFE

"Trifecta of soil health": Crop rotation, cover crops, no-till

tri·fect·a

/trīˈfektə/

noun NORTH AMERICAN AUSTRALIAN/NZ

a bet in which the person betting forecasts the first three finishers in a race in the correct order.

- a run of three wins or grand events.
  "today is a trifecta of birthdays"

Production roundup

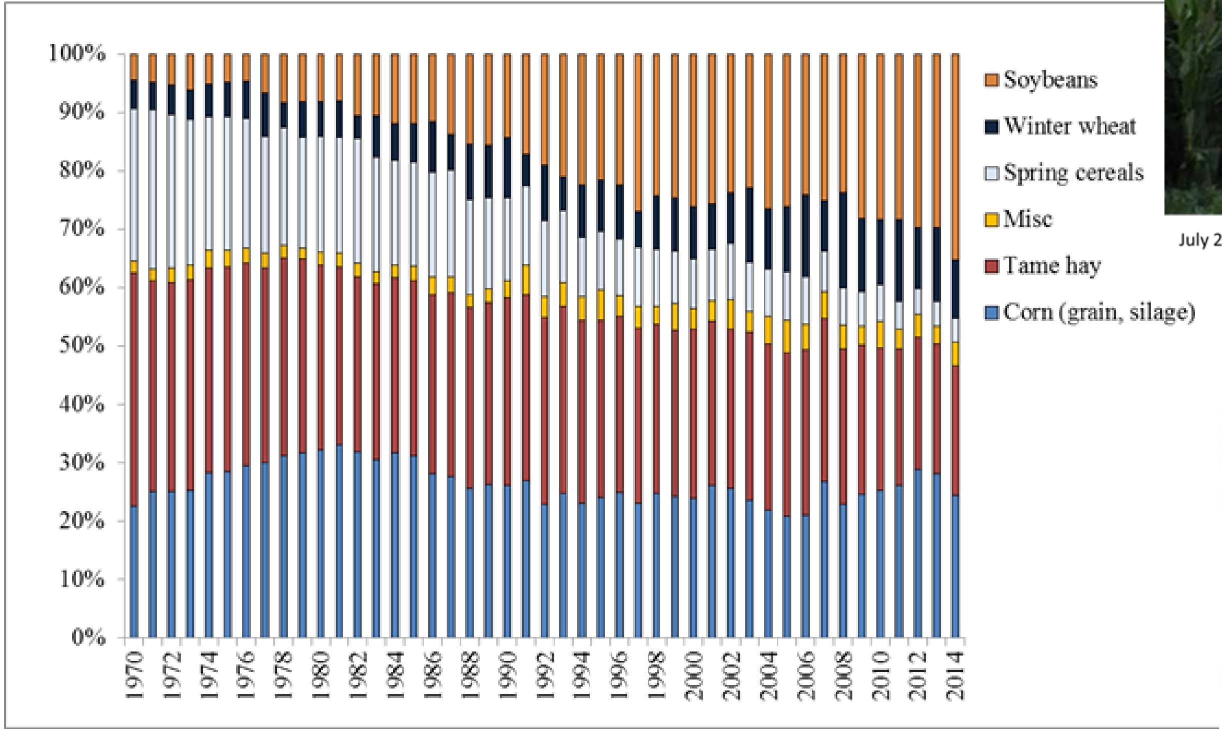
BY PETER RESCHKE
The writer is an editor with Ontario Farmer Publications

Everybody's talking 'bout: soil health

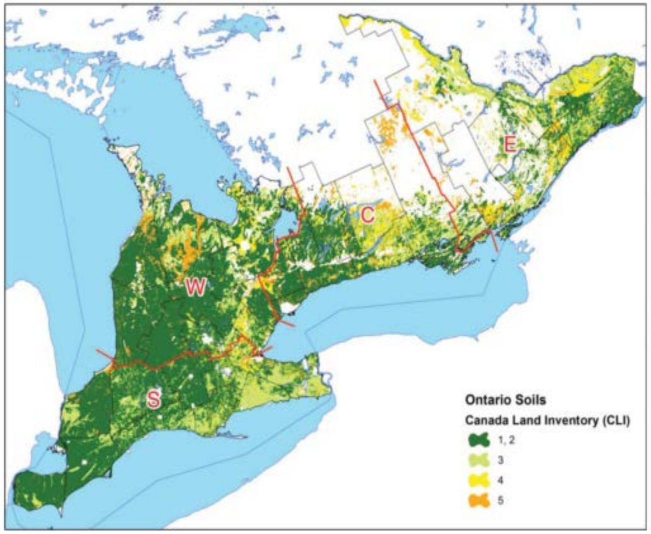
"We have too many chasing the "healthy soil" concept and ignoring some of the basics of crop production."

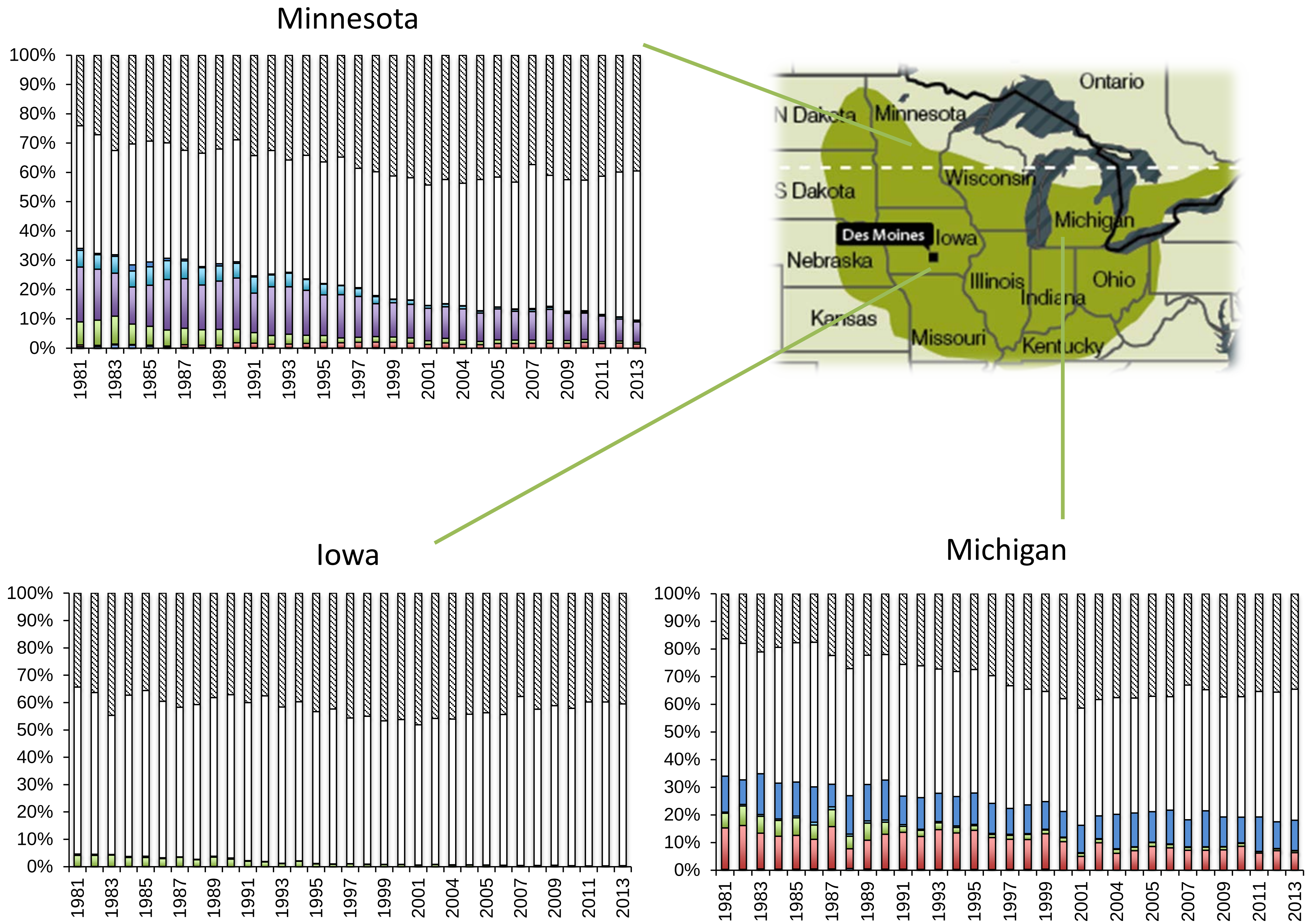
"I may not be able to define exactly what soil health should be, but I can tell you what it is not. It is not found on farms, that for the last 25 years have had a history of 50% or more soybeans grown in the rotation.. But these farms have been profitable for the owners. Who am I to say this is wrong? 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 areas (hectares) of major field crops shown as % of total harvested area from 1970 to 2014 for Ontario. (Source: Statistics Canada, 2016.) (Reproduced from Deen et al., 2016)



July 2014, somewhere near London, ON





% total harvested areas USDA-NASS, 2014

Elora Research Station : 1625 acres, silt loam soil, 900mm annual rainfall, 2700-2800 CHU

- Initiated in 1980
- Rotations – CCCC, AAAA, CCAA, CCSS, CCSW, CCSW(rc), CCOB, CCO(rc)B(rc)
- Conventional tillage and no-till

LONG TERM ROTATION x TILLAGE x N TRIAL

Initiated in 1995 (21-year)

Ridgetown Research Station

Crop diversity gradient (± wheat)

2009 ± RC split, 4 N (12 starter, 0-180 kgN/ha)

1 crop = Continuous Corn / Continuous Soy

2 crops = Corn-Soy / Soy-wheat

2 crops + 1 cover crop = Soy-Wheat$_{(RC)}$

3 crops= Corn-Soy-Wheat

3 crops + 1 cover crop = Corn-Soy-Wheat$_{(RC)}$

Tillage gradient

Heavy tillage (Moldboard plow)

No till / Strip till (corn)

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

Meyer-Aurich et al, 2006a; Meyer-Aurich et al 2006b; Sanscartier et al, 2013; Munkholm et al, 2012; Munkholm et al, 2013; Muellera et al, 2009; Gaudin et al, 2013; Gaudin et al. 2014; Gaudin et al. 2015, Kludze et al. 2013.; Van Eerd et al.. 2014

AAAA

CCSW(rc)-NT

CCSW(rc)-CT

CCCC- CT

CCSS- NT

CCSS- CT

PLOS | ONE

RESEARCH ARTICLE

Increasing Crop Diversity Mitigates Weather Variations and Improves Yield Stability

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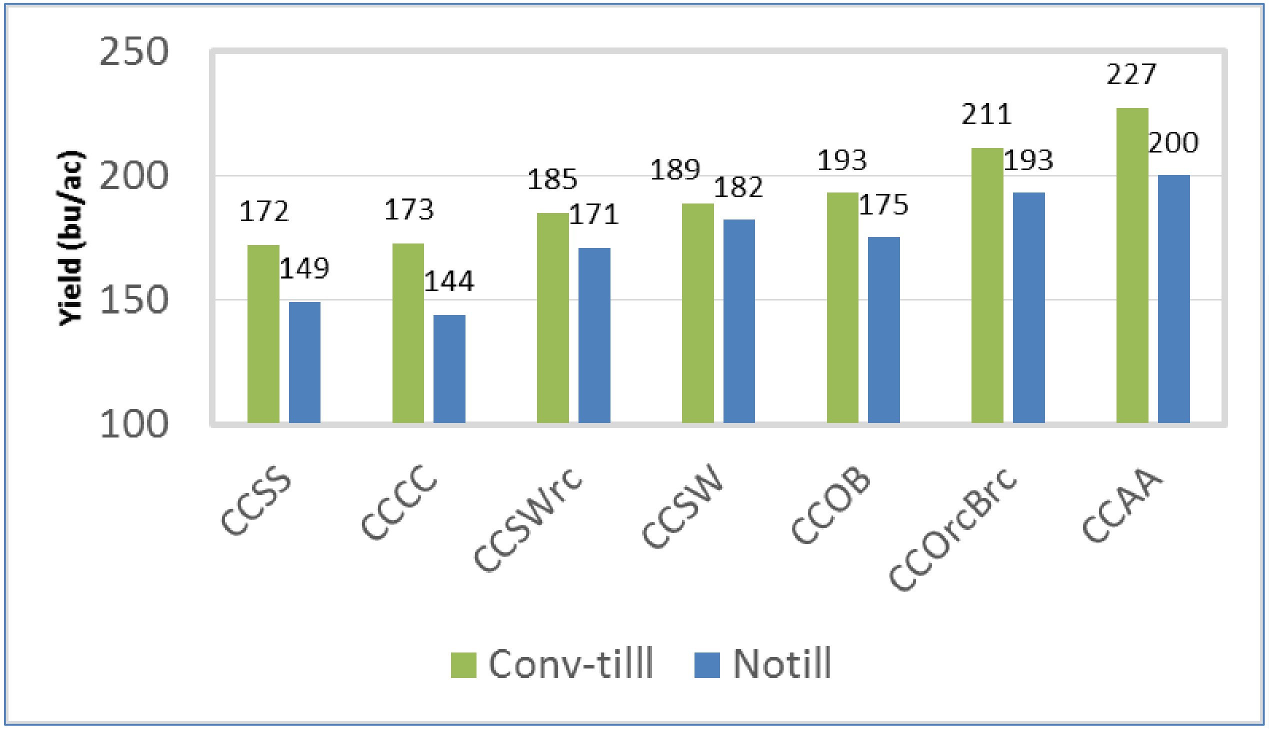
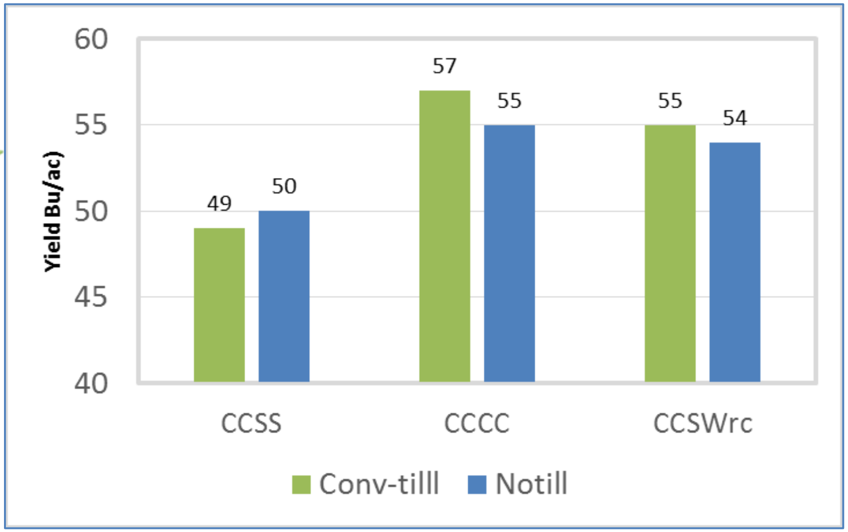
Cropping sequence diversification provides a systems approach to reduce yield variations and improve resilience to multiple environmental stresses. Yield advantages of more diverse crop rotations and their synergistic effects with reduced tillage are well documented, but few studies have quantified the 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 by7%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.

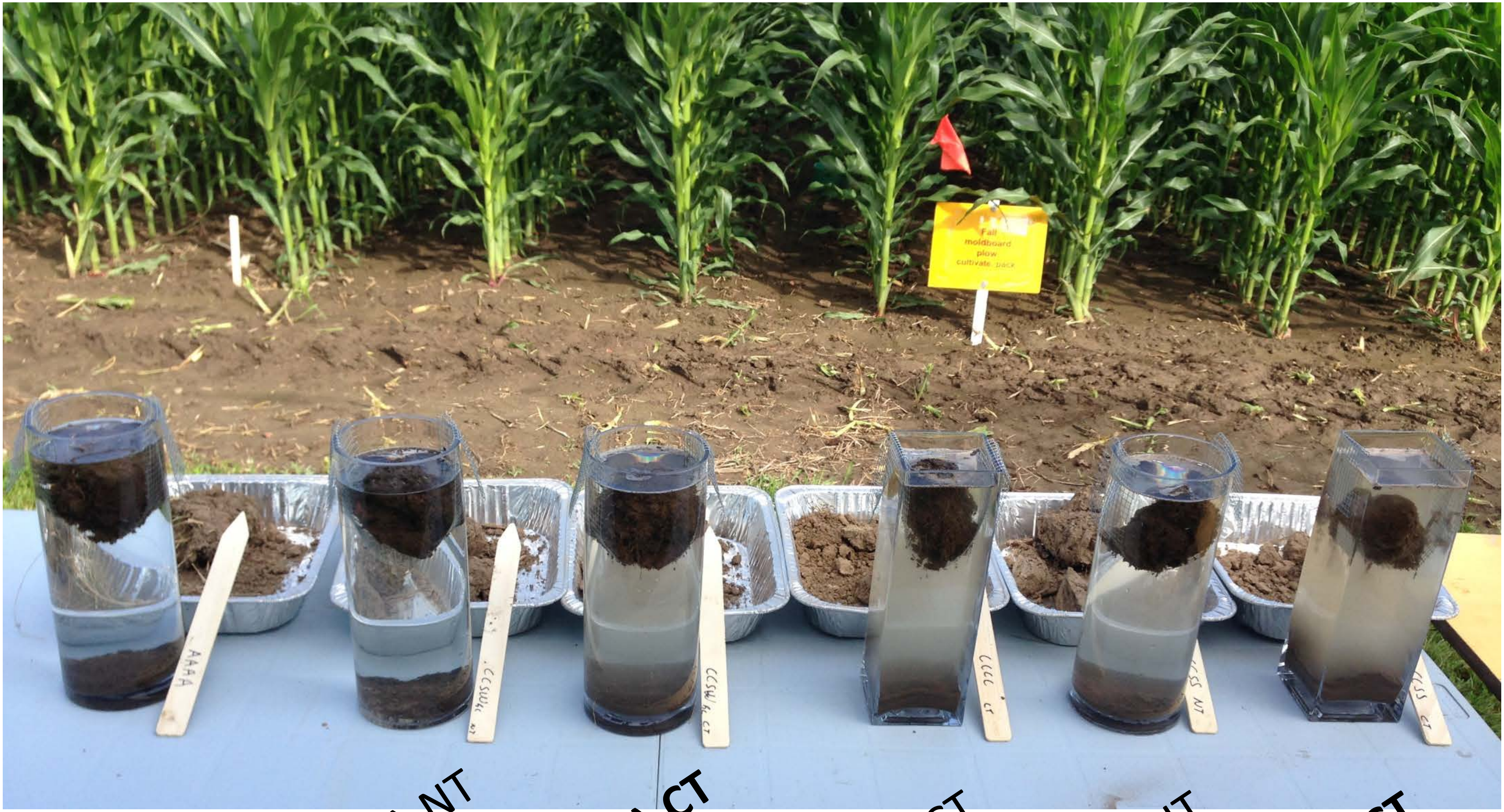
Corn and soybean yield: Elora rotation trial, 2016





2016 precipitation

May - 1.7”
June – 1.4”
July 1-13 – .4”
July 14-24 – 1”
July 25-31 – 1.5”
August – 5.8”
Sept – 2.6”



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CCSW(rc)-NT

CCSW(rc)-CT

CCCC- CT

CCSS- NT

CCSS- CT

- No-till not associated with increased soil carbon (Deen and Kataki, 2003, Meyer-Aurich et al., 2006)

PERSPECTIVE

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nature climate change

Limited potential of no-till agriculture for climate change mitigation

David S. Powlson[1]*, Clare M. Stirling[2], M. L. Jat[3], Bruno G. Gerard[2], Cheryl A. Palm[4], Pedro A. Sanchez[4] and Kenneth G. Cassman[5]

The Emissions Gap Report 2013 from the United Nations Environment Programme restates the claim that changing to no-till practices in agriculture, as an alternative to conventional tillage, causes an accumulation of organic carbon in soil, ... ugh carbon sequestration. But these claims ignore a large body of experimental evidence ... nal organic carbon in soil under no-till is relatively small: in large part apparent increases ... ution. The larger concentration near the surface in no-till is generally beneficial for soil ... ways, translate into improved crop growth. In many regions where no-till is practised it is ... nventionally every few years for a range of agronomic reasons, so any soil carbon benefit ... beneficial for soil quality and adaptation of agriculture to climate change, but its role in

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Commentary

The myth that no-till can mitigate global climate change

CrossMark

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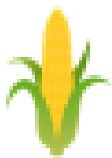
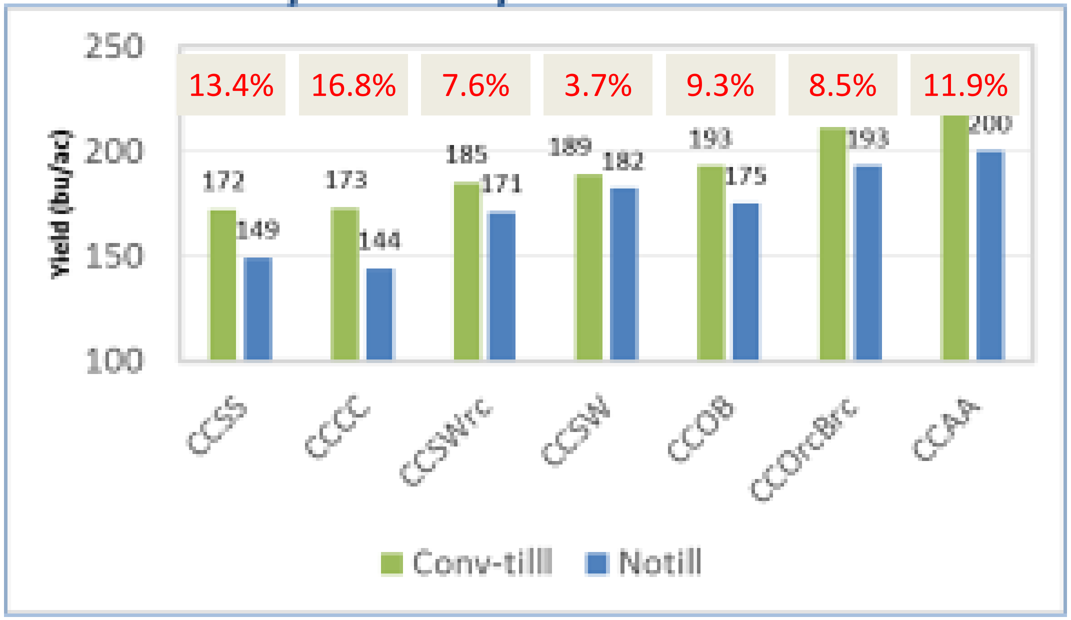
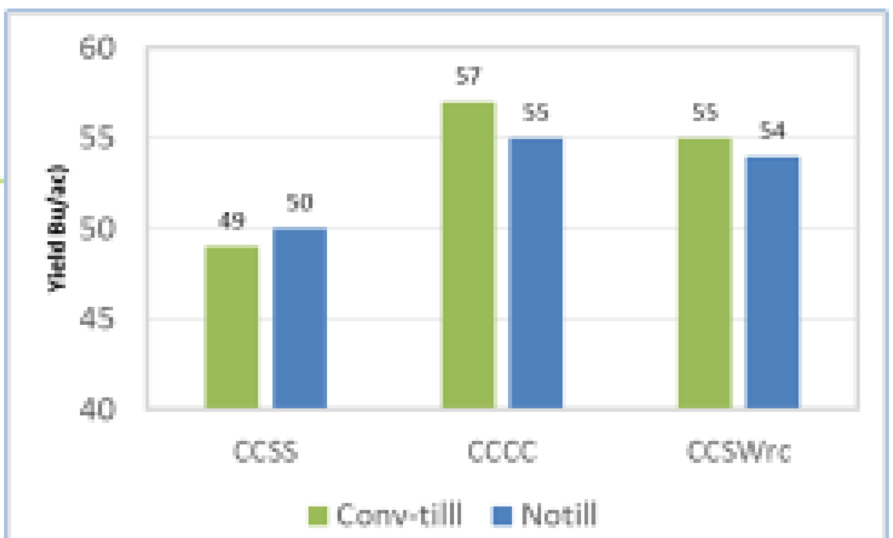
ABSTRACT

There has been a careless use of terminology like "climate change mitigation" and "mitigate global warming" in scientific papers on no-tillage management in agriculture. This is because it has yet to be shown unequivocally that no-tillage can lead to carbon (C) sequestration let alone climate change mitigation. I briefly summarize evidence that shows that the claims of climate change mitigation through no-tillage agriculture are highly overstated.

Corn and soybean yield: Elora rotation trial, 2016







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

LETTER

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Productivity limits and potentials of the principles of conservation agriculture

Cameron M. Pittelkow[1]*†, Xinqiang Liang[2]*, Bruce A. Linquist[1], Kees Jan van Groenigen[3], Juhwan Lee[4], Mark E. Lundy[1], Natasja van Gestel[3], Johan Six[4], Rodney T. Venterea[5,6] & Chris van Kessel[1]

One of the primary challenges of our time is to feed a growing and more demanding world population with reduced external inputs and minimal environmental impacts, all under more variable and extreme climate conditions in the future[1-4]. Conservation agriculture represents a set of three crop management principles that has received strong international support to help address this challenge[5,6], with recent conservation agriculture efforts focusing on sma... ing systems in sub-Saharan Africa and South Asia[7]. Ho... vation agriculture is highly debated, with respect to bot... crop yields[8-10] and its applicability in different farming... Here we conduct a global meta-analysis using 5,463 pair... vations from 610 studies to compare no-till, the origin... concept of conservation agriculture, with convention... tices across 48 crops and 63 countries. Overall, our res... no-till reduces yields, yet this response is variable and... conditions no-till can produce equivalent or greater yi... ventional tillage. Importantly, when no-till is combined... two conservation agriculture principles of residue reten... rotation, its negative impacts are minimized. Moreo...

A comprehensive meta-analysis was performed on data from peer-reviewed publications, representing the largest assessment so far on this topic. Because not all three principles of conservation agriculture are adopted by all farmers[8,17], studies at a minimum had to include no-till, the original and central concept of conservation agriculture, and conventional tillage treatments (note: minimum-tillage practices were not

"Overall, our results show that no-till reduces yields, yet this response is variable and under certain conditions no-till can produce equivalent or greater yields than conventional tillage. Importantly, when no-till is combined with the other two conservation agriculture principles of residue retention and crop rotation, its negative impacts are minimized. "

Ridgetown College researcher David Hooker says interseeding cover crops in corn is nothing new. He unearthed a sign from a 1980s interseeding research trial at the college.

Cover crops interseeded to corn (Jackie Clarke (MSc student, U. of Guelph) Mehdi Sharifi (Trent University) Bill Deen, Dave Hooker, Laura VanEerd (U of Guelph)

- 3 sites: Elora, Ridgetown, Trent (2 seasons)
- 2 harvest treatments: silage corn & grain corn
- 5 cover crop treatments
  - Control
  - Annual Ryegrass drilled
  - Red Clover drilled
  - AR + RC drilled
  - AR + RC broadcast

Objectives

1. Quantify impact of interseeding cover crops on silage corn, grain corn or soybean yield.
2. Analyze above ground biomass achieved by cover crops singly and in combination, as well as drilled and broadcast.

Funded by: Grain Farmers of Ontario

Measurements & Management

- Cover crops drilled/broadcast V4-V6
- Overwintered, chemically terminated
- No-till soybeans planted the following spring
- Measured: silage DM, grain yield, cover crop and weed biomass, soil parameters

Preliminary observations

- Cover crop biomass (above ground) in the fall following grain corn is low and highly variable (0-1000kg ha^{-1})
- Cover crop biomass (above ground) in the spring is also low and highly variable
- Establishment and biomass is improved by drilling
- Greater biomass in silage corn
- Greater biomass with mixtures
- No impact on corn yield

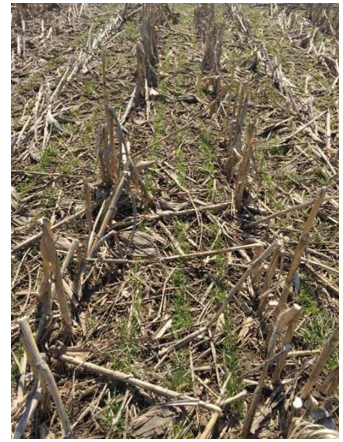
Elora - 2015

Preliminary Results: Biomass

- Season 2: Ridgetown – October 24th 2016

- Season 1: Elora - April 15th 2016






- Season 1 – Ridgetown– April 22nd 2016




Drilled Broadcast Drilled Broadcast

Silage Grain corn

Cover crops into soybean (Bill Deen, Dave Hooker U of Guelph)

- 2 sites: Elora, Huron (3 seasons)
- 6 cover crop treatments
  - Cont. soybean
    - No cover crop
    - Fall rye broadcast pre-soybean leaf drop
    - Fall rye drilled immediately after soybean harvest
    - Annual ryegrass broadcast pre-soybean leaf drop
    - Annual ryegrass drilled post soybean harvest
  - Soybeans following corn in a 2-year rotation
    - no cover crop

- In three years (with cooler, wetter falls) fall biomass (above ground) was low and variable (0-500 kg ha^{-1}).
- Drilling was more consistent
- Fall rye more consistent and greater biomass
- Spring biomass determined by planting timeliness, winter survival, date controlled,

November 24, 2009

April 27, 2010

May 8, 2010

Challenges of Cover Crops in CS

- Biomass production of cover crops in CS rotation is low and variable, particularly when interseeded to corn, particularly in shorter season regions
- Interseeding/drilling results in higher and more uniform biomass than broadcasting BUT increased cost may not be justified
- Mixtures also result in higher and more uniform biomass BUT
  - may increase cost
  - will increase/reduce risk of herbicide injury
  - may increase difficulty to control

Challenges

- "Planting green" is a method to increase spring biomass BUT
  - In a dry year may reduce moisture
  - In a wet year may delay control and planting
  - Residue may interfere with planting
  - May make control more difficult (eg ARG, RC)
  - Will increase management and may not be as scaleable

- Delayed planting to increase spring cover crop biomass a questionable strategy

Planting Green in 2016

Cover crop roots and residue help hold soil and nutrients in place. Planting green can increase fertility and increase biological activity but how did it work in a season of drought? Farmers and experts share their experiences growing cover crops this season and remain optimistic that they are going to try again....with fine-tuning

Diversity is better than density and other cover crop lessons learned in a season of drought

Story and Photos by Mel Luymes

Agriculture has been evolving for centuries, and our most recent advances in technology and understanding are again changing the rural landscape. Readers may have seen a few more lush green fields this spring and that's because more and more farmers see the soil benefits of keeping a cover crop over the winter. So much so that some no-tillers wait to terminate their cover crop until after they have planted their cash crop. The dry conditions in 2016 are arguably the most difficult for this system to work, so let's find out how these farmers have made out this year.

To start, why are these farmers cover-cropping in the first place? Well, data shows that most soil and nutrients are lost off fields in the spring thaw and with the spring rains. Cover crop roots and crop residue help hold soil and nutrients in place so overwintering cover crops is important for keeping our Great Lakes blue, not green with algal blooms.

There are plenty of other benefits to keep cover crops growing for as long as possible.

• Soil life: Green plants are harvesting sunlight and literally pumping carbon into the soil, feeding beneficial soil organisms and increasing organic matter, thereby improving soil structure, nutrient cycling, water holding capacity, etc.

• Fertility: Cover crops scavenge nutrients in the fall and overwintering crops hold onto these nutrients through the spring to release them to the cash crop the following year. In the case of legume covers, the longer they grow the more nitrogen they are making for the farmer.

•Residue management: By increasing biological activity, cover crops help break down residue from previous crops. This is counter-intuitive, of course, because cover crops will also create residue; but cover-croppers swear that keeping fields green is the secret to residue management. If residue isn't breaking down quickly enough, it means there aren't yet enough microbes in that soil. And in that case, the soil needs time, not tillage.

Some farmers terminate their cover crop a few weeks before planting, though research shows that cover crops

OCTOBER 2016 25

Challenges of Cover Crops in CS

- Cover crop benefits for soil health and erosion reduction associated with overwintering and spring growth. Inclusion of fall tillage will negate these benefits. No-till less effective in a CS rotation….strip tillage??

Value of adding wheat to rotation

- Provides a proper niche for cover crop
- Enables no-till/reduced till (… and associated benefits)
- Increases yield and yield stability (…and associated benefits)
- Increases weed resistance management options
- Reduces N requirement

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Wheat improves nitrogen use efficiency of maize and soybean-based cropping systems

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ABSTRACT

Integrated nitrogen (N) management strategies could make significant contributions to improving the efficiency of N use in the northern Corn Belt, particularly for maize, which has high N requirements. Using legume cover crops has been shown to increase both the soil's capacity to supply N and nitrogen use efficiency (NUE), through the reduction in the amount of N fertilizer that must be applied to the following crops. However, the impact of non-legume crops such as winter wheat (*Triticum aestivum* L.) on the diminishing return function between crop yield and N supply and its influence on N fertilizer use remains unclear. We hypothesized that maintaining wheat in short maize and soybean- based rotations is instrumental to improve cropping system performance and increase N fertilizer use efficiency while decreasing N requirements for maize. Seven maize and soybean rotations with different frequency of winter wheat with or without underseeded red clover (*Trifolium pratense L.*) were grown in two tillage systems (conventional and zone-tillage) and four long-term N regimes in Ridgetown, ON, Canada (2009–2013). Wheat in the rotation increased maize and soybean yields, negated crop yield lags due to zone-tillage, and decreased maximum economic rates of fertilizer N (MERN). The benefits of wheat in the rotation on maize yield were negated by high N rates; however, similar yields were obtained with lower N levels in rotationally grown maize, resulting in a 17% (conventional till) to 21% (zone-till) increase in partial factor productivity for N fertilizer at MERN (PFP_{MERN}). While N benefits to crops following wheat alone may be attributed to a higher indigenous plant available soil N, underseeding red clover further increased the agronomic efficiency (AE) of N fertilizer (AE_{MERN}) up to 32%. Maize yields were also less limited by N supply and less responsive to N fertilization when grown in rotation with wheat, especially in the zone-till system. These results highlight the value of wheat as a system component of dominant maize/soybean short rotations of Ontario and its potential to increase both maize and soybean productivity using less N input.

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)	??

- Benefits to farmers of rotation diversity (eg. addition of winter wheat) may increase
  - Climate change
  - Increased yield potential
  - Biomass removal
  - Herbicide resistance

- Other stakeholders are increasingly recognizing importance of rotation diversity and may provide incentives to farmers

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