Low Carbon Story: Axten Farms

Farm Purpose: “Loyal to the Soil”

Farming Goals:
- Keep soil covered at all times
- Eliminate soil disturbance
- Live root in the soil as much as possible
- Species diversity in plants
- Incorporate livestock when possible

Summary
- Intercropping or growing more than one crop in a field at one time
- Keeping soil covered at all times, whether through a living cover or crop residue
- Integrating compost and compost derivatives into their soil management to stabilize soil pH and nutrients
- Eliminating or minimizing soil disturbance through low-disturbance seeding and controlled traffic farming
When Derek Axten traveled from his farm near Minton, just kilometers from the U.S. border, to Gettysburg, South Dakota in 2006, he had no idea that the trip would start him on a multi-year journey that would re-orient his approach to farming from feeding plants to feeding the soil.

He wanted to reduce soil disturbance on his farm, so was in the market for a used disc drill seeder. A dealership in Gettysburg had one. Based on his interest in a disc drill, the sales manager at the dealership asked him if would also be visiting Dr. Dwayne Beck\(^1\), the research manager at Dakota Lakes Research Farm\(^2\) in Pierre, South Dakota. Dr. Beck, a South Dakota State University professor, promotes no-till, low-disturbance farming that integrates high diversity rotations, cover crops, and minimal herbicides and fungicides.

What Derek learned about Dr. Beck’s work intrigued him, so he set about learning more about it once he got home. His research prompted him to return to South Dakota in 2007 to attend a field day at the Dakota Lakes Research Farm. The moment that he most remembers is when Dr. Beck showed him a field that had retained two inches of moisture through irrigation in nine minutes, with no resulting run-off, puddles, or mud. Derek did not irrigate on his farm, but he knew a lot about the effect of too much precipitation in too little time – run-off and soil loss. It seemed to Derek that something about the way that the Research Farm’s fields were being managed was allowing them to hold onto moisture.

Back home, Derek implemented some of the approaches advocated by Dr. Beck, but in general was not convinced that they were relevant to his farm. This changed through another chance encounter at a Field Day in North Dakota, where he met Gabe Brown\(^3\) who invited him to his 5,000-acre farm and ranch near Bismarck, North Dakota. With a shovel in hand, they checked out the soil in Gabe’s fields which Derek describes as looking like black cottage cheese or chocolate cake. Although impressed by the soil quality, he attributed it to favourable local conditions, until they walked across the grid road and checked out the neighbour’s field. Derek says, “It was Minton. The soil was dry, brown, sad and hard.” That moment convinced him that management of Gabe’s fields based on no tillage, plant diversity, companion crops, cover crops, and strategic livestock grazing was what had improved his soil.

The next year, in 2011, Derek and Tannis started intercropping companion crops on some of their fields to increase plant diversity and help fix nitrogen through nitrogen-fixing companion plants. Over time, the intercropping allowed them to significantly reduce synthetic fertilizers on those fields.

Another turning point came in 2015 at a soils meeting in Forsyth, Montana. Derek was introduced to the work of Dr. Elaine Ingham’s\(^4\) work on compost-based approaches to restoring soil microbiology, reducing erosion, and reducing the need for inputs. Derek had been thinking about building up the organic matter in his soil, but did not see how he could realistically graze livestock on 6,000 acres that were not all fenced and did not have readily available water. Dr. Ingham’s approach, based on extracting microorganisms from compost, provided an answer.

Tannis, a biology teacher, was quickly on board, especially when she learned that a microscope would be involved. She enrolled in Dr. Ingham’s online self-study “Life in the Soils” courses. After completing them, she went to California for five days of intensive training on identifying microorganisms in soil and compost samples. Since that time, Tannis has has been the farm’s “brew master,” brewing up the compost extract that is used in place of starter phosphorous in planting furrows and the compost tea for foliar applications.\(^5\)

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1 sdxcellence.org/Dr_Dwayne_Beck
2 www.dakotalakes.com/
3 understandingag.com/gabe-brown
4 www.soilfoodweb.com/
5 Foliar feeding involves applying liquid fertilizer to the leaves of plants.
Tannis and Derek say that since 2011 their farm practices have moved from a focus on growing plants to focusing on the soil’s needs. Their view is that if you take care of the soil, you necessarily take care of the plants. In keeping with this, they focus on reintroducing and protecting beneficial soil microbes lost after years of tillage and agronomy not focused on soil health. The net effect of their approach has been a reduction in inputs, while maintaining or even improving yields.

The cornerstones of the Axtens’ approach to farming are intercropping, cover crops, compost and controlled traffic and low-disturbance seeding.

**MIXED GRAIN INTERCROPPING**

Intercropping involves growing more than one crop in a field at one time. Chickpeas and flax are the only intercrop that they seed in alternate rows, which is done using a double chute air kit. The other intercrops are seeded in the same row. The Axtens have tried many different combinations, and have found their preferred combinations are flax with chickpeas, flax with lentils, and mustard with peas.

Derek and Tannis grow all broadleaf crops as an intercrop of some kind. They have observed that some crops help each other out. For instance, peas trellising up mustard keeps the peas off the ground, which helps reduce issues with disease and pests. The peas are also much easier to combine because they are standing upright, instead of laying on the ground.

Harvesting intercrops is more complex than harvesting monocrops and requires some finessing. Swathing and desiccants are used when needed. A mobile seed cleaner separates the crops.

Their cereal crops are not currently intercropped, as this is more difficult to do, but they continue to experiment with different approaches. For instance, they have under-seeded clover into their cereals with the clover continuing to grow after harvest of the cereal. They are now experimenting with seeding a cover crop between the rows of cereal.

In terms of impact on yields, it varies from year to year. They have an average land equivalency ratio of 1.25:1 on their intercropped fields, which means that their intercropped fields have, on average, increased yields by 25%. In terms of inputs, depending on the year, these have been reduced between 50% and 60%.

Intercropping has been identified as a strategy that can help to reduce soil depletion and erosion and to control weeds by keeping more of the soil covered. It can help support biodiversity by providing habitat for a greater diversity of insects and soil microorganisms. Intercropping with legumes can also help to fix nitrogen in the soil and reduce fertilizer use for non-legume companion crops.

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6 Equivalency ratios are a way to measure yields between cropping systems so you are comparing apples to apples: for example, 140 acres intercropped compared to 2 x 70 acres mono-cropped. The UN-FAO defines land equivalency ratios as “the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level. It is the sum of the fractions of the intercropped yields divided by the sole-crop yields.”


8 [words.usask.ca/plsc243/management-techniques/plant-competition/intercrop/](http://words.usask.ca/plsc243/management-techniques/plant-competition/intercrop/)

COVER CROPS
The Axtens try to keep their soil covered at all times, whether through a living cover or crop residue. Their mixed grain intercrops help out with crop residue. Some crops leave more residue on the field after harvest than others. For instance, lentils don’t leave much residue, but when paired with flax there is more residue left on the field after harvest.

If a field doesn’t have much crop residue covering the field after harvest, planting cover crops is the priority. To support this, they seed their cover crops as soon as possible after harvest. They also try to establish cover crops between the cash crop rows before harvest to maximize growing days. For example, they plant season-long cover crops, such as red clover, together with annual grain crops, such as wheat or rye.

Every year is different, but the Axtens’ goal is to have a living root in the soil as long as possible. The Axtens see cover crops as a way to ensure that there is living root in the soil which supports microbial diversity, drought tolerance, and nutrient cycling. Cover crops also provides grazing for neighbours’ cattle, which in turn provides compost for their operations.

Covered soil buffers temperature variation, reduces moisture loss, protects against erosion, reduces weed competition and provides habitat for soil microorganisms. Living roots also protect the soil from water and wind erosion and increase soil organic matter which improves water holding capacity. As well, cover crops help soils sequester more carbon.\(^\text{10}\)

COMPOST
Compost stabilizes soil pH and nutrients and supports an environment that fights plant diseases and makes nutrients available to plants.\(^\text{11}\) The Axtens integrate compost and compost derivatives into their soil management in a number of ways.

With manure from a neighbour’s beef feedlot, straw, hay, grain screenings and wood chips, the Axtens create compost windrows. They aim for a ratio of 25 to 30 parts carbon to one part nitrogen.\(^\text{12}\) In order to get rid of potential pathogens and weed seeds, the Axtens allow the compost windrows to heat to over 55°C (131°F) at the centre for at least three days. Then the compost is turned at least 5 times to distribute the heat. Once the compost is back to ambient temperature, it is ready to use. Some is spread on fields, but it is impossible to use this compost throughout their 6,000 acres.

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\(^{10}\) publications.gc.ca/collections/Collection-R/LoPBdP/BP/prb0038-e.htm
\(^{11}\) www.livescience.com/63559-composting.html
\(^{12}\) compost.css.cornell.edu/calc/cn_ratio.html
Instead, with the help of her microscope, Tannis identifies those windrows with the strongest and most diverse population of beneficial organisms to make compost extracts and teas which allow the benefits of the compost to be spread over many acres. Tannis emphasizes that farmers need to be prepared to learn the science of compost if they are interested in the approach. They must be able to identify the microorganisms in their compost to avoid growing undesirable ones. Farmers not able to identify microorganisms with a microscope can use a phospholipid fatty acids (PLFA) soil test.

Making compost extract involves washing water through the compost to extract microorganisms. The concentration of the microbes in the extract depends on the compost. This is why Tannis tries to identify those windrows with the most microorganism diversity and keeps changing the compost in the baskets through which she washes the water, until she is happy with the concentration and diversity of organisms in the extract. The Axtens then use this compost extract in the liquid system of their seeder to apply in furrows when seeding instead of liquid phosphorous, although they still use a small amount of dry phosphorus. The main goal is to reintroduce these organisms into the soil and restore soil biology.

A major difference between compost extract and compost tea is that foods are added to a tea. To make compost tea, Tannis mixes the compost extract with foods such as fish hydrolysate, kelp, humic acid, and molasses in a large steel tank with aeration. The added foods help to feed the microorganisms to increase their numbers in the tea. When the organisms grow rapidly they produce glues that help them to stick to surfaces. This compost tea is spread with the sprayer as a foliar application which sticks to leaves to help prevent disease and migrates into the crop’s root exudates.

Starting in the fall of 2018, Tannis and her son have started experimenting with vermicomposting to test its potential to produce a compost inoculant. With the help of Red Wigglers and European Night Crawlers, they are testing a variety of worm diets to see which produce the most microbially diverse compost. These test diets range from grain screenings to household organic waste. If these experiments are successful, they may provide another route to enhance their compost extracts and teas.

CONTROLLED TRAFFIC AND LOW-DISTURBANCE SEEDING

The disc seeder that Derek bought on his 2006 trip to South Dakota is long gone, but the Axtens still use a disc seeder as a way to eliminate or minimize soil disturbance to preserve soil structure.

The Axtens also use controlled traffic farming, which involves using the same track for all operations, confining machinery load to the smallest possible area. For instance, while most farming systems compact 75% of area; CTF only compacts 15%. By minimizing the impact of equipment on soil, soil structure is maintained.

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13 Extract doesn’t have to be made first. Most people just add foods as they are extracting the organisms out of the compost and then let it brew.
The Axtens assess the impacts

The Axtens says that the changes they have made to their farming operation have had impacts, some of which are tangible, other not.

For instance, they have maintained or improved their yields. They have an average land equivalency ratio of 1.25:1 on their intercropped fields. The impact of the compost application on yields is more difficult to measure, but the Axtens maintain that to date they have sustained yields with significantly lower synthetic inputs.

The Axtens have significantly reduced their use of synthetic inputs. Depending on the year, they use between 50% – 60% less than they used to. They have not used insecticides in six years. They apply small amounts of nitrogen ahead of those crops that are not intercropped, notably cereal crops. Reducing their investment in inputs has reduced their financial risk, especially in dry years when yields are low.

The work that Derek and Tannis are doing on their farm is beginning to get recognized. For instance, in 2017 they were awarded the Saskatchewan Outstanding Young Farmer Award, for which they had been nominated by their accountant. Later that same year, they shared the National Outstanding Young Farmer Award with a couple from Quebec. In 2018, the Saskatchewan Soil Conservation Association awarded them the L.B Thomson Conservation Award that recognizes individuals making contributions to improving soil and water conservation.

By the numbers

Since 2013, the Axtens have improved yields by about 25%, while reducing input costs by 50% – 60%.

<table>
<thead>
<tr>
<th>PESTICIDE INPUT ($/acre)</th>
<th>FERTILIZER INPUT ($/acre)</th>
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</thead>
<tbody>
<tr>
<td>2013 37.91</td>
<td>50.26</td>
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<td>2014 47.31</td>
<td>50.28</td>
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<td>2015 50.99</td>
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<td>2016 39.95</td>
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<td>2018 32.98</td>
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A significant part of these input reductions would be nitrogen fertilizers which would reduce associated greenhouse gas emissions. Soil microbes convert nitrogen fertilizers into nitrous oxide, a greenhouse gas with 300 times as much heat trapping power as carbon dioxide. Calculating these emissions is difficult because it depends on many factors, including soil type, soil microbial activity, moisture, temperature, season, crop type, fertilization rates and other agricultural practices. Researchers have pegged the microbial conversion of fertilizer to gas at somewhere between 1.75 and 5 percent.

In addition, approximately 50% of the greenhouse gas emissions associated with fertilizers are attributable to their production. Any reduction in the use of synthetic fertilizers represents a drop in the greenhouse gas emissions associated in the production of those fertilizers, before even considering emissions associated with transportation.

The Saskatchewan Soil Conservation Association states that Canadian cropland could sequester about 22 million tonnes of atmospheric CO₂ per year by using best management practices. These best practices include increasing biomass and cover crops,

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14 See footnote 2.
15 www.sciencenews.org/article/fertilizer-produces-far-more-greenhouse-gas-expected
16 www.farmcarbontoolkit.org.uk/toolkit/fertiliser-production
17 ssca.ca/soil-carbon-sequestration

www.environmentalsociety.ca | 6
Derek and Tannis would do it all again. They are happy with the changes they have made and feel that they are working well for their farm. They feel that the biggest barrier to making the changes was mindset. Changing from a focus on plants to an ecosystem focus required them to re-evaluate many of their practices and beliefs. This is not an easy thing to do.

For instance, making changes required moving away from focusing only on maximizing yields to an approach that looks at the cost of production and its impacts on the bottom line. It also required moving away from a mindset that demands perfect rows of one crop, totally weed-free. Intercropped fields look messier. You also have to be prepared to do things differently than your neighbours, which is not always easy, as everybody likes to fit in.

Finding what works best for their farm required a willingness to learn and experiment with new approaches. The key is to start experimenting. The experiments can initially be small in terms of acreage but ambitious in terms of the boundaries that they test.

The Axten’s farm purpose is “Loyal to the Soil.” All farm decisions are held up to that purpose. Their farm is not just a business, but also an investment in the future.

While agriculture is only one of many sectors contributing to the climate crisis, it will disproportionately be affected by its impacts. Saskatchewan farmers have always been vulnerable to the weather extremes. As these extremes are amplified by climate change, Saskatchewan farmers will become increasingly vulnerable to extreme water events, droughts and changing pest and disease ranges.

Agriculture is a difficult sector in which to reduce greenhouse gas emissions, but by being “loyal to the soil,” the Axtens are not only taking steps that reduce some of the greenhouse gas emissions associated with their farm, but are also buffering against the impacts of extreme weather. While the Axtens’ approach may be not for everyone, it does show that reducing greenhouse gas emissions on the farm need not be detrimental to the bottom line.

Both of which are central to the Axtens’ approach to farming.

Despite farming very differently than they used to, they have not notably increased their use of fuel. Their controlled traffic farming has reduced fuel use, but this is balanced out by making extra passes with the seeder to plant cover crops.

For Your Information

Southeast Research Farm: www.southeastresearchfarm.org/home.html
Dwayne Beck: notill.org/dwayne-beck
Dakota Lakes Research Farm: www.dakotalakes.com
Gabe and Paul Brown, Brown’s Ranch: brownsranch.us/soil-health/
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