Leading Edge

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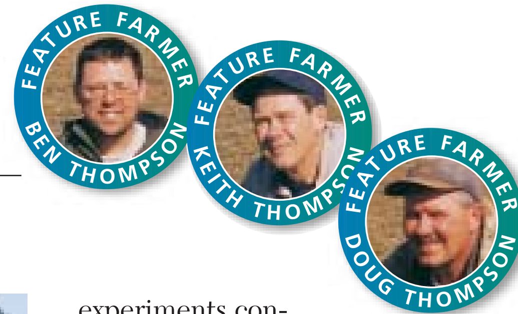
No·till On The Plains

# Think Twice

by Matt Hagny




"Organized Chaos"—are the words used by Kirk Gadzia to describe 'stacked' rotations and the resulting 'confusion' of the pests, but this phrase aptly describes Thompson Farms LLC as well. Brothers Keith and Doug Thompson, along with Keith's son Ben, and the family patriarch Jim, juggle lots of activities both on and off their farm south of Topeka, KS. The result might appear haphazard, but the farm has a fluid structure and solid management that runs deep.

No aspect of their operation is left undisturbed as Thompsons search for greater efficiencies in everything: wringing a few more dollars out of their budget, tinkering towards better seeding equipment, testing crop varieties, or reinventing how they

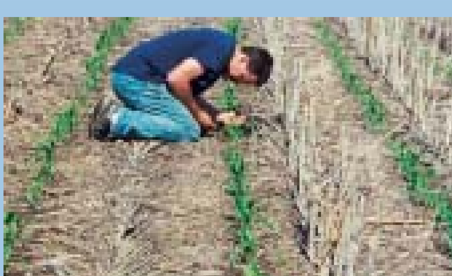


Photo by Keith Thompson.

Ben checks the root development in a young milo crop. Everything is closely monitored for desired results at Thompson Farms.

Photo by Keith Thompson.

For Thompsons, double-cropping after wheat is both an opportunity and a necessity. 2001 double-crop milo here.

write their lease arrangements. The Thompsons search far and wide for improvements, with Keith having made three trips to South America to gather new understanding, with Ben the voracious reader, and with Doug keeping tabs on the latest developments in the seed & herbicide industry through a Dekalb/Asgrow dealership. They take the best of what's around, add a few ideas of their own, and put them all to the test in dozens of different experiments conducted each year on Thompson Farms. Yield maps, detailed financial records, and lots of analysis keep them honest with themselves.

The departure from conventional thinking must be genetic—at least that should be your conclusion after getting to know the Thompsons. Jim first tried no-till in nineteen-*forty*, on hundreds of acres! Far from being a sign of lunacy, it was a calculated decision during an exceptionally wet spring & summer as a last-ditch effort to get the crop planted. Jim notes, "We got a stand,

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Photo by Keith Thompson.

Extra-wide tires on the combine (60*50*32 front, 28L*26 rear) keep Thompsons' future seedbeds in good condition.

but it was a wreck due to the lack of herbicides . . . but at least we made a crop. It was either that or no crop at all that year." No-till had some growing up to do.

Keith took up the challenge in the early 1970s, after attending K-State and hearing about this revolutionary new concept of no-till to increase infiltration. In ag technology, no-till "was really the hot topic at the time." During the '70s, Keith tried no-till on some little 5- or 6-acre tracts almost every year, typically with milo planted with a Deere 1250 planter and using Gramoxone for weed control. Keith: "We had good weed control, but no stand. But it worked good in the anhydrous track [where the soil was disturbed] . . . . We basically quit dinging with no-till during that time because I didn't like the danger of spraying paraquat from an open-station tractor." Keith expresses regret at not having pulled all the necessary pieces together in the 1970s: "It was the same time that Carlos Crovetto and Rolf Derpsch were [independently] in the U.S. studying no-till—Carlos put two and two together: no-till planting with Roundup. I hadn't heard about Roundup yet."

**Thompsons learned years ago: "There was apparently more to no-till than just taking the tillage out. What I had missed was the idea of using rotations to get rid of the weeds."**

Still, Keith knew that reducing tillage was where he needed to go, and he was truly min-till all through the '70s and '80s—basically he field cultivated and planted, or chiseled, field cultivated, then planted. Technology suitable to no-till continued to improve, and Thompsons advanced their understanding. By 1991, Thompsons were 100% no-till in their *planting* methods, having been convinced of its feasibility at a no-till conference in St. Louis that year. They still did some in-crop cultivating for a couple years, in the spots or fields that appeared to need it. Ever the observer, Keith began noticing he always had more weeds emerging shortly after each cultivation—he was planting as much shattercane as what he was killing out. Not to mention the cultivator made the fields rough. "Cultivating was causing more problems than it was curing," says Keith, and it was soon abandoned—by '93 they were true no-tillers on all their acres. The commitment was to permanent no-till, as Ben notes, "Lots of tillage equipment was being sold while I was in high school."

## Getting a "Brain Transplant"

Thompsons' rotation during that time was a continuation of their milo >>soybean, or corn >>soy, rotation carried in from their min-till system. It was no bed of roses. Keith remarks, "During those first three or four years of no-till, our shattercane was getting worse—we fought it tooth and nail . . . . There was apparently more to no-till than just taking the tillage out . . . . What I had missed was the idea of using [long] rotations to get rid of the weeds." Keith's friendship with Bud Davis, NRCS state agronomist, helped him see the light: "Bud was saying that I really needed to be looking at no-till as a way to *cut* herbicide costs—Bud had heard [Dwayne] Beck and quickly latched onto the concept." Davis finally con-


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**No-Till on the Plains Inc's Mission:** To assist agricultural producers in implementing economically, agronomically, and environmentally sound crop production systems.

**Objective:** To increase the adoption of cropping systems that will enhance economic potential, soil and water quality, and quality of life while reducing crop production risks.

**"No-till really started to work with stacked rotations."**

vinced Thompsons to plant wheat in the fall of '94 with the Deere 750 drill Keith had won as a door prize at Monsanto's Main Event conference in '93 (they hadn't had much use for the drill up until that time—they hadn't grown wheat since '88, and put in most of their milo and beans with a planter at that time).

Keith explains, "The turning point [in our thinking] was in '95 during the bus tour to Beck's farm." Ben chuckles and adds, "We really thought we were wild by adding this extra crop of wheat to our rotation—then we went up there and Beck had *all* these *other* crops. And his wheat yields were so much better. It was a shock how much more could be done—a humongous difference. After seeing what Beck was doing, we had a completely different mindset on how we should be farming." Keith laughs, "During that tour, Beck was so far ahead of us, Ben and I were embarrassed to tell anyone that we farmed!"

Thompsons went home and got busy developing their rotations. They started managing their wheat for higher yields instead of treating it like "the poor step-child" of crops, although Keith admits they still don't know what they're doing. They added double-crops after the wheat, including soybeans, milo, sunflowers and even double-crop corn. They experimented with a wide assortment of sequences, and have been doing a considerable amount of stacking in the last few years ('stacking' is planting the same crop back-to-back, following a long break).

They don't really have a set rotation yet, but have gathered up lots of desirable—and undesirable—sequences for their area. They are quick to point out their failure with wheat after corn—it was miserable. They are having good success with wheat after soybean, which is the typical place for wheat for them. After the soy >>wht/double-crop b-lf, they often will grow two years of corn or two years of milo. Up until last year, nearly all their corn was on bottomland near creeks, with the milo up on the hills—'02 had them planting much more upland corn, partly due to shattercane problems and partly due to finally becoming convinced of its viability. After the corn or milo crops, the rotation continues with one or two years of soybeans. "We'd eventually like to add stacked wheat,

**"For us, the most important component is the rotations."**

possibly with a cover crop of sunn hemp between," as a few farmers in the state are doing.

Keith explains the move to stacking of the crops: "When Ben and I got back from Argentina [in Dec. of '99], we were asking ourselves, 'How do we get the weed pressure down?' Dwayne Beck had been talking about stacking to do exactly that, so we decided to try it." The proof is in the pudding. Keith again: "Wherever we had a crop that followed a stack [of a different crop], our herbicide requirements were less. Stacks are getting rid of our weeds . . . . No-till really started to work with stacking."

Double-cropping is now standard for them. "For us, the most important component is the rotations. We don't want to waste the water. Always plant something," explains Keith, "We haven't had much difference in profit between double-crop milo and double-crop corn, even with the zero yield of double-crop corn in the drought of 2000. Seed costs are higher with corn, especially since it's nearly all *Bt* [on the double-crop corn, due to high corn-borer pressure later in the season], but the grain sells for more, and yields have been similar."


Photo by Keith Thompson.

Seedling soybeans, showing the difference between cover crop rye and none—note the extreme density of waterhemp in the foreground where no rye was grown. Ben emphasized how much better the field planted where the cover crop was.


The Thompson tribe—Ben, Keith, Doug.


What the heck did they lose?

Photos by Matt Hagny.

You can't understand this farming operation without some knowledge of the characters who make up the cast. Keith is the farm's technology guru and chief number-cruncher, who loves his "dirtbag" mountain-biking trips, scuba diving, blues concerts, giving no-till presentations, and taking a drubbing at the hands of a new software installation (he's a true techie Linux-lover). Ben is the chief engineer, machinery maintenance guy, and goat-keeper; he also rides dirt bikes and spends time with a new baby daughter, Josie. Doug runs the farm's retail seed business and is chief architect of herbicide strategies, still finding time to enjoy hunting and golfing. Thompsons take their diversity seriously!

**"Tractor driving isn't a hobby around here."**

Actually, Thompsons don't see that much difference in profitability among any of the double-crops of corn, milo, sunflowers, and soybeans, noting only a few dollars difference so far. Thompsons are quite excited about double-crop sunflowers, having hit a home run with them in '02—after many failures in previous years. It is a love/hate relation. "Every time we've had double-crop flowers, the next year's milo or corn would be the best yield ever for that field. The problem is that every damn thing in the world wants to eat sunflowers [requiring much management and intervention]," explains Keith. While Thompsons are still experimenting with flowers, double-cropping is proven for them—"Even with the losses of 2000, averaging all the years since '96, double-crops are profitable for us."

Thompsons are also working to integrate cover crops into their rotations, having experimented with red clover, rye, winter oats, cowpeas, sudan, and turnips—although on a very limited basis with each. Once they b'cast seeded red clover into their wheat, only to have it grow up to weeds after wheat harvest—the clover was too slow. A mower took care of the weeds, and a neighbor took some good hay off late in the summer. Two years later the part of the field that had clover yielded over 15 bu/a more corn.

Thompsons are excited about oats (either spring or winter) for a cover ahead of soybeans, and are intrigued by a few other species for certain niches. Doug observes, "We will pick and choose cover crops carefully—no different than other crops. It's management." Ben likes the plantability of a living cover crop. Ben also sees the potential in growing some of these double-crops for forages, either for hay or grazing. Ben has assembled a goat herd, and is always looking for grazing: "I planted a small field to pearl millet/cowpea mix; grazed it into the ground, then planted millet again and grazed it off. Next I bought some turnip seed for $2/a—half of that was for UPS—and broadcast seeded it. I got two months worth of grazing out of the turnips."

### This is fun??

Thompson's approach to fertilizing has run the gamut of experimentation as well, currently with much of the N, K, and S being b'cast in March. Back in the early and mid-90s, they typically used anhydrous applied with a knife. The soil disturbance was always a problem, as Doug notes, "The weeds came up really well in the anhydrous slot." Erosion was also a factor, as was safety. Anhydrous was dropped in '97. Keith explains, "K-State's own data shows only a 3 bu/a advantage for milo with anhydrous [versus other N fertilizer methods]. *But it isn't more profitable*—it was costing me more to put it on than what I was getting in extra yield! Not to mention the extra herbicide needed to control the weeds." Ben grins slyly and adds, "But the way we do it does rob you of the opportunity to drive the tractor."

**Thompsons' herbicide costs during the last 3 years averaged $15 to 18 per crop acre, excluding RR tech. fees. That is a far cry from the $37/a they spent in their min-till days.**

To the Thompsons, driving the tractor around is a necessary evil, not some pleasant event—all of them have hobbies, family, and friends that they enjoy far more than driving tractor. Keith emphasizes that work allows fun time, and isn't a substitute: "You drive tractor so that you can go ride bike, or go climbing, or scuba diving—tractor driving isn't a hobby around here."

Photo by Keith Thompson.

The rest of the workforce: Jim (Keith & Doug's dad) and Erinn (Keith's daughter—home from college to supervise the planting).

### Diligence Pays

Their no-till is moving them in the right direction, with herbicide costs during the last 3 years averaging $15 to 18 per crop acre, excluding RR tech. fees. That is a far cry from the $37/a they spent in their min-till days. Doug mentions, "One of the keys is being on time. We typically cover much of the acreage in the winter, using Sencor, 2,4-D, Roundup or other products to keep down the winter annuals." They are dropping wintertime atrazine due to its potential to move off-site with the occasional runoff that still comes off their clay hills, but will replace that program with either Sencor or simazine. By spring, low rates of glyphosate + 2,4-D get things set up, then frugal rates in-crop. They are getting things cleaned up to the point of often not needing grass herbicides in the milo and corn. Their weed pressures are low enough that their control costs are less on traditional corn than it is on Roundup Ready corn (no surprise which one they favor, then). They are willing to tolerate a few escapes in any of their weed control programs, knowing the rotation will take care of many weeds by itself.

Thompsons' yields are getting better, too, and costs continue to shrink. Profitability has been better than in their tillage days, although the droughts of 2000 and '02 don't help that picture. Thompsons are noticing other benefits, too. For instance, milo doesn't fall over due to diseases and drought stress like it did for them in min-till. Their wheat yields continue to improve "as we learn how to grow it."

Getting back to the timeline of their no-till experience, Ben & Keith recount their successes in the late '90s, when they were really getting it put together. "People started asking us lots of questions, and we got our pictures in the magazines. We started to think we had this figured out. Then we went up to Beck's farm two years ago and got a reality check—we really don't know anything," laughs Ben.

Ever the diligent students, Keith, Ben, and Doug continue to study up on better management, more efficient no-till, and just plain better ways of doing things. They put considerable thought into each move, preferring to think twice before acting, rather than always trying to extricate themselves from some mess of their own creation. You can hear the excitement in each of their voices when they tell of a new discovery. Never 'business as usual' at Thompson Farms—the flurry of activity and persistent experimentation can be dizzying, the sharp thinking contagious.

# Plan ahead . . .

Now is the time to order inoculants for your legume crops and cover crops. Taking delivery early and storing the inoculants yourself will prevent the loss of viability that commonly occurs during the summer months when inoculants are being shipped in trucks and stored in warehouses that get much too warm for these organisms. Shipping direct also reduces 'unknowns' in the handling chain. Once in your possession, store the inoculant in a cool place away from sunlight, such as a basement. Do not freeze liquid or peat inoculants, and do not thaw frozen inoculants until ready for use. Do not thaw in a microwave, and do not mix inoculants with chlorinated water.

Which inoculant type is needed creates much confusion, so we offer the following chart as a guide. Remember that if an inoculant species hasn't yet been introduced to a particular field, it is imperative to deliver a high load of live inoculant of the proper species & strain—as a general rule the *Rhizobia & Bradyrhizobia* do not cross-over between groups, i.e., *a soybean inoculant won't do much for a cowpea, nor will a cowpea inoculant do anything for alfalfa, and vice-versa.*[1] Since close doesn't count in this game, check with your inoculant company for specific products and their uses (not every company's products and/or strains will exactly match these groupings).


Photo by Roger Long.

| | |
|---|---|
| **Alfalfa group**[2] | alfalfa<br>sweetclover<br>medic |
| **Clover group**[3] | crimson clover<br>red clover<br>white clover<br>other true clovers |
| **Arrowleaf clover group** | arrowleaf clover |
| **Vetch/pea group** | lentil<br>vetch<br>faba bean (a.k.a. bell bean)<br>field pea (a.k.a. spring pea)<br>Austrian winter pea<br>sweet pea<br>garden pea |
| **Trefoil group** | Trefoil *(Lotus spp.)* |
| **Chickpea (garbanzo) group** | chickpea |
| **Lupin group** | lupin<br>seradella *(Ornithopus spp.)* |
| **Dry/garden bean group** | red kidney bean<br>pinto bean<br>navy bean<br>wax bean<br>garden bean<br>scarlet runner bean |
| **Lima bean group** | lima bean |
| **Cowpea group** | cowpea (a.k.a. crowder)<br>black-eyed pea<br>mung bean<br>*Crotalaria spp.* (sunn hemp)<br>guar<br>lespedeza<br>velvetbean<br>jackbean *(Canavalia ensiformis)*<br>pigeonpea *(Cajanus cajun)*<br>indigo, others<br>peanut[4] |
| **Soybean group** | soybean |

[1] However, some legume plant species *are* colonized by more than one species of *Rhizobium* or *Bradyrhizobium*, although not equally well—confusing, isn't it?

[2] Some companies offer strains for the annual medics that are slightly different from the alfalfa/sweetclover inoculant, while other companies' products may include several strains and be rather effective on both groups. Also, within these groups, some very specific strains may have been developed for better compatibility with a certain crop even though some other inoculant strains will be at least partially effective.

[3] Again, some companies separate the clovers into two or more groups with separate inoculants for each, while others combine the strains for all the clovers in with the alfalfa strain to make a single inoculant.

[4] Some companies have a separate inoculant for peanuts.

# Soil Organic Matter and N Cycling

by Ray Ward

SCIENCE

Raymond C. Ward is a soil scientist & founder of Ward Laboratories at Kearney, NE.

Photo by Doug Palen.

The author examines soil structure during the '01 Kansas No-Till Tour. During these forays, Ward is always armed with his trusty spade and his quick wit.

There are a lot of questions about fertilizers, fertilizer application, and plant nutrition. To address some of these questions, I thought I would discuss some of the basics of soil fertility and soil chemistry. Since carbon (C) is the largest nutrient required by a growing plant, and N is second, I will discuss those relationships first.

Soil organic matter (OM) is the *decomposed* plant residues and microorganisms. The pieces of plant material you see on the soil surface either from the last harvest or from several years ago is crop residue, not soil organic matter. The real carbon sequestration occurs in the decomposed plant residues.

The stable organic matter in the soil has a carbon to nitrogen (C:N) ratio range of 10:1 to 12:1. One percent organic matter is the same as 10,000 pounds of OM per 1,000,000 pounds of soil. Since one inch of soil across one acre weighs about 300,000 pounds, an 8-inch layer of soil containing 1% OM is the same as 24,000 pounds of OM. This is 12 tons of OM. If a soil has 3% OM in the top 8 inches of soil then there are 36 tons per acre.

Organic matter is 58% carbon, which is almost 21 tons of carbon per acre in those 36 tons. So with a C:N of about 10:1, if there is 21 tons of carbon then there is 2.1 tons of organic N or 4200 pounds of organic N per acre in an 8-inch layer of soil. How much of this organic N is available to a crop in one year? In the days of conventional tillage we considered the following as useful guidelines for a soil with 3% OM (i.e., 4200 lbs. organic N):

for small grains: 1% release per year (42 lbs of N)
row crops: 2% release per year (84 lbs of N)
summerfallow: 4% release per year (168 lbs of N)

With tillage a considerable amount of organic nitrogen was released per year, and the variation in the above figures is due to the timing and extent of tillage and the timing of the crop's growth. One of the reasons for summerfallowing was mineralization of organic N to nitrate. As the N was released, carbon was lost as carbon dioxide ($CO_2$). Therefore as we continued to cultivate the land we lost organic matter. Turnover in undisturbed grasslands is much slower, at about 0.5% release per year (21 lbs of N).

## An Empty Warehouse?

Why is soil OM important? As I described, it is a 'warehouse' for N storage, as well as other nutrients, which are slowly released or 'spoon-fed' to the crop under no-till. Soil OM also improves the water-holding capacity of the soil, as well as the physical properties of the soil which will be discussed.

**As no-tillers try to build organic matter in the soil, one must remember that N has to be sequestered as well as carbon. This does not imply that we can build OM just by over-applying N.**

As no-tillers try to build organic matter in the soil, one must remember that N has to be sequestered also. By leaving residue on the surface it is hoped that OM will build. How does this happen? When crop residues are incorporated by tillage, the microorganism population increases very rapidly. If there is good moisture, warm temperatures, and available nitrate, decomposition is complete in a few short months. *(Editors' Note: The atmospheric oxygen introduced into the soil by tillage allows the population explosion of decomposing organisms, which need the oxygen for respiration—their 'feeding frenzy' typically oxidizes more C than what the crop accumulated during the season.)* Tillage also decreases the size of aggregates (granular clumps of soil), allowing microorganisms more access to carbon inside those aggregates. Therefore, tillage over a period of 50 to 60 years released carbon (and other nutrients) that had taken dozens of centuries to accumulate. By leaving the soil undisturbed we begin the process of building OM. However, for every 10 pounds of carbon trapped, one


Photo by Matt Hagny.

Ward in his natural habitat. He developed and managed several different soil labs in various states before founding his own at Kearney.

pound of N must be trapped. This will take a very long time because we are applying just enough N to meet crop needs. It does *not* imply that we can build OM just by over-applying N. The problem is surface residue and solubility of nitrate: An inch of rain will move extra nitrate away from the residue with the possibility of it moving through the root zone if not used by the growing crop. Building soil OM can best be done simply by managing for high-yielding crops under permanent no-till, using N fertilization methods that are efficient for plant growth and application.

**With tillage a considerable amount of organic nitrogen was released per year from those prairie soils. This shows how the pioneers were able to grow good crops without N fertilizer: it was supplied by the OM.**

Getting back to the old guideline of N release from organic matter. It was the method we used to estimate N availability before we started using nitrate soil testing. This shows how the pioneers were able to grow good crops without N fertilizer: it was supplied by the OM. As tillage continued, organic N was mineralized until equilibrium was reached where very little OM was being mineralized. That is when farmers on the Great Plains started using N fertilizer.

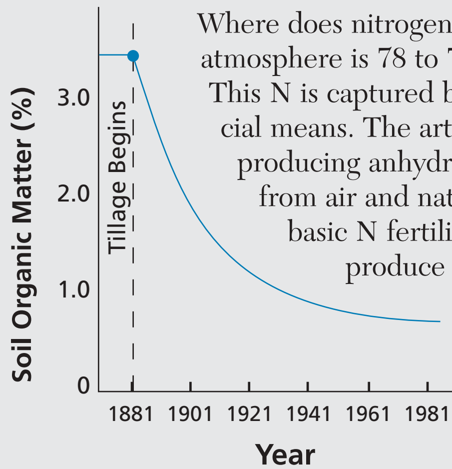
## Recovery

Why does the soil in no-till seem like it has a lot more organic matter even though the OM soil test is increasing very slowly? Leaving residue on the surface increases soil biology. High residue favors increased earthworm activity. This activity increases water infiltration, reducing water runoff. In addition, residue on the surface reduces water evaporation, allowing the soil to remain wetter for a longer period of time. Microbe populations thrive with better moisture and a constant supply of food (residue). Compounds produced by the microorganisms bind soil particles together to form aggregates. Some of the 'glue' is water-stable so the aggregates remain intact during rainfall; however, residue must remain on the surface to protect the aggregate from raindrop splash.

Surface soil structure improves quickly when no-till is adopted, and we see great benefits in 3 to 4 years. The improved soil structure is noted by the no-tiller, who assumes OM is increasing (it probably *is* increasing, but at a rate too low to reliably be detected in soil tests; it may also be increasing at depths greater than are typically sampled for OM, if rotational changes occur which include more deeply rooted crops).

Improved soil structure in no-till also helps to retain nitrate-N. The nitrate ion can migrate inside of the aggregate. Water flows through the soil in the macropores between the aggregates. Since much of the nitrate is 'protected' in the aggregate, it is less subject to leaching as water infiltrates the soil.

## From Thin Air




Where does nitrogen come from? The atmosphere is 78 to 79% nitrogen gas. This N is captured by natural and artificial means. The artificial method is producing anhydrous ammonia ($NH_3$) from air and natural gas. $NH_3$ is the basic N fertilizer that is used to produce all other commercial N fertilizers.

The natural means include N fixation by symbiotic and non-symbiotic (free-living) microorganisms. Certain bacteria (such as *Rhizobia*) in relationship with legume crops can carry out symbiotic N fixation. These bacteria infect the root hairs and establish colonies or nodules on the roots. The *Rhizobia* fix N for the plant and the plant feeds the bacteria from the photosynthate produced by the leaves: a symbiotic relationship. Each legume has a specific *Rhizobium* symbiont. It is interesting to note that the artificial and natural processes do the same thing: taking atmospheric $N_2$ gas and converting to $NH_3$.


Photo by Matt Hagny.

Growing high-yielding crops is one of the key steps to building and maintaining soil OM.

Free-living, non-symbiotic N-fixing microorganisms are able to fix N from the air without living with another plant. The annual supply of N contributed by non-symbiotic fixation probably amounts to a maximum of 6 pounds of N per acre per year. This estimate is based on cultivated agriculture. There is some research that indicates we can expect 2½ times more N to be fixed by non-symbiotic microorganisms in a no-till system. By developing a more vibrant population of microorganisms in no-till, we can expect to continue to improve N fixation. There is potential to sequester more carbon when we have an increase in fixed N from the microbes. As we use more cover crops, especially legumes, we will see an increase in N availability.

A small amount of N is also added to the soil through rainfall. Rough estimates say 4 to 7 pounds of N per acre are added annually.

Photo by Matt Hagny.

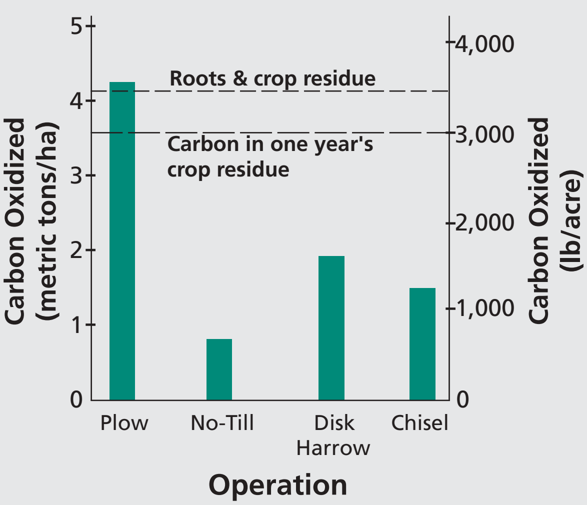
Permanent no-till is the other vital ingredient for increasing soil OM. Good structure in the soil is another by-product of leaving it undisturbed. Note that the mulch on the surface is not soil OM, nor will all of it become soil OM. Stable soil OM is formed of decomposed plant residues and microbes during a lengthy process. Tillage disrupts the balance by letting the microbes on the soil surface have too much plant residue and oxygen all at once, which they quickly consume, releasing all the carbon as $CO_2$ during respiration.

Legume crops have a higher concentration of N, which is reflected in their greater protein content (N is a component of protein). The C:N ratio of legumes is generally less than 20:1, which is equal to crude protein content of greater than 12%. Therefore, legumes start releasing nitrate as soon as decomposition begins. This is the reason that legumes have long been considered a source of soil fertility.

Corn stalks have C:N of about 70:1 (about 5% crude protein), and wheat straw also has C:N of approximately 70:1. As the residue begins to decompose, the microorganisms immobilize nitrate-N. In general, small grain straw and corn stalks 'tie up' from 18 to 30 pounds of N *per ton* of residue. After 3 to 4 years of no-till the decomposition of old residue is such that additional N is not needed. As decomposition proceeds further, nearly all the N that was initially immobilized in the small grain, corn, or milo residues will be mineralized (released). If only corn, milo, and small grains are rotated, the soil will have a rough equilibrium of immobilization by new residues and mineralization from old residues.[1] However, any legume in rotation will make mineralization dominate the equation while that residue is decomposing.

## From Stubble to OM

What happens to N when crop residue and N fertilizer are added to the soil? If the crop residue has a C:N ratio of greater than 30:1, the microbial population will use any available soil N to decompose the residue. This process is referred to as immobilization of N. On the other hand, if the C:N ratio of crop residue is less than 20:1, the microbial population will begin releasing available N as soon as decomposition starts. This process is referred to as mineralization. *(Editors, again: The microbes decomposing the residue aren't the same type that fix N.)*




Carbon oxidized in *19 days* in September following various tillage operations on wheat stubble in Morris, MN, from measured $CO_2$ emissions.
Source: D. Reicosky and M. Lindstrom, 1993.

What is happening to make the C:N ratio go from 70:1 down to 20:1, and eventually down to 10:1 in soil OM? The microbes are using the residues as a food source, and respiring $CO_2$ and so only a very small percentage of surface residues becomes soil OM. A much larger percentage of crop roots ends up as soil OM, even though root biomass is typically less than the aboveground portion for most annual crops. Note that the C:N ratio can be narrowed by either a substantial oxidizing of carbon by the microbes, or by the acquisition of additional N, typically organic N.

## N for Crops

Mineralization is the conversion of organic N to plant-available N ('organic' here means compounds containing C, 'plant-available' refers to $NH_4$ or $NO_3$). The process includes ammonification and nitrification. The controlling process is ammonification. If ammonium compounds are not produced then nitrification (the production of nitrate from ammonium) will be zero. Ammonification is able to

[1] N fertilizer is still required to grow the crop and to replace what is removed from the field in grain, as well as any other losses from the system (leaching, denitrification, etc).

Photo by Tom Will.

Dwayne Beck describes the fact that corn does exceptionally well following certain cover crops. This probably has something to do with creating elevated $CO_2$ levels in that corn canopy as the legume decomposes. Also because the legume N is naturally 'time released' or synchronized with corn root growth, and more dispersed through the profile. Additional biological reasons may exist.

continue under waterlogged conditions; therefore it is less affected by waterlogging than nitrification. Nitrification requires oxygen. If oxygen is low in the soil, nitrification will be low. Plant roots can take up the ammonium ($NH_4$) directly, before it converts to nitrate ($NO_3$), although if oxygen levels are too low to form nitrate then root growth will also be restricted. But as far as the plant is concerned, nitrate is nitrate and ammonia is ammonia—the plant cannot tell the difference between those N molecules derived from mineralized OM or from fertilizers or from legume fixation.

The optimum soil temperature for mineralization is between 77 and 95 degrees F. Below this temperature, mineralization gradually decreases and practically stops at or near the freezing point. This is why soils in the Dakotas accumulate and retain OM more easily than soils in Kansas or Oklahoma.

Partial sterilization of the soil also has an effect on rate of mineralization. Nitrate production is more rapid after the soil has been partially sterilized by drying or by freezing and thawing. This partial sterilization may account for the high rate of mineralization of nitrate-N in early spring or after a prolonged drought.

Early in the article I gave an example of estimating available nitrogen for different crops based on cropping practice and soil OM. In no-till we don't disturb the soil so the rate of release should be near the rate of undisturbed grasslands. When we hear about tilling land that was no-till, we can assume that we will get a tremendous release of available N from the organic N on or very near the soil surface. However, it will only take one year to release most of this N from the organic matter and then the process will have to start over again. The short-term benefit could be very costly to future cropping.

**The microbes are using the residues as a food source, and respiring $CO_2$. So only a very small percentage of surface residues becomes soil OM.**

From purely the standpoint of cycling N from soil OM, then, there is no reason to move to no-till. Those reasons are found elsewhere, such as improved moisture storage and usage, improved plant health, reductions in equipment and labor, etc. Even that is an oversimplification. The N being released from OM under no-till will be primarily temperature-dependent, since that is the limiting factor for mineralization in that system. Because crop growth is also temperature dependent, mineralization and crop uptake are closely matched, resulting in fewer losses. In a tillage system, mineralization is primarily influenced by when the tillage is done, which is typically long before planting the crop. Therefore, there is more chance for mineralized N to be leached or otherwise lost from that system. Soil and nutrients lost in runoff make the tilled system even more inefficient.

In future articles I will take up the problem of predicting N fertilizer requirements for a crop, as well as sources and methods for N fertilization and how those might differ in no-till compared with tilled systems.

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***Editors' Note: Very few people, scientists included, think of carbon as an essential plant nutrient to be managed as such. Dwayne Beck reminds us of this, noting that most greenhouses fortify their air with $CO_2$ to enhance plant growth. Managing the cycling of carbon in the context of no-till field crops is a new concept—basically sequencing the crops or timing the N applications to match $CO_2$ emissions from decaying residues with crop canopy conditions. Cycling nutrients is nothing new, but everyone forgot about the most important nutrient, carbon. Beck remarks playfully: "That's why we have Dwayne Beck around—to talk about the obvious stuff."***

Photo by Matt Hagny.

Rebuilding soil OM requires plants to accumulate carbon from the air, but also N must be acquired from somewhere. That N comes from the atmosphere by several routes: 1) from fertilizers synthesized from reacting natural gas with the air (under heat and pressure), 2) from N fixed by free-living organisms in the soil, and 3) from N fixed by bacteria living symbiotically on the roots of legume plants, such as this sunn hemp.

# Tillage Reincarnated

by Matt Hagny



Matt Hagny is a consulting agronomist for no-till systems, based in Salina, KS

Tillage has been reinvented. No longer the clumsy scratching and churning of the soil with crude instruments like plows, tandem discs, and the sweeps of yore, tillage has been redefined into some sexy nouveau alteration of the soil to enhance crop root growth and water infiltration. Just look at the ads—machines featuring cutting discs, chisel points, covering discs, and treaders all gathered into some perfect constellation to place fertilizer or "break up" compaction or create "rooting zones" or some other hoopla. At least in the old days tillage tools were simple, cheap, and effective. The new stuff is at least twice as complicated, and twice the price. At least you get to tear around in a big tractor and blow smoke.

Strip-till. Zone-till. Para-plow. Mole-knife. Vertical till. "No-till" rippers. Coulter machines. The list goes on. It is amazing how resilient the idea of tillage is. Let's take a minute to confront ourselves with the facts:

First, tillage does not eliminate or alleviate compaction. It applies pressure to the soil (if you don't believe it, have someone lower that ripper point onto your foot), which pushes the clay platelets together. Any and all tillage implements do this, it is just physics. Lifting and fluffing the soil creates equal pressure downward, not to mention the compressing action as the soil is inverted and/or lifted. All soils will be *more* compacted after the implement has passed than what they were before, even if the result is a fluffier soil. The temporary fluffing will go away with a few precip. events, leaving a true picture of what you have: soil with no structure. Tillage will not make compaction go away. Only natural processes can do that. The absolute best a tillage implement can hope to do is to rearrange your compaction (while adding a little more in doing so).

> **We grew up looking at crops planted into black tilled soils and think of it as 'natural.' This is a faulty paradigm. Nature does not grow plants in tilled soils.**

Secondly, tillage may temporarily reduce 'nutrient stratification,' as if that were some sort of problem. The prairies were stratified. Forests are stratified. Plants evolved to deal with this: they tend to have the greatest root mass near the surface—near the nutrients. No-till crops generally have more roots in the top two inches due to improved moisture conditions there, as well as greater root mass at depth (following old channels). While having some nutrients at depth is desirable, getting them there quickly requires big horsepower, and great destruction if you are already no-till. However, many natural processes will redistribute nutrients to depth quite effectively, including leaching, earthworms (particularly nightcrawlers), deep rooting crops, and the self-mulching (shrink/swell) of some clayey soils.

Photo by Matt Hagny.

High-yielding no-till corn. Would it have been better with strip-till or zone-till? Depends on the details of the comparison.

Third, tillage does not create the optimum environment for seedlings. This misconception apparently is perpetuated by various factors, including seedlings sometimes growing slightly faster in tilled soils (due to warmth and a flush of nutrients being released from oxidizing OM—but fast seedling growth does not a crop make). Or seedlings being more visible against the blackened soil. Or simply because most of the rural community grew up looking at crops planted into black tilled soils and think of it as 'natural.' This is a faulty paradigm. Nature does not grow plants in tilled soils. Look at a pasture, a prairie, a forest. The plants are growing fine without tillage. As for the seeding equipment, yes, much of what is out there has been engineered to work in a tilled fluffy seedbed. This is an engineering problem, not an agronomic one.

## *Why* Did That Result Occur?

So what to make of all the research showing yield improvements with strip-till, zone-till, ripping, or whatever? Well, look at the details. Since most scientists strive to minimize all variables except the one or two under scrutiny, something has to give. Often it is the case that the planter used in the study is optimized for tilled seedbeds, but not the no-till comparison, since the vast majority of planters are optimized for tilled systems by default—built that way and never changed. This gives an unfair advantage to strip-till right out of the gate.

**Kirk Gadzia: if it 'consumes' people or land, it isn't sustainable.**

Another detail is fertilizer placement. Part of the yield effect in strip-till is fertilizer placement, which can be duplicated in no-till (with pop-up applied in the seed row, and other fert. applied 3x0), but often is not done in the comparison, or is done incorrectly.[1] As for the soil warming effect, this too can be approximated with well-designed and properly adjusted row cleaners. Another effect is soil drying—if this is actually a concern, it is probably better addressed by intensifying rotations, perhaps by adding cover crops (note that you can seed a cover crop for roughly the cost of running a strip-till rig, using a piece of equipment that's already in inventory).

Other effects abound—the 'devil's in the detail.' In very short rotations, tillage will provide a partial sanitizing effect (by burying or decomposing more pests), and a corresponding yield boost. No-till accomplishes the same thing by maximizing decomposition and predation on the surface, taking more time but using fewer dollars.


Photo by Doug Palen.

Soils under no-till regain structure. Ironically, the tillage that is proposed to 'cure' compaction is the very thing that is *causing* the compaction.

On certain other occasions (e.g., when a very identifiable tillage-pan or natural fragipan is present, and moisture is not limiting) some sort of shank or ripper may produce yield improvements. These are often one-time improvements, and repeated usage will not produce the same response each time. In fact, they will tend to get smaller.[2] Another oft-overlooked aspect is that the tillage treatment is producing *yield* improvements, but not increasing *profitability*. Or, if it is, it does so with an increase in overhead or time investment. Remember Kirk Gadzia's words: if it 'consumes' people or land, it isn't sustainable.[3]

One of the least-recognized effects of deep tillage is the release of nutrients from soil OM, by introducing oxygen to depths it has never reached before. Apparently it isn't enough that we humans have plundered most of the OM in the surface 8 inches, we now must mine

**Richard Feynman: science is a way of preventing us from deceiving ourselves.**

| | '02 Corn bu/a |
|---|---|
| Fall strip-till, with 50 lbs. $P_2O_5$ | 171.6 |
| Fall strip-till, no $P_2O_5$ in fall | 165.6 |
| No-till, no $P_2O_5$ in fall | 169.4 |
| LSD (P=0.05) | 2.9 |

Location: Max Williams farm, Redfield, SD. Previous crop: wheat.

All treatments had 7 gallons of 10-34-0 (25 lbs $P_2O_5$) applied in the seed furrow at planting. All N was fall b'cast.

Protocol by Max Williams, Ron Christensen (Monsanto), and Jason Miller (NRCS). 4 replications, randomized.

| | '02 Corn bu/a |
|---|---|
| Fall strip-till with fert. placement | 153.0 |
| No-till, with b'cast fert. (fall) | 146.5 |
| Reduced-till, b'cast fert. (fall) | 152.0 |
| LSD (P=0.05) | not significant |

Location: Monsanto Ctr. Excellence, Beresford, SD. Previous crop: soybeans.

All treatments had 5 gallons of 10-34-0 applied in the seed furrow at planting.

10 lbs. N + 30 lbs. $P_2O_5$ placed with fall strip-till, same blend b'cast on other treatments. All treatments had 145 lbs. N fertilizer b'cast in the spring.

Protocol by John Thompson & Ron Christensen. 2 replications, randomized.

Although many strip-till studies have been done over the last two decades, the above are unusual in that they include P fert. applied in the seed furrow, which more closely matches the P availability effect of strip-till (note that 3x0 phos. placement does not, especially when high ammoniacal N rates are included there). Rotations, climate, planting date, and planter setup & adjustment will further affect the outcome of such studies.

[1] E.g., no phos. applied in the seed furrow (everything 3x0), improper rates or toxic sources (thiosul.) applied in the seed furrow, etc.

[2] Except perhaps with the natural fragipan that reforms each season in a certain few soils (some on the Coastal Plains of the southeastern U.S., some forest soils with cemented layers of iron compounds, etc.), and even then, crop roots, earthworms, and other biology may be more effective and/or economical in keeping the fracture lines in those fragipans open.

[3] in a presentation at No-Till on the Plains' Winter Conference (27 Jan. 2003). New Mexico-based Gadzia is a management consultant specializing in holistic approaches, with special expertise in intensive grazing.

deeper!!

### Why Tillage?

Remember that tillage is very effective at certain things. It is effective at releasing nutrients from OM, although this is not a bottomless resource, and does in fact run out. So if any nutrients are limiting in the study—N, P, K, S, Zn, etc.—tillage may show yield improvement in the short-term by oxidizing OM more quickly to cover those shortages. Probably better to just buy the nutrients.

**We are not passing judgment on our ancestors who did tillage, or those of you who were doing tillage several decades ago. At one time, it was the most efficient way to grow a crop, and civilizations were built upon that plentiful food supply.**

Tillage is effective at soil drying. Since agriculture is basically turning rain, sunlight, and nutrients into food, finding a way to make use of that moisture might be a better idea. If not used to grow cash crops directly, the water can be used for a cover crop to fix N (if leguminous), store nutrients (that otherwise might leach or denitrify), sequester carbon, suppress weeds, or create habitat for beneficial insects. Cover crops can also be effective at 'faking-out' some pests from dormancy.

Tillage is also good for sanitizing fields by accelerating the decomposition of disease organisms. If this is really the problem, find a longer rotation to break the disease cycle, and sequence crops so that they do not 'interfere' with each other (by allelopathy). However, most studies do not attempt to optimize rotations for no-till—they simply take the rotations commonly done and remove the tillage.

Some things tillage is not so good at doing. It does *not* control weeds in the long-term—if it did, we would be rid of them by now. Tillage does *not* increase infiltration—rainfall (simulated or real) provides visual confirmation of this. Tillage does *not* cut evaporation by "covering the cracks"—studies of fallow efficiencies and evaporation losses confirm this; however, surface residue is effective. Tillage does *not* aid root development—if it did, surely ripping pastures would be all the rage by now. Tillage does *not* prepare a good seedbed—did you ever ask the plant which it preferred? Okay, that is silly, but observe that all plants growing in nature are no-till, and that many no-till farmers are more consistent with stand establishment than their tillage-based neighbors. For some reason the cloddy soils, crusting, and poor germination of tilled seedbeds are just "facts of life," but the occasional problems no-tillers encounter are regarded as insurmountable, that "no-till just won't work here."

**Most of us deceive ourselves all too willingly.**

We are not passing judgment on our ancestors who did tillage, or those of you who were doing tillage several decades ago. At one time, it was the most efficient way to grow a crop, and civilizations were built upon that plentiful food supply (civilizations also crumbled when the soil became so eroded as to no longer provide that food, such as what happened in most of the Middle East and northern coast of Africa). However, times have changed—no-till is not only possible now, on large scales,[4] but is actually considerably more efficient than tillage-based systems. I personally know several producers who have been doing no-till for 20+ years, with profitability figures that stack up favorably with anyone's (avg. annual ROA in the double-digits, in at least one case), and who have no other income sources. Their yields and soils both continue to improve—what further proof is needed of continuous no-till being both achievable and functional? Do you think the results may be different if we wait another 20 years?

It is high time that we start the analysis from the proper stance: tillage is no longer to be thought of as acceptable (or desirable), but should instead be regarded with the utmost suspicion, as the destructive force that it really is. If there is any reasonable doubt, if the studies were flawed in any way, if there were aspects that were not considered, then we should *presume* that no-till is the right choice. There is no other way to confront the deeply embedded but erroneous mindset that tillage is acceptable, no other way to consider a question that almost never gets an unbiased assessment—too much money is at stake in selling steel, and very few people take the time and effort to do research that puts no-till on an equal footing. (Not all of this is intentional or mischievous; some is merely neglecting to consider all the details and their repercussions, or a lack of understanding of no-till methods.)

To paraphrase Richard Feynman, the great physicist: Science is a way of preventing us from deceiving ourselves. We really should think deeply about what it is we *want* to believe, before undertaking any study. Only then can we guard carefully against

[4] It was possible before, on small scales, if you were willing to poke seeds into the soil with a stick, and come back later and remove the weeds by hand.

our biases, to be more likely to arrive at the truth. A good scientist tries to disprove his or her own pet theories. A really good scientist wants very much to learn the outcome of a careful, insightful experiment, but does not really care *which* way it comes out—a position a bit difficult for some people to understand. Most of us deceive ourselves all too willingly. But if a person can achieve that detached view—that disinterested interest—real progress is possible. The human mind is indeed capable of logic and reason; we should make better use of it.

As Edward Faulkner wrote[5] way

[5] Edward H. Faulkner, 1943, *Plowman's Folly,* Univ. Oklahoma Press.

# "What Do You Mean, Herbicide Resistance?"

by Roger Long

SCIENCE

Roger Long is a Syngenta sales rep. for south-central KS

## Part II of a two-part series

**"But I used XYZ herbicide for the first time this year and the chemical rep said my weeds are resistant. How can this be?"**

Unfortunately, there are a couple of reasons why you could have weeds resistant to a product you've never used previously. Be aware that just because you use a new product, that doesn't necessarily mean you have never used the product's mode of action (MOA) before. Some MOA families are quite large, with the ALS-inhibiting group being a great example (refer to the MOA chart insert). The ALS herbicides also have a large number of weed species with biotypes resistant to this class of chemistry (refer to table). There are currently nine species with known herbicide resistance in the region, with three species having resistance to more than one MOA.

**Once a biotype is resistant to a particular herbicide, it is more likely to be resistant to other herbicides with the same mode of action (MOA)—what is called target-site "cross-resistance."**

Remember when most everyone used Pursuit (imazethapyr) on soybeans? During those years, a biotype resistant to imazethapyr (an ALS-inhibiting herbicide) began to flourish. It is now rare to kill Palmer amaranth with *any* ALS herbicide. One might argue that we now use glyphosate (a non-ALS mode of action) on Roundup Ready soybeans so it doesn't really matter, right?—*Wrong!* The ALS chemistry is not used very much on soybeans anymore but is commonly used on corn, milo, and wheat. This simple fact is why it is so important to know which MOA the herbicide you purchase utilizes. Once a biotype is resistant to a particular herbicide, it is more likely to be resistant to other herbicides with the same MOA—what is called target-site "cross-resistance."

Photo by Darrell Smith, *Farm Journal*.

Plan your herbicide applications so that different modes of action (MOAs) are used, preferably so that each weed species is controlled by several different MOAs during your crop rotation.

Both field observation and lab experiments validate the idea of cross-resistance within a MOA. As stated earlier, Palmer amaranth was first known to have ALS resistance in Kansas in 1991. The specific ALS herbicide in that case was Pursuit. In 1993, the company I worked for introduced Peak (prosulfuron), which was the first ALS herbicide labeled for milo. Peak provided very acceptable control of Palmer amaranth in '93 with only limited escapes. The following year, Palmer amaranth control was very inconsistent with many calling it nonexistent! What happened? My theory is that the existing population of Palmer amaranth was only partially susceptible to prosulfuron, which works slightly differently from Pursuit (these are MOA *families*, not twins). There likely was a biotype that was fully resistant to Pursuit and partially resistant to prosulfuron, and when only those individuals survived to produce pollen or seed, they repopulated the field with a biotype fully resistant to *both* Pursuit and Peak. The science of herbicides agrees with field observation—not only are there subtle differences in the way an 'imi' binds to the target site compared with a sulfonylurea, but ALS-resistant plant lineages can have their resistance conferred by different genetic sequences, creating several different versions of the ALS enzyme target site. So levels of cross-resistance will vary within any herbicide group, and even within any given weed population.[1]

**Some species spread resistance genes through pollen which can be carried for miles by wind.**

Troublesome fact number two: Mother Nature made weeds to spread! Some species spread resistance genes through pollen which can be carried miles and miles by wind. Palmer amaranth plants are either male or female, which means that a plant cannot pollinate itself and relies upon cross-pollination for seed production.[2] Put another way, in the dark of some windy summer night, a field down the road that has oodles of mature ALS-*resistant* Palmer amaranth males could pollinate your quiet, unassuming, and seemingly innocent ALS-*susceptible* female plants. The following year *you* have resistant Palmers.

Photo by Matt Hagny.

Keeping a heavy mulch on the soil surface will also inhibit weed germination, adding another layer of defense.

Photo by Matt Hagny.

Low disturbance of the soil helps, too. Weed seeds lying on the soil surface face a harsh reality—typically rotting or becoming fodder for other organisms before they ever get a chance to establish. Here, too much disturbance with the drill opener planted massive numbers of foxtail seeds, which appear as rows due to that disturbance (there's a stand of soybeans hidden amongst the foxtail). Because weed seeds have a certain percentage that lie dormant, often for several years, 'planting' them will ensure that you have weeds for as long as you farm.

There are other, more obvious, methods for weed biotypes to move around as well. Kochia (one of the tumbleweed species), which has enjoyed widespread ALS resistance for many years, will roll and tumble for many miles dropping seeds with each bounce. Machinery and wildlife move plenty of seeds around also. There is no foolproof way of fully guarding against resistance but it is important to give yourself the best chance at avoiding the problem.

**"What are some things I can do to manage my resistant population and keep from developing new problems?"**

One simple guiding principle answers this question . . . *change.* And I don't mean the stuff you jingle in your pockets. As stated in the first article, selection pressure (a control method that kills susceptible plants) in effect 'chooses' which individuals, biotypes, and species survive.

[1] For instance, "The variations in target site cross resistance among herbicide-resistant mutants indicates that the binding domains for the various classes of ALS-inhibiting herbicides do not fully overlap. [From gene sequencing studies], it is clear that there are several possible mutations of the ALS gene which will confer resistance to sulfonylurea and imidazolinone herbicides and yet retain enzyme function. It is likely, although not yet established, that these dif ferent mutations in the ALS gene provide different levels of target site cross resistance within and between ALS-inhibiting herbicide chemistries." Stephen B. Powles & Christopher Preston, *Herbicide Cross Resistance and Multiple Resistance in Plants*, from Herbicide Resistance Action Committee website.

[2] interview with Kassim Al-Khatib, KSU herbicide physiologist.

We too often fall into the trap of thinking only about herbicides in regards to selection pressure, but it is much more involved than just herbicides. For instance, the competitiveness of the crop also plays a huge role. Even with competitiveness, there are facets we often overlook. We generally think about a crop's canopy when we consider how a crop competes. This is a big factor, but far from the only one. The competition below ground may be more fierce than what goes on aboveground. Milo's fibrous root system competes very well for moisture in the upper portion of the soil, but allows a fast-growing weed with a deep taproot like puncturevine to more effectively pull moisture from farther down. Milo in 30-inch rows develops a late canopy that allows the puncturevine to get going early. When a weed germinates in relation to your crop is also a big factor. If a weed germinates at the same time your crop does (like downy brome in wheat) it is much more difficult to control than weeds germinating much earlier or later than your crop.

**Using several modes of action on each weed species during your crop rotation will help prevent resistance problems.**

Allelopathy plays a role as well, but science is only on the threshold of tapping into the nuances of this mechanism. 'Allelopathy' is the name for weed- or crop-made chemicals being excreted from the source plant that slow the growth or kill neighboring plants. I have always been fascinated with the effects puncturevine can have on the area it encompasses. If puncturevine gets up and growing before other plants germinate, there won't be anything else in the spread of its vines—in fact, nothing grows in that spot for a long time even after the puncturevine is dead.

Finally, get to know your herbicides and the MOA family to which they belong. Now that you're armed with this knowledge, use it!

### A Few Guidelines:

1. Try to avoid using only one MOA in a given year. If you do, as in the case of Roundup Ready soybeans (even with Roundup Ready there are some good, inexpensive pre-emerge options available to keep weed populations off-balance), be sure to use a different MOA on that field the following year. In other words, don't rely on glyphosate for weed control in corn when you relied solely on that MOA in the Roundup Ready soybeans on that field the year before.
2. Now that you are using two different MOA groups, do both active ingredients provide control of your targeted weeds? For example: combining an ALS herbicide with a synthetic auxin (growth regulator) herbicide for foxtail control is effectively like using only one MOA since synthetic auxins have virtually no activity on foxtails. In other words, are you controlling each species with several different modes of action during your crop rotation?
3. Have a working knowledge of which MOA groups are labeled on which crops and keep this in mind when developing crop rotations and MOA rotations that will go on those crops. Some MOA groups have found their way into numerous crops—ALS herbicides are labeled on corn, soybeans, wheat, and milo—while others, such as synthetic auxins, are primarily labeled only on grass crops.
4. When possible, rely more heavily upon families that don't show up on the chart as having resistance problems. You can see from the table that the ALS family has a rather checkered past, but chloroacetamides (which have been around much longer) have no known resistance issues.

### Herbicide Resistant Weeds in the Plains States

*(Colorado, Kansas, Nebraska, Oklahoma, South Dakota)*

| Weed | Mode of Action weed has resistance to: | HRAC group | Year and State where identified |
|---|---|---|---|
| field bindweed | synthetic auxins | O | 1964 KS |
| kochia | photosystem II inhibitors | C1 | 1976 KS<br>1982 CO |
| | ALS inhibitors | B | 1987 KS<br>1988 SD<br>1989 CO<br>1992 OK |
| Palmer amaranth | ALS inhibitors | B | 1991 KS |
| | photosystem II inhibitors | C1 | 1995 KS |
| redroot pigweed | photosystem II inhibitors | C1 | 1982 CO<br>1995 KS |
| common waterhemp | photosystem II inhibitors | C1 | 1995 KS<br>1996 NE |
| | ALS inhibitors | B | 1995 KS<br>2002 OK |
| common sunflower | ALS inhibitors | B | 1996 KS, SD |
| shattercane | ALS inhibitors | B | 1994 NE<br>1996 KS |
| common cocklebur | ALS inhibitors | B | 1996 OK<br>1997 KS |
| wild oat | ACCase inhibitors | A | 1997 CO |

from www.weedscience.org (Weed Science Society of America).

# Survival, Prosperity, & Managing Your Luck

by Matt Hagny

**PERSPECTIVE**

Most of the U.S. Plains is experiencing drought, and in many cases it is the worst in (modern) recorded history. It may not relent in '03. While optimistic personalities are the most pleasant to be around, effective managers keep in mind both the worst-case and best-case scenarios during their planning process.

Since farmers have a natural tendency to be optimistic (sorta like the song about the rodeo guy thinking he'll win in the next go-round), we will take a look at the downside for a moment. What if the drought lasts

> **I think it an imperative exercise to go through the numbers before the first dollar is ever spent on the coming crop—how much is at risk?**

another year? Two years? Ten years? Will all your equity be gone? I think it an imperative exercise to go through the numbers *before* the first dollar is ever spent on the coming crop—how much is at risk if yields are zero? How much if they are below insurance levels, and you bear the cost of harvesting?

One method of measuring the risk is to back-track, using a spreadsheet and plugging in insurance guarantees (at various levels) and Farm Bill payments as the only revenue sources, then subtracting all over-

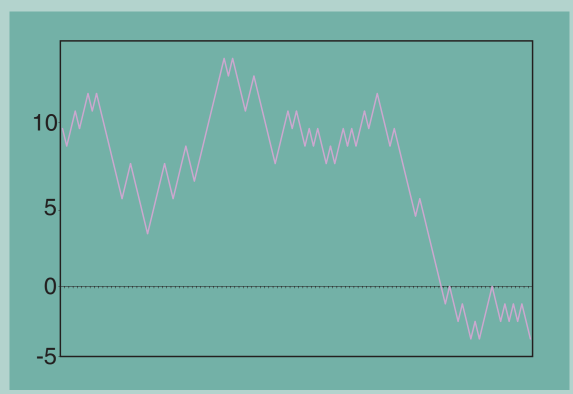
Photo by Matt Hagny.

Soybeans dying from drought, not maturity. Many areas of Colorado, Kansas, Nebraska, and S. Dakota experienced the worst drought on record last year. In some places, it was the third year of little or no crop. There are no guarantees it will end in '03.

head costs (including cost of living, unless that is covered by another source, e.g., a spouse's paycheck).[1] What is left can go to variable inputs, if you want to have zero risk. Most likely this is an extremely low number, and probably not a good choice for preserving any upside potential by doing the agronomy right. Also realize that this number will shrink even further for '04 and following years if overhead remains the same but insurance levels fall due to another crop failure. But the calculation gets you close to worst-case scenario (we can envision even worse, like the spouse's job going south, unexpected lawsuits, gov. regulatory intrusion, health problems, etc., so there is always need for reserves).

So you don't like those numbers? One solution is to do something about the overhead, but that will also be unpleasant, since you are selling at depressed prices for most items. Still, if it is dictated by good management, best to take your lumps now and move on.

The other possibility is to slash the variable inputs as suggested. Perhaps this is just too much of a cut to do a decent job of growing a crop, and you think you have the reserves to handle some risk beyond what is covered by worst-case revenues. At least the calculation gives you the estimate of the total amount that is




The chart shows what happens to a resource (such as business equity, or a gambler's cache) during what mathematicians call a "random walk" in a series of events, such as flipping a coin. In this case, the probability of success is 50%, and each success is charted as a +1, while the losses are -1. Given enough time, any outcome is possible—if you escape extinction events.

[1] This is an analysis of equity fluctuations. It will also be highly beneficial to construct a spreadsheet for cash flows, as a crunch there may force you out of the game long before equity drops substantially. At least in this example, we aren't including the opportunity cost of one year's worth of your time & man agement skill, although there is indeed an opportunity cost—you *could* have taken a job somewhere else—and arguably this cost should also be included. Opportunity costs pertaining to capital should definitely be included (such as rental values on owned land), as well as tax implications, and risk of valuation changes. Don't get hung up on small details, just plug in a good estimate and move on—you can always refine your estimates later.

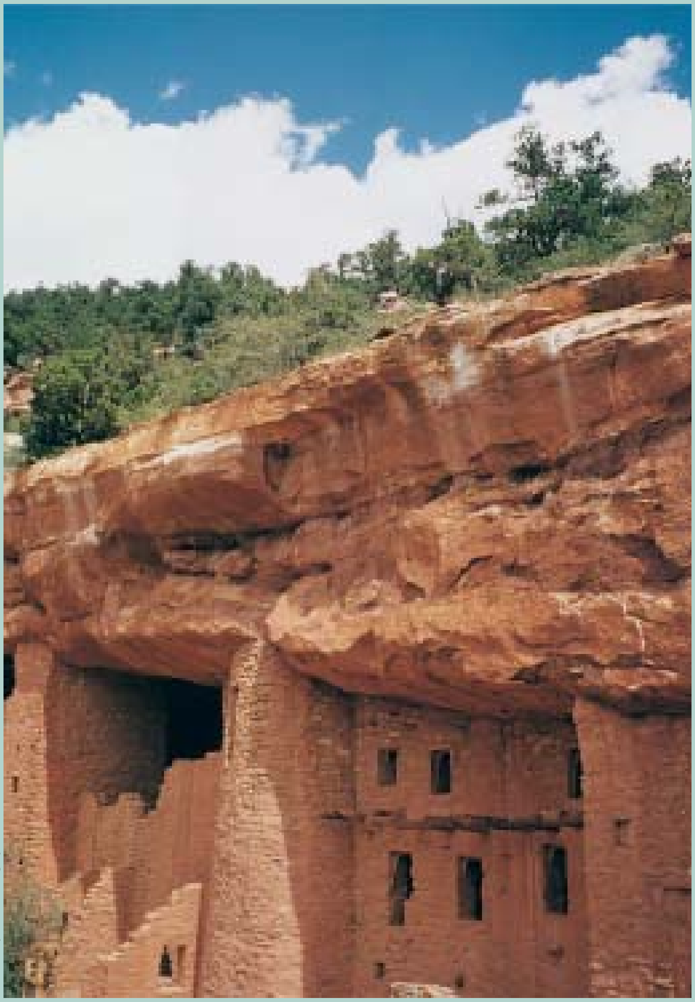


Photo by Matt Hagny.

Droughts have destroyed civilizations in the past, such as the farming-based society that built these dwellings in Colorado. Despite surviving and flourishing for many centuries, a 26-year drought in the late 1200s was the breaking point.

being risked, and how many consecutive disaster years you can handle before your equity is gone. Confronted with this number, you may wish to rethink how much is 'necessary' to do a decent job of growing a crop.

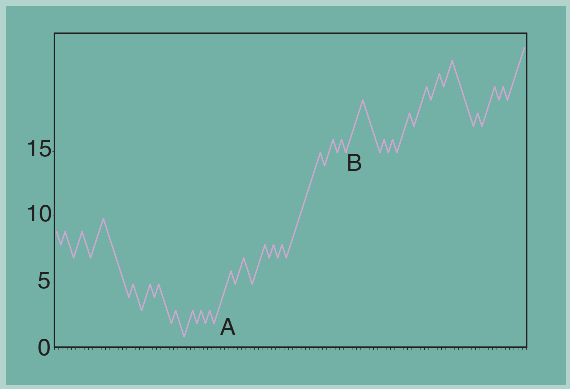
Another 'thought experiment' that may prove useful is the Gambler's Rule, which is mathematically a 'random walk'—sometimes you make several successive wins and get ahead, and sometimes the house is ahead—but with the result that *if you play long enough, the house will take all your money.* The length of time until this happens will vary, but the outcome is almost inevitable if the house has significantly greater resources than you.

However, the Gambler's Rule is for a *zero-sum* game—no one ever gets ahead except at the other's loss, i.e., the slices may change, but the total pie never grows. However, business enterprises such as farming are different in that wealth can be created; it is not zero-sum[2]—the average standard of living improves, or GNP goes up, or whatever your preferred yardstick.

However, the random walk still occurs, even if it can have a slightly upward trajectory now—sometimes you have a single bad year in a mostly good decade, sometimes you get maybe 3 or 4 bad years in a row, and (much less frequently) there will be even more than 4 bad years in a row. Some droughts last more than a decade, for instance.[3] This drives home the importance of (1) earning average or higher-than-average returns, (2) saving a significant part of those earnings (not doubling-up on your bets), and (3) being willing to walk away at any time.

Alan States, a farmer (and later, bank owner) near Hays, KS relates what a trader once told him, "'Never bet more than 10% of your kitty on any trade, and if you ever lose 30%, *stop immediately* and figure out what you are doing wrong.' " States concurs, noting that people really should scrutinize their equity history, and set predetermined limits on what they are willing to lose—before the emotion of a crisis and exit choice are faced.

The value of this exercise is to realize that your luck doesn't *have* to turn this next year; it is just a probability game. The house (Nature) has a deeper reserve than any of us. We should not underestimate the graveness of the situation, but arm ourselves with a careful assessment of the risk, judge accordingly, and only then go forth on our chosen path with resolve and with vigor.




This chart shows another random walk, this time with probability of success at 55% as in a case when there is wealth creation (no longer a zero-sum game as in the first chart). Even if the overall trend is upward, some nasty chasms exist. Note that in this particular random walk one would need to survive point A to enjoy the prosperity of point B.

[2] This is not universally true of industries or societies—wealth creation is only possible given certain political and market structures, currency stability, etc.

[3] A series of droughts in the mid- to late 1200s decimated the farming-based Anasazi culture of what is today Arizona, New Mexico, Colorado, and Utah; their culture had flourished in that region for many centuries, building the Mesa Verde cliff dwellings and many other spectacular sites. The dates of the droughts varied by location, but many lasted 14 to 30 years, which is well documented by tree rings. "The Great Drought" lasted over 25 years and was worse than any the region had experienced for centuries. It triggered the collapse of that civilization.

# For Land's Sake

by Roger Long


Somewhere around 1945 Charlie Unruh used the Soil Conservation Service to lay out the exact contours of his strongly sloping fields on his farm northeast of Newton, KS. He then followed those contours with his planter to reduce rill and gully erosion being created by water running straight down the hill. In the late '40s terraces were being built to slow the runoff and reduce the amount of soil coming off his fields. His son, Lewis, first tried no-till way back in 1975 when he planted wheat into milo stalks, a practice common today among many neighbors who are not necessarily in a no-till system. Now, in the dawn of the 21st century, Lewis is in his 7th year of continuous no-till and now makes a common practice of planting winter cereal cover crops ahead of his cotton to add yet another instrument of erosion control to his conservation toolbox. Lewis & Charlie have that unique personality that somehow is both ultra-conservative and extremely progressive; their conservation of resources, both land and money, is remarkable, yet they adopt new cropping practices with mind-numbing speed.

Photo by Lewis Unruh.

Unruh seeding in cotton stubble. Despite the field being in very low-disturbance no-till for 8 years, not much residue remains on the surface—cotton just doesn't produce much residue.

**"No-till is not without its problems, but they're certainly not any worse than with tillage—they're just different."**

Some don't even know what a cover crop is (a crop planted but not intended to be harvested, for agronomic or conservation reasons), and others are only beginning to investigate the notion. While Lewis may not claim to be an old pro, he's well beyond the early experimentation stage. While Lewis had tried various clovers, vetches, lespedeza, and other leguminous cover crops off and on over the years, he became serious about his cover crop program several years ago when he discovered the value of using wheat between 'stacked' cotton crops in his rotation. The original purpose of this cover crop was erosion control (cotton produces very little residue, and its stubble is prone to allowing the soil to wash, even in long-term no-till) but Lewis soon found additional benefits as well.

The fact that Lewis received immediate production benefits from the cover crop wheat probably didn't hurt any. That year, Lewis had planted the second cotton crop in that stacked rotation into a living wheat crop. Soon after planting, they got a pounding rain that severely crusted many neighboring tilled fields, but Unruh's cotton emerged without problems due to the standing wheat's absorption of raindrop impact, which allowed the cotton to come through a mellow soil. While his original program was to spray out the cover-crop wheat just before seeding cotton, he now waits until sometime after the (RR) cotton has emerged to spray glyphosate to kill the wheat. Lewis purposely waits as long as possible to let the wheat build up as much biomass as possible, with the wheat often in the boot stage or even heading when terminated, so that the stalks will be strong enough to last through the summer. Lewis also finds he has fewer insect concerns and better seedling root development in the cotton that goes into cover crop wheat.

Photo by Matt Hagny.

Unruh's second-year cotton, but with a cover crop of wheat between them—much better soil cover. Unruh has several years of experience doing a winter cereal cover crop ahead of cotton, and now does it on nearly all of his cotton acres. With the cover crop, he gets better cotton stands, better early plant vigor, and has fewer insect concerns. Yields tend to improve also. Unruhs normally do not apply any insecticides to their cotton, nor is it *Bt*—a sharp contrast with the typical cotton growing practices of 'modern' agriculture, which rely heavily on such technology.

Photo by Matt Hagny.

Lewis shows off his heavy residue from stacked corn—he prefers to have the soil covered like this all the time.

Lewis is currently experimenting with winter oats in place of wheat for the cover crop, since he already has wheat in his rotation as a cash crop—using it as a cover perpetuates root diseases that would otherwise be disrupted by the long rotational break. Oats generally doesn't harbor wheat diseases. Winter oats will provide a wider planting window than spring oats, although its winter hardiness is very questionable.

## Blend of New & Old

Other forays into cover crops include planting sunn hemp (*Crotalaria juncea*) between his stacked wheat sequence. The quick growth habit of sunn hemp, combined with its properties for creating a desirable seedbed for the second wheat, was appealing. Last year, Lewis' sunn hemp was planted in dry soil in July and didn't come up until they got a two-inch rain on August 15th. With only a 45-day growth spurt, it reached 4 to 6 feet in height; he then sprayed it with 18 oz of Roundup and 16 oz of 2,4-D at the end of September. Lewis prefers a herbicide application over the South American method of "rolling down" (using large tractor-drawn rolling drums with transverse "knives" that roll over the cover crop and crimp the stalks, typically killing the plant). "We had a little volunteer wheat in with our sunn hemp and a roller would have missed the wheat. You also have to let the sunn hemp get big and mature in order for the roller to work and I didn't want to let it get that big." The wheat is now up and flourishing and the sunn hemp stalks are mostly still standing, waiting to catch the next edition of blowing Kansas snow. (*Editors' Note: We have learned more about managing sunn hemp in Kansas, and have found that allowing it to grow more than 45 days results in residues that are excessively 'stringy' the following spring, which can result in problems with wrapping on rotating parts of planters and drills. The South Americans likely do not experience this because they seed into the sunn hemp while it is freshly rolled and still green while ours gets 'cured' over the winter.*)

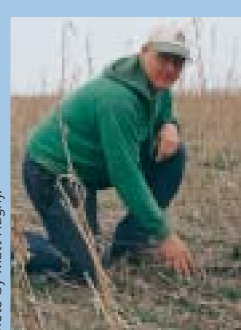
Photos by Lewis Unruh.

Unruhs harvest their own cotton with this older AC stripper. They have been growing cotton for nearly 15 years, in an area without any. Lewis & Charlie are very open-minded, and quick to see the potential of new things, whether it is a new crop like cotton, changing to permanent no-till, or adding cover crops. Nothing is taken for granted, and everything must pay its way on this operation.

So far Unruh's main use for cover crops has come in-between stacked crops in his rotations, but he is also looking at sunn hemp or maybe cowpeas or mung beans for the wheat >>corn transition, instead of the milo and soybean double-crops he has been using. "I really haven't had too much trouble in planting any of the cover crops so far." According to Lewis, "The hardest part has just been figuring out how to set the seeding rate on the drill." Funny how there isn't any seeding charts in operators' manuals for sunn hemp!

The learning curve on cover crops is currently pretty steep, but Lewis has enough years of experience with his no-till system to know that it is superior to his old tillage methods. Lewis began his full no-till system eight years ago. His operation has expanded from an approximate ⅔ wheat, ⅓ milo mix to about ¼ wheat (both winter and spring types) and the balance in corn, milo, soybeans, and cotton. Alfalfa is also grown. Like many no-tillers, Lewis relies upon his no-till drill for the bulk of his seeding. His 15-foot John Deere 1560 drill plants everything except his corn. The drill is equipped with both nitrogen and starter tanks that he uses for milo and cotton planting. The drill has 7.5-inch spacing but he plants cotton and milo in 15-inch rows and dribbles N over the slice made by the middle opener that is not dropping seed. As Lewis started no-tilling, he put his nitrogen on in the winter but felt he was losing too much to denitrification in the spring and has since switched to putting all of his N on at planting. Lewis uses some of the same concepts on his JD 7000 planter, as he doesn't really 'place' the nitrogen but rather dribbles on N behind a coulter that runs a couple of inches off to the side of the seed furrow. He also puts a starter blend in the furrow to give things a fast vigorous start. Despite the planter nearing its 30th birthday, Lewis' diligent maintenance (and a few aftermarket attachments) keep it humming along—nearly every year his crop consultant remarks on how consistent his corn stands are.

Photo by Matt Hagny.



Lewis examines his second-year wheat in amongst the sunn hemp (cover crop) stalks. The residue from the first wheat is visible on the surface yet.

## Subtle Progress

When asked about problems with no-till in his beginning years, Lewis recalls, "We had some problems with our drill in loose, powdery soils. The fluffy soil didn't give the openers anything to cut against and we had a lot of soil sloughing off into the furrow [before the seed was placed]." These problems quickly took care of themselves after just a year or two in no-till. "Our soils are much firmer now than they used to be.

They're not hard or compacted, but they have the firmness that comes with good soil texture."

Reflecting upon those beginning years of his no-till system, Lewis was happy to watch his bindweed patches quickly fade away. "We saw a big difference in bindweed pressure after the first couple of years in no-till." He attributes much of the decrease in pressure to more efficacious herbicide applications. "In no-till, you're not cutting and covering up the plants, so you get more herbicide into the plant and [moved] down to the roots." His better soil condition and improved seeding equipment help create a healthier, more competitive crop which further makes life tough on the bindweed plants. Unruh had a major buckwheat problem back when he had lots of continuous wheat, but now with his diverse rotation allowed by no-till, buckwheat is nearly extinct on his acres. He used to routinely apply Glean or Finesse to every wheat acre to keep his buckwheat problem in check, but now only spot treats for henbit and pennycress with Harmony Extra.

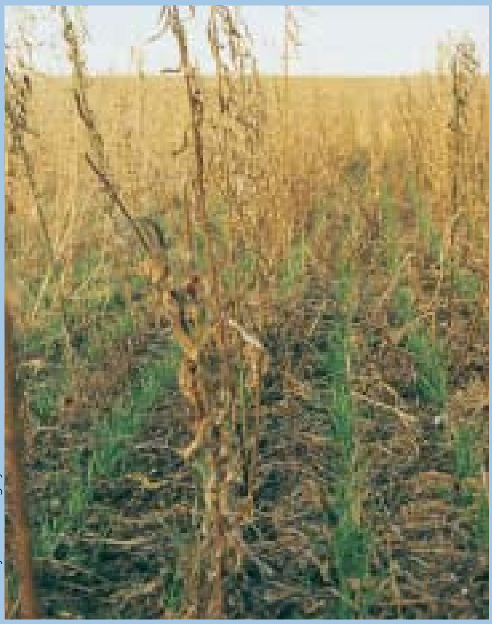


Photo by Matt Hagny.

Unruhs' second-year wheat in sunn hemp cover. Nice wheat stand!

Some of the benefits of no-till may be very subtle but they're generally right under your feet—if you just look. Lewis noticed a couple of years ago that while his neighbors were unable to harvest because their fields couldn't carry the combine, his soils were firm enough to run over—firmness created by soil structure redeveloped after years of no-till. "You could see the imprints of the lugs and that was about all the track we made." Another illustration was when beavers had backed up water into their field and they didn't even realize they were driving through very shallow water standing on their field (underneath the residue) until they noticed the combine tires were wet! Again, this is not to say that Unruh's soils are compacted. Lewis routinely digs up plants to examine root architecture and sees nice, long roots heading straight for China. Want more evidence of a change in the soil? Look at the color. Comparing his soil to a tilled soil across the fence, he sees a deeper, darker color developed through his years of building organic matter. Of course, Lewis' soils are covered with a mat of residue, so some scratching around is needed to make the comparison!

Lewis explains the history behind their move to no-till, "We had been playing around with no-till for awhile but hadn't figured out how to make the whole thing work." Once he saw a game plan that laid out the concept of the rotations, he jumped in and hasn't looked back. "No-till is not without its problems, but they're certainly not any worse than with tillage—they're just different. Sometimes you can see a little difference in moisture make quite a difference in yield, and that is why we like no-till—to get that extra chance at making a profit." Lewis understands the only way to long-term sustainability is by utilizing the resources at hand. Having seen his share of droughts, floods, roller-coaster price changes, and other calamities, Lewis keeps his calm—and an eye on the long view.

No·till On The Plains

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