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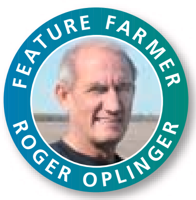
No·till On The Plains

Eye of the Storm

by Roger Long



There's a calmness that comes with confidence. Confidence that you know what you are doing, and what you are doing is right. For Roger Oplinger, it's doing what is right economically, and what is right with nature. And in the case of Oplinger, proprietor of Spring Creek Farms, the calmness is pervasive. With all the enterprises Roger has, he still takes time to share his thoughts on equipment management, soils, no-till experiences, his new outfitting venture, and more.

With so many entities demanding Roger's attention, the list alone would drive most people into exile—with three distinctly different farms totaling over 13,000 acres, a new guide service 'Spring Creek Outdoors,' cattle, a house in Jewell at the farm, and a house in Manhattan where his wife, Barbara, is the coordinator for Ks Foundation for Ag in the Classroom.

Roger Oplinger returned to his Jewell, KS home in 1971 after graduating from Kansas State University. He started with 12 gilts purchased "by mortgaging a '66 Pontiac," and a modest bit of farmland of around 400 acres. Approximately four years later, a couple of retiring farmers in the area turned over their cropland to Roger, jumping him to around 2,000 acres. Oplinger was off and running. Before long, the hogs were gone, displaced by his nicely profitable cropping enterprises: "We run ROIs from 30 to 50% on Spring Creek Farms [excluding land investment which comes in at 6 to 7%]." Numbers that are shocking—pleasantly shocking—to their banker (and I'm guessing Roger isn't too disappointed, either.)

Photo by Barbara Oplinger.

Dryland corn, a 500-acre "experiment" at Oplinger's Jewell County farm.

Contents

In the face of what are oft-said to be trying times in production agriculture, calmness is an elusive quality, a trait seemingly unique to Oplinger. With fall harvest over, Roger has time to catch his breath and contemplate his progress. “I just love to be able to go around and look at everything this time of year. I go out and pull up plants, look at roots, and look at how healthy the soil is.” Oplinger has had his Jewell farm in no-till for over 8 years and sees the difference it has had on soil structure. “Now, when I pull up an old milo plant, the roots go straight down [don’t bend in unnatural ways]. They didn’t do that the first couple of years in no-till—they went down four inches and then had 90-degree angles.” Oplinger is reminded of his progress anytime he takes over ground that has been tilled for many years—aggregation is poor, water infiltration is hampered, roots contort unnaturally, and production is lower.

Now *That’s* Diversity

Calmness is not the only trait unique to this Jewell (north-central KS) and Greensburg (south-central KS) *and* Brewster (northwest KS) grower. Those three distinct locales, each with its own soils and climate, create quite different production challenges and opportunities. Jewell is all dryland—the largest farm with over 8,000 planted acres—and is the home base and genesis of Spring Creek Farms. The Greensburg farm is north of that town, and all irrigated on rolling sandhills that set atop good wells. It began with 12 pivots leased in 1998, with a lease acquisition in 2001of another 12 pivots of alfalfa that have since been converted to no-till corn and beans. The Brewster farm—irrigated like Greensburg, yet with soils more like Jewell—is really like neither, due to its high elevation and other climate differences.

The business of agriculture is fraught with unknowns: When will it rain? Where will markets go? What will input prices do? What will be the next pest crisis? Oplinger takes such problems in stride via preparation for these unknowns. He has found that diversely and intensively cropped no-till soils are among the best preparations for the unknown. Oplinger cites the 50-bu/a milo yields at Jewell during drought years when tilled fields in the neighborhood were yielding 20 to 30 bushel or not even harvestable. Oplinger’s mantra: Protect the low side in bad years and maximize the upside in good years. What does a good year look like? In 2005, his worst milo (a short-season hybrid) netted 115 bu/a, and most of the full-season fields were in the 135-bushel range. With a few years of no-till under his belt, Oplinger is ratcheting up his own expectations. “We used to shoot for 100-bushel milo—anymore, that’s going to be too low.”

Photo by Barbara Oplinger.

Milo at the Jewell farm.

With some exceptions, Oplinger has settled into a wheat >>wheat >>milo

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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.

>>soybean rotation for the Jewell farm. Oplinger notes the anxiety that some people have about planting wheat into wheat stubble. He sees it as one of the easiest planting scenarios for them: "Our best wheat is always the second-year wheat," but he warns, "You never want to go more than two years of continuous wheat—you have to have a rotation." Oplinger recounts further benefits to no-till, "So many [producers] are planting wheat early to ensure they have enough moisture to get a stand—and then they have to deal with Hessian fly. Due to the no-till, we have more moisture . . . that allows us to plant later [generally Oct. 3d through the 10th], which reduces fly problems." For wheat, he puts out around 25 lbs of P_2O_5, 25 lbs of N, 2 lbs Zn, and 1 lb S in-furrow with 7-inch spacing, and then top-dresses additional N as needed in the spring with a residual herbicide. "I'm confident our no-till wheat yields are comparable to conventionally tilled yields in the area."

As Oplinger drives by one of his old "problem fields," he recalls the production issues he had when he was tilling. "This field has bad alkali spots all over. It lays nice and the soil looked good visually, but it was the worst-producing field we had. After we had it in no-till for several years, the production really picked up and now it is one of the better-producing fields we have." (*Editors' Note: 'Alkali' areas can refer to a variety of salts accumulating on the soil surface. Given the region, it is likely a salinity problem, not sodicity, and the white deposits Oplinger sees on the surface are gypsum [calcium sulfate]. Either way, such areas have poor soil structure, thus 'sealing off' with low infiltration rates. Continuous no-till allows formation of water-stable aggregates so that percolating water can move the salts away from the surface. Generally, increased cropping intensity to extract more soil water is also necessary to prevent these soils from becoming saturated and the salts at depth moving back to the surface.*)

Photo by Barbara Oplinger.

Oplinger's "cover-crop" sunflowers, which (so far) are quite the cash crop themselves.

Always trying to push the envelope, Oplinger heard about the advantages of cover crops at a No-till on the Plains Winter Conference and began thinking about how to implement the practice with his system. More years than not, wheat stubble held so much moisture at milo planting time that Oplinger was faced with

"We run ROIs from 30 to 50% on Spring Creek Farms."

either planting into muck—or planting later than he wanted. Knowing the drying effect sunflowers had on soils, Oplinger used the cover-crop concept to plant sunflowers immediately after '04 wheat harvest to improve milo planting conditions the following spring. Oplinger used Clearfield (imi-tolerant) sunflowers to mitigate the residual effects of Finesse on this broadleaf crop.[1] He liked the concept of creating a better milo planting condition, but decided he might as well keep his options open to harvest a little something from the flowers if conditions were favorable—sunflower yield wasn't the priority, but rather the better sorghum yields from improved planting conditions. With average to slightly above-average rainfall, his '05 milo fields following wheat/dc sunflowers had slightly better yields compared to wheat stubble alone. And, oh yeah, the "cover-crop" sunflowers have yielded around 1,500 lbs/a (average '04 & '05), with no herbicide and minimal fertilizer. Compare that to stubble-only fields, requiring 2 to 3 herbicide applications through the summer, and the economics make it look even better.

Seeing Things Differently

If anxiety is the product of the unknown, then tranquility must be the result of the known. Oplinger focuses on production and recognizes the value of business management. His "partner" Todd Zenger, Wamego, KS handles all purchasing and marketing. Zenger markets grain through hedges and forward contracts, is his own crop insurance agent, and purchases inputs with various contracting tools and in volume. Few know their numbers like Zenger and Oplinger, who states, "Our goal is to be the least-cost bulk producer of grain commodities." They are masters of reducing costs on a per-bushel basis, but not necessarily spending less money. "My first combine cost around $35,000. It cost me about $.07 per bushel to own that machine. The last combine

[1] The Finesse label states that a bioassay be conducted to determine the rotational restriction to flowers. Imi-tolerant sunflower hybrids are less susceptible to SU carryover than those without this trait.

I traded off was around $250,000 to buy; it cost me about $.04 per bushel to own that machine. We ran right at 1,000,000 bushels through that machine before trading it off."

As Oplinger strolls around his farmstead, circulation fans from on-farm storage spur him to talk a little louder, "Everything's full of milo right now!" He goes on to point out that they use their bins to increase harvesting efficiency, with less time waiting in lines at the elevator, and fewer miles to go—thus, fewer trucks needed. No-till—which let them diversify crops, thereby spreading harvesting times—has allowed them to turn their bins three times in '05. "We filled them full of wheat, emptied that out and put the sunflowers in them, trucked all the flowers ourselves, and now they're full again."

Where Oplinger has the resources, he maximizes efficiency, and once those are maxed-out, he brings in additional help as needed. The labor consists of Cory Zenger, manager of the Greensburg farm (and a brother to Todd); Robbie Smith, the Jewell farm manager; Curt Doxson, the Brewster farm manager; plus Roger and Todd. They bring in seasonal help (Oplinger's son, Luke, is heavily involved when not attending classes at KSU) during crunch times such as harvesting or sometimes spring planting. Again, costs are held to a minimum at every juncture. For instance, they normally have approximately half of their wheat at Jewell custom planted because of a labor and equipment crunch at that time of year. "We have a neighbor that does a nice job for us. He has the time, the right fertilizer attachments [mid-row banders], and really has a little better seeder than we do." Spreading equipment costs over more acres was a goal that gave birth to the idea of separate farms. Since they are so far apart, harvesting is done at different times, which allows them to use the same two combines on almost all of their acres; a third machine is generally rented to fill in as needed. The Jewell and Brewster farms also share the same Patriot sprayer, while the Jewell and Greensburg farms share the same two planters.

Savvy Irrigating

While no-till crop production has a small minority of dryland acres in Kansas, albeit growing, no-till under center pivots doesn't even show on the radar. However, Spring Creek now farms 24 pivots that have been continuous no-till for the last 3 years. Oplinger is currently getting into a corn >>corn >>soybean rotation with cover-crop rye planted for winter grazing on most pivots. For a producer who has spent his life on silt loam soils in north-central Kansas, the sand of south-central Kansas was a huge change. "Those aren't soils down there—it's a beach!" Maybe . . . but with some fertilizer, timely water, and keen no-till management, it grows pretty good corn—240 bu/a in '04.

Photo by Barbara Oplinger.

Oplinger's soybeans at Jewell, with the farmstead and bin sites in the background.

Photo by Roger Long.

Oplinger examines a sunflower taproot. Roger is excited about the changes he sees with the no-till management system: "The new techniques will allow us to turn over better farms than we took them on as."

"When we first started farming down there [Greensburg], we tried minimum- or reduced-till because that's what everybody said had to be done. That was a mistake for us," says Roger. As he and farm manager Cory Zenger got more comfortable with the soils, they switched to full no-till. "We were having trouble managing and planting into the residue—we tried chopping the stalks but then everything just blew." Being a hawk on expenses, Roger didn't like the ripping, cultivating, and dammer/diking that many area growers were doing. "I finally decided that we just

On the irrigation: "I finally decided that we just needed to go full no-till and figure out how to make it work." With over 240 bu/a corn and 75 bu/a beans, apparently he did.

needed to go full no-till and figure out how to make it work. . . . [At first] we were trying to plant over the old rows to take advantage of residual phos from previous starter bands, but the old root balls that were many times kicked out of the row made getting good seed-to-soil contact difficult." They are now splitting the old rows and using grazing to reduce the residue that comes from 240-plus-bushel corn. It's hard to argue with success: Outstanding corn yields, soybean averages from 75 to 80 bu/a, plus the opportunity to harvest pounds of beef through the winter—they all add up to excellent returns. Rye is drilled directly after corn harvest to supplement their grazing program. The only rye that is harvested is done by four-legged animals—come spring, glyphosate, pre-emerge herbicide, and planting are all that's needed. (For those wondering about allelopathy, Oplinger says the corn actually plants nicer and grows better where the rye was, even if sprayed out just ahead of corn planting. However, he does state that the rye is "grubbed down" by grazing, so perhaps this reduces the allelopathy sufficiently.)

Always trying to push the boundary, Roger has considered the 20-inch-row idea but admits that maintaining his 2x0 fertilizer placement with coulters on the planter would be rather difficult and "fertilizer placement is more important than width of row." Just how do they supply all the necessary N for those irrigated corn yields? At Greensburg, they apply 30 – 40 units in the planters' 2x0, broadcast another 80 units at planting, and fertigate the rest through the pivots. Efficiency is generally quite good, right at 1 pound applied N per bushel of corn.

Lobbing Snowballs

Their new outfitting service arose out of the abundant wildlife that flourishes on Spring Creek's no-till fields at Jewell. Wildlife biologist Monte Kuxhausen assists them with guiding and game management for their controlled hunts. The farmhouse provides a comfortable hunting lodge, and the thousands of acres of no-till create a plentitude of hunting. "No-till fields provide great habitat for game birds. We just saw an opportunity to capture additional revenue from the no-till. It's our first year so we'll see how things work out."

Physics teaches that momentum derives from an object's mass multiplied by its velocity. Maybe the confidence Oplinger exhibits is derived from the momentum his farming operation has gathered. Once an entity has momentum, it takes more than a few minor bumps to bring it to a halt. And once momentum is created, it doesn't take much energy to keep it going on that trajectory. Like a snowball headed downhill, Oplinger isn't concerned about getting things rolling, he simply looks for ways to add to the already growing sphere, ways to add to an already robust bottom line.

Editors' Note: Oplinger has declined interviews by various publications for a decade. We're honored he chose to break his silence in our *publication.*

Sulfur: A Key Nutrient

Sulfur deficiencies are not uncommon in long-term no-till fields, especially for those who neglect this nutrient. In the Great Plains region, identifiable symptoms are not uncommon in young corn or milo plants, and indeed many studies find 5 – 20 bu/a responses to applied sulfur for those crops.

We don't think of soybeans or wheat as being very responsive to sulfur, but we might be missing something. In north-central Kansas, 2005 conditions induced severe sulfur deficiencies in a few no-till wheat fields. Generally, these were fields of wheat following high-yielding '04 soybeans, and little or no sulfur fertilizers had been applied for many years.

While some sulfur is naturally supplied in rainfall, it often is not sufficient to keep pace with crop removal. Well-managed no-till systems also may be increasing soil organic matter, of which sulfur is a component. Accumulation of soil organic matter requires about one part sulfur for every 10 parts of nitrogen, and many grain crops have similar nutritional needs.

Generally, 10 – 20 lbs/a/yr of applied sulfur will stave off deficiencies and create healthier crops. Sulfur fertilizers can easily be included with dry or liquid surface applications, or in 3x0 starter bands. Do *not* apply thiosulfate in the seed furrow.

Photo by Matt Hagny.

Sulfur-deficient wheat in long-term no-till.

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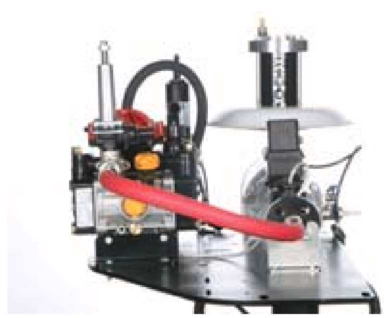

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Photo by Brian Lindley.

Managing Carbon: Do You C What I C?

by Dwayne Beck

SCIENCE

Dwayne Beck is manager of Dakota Lakes Research Farm at Pierre, SD.

The following is reprinted from AAPRESID's 2005 Congress (a large influential no-till conference) in Rosario, Argentina.

If I were to ask a class of university agronomy students, "What chemical element is taken up in the largest quantity by plants?," the response given by most of them would be: "Nitrogen." That same answer would probably also be given by most scientists and farmers. In reality the answer is carbon. Carbon, oxygen, and hydrogen constitute the vast majority of the atoms (and the mass) contained in plant dry matter. Carbon is the chemical element taken up in the largest quantity by plants.

Some of the leading books on plant nutrition (by Mengel and Kirkby; Tisdale and Nelson; or Stanley Barber) mention carbon, hydrogen, and oxygen only briefly as being essential elements. The Tisdale and Nelson book goes on to state that little or nothing can be done by man to directly impact the supply of carbon dioxide to a plant. Cook and Veseth make a similar statement in their *Wheat Health Management* publication. I believe they are wrong. I further believe that the lack of attention to carbon as a plant nutrient will be viewed as a major shortcoming of the practice of agronomy in the 20th century.

Photo by Matt Hagny.

'Old land' (long history of cropping with tillage) just never produced like 'new land.' Why *was* that? Scientists told us it was soil organic matter supplying nutrients and storing water, so why didn't irrigation water and fertilizers fully restore the productivity? What was the mystery ingredient?

Carbon chemistry is the basis of life as we know it. The search for life on other planets begins with a search for water and carbon-containing compounds. Carbon has some very unique chemical properties. In its lowest energy level it has the electron distribution of 1s2, 2s2, 2p2. This would lead us to believe that it would form the most stable compounds when it has a valence of +2. In fact, carbon forms its most stable compounds when it has a valence of +4 (or -4). The reason for this lies in the promotion of one of the paired 2s-level electrons to the empty 2p orbital (there are two half-filled p orbitals and one that is empty). This is followed by the formation of 4 hybrid sp^3 orbitals when bonding occurs. These hybrid orbitals are the basis for the tetrahedral shape that gives diamond its hardness. This property allows carbon to form rings and long chains with carbon bonded to carbon as the skeleton. Carbon forms more compounds than any other element except hydrogen. The fact that an entire field of chemistry (organic chemistry) is devoted exclusively to compounds of carbon is a testament to the importance this element holds for science.

The introduction of European-style tillage-based farming over large expanses of formerly undisturbed lands during the late 1800s and early 1900s is a prime example of wholesale mining of stored nutrients. The "homesteaders" were searching for the stored nitrogen and other nutrients and were willing to waste organic carbon in the process.

Carbon in Soils

Most agronomists and farmers recognize that soils high in organic matter differ in their characteristics relative to others that have lower levels of organic matter. (That is the reason many of the grandfathers of the farmers in both the United

Photo by Brian Lindley.

Beck giving a tour of some rotations being studied under long-term no-till at Dakota Lakes Research Farm. Thinking about things from unusual perspectives is signature Beck style. Oh, and he does have a Bachelor's in Chemistry and a PhD in Agronomy.

States and in Argentina left their European homes.) Most farmers for centuries had utilized manure as fertilizer. It was valued for adding nutrients like nitrogen and phosphorus and for making the soil easier to till and capable of holding more water. Soil scientists even developed methods of classifying soils that were heavily influenced by the amount of organic matter present. The system still in use in Canada classes soils based on color (brown, black, dark brown, grey). These colors are caused by differing amounts of organic matter. Scientists such as Hans Jenny spent a lifetime studying the climatic factors that led to soils in different areas developing different organic matter contents.

Many greenhouse operators enhance the carbon dioxide concentration of their air to reduce water vapor loss from plants.

Scientists did determine that tillage-based farming systems reduced organic matter levels of soils and made them less productive over time. Crops that produce low levels of residue (cotton, soybean, etc.) speeded the rate of organic matter loss as compared to crops with higher residue levels (more carbon). Raising perennial grass pastures and alfalfa on a piece of land increased organic matter levels relative to when it was used exclusively for tillage-based annual cropping.

The introduction of European-style tillage-based farming over large expanses of formerly undisturbed lands in North and South America, Australia, and Eastern Europe during the late 1800s and early 1900s is a prime example of wholesale mining of stored nutrients. The "homesteaders" were searching for the stored nitrogen and other nutrients and were willing to waste organic carbon in the process. It is not uncommon for organic matter levels in the Pampas and the Great Plains or Prairies to have been reduced to less than one-half the amount present before settlement by Europeans. (If this reduction was from 4% to 2% organic matter, the amount of carbon dioxide released would be equivalent to burning 100 tons/acre of coal). Obviously, the soil was out of balance relative to what it had been in its native condition.

Atmospheric Carbon

Even though everyone was aware of organic matter and realized it was valuable, no one paid much attention to the carbon part of the carbon cycle. That attitude changed when scientists noticed the concentration ('partial pressure')[1] of carbon dioxide in the atmosphere was increasing relative to historic levels. A massive amount of effort has been expended trying to quantify the amount of change that has occurred and to predict the potential impact. Reasons for this change have been attributed to use of fossil fuels, deforestation, natural causes, etc. Some of it might also be due to the impact of tillage on the organic matter in the soil. (*Editors: Beck is being sarcastic and playful here. The evidence overwhelmingly leads to the conclusion that loss of organic matter due to tillage and other land-use changes has been a major contributor to rising atmospheric carbon dioxide [CO_2] levels in the last two centuries, quite possibly the single largest emissions source from human activities from the early 1800s to the mid-1900s. Burning of fossil fuels probably didn't become the dominant anthropogenic source until around 1970.*) There were now incentives and funds available that encouraged scientists to look at all parts of the carbon cycle.

Plants grown in higher carbon dioxide environments are better able to obtain adequate carbon under water stress conditions when stomatal closure occurs for substantial periods of time during the day.

Scientists like Don Reicosky (USDA-ARS) began to study the carbon system in the soil. He found that there

[1] *Editors: Partial pressure is the pressure exerted by a component in a mixture of gasses.*

was a large "flush" or release of carbon dioxide in the 3 to 4 days immediately following a tillage operation. On land that remained untilled and had been in grass for several years (after many years of farming), less carbon was released during the season and the release happened later in the year when the weather warmed. Reicosky's research is mostly concerned with how and why carbon enters and exits the soil. It does not focus on what happens to it after it leaves the soil. But we are intensely interested because our crop needs to find carbon. The more carbon it can find the better.

In native prairie, carbon dioxide emission by soil microbes coincides almost exactly with maximum demand by plants. It is easy to visualize the dense canopy of a tall-grass prairie serving as a trap for preventing carbon dioxide from leaving an area until it can be used by the plants forming the canopy.

Let us look at the immobilization side of the carbon cycle. Much of what we know about the differences that carbon dioxide partial pressures have on plant growth comes from studies dealing with the "greenhouse effect" (trapping solar radiation either with physical barriers such as plastic or glass, or with atmospheric gasses). These data suggest that plants have higher water-use efficiencies when grown under elevated carbon dioxide levels. The phenomenon is attributed to the fact that these plants do not have to open their stomata as widely to obtain the carbon dioxide they need. Consequently, less water vapor 'leaks' out. Many greenhouse operators actually enhance the carbon dioxide partial pressure in the greenhouse atmosphere to reduce water vapor loss from plants. Reducing transpiration cuts down on water condensation on the ceiling and walls. Plants grown in higher carbon dioxide environments are also better able to obtain adequate carbon under water stress conditions when stomatal closure occurs for substantial periods of time during the day. The reason for this is the greater concentration of carbon dioxide in the air that enters the plant when the stomata are open. These impacts should be most pronounced on C_3 plants as compared to those with the C_4 pathway. The C_3 pathway is not as efficient as the C_4.

Plundering the Stockpile

The best way to understand how something should work is to examine it in a natural system or several natural systems. If we look at carbon cycling in the Pampas or the Prairies, the system was in equilibrium. The same amount of carbon entered and left the soil each year (on average). Carbon dioxide was formed during the decay of dead plant residue, soil organic matter, and dead animals, and as living organisms breathed. Warm-blooded animals are breathing throughout the year, but the microbes that mediate most of the decay process operate best when the temperatures are neither too hot nor too cold. They also like the proper moisture. That means that the "flush" of carbon dioxide associated with microbial activity occurs after soils warm in the spring and increases when moisture is adequate. This is coincident with the time of peak vegetative growth of most species native to these regions. This is most likely an evolutionary adaptation because most other fertilizer elements are associated with (bound within) the organic material that is decomposing. If it did not decompose, there would be less nitrogen, sulfur, zinc, etc. for the next generation to use. If organic material decomposed before the period of maximum plant growth, there would be a high probability that many nutrients would be lost from the system (perhaps permanently). Neither the microbes nor the plants planned this. The individual organisms involved were simply exploiting opportunities presented for growth and reproduction, and over long periods of time the groups of organisms became 'tuned' to use one another's waste products in a cycle with little leakage. Most interesting to this discussion is the fact that carbon dioxide emission coincides almost exactly with the maxi-

Photo by Matt Hagny.

A remnant of the Pampas of Argentina. While the lack of grazing has certainly taken its toll on this parcel, one can still visualize the dense canopy recapturing some of the carbon dioxide escaping from the soil.

mum demand for carbon dioxide by plants. It is easy to visualize the dense canopy of a tall-grass prairie serving as a trap for preventing carbon dioxide from leaving an area until it can be used by the plants forming the canopy.

The rainforest operates in much the same manner other than it does not have its reserves of nutrients stored as soil organic matter. It does not 'need' this because the nutrients (and carbon) are stored in living material that is cycled quickly. In the prairie, most of the biological activity occurs in the soil or near the soil surface. In the rain forest, most of the biology is above the soil. Soil scientists have traditionally thought of rainforest soils as being 'poor.' They are poor if you look only at the soil. The rainforest ecosystem consisting of the soil plus the plants and animals is not poor.

Tillage of prairie soils by settlers was tremendously efficient at 'burning' the stored organic matter and releasing nutrients. The nutrients became available for use by annual crops, but were available too early and therefore prone to loss.

When farming first came to these areas, there was little understanding of plant nutrition. In the rainforest it was advantageous to cut down the vegetation and burn it (slash-and-burn agriculture). This released the nutrients being stored in the vegetation so they could be used (mined) by the farmer's crop. The use of fire, along with making all of the nutrients available at once and at a time well before the crop would use them, led to loss of most of the nutrients. There were enough remaining to raise small crops of annual plants for a few years. Soil degradation did not seem important since there were many hectares of forest and very few people, so more land could be found.

The process was similar for the Pampas and Prairies. In these ecosystems, many of the nutrients were 'locked up' in the soil organic matter. Burning the aboveground vegetation did not have the same effect. Tillage, on the other hand, was tremendously efficient at 'burning' the stored organic matter and releasing nutrients for use by the crop. The benefits and problems are almost identical to the slash-and-burn system of the rainforest. The nutrients became available for use by annual crops but they were available too early and therefore prone to loss. It just looked less destructive because there was no visible fire. There was burning going on just the same. The land degraded after some years of doing this. Productivity declined. Nutrients leached or leaked from the system into water sources. But it didn't matter; there were lots of grasslands and very few people. Once a parcel was degraded, the farmer simply moved to another one.

What Are We Missing?

At first blush, most practicing farmers probably think this has little to do with their operations today. In areas where the supply of new land became limited, farming practices evolved to include strategies designed to help slow the rate of productivity loss. Mineral fertilizers have allowed raising the soil or plant content of many elements to levels equal to or greater than in the native system, although they continue leaking from the system. Even with this technology, the productivity of land with a long history of farming is not as good as 'new' land. The most striking characteristic of old land is that the level of carbon in the system remains well below that in the native system.

Most scientists believe that soils with more organic carbon in the system are more productive because of improved soil properties such as enhanced water-holding capacity, better structure, and more cation-exchange capacity. These benefits undoubtedly play a major role.

Photo by Brian Lindley.

Everyone worries about N, P, K, S, etc.—are we missing the chance to fertilize our crops with carbon? Carbon dioxide escaping from the soil must go past the plant leaves to get to the atmosphere. With no-till, CO_2 fluxes are at least somewhat synchronous with the crop uptake. In Beck's words, if you don't have immobilization (by microbes plus plants) matching up to mineralization, you have 'leakage' of nutrients from the system. The leakage is called leaching or denitrification as it pertains to nitrogen. For carbon, we call it soil organic matter loss.

Still, almost no one has considered that there might be direct impacts on carbon dioxide partial pressures in the crop canopy as well. In tilled systems, where most carbon dioxide cycling is going to occur soon after the tillage operation, the farmer has lost the ability to manage his carbon to better suit the plant's needs. That *may not* be true for no-till farmers whose carbon will cycle later in the season, similar to what it does under natural conditions.

Even with fertilizer technology, the productivity of land with a long history of farming is not as good as 'new' land. The most striking characteristic of old land is that the level of carbon in the system remains well below that in the native system.

For agriculture, the good news about the recent emphasis on understanding global warming and the carbon cycle includes results like the following passage from an annual report submitted by Jerry Hatfield and others doing work at Ames, Iowa under no-till conditions:

> **Single Most Significant Accomplishment during FY 2002**: Carbon dioxide and water vapor exchanges measured within a corn canopy during the summer of 2001 revealed that distributions with height varied throughout the day. Concentrations of carbon dioxide in the lower canopy increased to levels near 900 ppm during the night and then rapidly decreased as solar radiation began to penetrate into the canopy during the early morning. Mid-afternoon concentrations were less than 300 ppm indicating that carbon dioxide values may be limiting crop growth. Examination of the patterns of carbon dioxide and water vapor suggested that the soil may be a significant source of carbon dioxide when the canopies completely cover the soil surface. Combining the gas measurements with the biomass estimates of carbon stored in the canopy and the patterns in the above canopy measurements indicates that the soil release of carbon dioxide during the growing season may contribute up to 40% of the carbon stored in the corn crop.

(*Editors: Beck is providing this example as evidence that CO_2 levels can differ between the crop canopy and outside the canopy in the ambient atmosphere, which today is around 340 ppm. The elevated CO_2 in-canopy during the night will be partly from plant respiration, and partly from soil emissions.*)

Can We Manage Carbon?

(Beck's caveat: The following two paragraphs are conjecture, based on observation and circumstantial evidence. Some of this has not been proven using recognized methods.)

It is conceivable that carbon cycling could be manipulated through rotation choice, residue management techniques, nitrogen application methods, etc., with the goal of raising carbon dioxide partial pressures in the crop canopy at the time when the crop needs more carbon. This may sound silly until you consider that it is possible (probable) that carbon-cycling effects are partially responsible for the fact that soils with high organic matter content normally produce higher yields than those with less organic matter. Similarly, fields that have recently been converted from perennial crops or from sod into crop production might produce superior yields for the same reason. Almost every seasoned no-till farmer has had instances where a crop yielded much better than would be expected based solely on the water-saving aspects of no-till. Something else had made a contribution.

Almost no one has considered that soil organic matter levels might be directly impacting carbon dioxide concentrations in the crop canopy. In tilled systems, where most carbon dioxide cycling occurs soon after tillage, the farmer has lost the ability to manage his carbon to better suit plant needs. That *may not* be true for no-till farmers whose carbon will cycle later in the season.

Perhaps no-till and crop rotations are not ends but rather the best means or tools we have available to manage the carbon cycle in our cropping systems. Maybe this [AAPRESID] conference should not have as its title direct seeding but carbon managing. *If carbon cycling is to be controlled, low-disturbance no-till now becomes the only option in terms of tillage choice.* The focus then turns to optimizing that system.

I am a farmer. I take sunlight, water, and carbon dioxide and turn them into products I can sell.

An Owner's Manual for Cropland

Organic Matter Changes & Fertilizer Efficiencies in Long-Term No-Till

by Matt Hagny

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

Dwayne Beck has posed the question, if you could know only one thing from your soil test, what would it be? The answer should be organic matter (OM). While farmers, gardeners, and ranchers are vaguely aware of the value of organic matter, little effort is put into preserving or increasing it. Here are some guidelines for those who want to travel the path of actually improving the land.

Photo by Gary Maskus.

Changes in soil OM are closely associated with amount of biomass supplied to the soil—the amount of carbon captured by the plants and fed to the microbes . . . slowly. This process is derailed by soil disturbance (tillage).

When land is converted from native vegetation (e.g., grassland) to cropland with tillage, the loss of soil OM is substantial, often 30% or more in the first 20 years in temperate regions (the loss is larger in tropical areas). On the central U.S. Plains, soils tilled for 80 – 100 years commonly have lost 70% of the original OM content.[1] Simple comparisons will underestimate the loss, because nearly all grasslands today are impoverished due to their management (unnatural grazing patterns, hayed every year, no haying/grazing at all, etc.). Soil OM measurements from native tall-grass pastures in north-central KS sometimes have readings of 5.0 – 6.0%. Yet historical accounts of Smith County, KS describe grass in the draws being as tall as a man's head *on horseback*—a far cry from what we find today in this region.[2] Clearly, our grasslands have lost vigor and carbon due to mismanagement, mostly inadvertent. So, using the benchmark of the original pre-settler sod condition, we find that land condition under tillage actually declined even more than we previously thought.

Going the other direction is more difficult. Most studies show that reducing tillage is ineffective at increasing OM *unless tillage is reduced to zero*.[3] Don Reicosky, USDA-ARS (Morris, MN), has shown that carbon loss in a 24-hour period is very closely related to cross-sectional area of soil loosened by whatever soil-engaging tool is under discussion (see Figure 1).[4] In fact, the correlation is almost perfect, with $R^2 = 0.97$. The trend held for 2 trials later that season with

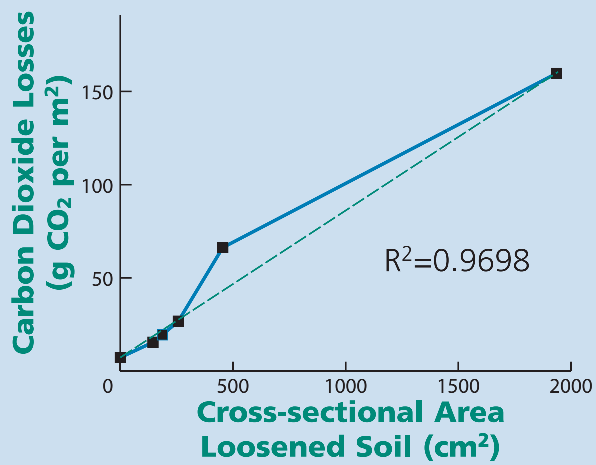

Figure 1. Cumulative carbon dioxide losses in 24 hours following tillage. Carbon losses are directly related to cross-section of soil disturbed. Study conducted by Don Reicosky at Swan Lake, MN in 1997. The cross-sectional area disturbed was calculated from measurements after carefully excavating the loosened soil from each of the treatments. Cross-sectional area multiplied by distance traveled would be volume of soil disturbed. Source: Reicosky, 2005.

1 This assumes the *original* prairie in north-central KS at 6.0% OM, and cropland with an 80- or 100-yr tillage history at a typical value of 1.8% today. Anderson states a 60% loss of OM from tillage in eastern Colorado in the March 2005 *Leading Edge* (citing R.A. Bowman, J.D. Reeder & L.W. Lober, 1990, Changes in soil properties after 3, 20, and 60 years of cultivation, *Soil Sci*. 150: 851-857). Data from the Morrow Plots in Illinois and from the Argentine Pampas show similar magnitude of losses.

2 Kent Stones' great-great-grandfather's diary. Granted, neither the people nor the horses were tall in the 1800s, at least not by today's standards. Still, we must be talking 7+ feet of height for the grasses of the 1800s versus ~ 5 feet today, at the most. The processes of degradation of grasslands (and the remedies) are studied by rangeland management gurus such as Kirk Gadzia, Allan Savory, and many others.

3 Or extremely close to zero. J.S. Kern & M.G. Johnson, 1993, Conservation Tillage Impacts on National Soil and Atmospheric Carbon Levels, *Soil Sci. Soc. Am. J.* 57: 200-210. T.O. West & W.M. Post, 2002, Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation: A Global Data Analysis, *Soil Sci. Soc. Am. J.* 66: 1930-1946.

4 D.C. Reicosky, 2005, PowerPoint presentation at the Agro-Soyuz NT-CA Conf. (Maiskoye, Ukraine, 17-20 Aug. 2005) (data from the 3 June 1997 study at Swan Lake, MN, reported elsewhere).

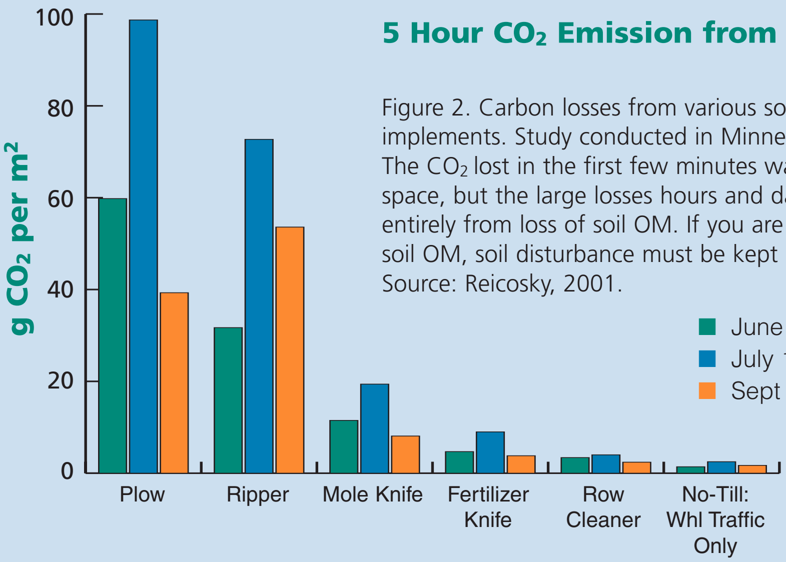

Figure 2. Carbon losses from various soil-engaging implements. Study conducted in Minnesota in '97. The CO_2 lost in the first few minutes was in soil pore space, but the large losses hours and days later are entirely from loss of soil OM. If you are trying to build soil OM, soil disturbance must be kept extremely low. Source: Reicosky, 2001.

slightly drier soils (see Figure 2).[5] Some farmers brag about having given up the plow in favor of chisels and disks ("reduced," or "conservation tillage"), although we can see from CO_2 losses that these methods are only slightly less abusive. Lost CO_2 can mean only one thing—lost organic matter.

Another study, conducted in Iowa, used tillage (or non-tillage) treatments on the same subplots for 3 years prior to measuring CO_2 fluxes during 20 days following the tillage passes in autumn of Year 3 (see Table 1).[6] Again, the carbon losses were closely associated with the volume of soil disturbed.

Neither of these studies captures the full magnitude of CO_2 loss, since a large amount of CO_2 in pore space escapes within the first few seconds after tillage[7]—before the measurement instruments used in those studies were placed onto the tilled areas.[8] Also, the loss continues for many months beyond the periods measured in these studies.[9]

Reversing the Decline

Increasing OM with long-term no-till is dependent on cropping intensity and amount of residues remaining on the field each year. While roots contribute 2 to 3 times more to OM than does the aboveground portion,[10] the aboveground material is highly important because it protects the soil surface from raindrop impact, weathering, and erosion. Roots may be the direct cause of most of the improved aggregation and higher OM, but the residues on the surface are critical to preserving these gains.

One comprehensive analysis of 67 studies from around the world reveals that soil OM increases very little in the first 5 years of no-till on any given tract of land, followed by large increases in Years 5 – 10.[11] Beyond Year 10, annual increases were not great unless rotational complexity increased. Contrast this with Juca Sá's research showing continued increases (roughly linear) out to Year 22 of no-till implementation.[12] However, Sá's results are from a tropical location that perhaps

20 Day CO_2 Emission from Soil

Method	kg CO_2 per hectare
Plow	511
Chisel	416
Deep Rip	402
Strip-till	378
No-Till	300

Table 1. Treatments in place for 3 years before these measurements were taken following tillage in fall of '01. Study conducted in Iowa. Different measurement instruments and durations resulted in absolute and relative values different from Reicosky's. However, all studies of carbon losses from soil are unambiguous: *the amount of CO_2 flux is directly related to volume of soil disturbed.* Source: Al-Kaisi & Yin, 2005.

[5] D.C. Reicosky, 2001, Effect of Conservation Tillage on Soil Organic Carbon Dynamics: Field Experiments in the U.S. Corn Belt, in *Sustaining the Global Farm* (peer-reviewed papers from ISCO:10 conf., West Lafayette IN, 24-28 May 1999), ed. D.E. Stott, et al., International Soil Conservation Organization, with USDA-ARS. The field wasn't cropped during the year of the studies. Weeds were killed using contact herbicides ~ 2 weeks prior to each test.

[6] M.M. Al-Kaisi & X. Yin, 2005, Tillage and Crop Residue Effects on Soil Carbon and Carbon Dioxide Emission in Corn-Soybean Rotations, *J. Environ. Qual.* 34: 437-445.

[7] Merle Vigil, personal communication Mar. & Nov. 2005. The air in the soil pore space is at least 30 - 40 times higher than in the air just above the soil surface.

[8] Reicosky's 1997 measurements of ambient CO_2 downwind *during* the tillage passes show large spikes within 2 minutes following the tillage event, which taper off significantly at later intervals. Reicosky, 2001.

[9] The Al-Kaisi study measured significant differences persisting between the treatments 12 - 20 days after tillage. No rainfall had occurred, which would likely spur further decomposition and CO_2 losses.

[10] Reicosky, 2005 (data published in A.R. Wilts, D.C. Reicosky, R.R. Allmaras & C.E. Clapp, 2004, Long-term corn residue effects: Harvest alternatives, soil carbon turnover, and root-derived carbon, *Soil Sci. Soc. Am. J.* 68: 1342-1351). Other research has shown that surface residues can become part of soil organic matter due to water percolation. Infiltrating water passing through residues often carries over 100 ppm of dissolved organic matter. So 24 inches of precipitation infiltrating the soil could carry 650 lbs/a of organic matter into the soil. W.C. Moldenhauer, W.D. Kemper & B.A. Stewart, 1994, Long-Term Effects of Tillage and Crop Residue Management, in *Crop Residue Management To Reduce Erosion and Improve Soil Quality (Northern Great Plains)*, ed. W.C. Moldenhauer & A.L. Black, USDA-ARS.

[11] West & Post, 2002.

[12] J.C. de M. Sá, C.C. Cerri, W.A. Dick, R. Lal, S.P. Venske Filho, M.C. Piccolo & B.E. Feigl, 2001, Organic Matter Dynamics and Carbon Sequestration Rates for a Tillage Chronosequence in a Brazilian Oxisol, *Soil Sci. Am. J.* 65: 1486-1499.

was quite degraded initially (due to rapid decomposition and intense weathering, tropical soils lose OM quite easily when human activity adversely affects the ecosystem), and Sá's experiment was on land where the no-till management scheme made extensive use of cover crops.

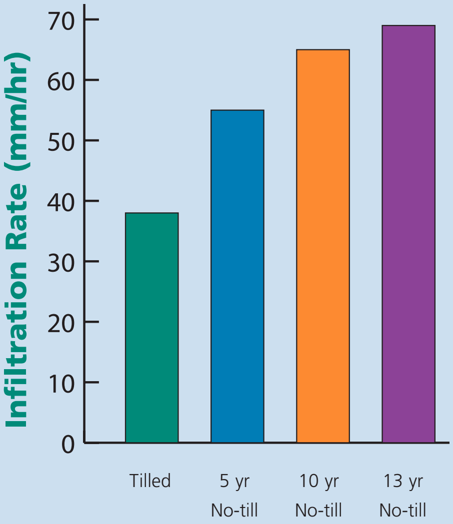

Figure 3. Effects of length of no-till on water infiltration (81 mm applied in 1 hr). Source: Lafond, 2005.

This makes sense: more vegetation growth translates to greater increases in OM.

Many studies from temperate regions also draw the connection between amount of plant biomass supplied to the land and soil OM levels. For instance, decreasing the frequency of fallow in semi-arid regions (fallow once in 3 – 5 yrs, instead of every 2 yrs) improves OM under no-till.[13] Continuous cropping is better yet, accumulating OM about 5 times faster than rotations with fallow.[14] Not surprisingly, unfertilized plots are much slower to gain OM regardless of rotation. Generally, growing high-residue crops (such as grasses) frequently in relation to broadleaf crops causes OM to increase more rapidly, although this is overly simplistic. To a large extent it is merely the amount of carbon captured by the plants per year (averaged over the rotation) and fed to the microbes . . . slowly.[15]

Most studies conclude that the greatest accumulation of OM occurs in the surface 6 inches, and up to 85% in the surface 3 inches.[16] This in particular demonstrates the futility of attempting to increase OM if significant soil disturbance occurs anywhere in the rotation, since it will expose the portion of the soil with most of the OM to atmospheric oxygen. Drills with shanks (knife/hoe/sweep openers), v-blading fallow occasionally, coulter carts, aggressive strip-till, or any other disturbance of significant soil volume will cause sufficient carbon loss that OM accumulation will be severely curtailed. This is especially true for warmer climates in which OM degradation occurs year-round.

Stable aggregates and water infiltration also show continued improvement in long-term no-till (see Figure 3).[17] These changes are related. Soil OM is the 'glue' that binds soil particles together and imparts structure. These soil improvements, along with the fact that soil OM can hold up to 20 times its weight in water, certainly aid the ability to grow crops. Better crops produce more residue to continue the soil-improving processes. Randy Anderson's 'Spiral of Regeneration' is real.

More Efficient Fertilization

While crop yields often trend higher with long-term no-till, especially if good rotations are used, the efficiency of fertilization also

Spring Wheat, 2002

Treatment	N Rate (kg/ha)	Yield (bu/a)	Protein (%)	Net ($/a)
20+ yr No-Till	0	42.6	13.3	55.02
	30	44.8	13.7	61.86
	60	49.1	14.0	76.62
	90	51.5	14.2	83.51
	120	49.8	14.4	72.94
1 yr No-Till	0	26.2	10.9	-26.76
	30	32.9	11.0	-9.30
	60	40.2	11.6	12.39
	90	47.9	12.3	39.39
	120	47.7	13.1	42.82

Table 2. In canola stubble. Part of a longer study being conducted by Guy Lafond, a scientist with Agri-Food Canada at Indian Head, Sask. The '03 to '05 data are similar, Lafond says, although not yet published. (Lafond, personal communication.) Note that the optimum N rate in the short-term no-till was *only half as profitable* as the optimum rate in the long-term no-till. Economic returns included protein premiums, and used the then-prevailing prices in Canada, such as $0.27/unit for N. Source: Lafond, 2005.

[13] C.A. Campbell, H.H. Janzen, K. Paustian, E.G. Gregorich, L. Sherrod, B.C. Liang & R.P. Zentner, 2005, Carbon Storage in Soils of the North American Great Plains, *Agron. J.* 97: 349-363. L.A. Sherrod, G.A. Peterson, D.G. Westfall & L.R. Ahuja, 2003, Cropping Intensity Enhances Soil Organic Carbon and Nitrogen in a No-Till Agroecosystem, *Soil Sci. Soc. Am. J.* 67: 1533-1543.

[14] Campbell et al., 2005.

[15] An example will suffice: A 100-bu/a sorghum crop might produce 6,000 lbs/a of stalks & leaves. A 30-bu/a soybean crop might produce only 1,800 lbs/a of residue. These aboveground residues would each contain roughly similar percentages of carbon (40 to 45% of dry matter). Belowground, the disparity would persist between remnants of annual grass crops versus annual broadleaf crops, although the quantities of each will be highly dependent on climate, varieties, plant health, etc. The microbes that create stable soil OM rely on the complex carbon compounds from plant remnants for energy. The 'feeding' of microbes must not involve tillage. Researchers in Oregon found that adding manure at 10 tons/a/yr for nearly 60 years, but plowed into the soil, only increased soil OM from 1.9% to 2.1%. Moldenhauer, 1994 (citing Rasmussen et al., 1989).

[16] West & Post, 2002.

[17] G.P. Lafond, 2005, No-Till: What have we learned on the Canadian Prairies, in Proceedings: NT-CA Conference (Maiskoye, Ukraine, 17-20 Aug. 2005), Agro-Soyuz Corp (data collected by Charles Maule at the Indian Head site); G.P. Lafond, 2005, PowerPoint presentation at this conference.

improves.[18] In other words, it takes fewer units of applied N fertilizer to make a unit of grain for harvest. This might be surprising, since something must feed the OM accumulation.[19] However, losses from the system (erosion, denitrification, runoff, leaching, etc.) apparently can be decreased sufficiently in well-managed long-term no-till such that N requirements can be less (see Tables 2 & 4). This efficiency is highly dependent on crop sequence, crop species, method & timing of N application, etc. Improved root exploration of the soil, mycorrhizal activity, and free-living N-fixing bacteria could also account for some of the enhanced N-efficiency.

The efficiency of other nutrients supplied as fertilizer (or manure) is also improved in long-term no-till. This is primarily due to elimination of a large component of loss from the system—soil erosion. However, nutrients such as phosphorus will need to be supplied to feed the organic matter increase, as well as to replace what is removed as grain.

With no-till and abundant mulch covering the soil surface, we find—in stark contrast to nearly all of agricultural history—a method of growing crops that can *accurately* be called sustainable. With this better understanding of natural systems, farmers adopting continuous no-till can improve efficiency and can state (with veracity) that they left the land better than they found it.

Soil Characteristics After 20 Years

N appl./year lbs/a	% Organic Matter No-tillage	% Organic Matter Tillage
0	4.10	2.40
75	4.93	2.53
150	4.28	2.45
300	5.40	2.73

Tables 3 & 4. Long-term study in Kentucky, using continuous corn with vetch as a cover crop. The soil improvements are reflected in corn yields in Year 20 of the same experiment. Note that this was conducted in the ’70s and ’80s—long before the advent of many modern tools for no-till planting, and yet the yields under no-till easily trump the tilled plots. Soil quality overrides many other things. Source: Derpsch, 2005, citing Thomas, 1990.

Corn Yields in Year 20

N appl. lbs/a	bu/a No-till, 20 yrs.	bu/a Tillage, 20 yrs.
0	125	83
75	136	110
150	144	126

[18] R. Derpsch & K. Moriya, 2005, Implications of soil preparation as compared to no-tillage on sustainability of agricultural production, in Proceedings: NT-CA Conference (Maiskoye, Ukraine, 17-20 Aug. 2005), Agro-Soyuz Corp (citing G. Thomas, 1990: Labranza Cero: resultados en EEUU y Observaciones en campos Argentinos, in Proceedings: AAPRESID Congress (Rosario, Argentina, 31 January 1990). Lafond, 2005.

[19] Note that a 1% increase in soil OM (e.g., from 2.0% to 3.0%) to a 6-inch depth (18,000 lbs/a OM) requires assimilation of ~1,000 lbs/a of N, 100 lbs/a of sulfur, 100 lbs/a of P, and so on.

Long-Term No-Till in South America

by Rolf Derpsch

The following is excerpted from a paper presented at the 10th ISCO Conference (May 1999), West Lafayette IN, and also available at www.rolf-derpsch.com/notill. Derpsch has been working with no-till in South America for four decades, and can be credited with some of the tremendous success and large-scale adoption in Paraguay, Brazil, and Argentina. More recently, he has undertaken major consulting efforts in Africa, Eurasia, and Australia.

A mental change of farmers, technicians, extensionists, and researchers away from soil-degrading tillage operations towards sustainable production systems like no-tillage was necessary . . . . *As long as the head stays conventional it will be difficult to implement successful no-tillage in practical farming*. Through time we have learned that if the farmer does not make a radical change in his head and mind, he will never bring the technology to work adequately. We found that this is not only true for farmers but for technicians, extensionists, and scientists as well. No-tillage is so different from conventional tillage and puts everything upside down, that anybody who wants to have success with the technology has to forget most everything he learned about conventional-tillage systems and be prepared to learn all the new aspects of this new production system. We believe that a farmer first has to change his mind before changing his planter . . . .

Concepts about liming and fertilization have changed a lot in Latin America after shifting to the no-tillage system. Experience shows us that we have to forget everything we have learned in the University about fertilization and liming and get acquainted with the new concepts in fertility management in this system . . . .

Soil compaction in permanent no-tillage is an issue that is discussed over and over again . . . . Three no-till pioneer farmers from Brazil were interviewed in 1997 to express their views on this problem. The interviewed farmers were Nonô Pereira (22 years of permanent no-tillage), Frank Dikstra (22 years of continuous no-tillage), and Herbert Bartz (26 years of continuous no-tillage), totaling 70 years of experience. Their soils vary from about 80% sand to about 80% clay. The farmers were unanimous in stating that they do not perceive compaction as a problem in permanent no-tillage (Revista Plantio Direto, 1999). They also stated that *there is no need to till the soil every so often after no-tillage has been established* [emphasis added]. Finally they said that the best way to avoid compaction in the no-tillage system is to produce maximum amounts of soil cover, [and to] use green manure cover crops and crop rotations, so that roots and biological activity as well as earthworms and insects, etc., loosen the soil. Good soil cover is also essential to maintain higher moisture content on the soil surface and this will result in better penetration of cutting elements of the seeding equipment.


Photo by Doug Palen.

As Derpsch has repeatedly emphasized, many of the benefits of no-till derive from keeping the soil covered with residue.

Another Look at Strip-Till

The data on carbon losses and soil degradation certainly undermine the notion that a little tillage is okay. Yet, with all the recent hoopla in the U.S. over strip-till, zone-till, “vertical tillage,” and similar crazes, one might wonder. Certainly the South Americans don’t spend any time or energy worrying about such stuff. Attendees at recent AAPRESID Congresses find it tightly focused on *low-disturbance* no-till, and how to do it better—and AAPRESID is sufficiently large and democratic that it can be seen as a measure of the pulse of Argentine agriculture. The number of hectares under low-disturbance continuous no-till in Argentina is enormous (60% of cropland), with a significant amount entering its second and third decade under no-till. The variability in climate and soils under successful no-till there is tremendous. Maybe the economics are different in S. America. Maybe we in the U.S. know something they don’t . . . .

Leading Edge has twice before (March ’04 & March ’03) reported on strip-till experiments that used row cleaners and pop-up fertilizer for the no-till plots. Here’s another look (see sidebar). Nope, still no yield advantage to strip-till. And if we figure the cost of the strip-till pass versus the cost of equipping the planter with row cleaners and pop-up fertilizer, the economics strongly favor no-till. (If you are assuming savings of 10 cents/unit of N for NH_3 versus other fertilizer sources, you should remember that at-planting & in-crop N applications are from 10 to 30% more efficient than fall applications—as Beck would say, there’s too much opportunity for ‘leakage’ of N with fall applications.) With the additional weed control costs associated with strip-till, it looks worse yet. Some regions will have further issues with time constraints for getting the strip-till done in the fall. And if soil organic matter has any value at all, strip-till definitely makes no sense. Why strip-till and similar schemes have so much popularity defies explanation, unless a big segment of the population secretly has a tillage fetish.

’04 Corn Yield bu/a

No-Till	160.1
Fall strip-till	163.4
LSD $_{(P=0.05)}$	not significant

Location: SDSU Agronomy Farm, Brookings, SD. Previous crop: soybean. Soil test: 14 ppm Olsen P. Long-term no-till. Part of a larger demonstration with various fertilizer treatments.

Liquid fertilizer of 5-16-5 (N-P_2O_5-K_2O) applied in the seed furrow at planting for no-till, and applied ~ 7 inches below the surface with the strip-till rig in the fall.

All other fertilizers broadcast. Planter with row cleaners.

Conducted by SDSU (A. Bly, R. Gelderman, J. Gerwing). 5 replications, randomized.

’04 Corn Yield bu/a

	Soybean Stubble	Wheat Stubble
Fall strip-till with P_2O_5 fertilizer placement	208	N/A*
Fall strip-till, no P_2O_5 in fall	204	214
No-till	205	208
LSD$_{(.05)}$	ns	ns

*Data not available due to misapplication of P fertilizer.

Location: SDSU research farm near Beresford, SD. Soil test: 10 ppm Olsen P. Long-term no-till.

All treatments had 46 lbs. P_2O_5 applied in the seed furrow at planting, except the fall strip-till with fert. placement which had 46 lbs. P_2O_5 applied with the strip-till rig ~ 7 inches below the surface.

N fertilizer was broadcast on all plots. Planter with row cleaners.

Conducted by SDSU (A. Bly, R. Gelderman, J. Gerwing & B. Berg). 4 replications, randomized.

Some Assembly Required

by Matt Hagny

The instructions are in a foreign language, with a corner missing, no pictures, and you're not even sure all the necessary parts are in the box. That's much how Brian Berns felt about no-till during the late '80s and most of the '90s. Yet he had seen the moisture savings from the outset, and knew the water could be translated to yield and profit. He persisted, and now the new contraption is doing what it should.

On a regular basis, the Berns tribe reinvents their operation, located some 25 miles southwest of Hastings, NE. As Brian's dad "retired"—sort of—and Brian's brother, Keith, returned to the farm (after a 10-year stint of teaching high-school vo-ag morphed into a computer technology career), they found opportunities in extensive custom seeding with their no-till drill. Plus, they've put up 5 center pivots in the last 4 years, having had only a smidge of furrow irrigation before that. The changing workforce and economic opportunities forced them to repeatedly tailor their rotations and agronomic practices to fit those needs.

Brian started farming in '88—just in time for a bad drought. That experience quickly taught him the value of moisture, and his reaction was to try preserving a field of wheat stubble to plant to corn in '89—the "ecofallow" program developed in western KS and NE. That no-till corn in '89 was a success for Brian and his dad, and quickly led them to experiment with no-till seeding of wheat into corn and milo stalks. They rented a 15-foot Deere 750 drill from SCS (NRCS) for a couple years, eventually buying it when the rental program was discontinued.

Corn in itself was a bit of a change for the Bernses, who did mostly wheat >>milo >>summerfallow, or wheat >>milo >>milo >>fallow back in their tillage days. Brian explains, "Before 1990, very little dryland corn was grown in this area." Embarking on the no-till adventure had Brian in search of information, sending him to Lessiter's National No-till Conf. in '92. "You'd go to a conference and hear all these ideas, and then try to figure out if any of it would work for us."

On surface-applied side-dressing under pivots: "Streaming isn't a risk at all."

Still, the pieces weren't exactly falling into place, and Brian continued to do some tillage in the fallow year of the rotation, as well as on the flood irrigation (to ease rebuilding the furrows each year). By '95 he was getting fairly close to continuous no-till on the land he farmed, even though his dad was a little slower to totally convert his land. Even after Keith returned to the farm in '98, they occasionally "disked fields going to second-year wheat, and silly stuff like that," remarks Keith sarcastically—reflecting the dramatic change in their thinking. By 2000, they were 100% no-till, and the tillage equipment got sold during their dad's retirement sale in '01. Keith notes the helpful change in attitude: "It's amazing. When the tillage equipment isn't there, you don't even consider it. Before it was always tempting to use it, even if you knew all you were doing was a temporary fix."

Photo by Brian Berns.

Bernses' irrigated corn in soybean stubble. The mulch covering the soil improves irrigation efficiency substantially.

Dryland Practices

"Corn into wheat stubble is our #1 moneymaker," notes Brian, "A combination of 'Freedom to Farm' ['96 Farm Bill] and no-till has allowed us to go heavier into corn." And corn has been undoubtedly successful for them, with a 10-year average (dryland) of nearly 120 bu/a. As of '05, corn has totally displaced milo in their rotation, and they even do stacked corn on dryland.

However, dryland soybeans have been a struggle for the Bernses, since insurance coverage is so poor and the lengthy drought decimated yields. However, they 'hit' in 2005 with dryland soybeans averaging 45 to 50 bu/a. To the extent possible they go corn >>corn >>soy >>wheat, but since they're still gun-shy of soys, some wheat gets planted directly into corn stalks. Keith notes, "Wheat into beans is a much better system than behind corn."

"Some think irrigation doesn't go with no-till. We think differently."

Brian lays out the roadmap, "We plan on increasing wheat and beans in '06 and future years—trying for a more balanced rotation, an agronomic rotation."

Bernses' dryland corn is planted at 23,000 to 24,000 seeds/a, and never under 22,000. Brian says stands generally run 20,000 to 21,000. Most is Cruiser-treated (low rate), or has a synthetic pyrethroid applied with the pop-up. Generally, all the fertilizer (110 units of N) for their dryland corn is applied at-planting with low-disturbance 3x0 openers, plus 5 gal/a of 10-34-0 pop-up through the Keetons (Bernses' planter is plumbed with 2 completely separate liquid systems fed through piston pumps and RedBall manifolds).

Wheat is seeded at 90 to 120 lbs/a on 7.5-inch spacing, and gets 8 or 9 gallons of 10-34-0 as a pop-up (in some cases the Bernses use only 5 gallons for pop-up, but broadcast a load of dry P to build levels in certain fields). The remainder of the N fertilizer is streamed on in early spring. Occasionally they stack the wheat if they consider their residue levels to be low in a field, although heavy first-year wheat stubble usually gets planted to corn, since that's their most lucrative crop.

Photo by Brian Berns.

Achieving vigorous stands of irrigated corn in heavy residue (2d-yr corn here) is no problem for the Bernses.

The Rainmakers

The Berns brothers are just getting started on developing rotations for their pivots, but are doing corn >>soybeans currently, or corn >>corn >>soybeans, and trying out some wheat. This is a major departure from the irrigation practices in this part of Nebraska, most of which has been in continuous corn for decades (this is slowly changing). In 2005, Keith & Brian had half a circle of wheat planted behind soybeans to see how that worked. The field averaged over 80 bu/a, which included the dryland corners, so the pivot itself made around 85. They're trying to figure a way to make a little extra profit in the wheat year, and were contemplating double-crop sunflowers—until they realized their wheat herbicide precluded that option. They put in double-crop corn instead, on the 4th of July, which made 65 bu/a (it ran out of time when a killing frost hit in late September). They have also considered doing a forage.

"That's why we no-till—to bring the soil back to how it was originally."

Up till '04, the Bernses ran a knife applicator in the spring to put down either NH_3 or liquid N & P to meet the fertility demands of irrigated corn. Brian wasn't satisfied: "I never liked running through with the knife and messing up the seedbed." Instead, for the last 2 seasons they've applied some N at planting followed by side-dressing. For irrigated corn, they put down around 90 units of N as liquid via the fertilizer openers on their 12-row White planter. Another 80 – 90 units of N are streamed with drop nozzles when the corn is knee to waist high—and immediately watered-in, so "streaming isn't a risk at all." Five gallons of 10-34-0 still goes in the seed furrow, with additional P often included in the 3x0.

The planter itself is a bit of a work-in-progress, with the Bernses having tinkered with nearly every aspect to discover what might perform best. Currently it has Yetter row cleaners, heavy down-pressure springs, Keetons, and a motley assortment of closing wheel styles. Brian is noticeably frustrated at trying to make it function properly in all conditions, although life did get easier when they eliminated furrow irrigation and went 100% no-till. Yet their experimentation and attention to detail are rewarded with nice stands and some highly respectable corn yields in both dryland and irrigated.

Photo by Matt Hagny.

Bernses' irrigated wheat, fall '04.

Despite below-normal precip from 2000 to '04, the Bernses' irrigation has been quite efficient due to no-till. They frequently top 200-bu/a corn with less than 10 inches of water applied. "We don't have excess water . . . . We're right on the edge of [the aquifer]. These are only 600-gallon-per-minute wells." Keith muses: "Some people around here think irrigation doesn't go with no-till. We think differently."

The Bernses continue to dream up ways of using the water from the wells, and the abundance of residue produced. They've always had some cattle, and are toying with the idea of seeding rye or forage turnips under the pivots and grazing this vegetation along with the corn stalks. Keith remarks, "I think there's some real opportunity to utilize some of that."

Parting Thoughts

The brothers Berns see evidence they're on the right track. Brian explains, "I started no-till because of moisture savings. Now, time savings and fuel savings are showing up. But the Number One thing with no-till is still the yield advantage." With farm diesel recently over $3/gallon, that part needs no explanation. The time savings are put to use on the Berns farm in many ways, since they do all their own spraying and harvesting, plus a big push with custom seeding (they covered 2,500 acres with their 20-foot JD 1560 drill in the fall of '05 alone). Keith says, "Custom work teaches us to farm more efficiently"—a comment echoed by Brian: "Getting the equipment over more acres is a big issue [for profitability]." This, plus minding a cow/calf herd and some backgrounding, along with Keith's website-development business, ensures that every hour matters. And they do enjoy time set aside for themselves and their families.

The Berns boys are adding 600 acres of dryland in '06, so that has them further scrutinizing their efficiency and priorities. Likely, they will be cutting back on cattle numbers or outsourcing some of those activities, in order to capitalize on proficiencies in cropping. In a related move, they will probably sell their haying equipment and rely more on winter forages under the pivots for cattle grazing.

Brian & Keith are still the iconoclasts of their region. Keith notes the reluctance of most of the locals to accept permanent no-till, whether they're active farmers or landlords who once farmed themselves: "It's tough for these guys to admit that the farming methods they used their whole lives was damaging the land—that tillage wasn't benefiting the crops or the soil. There's a lot of pride at stake. . . . But they have to realize that they didn't have all the tools [to no-till] a couple decades ago. Glyphosate at $15/gallon versus $80 makes a huge difference in the degree of economic advantage to no-till." Brian explains some of it is just trading of expenses—"you spend money on seeding equipment instead of tillage equipment"—but overall they're quite pleased with the economic advantages of no-till.

Keith further notes how far we've come in our understanding of no-till methods, as well as beginning to grasp what is happening with soils: "Every year that we no-till confirms what we thought we knew [going into the practice]. Long-term no-till is always the best-yielding. It's good to have confirmation that we're going in the right direction." Brian expounds on that message: "It seems like our yields vary mostly according to organic matter. . . . The field that yields the best was sod 6 years ago. This year [2005] in the draws in that field, the yield monitor showed spikes over 200 bu/acre [field average over 150 bu/a] with only 110 lbs of N fertilizer. . . . That's why we no-till—to bring the soil back to how it was originally." That respect for soil conditions led them to try bringing a sod field directly into no-till cropping in 2005, with reasonable success.

Photo by Matt Hagny.

Keith seeding wheat in dryland soybean stubble. Brian says, "Long-term no-till is always the best-yielding."

The Bernses take a strong interest in perennial improvement of all their talents and endeavors, and if that means developing something from scratch—well, so be it. Keith has a bit of an idea of what it is to be self-taught, having acquired most of his computer skills the slow way in the late '80s—by trial and error, since "there weren't any classes." And Brian got educated on no-till in the '80s and '90s with substantial tuition to the School of Hard Knocks. But the plucky duo seems to be making their cropping system run just fine without much help from those cryptic instructions.

No·till On The Plains

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