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No·till On The Plains

# New Frontiers

by Matt Hagny


On the western prairie province of Alberta, a plucky set makes a go out of grain farming. While "direct seeding" (no-till planting a crop without a separate tillage pass) is fairly common, only the more adventurous have adopted continuous no-till with narrow knife openers. Extremely rare is the person running disc openers on their drill, since the climate is so cool that soil warming is a persistent challenge, and residue decomposition very slow.

A third-generation farmer near Lethbridge, AB, savvy Rod Lanier shifted to low-disturbance disc openers five years ago: "It's working great," he reports. Lately he's added a Shelbourne stripper head, with synergistic effects: "There's a beautiful fit between a stripper head and a disc-opener drill." The reason, he says, is "dramatically less hairpinning," since all the stubble is standing at seeding time (which is almost always the case in their cool climate—the straw is slow to rot off at the soil surface). Lanier harvests all his wheat, field peas, and safflower with the stripper head.

Late spring frost worse in high-residue conditions? Not necessarily, says Rod. He cites research from Reduced Tillage Linkages (the Albertan 'direct seeding' organization) showing smaller temperature fluctuations in high residue than in black soil, due to the insulating effect of the stubble. Indeed, the Albertan experiences with frost damage are so contradictory in comparing disc openers versus shanks (knives, etc.) that a person could be forgiven for concluding there is no pattern at all.

Photo by Rod Lanier.

Lanier enjoying a good wheat harvest in Alberta.

## Contents

## If Summer Is on a Saturday

. . . they have a baseball game! So goes the old joke about the brevity of the Canadian thawed season. The farming session is greatly compressed, with field peas being drilled anytime after April 1 (more typically the second week of April), followed immediately by durum (a type of spring wheat), and then an oilseed—which for Rod currently consists of flax and safflower primarily (the Lanier farm grew canola for 22 years, but hasn't grown any the last 3). All of this seeding must happen in about 3 weeks' time. Luckily, about 25% of Rod's acres is already in winter wheat, which gets seeded during the first half of September. (Laniers have grown winter wheat for decades as well, with long-term yield averages of 30 – 35 bu/a, usually limited more by dryness than winter-injury or winterkill.)

Harvest begins with field peas in early August, then winter wheat in late August, durum in early September, concluding with safflower (or canola) in late September. It is imperative that harvest be expeditious, lest you fight snowdrifts, frost in combine sieves, increased drying costs, etc. Rod, along with one full-time person from mid-March to mid-October, is able to accomplish the harvest on their 3,300 acres (plus some custom farming) with a solitary MF 8680 conventional combine, partly due to the efficiencies of the 28-ft Shelbourne head. (Rod's wife, Lori, has a background in finance and marketing, and runs the farm's office.)

Lanier's crop rotation has been standardized to oilseed (flax, safflower, mustard, and canola) >>w.wheat >>"pulse" (a.k.a. legume, in his case usually field peas) >>durum. The oilseed is planted in the durum stubble to repeat the cycle. In recent years, Rod has applied as much N fertilizer as possible in the seed row (25 lbs/a of N) for wheat with his single-shoot 36-ft JD 1890 drill on 7.5-inch spacing, with the majority of the N (60 – 70 lbs/a of N) going out as top-dressed urea in March for winter wheat, and as a pre-seeding surface application for durum and oilseed crops. To apply dry fertilizers, Rod has been running a farm-built 85-ft wheel-boom behind his tow-between air cart, although he notes that several companies now sell these booms. Rod has also been doing some coated urea (ESN) down the seed row for durum, since the tolerated rates are considerably higher than with standard urea—enough so that he can eliminate a separate surface application. Plus,

Photo by Rod Lanier.

Rod's field peas flourish in low-disturbance no-till.


**Leading Edge**

No·till On The Plains

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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.

the delayed release of N allows him to capture protein premiums for the durum.

Crop diversity in Lanier's area is considerable. Rod has grown sunflowers in the past, and a couple of other progressive no-tillers (e.g., Brian Hildebrand and Greg Bauer) in the region tried corn (for grain) in '07 with good profitability despite a dry growing season. However, Rod thinks that if his operation expanded by another thousand acres he would probably add alfalfa. For '08, he is planning to try proso millet, his first foray into warm-season grasses to lengthen his rotation. As an interesting aside, much of Lanier's safflower is marketed through a birdseed company that he and 4 other farmers own—the birdseed company sells about 3 million pounds of safflower annually.


Photo by Rod Lanier.

Rod's dry fertilizer boom.

### Long Way There

Rod's area is classified as a "brown soil zone" in Canadian lingo, which is to say a sandy clay loam with decent soil OM of about 2.5%. Precipitation averages about 15 inches per year, which goes a long way in such a cool region (low evaporation), but is extremely erratic from 6 inches to 20+ in any given year. As you might imagine, these loamy soils were quite vulnerable to wind erosion when tilled, which was the primary impetus for Rod's father, Ike, to experiment with direct seeding of winter wheat into oilseed stubble in the early 1980s. Rod says, "You can still see the wind erosion effects [from decades past]. That was an obvious reason to quit doing tillage."

For his direct seeding, Ike was simply using an IH hoe drill with carbide points. Rod recounts that a few of the neighbors—upon seeing Ike scratching around checking seed placement behind his drill—would comment: "No-till finally brought Ike to his knees!" —But Rod thinks Ike had the last laugh out of that deal: no-till really was quite effective for them. Even though Roundup cost \$80/gallon in those days, there were substantial cost savings with no-till in the fewer trips across the field. Moisture savings were also obvious, which allowed for better crops and the gradual phasing out of summerfallow. The matter was soon settled: "The last time we pulled anything wider than a 3/4-inch knife through the soil was in 1984. We were totally convinced that no-till was the correct path. We never looked back."

**"It's far easier to get canola, flax, and safflower seed to come up from 1 inch with a disc drill versus 1 inch with a hoe drill."**

During the '80s, the Laniers primarily used a Haybuster hoe drill (box drill) on paired rows, with a fertilizer boot in the middle of the pair of seed rows. "When it was dry, it brought up enormous pieces of earth, and [the boot] kept breaking," which led to abandoning the fertilizer boot on the drill and going to top-dressing with ammonium nitrate, and in some cases applying anhydrous in the fall with a crude hoe opener. Eventually they went to a slightly more sophisticated slender knife for $NH_3$, called a Bandicator, and the drill was upgraded to a Flexi-coil 5000 air drill, but still a knife opener. By the mid-'90s, Laniers were testing Flexi-coil's Barton disc opener for anhydrous application in the fall.

Then, in 2003, Rod bought the Deere 1890 and ceased fall anhydrous altogether, going totally to top-dressing with urea. The 1890 is on 7.5-inch spacing, which Rod prefers to their previous 9-inch drill spacing. Because of the crop's cold tolerance, Lanier's field peas are planted into the heaviest wheat stubble, and about 2 inches deep. Canola, flax, and safflower are planted only an inch deep. Rod comments, "It's far easier to get the seed to come up from 1 inch with a disc drill versus 1 inch with a hoe drill. It comes up so nicely through the slot from a disc drill." (*Editors' Note: This effect is only with openers that place the seed so that the blade's cut is vertical and directly over the seed, and only if the packing over the seed isn't too severe, i.e., with a true gauge-wheel drill.*) Rod elaborates, "We can go in much wet-

Photo by Rod Lanier.

Lanier's wheat, looking prosperous.

ter soil with a disc-opener drill. It does take more management to use a disc drill—especially the residue management at harvest is more critical. A hoe drill is more forgiving of mistakes, but it can't take you to the next level."

## Stubble Effects

Rod hasn't seen much difference in weed pressure between the drill opener types, but he adds that his weed pressure (foxtails, wild oats, and kochia) had already declined considerably with direct seeding and more diverse crop rotation. (Downy brome is currently his biggest weed challenge.) As for the drill openers, Rod adds, "What we love about the disc-opener drill is that we can wait to do a burndown until just before crop emergence. With the hoe drill we had to spray before seeding, so weeds had another 8 to 14 days to emerge. With the disc drill, the crops always get a clean start."

How does Rod get the Deere disc opener to function reasonably at shallow depths? The secret, he says, is the Shelbourne-harvested stubble—once you remove the need to cut through a thatch of residue on the surface, everything goes so much better. And now that straw distribution behind the combine is eliminated as a problem, he has started noticing the effects of uneven chaff spreading, even though the combine has a chaff spreader: "The stripper head allowed me to see it. Once you remove one problem, you get pickier about other things." In the past, Rod has baled wheat straw from fields yielding over 65 bu/a to facilitate seeding and soil warm up, but he says the stripper head alleviates the problem sufficiently that he will have less need for baling. (And in the past, he would only sell straw if the price was double the total nutrient value contained in the straw.)

**Gauging soil health: "I've got about twice as many earthworms as my 'organic' neighbors."**

Other techniques Rod has deployed to adapt to cooler and wetter soils in the spring include applying all the P fertilizer with the seed, always applying fungicide seed treatments, and choosing the best seed by cold-germ testing as well as seed weight. He does plant slightly higher rates than previously, but he also pushes the envelope on early planting rather than risking heat cutting yield with later plantings: "A durum crop can get zipped off by a frost and still come back to make a wonderful crop compared to later seeding." (The one crop that he dares not plant too early is canola, because it is so sensitive to frost.)

Rod's absence from canola production in recent years is an interesting digression. When discussing recent problems with pea leaf weevil, Rod mentions, "We've dropped crops [from the rotation] due to insecticide needs" —specifically, canola. Insect problems in canola have become significant enough for Rod's region that one or two insecticide applications is considered normal. Aside from safety concerns for the applicator, Rod is leery of what these products are doing to his earthworms and other soil-dwelling organisms: "Soil ecologists won't come out with a simple answer, and the issue is complex. But it is a concern. To us, earthworms are a gauge of soil health." Rod has used insecticides on his fields in the past, without observing any declines in earthworm prosperity, but still he prefers to avoid the risk (and expense) by growing crops that don't need this input. Along this line of reasoning, Rod mentions, "I've got about twice as many earthworms as my 'organic' neighbors, and some of them are exceptionally good at 'organic' production. I happily swap field visits with these 'organic' producers, but with my spade in hand."

## Eking Out More Efficiency

Another tactic Lanier has used for better timeliness in the spring is to spray glyphosate in the fall on any open acres. Rod reports that this has been very successful at combating dandelions, which are inexpensive to kill in the fall with glyphosate. Rod also likes desiccating his field peas with pre-harvest glyphosate (applied by a custom applicator with a narrow-wheel self-propelled sprayer) because it is a unique herbicide window and this diversity adds value for controlling certain weeds.

One new challenge is deciphering which nozzles, pressures, and ground speeds are best when spraying tall stripper stubble. So far, researchers are indicating that slower ground speeds and angled nozzles may be the most effective. Rod currently uses a 133-ft Flexicoil wheel-boom sprayer, pulled by an older 'retired' 4WD tractor without the duals. Most of their fields are a mile square, so covering the acres rapidly is quite feasible.

Lanier reflects on their no-till history: "We've always known the moisture-use efficiency gets better and better. We're starting to figure out that the fertilizer efficiency is better too. We're getting more bushels with less fertilizer." Rod applies N, P, and S according to soil tests, and occasionally K as well. Sulfur typically is applied only for the canola crop ("for insurance" against deficits) as ammonium sulfate in the seed row. While Rod has yet to apply any micronutrients, he keeps watching.

Photo by Rod Lanier.

Rod drilling peas in stripper-harvested wheat stubble. Lanier: "There's a beautiful fit between a stripper head and a disc-opener drill."

The Lanier operation goes by the name 'NeverIdle Farms,' which isn't literally true (fortunately), especially with all of Rod's newfound efficiencies. The long Alberta winter offers great opportunity for Rod, Lori, and their 4 children to spend time at their cabin in the mountains, the perfect venue for their snow skiing and snowshoeing, among other diversions. Work smart, play hard!


Photo by Jana Lindley

# No-Tillage & Mulch Cover

by Rolf Derpsch

SCIENCE

Derpsch is a no-tillage consultant, based in Germany and Paraguay.

*Rolf Derpsch has studied and consulted on no-till systems for 35 years, frequently traveling to far-flung places on his consultancies. Derpsch is one of the world's foremost authorities on no-tillage cropping.*

Although no-tillage is at present practiced on roughly 100 million hectares (2.5 million acres) around the globe, the basic principles of the no-till system are not fully understood by many farmers worldwide. Some no-till farmers still view crop residues as a waste product, or something that is causing trouble at seeding, and only a few farmers have understood the importance of soil cover in the no-till system. The low levels of soil cover in many places, because the straw and stalks have been eaten by animals, baled and hauled away, or burned, demonstrates that crop residues are not viewed as a valuable product that enhances soil fertility and increases yields. In other cases, significant opportunities to grow more cover are neglected while the fields are maintained in a sterile fallow condition with multiple herbicide applications.

Low levels of soil cover lead to higher evaporation and lower water-use efficiency. A no-tillage adoption with low amounts of crop residues, limited crop diversity, and high amounts of soil disturbance will plateau and does not attain the full potential of the no-tillage system. Under these practices and/or the use of occasional tillage, it is difficult to move the system a step further. To be able to move a no-tillage system to the next level it is necessary to implement quality no-till, which includes: full stubble retention and maximizing soil cover; use of low-disturbance seeding equipment; development of more diverse crop rotations including cover crops; and instead of using rotational tillage, practice a permanent no-till system. This will result in higher carbon content of the soil and consequently in higher yields of crops. The development of higher carbon levels in the soil will be an indicator of the quality of the system.


Photo by Unknown, via Rolf Derpsch.

Favorable no-till results as well as long-term soil productivity depend on maintaining an adequate mulch covering the soil.

## Importance of Soil Cover

It is always necessary to be reminded of the importance of soil cover in a no-tillage (zero-tillage) system. *Many of the benefits and advantages of the no-tillage system come directly from the permanent cover of the soil, rather than from not tilling the soil.* In other words it is not so much the absence of tillage, but the presence of crop residues on the soil surface that results in a better performance of no-tillage in comparison to tilled systems. (*Editors' Note: Both mulch cover and continually undisturbed soil are necessary.*) Failure to pay attention to soil cover has resulted in poor performance of the system (lower yields, increased runoff and erosion, low biological activity, etc.). There is plenty of scientific evidence that no-tillage without soil cover results in poor crop yields.[1]

[1] J.E. Ashburner, 1984, Dryland tillage practices and studies in Algeria, in Proceedings: FAO Panel of Experts on Agricultural Mechanisation, 6th Session (Adana, Turkey, October 1984); P. Wall, 1999, Experiences with crop residue cover and direct seeding in the Bolivian highlands, *Mountain Res. & Development*, 19 (4): 313-317; K. Sayre, B. Govaerts, A. Martinez, M. Mezzalama & M. Martinez, 2006, Comparison of alternative conservation agriculture technologies for rainfed production in the highlands of Central Mexico, in Proceedings of the 17th ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006).

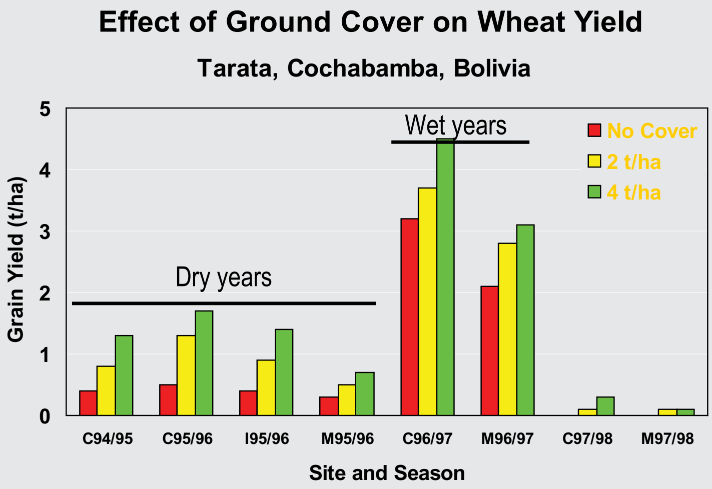



Figure 1. Effect of mulch cover on no-till wheat yield. In both wet and dry years, wheat yields were higher with greater mulch levels. Annual rainfall averages for sites are 500 – 650 mm (20 – 25 inches); elevation is 2,500 m (8,300 ft). Source: Wall, 1999.

Soil cover is needed to increase water infiltration into the soil and to reduce runoff and erosion. Research conducted in Brazil and other parts of the world has shown that the percentage of soil covered with plant residues is *the* most important factor that influences water infiltration into the soil.[2] Non-infiltrated water is lost to production, reducing water-use efficiency.

Research conducted in a low-rainfall area of Bolivia showed that in all seasons the highest yields were

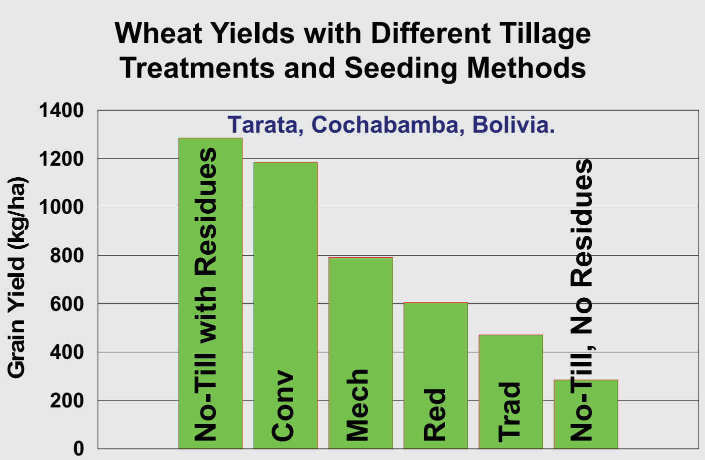



Figure 2. Depending on mulch cover, no-till plots were either the best or the worst. 'Conv,' 'Mech,' 'Red,' and 'Trad' all involved substantial tillage, representative of typical practices in the region, and of these, 'Mech' was the only one using a mechanical seeder—the others were broadcast and incorporated with shallow tillage. Source: Wall, 1999.

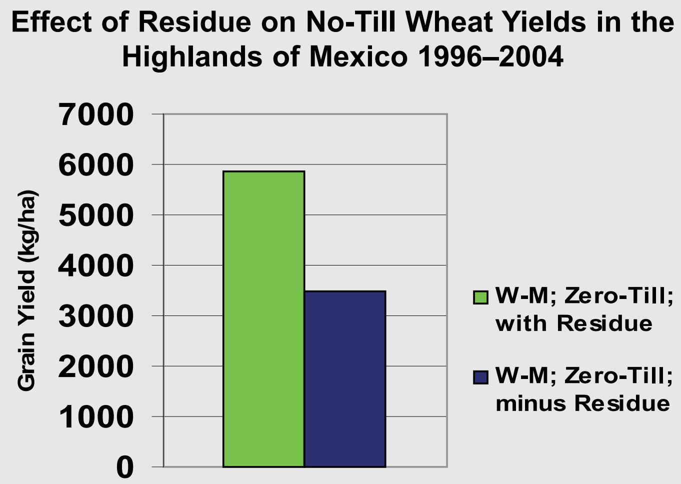



Figure 3. In rainfed cropping in the central Mexico highlands, no-till wheat yields were higher with residues retained. A still greater disparity existed for economic returns over direct costs: Retaining residue at ~ 2,900 pesos, without residue at only 300 pesos. Crop rotation was a 2-year cycle of wheat >>maize (corn). Similar yield and economic advantages were found for the maize component: 5,100 kg/ha for residues retained, versus 4,000 kg/ha without mulch, and returns above variable costs were 2,250 pesos for retained residues, versus 1,800 without residues. The various management practices for the plots had been in place for 5 years prior to this data being collected, so that the systems could stabilize. Average annual precipitation during the trial years was 633 mm (25 inches); elevation is 2250 m (7,400 ft); replicated plots. (Source: Sayre et al., 2006.) Researcher Ken Sayre explains the results: "Lack of water retention in the soil is the main problem with zero-till without residue retention. We can receive 15 – 20% of the total rainfall in 20 minutes during a July afternoon. If the water can't infiltrate rapidly, it runs off. Practicing zero-till with no residue retention leads to marked degradation of most soil physical properties, like aggregate structure and stability. The soils become seriously compacted; water just runs off with associated erosion." See photos, p. 425. (Source: Ken Sayre, personal communication, March 2008.)

obtained from the plots with no-tillage plus full crop residue retention, intermediate yields were obtained with different tillage systems from conventional to minimum-tillage, and the lowest yields were from the plots with no-tillage *without* residues (see Figures 1 & 2).[3]

Similar results have been obtained by CIMMYT researchers under rainfed production systems in the highlands of central Mexico (see Fig. 3).[4] Wheat and maize (corn) had their yields and economic returns drastically reduced when residues were removed in the no-till system. The researchers concluded that *no-tillage without crop residues on the soil surface leads to disaster.* Comparing production systems, the researchers found that no-till practices (with residues retained) had much greater profitability than the typical farmer practices in the area (tillage, plus removal of residues for livestock).

[2] C.H. Roth, 1985, Infiltrabilität von Latossolo-Roxo-Böden in Nordparaná, Brasilien, in Feldversuchen zur Erosionskontrolle mit verschiedenen Bodenbearbeitungs-systemen und Rotationen, Göttinger Bodenkundliche Berichte, 83: 1-104.

[3] Wall, 1999.

[4] Sayre et al., 2006.

In the no-till system, the researchers found that retaining residues produced additional grain yield such that *the residues should be valued at 4 to 6 times the current market price of fodder.*

## Crop Diversity

Cover crops and crop rotation play a very important role in a no-till system in order to achieve the high amounts of soil cover needed. The development of cover cropping along with no-till systems has been a major factor in the unprecedented growth of this technology in Brazil and Paraguay.

In drier climates, farmers are often concerned that cover crops will take moisture out of the soil, making it unavailable for the primary crops. This is and should always be a concern in drier climates. Managing cover crops at the right time, in the right way, and using species that use less moisture are ways of getting around this problem. It must be remembered that while the cover crop removes some soil moisture, the additional mulch from the cover crop will improve water-use efficiency later in the cash crop, as shown by recent research performed in Argentina.[5]

Photos by Ken Sayre, CIMMYT.

Weed pressure in monoculture maize, no-tillage with residues removed (left photo) as compared to a maize >>wheat rotation with residues retained, in the studies reported by Sayre. Herbicide applications were the same in both plots, although Sayre reports, "With no-till where residues have been retained, herbicide use can be dramatically reduced. . . . We have observed a tremendous reduction in weed populations (both annual grass and broadleaf weeds including yellow nutsedge) where we are practicing zero-till under the maize-wheat rotation combined with adequate residue retention on the soil surface, especially compared to the common farmer practice of tillage, continuous maize, and residue removal for fodder." Ken Sayre, personal communication, March 2008.

## Long-Term Benefits of No-till

While more than 70% of South American farmers are using permanent no-tillage systems, this is only the case with 10 – 12% of farmers in the USA. Yet research and farmer experience have more than adequately demonstrated the long-term benefits of a no-tillage system.

Figure 4 illustrates the evolution of a long-term no-till system as understood by the esteemed soil scientist J.C.M. ('Juca') Sá of the University of Ponta Grossa, Brazil. In the Initial Phase (Years 0 – 5), the soil starts rebuilding aggregates and measurable changes in the carbon content of the soil are not expected. Crop residues are low and extra nitrogen (N) needs to be added to the system.

In the Transition Phase (Years 5 – 10), an increase in soil density is observed. Soil carbon and extractable phosphorus start to increase.

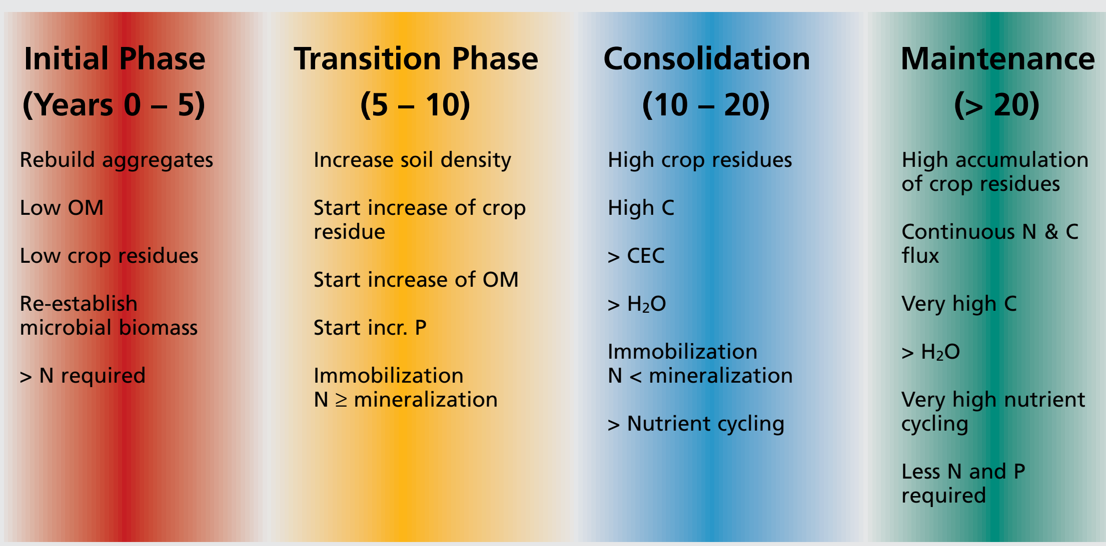



Figure 4. Progression of a no-tillage soil. Years are approximate and only apply to continuous no-tillage with full stubble retention. Too many low-carbon (low-biomass) crops such as broadleafs will also hinder the progression of the system. Source: J.C.M. Sá, 2004, Adubação Fosfatada no Sistema de Plantio Direto, in *Fósforo na Agricultura Brasileira*, ed. T. Yamada & S.R.S. Abdalla, Sao Pedro-SP, Associaçao Brasileira para a Pesquisa da Potassa e Fosfato, Piracicaba, SP.

[5] Roberto Gil, INTA (Argentina), personal communication, 2006.

In the Consolidation Phase (Years 10 – 20), higher amounts of crop residues as well as higher soil carbon contents are achieved; higher cation-exchange capacity and higher water-holding capacity are measured. Greater nutrient cycling is observed.

It is only in the Maintenance Phase (Years > 20) that the ideal situation with the maximum benefits for the soil is achieved and less fertilizer is needed.

Any tillage performed in Phases 2 – 4 means a return to the Initial Phase. Tilling the soil once in a while means that the soil is in constant transition and farmers will never get to see the full benefits of the system. Farmers practicing a no-till system without full stubble retention, i.e., letting animals graze their stubble, baling and removing the residues, and/or burning the residues, will probably never leave the Initial Phase. Also if the climate is one where residues decompose rapidly and no cover crops are used, the system may never leave the Initial Phase. (*Editors: If too many broadleaf crops and too few grass crops are grown in the rotation, the system will not progress. Also, chronic nutritional deficits in the crops will hinder the system's progression.*) If some residues are occasionally removed but otherwise fields are well-managed, leaving a reasonable amount of soil cover, the fields eventually may start entering the Transition Phase.

**Landlords in South America in general will only lease their land to a no-tiller to ensure protection against erosion, avoid soil degradation, and not only maintain but improve soil fertility over time. It is astonishing that many landlords in the USA have not yet understood this.**

It is estimated that farmers using a tine seeder (hoe or knife opener), even when practicing no-tillage with full stubble retention otherwise, will only reach the Transition Phase and perhaps just those who manage to handle higher amounts of residues and have a higher biomass yield may start entering the Consolidation Phase. It is the opinion of the author that only with disc-opener seeders, full stubble retention, and adequate crop rotations, will it be possible to reach the Maintenance Phase, reaping the full benefits of a no-till system. Practicing adequate crop rotations and using cover crops once in a while will help in reaching the Maintenance Phase.

In general, the main reasons why farmers in the USA persist in occasionally tilling the soil are the following: 1) lime incorporation, 2) phosphorus redistribution, 3) soil compaction, and, 4) mindset. One important factor that influenced the quick growth of no-tillage in South America is the fact that there virtually nobody believes in the necessity of incorporating lime with tillage implements after no-tillage has been started. Surface application of lime, especially in combination with cover crops such as black oats and/or oilseed radish, allows the mobility of lime in the soil profile, and this has been widely understood in South America for many years now. (*Editors: Lime is mobile with percolation of water, even without cover crops.*) This is still something of intensive debate in other parts of the world, even though lime mobility in soils operates by the same mechanism everywhere.

Soils which have been many years under no-tillage show a higher concentration of phosphorus in the upper soil layer. In the USA, many researchers, extensionists, and farmers believe that one has to perform tillage once in a while to redistribute phosphorus that concentrates near the soil surface after a few years in the no-till system.

Photos by Ken Sayre, CIMMYT.

Ken Sayre's plots, 2004. Both were maize >>wheat rotation under no-tillage, but the plot in the photo on the right had residues removed.

This is not the case in South America, where farmers have learned that the concentration of this element in the upper soil layers is not a problem at all for obtaining high yields of crops. (*Editors: See the stratification article in the Sept. '07 issue for an exhaustive review of the research in the U.S. and Canada on this subject.*)

Most farmers in South America have found that there is no need to till the soil every so often after no-tillage has been established and that the best way to avoid compaction in the no-tillage system is to produce maximum amounts of soil cover, and to use cover crops and crop rotations, so that roots and biological activity as well as earthworms and insects, etc., will loosen the soil as well as to secrete substances that bind the soil particles into stable aggregates and a beneficial soil structure.

Long-term no-tillers in general report mellower soils after many years of continuous no-tillage. Plentiful soil cover is also essential to maintaining higher moisture levels at the soil surface and this will result in better penetration of cutting elements of the seeding equipment, as well as of crop roots. Field traffic should be reduced and carefully managed in this system and no heavy trucks allowed indiscriminately in the fields. Low-pressure tires are also a 'must' in the no-tillage system.

**When practicing quality no-tillage, soil erosion must be banished from farmland. No erosion of any kind should occur.**

An additional factor is mindset. Often landlords in the USA will not lease their farm to a no-tiller because they don't like the "trash" that is left on the soil surface. Thus, the long-term benefits of continuous no-till will never happen. Contrary to this, landlords in South America in general will only lease their land to a no-tiller to ensure protection against erosion, avoid soil degradation, and not only maintain but improve soil fertility over time. It is astonishing that many landlords in the USA have not yet understood this. Something has to be done to educate landlords so that they understand the benefits of long-term no-tillage for their soil and for increased productivity of their land.

## Quality No-tillage

Seeding without tillage does not necessarily mean no-tillage seeding. Poor-quality no-tillage, that can hardly be called as such, is often practiced by farmers in many parts of the world. High soil disturbance at seeding, low percentage of soil cover, monoculture or low cropping diversity, and rotational tillage characterize poor-quality no-tillage.


Photo by Unknown, via Rolf Derpsch.

Derpsch advises: "Strip-till is half-hearted no-till; a half-step in the right direction." —Indeed, why not get the full benefit?

Criteria to determine the quality of no-tillage:

1. The percentage of soil covered with plant residues, especially after seeding.
2. The amount of soil disturbance while seeding or fertilizing.
3. The number of years in continuous no-tillage without tillage of any kind.
4. The length of fallow (non-crop) periods, and the diversity of crop species, including cover crops.

(*Editors' Note: In measuring whether the non-crop period is appropriate for an area, calculate the average precipitation during that time, i.e., from the maturity of the previous crop until the next crop is established. Then calculate the water-holding capacity of the soil to a depth of 4 feet [if soil is shallower than this, use the smaller number], e.g., a silt loam may hold 2.2 inches of plant-available water per foot of soil depth, which is 8.8 inches to a 4-ft depth. If average precipitation is greater than the soil's water-storing capacity, then a cover crop is needed. Note that the next grain crop yield is generally not negatively affected by growing the cover crop, since the water-use efficiency increases due to the mulch effect.*)

**In quality no-tillage, fallow periods without crops must be avoided and living roots should be present as long as possible.**

The importance of soil cover was highlighted earlier in this article. Management practices should consequently be directed towards maximizing biomass production for a certain location (adequate fertilization, sufficient weed as well as pest and disease control, use of high-biomass-producing species and varieties, etc.).

Full stubble retention, the use of disc-opener seeders with ability to cut through high amounts of crop residues while causing little soil disturbance, many years under permanent no-tillage, and the inclusion of cover crops in rotation systems (cropping diversity) are the basis for high-quality, sustainable no-till systems. Quality no-tillage is essential to reap the full benefits of this system and to experience the benefits more rapidly.

When practicing quality no-tillage, soil erosion must be banished from farmland. *No erosion of any kind should occur.* Most of the erosion control will need to be achieved with high residue levels, improving soil structure with no-tillage, and high cropping intensity including cover crops. On steep slopes in high-rainfall areas, additional protection against rill erosion must be used, such as contour bunds, terraces, or buffer strips at adequate intervals. Roads on the farm have to be placed in such a way that they follow the contour and an adequate water-capturing structure should be in place in areas where erosion could occur. In southern Brazil, many farmers have made a big mistake by leveling all their contour bunds (terraces) and are now facing the problem of erosion because the residue levels they achieve in soybean monoculture are much too low for adequate soil protection. Adequate levels of crop residues must also be maintained where wind erosion is a problem.

**A sustainable agricultural system will have soil carbon inputs equal to or greater than outputs. Carbon inputs are achieved through vigorous growth of plants and by the plant roots remaining undisturbed in the soil as well as plant residues remaining on the surface. Large C outputs or losses occur with any type of tillage or by harvesting the aboveground biomass.**

In quality no-tillage, fallow periods without crops must be avoided and living roots should be present as long as possible. Roots of crops or cover crops and organisms living in the soil contribute to biological soil preparation. Instead of using horsepower, diesel, and iron to till the soil, biological soil preparation works day and night without using fossil fuels. Soil organisms just need to be fed with mulch. Finally,

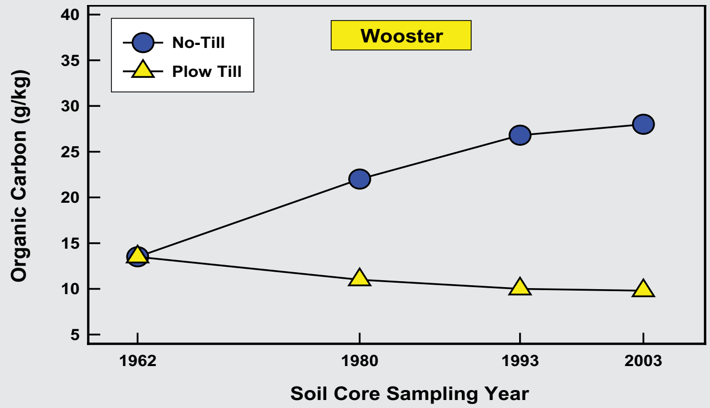



Figure 5. Development of the organic carbon content (g/kg) in the upper 3 inches of soil in long-term no-till versus tillage (Plow Till) at Wooster, Ohio. Source: Warren Dick, 2006.

consider avoiding indiscriminate traffic of heavy vehicles on the field, especially on wet soils. In very flat terrain, controlled traffic may be useful. In undulating topography, random traffic must be used, but heavy equipment should stay out of the field. Low-pressure tires (14 psi or less) should be used. An automatic pressure-regulating system for travel on roads is advisable, so that the higher inflation pressures necessary for safe transport at high speeds can be quickly readjusted to low pressure in the field. These systems are becoming commonplace on European tractors.

While tillage destroys soil aggregates, a no-till system greatly increases aggregate stability. This makes the soil more resistant to erosion and also allows for a higher trafficability of the soil with farm machinery since the soil is more structured and supportive, and may also have higher density. A higher soil density should not be confused with soil compaction, but is instead a natural condition of untilled soils. This higher soil density allows farm machinery to drive on the fields in situations when it would not be possible under tillage practices.


Photo by Rolf Derpsch.

Derpsch thinks "invisible seeding" is the ultimate for attaining the best results with no-till.

## Organic Matter as an Indicator

Any agricultural or livestock production system that contributes to constantly reducing the organic matter content of the soil is not sustainable and results in poor soils that eventually fail to support agriculture entirely. Soil organic matter is *the* most important factor that indicates fertility of a soil. Low values of organic matter mean low fertility while the same soil with high values is a more fertile soil, where higher crop yields can be obtained. Soil tillage is the typical management praxis which results in decline of soil organic matter as well as the corresponding emissions of carbon dioxide into the atmosphere. No-tillage, on the contrary, can result in sequestering carbon from the atmosphere and increasing carbon content of the soil.

A sustainable agricultural system will have soil carbon inputs equal to or greater than outputs. Carbon inputs are achieved through vigorous growth of plants and by the plant roots remaining undisturbed in the soil as well as plant residues remaining on the surface. Large C outputs or losses occur with any type of tillage or by harvesting the aboveground biomass (some C is also lost during normal decomposition, although at a slow and non-exhausting rate if quality no-tillage is used).

A light disk-harrow is sometimes used in South America to incorporate seeds of black oats as a cover crop. In this case it has been demonstrated that the total loss of carbon due to the use of the disk-harrow is 0.90 t/ha, while the return of carbon from the cover-crop residues is only 0.52 t/ha.[6] This is clearly a negative balance. Also soybean monoculture or a (one-year) two-crop system

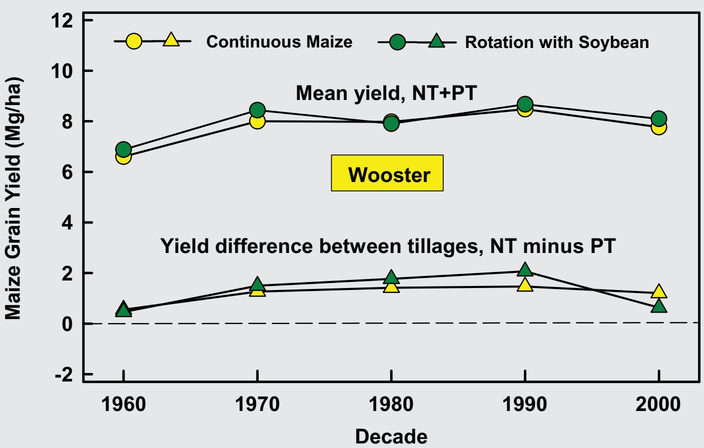



Figure 6. Results from Wooster in northern Ohio, one of two sites for the longest-running no-till experiment in the world. Corn yields were higher for no-tillage in all decades, regardless of crop rotation (or lack thereof). Source: Warren Dick, 2006.

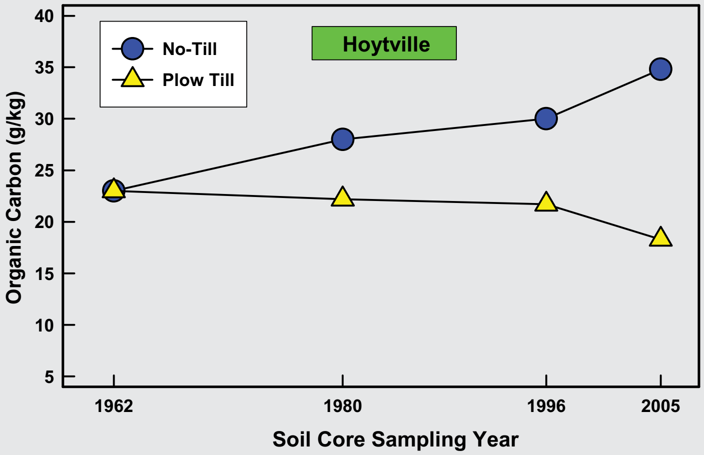



Figure 7. Development of the organic carbon content (g/kg) in the upper 3 inches of soil in long-term no-till versus tillage (Plow Till) at Hoytville, Ohio. Source: Warren Dick, 2006.

of wheat /double-crop soybeans has a negative balance because the amount of carbon added (3 – 4.5 t/ha/yr in Brazil) is insufficient to sustain the system in a tropical region with high decomposition rates that remove carbon (in this case) at rates higher than what is being added by the crops. According to Juca Sá, additions of more than 8 t/ha/yr of carbon from plant residues (shoots and roots) are needed in this part of Brazil to maintain a stable equilibrium and ensure the sustainability of the system.[7] Therefore, high-biomass-producing crops such as corn should be part of a rotation, and that low-biomass and low-carbon crops such as soybeans and most other broadleafs (dicots) should be used sparingly in crop rotations, especially in warmer and wetter regions, and these should be used in conjunction with high-carbon cover-crop species (grasses).

**Any agricultural production system that gradually reduces organic matter content of the soil is not appropriate for that site, will result in soil degradation, and is not sustainable.**

Management practices that are directed to obtaining maximum possible amounts of crop residues for a specific location (e.g., crop rotations including corn if possible, cover crops, sufficient fertilization of crops, adequate weed and pest management, etc.), will increase yields of crops and enhance carbon content of the soil.

[6] J.C.M. Sá, J.B. dos Santos, E.G. Cardoso, S. Siuta Jr., C.F. Ferreira, A. Oliveira, M.F.M. Sá, L. Seguy, S. Bouzinac, 2006, Balance de carbono y nitrógeno en rotaciones bajo sistemas de siembra directa, in Proceedings: XIV AAPRESID Congress (Rosario, Argentina, Aug. 2006).

[7] Sá et al., 2006.

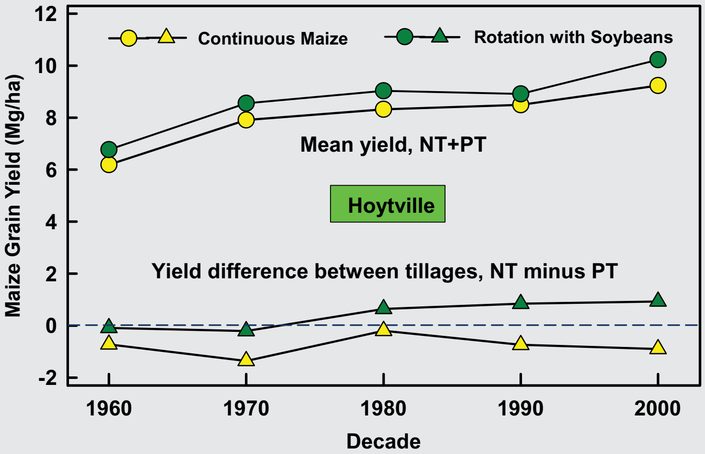



Figure 8. Results from the Hoytville site showed no-till corn approximately equal to or slightly outyielding plow tillage if rotated with soybeans, but lagging if monoculture corn was grown. Source: Warren Dick, 2006.

## Yields Related to Soil Carbon

An ongoing experiment was begun in 1962 at Wooster, in northern Ohio, USA, thus being (with 46 consecutive years) the oldest mechanized no-till experiment in the world (results discussed in this article are through 2003; more recent data are not available). Figure 5 shows that carbon content of the upper 7.5 cm (3 inches) of soil increased steadily in no-tillage from 13 to 27 g/kg while it decreased steadily in conventional tillage from 13 to less than 10 g/kg.[8] The carbon pool in the upper 31-cm (12-inch) soil layer was greater under no-tillage (6.75 kg/m$^2$) than for plow tillage (5.56 kg/m$^2$).[9] As contrasted with Brazil, a temperate climate such as in Ohio allows for a crop rotation with one-half soybeans (but in rotation with high-yielding corn) to have adequate carbon inputs to cause an increase in soil organic matter. However, rotations with higher carbon inputs would improve the soils more quickly.

For the Wooster site, maize (corn) yield results through 2003 are shown in Figure 6. Several crop rotations were in this experiment; highest corn yields occurred in the rotation where corn was grown after hay (in a 3-year rotation, with oats following corn). No-tillage consistently produced higher yields than plow tillage, regardless of crop rotation. The authors conclude that continuous, long-term no-till management can sustain or even enhance crop yields and soil quality as compared to long-term plow tillage management.[10]

During the same years, a similar experiment was conducted at Hoytville, Ohio, again with the carbon content of the soil increasing continually in no-tillage from 23 to 34 g/kg, while decreasing continually in conventional tillage from 23 to less than 18 g/kg (see Fig. 7).[11] Several crop rotations were used at Hoytville, with corn yields shown in Figure 8. Corn yields in no-tillage in a corn >>soybean rotation were slightly lower in no-till compared to plow tillage in the first decades of the experiment, but no-till yields have been higher since 1980. When using continuous corn, yields were always lower in no-tillage compared to plow tillage, thus highlighting the importance of crop rotation.[12]

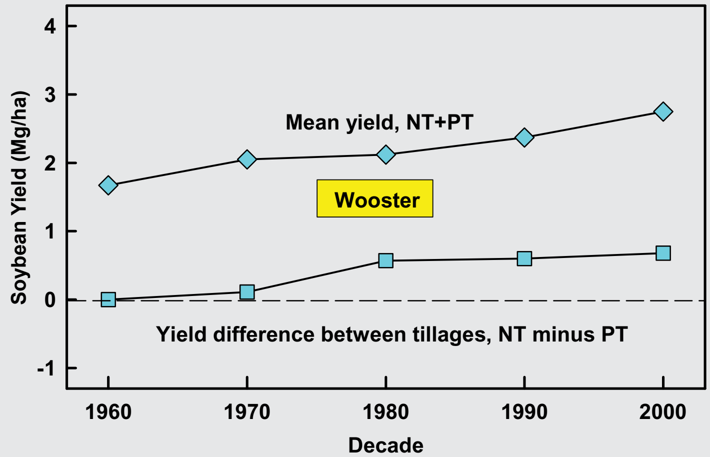



Figure 9. Soybeans under no-till have continually outyielded plow tillage at Wooster. Source: Warren Dick, 2006.

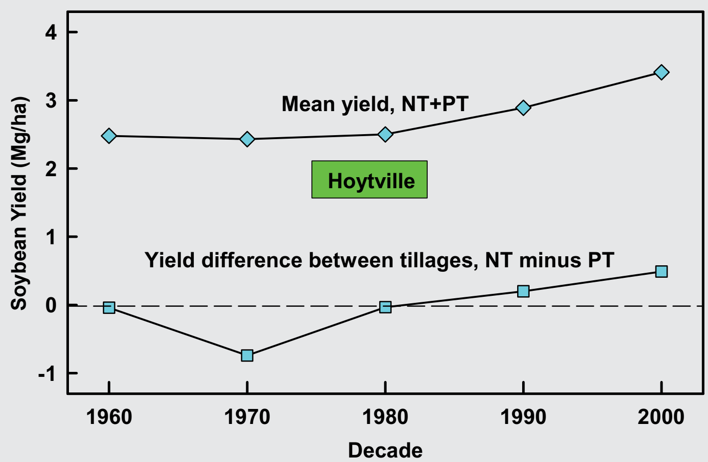



Figure 10. At Hoytville, OH, no-till soybean yields initially lagged plow tillage, but eventually equaled and then overtook yields from the tilled plots. Source: Warren Dick, 2006.

8 Warren Dick, Ohio St. Univ., personal communication, 2006.

9 S.A. Mestelan, N.E. Smeck, J.T. Durkalski, W.A. Dick, 2006, Changes in soil profile properties as affected by 44 years of continuous no-tillage, in Proceedings of the 17th ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006). The carbon pool was also greater for no-tillage than plow tillage at depths from 31 – 148 cm deep.

10 Mestelan et al., 2006.

11 Warren Dick, personal communication, 2006.

12 Warren Dick, personal communication, 2006.

For soybeans at Wooster, yields in no-tillage were only slightly higher in the first decade of the experiment, but after 1980 have been substantially higher compared to plow tillage (see Fig. 9). At Hoytville, soybean yields in no-tillage were significantly lower during the first decades of the experiment, although they equaled in 1980 and since then yields are getting continually higher in no-tillage compared to plow tillage (see Fig. 10).

Photo by J.E. Denardin, EMBRAPA, Brazil.

When grown too frequently, low-biomass crops such as soybeans do not produce enough residue to prevent erosion. The problem is avoidable.

It should be remembered that any agricultural production system that does not add sufficient organic material and/or gradually reduces organic matter content of the soil is not appropriate for that site, will result in soil degradation, and is not sustainable. Therefore we should think carefully before using crop residues other than for soil protection and enhancing soil fertility. Consequently, ethanol produced from plant biomass will not be sustainable agriculture. (*Editors: Removing biomass of* annual *crops will be particularly damaging*.)

Highly regarded Ohio State University researcher Rattan Lal (who is also the immediate past president of the Soil Science Society of America) in a recent paper concludes that: "Crop residue return to the soil is essential for maintaining soil quality. It provides numerous ecosystem services including recycling nutrients, sequestering C, moderating soil temperature and moisture regimes, providing food and habitat for soil fauna (e.g., earthworms), and protecting [the] soil surface against erosivity of water and wind. Use of crop residue mulch, in conjunction with no-till farming, has important implications to achieving sustainable use of soil and water resources and meeting [the] food needs of growing world population . . . . *Expansion of no-till farming, necessary for erosion control and soil C sequestration, necessitates use of crop residue as surface mulch. . . . For meeting [the] world's food demands[,] crop residues must be used as soil amendments.*" (emphasis added)[13]



### Important Task at Hand:

The public in general is not aware of the important contribution that the no-till farming community is making to society as a whole: Producing food without harming the environment and while improving the quality of the world's soils. It is our duty to inform society about the outstanding contribution that farmers who practice the no-tillage system all over the world are making to provide the population with low-cost, high-quality food while at the same time protecting the environment.

*Editors: The reader might also wish to reference 'Understanding Water Infiltration' by Derpsch in the Dec. '03 issue, and Matt Hagny's 'Maximize Crop Residues' from March '05. For the long-term effects of no-till, see 'Cropland Owner's Manual' from Dec. '05. For a comprehensive review of no-till effects on corn and soybean yields in the U.S. & Canada, see 'Ending the Debate,' Sept. '06.*

[13] R. Lal, 2006, Soil quality impacts of residue removal for bioethanol production, in Proceedings of the 17th Triennial ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006).

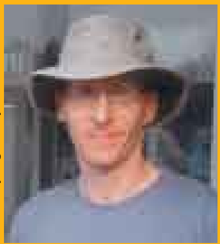


Photo by Agro-Soyuz, Ukraine.

# Field Ecosystems, Part II

by Matt Hagny

TECHNIQUE

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

*This is a continuation of the article appearing in the March '06 issue.*

Increased cropping intensity and cover crops have gained momentum lately, so perhaps it is appropriate to recap some of what we've learned so far, and how some of the pieces may best fit together. Because of the geographically diverse readership, I'll try to provide regional cues when possible.

Before we start, I would mention that cocktails (mixtures) of cover-crop species are in vogue currently, and perhaps rightly so. The only caution I would put forth is the need to be aware of what diseases might be carried by certain cover-crop species, or other problems that might be posed (harboring pests, allelopathy, etc.). However, if 2 or more species will both work reasonably well in a niche, *why not mix them?* The only thing you will need to sort out will be the seeding rates in the mixture (or seed them in alternate rows), so that competition doesn't overwhelm one of the species. Another nifty aspect of cocktails is it ensures that something will produce appreciable biomass—this method guards against problems with poor seed quality of one of the species or components, problems with herbicide carryover damaging or eliminating one species, and/or issues with insects severely thinning or destroying stands of a single species (e.g., grasshoppers on sunn hemp or sunflowers).

Other reasons we use mixes is to have different things growing at different times: cowpeas (*Vigna unguiculata*) grow when it is hot but die with the first frost, which lets the lentils take over. There are other reasons, such as having the canola sequester N so the lentils have to fix N. The canola competes with weeds but leaves room in the understory for the lentils. Oats provides a fibrous root system to better prevent erosion when mixed with canola. (We normally do not mix grasses and broadleaf crops except for circumstances such as these, or when growing a forage. Mixing oats with broadleaf species when you are going to corn is probably okay, although it hasn't been tested adequately.)

> **Chem-fallow for summer-fallow: Costs are high, residue loss can be severe, and some weed species thrive because of lack of competition.**

**A. Grain-only Farmers:** First, let's consider the possibilities for the grain-only farmer with no livestock, no neighbors with livestock, and no interest in adding livestock.

**1. Replace summerfallow:** In the more arid regions, many producers continue to retain a "long fallow" (summerfallow) for the transition from corn or milo to winter wheat, essentially carrying the corn stalks or milo (or sunflower) stalks for 11 months with chem-fallow. This doesn't work very well, as many have noted. Costs are high, residue (mulch) loss can be severe, and some weed species thrive because of lack of competition.

A few producers have attempted to eliminate the summerfallow by planting winter wheat immediately after the corn, milo, or sunflowers, but with limited success. Think of it this way: Wheat is a highly profitable crop in the Great Plains region, and you can only grow it about 2 years out of 4 or 5 in your rotation,[1] and you just wasted one of those on an inherently low-yielding crop sequence. It is almost always low-yielding because of delayed planting (for winter wheat), lack of soil moisture for adequate fall establishment, allelopathy (especially milo residue), and extreme lack of nutrients (the milo or corn took everything that was available, and those residues will be very slow to decompose). These

Photo by Brian Lindley.

Field peas are a great replacement for summerfallow.

[1] Growing wheat more frequently than 2 in 4 years in a no-till system is problematic from a disease and weed standpoint, and profitability declines markedly.

Photo by Brian Lindley.

Chickpeas (garbanzos) are a nice fit for producers with non-base acres and the aptitude for growing these crops. Here, chickpeas await harvest on Mike Arnoldy's operation near Oelrichs, in the far southwest corner of South Dakota. The chickpeas were seeded into stripper-harvested stubble.

problems are worst in cooler and drier climates. Winter wheat drilled into sunflower stalks poses the additional problem of soil blowing (spring wheat only partly solves the problem) unless abundant mulch remains from the crop preceding the sunflowers.

So the first order of business is getting this awkward niche replaced with either an early-maturing grain crop or a pure cover crop (forages will be discussed later in the article). Some ideas:

**Field peas (*Pisum sativum*):** Perhaps the species that is the most beneficial to the following wheat crop, largely for unknown reasons (wheat following field peas often outyields wheat on chem-fallow).[2] Field peas are planted in the spring, about 3 – 4 weeks before you would normally plant corn. Seeding rates are about 3 bu/a (350,000 live seeds/a), and you need good inoculum of the pea/vetch type. Peas don't tolerate pop-up fertilizer very well, although they can be quite responsive to S (sulfur), Mo (molybdenum), Cu (copper), and other nutrients if your soils are marginally low, so apply these as broadcast applications. Herbicides such as sulfentrazone (Spartan) are labeled for pre-plant on field peas (caution on sandy or high-pH soils, however) which controls kochia and lettuce relatively well, and 'cheatgrass' can be controlled with post-emerge application of graminicides such as Select. Many different varieties have been developed in the last 5 or 6 years, with the greatest advances being the upright varieties that are easily harvested with a flex head. There may be some improved heat tolerance as well. Contact Pulse USA for more info on varieties. Markets are somewhat limited on field peas, which are used in livestock rations and compete directly with corn and soybean meal.[3] (The vegetation is highly valued for livestock feed as well, although if you take the residue for feed you have not solved the problem.) Seed cost for peas is generally too high to be the ideal cover crop.

**Chickpeas (*Cicer arietinum*):** The kabuli type, a.k.a. garbanzo bean, goes into a market for human consumption, so long as they make size requirements and aren't weather-stained. These require a higher level of management, since seed costs are high and *Ascochyta* blight often must be controlled with foliar fungicides, although lengthy crop rotations (of non-hosts) are the first line of defense. Planting is a couple weeks before corn planting, and harvest is several weeks after wheat harvest. Wheat doesn't do quite as well following chickpeas as compared to field peas, but if you make enough money on the garbs you don't care. Note, however, that chickpeas are considered vegetables under the U.S. Farm Program rules.

**Proso millet (*Panicum miliaceum*):** This grass crop (a.k.a. French White millet) is extremely short-season and quite drought tolerant. It is a common transition crop in eastern Colorado for the year after corn or sunflowers, but prior to wheat (they seed wheat a few weeks after proso harvest). It is a highly mycorrhizal crop and rebuilds residue levels. Proso's planting timeframe is typically after corn and sunflower planting is completed, and proso harvest would occur well after wheat harvest, but before corn harvest. Proso can be harvested with a flex head or Shelbourne stripper head. Proso mostly goes into the birdseed market, which is a small and volatile market.

Photo by Brian Lindley.

Safflower, another cool-season broadleaf, does well on Mike Arnoldy's Oelrichs farm. Arnoldy has done quite well with no-till and good management, adding this site to his main operation at Kennebec, SD.

[2] Field peas don't root all that deeply, so it is speculated that soil moisture is causing the effect, but that explanation only goes so far since 2d-year wheat has far more moisture available, as does chem-fallow. Field peas are one of the few crops to be non-hosts for lesion nematodes (*Pratylenchus* spp.), but usually those levels are low enough on clay loam soils in Kansas & Nebraska that this answer is suspect. Mycorrhizae may be part of the answer. Nutrient cycling may be another, since field peas decompose very quickly, releasing zinc, phosphorus, sulfur, etc.—but then why doesn't wheat on chem-fallow do better yet? Perhaps it is the exact combination of some of these aspects, or other soil ecology factors of which we are unaware.

[3] Field peas have extremely high nutritional value. See, e.g., http://www.ag.ndsu.edu/pubs/ansci/livestoc/as1224w.htm.

Again, the vegetation is considered a good animal feed, although removing residue runs contrary to what you are trying to do. Proso may not be the perfect crop preceding wheat, but it is a reasonably good fit (the incidence of crown rot in wheat may be higher with this sequence).

**Carrying wheat stubble: For some regions, this fallow period is as problematic as summer-fallow. Soils become overly saturated, resulting in erosion and problems with planting the corn or milo (and with crop health). Leaching and denitrification are common nutrient loss mechanisms here.**

Because of the low cost of seed, this species could also make a good cover crop in this niche, although if you kill it before it sets seed, the stems will not have lignified—so the residue will decompose and disappear in a couple months (however, you still have built mycorrhizae levels, and recaptured some nutrients). Seeding rates are ~ 20 lbs/a.

**Oats (*Avena sativa*):** Common spring white oats is planted about 3 – 4 weeks ahead of corn and harvested about the same time as wheat. Again, oats can be used purely as a cover crop. Unlike rye, triticale, and barley, oats tends *not* to carry root diseases that afflict wheat. Oats are generally tolerant of residual herbicides used in corn or milo, including Callisto (high atrazine rates can be a problem, however).

Many other options exist for filling the long non-crop period (long fallow) between a summer crop harvest and winter wheat planting. In cooler regions, spring lentils and flax are possible, as well as spring canola, chickling vetch (*Lathyrus* spp.), and safflower (*Carthamus tinctorius*). In warmer regions, pearl millet (*Pennisetum glaucum*), sudangrass, and teff (*Eragrostis tef*)—an annual warm-season forage grass—become feasible, and the benefits of maintaining soil cover with a grass species become more important. Note, however, that use of an occasional broadleaf crop somewhere in the rotation can be important for disrupting diseases that afflict grass crops, as well as providing other benefits to the soil ecology.

**2a. Eliminate carryover wheat stubble.** In much of the U.S. central Great Plains region, it is common to carry wheat stubble for 11 months until a corn or milo crop is planted. For some regions, this fallow period is as problematic as the summerfallow previously discussed. Soils become overly saturated, resulting in erosion and problems with planting the corn or milo (and with crop health). Leaching and denitrification are common nutrient loss mechanisms here. Saline seeps may worsen. In warmer regions, it can be very expensive to keep the stubble reasonably weed-free during this time, and some species such as nutsedge, windmillgrass, and prairie cupgrass may become worse due to the lack of competition (these species easily survive moderate rates of glyphosate, especially if no crop competition is present).

In the warmer and wetter areas, it is common to see attempts made at double-cropping wherein a second grain crop is planted immediately after wheat harvest. This is generally moderate to high risk, although the payoffs can be quite large if you catch a wetter year or are in a wet climate. Soybean, sunflower, milo, pearl millet, and proso millet all fit, as well as cowpeas (*Vigna unguiculata*), mung beans (*Vigna radiata*), and cotton in warmer regions, although we won't discuss those here (note that proso millet is a good choice preceding corn, but a very poor choice ahead of milo due to volunteer issues).[4] Note that cowpeas and mung beans are defined as veggies under the U.S. Farm Program, although mung beans are then 'excepted' (i.e., not regulated as veggies and can be grown on base acres). Many attempts have been made at double-crop corn over the

Photo by Doug Palen.

On wheat stubble going to milo or corn the following year, cover-crop cocktails such as this lentil + canola mix are a good choice.

[4] While the grain markets for *pearl* millet are extremely thin, it does have superior feed value to milo, and equal to corn. Pearl millet is an intriguing choice for double-cropping after wheat since it is slightly earlier-maturing than milo, is somewhat more drought tolerant, and poses little risk for volunteer in the subsequent crop.

years, but it is the author's opinion that this is an excessively risky crop for this niche due to high input costs, heavy insect pressure, and lack of drought tolerance.

**Canola, radish, or turnip (*Brassica* spp. *&* *Raphanus sativus*):** These species are also called crucifers (or brassicas) and have become one of the cover crops of choice for this niche, particularly in blends with lentil (this has grown quite popular in central/eastern South Dakota partly because seed suppliers have created blends that are ready-to-go). Bin-run canola is particularly affordable, with seeding rates of 10 – 15 lbs/a for a cover crop. If you want it to survive the winter, plant a winter canola. Turnips are cheap also, with planting rates of only ~ 1 lb/a, and the 'Pasja' hybrid is particularly good at producing robust vegetative growth and slender but deep taproots. Forage radishes (*Raphanus sativus*) such as 'Daikon' are also a great choice, particularly if you have a local grower to keep the costs down (seeding rates are 10 – 15 lbs/a). Oilseed radish is the same species but less frost tolerant.

Photo by Brian Lindley.

Cover-crop cowpeas in wheat stubble at Dakota Lakes Research Farm, Pierre, SD. Cowpeas thrive in hot weather.

Crucifer (brassica) species such as turnips, radish, and canola have enormous S requirements—about triple what grass crops need. Brassicas are also quite sensitive to low molybdenum. They aren't leguminous, so they will need to subsist on soil nitrate or be fertilized (if you took off a huge wheat crop, you may need to supply some N fertilizer to your brassicas to get them to grow properly—you can think of this as merely a 'vehicle' to supply fertilizer to your subsequent corn or milo crop, since the brassica residues decompose quickly). Brassicas are totally *non*-mycorrhizal, and this is the reason a mixture with species such as lentil makes sense, since the lentil will build or at least maintain mycorrhizae numbers (also it is hoped the lentil or other legume in the cocktail will fix some nitrogen after the brassica scavenges the existing nitrate). Note that you will need to avoid using Finesse, Amber, Rave, Olympus, Maverick, and other long-residual herbicides in your wheat if you are going to plant brassicas, lentils, vetch, etc.

**Lentil (*Lens culinaris*):** Varietals range from spring types to winter hardy, and from yellow to red to black seed color. Lentil is a leguminous species with relatively small seed (especially some varieties such as Indianhead) and respectable grain yields where adapted, so it is affordable as a cover crop. Its growth habit is distinctly cool-season, and relatively slow-growing even under ideal conditions, so mixtures with more aggressive species make sense. Lentil is quite sensitive to Finesse carryover. Seeding rates would be about 35 lbs/a for lentil by itself (750,000 seeds/a), or 10 – 15 lbs/a in a cocktail with an aggressive plant such as a brassica.

**Hairy vetch (*Vicia villosa*):** Another cool-season legume. Some types are winter hardy. There are related species such as common vetch (*V. sativa*), woolly vetch, smooth vetch, etc. They can be quite competitive plants when cool temperatures prevail.

There are many other cool-season legumes that could also be part of a blend, such as sweetclover (*Melilotus officinalis*), black medic (*Medicago lupulina*), and so forth. The idea with most of these would be to plant them 3 – 8 weeks after wheat harvest or anytime in the late summer or early fall where you could expect decent fall growth. Try to kill at least one flush of volunteer wheat before planting the cover crop. The later cover-crop plantings will have less problem with volunteer wheat being a host for problem insects or diseases that could affect nearby planted wheat (if necessary, these broadleaf cover crops can be sprayed with a graminicide to control volunteer wheat; also, thick and vigorous cover crops may suppress or choke out volunteer wheat). If you are planting your mix somewhat earlier, it is possible to include warm-season species such as sunflowers (bin-run), cowpeas, etc. In wetter regions, especially those with short seasons, another option is aerially seeding the cover crops while the wheat is still maturing, especially crucifers and clovers (lespedeza is also used)—when broadcast seeding, use a higher rate than for drilled or planted. Note that attempting to

**You will need to aerially seed in wetter years.**

Photo by Jerry Burger.

Cover-crop sunflowers (bin-run) were drilled on 15-inch spacing after wheat harvest.

establish the cover crop earlier in the wheat (such as 'frost seeding' of clover) doesn't work if the wheat crop is vigorous, since it will choke out the smaller clover plants.

**2b. Eliminate carryover cool-season broadleaf stubble.** If stubble from crops such as field peas or canola are carried over for corn or milo, the situation is much the same as carryover wheat stubble, but at much greater risk for erosion due to lack of mulch cover. In this case, you would want to choose a grass crop to regain some residue, and choices would include proso millet, pearl millet, sudangrass, teff, corn, milo, etc. For these to grow, you will need to avoid using Pursuit in the field peas.

**3. Between wheat crops.** In some areas it is common to grow two wheat crops back-to-back ('stacking') and sometimes this niche can get too wet. The window isn't particularly lengthy in Kansas or Nebraska, so you need fast-growing crops (and you will need to aerially seed in wetter years). In Oklahoma or Texas, it would be feasible to grow a true double-crop (e.g., soybeans) and still get it harvested early enough to be timely with seeding the second wheat crop (occasionally this works in south-central Kansas too).

**(Bin-run) sunflower:** Usually drilled at 8 – 10 lbs/a, on 15-inch row spacing. A very affordable cover crop even at today's market price for sunflower grain. Sunflowers will be quite sensitive to Finesse or Amber carryover, unless you happen to have sunflower grain produced from Clearfield seed.

**Sunn hemp (*Crotalaria juncea*):** Often drilled at 3 – 5 lbs/a. Seed can be somewhat expensive in the USA, so mixing it with sunflowers may be advantageous. Use a cowpea-type inoculant, but don't expect superb results for nodulation unless everything happens to be perfect—including obtaining a high-quality inoculum. Sunn hemp appears to tolerate Finesse carryover fairly well. Remember to kill the sunn hemp with glyphosate (and/or 2,4-D) after about 35 – 40 days of growth, lest the stalks become too fibrous to plant nicely. Sunn hemp is tropical, so areas with plenty of heat will find it growing rapidly if moisture is adequate.

Other broadleaf species such as mung beans are also feasible if you can find affordable seed. For areas that are extremely warm and cannot build surface mulch fast enough, it is possible to use cover crops of sudan or millet in this niche also. Be aware that the grass crops will decompose more slowly (wider C:N ratio), so you will need to be extra diligent in supplying the following wheat crop with all nutrients needed, with special attention to N, S, zinc, and so forth. Teff could also be useful (although no one seems to know if it is allelopathic to wheat or not). With all of these, terminate them with herbicides 3 – 4 weeks prior to wheat seeding, and be sure to control all volunteer wheat and other grasses during this time to prevent 'green bridging' of diseases as well as Hessian fly problems.

**4. Between summer crops.** In humid regions, soils may become too wet over the winter, such as

## Inoculant Types

| | |
|---|---|
| Alfalfa group[1] | alfalfa<br>sweetclover<br>medic |
| Clover group[2] | 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[3] |
| Soybean group | soybean |

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. However, some legume plant species are colonized by more than one species of *Rhizobium* or *Bradyrhizobium*, although not equally well.

[1] 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.

[2] 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.

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

between soybean or corn crops, after a wheat/double-crop, etc. All of the cool-season species mentioned earlier are well-suited to this niche, with the general pattern being broadleaf species preferentially ahead of corn (or milo), and grass species preferable ahead of soybeans or cotton (although the brassicas appear to be feasible also). If you are planning on using a brassica, do not use Callisto or Lumax (or related chemistries with long residuals) in the preceding corn or milo crop since the carryover usually precludes any chance of the crucifer growing properly; crucifers are extremely sensitive to this herbicide family. To get cover crops started earlier for this niche, and to manage workload, you will need to use airplanes or helicopters to apply the seed—stands will not be as consistent as with a drill or planter, but you gain 6 or more weeks of growth which can make the practice viable (tens of thousands of hectares in Brazil are seeded this way).

**Warmer regions have great difficulty maintaining surface residues, as well as having problems with erosion (even in long-term no-till). Removing residues as hay, ensilage, or during grazing can negatively impact your entire crop production ecosystem.**

**Rye (*Secale cereale*) or Triticale:** For regions that don't grow wheat at all, or only grow it sparingly in their rotations (less than 1 in 3 years), rye is the Number One choice ahead of soybeans or cotton because of its ability to grow vigorously at relatively cold temperatures, as well as low seed costs. Triticale, a hybrid of wheat x rye, fills a similar role. Barley can also fit. In the author's opinion, stay away from annual ryegrass (Oregon ryegrass, a.k.a. Italian ryegrass) since it has weedy propensities—cereal rye will do everything ryegrass does without the risks.

Photo by Alan Mindemann.

Seedling cotton established in killed rye cover. Oats (winter or spring types) performs the same function without carrying root diseases that afflict wheat cash crops.

**B. Possibilities with Livestock:** We'll now turn our attention to species with potential for utilization as forages that can be grown in rotations with grain crops. I already mentioned the forage value of oats or peas (alone or in combination). In fact, almost all of the crops mentioned can be used as forages (either grazed, hayed, or ensiled), although with the usual concerns about nitrates, bloat, and so forth (these can generally be managed or overcome, particularly by planting cocktails which have better feed characteristics anyway).

Photo by Steve Groff.

Crimson clover on the Steve Groff farm in Pennsylvania. In pure stands, clover seed can be expensive. However, many other good options exist for cool-season broadleaf cover-crop species.

A caution when using livestock: Many of the warmer regions (Kansas, Oklahoma, Texas) already have great difficulty maintaining surface residues, as well as having problems with erosion (even in long-term no-till). Removing residues as hay, ensilage, or during grazing can negatively impact your entire crop production ecosystem (loss of mulch will markedly decrease crop water-use efficiency). However, this can be mitigated if large quantities of residue are produced, such as with sudangrass, and if a considerable portion remains on the field after the grazing or forage harvest. Similarly, if crops such as oats or turnips/radishes are allowed to regrow after a grazing event, the residue loss will be minimized.

**If properly done, the cover crop adds enough mulch so that later precipitation (i.e., while the cash crop is growing) is more efficiently stored, while in the near-term making the soils less saturated (a good thing).**

As for grazing versus haying (or ensiling), there is considerable debate about hoof impact and so forth. I would like to make the distinction between trafficking a living plant versus a dead one. Look at all the traffic that an alfalfa field (or perennial pasture) endures, and yet it is the mellowest soil on the farm. Some of that is due to it being a perennial instead of an annual, since perennials have far greater root mass. But a major reason the traffic is not as damaging to the soil is because it occurs on a living root system. Similarly, *grazing of living plants is tremendously different from grazing dead remnants, such as milo or corn stalks*. One further point is the inherent advantage of grazing as opposed to baling or ensiling. As Dwayne Beck has noted, "The problem with removing biomass to feed livestock is that you guys aren't very good about bringing the poop back to the field." However, if it is grazed, all those nutrients are returned to the soil (and they are reasonably dispersed over the field)—everything stays in place (except the animal flesh being 'harvested'), and you didn't have to expend diesel fuel or precious labor to get it done. (I realize that grazing of cropland poses some logistical problems, especially if tracts are scattered, but look at all the previous logistical problems that are now solved.)

Again, balance the removal of biomass for livestock against potential negative effects in subsequent crops. There are times and places where removing some biomass is relatively benign (in high-residue rotations and climates; on creek bottoms where it tends to float away anyway), and there are other cases where removing biomass is very detrimental. It would be silly to gain $50/a of grazing or forage and lose $100/a in production of subsequent cash crops. All too often a short-term reaction (e.g., the attempt to salvage forage from a failed corn crop) comes at a substantial long-term cost via reduced yield in subsequent crops, as well as greater fertilizer requirements (more nutrients were removed in the biomass harvest). The crisis of the moment tends to get in the way of long-term goals and planning.

## Parting Remarks

Cover crops and increased cropping intensity have wonderful ability to improve conditions for your cash crops. We often hear worries about removing too much moisture from the soil profile and harming the following cash crop, but the reality is that this almost never happens (and it's been tested a lot). If properly done, the cover crop adds enough mulch so that later precipitation (i.e., while the cash crop is growing) is more efficiently stored, while in the near-term making the soils less saturated (a good thing) for better planting conditions for the cash crop, and improved early-season growth. The cover crop may also build mycorrhizae levels, which again improves water-use efficiency in later crops. David Gillen of White Lake, SD, comments, "I have never had corn after a cover crop have more drought stress than no cover crop. . . . Many years I have yield losses from being too dry. But the healthier the plant before the drought, the better it handles the lack of water during the drought. Our worst losses are when we have cold and saturated soils in the spring followed by a dry summer. As for me and my high-clay fields [and planting corn] after wheat, I would rather be a little drier than wetter at planting time."

**David Gillen: "I have never had corn after a cover crop have more drought stress than no cover crop."**

Choose cover-crop species that enhance subsequent crops, and avoid the ones that interfere such as with allelopathy. You should also choose cover crops that are unrelated to your current cash crops. Unless you grow canola, the brassicas are quite unrelated to other grain crops (although they do carry white mold—*Sclerotinia*—which afflicts sunflowers and some edible beans, but if you

Photo by Jon Stika, NRCS.

A cover-crop cocktail consisting of pearl millet, sunflower, soybean, radish, turnip, sweetclover, and buckwheat. This mix was in a demonstration plot near Bismarck, ND, put out by the Burleigh County Soil Conservation District, although nearby producer Gabe Brown often uses similar concoctions on large acreages.

have a couple grass crops between the brassica and the sunflowers, the risk of problems is minimal). Even if some root diseases that afflict cash crops are also hosted by cover crops, by having that added diversity the pathogens have difficulty becoming highly adapted to either species because they are always being put 'off-balance' by the rotational cycling of hosts (note that this effect depends on the cover crop being a different species than the cash crop).

In summary, cover crops are of critical importance for many regions in balancing soil moisture (so that extraction equals or exceeds storage), and for adding much-needed diversity to many grain cropping systems. Cover crops hold tremendous opportunity, and the thoughts presented here are only a fraction of what we will know a few years hence. So have fun trying new things!

*Editors: For further reading, see Beck's 'Cropping Strategies in Semi-Arid Climates' in the Dec. '04 issue. See also the Feature Farmer stories on Gary Maskus, Alan Mindemann, and Gabe Brown. Yet another reference is* Managing Cover Crops Profitably, *3d Ed., Sustainable Agriculture Network, Beltsville, MD, 2007 http://www.sare.org/publications/covercrops.htm.*

# Follow Up on Controlled Traffic

by Matt Hagny

**TECHNIQUE**

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

*Postscript to the article in the March '05 issue.*

A few speakers at recent conferences have again promoted controlled traffic, and have attempted to persuade us that water erosion in the traffic lanes can be avoided by planting the lanes to the crop, then using GPS to easily locate and stay on the lane. This *might* prove acceptable for passes made in the live crop, so long as the traffic occurs elsewhere (randomly) for all pre-plant and post-harvest spraying passes, *and different lane locations are established for each crop*. However, if repeated traffic occurs in one lane, even on top of a living root system, this will still create a difference in infiltration rates and a tendency for water to wash downslope in the track. Granted, it won't be as bad as bare lanes, so it might take a few more years for the effect to become obvious, but you'll still end up with gullies that will need to be repaired somehow—most likely by hauling soil in to fill them, an expensive and labor-intensive operation.

I'm not the only one to make these observations. Many producers say the same thing. For instance, longtime no-tiller Kevin Wiltse of Timken, KS, says, "I don't dare drive the sprayer in the same place twice, or it will start washing." Doug Palen of Glen Elder, KS, comments: "We don't leave blank trams, and we don't intentionally drive in the same place, but often that happens out of convenience. We had to start changing it up more, or it would start cutting in the wheel tracks." Kent Stones of Lebanon, KS, and Joe Swanson of Windom, KS, have reported similar experiences, as have many others. The Dakota Lakes West River (Lyman County) site also had problems with this, in a relatively arid climate and gentle slopes.

Some have suggested that terraces would prevent the problem. Um, no. Terraces might redirect the gullies every so often, but the result would be the same—the gullies in the wheel tracks just won't get quite as deep at the bottom of the hill (because the water is diverted occasionally), but they will still wreak havoc, and get worse with time.

So, again, the conclusion is that controlled traffic in permanent no-till is only feasible in areas that are so flat or so arid that runoff never occurs.

Photo by Matt Hagny.

Severe erosion due to driving in the same path repeatedly for spraying. Note that the inadvertent traffic lanes had grown a crop every year in the past, yet were still eroding badly. Once the rills or gullies get started, they are extremely difficult to get stopped.

# '08 Winter Conference Recap

by the Editors

The number of seasoned no-tillers goes up every year in Kansas and the surrounding region, so the quality of the interactions continues to improve at this event. Sharp minds and diverse experiences add to the dynamic.

Keynote speaker Dwayne Beck focused our minds: "Researchers are now studying whether taking the corn stalks away for ethanol will cause loss of soil organic matter or other soil degradation. It's a stupid question. The soil is *already* degraded. The question we should be asking is how to reverse some of that degradation." —The answer, of course, is no-till with high biomass production and retaining that biomass to feed the soil.

Scientist Jerry Hatfield of ARS presented evidence that 40% of the carbon in a no-till corn crop comes from soil emissions of carbon dioxide (rather than the ambient atmosphere)—and since water-use efficiency can be improved by elevated $CO_2$ in the crop's canopy, the ability to manipulate the timing of carbon fluxes creates yet another reason for permanent no-tillage systems. Kris Nichols, an ARS soil ecologist, vividly showed the effects of soil aggregation, created in large part by mycorrhizal fungi, and discussed 'engineering' of soil biology with crop selection—including the mysterious beneficial effects of cover-crop cocktails.

Dan Forgey, cropping manager for Cronin Farms of Gettysburg, SD, discussed their *twelve* crop rotations on 8,900 acres of farmland—and they're adding more cash crops and cover crops all the time. Rick Bieber, who's been in continuous no-till for 25 years, and farms about 50 miles northwest of Forgey, described cropping practices with similar diversity (and excellent financial success). Some 750 miles to the south, Alan Mindemann of Apache, OK, explained his no-till successes with extremely high cropping intensity and diversity. The principles are the same everywhere!

Greatly reduced N & P fertilizer use in long-term no-till was mentioned by several speakers including Gabe Brown of Bismarck, ND. In comparing Gabe's to Kansas or Oklahoma cropland, several points are worth noting. First, soils in the Dakotas haven't been cropped as long (the settlers arrived later), haven't eroded as much, and haven't been tilled as intensively. Also, soils in cooler climates naturally have higher organic matter. Many of the soils in the Dakotas are geologically much younger and less weathered, and therefore again have higher natural fertility. Also, ecosystems that are N-limited for many

Photo by Jana Lindley.

The '08 conference had over 1,200 in attendance.

years favor the population build-up of free-living (and associative) N-fixing microbes (although there may be substantial yield hits to get to this point unless legumes are grown frequently). Plus, Gabe Brown has had lots of alfalfa in his rotation for many years, which supplies a great deal of N to his other crops. Finally, his cropping regimes often include other legumes, and much of his grain and biomass production is returned to the land as manure, so exports of nutrients are held to a minimum. Brown has assembled a wonderful system, but one must be careful how one applies those lessons elsewhere.

From the other side of the globe, hailing from the state of Victoria in Australia, Robert ('Ruwy') Ruwoldt also mentioned rather meager P and N usage in his 20-year-old no-till system (grain cropping only; no livestock). Australian soils are incredibly ancient and highly weathered, so his results were a bit of a head-scratcher. But Ruwoldt's crops are so healthily grown, and residue retention *truly* at a maximum, that soil ecologists rave about the biological properties of his soils. So while it is generally true that long-term no-till is more efficient in terms of production from N and P inputs, one must be very cautious on *when* to cut usage—if you back off the N too soon (before the system reaches its new N-cycling equilibrium), it will reduce profitability and impair the system's development.

Dozens of other great speakers kindly shared their experiences in detail, and we can't begin to do justice to conveying their ideas in this brief recap. You'll just have to attend future events, and keep reading these pages!

# Still Thinking

by Matt Hagny




*The original story on Thompsons ran in March '03.*

Brothers Keith & Doug Thompson, and Keith's son, Ben, persistently reinvent their operation near Osage City in eastern Kansas. Summertime droughts continue to plague the area, which is particularly vulnerable due to its thin upland soils, yet they have excess moisture during many months of the year—a frustrating situation, to say the least.

Thompsons have responded by greatly reducing corn on upland the last few years, so those rotations have become either wheat/dc milo >>soy, or wht/dc milo >>milo >>soy. That's not to say they have had those short rotations in place for long periods, or that they intend to keep them indefinitely—they still do some upland corn (usually following wht/dc sunflowers), and continue to experiment. Prior to no-till, some of those fields had a 20-year history of a milo >>soy rotation, so shattercane was rampant. Keith reports good progress cleaning up the cane, but still they're loathe to do full-season milo on some fields for this reason (dc milo has less of a problem due to later planting and less likelihood of big rains to bring on a flush of cane). For Thompsons' bottomland, the rotation is typically 2 years of soys, then 2 years of corn, with an occasional wheat crop added. "When we do that, it's always been some of our best wheat, without exception," says Keith. This wheat is also followed by a double-crop.

Double-crops are taken quite seriously on the Thompson farm, and every acre of wheat is planted to a double-crop every year. They hit a home run on dc flowers in '07, with most fields making over 2,000 lbs/a. Double-crop milo comes within 10 bu/a of their full-season milo, and is very low-cost. Ben says, "Wheat/double-crop milo is our most dependable thing [on upland]." For '08, they've added field peas, which will be double-cropped to milo.

To beat the summer dry spells, Thompsons' strategies now include planting the single-crop milo 3 weeks later than they once did, and using mostly mid-4 maturities for single-crop soybeans. Also, they're experimenting with cattle to harvest forages on cropland. Ben, the livestock enthusiast, has greatly expanded the farm's cow herd in the last 5 years, while cutting back on goats now that they've done their job of cleaning up brush in the pastures.

**"Only *once* since we started no-tilling have we had to replant anything. Other people around here just assume they'll need to replant something every year."**

Grazing on cropland includes milo stalks as well as true forages such sudan, turnips, radishes, and cereal rye. Ben keeps stocking rates high, with 4 animal units/acre on sudan, for instance: "Stocking rates have to be high to make any money at it." However, grazing durations are short, and Keith says there's no damage in the fields: "On milo stalks, we don't ever remove more than 30% of the residue anywhere in the field." To manage tracking in wet weather, Ben often puts some hay in a grass waterway, which easily entices the cattle to stay nearby rather than tromping about in the field.

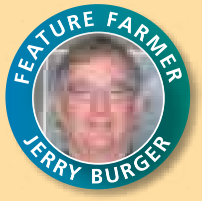
Thompsons also use true cover crops (no grazing), primarily rye ahead of soybeans. They've attempted broadcasting turnips and radishes on fields going to corn, but radish stands have been slow and erratic. So they bought an ancient Crustbuster press drill (disk openers) for seeding cover crops, which they adjust to barely make a cut (less than 1/2-inch), and Ben says, "I'm surprised at how well that worked."

Thompsons' seeding tools for cash crops, a 30-ft Deere CCS drill and a 12-row JD planter, have been refined with the inclusion of pop-up fertilizer capability on both rigs. "Liquid pop-up is a religion now," says Keith, which is typically 10-34-0 plus zinc. He and Ben both agree this has helped their crops tremendously, along with build-up of P and K with dry applications on the surface or 4x0 with the planter.

Seeding tool tweaking has been a priority for Thompsons over the years, and the diligence pays, Ben notes: "When you get the field planted, you're done. Only *once* since we started no-tilling have we had to replant anything. Other people around here just assume they'll need to replant something every year." Keith marvels at how perfect their stands are these days, and how their soils have changed: "Our soil structure has really improved the last few years." Their yields have generally been higher than the neighbors' crops with tillage, so Keith and Ben think they're doing well against their benchmark.

# A Continual Quest

by Roger Long




Jerry Burger of Palmer, KS, is one of the first to say that he doesn't have it all figured out yet. But it wouldn't be from lack of trying. Those who know him well can attest that Jerry is always asking the age-old question: 'How can we make it better?' Jerry doesn't simply ask the question, but gets busy trying to figure out how to do it. From revamping planter components, to finding the 'just right' nutrient mix, to trying new cover crops, Burger readily tackles the unknown. And, like any inquisitive mind, he typically discovers several new questions during the process of answering the previous ones.

Many no-tillers are now looking at cover crops as the next frontier to take yields and profits higher. Jerry has been at the forefront of this search as well: "We started getting serious with cover crops about five years ago, but I had played around a little even before that." He has been at it long enough that when asked what his first cover crop was, Jerry replies, "You know, I'm really not sure. I think maybe oats?"

**"We should be trying to build soil, not seeing how much erosion we can tolerate."**

Since Jerry double-crops (for grain harvest) most of his wheat acres that are going to milo or corn the following year, his efforts have been primarily focused upon the gap between June/July wheat harvest and fall wheat planting for his second-year ('stacked') wheat. Too often, late summer and early fall rains either delay or, at the least, make for less than ideal wheat seeding in October. Jerry's main goal was to minimize or eliminate muddy planting conditions to which his clay and silty clay soils lend themselves. He also wanted the additional residue and improved soil structure that a cover crop would leave behind. Finally, Jerry thought that if he could pick up a little nitrogen from a legume crop, it would be icing on the cake.

So Jerry started by growing sunn hemp in '03, which eventually led to three different summer legumes and an inoculant experiment dreamt up by his agronomist, Matt Hagny, to try and find the best N-fixing combination for mung beans, cowpeas, and sunn hemp. Unfortunately, none of the inoculations was especially impressive, Jerry confesses: "I think it just gets too hot when we're planting them." (Hagny says that on occasion good nodulation is obtained, but getting consistent high-quality inoculants is difficult due to the very small size of the market for this inoculant type, which often is developed for peanuts and not these other species.) Jerry did see a few nodules but nothing to get excited about and thus no appreciable nitrogen fixation (nitrate left in the soil from the previous wheat crop would also hinder nodulation). The following wheat crop also failed to show any advantages.

Jerry still wanted to cash in on some of the other benefits of a cover crop and went back to the drawing board. Like a blacksmith who looks for some idle scrap iron, Jerry found a solution in using some sunflower grain he had grown, a very inexpensive option that turned out to be an acceptable fix. To avoid any potential disease problems, Jerry is careful not to plant double-crop sunflowers as a grain crop in any fields where sunflowers were grown as a cover crop the previous year. With the exception of a few minor hiccups, such as letting the sunflowers go too long and drying the soil too much, Jerry has been quite happy with his (Kansas) state flower cover crop. He does recognize that the cover necessitates some ratcheting up of a balanced nutrient program for the fol-

Photo by Jerry Burger.

The '07 wheat crop had a major insult with the late freeze, plus wet weather at harvest, but Burger's management allowed for respectable yields. Never spun a tire at harvest, he reports.

Photo by Jerry Burger.

Burger seeding second-year wheat into cover-crop sunflower stalks.

lowing wheat crop, although long-term his overall fertilizer efficiency will be improved with cover cropping.

Burger's experience spans an interesting array of cover crops. He is in his fourth year of trying small acreages of radish and/or turnips in wheat stubble slated for corn the next spring. He plants somewhere between one to three pounds of the small-seeded brassicas, enough to keep the biology alive, maintain soil structure, and extract surplus moisture. Finally, no worry about termination costs with these, since Jack Frost picks up the tab. Not every trial has been a big financial boon, but lessons have been learned. Jerry had great success broadcasting the turnips one year, then had two failures with that seeding method, so back to using a drill. Poor seed vigor cost him a cowpea stand one year. One lesson might be to keep trying and adjusting after apparent failure—Jerry knows the cover-crop concept is right, and that his moisture balance in soils is too great in many cases.

**"Erosion can't be fixed with terraces—it has to be done with no-till, good crop rotations, and high levels of residue cover."**

## Harvesting the Gains

Of all Jerry's crops, wheat has seen the largest increase in bushels from his early no-till days to current-day yields. Jerry attributes most of the gains to a ramped-up fertility program that spans several nutrients. It includes higher nitrogen and sulfur rates when top-dressing with liquid streams in March, a healthy up-front dose of 10-34-0 plus 1.5 quarts of ammoniated zinc for the pop-up, and a phosphorus build-up program instituted a few years ago. His second-year wheat in the rotation has been as good or better than his first-year wheat—an interesting statistic reported by many successful no-tillers (and contrary to those who attempt the practice without an adequate rotational break from wheat, then say that their yields severely drop off in second-year wheat). Never content, Jerry continues to look for little strategies that can tack on a few more bushels. He experimented with adding both copper and molybdenum last year but unfortunately the freeze wiped out any chance of meaningful analysis, although he continues to aggressively pursue these and other potential improvements to his wheat nutrient program. (Burger has documented acute molybdenum deficiencies in his crops with tissue testing.)

While not every venture has proven fruitful, Jerry's yield histories show that he is doing most things right in a region awkwardly situated neither in the Corn Belt nor the Wheat Belt. Jerry's proven yields come in at an impressive 52 bu/a for wheat, with dryland corn at an equally impressive 100 bu/a, milo at 103, and single-crop soybeans at 41. His top-end yields will run with the best dryland farmers in the area—he's had sizable wheat fields go over 75 bu/a, milo topping 150, corn over 170, several fields of soybeans exceed 60, and a farm-wide *double-crop* bean average of over 40 bu/a in '07. Jerry's yields still fluctuate with yearly rainfall patterns, but the dry years are cushioned by his long-term no-till.

Burger runs a rotation of wheat >>wheat >>milo (or corn) >>milo (or corn) >>soybean. Corn and milo are almost always stacked, and if the field is corn the first year it is usually corn the second year as well. Jerry avoids planting corn into milo stalks. If, and only if, the field has ample residue after the first soybean crop will he occasionally stack soybeans—and only on bottomland at that. He has done stacked soybeans on upland, but finds it damaging in that his mulch cover disappears.

A self-made man, Burger bought his first cropland in 1984 and has continued to expand over the years. Some growers have the luxury of taking over substantial acreages when they start, but Jerry's father farmed only a few hundred acres, so Jerry's growth has come through his own success. For a labor force, Burger gets quite a bit of help from his father, and occasional seasonal help from others during crunch times like harvesting and planting.

## Developing His System

The origin for Burger's long-running no-till endeavor came from several different avenues. Jerry remembers his frustration with terraced ground and their 'band-aid' effect on soil erosion: "I remember reading the [*Leading Edge*] story on Kent Stones and his take on 'T' levels and how they just weren't adequate for saving soil. That's really how *I* felt—we should be trying to build soil, not seeing how much erosion we can tolerate." Jerry continues, "Erosion can't be fixed with terraces—it has to be done with no-till, good crop rotations, and high levels of residue cover." Jerry could see from several years of dabbling in no-till planting that fewer expenses would also be a nice benefit of a continuous no-till system.

**"It's not just one thing, like quitting doing tillage. All the pieces work together. Then it's very profitable."**

Burger doesn't spend much time documenting his success—he's too busy trying to find the solution to his latest thoughtful inquiry. And he's never quite satisfied with the status quo. Always tinkering, Jerry spends countless hours through the winter adjusting, tweaking, and fine-tuning his planter and other machinery. (Before farming full-time, Jerry worked as a mechanic in nearby Washington—maybe that is what nurtured his aptitude for attention to mechanical detail.) Jerry started no-tilling with his existing Case-IH Early Riser planter: "I really didn't start by making a lot of changes." But as Jerry learned more about no-tilling and its seeding requirements, there came a desire for a more adaptable opener and better seed metering. The gauge-wheel positioning on the Case-IH was allowing too much lifting of the soil around the furrow, and Jerry was frustrated with the somewhat uneven emergence. This problem was actually exacerbated as Burger's soils became more structured in long-term no-till.

Finally, needing a new canvas, Jerry went with a White planter for 2004 and has made numerous amendments since. For his 4x0 side-band placement, he added John Deere single-disc fertilizer openers. He tested several row cleaners before settling on Yetter's Shark Tooth. The planter also is equipped with R-K seed tube guards, Keeton seed firmers with reinforcing Mojo Wires, and Thompson closing wheels. Jerry doesn't think he's attained perfect seed placement yet, but he thinks he has progressed considerably, although he notes there were things he liked about the Early Riser, especially the offset opener discs and the narrower seed trench.

A major thorn in Jerry's side right now is hairpinning: "My problem is my soils get too soft on top and I can't cut my stubble." Row cleaners help that situation on Jerry's planter, but the drill is quite another matter. At first, Jerry ran his conventional Great Plains press drill, which halfway worked, he says, since the only thing it did was plant wheat into soybean stubble. He reflects from today's vantage point, "I see now how poor a job it was doing." Jerry knew he needed something heavier that could provide more down-pressure, and decided on a Krause that he ran for a couple years, to no avail—"Seed placement was horrible." He switched to a Deere 1560 for the fall of 2000. Burger says that was an improvement, particularly after making a few upgrades such as 90-series boots and SDX firming wheels. Yet he continues to be plagued by hairpinning and less-than-perfect seed placement, and he can't wait for a better no-till drill to come along.

Another change Jerry has embraced is his switch from pre-plant anhydrous to a total at-planting application of liquid fertilizer with his planter. For corn and milo, Jerry applies both a seed-furrow stream of 10-34-0 with added zinc as well as a 4x0 starter of 32-0-0 with added sulfur.

### The Root of It All

A stickler for details, Jerry continues to refine all facets of his operation, not just equipment. Back in the early '90s, Jerry decided he was going to go no-till and thought

Photos by Roger Long & Jerry Burger.

Jerry's experiment with canola versus a turnip + radish mix, planted after second-year wheat. The turnips have largely decomposed by the following spring, releasing nutrients that otherwise might have leached away. (His seeding rate in lbs/a was higher on canola, but costs were similar to radishes or turnips).

he should first try to get his pH levels up a bit as many were in the 5.5 to 6.3 range, so he limed zealously along with tillage for incorporation. Now, in reflecting back, Jerry realizes lime incorporation with tillage was unnecessary. His pH levels have stayed fairly constant over the last 10 to 15 years, although he now has no qualms about leaving lime on the surface to be moved into the soil with percolating water. Jerry soil tests about every other year and now sees OM levels in the 2.4 to 2.9% range—improvements that are maddeningly slow to appear in those tests, yet the changes in his soils are so obvious to his eyes.


Photo by Debra Carlson Ohlde.

Burger's corn after wheat/dc sunflowers in the field with nightcrawler inhabitants.

Burger never really experienced the three- or four-year slump that some no-tillers talk about in soil health and productivity: "It was just a slow gradual improvement in soil structure and health." Except for newly acquired fields, all of Jerry's cropland has been continuously no-tilled since '98 (some fields since '95), plus several years of 'skip-a-till' planting before that. He wishes he would've converted sooner: "I now realize I spent too much time trying to fix all the tillage problems first. . . . I started back before there was a No-till on the Plains and all the great information there is today." While his county averages around 31 inches of annual precipitation, July and August temperatures can be brutal on crops, so moisture conservation and cooler soil temperatures from crop residues can pay dividends in higher yields. Right away Jerry saw some nice yield advantages over his tilled system, which kept him pushing in the right direction. Jerry remarks, "The whole system is working well for the soil and for the financial aspect. It's not just one thing, like quitting doing tillage. All the pieces work together. Then it is very profitable."

Not knowing whether to advocate or denounce, Jerry watches with amusement another development in his no-till soils—a bottomland hundred-acre field that has been colonized by night crawlers. He can't say with any certainty whether they have helped or hindered crop yields but has noticed that water infiltration is sped up and it's becoming increasingly difficult to keep residue on the field due to the worms' appetite for material.

Just a couple miles south of the 'Palmer corner' on Highway 15, sets Burger's home and shop, nearly hidden behind elm, hackberry, and oaks. To most passing by, the beautiful modern home and efficient shop go unnoticed. In parallel fashion, Jerry's advanced, cutting-edge farming operation also goes largely unnoticed. Not to worry—Burger's not after the praise anyway—he's too busy asking questions and looking for answers.

No·till On The Plains

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