Tillage Reincarnated

by Matt Hagny

SCIENCE

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

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

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

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

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

Photo by Matt Hagny.

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

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

Why Did That Result Occur?

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

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

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

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

Photo by Doug Palen.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

deeper!!

Why Tillage?

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

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

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

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

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

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

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

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

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

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

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

As Edward Faulkner wrote[5] way

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