Pale no-till crops? Lackluster yields?

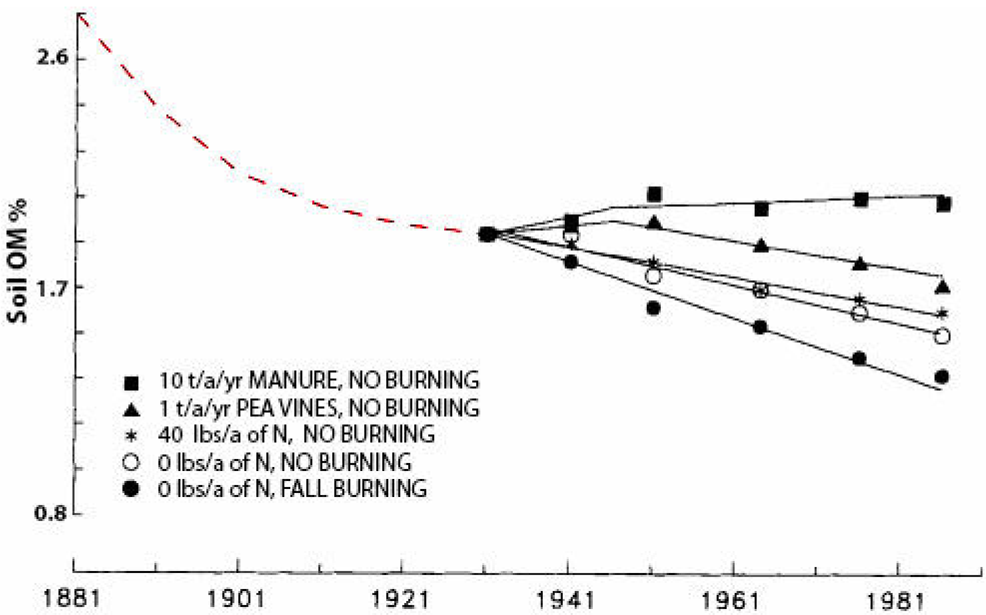
Hidden nutrient deficiencies are often the culprit.

by Matt Hagny March 2013

One of the foremost reasons crops fail to thrive is lack of key nutrients, many of which result in some degree of crop paleness (N, S, Mg [magnesium], Fe, Cu, Zn, Mn [manganese], moly; to a lesser extent, K) as well as lackluster growth (all the aforementioned, plus B [boron] & P), and/or poor grain fill – i.e., you grew a lot of vegetation, but not much grain. In general, many of these deficiencies are *more* likely in no-till conditions, particularly long-term, continuous no-till (a highly desirable system).

Keep in mind the Big Picture. Harvesting grain (or biomass removal) is a continual 'mining' process, wherein all 15 minerals that are known to be absolutely essential to plant growth are being hauled away to the cities, never to return. Originally, the native soils of the Great Plains of USA/Canada were highly fertile when the sod was broken with tillage to grow crops in the late 1800s & early 1900s. This tillage allowed oxygen to reach what was previously quite stable soil organic matter (OM) in soil aggregates; the oxygen influx allowed microbes to feast on this OM that had been inaccessible to them. The resulting breakdown of soil OM (specifically, as the microbes died) released all 15 essential minerals, as well as carbon dioxide. No fertilizers were needed back then, as this stockpile of nutrients was plundered with

tillage. Indeed, the abundance of nutrients was so great that it usually exceeded what crops needed, and so it leached away. (Incidentally, the grains had superior nutrient status at this time, generally to the benefit of the people and livestock consuming these.)



Effect of management practices on long-term change in soil OM in the upper 12" of soil in Oregon since 1881. Under a wheat >>summerfallow system with tillage for a century, the only practice that halted the OM decline was large application of manure annually. Most of the OM change was in the 0-6" depth, and would show an even steeper decline. Source: Rasmussen (USDA-ARS) et al., 1980, 1988. Many studies around the world show the quantity of biomass applied or remaining on the soil drives the change in soil OM, along with severity of tillage (no-till being the best at maintaining or building soil OM, when all other factors were equal).

But this couldn't go on forever: There initially was a steep decline in soil OM for the first 30 – 50 years of tillage, then it gradually leveled off. The free ride was over. Soils started becoming responsive to N & P fertilizers, which would soon became standard practice (circa 1950s) because the yield response was often substantial. In the Corn Belt, responses to K became common, and ever more frequent with installation of tile drainage (more K leaching), and later with no-till (more water percolation, although this can be completely reversed with cover crops scavenging deep K and bringing it back to the surface—stratification is a wonderful thing).

By the 1980s and '90s, responses to Zn were becoming more common in grain crops, and in some places, sulfur & chloride were providing benefits. Irrigators were often the first to need additional nutrients such as Zn, since their grain yields were so high (more removal). But dryland was also affected. Indeed, as the soils become more mined out, we shouldn't be at all surprised that 'new' (unfamiliar) minerals must be added to the fertilizers to maintain or improve yields.

As no-till was adopted, new deficiencies showed up. The reason? —nutrients are being 'banked' in the mulch cover (and any increase in soil OM), soils are colder & wetter, and may become less aerated (depending on clay content, equipment used, earthworm activity, and so forth), and total year-round microbial biomass may be substantially higher (and the microbes look out for their own interests—rather than the crop's—and are far quicker and more adept in gobbling up nutrients than are the plants). One way to think of it is that the increased soil biota and any increase in soil OM are net sinks for nutrients. There's a flow in and out, but the 'savings account' is growing, so the net available to the crops is less—until a new equilibrium is reached. Hence, no-till is often confronted with these yield-limiting nutrient deficiencies while nearby tillage cropping isn't (yet).

It is true that some soil microbes help plant nutrition, and this is especially true for mycorrhizae, a fungal symbiont on roots. However, some of our crops, such as modern wheat varieties, are not good hosts to these fungal helpers, so the wheat roots must do more themselves—which means more or different fertilizers for no-till wheat. Even with corn, milo, or soybeans, which are more mycorrhizae-friendly, the effect often isn't enough to overcome the other net sinks for nutrients in the soil—such that these crops in long-term no-till often require more (and more diverse) fertilizers than tillage crops nearby.

So, with the extra fertilizers required, is no-till still worthwhile? From a sustainability standpoint, absolutely. From an economic standpoint, no-till is still the champion at conserving moisture for the crop, and while you can buy more fertilizer, you can't buy more rain (unless you irrigate). Any area that experiences moisture shortages at any time in the crop's life cycle will be ahead with no-till, if the no-till is done correctly. With good no-till techniques, and plentiful (but balanced) crop nutrition, the yield potential is raised.

And, there's other good news: Despite the net sink effect, quite often P supply to no-till crops is improved as compared to tillage systems, partly because the P fertilizer bands or prills aren't constantly being stirred into the bulk soil, which reduces P availability due to adverse chemical reactions ('fixation' occurs). Also, to the extent that cropping intensity increases under no-till, the organic acids from roots may prevent some fixation. Quite often, well-managed no-till crops can have ample P uptake at lower soil-test levels than would be required in tillage systems on the same soil (although some no-till crops may be more responsive to P fertilizer applied near the seed, due to soils being cooler). Overall, no-till can still be (and often is) the most profitable. We just need to be vigilant that these 'new' nutrient deficiencies don't sneak up on us and start causing yield drag, more susceptibility to frost, more disease, etc.

Think you've got it under control? Always benchmark your fields against old feedlot areas, old grain spills, fertilizer spills, etc.—this is your true potential. Visually, it's often strikingly different—the crops will have larger leaves, healthier color, and more grain. After your eyes are opened, then it's a matter of doing the detective work to figure out what nutrients are needed to close the gap. (Or get yourself some manure or poultry litter—these work wonders on soils, although they're not always a balanced nutrient program for crops.)

Don't rule out certain nutrients because the soil test is 'High' or the plant tissue-test report says it's 'Sufficient.' All too often, those can lead you astray. Soil tests make the assumption that the nutrient will be continually available and taken up by the plant, which may or may not be true, and, in any event, no-till conditions may require higher levels of soil nutrients to overcome cold, wet soils. Plant tissue testing removes one layer of assumptions—the nutrient is now in the plant. However, a tissue analysis is only a snapshot in time, so it takes a series of them to see the patterns. And, again, what's termed 'Sufficient' by the lab often isn't truly adequate for modern crop genetics (most of the breeding work is conducted on soils with a surplus of all nutrients, thus inadvertently selecting for genotypes that are inefficient at taking up and/or utilizing nutrients—i.e., they may require a higher ppm tissue content of a nutrient to be sufficient).

Note: Cover crops help recycle N, K, & S that might otherwise be lost to leaching, and some cover-crop species can unlock (liberate) a large amount of P from soil that otherwise would be too strongly bound for other species to obtain. Brassicas and certain lupins excel at this, and have been shown to improve soil-test P values, and enhance P nutrition of subsequent cash crops. In the Corn Belt, adding cover crops in the fall will prevent a tremendous amount of N, K & S loss due to leaching. Yet cover crops are also net sinks, especially in drier climates, and can worsen many other deficiencies (N, S, Zn, Cu, Mn, B) in the short term.

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