FFF Review

Good Residue Management Improves Soil Productivity

Helps produce a more favorable high-yield environment for the conversion of residue into organic matter.

A nutrient analysis of each soil in Figure 1 shows a similar NPK-S-Zn plus micronutrient content in each. Yet there is considerable difference in productivity. Why? Though each soil is chemically about equal, there is a large difference in organic matter content. The soil on the right (lifeless, high in clay, compacts easily) is low in organic matter. The soil on the left, which is high in organic matter, has extremely high microbiological activity. The grower's challenge is to develop the skills required to convert poor soil into productive high-yielding soil through good residue management, smart cropping practices, and proper fertilization. It is not a short-term program but a long-term commitment. This discussion will center on the specifics that must be learned in meeting that challenge.

Organic matter a key

Even though organic matter represents only two to four percent of the soil, its presence significantly improves root environment and soil productivity. The time and expense involved in converting residue into organic matter are well worth the effort because organic matter:

- makes heavy soils friable, easier to work
- promotes a crumbly soil structure
- promotes greater water-holding capacity
- improves water infiltration rate
- increases aeration, which is important for phosphorus availability, nitrification of nitrogen, and microbial activity
- supplies nitrogen and other nutrients in summer months when crops need them most.

Organic matter contains tremendous amounts of nutrients as a reserve in the soil. That is why black soil is worth $2,000/A and lighter soil is worth only $500/A. Soil containing 5 percent organic matter contains 100,000 lbs/A of organic matter in the top six inches. Tied up in that organic matter is 5,000 lbs of nitrogen that can be broken down to feed crops in the summer.

Residue cycle

Understanding the residue cycle (Figure 2) is important in learning how organic matter can improve soil productivity. Nitrogen is the star player in the residue cycle. From the beginning of time, plants have grown, died, and decayed. The decaying process leaves the black residue we call organic matter. Billions upon billions of bacteria go to work, feeding on residue, digesting it, leaving behind the organic matter. But the process doesn't end there.

Mineralization. Other families of bacteria decompose organic matter further into available ammonium nitrogen, phosphorus, and sulfur. Agronomists call this process "mineralization." The mineralization process can provide tremendous reserves of nitrogen, phosphorus, sulfur, and other nutrients to feed crops in July and August when demand is heaviest.

Immobilization. Nitrogen and other nutrients that are released into the soil solution are absorbed by plant roots. Bacteria that digest residue require large amounts of nutrients that are taken from the soil solution and fertilizer. When nitrogen is removed from the soil by residue-digesting bacteria, the process is called immobilization because the nitrogen is taken away from the plant roots and is tied up in the residue.

This is the residue cycle.

Warmth, moisture best

The process of decaying residue into organic matter requires nitrogen, phosphorus and sulfur, which are taken from the soil. Bacteria literally rob plants of nutrients during certain times of a growing season. The residue-decaying process works best in the top four or five inches of soil where aeration is better, and when the soil is warm, moist, and has a neutral pH. The process does not take place when the soil is cold, compacted, too wet or too dry, or too acid or too alkaline.

Management critical

Residue should be considered an asset, not a problem. Managing residue properly is the key to soil productivity and high yields. In every acre of land as many as 10 billion microorganisms live, work, and die. These tiny organisms make up the "microscopic society" beneath the soil. They devour and digest plant residue. They need warmth, moisture, and oxygen from the air. They release tremendous quantities of carbon dioxide. Without these bacteria and fungi, the best ground would become useless.

We can help these organisms convert residue to organic matter by using proper tillage, and by providing enough food. Bacteria require a diet that consists of nitrogen, phosphorus, and sulfur to balance content of nutrients in the residue. Organic matter produced by these microscopic workers adds tilth and productivity to the grower's soil.

Carbon/nitrogen ratio. Likening it to what happens to ruminants in the field will help us understand what happens when residue is converted to organic matter. We know, for instance, that corn residue has a carbon/nitrogen ratio of 50:1, or, for purposes of this illustration, corn residue has a 5 percent protein level. For ruminants, the best protein level is not 5 percent but 10 to 12 percent because they digest stalks best at that level. So, residue with a 50:1 carbon/nitrogen ratio, not unlike cattle, obviously needs extra nitrogen in order to convert cellulose into organic matter. Similarly, if cattle are fed roughage, they will need additional protein (or nitrogen) so that bacteria in the rumen can multiply and do a good job of breaking down roughage. Out the other end, of course, comes manure or organic matter. We want to encourage this same reaction in soil. Think of a field as one giant rumen. We want to incorporate residue, add nitrogen, and digest the residue into organic matter. It is simple if conditions are favorable for this conversion to take place.

Adjusting ratio. Why do it and how is this done? In the example above, we know there are 1,000 lbs of carbon in 2,000 lbs of corn but only 20 lbs of nitrogen, giving us the 50:1 ratio. Add 20 pounds of N per ton of residue, the ratio will be lowered to 25:1. This helps bacteria by giving them a balanced diet. They now can proliferate, grow and digest residue. The same quantity of straw takes even more N—30 lbs per ton of straw—to lower a 100:1 carbon/nitrogen ratio to 25:1. The concept is the same as feeding cattle: the soil is like a giant rumen. Instead of feeding extra urea or protein, nitrogen is added to decay residue into organic matter.

Building tilth. Good residue management builds soil tilth. Analyzing Kentucky data, Table 1 shows that in ten years organic matter increased from 2.5 to 5 percent! The amount of organic matter doubled from 17,000 to 34,000 lbs/A. There was also a net gain of 700 lbs/A of nitrogen contained in the organic matter. The gain per year of organic matter in the top two inches was 0.25 percent. Spreading the increase over the top six-inch layer of soil, the increase would amount to 0.15 percent per year. Note also that nitrogen tied up in organic matter amounted to 70 lbs/yr/A. The production of organic matter was not cheap. It cost money in terms of nitrogen. But that nitrogen was not wasted. It went into the organic fraction, available to be taken out in the summer months under proper conditions.

"We can help organisms convert residue to organic matter by using proper tillage and providing enough food."

In Table 2, the possible addition to the organic matter reserve for 150-bu/A corn is 0.18 percent per year in a six-inch profile. Some may question the extra $20/A to tie up 75 lbs/A of N and increase organic matter. Is it justified? If it means a more productive soil, higher yields, and improved profits, the answer

Table 1. Increase in organic matter after ten years in a Kentucky no-till field under good residue management.

Year	% organic matter (0-2")	Organic matter lbs/A	Nitrogen in organic matter lbs/A
1970	2.5	17,000	700
1980	5.0	34,000	1,400
Net gain (10 yrs)	2.5	17,000	700
Gain/yr	0.25	1,700	70

Figure 1. Organic matter level can make a difference in the productivity of soils.

is a resounding yes. A good rule of thumb to remember: the harder you work a soil, the better it becomes.

Tillage. Some forms of tillage are more desirable than others for the production of organic matter.

The old moldboard plow, used to break prairie soils, is one sure way of destroying organic matter. Two things happen when a moldboard plow is used. First, it exposes the deep soil to excessive aeration, which causes loss of organic matter. Second, residue that is turned under experiences what is called “anaerobic conditions” where there is a lack of air that prevents decaying of residue into organic matter. How many times have you plowed under crop residue and found it there a year or two later?

The disk can create a good environment for digestion of residue into organic matter. But the disk also creates a compaction zone three to four inches deep, which can restrict root development. The disk also puts too much residue under the surface, losing two of the primary benefits of residue: erosion control and increased water infiltration rate.

The chisel plow does an excellent job of fracturing the subsoil and incorporating some residue four to five inches under the surface. This is the area of greatest organic matter productivity because it is warm, moist, and well aerated. It satisfies all the conditions discussed earlier about mineralization, immobilization, and nitrification.

Figure 3 compares the level of organic matter after ten years in the no-till field in Kentucky already cited and a conventional-till field. In the no-till plot, organic matter increased to 5 percent in the top two inches. However, the conventional-till field, using a moldboard plow, stayed at only 2.5 percent organic matter in the top two inches. The comparison demonstrates how the practice of reduced tillage, which leaves more residue on the surface, makes conditions more favorable for residue to be converted into organic matter. The payoff in the end is higher yields. ❑

Table 2. Nitrogen required to obtain different organic matter levels and corn yield levels while building tilth.

Yield	Tons dry residue	Possible addition to organic matter reserve	Additional N needed
bu/A	(ears removed)	%	lbs/A
100	2.5	.12	50
150	3.8	.18	75
200	5.0	.24	100
250	6.3	.30	125

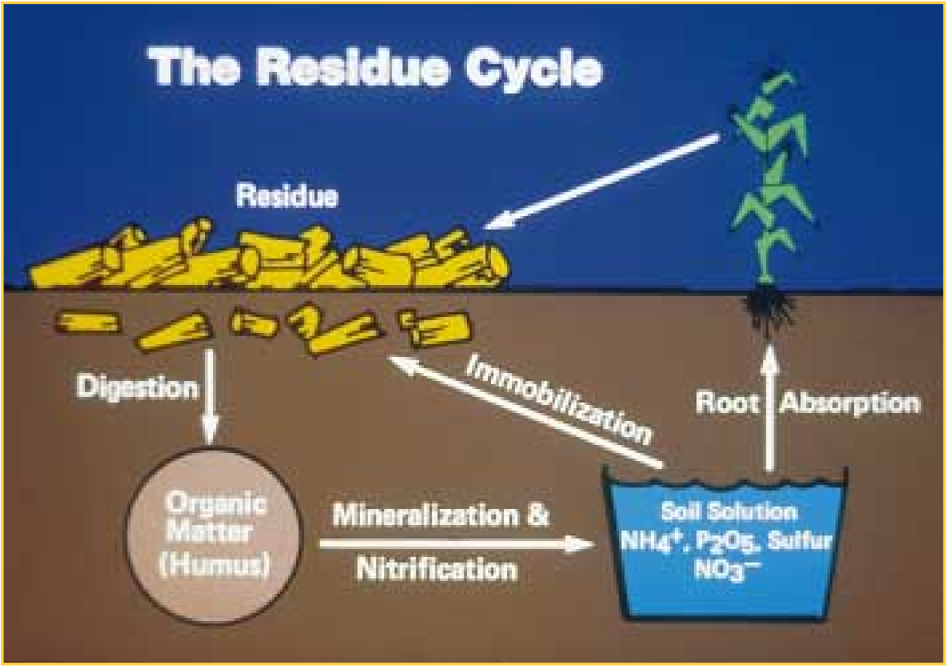

Figure 2. The residue cycle.

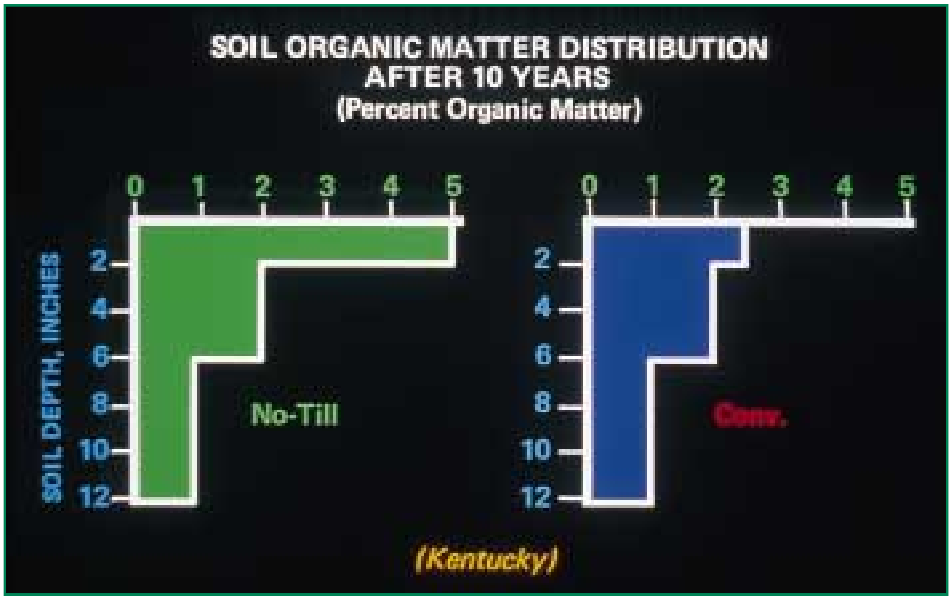

Figure 3. Soil organic matter distribution after 10 years in a Kentucky no-till field.