by Dr. Raun Lohry

Liquid Starter Makes Conservation-till Work

Research shows liquid starters continue to excel under intensive management

Summary: *The most important thing to remember is that proper fertilizer management takes into account total needs of the crop. Good management looks at the big picture and the best practices have proven performance over time. Liquid starters continue to prove their worth under intensive management. Advantages of starters include: 1) advancing maturity by 5 -10 days, 2) producing drier corn at harvest, 3) producing more vigorous plants that can better withstand weed and insect pressure, and 4) producing responses even in high-P and high-K soils.*

Make no mistake. Conservation tillage is here to stay. We must learn how to make it work. The practice can cut operating costs for producers. It can reduce erosion and increase water use efficiency. We all know, however, that success with the practice requires more than just saving fuel, time, land or water.

To be successful we must continue to increase yields per acre so that our unit cost can go down. In other words, the fixed costs (interest, taxes, depreciation and even labor, seed and herbicides) will choke us to death if our yield per acre is too low.

To survive, high yields are a must. We can accomplish this with conservation tillage, but bold new fertilizing techniques are imperative. Using liquid starter is one of the necessary operations that makes conservation technology work.

Inherent problems

Farmers often shy away from adopting conservation technology because of problems they confront when switching to minimum tillage.

Weed pressure. Residue often interferes with herbicide performance. Weeds can cut yields drastically.

Stratification. It's well-known that deep-placed nutrients promote deep root systems. Deep roots allow for higher populations and promote higher yields. No plowing means no mixing, so non-mobile nutrients tend to accumulate on the surface, causing shallow root systems, poor water use efficiency and poor fertilizer efficiency.

Nutrient tie-up. Excess surface residue immobilizes nitrogen, phosphorus, and sulfur, which all reduce nutrient availability to the crop.

Positionally unavailable K. Accumulation and decay of potash-rich residue contributes to the accumulation of potassium in the upper two or three inches of soil. As a result, the subsoil is low in potassium. This lack of subsoil potassium contributes to low yields.

Cool temperatures. The insulation effect of residue on the surface lowers subsoil temperatures at planting time. Cooler temperatures reduce phosphorus and potassium uptake and slow mineralization of organic nitrogen, causing yellow and deficient plants at a critical time in a corn plant's life.

Denitrification. Conservation tillage increases the potential for denitrification loss because of compaction, high moisture levels, and higher microbial populations. This loss of nitrogen can cost a bundle by reducing yields.

Poor fertilizer efficiency. Fertilizing conservation tillage with conventional methods can result in poor fertilizer efficiency because of stratification, cooler

temperatures, residue tie-up and denitrification loss. In other words, broadcasting fertilizer on residue, where levels of fertility are already high, can be a wasted effort. In addition, surface residue can immobilize tremendous quantities of nitrogen, phosphorus and sulfur. The result is poor fertilizer response.

Liquids the answer

Now that we're familiar with some of the problems, let's investigate how liquid starter can help solve them.

Weed pressure. Placing liquid starter about 2 inches below and 2 inches to the side of the seed is ideal for young corn plants and below germinating weed seed's roots. "Starter will get plants up faster so they will form a canopy sooner to shade out weeds," says Dr. Allen Bandel, Extension Soils Specialist at the University of Maryland.

Stratification. When starter fertilizer is used in a conservation tillage system, it is placed deep enough in deficient soil to optimize uptake. Lack of tillage has a tremendous effect on the distribution of nutrients in the soil. The data in Table l show stratification from five years of minimum tillage. Because of the lack of mixing of non-mobile nutrients, phosphorus accumulated in the upper 3 inches of soil. The sub-surface from 3 to 24 inches was deficient.

Table 1. Phosphorus stratification after 5 years minimum tillage.

Depth (in)	Phosphorus (ppm)
0-3	84
3-12	10
12-24	8

A deep root system plays a critical role in raising high yields at a low cost per bushel. The root system is a dynamic, vital system that expands, lives and dies-day after day. In a single plant, 14,000 new roots can emerge each day, replacing old roots no longer alive. Some roots may live about three to five days, turn brown and die. Measurements on a single rye plant have averaged a total root growth of three miles per day.

A healthy corn crop, therefore, needs a large functioning root system to collect moisture and nutrients to feed each plant. Higher yields require higher populations and higher populations require a large volume of moisture and nutrient-rich soil for the more extensive root mass to exploit. The more extensive root mass requires deep fertility with high nutrient concentrations.

If one studies high yields (over 200 bushels), the common thread is deep fertility with high soil test levels of the major nutrients deep in the soil profile. Again, liquid starter, together with root zone banding, preplant or sidedress, is the key program for producing high yields under conservation tillage.

Nutrient tie-up. Placing liquid fertilizer under residue can reduce nutrient immobilization loss. Starter fertilizer applied at planting time on conservation tillage will feed the crops and "cheat" the microorganisms by placing nutrients out of reach.

"Residue tie-up" or "immobilization" results from the high biological activity in the surface soil in conservation tillage. Conditions are close to ideal for residue digestion. The necessary ingredients (warmth, moisture, pH and aeration) tend to promote a highly reactive biological environment or the decomposition of residue. The amount of nutrients absorbed in this process is different for different types of residue. For corn, decomposition absorbs roughly 20 pounds of nitrogen, 8 pounds of phosphate (P_2O_5) and 3 pounds of sulfur (S) per ton of corn residue! Wheat residue may absorb up to 30 pounds of nitrogen per ton of residue. Any fertilizer applied on the residue will be swallowed by hungry organisms. It's only temporary, but it can cut yields by reducing nutrients available to the crop at a time when they are needed.

Certainly, an argument can be made that immobilization loss "is not all that bad" because these nutrients can be released to feed the crop at a later date. Meanwhile, the organic matter produced by immobilization can be used to improve soil structure. The benefits of organic matter are well-known: it reduces compaction, which increases aeration and increases water-holding capacity. Organic matter also increases the capacity to retain exchangeable nutrients (especially ammonium, potassium, calcium and magnesium).

Table 2 gives the approximate amounts of nutrients that can be tied up by residue. Several conditions—including residue amount, tillage practice, temperature, and moisture — control nutrient immobilization. From Table 2 one can see that significant amounts of nitrogen, phosphorus and sulfur are temporarily immobilized into the organic fraction.

Table 2. Approximate amount of nutrients tied up during residue decomposition per ton of residue or by a 125 bu/A corn crop (3 tons residue).

Nutrient	per ton	per 125 bu crop (lbs)
Nitrogen (N)	20	60
Phosphorus (P_2O_5)	8	24
Sulfur (S)	3	9

Research in Kentucky has shown a 34-bushel per acre increase from 80 pounds of nitrogen applied sub-surface at planting time, compared to broadcasting (Table 3).

Positionally unavailable K. Potassium in the starter can give excellent response (Table 4). In this Wisconsin test, starter proved to be the big equalizer. That is, yields from conservation

Table 3. Effect of at-planting fertilizer applications on no-till corn yield.

Treatment	Yield (bu/A)
No N	61
80 lb Broadcast	121
80 lb Injected	155

tillage equaled or exceeded conventional tillage because a sufficient amount of potassium was applied in the starter fertilizer. The test showed an 18-bushel per acre increase from starter on a till-plant plot compared to only a 9-bushel per acre increase in a plowed control. Even when 160 pounds of K_2O were applied broadcast, the starter fertilizer increased the till plant yield by l8 bushels per acre! The broadcast potassium was "positionally unavailable" because of sufficient K already in the surface zone.

Table 4. Effect of starter on corn grain yield.

Method	Broadcast	Plus Starter	Difference
	..... (bu/A)		
Plowed	117	126	8
Till Plant	118	136	18

In a 125-bushel per acre corn crop, above-ground residue contains about 100 pounds of potassium. If a field is not tilled, and the residue is allowed to accumulate and decompose, potassium will accumulate on the surface each crop year. After five years of no-till, 500 pounds of K_2O will be piped up from the subsoil to the surface! This potassium is essentially "positionally unavailable" to the current crop because it is sitting on the surface and subject to the drying patterns during the summer months. It makes no sense at all to surface broadcast potassium on no-till when chances are that the surface already contains enough K.

Cooler temperatures. Liquid starter at planting time can overcome the effects of low soil temperatures inherent in conservation tillage. A look at Figure l shows why. The "concentration effect" from the band of starter fertilizer offers

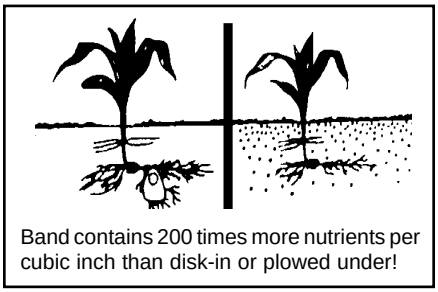

Figure 1. Starter fertilizer at planting counteracts low temperatures because concentration effect" helps roots absorb more.

a young root system a readily available source of complete plant food, including nitrogen, phosphorus, potassium, sulfur and zinc. The phosphorus concentration in a band is over 200 times higher than a broadcast and disk-in application. This higher concentration reduces soil fixation and helps to increase root uptake.

In conventional tillage, where the exposed soil is black, sunlight will warm the soil much quicker than in conservation tillage where insulating residue blankets the soil.

Resulting low soil temperature in conservation tillage reduces plant growth and nutrition. The residue, which beneficially reduces erosion, increases water infiltration and contributes organic matter, is also our biggest enemy because the insulating layer reduces soil temperature from early spring to corn planting time.

Soil temperature difference can amount to as much as 7°F. This doesn't sound like much difference, does it? But, think of this. An extra 9 degrees can triple the phosphorus uptake in the warmer soil! Figure 2 shows that banding starter fertilizer could increase the uptake of phosphorus 233 percent in cold soils and prevent deficiencies.

Denitrification losses. Addition of nitrification inhibitors to liquid starter can keep nitrogen in the ammonium form longer and reduce denitrification and leaching. Denitrification occurs when nitrogen converts to gaseous forms that are released to the atmosphere. Denitrification losses occur frequently in compacted or water logged soils because they lack oxygen and in conservation fields because of extremely active biological systems.

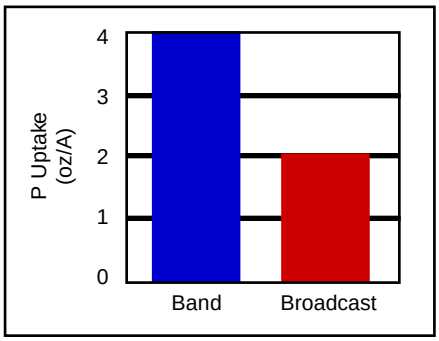

Figure 2. P_2O_5 uptake by young corn plants 14 days after emergence in 59^0 F soil.

Poor fertilizer efficiency. The most spectacular response from any plant food applied with starter is the tremendous increase in fertilizer efficiency gained by banding zinc in starter. In Nebraska tests, one-tenth of a pound of zinc increased yields by 37 bushels per acre! Researchers said, "With placement below and to the side of the seed only small amounts of zinc were needed to produce maximum yields" (Table 5).

Table 5. Effect of starter applied zinc on corn grain yield over two years.

lb Zinc/A	Yield bu/A	Increase
0	82	
0.1	119	37
0.3	127	45
1.0	135	53

Drastic changes in tillage practices, such as switching from conventional tillage to no-till, require drastic changes in fertilizer practices. For example, we have talked about tie-up of nutrients in residue, denitrification of nitrogen, lack of movement of phosphorus, potassium

and zinc, and compaction in the subsoil that restricts nutrient uptake. All of these problems contribute to poor fertilizer efficiency when using conventional broadcast methods of applying fertilizer. The solution to most of these problems is liquid starter applied at planting time**,** positioned below the residue. In addition, root zone banding of a complete fertilizer below the residue before or after planting will supply the balance of nutrients. This two-step fertilizer program can solve most of the problems of fertilizing a conservation tillage field.

Many agronomists say, "Build P and K levels before switching to conservation tillage." Do they realize how long it takes and how costly it is to build P and K levels by broadcasting and plowing? It is estimated that 16 pounds of P_2O_5 per acre (7 lbs P) are required to raise the soil test level by one part per million P. To raise the soil test level of 20 ppm P would thus require about 320 pounds of P_2O_5 per acre. During the time that they are trying to build these P and K levels, there is a tremendous loss of nutrients taken by fixation of phosphorus, the possibility of soil erosion or the loss of yields because of poor water use efficiency. Five-year tests at Purdue show that you can build the soil fertility levels almost 50 percent faster by banding fertilizer than by broadcasting. Their tests showed that P test for broadcast application was 2l ppm while P test for surface banding was 31 ppm after only 5 years.

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