MARYLAND COOPERATIVE EXTENSION
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Fact Sheet

Fact Sheet 514

No-Till Corn Production: Achieving Maximum Nutrient Efficiency

Maryland has long been a leader in the development and adoption of no-tillage crop production. No-tillage offers many benefits to the producer and to society in general. In addition to significantly reducing soil erosion and nutrient runoff, no-tillage often results in higher crop yields and more efficient utilization of plant nutrients. When properly implemented, the outcome is more acceptable profit margins for the farmer and considerably reduced nutrient pollution of Maryland's surface and ground waters.

According to a recent study by the Environmental Protection Agency (EPA), nitrogen and phosphorus from agricultural runoff are responsible for a significant portion of the biological decline of the Chesapeake Bay. Although difficult to prove, improper nitrogen and phosphorus management may be contributing to undesirable nutrient enrichment of the state's surface and ground waters. On the other hand, nitrogen and phosphorus are essential fertilizer nutrients. They are nonrenewable resources and are relatively expensive to manufacture and to purchase commercially. These are sufficient reasons for stringent efforts to conserve these nutrients.

To achieve maximum benefits from nutrient conservation, it is important to properly manage fertilizer nutrients and their use. New management systems need to be researched and implemented. This fact sheet examines some of the more critical factors involved in managing nitrogen and phosphorus under no-tillage crop production, specifically, in the production of no-till corn.

I. Nitrogen Management

Nitrogen and the Ecosystem
Nitrogen is essential for plant growth. With the exception of legumes which can fix their own nitrogen, this element may be obtained from commercial fertilizers, manure, crop residues or other resources.

Nitrogen also is one of the earth's most abundant elements. It surrounds us in the atmosphere. It comprises more than 80 percent of the air we breathe. But in the air, nitrogen is an inert gas. It does not react with other substances.

Plants or animals cannot use nitrogen in its inert form. Plants can only use nitrogen in the ammonium or nitrate form. Unfortunately, these forms of nitrogen can move easily through the soil, or disperse in the air or water if mismanaged. Management practices that result in unacceptably low nitrogen efficiency, increase crop production costs and the potential for environmental pollution.

II. Nitrogen Application and No-Till Corn

Factors to Consider
Some of the earliest researchers observed that when nitrogen was surface-applied to no-till corn near planting time at the same rates used on conventionally tilled corn, yields were often low and the plant showed more severe symptoms of nitrogen deficiency. This was especially true when nitrogen rates were less than optimal.

Rate of Application. No-till corn usually requires approximately 20 to 40 pounds per acre more nitrogen than conventionally tilled corn, at least initially, even when nitrogen has been managed properly to minimize losses. The extra nitrogen is needed because, in time, no-till corn yields will usually be about 10 percent higher than yields from conventional tillage. More nitrogen is released from the conventionally tilled soil because most soil nitrogen is contained in the organic matter. Tillage destroys soil organic matter, thereby releasing some of its nitrogen content.

On the basis of nitrogen required per bushel of corn grain produced, less nitrogen is normally required for no-till than for conventional till. Even though no-till yields may be lower the first year or two on those soils where no-till is recommended, after a time, no-till yields tend to equal or even exceed conventional tillage, regardless of nitrogen rate. Conventionally tilled yields often tend to remain static or decline over time.

These trends indicate that long-term reduced tillage improves soil productivity. This benefit may be the result of increased soil organic matter, improved soil tilth, improved moisture infiltration and water holding capacity, and improved nitrogen availability and balance in the soil.

Long-term nitrogen rate by tillage studies ultimately demonstrated that no-till corn normally requires slightly more nitrogen than its conventionally tilled counterpart, at least the first couple of years. This is not necessarily because of leaching.

When applied improperly to no-till soils, nitrogen: 1) may leach if applied to a porous sandy textured soil; 2) may be immobilized by micro-organisms in the process of decomposing crop residues; 3) can be lost to the atmosphere as a gas through the process of' ammonia volatilization; or 4) can be lost to the atmosphere as other nitrogen gases through *denitrification* (the conversion of nitrates into compounds of a lower oxidation state).

These observations have led to ongoing fertilizer management studies, in an attempt to establish appropriate guidelines for selecting the appropriate nitrogen rate(s), proper nitrogen sources, and the best time(s) of nitrogen application and placement for no-tillage crops.

Source of Nitrogen. Nitrogen solution (30 percent UAN) is the most popular type of direct applied nitrogen fertilizer in this region. One of its advantages is its compatibility with many pesticides. This enables applicators to combine many materials in a tank mix and make a single-trip application. This may be an excellent way to apply certain pesticides, but it is not always the best way to apply nitrogen. Soil nitrogen losses may be negligible following this practice, but when conditions are least suitable for nitrogen stability, soil nitrogen losses may exceed 50 percent.

This "weed-and-feed" practice poses a twofold problem. First, applying most of the nitrogen early in the season when it is most appropriate to apply pesticides may mean that this is the least appropriate time to apply nitrogen. Chances for nitrogen loss are increased. Second, surface-applied urea and urea-based nitrogen fertilizers are more susceptible to ammonia volatilization losses than are other nitrogen sources. If urea or UAN fertilizers are to be applied, more intensive nitrogen management must be used.

Time of Application. Most of the nutrient uptake by corn occurs during the period from about 25 to 30

days after planting until ear fill. For approximately the first month, young corn plants survive mainly on food reserves stored in the seed. The young plant's root system is confined to a relatively small volume of soil, and very little nutrient uptake from the soil takes place. Thus, during the early period of growth, the young plant virtually "ignores" most of the nitrogen fertilizer that has been applied. The crop does not need large amounts of nutrients at this time; if applied early, nitrogen may be more vulnerable to being lost than if applied at a later date.

Research shows that by delaying surface applications of UAN solution on medium- to heavy-textured soils, the efficiency of broadcast UAN can be improved by 12 to 13 percent. The efficiency of dribbled UAN can be increased by about 7 to 8 percent by delaying application 3 to 4 weeks after planting. On light-textured, sandy soils that are more subject to leaching, it is advisable to sidedress nitrogen at a later date to prevent nitrogen leaching losses. When nitrogen is applied by an injection method (usually placed 3 to 4 inches deep in the soil), delaying the application time makes no difference in UAN efficiency. Also, where leaching is not a problem, time of application is not critical to the injection technique.

Placement of Nitrogen. The efficiency of UAN solution can be significantly increased or decreased by any one of these placement methods: broadcast, dribble or injection.

Considerable variability can exist between placement techniques due to soil and location, but if nitrogen is applied close to time of planting, dribbling is slightly more efficient than broadcasting (about 5 percent more), and the injection method is superior to all other methods.When applied near planting time, injection placement of UAN averages about 20 percent higher yields than broadcasting, and is 15 percent more efficient than dribbling.

When applied a month after planting, injection placement is about 8 percent more efficient than either broadcasting or dribbling, and 21 percent better than UAN broadcast near planting time, as shown in Table 1. Inindividual cases where application is made near planting time, injected UAN may be as much as 100 percent more efficient than broadcast UAN.

Table 1. Effects of nitrogen placement and time of application on relative average no-till corn yields, using the broadcast method in May, equal to 100 percent

	1980-1985		1983-1985	
Nitrogen Placement and Timing	May	June	May	June
	. . . . . Percentage			
Broadcast	100.0	110.3	100.0	112.5
Dribble	---	---	104.7	112.8
Inject	107.4	114.2	119.8	121.1

Table 2. Effects of 30 percent UAN solution containing various nitrogen stabilizers on no-tillage corn yields.

Treatment	1985	1986	1987
	.....bushel/A.....		
UAN broadcast	140.0	129.0	103.1
UAN injected	149.6	166.4	135.6
UAN + N-SERVE broadcast		126.8	
UAN + N-SERVE injected	137.6	165.0	93.3
UAN + DCD broadcast		126.7	
UAN + DCD injected	137.2	166.1	88.6
UAN + Ammonium thiosulfate (17-0-0-5) broadcast		118.8	91.4
UAN + 10-34-0 (18-20-0) broadcast		124.7	99.8
UAN + Ammonium bisulfite (17-0-0-5) broadcast			97.7

Economically, the numbers mean that if a grower broadcasts 150 pounds of nitrogen per acre as 30 percent UAN solution near planting, usually as a carrier for his pesticides, he could do as well by injecting just 125 pounds nitrogen per acre. At $0.25 cents per pound of nitrogen, this is a saving of $6.25 per acre. In cases where apparent nitrogen losses due to improper timing or placement approaches 50 percent, injection could save the grower 3 times this amount on every acre planted. Therefore, UAN injection is attractive, both economically and environmentally.

Many kinds of injection equipment are available. The best one tested, so far, is the kind that uses a thin injector knife (about one-fourth of an inch thick), preceded by a coulter. This equipment places the fertilizer solution accurately with a minimum of soil disturbance. Another injection type, the innovative point injector, is also available. This method has not yet been thoroughly researched.

Injecting a stream of nitrogen solution between every crop row reduces the chance for error and may give a more uniform application, but placement between every other row has been found to be satisfactory. The latter technique may allow penetration more easily into dry soil, and at a lower cost, since fewer knives and coulters are needed.

Nitrogen Stabilizers. Materials like N-SERVE, DCD (dicyandiamid), ammonium thiosulfate, ammonium polyphosphate (10-34-0), and others, are often publicized for their reported nitrogen stabilizing properties. These products are supposed to help retain nitrogen in the soil for extended periods. However, in Maryland field tests, none of these materials has proven beneficial toward increasing nitrogen uptake and improving corn grain yields, as shown in Table 2.

Numerous field test results failed to demonstrate any advantages or disadvantages of using these materials with UAN. Recommendation of these materials for extending nitrogen availability in the soil under no-tillage conditions cannot be justified at this time. This is not to discount any of their nutrient or other value.

III. Phosphorus Management

Phosphorus and Its Efficient Use

Research shows that if not managed properly, phosphorus can be fixed in the soil and become

unavailable to plants. Regardless of the crop, phosphorus efficiency can be notably improved by following these guidelines:

- Maintain soil pH at the recommended level, usually between 6.0 and 7.0 on mineral soils.
- Band phosphorus fertilizers to minimize soil contact rather than broadcasting and incorporating thoroughly with the soil.
- Use granulated rather than pulverized phosphorus fertilizers.
- Broadcast, surface-applied phosphorus is much more efficiently utilized under no-tillage conditions than broadcast- incorporated phosphorus under conventional tillage conditions.

With the exception of adjusting soil pH to the recommended level, the success of the previous three factors depends upon reducing direct contact between phosphorus and the soil. By reducing the degree of direct soil and phosphorus contact, chemical phosphorus fixation can also be reduced.

No-Till and Phosphorus Efficiency

Tests done at the Poplar Hill Research Farm show that 40 pounds per acre of phosphate (P2 O5) on no-till corn is often equivalent to 80 to 120 pounds of phosphate per acre on conventional tillage corn. Apparently, soil fixation of phosphorus fertilizer is not as severe under no-till as under conventional tillage conditions. Some probable reasons for improved phosphorus efficiency by no-tillage are: 1) there is a physical separation between the phosphorus fertilizer and mineral soil particles caused by the development of an organic layer on the soil surface, and 2) with phosphorus concentrated near the soil surface with no-till, there is less soil involved for potential fixation.

On the basis of this research, the University of Maryland has significantly reduced its soil-test based phosphorus recommendations for no-till corn, in some cases, to as little as 25 percent of the phosphorus that would have been recommended for conventional tillage corn. Economically, this can save the producer as much as $18 to $20 per acre in reduced costs for phosphorus fertilizers.

To gain the most efficient response from nitrogen and phosphorus fertilizers under no-tillage conditions, consider the following simple steps:

- Soil-test on a regular basis, preferably annually, and always test at the same time of year. For fields that are already in no-till, take the soil sample from the 0- to 2-inch soil layer.
- Do not apply the major portion of your nitrogen fertilizer in a tank mix broadcast application with your herbicides. The proper application time for the herbicides is not always the best time to apply nitrogen most efficiently.
- If surface-applied, sidedress the bulk of the recommended nitrogen after the corn has been planted, preferably 3 to 4 weeks after planting, for maximum efficiency. This is true for most soil types.
- If injecting, the timing of application is not as critical as for surface applications. On well drained soils of medium texture, applications near planting time are just as satisfactory as delayed applications. However, to minimize nitrogen losses, it is best to apply nitrogen as closely as possible to the time of plant need, particularly on sandier soils where leaching could be a problem.
- No benefits have been obtained from the use of nitrogen stabilizers when combined with 30 percent UAN solution.
- Phosphorus efficiency can be maximized: by maintaining soil pH at the recommended level; by banding in the row, using granulated rather than pulverized fertilizers, and; by surface broadcasting, in the case of no-tillage.

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Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, University of Maryland, College Park, and local governments, Thomas A. Fretz, Director of Maryland Cooperative Extension, University of Maryland.

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