Soil Management and Fertility for No-Till Production

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No-till production of corn, soybeans, and grain sorghum has increased rapidly during the past 15 years. With development of no-till small grain drills in recent years, a large increase of no-till small grain production is expected. No-till seeding of forages is also expanding.

Recent shifts in tillage management have created concern among producers about the influence these management systems will have on soil productivity and the need for different fertilizer management practices. During the rapid expansion of no tillage in the early 1970's, research data was not available to provide direction for no-till soil management practices. Because of the lack of data, information obtained from researchers as well as progressive farmers received much attention from the farm press without much concern about its adaptability. Farmers in the south were wondering why publicized results from farther north were different from what they were being told, and northern farmers were wondering why no-till practices often performed differently for them as compared to results publicized from the south.

By the late 1970's sufficient information from long-term no-till studies in the Southeast was available to show the effect of long-term no-till production on soil characteristics. It became apparent from this information that the effect of no-till on some soil characteristics was great enough to merit consideration in developing no-till production systems.

EFFECT OF NO TILL ON SOIL PROPERTIES

Moisture Content,

As expected, a mulch reduces evaporation of soil moisture. Studies have shown that evaporation losses from no tillage was much less than that from conventional tillage, particularly in the interval from planting until the crop canopy completely shades the soil surface. Additionally, the mulch increases water infiltration, particularly on sloping surfaces. The net result is about 15 to 258 more available soil moisture during the growing season with no tillage than conventional tillage.

Soil Temperature

The mulch in no-tillage systems acts as an insulation barrier between the soil surface and the atmosphere. As a result, changes in soil temperature are considerably slower with no tillage than conventional tillage. This means cooler soil temperatures in the spring and summer and warmer soil temperatures in late fall with resultant less temperature fluctuation under no tillage. While cooler soil temperatures can be beneficial in mid summer by slowing plant metabolism, they can sometimes cause delays in spring planting. This delay can be greater on soils which have fragipans, hardpans or other barriers that restrict internal drainage and create waterlogged soils. Although the optimum corn planting date is mid-May in Kentucky, research (Herbek et al., 1984) has shown that no-till corn planted on a Zanesville soil (fragipan at about 24-inches) in early June will yield as well as conventionally planted corn in mid-May.

The key point is that no tillage results in cooler soils in the spring than conventional tillage, and while this is no particular problem for normal planting on well-drained soil, planting on water-logged soils should be delayed until they drain and warm in the seeding zone. An area not yet adequately described is the effect that warmer soil in late fall will have no-tilled small grain. Some research is currently underway in Kentucky on this topic.

Redistribution of Organic Matter and Immobile Nutrients

Plants act as a pump in the soil relative to removing minerals and accumulating them in their tops and roots. With conventional tillage, plant residues from the previous crop are mixed to varying degrees with the surface soil to plow depth. As a result, organic matter and minerals are mixed back into the plow layer. In contrast, there is no mixing of crop residues back into the soil with continuous no tillage. All residues from previous crops accumulate at the soil surface, and results in development of a surface mulch layer made up of partially decomposed plant residues. Decomposition of this thin surface layer of organic material produces acids and greatly increases acidity in the top 1 to 2 inches of underlying soil. With conventional tillage, this highly acidic layer would never accumulate at the surface because the source of the acidity (plant residues) would be diluted greatly when plowed and disked into the soil. The same is true for minerals contained in the plant residues. Those which react strongly with soil move very little and accumulate in the surface 1-2 inches in no-tillage systems. Initially, there was some concern that the surface accumulation of nutrients, especially P, would not be available for plant uptake. Research conducted in Kentucky, Georgia, and Virginia has shown, however, that the surface accumulation of nutrients would not result in an insufficient nutrient supply even if fertility levels below the surface 1 to 2 inches were low.

Greater Microbial Activity

As expected, accumulation of organic residues at the soil surface results in greater microbial activity in no-tilled than conventionally tilled soils. Greater numbers of both aerobic and anerobic bacteria have been measured under no-till as compared to conventional till. Even though large numbers of aerobes are present, the relatively large presence of anerobes, together with a higher soil moisture content under no tillage, results in no-tilled soils having a greater potential for loss of plant available nutrients by denitrification and immobilization than conventionally tilled soils.

Residual Soil Nitrogen

Although no tillage can result in greater leaching on well-drained soils and greater denitrification on poorly drained soils, recently published research has shown that the residual soil N content is higher with no tillage. While studies to-date have not indicated the extent to which this buildup of residual soil nitrogen contributes to plant-available nitrogen, they have shown that it is in the organic form, and that nitrogen fertilizer used in crop production results in a greater buildup of residual soil nitrogen. Although much of this increased nitrogen content is not readily available to crops, it does not mean N is lost from the no-till system. Low availability of this labile organic pool of soil N assumedly represents only a diminished nitrification of organic nitrogen reserves due to the soil not being aerated as the case in preparation of a conventional seedbed.

Bulk Density

The no-till practice in itself does not cause soil compaction. Similar machinery traffic is used on conventionally prepared seedbeds even more intensively with on no till. Reported low yields from no-tilled soils as compared to conventionally planted crops appear to result from no-tilling into soils which were already too compact for good root permeability through the soil or soils which already contained traffic pans resulting from moldboard plowing or disking in previous conventional-tillage practices. Reports are quite clear that if compaction problems already exist, no-till planting into such conditions is not likely to produce as well as conventional planting. However, if such conditions are known, no-till planting can be successful if "in-row" subsoilers are used. Touchton and Johnson (1982) reported that no-till soybean yields on Appling and Cedarbluff soils in Georgia were equivalent to yields from moldboard plowed or chisel plowed seedbeds when an "in-row" subsoiler was used with the no-till planter. Subsequent wheat yields drilled into disked soybean residues were better following soybeans planted into moldboard plowed, chisel plowed, or no-till with "in-row" subsoiled than from no-till without "in-row" subsoiling. Touchton (1984) has also reported results showing that "in-row" subsoiling was not likely to be as beneficial on Decatur and Hartsells soils of north Alabama as on the more sandy textured Coastal Plains soils of south Alabama. These studies also showed that use of a starter fertilizer placed into the "in-row" subsoil slit significantly improved yields on these soils with traffic pans as compared to "in-row" subsoiling without use of a starter fertilizer.

OTHER AGRONOMIC CHARACTERISTICS OF NO-TILL

Rooting Habit

There is much greater root activity in the surface 3 inches from no-tilled crops as compared to crops planted in a conventional seedbed. Assumedly, this results from the greater soil moisture content associated with no-tillage.

Effect of Topdressing All Lime and Fertilizer on Crop Yields

Since there is no practical way to incorporate lime or fertilizer into the soil in continuous no-tilled fields, it must be surface applied. Although there has been much concern about the effectiveness of such applications, particularly on acid soils with low residual fertility, several basic studies have been conducted showing them to be effective (Belcher and Ragland, 1972; Singh et al., 1966; Hargrove et al., 1982). This probably results from the greater surface rooting activity of no-tilled crops, making the surface applied lime and fertilizer (and the residual fertility which accumulates at the surface under no-till) more utilizable by the crop. So long as there is rooting activity at or near the surface, topdressed application of relatively immobile nutrients might be viewed simply as a horizontal band, with attendant band efficiency resulting from its use.

Nitrogen Fertilizer Efficiency

There is concern about N efficiency with no-till systems, just as with conventional-tillage systems. The likely routes of inefficiency are the same...leaching, volatilization, denitrification, and immobilization. Soil and climatic characteristics will often be the determining factors as to which route or routes of N inefficiency will be most likely. Such practices as incorporation, split applications, surface broadcasting, band application, use of winter legume cover crops, or use of nitrification inhibitors should be used in terms of the relative merits which have been tested and demonstrated under the various soil and climatic situations found throughout the south.

Since fertilizer N is usually surface applied for no-till, there is a greater potential risk for leaching, volatilization, denitrification, and immobilization. Of the commonly used N sources, the potential risk of surface losses from surface application of urea to no-till corn is greater than from ammonium nitrate or urea-ammonium nitrate solutions (Bandel et al., 1980; Touchton and Hargrove, 1982; McKibben, 1975). In a Kentucky report by Wells et al. (1976) it was indicated that although urea has a greater potential for surface losses, variability of results due to unpredictable rainfall make it difficult to discriminate among these sources for no-till corn.

Subsurface application of N has been shown to improve the efficiency for use by no-till Corn. Assumedly, this practice would lower the risk for volatilization and immobilization. Delayed applications of N give similar increased efficiency (Smith et al., 1984). Touchton et al., (1982) reported success in using crimson clover as a winter cover crop on a Cecil sandy loam soil in Georgia for no-tilling grain sorghum. They showed that if the grain sorghum was not planted until after the crimson clover set seed, the crimson clover would successfully reseed itself, eliminating the need for purchasing cover crop seed in the fall. Additionally, they found that nitrogen fixed by and released from the crimson clover was sufficient to get maximum grain sorghum yields without application of fertilizer N.

Wells (1984) has summarized nitrogen fertilizer management for no-till corn as follows:

> "Study of no-till corn experiments reported to the current time indicates that more efficient use of fertilizer N results from no-till corn than from conventionally grown corn. It should be noted that most data published to date come from the upper south and eastern seaboard areas. This better efficiency is assumedly the result of less moisture stress in no-till corn, which provides the potential for higher yields from dry land corn production at higher levels of fertilizer N use than is generally possible with conventional tillage. Even though use of no-till production techniques increases risks for immobilization, denitrification, and leaching of fertilizer N, results have generally shown that corn yields are equivalent to and often better for no-till than conventional tillage at rates of fertilizer N usage likely to be recommended for commercial production. Although such risks are great on soils likely to be near moisture saturation during the early growing season, delayed or split applications of fertilizer N, or use of the nitrification inhibitor, nitrapyrin, have been shown to be effective in overcoming them for surface N application on such soils. There is some indication that such risks can also be lowered by subsurface application of fertilizer N.
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> "Studies directed at increasing residual soil N content as a means of compensating for the lower mineralization of soil organic N inherent with no-till, have shown good results. This has involved use of winter annual legumes as cover crops and planting no-till corn into killed legume sods."

Phosphate and Potash Management for No-till

Although there is often much concern over surface application of P and K to no-till crops, particularly on low testing soils studies as previously cited (Singh et al,, 1966; Belcher and Ragland et al., 1982) have shown it to be as effective as incorporation. However, it has been shown that a row application of P and K on soils which were compacted improved yields of corn grain sorghum, and cotton (Touchton, 1984). Sharpe et al., (1984) reported on a study conducted on a Cecil sandy loam soil in Georgia to determine whether. it was necessary to raise a low P testing soil to high before no-tilling. They compared rates of P initially worked into the soil before no-tilling against annual or biannual broadcast application of P for double cropped soybeans and wheat over a 4 year period. They found that an initial application of 114 lbs P/A (260 lbs P_2O_5) was sufficient to maintain maximum wheat and soybean yields for at least 3 years on this low P soil. Annual broadcast application of 57 lbs P/A (130 lbs P_2O_5) either all in the fall before seeding wheat or half in the fall and half before seeding soybeans also maintained maximum yields.

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