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FERTILIZING AND LIMING CONSERVATION TILLAGE COTTON IN GEORGIA

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Abstract

Fertilizing and liming practices for conservation tillage systems need to be adjusted compared to conventional tillage systems. Four "different" practices for conservation tillage and the reasons for the differences are discussed. These include 1) getting off to a good start since there is no opportunity for incorporating lime and fertilizer with tillage, 2) soil sampling by depth and row pattern since there can be stratification and in-row differences of pH and nutrients, 3) using starter fertilizers since there is a better chance of response and 4) adjusting nitrogen management since cover crops can tie up or provide N.

Introduction

Conservation tillage of row crops continues to gain in popularity in South Georgia and throughout the Southeast. Along with the increase in "strip-till" cotton and peanut acres come a number of new questions by growers. How can lime and fertilizer work if I don't work them in? Should I soil sample differently? Should I use a starter fertilizer? Will it pay to fertilize a small grain cover crop?

Some say that conservation tillage systems should be limed and fertilized in the same manner as conventional tillage systems. While it is true that basic soil fertility requirements are the same for both systems (for example, you still need to maintain proper soil pH and supply essential plant nutrients), it is also believed that there are a number of liming and fertilization practices that should be done differently in conservation tillage systems to assure their success. These "different" practices are not necessarily new, just variations of practices that have been done in conventional tillage systems for years. Like many other aspect of the conservation-tillage system (for example, weed control) fertilization and liming practices simply need to be approached differently and adjusted accordingly.

The four "different" liming and fertilization practices in conservation tillage that will be discussed in this paper are 1) the need for a good start, 2) soil sampling, 3) use of starter fertilizers and 4) nitrogen management.

The Need for a Good Start

Before converting a given field from conventional to conservation tillage, proper soil pH and nutrient levels (especially P and K) should be established throughout the plow layer. This involves taking a soil sample to plow depth (usually 8 to 10 inches) and incorporating any lime and fertilizer that is recommended. Basically, this may be the "last chance" to incorporate any lime or fertilizer and correct deficiencies deep in the soil profile.

Why is this important? Because lime and some fertilizer nutrients (such as phosphorous) move very slowly into the soil profile. Therefore, if you start with good levels throughout the profile, these levels can be maintained with surface applications of lime and fertilizer. This is the answer to the farmer's question "how can lime and fertilizer work if I don't work it in?" On the otherhand, the consequences of not "starting right" can be quite drastic. For example, if a pH or nutrient problem deep in the soil profile is not corrected before starting conservation tillage, it can not be fixed quickly with surface applications of lime or fertilizer. If this type of problem is discovered after conservation tillage is started, there may not be any other solution than to incorporate the lime or fertilizer with deep tillage and basically start over.

A related situation is one where a grower may have started with good levels of pH and nutrients throughout the plow layer, but after several years of conservation tillage, problems develop that are deep enough in the profile and severe enough that, again, it might require deep incorporation and basically starting over to correct them.

The best way to avoid both of the unwanted situations described above is to soil sample conservation tillage systems differently than conventional tillage systems. This will be discussed in the following section.

Soil Sampling

Three ways that conservation tillage systems should be soil sampled differently compared to conventional tillage systems are 1) soil sample different depths, 2) soil sample by old row patterns, and 3) soil sample more frequently. Of these three, soil sampling by depth is by far the most important.

In conventional tilled systems the recommendation is to soil sample to plow depth. In conservation tillage systems the recommendation is to take shallow and deep soil samples separately. This system, developed by growers, involves taking a shallow soil sample (2 to 3 inches deep) and then a deep sample(down to 6 or 8 inches) -- from the same hole ! Samples from different depths are kept separate and analyzed separately.

The main reason for sampling as described above is to detect a drop in pH in the shallow sample so it can be corrected with surface applications of lime before it extends too deep into the profile.

In conservation tillage systems, acidity will develop at the soil surface first and then work it's way down into the profile. This is largely due to surface applications of nitrogen fertilizers on crops such as cotton and corn. Sometimes, after lime as been surface applied in conservation tillage systems, the pH in the shallow sample will be above the target pH. This is not necessarily a problem, since again, surface applications of nitrogen will usually soon lower the pH in the shallow sample.

So what is the purpose of the deep sample ? The main focus of the deep sample is again pH. If a low level of pH is detected in the deep sample, say a 5.5, it may be severe enough to limit crop growth and need correcting by incorporating lime with tillage. This is the situation you are trying to avoid by taking the shallow sample separately.

Won't a regular plow depth sample detect this type of pH problem ? Not necessarily. What can happen is that you may have a pH drop (say to 5.5) in the top two inches but soil from the deep sample underneath may have a pH of 6.2. A regular plow depth sample would integrate both pHs and may indicate you have a pH of 6.0. Where in reality you have a pH drop in the soil surface that needs correcting.

This difference in pH between the shallow and deep soil samples is called stratification. Stratification can also occur with fertilizer nutrients. Since it is relatively immobile (like lime), phosphorous usually stratifies in conservation tillage systems. It is common to see a buildup in soil test levels of P in shallow samples compared to deep samples in conservation tillage. This should not be an agronomic problem, i.e. lead to problems with crop production. Phosphorous does not usually "out compete" other essential plant nutrients (except maybe zinc) when soil test levels are elevated. High soil test may, however, contribute to dissolved P in water that runs off into surface waters where it can lead to eutrophication, a water quality concern. On the otherhand, conservation tillage usually dramatically reduces the amount of soil erosion and thus the amount of P that reaches surface water associated with eroded soil.

After taking shallow and deep soil samples as described above, a conservation tillage grower usually gets his results back and says "What do I do now? Which sample do I lime by? Which do I fertilize by?" There is no doubt that the grower should use the shallow sample to guide his liming program. Which sample should be use for fertilizing is a more difficult question. For agronomic (crop production) purposes, and to be conservative, you would fertilize by the deep sample since it will likely be lower in nutrients, especially P. However, as mentioned earlier, as P builds up in the soil it may become an environmental issue. What is needed is good research data that addresses this issue of P stratification and fertilizing with both agronomic and environmental considerations in mind. A common situation in the future may be where you have medium levels in the deep sample that would call for some P fertilizer. The shallow sample on the other hand will be high in soil test P and not call for any fertilizer. Ultimately the question comes down to "will the high soil test P in the shallow sample provide the crop with enough P ? Until this question is answered, I would recommend that a farmer "lime by the top sample and fertilize by the bottom".

Another question concerning soil sampling conservation tillage systems is "should I take all of my samples in the old "drill" (i.e. where the row was planted) or in the middles (between the planted rows)?" The current recommendation is to take more samples in the middles than in the drill. A rule of thumb is for every sample taken in the drill, take approximately 10 in the middles. The reasons for this are that 1) if starter fertilizers are used, samples taken from the drill may hit an old starter band and be concentrated in elements such as P (since 10-34-0 is a common starter fertilizer used on conservation tillage cotton) and 2) if the same row pattern is maintained in conservation tillage, roots from the crop can actually concentrate or "draw" elements such as P and K from the middles and into the drill area. In a worst case scenario, all the samples are taken from the drill and the results indicate you have adequate levels of nutrients (especially P and K). Where in reality you hit an old starter band or where nutrient levels where higher. In this case you have a "false high" or in other words you are not in as good as shape fertility-wise as the sample indicates. Another factor involved is that proportionally, there is a greater volume of soil in the row middles than under the narrow band around the drill. This is another reason to take more samples out of the middles. What if I alternate my row pattern in strip-till, i.e. I plant the new row (drill) into the old row middle? The chance of accumulating a "false high" due to crop roots drawing nutrients to the drill is less in this situation but you could still hit a starter fertilizer band. Therefore, the recommendation to take more samples in the old middles still holds.

A final consideration when soil sampling conservation tillage systems is frequency of taking samples. The current UGA recommendation is for row crop farmers to soil sample every field year. According to recent county agent surveys, most growers are already following this recommendation. Sampling every year should be sufficient for conservation tillage just as in con-

ventional tillage. However, if a grower samples less frequently than this in conventional tillage (say every other year) and switches to conservation tillage, then the frequency should be increased to every year as recommended. The biggest reason for this is again to catch the drop in pH in the shallow soil sample before the problem gets too deep. Coastal Plain soils are poorly buffered (sandy, low CEC, low organic matter) and therefore pH can drop fairly rapidly even in conventional tillage systems, let alone conservation tillage systems where nitrogen is surface applied.

Starter Fertilizers

There is no official UGA recommendation to use starter fertilizers in conservation tillage systems. This is because there is no research data base that indicates a consistent yield response. However, growers are encouraged to consider starters, especially for conservation tillage corn and early-planted (April) cotton. Soil temperatures are usually low enough at these planting times to cause an increase chance of getting a response to starter fertilizers, especially ones containing phosphorous. It is well documented that soil P mineralization and availability is limited when soil temperatures are low. Therefore, starter fertilizers such as ammonium polyphosphate (10-34-0) that contain P are often used.

A recent study in Georgia comparing different starter fertilizer materials for cotton production indicated that both soil type and weather conditions at planting should be considered when choosing a starter fertilizer (Bednarz et al, 2000). Although this study was conducted with conventional tillage, it is interesting to note that the only statistically significant cotton yield responses were measured when the crop was exposed to cool weather for an extended period of time immediately following planting. Also, the best starter fertilizer material contained P on a site that is known to fix soil P and contained N + S on a site that was much sandier and is known to have challenges with sulfur deficiency. Growers planting conservation tillage corm or cotton are encouraged to use a starter fertilizer containing P if soil test levels are medium or low. If soil test levels of P are high, then a N only or N+S starter material may be the best choice.

Another question concerning starter fertilizers on cotton and corn involves the use of poultry litter. If poultry litter is used when strip-tilling these crops, should a starter fertilizer still be used? This is a good question, especially since poultry litter contains significant amounts of N, P and S. Since the litter may be spread one to two months in advance of planting, and soil temperatures during corn planting and early planted cotton should still be low, there still may be a need for starter fertilizer in these situations. Current research needs to be conducted to confirm this theory.

Another area where current research data is lacking is the evaluation of different placements and rates of starter fertilizer in conservation tillage. The current UGA recommendations for cotton is to use a “2 by 2" (2 inches to the side and 2 inches below the seed) placement and not to exceed 15 lb N/a. However, there is a lot of interest in spraying starter fertilizer in a band behind the planter press wheels or approximately 10 inches deep under the seed in the subsoil shank. Growers believe they can put out more N and P with these placements. However, since the fertilizer is not concentrated near the seed in either of these placements, the “starter effect” may be lost. Some cotton growers have also tried to increase the rate of N in the starter in a 2 x 2 placement. A common starter treatment use to be 10 gallon per acre of 10-34-0. However, since this only gives 10 lb N/a and current recommendations for cotton usually call for 20 to 30 lb N/a preplant, many growers have tried “spiking” 10-34-0 with liquid N (UAN) or UAN+S combinations. Unfortunately, this can cause severe burn and under certain conditions, i.e. hot, dry and sandy soil) can result in the need for replanting. A better way to supply the recommended rate of preplant N on cotton in conservation tillage would be to include some N in preplant K applications to supplement what is contained in the starter. This broadcast N can also help to nullify tie up by soil N by small grain cover crop residue which will be covered in the next section of this paper.

As far as the economics of using starter fertilizers in conservation tillage, in the same study mentioned above by Bednarz et al, 23 out of 30 individual comparisons (treatments by locations by years) gave higher net returns compared to an untreated check. Again, this study was conducted using conventional tillage so it assumed that the chance of yield response and economical returns would be even greater in conservation tillage where the soil would be even cooler. Also, if you factor the nutrient input (N, P and/or S) into your total fertility program, any additional cost is largely due to application costs.

Nitrogen Management

When using a winter cover crop for conservation tillage cotton, which most growers do, nitrogen needs to be managed differently compared to conventional tillage systems. The majority of strip-till cotton growers in South Georgia use a small grain cover crop such as rye, wheat or oats. For cotton following a small grain cover crop, the total nitrogen rate needs to be increased by 25 %. This is due to immobilization or “tie up” of soil N by the decomposing small grain residue. Nitrogen deficiency on young cotton (soon after emergence) has been observed when this additional N is not applied. Therefore, the best way to apply this additional N is by broadcasting either preplant, at planting or soon after planting. Broadcast is preferred over banding in order to help alleviate the immobilization across the entire rooting zone. Since it is recommended to apply all recommended potash at planting, this extra N can easily be applied with the potash or with an N-P-K complete or “base” fer-

tilizer. Trying to supply this additional N by increasing the N rate in starter fertilizer can lead to burn and stand loss. Again, no more than 15 lb N/a should be applied in a starter fertilizer applications, even in a “2 by 2" placement.

A number of strip-till cotton growers, especially ones that have been practicing conservation tillage a number of years and have learned how to plant into heavy residue, consider applying some additional nitrogen to the small grain winter cover crop in early spring (February). The question then arises, can this additional nitrogen be counted toward my total N rate for cotton which will follow? Preliminary research results in both Georgia and Alabama indicate that no, this N will not be available for the subsequent cotton crop. Does that mean it was wasted? Not necessarily. The additional N on the small grain likely generates more residue which in turn can increase soil organic matter and all the benefits that come with it. These benefits however, are harder to put a direct dollar value on and are not immediately collected. Therefore, when someone asks “Does it pay to fertilize my cover crop? or Will I get my money back?” the answer should be not in the short term but probably in the long term.

Rye is the most popular winter cover crop in South Georgia. One reason for this is that growers have the option to utilize the cover for winter grazing of cattle. In this case the cover crop is also usually fertilized with N during the winter and early spring. Should a grower in this situation still increase his N rate on a cotton crop that follows ? Yes, because 1) the nitrogen gets tied up in the rye, cattle, manure cycle and is not evenly distributed across the field, and 2) even though the cows will remove most of the above ground residue or “biomass”, there is still a significant amount of residue left behind in the roots and crowns of the cover crop that can immobilize soil N.

Since Georgia is the number one poultry producing state in the U.S., using poultry litter (manure) as a fertilizer for crops is very common. For row crops in South Georgia, poultry litter is best used like a complete fertilizer and is commonly applied at a 2 ton/a rate just prior to planting. For strip-till cotton growers using small grain cover crops, it is important to apply the litter just prior to, or after, the cover crop is terminated (usually 30 days in advance of planting with a burndown herbicide). If poultry litter is applied to the small grain cover crop earlier, such as in mid-February, the small grain cover crop may “tie-up” most of the nitrogen just as if commercial inorganic fertilizer N was used. Again, if the goal is to grow more residue, then fertilizing the cover crop with poultry litter in February is a good idea. Again though, don’t expect the N applied in February to be available to the subsequent cotton crop.

Will poultry litter work in a conservation tillage system? Most growers doubt that it will and question this practice just like they question surface applying lime and fertilizer. The main concern is that they will lose all the N in poultry litter up into the air by volatilization. Actually, it is estimated that only 10 % more of the N in litter will be lost to volatilization compared to if it was incorporated. This value should even be less if the poultry litter is applied before the strip till operation and/or if a rain is received soon after applying the litter. Therefore, poultry litter should work fine for strip till corn and cotton. Peanuts and soybeans are not a good choice of crops to receive poultry litter applications since they are both legumes and fix their own nitrogen.

A small number of growers in South Georgia are experimenting with using legume winter cover crops to provide nitrogen to a subsequent strip-till cotton crop. Crimson clover, hairy vetch and lupine are some of the legume cover crops being looked at. In an on-farm study in Cook, County GA, a crimson clover cover crop provided all but 30 lb N/a for a subsequent cotton crop. Since an early maturing clover variety was used it reseeded. After three years of reseeding the study was repeated and the result was that the clover provided all the N needed by the cotton. Two concerns for this system are the potential for building nematode populations or having early spring insect infestations, especially cutworms. Although more research is needed to address these issues, this system looks promising.