Making "Different" Liming and Fertilization Practices on Conservation Tillage "Conventional"

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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 either tie up or provide N.

KEYWORDS

Soil sampling, nutrient management, liming, starter fertilizer

INTRODUCTION

Conservation tillage of row crops continues to gain 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 from growers, about how surface applications of lime and fertilizer can be effective, accurate soil sampling strategies, use of starter fertilizers, and the application of fertilizers to small grain cover crops.

Some say that conservation tillage systems should be limed and fertilized in the same manner as conventional tillage systems. While I agree 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), I also firmly believe 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, but merely variations of practices that have been done in conventional tillage systems for years. Like many other aspects 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. All four of these practices apply to cotton, whereas only the first two apply to peanuts.

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.

This is important because lime and some fertilizer nutrients (such as phosphorous) move very slowly into the soil profile. Therefore, if proper levels of lime and fertilizer are present throughout the profile at the start, these levels can be maintained with surface applications of lime and fertilizer. In this way, lime and fertilizers can work to maintain soil nutrients, even though they are not "worked in." The consequences of not starting the process properly 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 cannot 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, in essence, start over completely.

In a related situation, 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 and severe enough that, again, it might require deep incorporation and basically starting over to correct them. The best way to avoid both

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situations described above is to sample soils in conservation tillage systems differently than in conventional tillage systems. This will be discussed in the following section.

SOIL SAMPLING

Soil under conservation tillage should be sampled more frequently and according to old row patterns, but above all, should be sampled at different depths.

In conventionally tilled systems, the recommendation is to sample soils 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 stored 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 its 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.

The main focus of the deep sample is, again, pH. If a low pH is detected in the deep sample (for example, 5.5), it may actually limit crop growth, and require correction by tilled-in lime. This situation may be avoided by taking the shallow sample separately.

A regular plow-depth sample will not necessarily detect this type of pH problem. There may be a pH drop (for example, 5.5) in the top two inches, but soil from the deep sample is well within the normal range (for example, pH 6.2). A regular plow depth sample would integrate both readings and indicate a pH of 6.0, whereas the problem may lie only at the surface, and could be corrected without tillage.

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 (P) usually stratifies in conservation tillage systems. It is common to see a buildup in P levels in shallow samples (as compared to deep samples) in conservation tillage systems. 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 zinc) when P levels are elevated. High P levels may, however, contribute to dissolved P in runoff water, leading to eutrophication of stream, a water quality concern. On the other hand, conservation tillage dramatically reduces the amount of soil erosion and thus the amount of P that reaches surface water associated with eroded soil.

Another advantage of taking shallow soil samples in conservation tillage is that it can be used to help monitor the "pegging zone" for peanut production. Many were concerned about a buildup of potassium (K) in strip-till peanuts when in rotation with strip-till cotton. The fear was that potash surface-applied to cotton would carry over and interfere with calcium in the "pegging zone", the top 2-3 inches of soil where peanuts peg and pods develop. This has not turned out to be a great problem, possibly due to K movement past the pegging zone, especially after the peanuts are dug and the pegging zone is disrupted. Even though a shallow soil sample can help monitor potash in the pegging zone, this sample is usually taken in the fall or early winter. This should not replace taking a true pegging zone soil sample after peanut emergence when needed.

After taking shallow and deep soil samples as described above, a conservation tillage grower usually must determine which sample to lime or fertilize by. There is no doubt that the grower should use the shallow sample to guide any liming program. There is less certainty in determining which sample to use in planning fertilizer applications. For agronomic (crop production) purposes, and to be conservative, one would fertilize by the deep sample, since it will, in all likelihood, be lower in nutrients, especially P. However, as mentioned earlier, as P builds up in the soil it may begin to threaten the environment. What is needed is solid research to address this issue of P stratification and fertilizing, with both agronomic and environmental considerations in mind. In the future, a grower may have medium levels in the deep sample that would call for P fertilizer. The shallow sample, on the other hand, may be high in P and not call for any fertilizer. The question, ultimately, is whether P near the surface will provide the crop with enough P to grow properly. Until this question is answered, the grower is advised to lime by the shallow sample and fertilize by the deep.

There is also some question as to whether most samples should be taken between the planted rows, or in the old "drill" (where the row was planted). The current recommendation is to take more samples between the rows than in the drill. As a rule of thumb, a grower should take 10 samples between the rows for every one taken in the drill. 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) Also, 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 into the drill area. In a worst-case scenario, if all the samples are taken from the drill, the results may indicate adequate levels of nutrients (especially P and K), whereas, in reality, the samples where taken from an old starter band, where nutrient levels are higher. This is a “false high,” where actual nutrient levels are much lower than the samples indicate. Proportionally, there is a greater volume of soil in between the rows than under the narrow band around the drill. This is yet another reason to take more samples in between the rows. If an alternating row pattern in is used in strip-till, the chances of accumulating a “false high” due to crop roots drawing nutrients to the drill are reduced, but a starter fertilizer band could still be encountered. Therefore, the recommendation to take more samples in the old “middles” still holds true.

Finally, the frequency of sampling must be considered. Currently, UGA recommends that row crop farmers sample soil 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 conventional tillage. However, if a grower samples less frequently than this in conventional tillage (for example, every other year) and then switches to conservation tillage, then frequency should be increased to every year, as recommended. This sampling pattern is intended to catch the drop in pH in the shallow soil sample before the problem migrates into the deep soil, requiring tillage. Coastal Plain soils are poorly buffered (sandy, low CEC, low organic matter) and therefore, pH can drop fairly rapidly, even in conventional tillage systems. This condition is even more dangerous in conservation tillage systems, where nitrogen can only be applied to the surface.

STARTER FERTILIZERS

There is no official UGA recommendation on the use of starter fertilizers in conservation tillage systems, because there are no research data that indicate 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 facilitate a response to starter fertilizers, especially those containing phosphorous. It is well documented that soil P mineralization and availability are 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 fertilizers 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 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 frequent sulfur deficiencies. Growers planting conservation tillage corn 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 may be the best choice.

Growers using poultry litter when strip tilling these crops also question the use of starter fertilizer. This question is a valid one, since poultry litter contains significant amounts of N, P and S. 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, so there still may be a need for starter fertilizer in these situations. Current research must be conducted to confirm this theory.

Current research data is also lacking in the evaluation of different placements and rates of starter fertilizer in conservation tillage. UGA recommends that cotton growers use a “2 by 2” (2 inches to the side and 2 inches below the seed) placement and not exceed 15 lbs N acre^{-1}. There is significant interest in spraying starter fertilizer in a band behind the planter press wheels, or approximately 10 inches under the seed, in the subsoil shank. Growers believe they can put out more N and P with these placements. However, the fertilizer is not concentrated near the seed in either of these placements, and 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. In the past, 10 gallons acre^{-1} of 10-34-0 was commonly used as a starter treatment. However, this only gives 10 lbs N acre^{-1}, and current recommendations for cotton call for 20 to 30 lbs N acre^{-1} in the pre-planting period. Many growers have tried to “spike” 10-34-0 with liquid N (UAN) or UAN+S combinations. Unfortunately, this can cause severe burn and under certain conditions, (hot, dry, and sandy soil) can result in the need for replanting. A better way to supply the recommended amount of pre-plant N to cotton under conservation tillage would be to include some N in pre-plant K applications to supplement that contained in the starter. This broadcast N can also help to nullify tie-up of soil N by small grain cover crop residue.

The economics of using starter fertilizers in have only been studied under conventional tillage. In the study mentioned above (Bednarz *et al*), 23 out of 30 individual comparisons (treatments by locations by years) gave higher net returns, as compared to an untreated check. Again, this study was conducted using conventional tillage so, it is assumed that greater yield response and economic returns would result from conservation tillage, where the soil would be even cooler. When nutrient input (N, P and/or S) is factored into the complete 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 must be managed differently than in 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. When cotton follows a small grain cover crop, the total nitrogen rate must be increased by 25 %, to compensate for N tie-up by decomposing small grain residue. When this additional N is not applied, N deficiency on young cotton (soon after emergence) has been observed. The best time to apply this additional N is by broadcasting before planting, at planting, or soon after planting. Broadcast is preferred over banding in order to replenish N across the entire rooting zone. Since all recommended potash is applied at planting, this extra N can easily be applied with the potash or with an N-P-K complete, or "base" fertilizer. 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 lbs N acre^{-1} should be used in starter fertilizer applications, even in a "2 by 2" placement.

A number of strip-till cotton growers, especially those who have been practicing conservation tillage a number of years, and have learned how to plant into heavy residue, apply some additional nitrogen to the small grain winter cover crop in early spring (February). The question then arises as to whether this additional application can be included in the total N budget for the cotton that will follow. Preliminary research in both Georgia and Alabama indicate that this N will not be available for the subsequent cotton crop. This does not necessarily mean that the early spring application was wasted. The additional N on the small grain will generate more residue, which in turn can increase soil organic matter and all the benefits that come with it. These benefits, however, are harder to assign an exact dollar value, and are not collected immediately. Therefore, fertilizing a cover crop will not pay off immediately, but will be beneficial in the long run.

Rye is the most popular winter cover crop in South Georgia. Growers have often taken advantage of 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. A grower who grazes cattle on winter rye should still increase N application for cotton, because N becomes tied up in the rye, cattle, and the manure cycle, and will not be evenly distributed across the field. Even though cattle will remove most of the visible biomass, there will still be significant amounts of residue (roots and crowns) to tie up soil N.

Since Georgia is the number one poultry producer in the USA, poultry litter (manure) is commonly used as a fertilizer for crops. For row crops in South Georgia, poultry litter is best used as a complete fertilizer, and is commonly applied at 2 ton acre^{-1} 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. However, the N applied in February will not be available to the subsequent cotton crop.

Most growers doubt that poultry litter will work in a conservation tillage system and question this practice just as they question surface application of lime and fertilizer. They are concerned that all N in poultry litter will be lost to the air by volatilization. It is estimated that only 10 % more N is lost from surface litter than that which is incorporated. This value should even be lower if the poultry litter is applied before the strip till operation or if it rains soon after applying the litter. Therefore, poultry litter should work well with strip till corn and cotton. Peanuts and soybeans should not 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 legume winter cover crops, such as crimson clover, hairy vetch, and lupin, to provide nitrogen to a subsequent strip-till cotton crop. In an on-farm study in Cook County, GA, a crimson clover cover crop provided all but 30 lbs N acre^{-1} 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 it was found that the clover provided all the N needed by the cotton. However, the potential for building nematode populations or having early spring insect infestations (especially cutworms) are a cause for concern. Although more research is needed to address these issues, this system looks promising.

LITERATURE CITED

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