AN ECONOMIC ANALYSIS OF NITROGEN LEVELS AND ROTATION SYSTEMS IN COTTON

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Abstract

Tillage system, cover crop, and nitrogen fertilization levels were the variables controlled in an experiment designed to measure the effects of those variables on cotton lint production and leaching of nitrate. The experiment was conducted during three growing seasons, 1996 - 1998. The tillage systems utilized were conventional and strip till. The cover crops were fallow, crimson clover, and wheat. Four levels of nitrogen fertilization were used – 0, 60, 120, and 180 pounds N per acre. Cotton lint yield was not affected by tillage system or cover crop. Cover crop did affect nitrate leaching, but tillage system did not. Nitrogen level affected both yield and leaching. Because cotton yield varied with nitrogen levels only, and because production costs for the tillage systems are similar, the economic problem is not significant compared to the sustainability and intergenerational issues that must be addressed.

Introduction

This paper summarizes three years of field experimentation, 1996 - 1998, on tillage systems, rotations and application rates of nitrogen for cotton (Gossypium hirsutum L.) production. Tests included cotton lint yields and nitrogen levels at various levels of the soil profile.[1] Nonpoint source water pollution is an important issue for environmentalists and agricultural producers alike. Nitrogen leaching from agricultural production is one of several related subissues. Cotton, an agronomic crop with relatively great nitrogen needs, has attained significant acreage levels in the Southern Coastal Plains over the past decade. This research was conducted in order to arrive at economically sound best management practices (BMPs) that cause little environmental harm. The experiment was designed to evaluate four levels of nitrogen application used in three crop rotations.

Materials and Methods

The experiments were conducted at the North Florida Research and Education Center, University of Florida, in Quincy, Florida. All experiments were conducted in the same field over the period and the same rotation was maintained in each plot throughout. Initially there were two contiguous fields. In one bermudagrass (Cynodon dactylon L.) had been grown and the other was left fallow following soybean {(Glycine max (L.) Merr.} the previous year. The soil of both fields was sandy loam.

Tillage (Main Plots), Cover Crop (Sub Plots), Nitrogen Rates on Cotton (Sub Sub Plots)

Conventional followed by ripping in row and strip were the two tillage methods. Conventional tillage entailed mowing, disc-harrowing (twice), chisel-plowing (once0, and s-tine harrowing (once). There were two replications each with wheat (Triticum aestivum L.), crimson clover (T. Incarnatum L.), and fallow as fall cover crops. In addition there were four rates of nitrogen applied to cotton, the main crop. The rates were 0, 60, 120, and 180 pounds of nitrogen per acre. Ammonium nitrate was side dressed six weeks after planting to achieve the 60 and 120 pound N rates. To achieve the 180 pound N rate, 120 pounds of N as ammonium nitrate was side dressed after six weeks and then three weeks later an additional 60 pounds of N as ammonium nitrate was applied. No nitrogen was applied to the winter cover crop. To determine residual root zone N levels soil samples to a depth of four feet were taken and analyzed prior to planting cotton each spring (1996 - 1998). The design of the experiment, however, was not completely static. Results in one year influenced design in subsequent years. For example, the original design included soil testing to four foot depths alone. The planned samples were taken in 1996 and 1997, but heavy rains in 1997 moved the nitrates out of the root zone. Thus, in order to evaluate the movement of nitrate leached out of the root zone, soil samples at up to eight foot depths were taken in spring and fall of 1998. Other variables that were measured include plant height, boll weight, and cotton petiole nitrate level.

Economic Analysis

Enterprise production budgets are the basis for the economic analysis. Budgets for the annual crops involved in the experiment (cotton, clover and wheat) were developed based upon the experimental design, input levels and production or yields. The budgets were used to highlight any trade-offs that might exist.

Results

The results of the experiment are divided into two major groups. The first group is that of physical information. It includes the impact of the two tillage methods, rotations, and fertilization levels on nitrate movement and cotton yields. The second group is economic and converts physical results into dollar values. Data concerning the yield of the cover crops were not collected.

Physical Results

In all years nitrogen application rate (Table 1) influenced yields. In the first two years cotton yields were not influenced by tillage system or previous crop. In the third year, however, cotton yield was greatest when cotton followed conventionally tilled wheat. The low yields of the

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third year were caused by weather and by many boll hard locks. The origin of the hard locks is not certain, but may be weather induced. Wheat and clover yields were not recorded. The soil testing that was conducted prior to cotton planting and after its harvest (before clover and wheat planting) imply yields within the normal range for extant conditions.

Other results highlight the environmental importance of crop and fertilizer management. As indicated earlier in this report, there was movement of nitrate through the soil profile. At shallow depths (0 - 3 feet) prior to fertilization in the spring of 1998, nitrate levels were between 4 and 6 ppm for all fertilization levels. At intermediate depths (4 - 7 feet) there nitrate levels were statistically the same for 0, 60 and 120 pounds of N per acre, but nitrates were 50% greater for the 180 pound regime. Fall samples after the 1998 crop showed no differences at in soil nitrates at shallow depths between regimes. There were differences between three and eight feet. Nitrate levels were 67% and 91% greater for the 120 and 180 pound rates, respectively, than when no nitrogen was applied. Cover crop also affected leaching. The shallow and intermediate soil test results indicate that there is more movement of nitrates when clover follows cotton than when there is a fallow crop. Nitrate levels were least when wheat is produced. Timing of fertilization could also affect nitrate leaching. The cotton petiole samples indicate that over 60% of total N utilization by cotton plants occurs between blooming and maturity.

Economic Results

From an economic stand point cotton lint yield was the most important experimental results that were measured. For two of the three years of the experiment yield increased with nitrogen level until 120 pounds N was applied. Yields for 180 pounds N per acre were statistically the same as that of the 120 pound rate in all years, but was greater in two of the three years. The variation of the marginal lint to nitrogen ratio (calculated as the difference in lint yield divided by the additional N applied) in Table 2 is consistent with those yield results. Given the price ratio between cotton lint and N (including application cost) in two of the three years there was no economic advantage to applying 180 pounds as compared to 120 pounds of N. Yield did not vary with cover crop or tillage system. Each tillage system has two aspects or components: investment cost (fixed) and operating cost (variable). Given the consistency of results, the economic questions are more related to cost of tillage system and the related management issue of sustainability. If specialized equipment were to be used for the strip till, fixed costs would increase. The number of times over the field or the amount of time spent going over the field would be reduced, thereby decreasing operating costs. In sum, the issues are not truly economic.

Discussion

The economic issues are overshadowed by the physical results. Type of tillage need not be included in the decision process concerning leaching. The severity or amount of nitrate leaching can be decreased, if not eliminated, through appropriate management. Such management includes cover crop decisions and timing of fertilization.

Other research has shown that approximately 60 pounds of nitrogen are required to produce one (480 pound) bale within the standard yield range (from about 1.0 to about 3.0 bales). The marginal ratios displayed in Table 2 indicate that the most economic rate of application of nitrogen is probably between 120 and 180 pounds per acre in most years. The response factor in the 0 - 60 range is the greatest by far of any of the response factors and thus demonstrates that more nitrogen should be applied. The decline in the ratio indicates that there is decreasing marginal returns. (The 1996 results likely are an anomaly, but more experimentation might be necessary to illuminate the situation.)

Conclusions

Over the short term whether to use strip till or conventional tillage in cotton production is not an economic decision. In that the crop pattern was constant in each plot through the duration of the experiment, and therefore cotton followed and was followed by each cover crop and that yields did not vary with cover crop, in the absence of need for forage the choice of cover crop is not necessarily an economic issue either. Both of these sets of choices, however, have many related management issues. Strip tillage protects soil against erosion and compaction. Crimson clover, however, promotes nitrate leaching, and thus wheat might be preferred when the water table is vulnerable.

Nitrogen applied in excess or at an inappropriate time also promotes leaching. A conscientious soil testing program or regime that promotes proper amount of fertilizer and timing of fertilizer application could improve yields while guarding against leaching.

Endnotes

[1] Other tests were included in the experiment, but these are the ones relevant to this paper.