NITROGEN MANAGEMENT FOR DIFFERENT SOILS AND CROPPING SYSTEMS

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Abstract

The nitrogen rates that produce optimum cotton growth and yield vary widely among soil types and with cropping history. Researchers in Louisiana have for many years conducted nitrogen studies to determine the best nitrogen management practices for specific situations. From these studies optimum rates were identified for Mississippi River alluvial and loess silt loam (60 to 80 lb/a), clay (90 to 120 lb/a), Red River alluvial silt loam (60 to 110 lb/a), and Red River alluvial sandy loam (60 to 80 lb/a). The optimum rates varied within the soil types depending upon cropping history and other factors. In Louisiana splitting the fertilizer nitrogen has not increased yield or fertilizer efficiency. Cropping practices that affect the fertilizer nitrogen requirements of cotton include crop rotation, winter cover crops, irigation and tillage. Cropping practices that do not affect fertilizer nitrogen requirements include row spacing and plant density.

Introduction

Cotton is a crop that usually needs fertilizer nitrogen but the optimum rate is highly variable and dependent on many factors. Soil type is the largest single variable that affects nitrogen availability but field history is also important. Applying the correct rate of fertilizer N for each soil type and cropping situation is important because it determines not only yield but also the types and costs of other crop management inputs. Over fertilization is especially damaging as it results in increased production costs and can reduce harvested yield. Determining the optimum N rate for a particular crop requires the use of information on many factors and from many sources. These include but are not limited to field history, soil type, crop sequence, cover crops, residual N and water management. All of these affect the quantity of plant-available N, which can be substantial (Table 1). To utilize all sources of N efficiently and to avoid N deficiency or excess, monitoring crop N status during the growing season is an essential management practice.

Discussion

Optimal N Rates

Soil type affects plant availability of N and the development and efficiency of root systems, and thus, different soils have different optimum fertilizer N rates (Table 2). The soils that provide the greatest N efficiency are silt loams, although the Red River silt loam soils in central Louisiana require high N rates, possibly related to effects of their high pH. The least efficient soils for N availability are clay soils, which can limit root efficiency, immobilize N in clay lattices and denitrify soil N. On most silt loam soils, cotton yields are optimized with relatively low N rates between 60 and 80 lb/a (Figure 1). Nitrogen rates of 100 lb/a or more that are optimal for clay soils can reduce yields if applied to cotton on silt loam. There is no evidence in Louisiana research that the use of multiple N applications are beneficial to yield.

Cultural Practices

In addition to soil type, many cultural practices affect the optimum rate. The most important of these are the use of crop rotations and growing winter cover crops for erosion protection or green manuring. Cotton following a grass cover crop will usually need higher fertilizer N rates to compensate for the removal of residual soil N by the cover crop that is then sequestered in the crop residue and temporarily immobilized. On the other hand, cotton following a legume winter cover crop will need little or no fertilizer N because N fixation by the legume provides up to 75 lb N/a to the cotton crop. Crop rotation with heavily fertilized crops such as corn may increase the residual N available for a cotton crop. In rotation experiments where this effect has been evaluated, the residual N effect has been larger on the Mississippi River alluvial silt loam than on loess silt loam.

Tillage practice has had little to no effect on the N requirement of cotton, although we have seen slightly improved N efficiency of fertilizer N with no-till treatments compared with surface-till treatments on loess silt loam. The optimum N rate for ultra-narrow-row cotton (10-inch spacing) has proven to be the same as for wide-row cotton (40-inch spacing). Plant density has not affected optimum N rate for cotton within any row spacing or soil type.

Soil Amendments

Beneficial use of wastes as soil amendments will continue to increase as mandated reductions of land filling is enforced. The specific benefits of wastes depends upon its physical characteristics, organic matter content, C:N ratio and its plant nutrient content. Some waste materials contain relatively high amounts of organic N. Applying wastes as soil amendments that have a high N content and narrow C:N ratio can greatly reduce or eliminate the need for fertilizer N. Some waste materials, however contain large amounts of carbon and very little N. Application of these wastes as soil incorporated soil amendments will greatly increase the fertilizer N requirements of cotton because they will act to immobilize soil-and fertilizer-N.

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Excess N Fertility

Using the optimum N rate for cotton creates a balance between plant growth and fruit set, which contributes to:

- earlier boll set
- minimal loss from boll rot
- minimal number of insecticide applications
- minimal need for growth regulators
- decreased defoliation cost
- earlier maturity and harvest
- optimum yield production

The use of optimum N rates for cotton results in the lowest possible production costs for all seasonal inputs following planting.

Excess N fertility, on the other hand, causes excess vegetative plant growth, which contributes to:

- delayed boll set
- increased boll rot
- increased number of insecticide applications
- reduced insecticide application efficacy
- increased defoliation cost
- increased use of growth regulators
- delayed maturity land harvest
- reduced yield
- decreased micronaire
- increased immature fiber content

The cost of excess N fertility can clearly be quite high as a result of the increase in inputs required to manage over-fertilized cotton as well as the potential for yield loss due to insect damage, delayed maturity and boll rot. As shown in Table 3, these costs can exceed $72.00 per acre.

Monitoring Crop N Status

There are several methods or procedures to determine whether a cotton crop is N sufficient or N deficient. In the mid-South, the most widely used is petiole nitrate-N monitoring. This requires sampling the petioles from the uppper-most fully expanded leaf and sending the plant tissue to a laboratory for determination of nitrate-N concentration, a process that takes 5 to 10 days. The leaf blade can also be used for determination of N sufficiency, but this requires a more extensive laboratory procedures for analysis of the total N concentration. The leaf blade procedure is probably a more reliable indicator of N status than is petiole nitrate-N because it is less variable over time and is affected less by day-to-day changes in the field-environment. Another tool that is gaining in popularity is the SPAD chlorophyll meter. This instrument is used to monitor leaf greenness, which is a function of N content of the leaf. The chlorophyll meter is fast, accurate and repeatable and gives real time assessment of the crop N status. It has some limitations, however, as it must be calibrated for each location, soil type and variety.

For end-of-the-season diagnostic purposes, plant tissue testing can be useful. Boll carpels have the largest and most consistent response among plant components to the quantity of nitrogen available during boll fill. A carpel nitrogen concentration of 1.5% to 2.0% indicates that the crop was adequately fertilized. Carpel N concentration above 2.0% indicates that the crop had excessive plant-available N during boll fill.

Table 1. Optimum nitrogen rates for Louisiana soils [1, 2].

Soil type	lb N/a
Mississippi River alluvial silt loam	60–80
Red River alluvial silt loam	100-110
Red River alluvial sandy loam	60-80
Loessial silt loam	60-80
Alluvial silty clay and clay	80-120

[1]Optimum rates will vary within the soil types depending upon cropping history and other factor.

[2] There is no evidence in Louisiana research results that the use of multiple N applications are beneficial to yield.

Table 2. Sources of N in a typical cotton field.

Source	Quantity	
	Minimum	Maximum
	------------lb per acre---------	
Residual N	20	80
Mineralizable N	20	30
Clay-fixed N	20	40
Other Sources	10	20
Fertilizer N	0	?
Total	70	170

Table 3. Estimated Change in inputs and returns with 30% N over-fertilization.

Management Practice	Cost Per Acre (dollars)	
	Best Case	Worst Case
N fertilizer	5.60	5.60
Pix (4-12-oz)	4.00	12.00
Insecticide (1-2 appl)	10.27	23.27
Defoliation	3.85	9.40
Yield loss	0.00	3.00
Harvest loss	0.00	19.00
Total	-23.72	-72.27

Table 4. Estimated change in inputs and returns with 30% N under-fertilization.

Management Practice	Cost Per Acre (dollars)	
	Best Case	Worst Case
N fertilizer	+5.60	+5.60
Pix	+4.00	0.00
Insecticide	+23.27	+10.27
Defoliation	+6.02	0.00
Yield loss	0.00	-35.00
Harvest loss	+8.00	0.00
Total	+46.89	-19.13

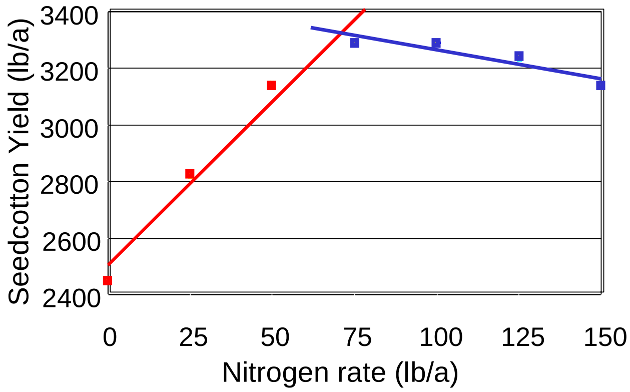

Figure 1. Cotton yield response to fertilizer N - Commerce silt loam, 6- yr. avg.

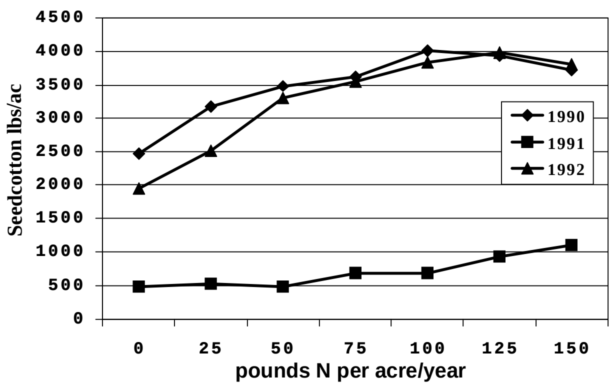

Figure 2. Nitrogen effect on seedcotton yield on Norwood silt loam in central Louisiana.