Nitrogen Requirements of Contemporary Cotton Cultivars

Authors

Chris Main, formerly University of Tennessee
Tom Barber, University of Arkansas
Randy Boman, Oklahoma State University
Kevin Bronson, USDA-ARS
Kent Chapman, University of North Texas
Darrin Dodds, Mississippi State University
Stewart Duncan, Kansas State University
Keith Edmisten, North Carolina State University
Patrick Horn, University of North Texas
Mike Jones, Clemson University
Gaylon Morgan, Texas A&M University
Randy Norton, University of Arizona
Shane Osborne, Oklahoma State University
Jared Whitaker, University of Georgia
Robert Nichols, Cotton Incorporated

Summary

Nitrogen (N) is often the nutrient applied in greatest quantity to cotton and the nutrient that is most chemically dynamic in the environment. While a standard N recommendation for cotton has been 50-55 lbs. N/480 lb. bale, small-seeded, modern cotton cultivars might require less N than did those previously grown. A common experiment was conducted in ten states for two years. The objectives were to determine the response of modern cotton cultivars to N rates, to evaluate the utility of pre-plant soil nitrate testing for determining optimum N application rates in arid to humid regions, and to assess the effect of N rates on cultivars with different sized seed. At each location treatments included three locally-adapted cultivars with planting seed of different sizes, and four N rates, 0, 40, 80, and 120 lbs./acre. High levels of soil nitrate (NO_3) in the top two feet of soil, > 81 lbs. nitrate nitrogen (NO_3-N)/acre, were found at two western sites, and 40-65 lbs. NO_3-N/acre were commonly found at locations in the Mid-South. Lint yields responded positively to fertilizer N at only 11 of 20 sites. Total N increased plant height and number of fruiting nodes, decreased relative crop maturity, and increased seed weight, lint yields, and fiber strength up to a maximum of 147 lbs. applied N + pre-plant soil NO_3-N/acre. Large seed size was associated with increased fiber strength and decreased gin turn out. No significant interactions of seed size and N rate were found for yield. **Results of this research are reported more fully in Main et al. 2013 Effects of Nitrogen and Planting Seed Size on Cotton Growth, Development and Yield. Agronomy Journal 105 (6): 1853-1859.**

Introduction

Nitrogen is frequently the plant nutrient provided to cotton in the greatest quantity. But occasionally applied N is not used efficiently by the crop. Applied N may be unavailable because of runoff, leaching, and/or volatilization. Such losses represent unrecovered input costs for growers and potentially detrimental effects to the environment. In recent years, prices of N fertilizers have increased and been more unpredictable. Thus, there are both economic and environmental motives for improving the efficiency of N fertilization practices in cotton. Cotton will utilize ammonium (NH^4) and NO_3-N from all sources, including fertilizer, atmospheric deposition, rain, irrigation, and the N released by soil mineralization. While soil NO_3 testing is not extensively used in some states for cotton production, pre-plant soil NO_3 testing could prove to be economically beneficial, especially where large quantities of residual NO_3 are present.

A problem with selecting a single optimum N rate for cotton is in part due to cotton's physiology. In contrast to annual grain crops, cotton is an indeterminate plant. Cotton that receives supra-optimal N may produce excessive vegetative growth and fewer reproductive structures than will cotton receiving less N. Moreover, increasing N fertilization tends to increase the yield of cotton seed more than that of lint. Cotton lint is comprised of fibers growing from the cotton seed surface. Because a larger number of small seed can have more surface area than do a fewer number of large seed, greater lint yields may be achieved by selecting for reduced seed size and increasing seed numbers. Such a result could occur from simple selection for high gin turnout, i. e. the fraction of lint obtained from ginned seed cotton. The mean seed size of cotton varieties has been decreasing for the last 30 years. Since cotton seeds are an N sink, maximum lint yields might be achieved with lower rates of N than previously recommended. The objective of this research was to compare the N use requirement of contemporary cotton cultivars based on their planting seed size.

Experiments and Data

A common experiment was performed by state co-operative extension cotton specialists at ten locations each in 2009 and 2010. At each location, the experiment was a factorial arrangement of three cultivars and four N rates within a randomized complete block design with four replications. Locally adapted cultivars were chosen that had seed counts per lb. in the following three classes, large (< 4,400), medium (4,401-5,000) and small seeds (> 5,000 seed/lb). (See Table 1.)

Table 1. Locations, Years, and Cultivars by Seed Size

Location	Years	Cultivar Seed Size		
		Small	Medium	Large
Arkansas	2009-2010	ST 5288B2F	DP 0924 B2RF	FM 1740B2RF
Arizona	2009	DP 164 B2RF	ST 4498B2RF	PHY 745 WRF
Arizona	2010	ST 5288B2F	DP 0924 B2RF	FM 1740B2RF
Georgia	2009	DP 555 BG/RR	PHY 485 WRF	FM 1740B2RF
Kansas	2010	ST 5288B2F	DP 0924 B2RF	FM 9180B2F
Mississippi	2009-2010	ST 5288B2F	DP 0924 B2RF	FM 1740B2RF
North Carolina	2009-2010	ST 5288B2F	DP 0912 B2RF	FM 1740B2RF
Oklahoma	2009-2010	DP 164 B2RF	ST 4554B2RF	FM 9180B2F
South Carolina	2009-2010	DP 555 BG/RR	DP 0935 B2RF	PHY 745 WRF
Tennessee	2009-2010	ST 5288B2F	DP 0920 B2RF	FM 1740B2RF
South Texas	2009-2010	DP 0949 B2RF	DP 0935 B2RF	FM 840B2F
North Texas	2009	DP 161 B2RF	FM 9058F	FM 9180B2F
North Texas	2010	ST 5288B2F	DP 0924 B2RF	FM 9180B2F

Standard soil tests were taken for plant nutrients, and the crops were managed for high yields according to the respective states' recommendations. Additional soil samples for NO_3 were taken from each plot at the 0-6 and 6-24-inch depths before N application. Stand counts were taken 10-14 days after planting. Cotton vigor was monitored by recording nodes above white flower (NAWF) weekly from first bloom through defoliation. At 120 days after planting, plant height, number of main stem nodes, number of bolls, and nodes above cracked boll (NACB) were recorded. The date was recorded when each treatment (cultivar x N rate combination) reached 60% open boll and the treatment was defoliated as soon thereafter as possible. Plots were mechanically harvested. Seed cotton samples were ginned on a laboratory-scale 10-saw gin; turnout and lint yields recorded. Ginned lint samples of 50 grams were sent to Cotton Incorporated and fiber properties measured. Fuzzy seed index was determined by counting the seed in three 100-g samples. Seed oil and protein contents were quantified in samples of fuzzy seed using a new nuclear magnetic resonance (NMR) method.

Results

A combined analysis of all locations found no differences in responses to N rates among sites (Figure 1.) Thus the response of cotton yield to fertilizer N or total available N (applied fertilizer plus spring soil nitrate) was not affected by the diverse environments represented by the 20 locations, or by the groups of cultivars tested at the respective locations.

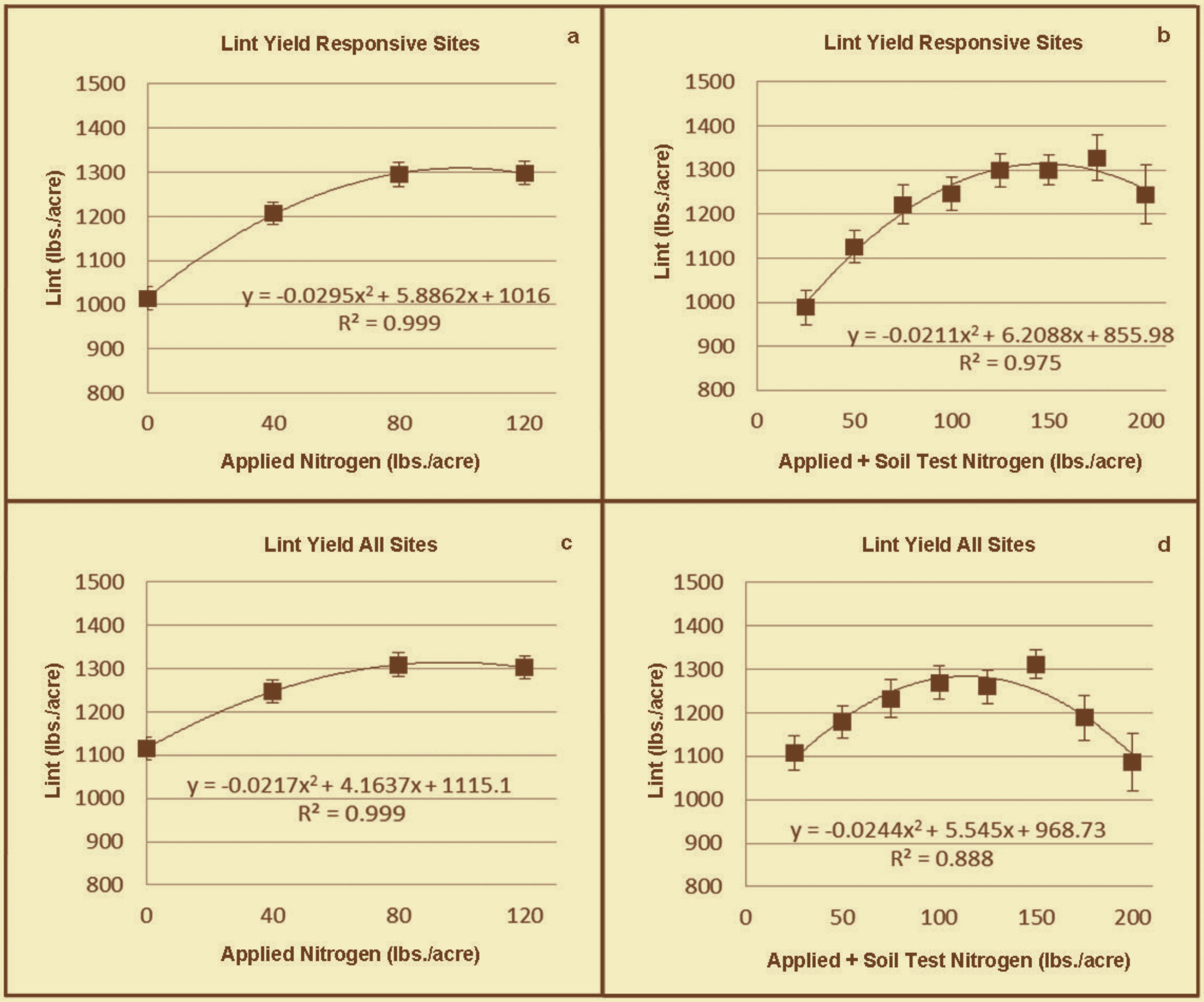
Table 2. N Rate Affects Height, Nodes, and Maturity

Nitrogen	Plant height	Plant nodes	NACB[1]
lbs./acre	inches	number	number
0	30	16.6	4.3
40	33	17.1	4.9
80	34	18.0	5.3
120	36	18.5	5.9
LSD (0.05)	3	1.0	0.5

[1] Number of nodes above highest first position cracked boll to the highest harvestable first position boll.

While the trends were similar across sites, only about half of the sites (11 of 20) responded significantly ($P < 0.05$) to N rate. Relatively high soil NO_3 levels were found in the Western U. S. and to a lesser extent in the Mid-South (data not shown). In general more soil NO_3 below the 6-inch soil depth was found in the West. Sites with the higher levels of NO_3 nitrate tended to be the ones that did not respond to applied N. Cotton responds to N as NH^4 and NO_3 from all sources including from soil, water, and atmospheric deposition. While measurement of pre-plant soil NO_3 is valid for only one season, soil NO_3 is easily obtained and relatively inexpensive through many state and private soil testing laboratories. As expected, higher N rates increased plant height and the number of nodes at harvest, and decreased relative maturity as measured by nodes above cracked boll at 120 days post-plant (Table 2.). When considered over all 20 sites, the response to N rate appeared reduced by the inclusion of sites where there was no significant ($P < 0.05$) response (Figure 1. c, d). In contrast, N response was clearer when only those sites that responded significantly to N were considered (Figure 1. a, b). An optimum response to N, and the effects of over-fertilization were evident when all sites were depicted (Figure 1. c, d). We reason that because substantial N was available from environmental sources at many locations, the combined data showed that yields of about 1,100 lbs./acre were commonly achieved with no applied N. To achieve additional yields of 200 more lbs. of lint/acre, applications of another 80-100 lbs. N/acre were required. However, fertilization above 80-100 lbs. N/acre did not achieve additional yield gains, and when available N was considered, fertilization about this level decreased lint yields. (Figure 1. b, d).

Figure 1. Effect of Applied N, Measured Available N (Applied + Spring Soil Nitrate) on Lint Yields



Increasing N rates decreased gin turnout (increased seed yields vs. lint) but increased fiber strength ($P < 0.05$). Larger planting seed produced larger fuzzy seed at harvest and reduced gin turn out. Increased N slightly increased seed protein and decreased seed oil content. (Data not shown.) Although 18 cultivars overall were included in the tests at one or more sites, the specific choice of cultivars and their distribution among sites may have influenced the results. Therefore, interpretation of the effects of seed size on fiber properties should be considered with caution.

Table 3. Lint Yield, Fuzzy Seed Weight, and Fiber Properties as Affected by Applied Nitrogen and Planting Seed Size

Nitrogen lbs./acre	Lint lbs./acre	Seed weight g/100 seeds	GTO %	Micronaire	Length Inches	Strength g/tex	UI %
0	1,115	9.08	38.6	4.7	1.12	28.8	81.8
40	1,247	9.27	38.3	4.6	1.11	29.0	81.9
80	1,306	9.30	38.1	4.6	1.12	29.2	82.0
120	1,302	9.37	37.6	4.5	1.12	29.3	82.2
LSD (0.05)	57	0.19	0.4	0.1	0.01	0.3	ns
Seed Size number/lb.							
< 4,400	1,185	9.65	37.9	4.5	1.13	29.4	82.3
4,401-5,000	1,259	9.33	38.7	4.7	1.11	28.5	82.3
> 5,000	1,212	8.80	38.5	4.6	1.12	28.9	81.8
LSD (0.05)	49	0.16	0.3	0.1	0.01	0.3	0.2

GTO = Gin Turnout; Micronaire = measure of fiber fineness & maturity,
UI = length uniformity index; tex = 100g fibers/1,000 meters

The cotton cultivars representing the three size ranges tested here required the same amount of fertilizer N plus measured, pre-plant soil NO_3-N, i. e. about 50-55 lb./480 lb. bale to achieve maximum lint yields. This field calibration was virtually identical to those of two previous multi-site, multi-year projects supported by Cotton Incorporated in California and Texas, i.e. Hutmacher et al. 2004 and Hons et al. 2004, respectively. These reports are fully cited in Main et al. 2013, the reference shown at end of the Summary on the first page. Yields of approximately 1,300 lbs. lint/acre were achieved with approximately 100 lb. applied N/acre and 147 lb. N/acre of applied plus pre-plant soil NO_3-N.

Conclusions

- Base N application rates on realistic yield goals for the field or site-specific zone. Historical field production records and performance of cultivars in replicated field tests on similar soils in your region provide good references for estimation.
- For the yield levels found in these trials, cotton will generally need 50 lbs. N/bale from all sources. (No four-bale crops were grown in these tests.)
- Pre-plant soil NO_3-N can be deducted from the application rate for applied N without sacrificing yield.
- Over fertilization with N will delay maturity, make defoliation more difficult, and if excessive, can reduce lint yields.
- To potentially increase N use efficiency, apply N as close to the time the crop will use it as possible, allowing time for movement into the root zone. To avoid losses to de-nitrification and leaching, apply split applications by using starter fertilizer and applying the remainder 30-40 days post plant, or applying one third of the total at pre-plant and the remainder as if following a starter application.

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