NITROGEN REQUIREMENTS OF MODERN GENETICALLY MODIFIED COTTON VARIETIES

Dan D. Fromme
Texas AgriLife Extension Service
Corpus Christi, TX
Frank Hons
Texas AgriLife Research
College Station, TX
Robert G. Lemon
Dale Mott
Texas AgriLife Extension Service
College Station, TX

Abstract

Previous research in Texas has found widespread incidence of high residual nitrate concentrations in soil profiles in all cotton production regions throughout the state. One reason for the excess nitrate may be over fertilization with nitrogen (N). Currently, Texas AgriLife Extension Service recommends 50 pounds available N/bale of lint. However, these recommendations were based on older conventional varieties. The objective of this study was to determine the nitrogen requirements of commonly used GMO cotton varieties so that fertilization guidelines may be modified to result in more accurate and effective nitrogen recommendations. The study was implemented in San Patricio County, Texas to evaluate four cotton varieties and five nitrogen rate treatments (NRT) under center pivot irrigation. Prior to nitrogen applications, soil samples were taken to depth of four feet to determine residual soil nitrate. Prior to applying the NRT, a total of 54 pounds of residual NO_3-N was found to the depth of four feet. For the five NRT, no differences in pounds of lint per acre were found. The 0 NRT produced 1205 pounds of lint per acre on 54 pounds of residual NO_3-N. Based our nitrogen recommendations, we had enough residual nitrogen to produce only 540 pounds of lint. Therefore, 66.5 pounds of nitrogen would have to come from mineralization and irrigation water to meet the nitrogen requirements of the additional 665 pounds of lint per acre that was produced.

Introduction

Previous research in Texas has found widespread incidence of high residual nitrate concentrations in soil profiles in all cotton production regions throughout the state. One reason for the excess nitrate may be over fertilization with nitrogen (N). Currently, Texas AgriLife Extension Service recommends 50 pounds available N/bale of lint. However, these recommendations were based on older conventional varieties. The objective of this study was to determine the nitrogen requirements of commonly used GMO cotton varieties so that fertilization guidelines may be modified to result in more accurate and effective nitrogen recommendations.

Methods

A field study was conducted in San Patricio County, Texas to determine the nitrogen requirements of commonly used GMO cotton varieties so that fertilization guidelines may be modified to result in more accurate and effective nitrogen recommendations. Previous crop was grain sorghum. Planting date was on April 2, 2008. Planting rate was 52,000 seed/acre. Harvest date was on September 2, 2008. The study evaluated four cotton varieties and five nitrogen rates under center pivot irrigation. Prior to nitrogen applications, soil samples were taken to depth of four feet to determine residual soil nitrate (Table 1). The four cotton varieties consisted of DP 141B2F, ST 4498B2F, PHY 375WRF, and FM 840B2F. Nitrogen rates utilized were rates of 0, 35, 70, 105, and 140 lbs/acre. Prior to planting, NRT were knifed and placed at a depth of six inches. Nitrogen source utilized was urea (46-0-0). The experimental design was a split plot with four replications in a randomized complete block. Varieties were the main plots and nitrogen rates were the sub-plots. Plot sizes were four rows (38-inch centers) by 35 feet long. Field data that was evaluated include plant population, plant height and total number of nodes at pinhead square, first bloom and at cutout (NAWF=5), percent canopy cover at peak bloom, number of days to cutout, number of bolls per plant at harvest, pounds of lint per acre, fiber quality, and percent seed nitrogen content. Statistical analysis was conducted in Proc GLM. Mean separation was determined by using Fishers Protected LSD at the $\leq .05$ level.

Results

Prior to applying the NRT, a total of 54 pounds of residual NO_3-N was found to the depth of four feet (Table 1). Final plant population was significantly higher for PHY 375WRF compared to the other three varieties. For FM 840B2F and ST 4498B2F, final plant population was significantly higher than DP 141B2F. Final plant population for DP 141B2F was significantly less than the other three varieties. There were no significant differences in final plant populations when comparing the five NRT (Table 2).

Plant height at pinhead square was significantly higher for DP 141B2F. FM 840B2F and ST 4498B2F were significantly higher in plant height compared to PHY 375WRF. Final plant height at pinhead square for PHY 375B2RF was significantly less compared to the other three varieties. There were no significant differences in plant height between the 0, 35, 70, and 140 NRT. Plant height was significantly less for the 105 nitrogen rate treatment compared to the 0 and 140 NRT. There were no significant differences in plant height between the 35, 70, and 105 NRT (Table 3). Plant height at first bloom for DP 141B2F was significantly higher compared to PHY 375WRF and FM 840B2F. There were no differences in plant height between DP 141B2F and ST 4498B2F. Plant height for FM 840B2F was significantly lower when compared to the other three varieties. There were no significant differences in plant height between the 0, 35, 70, and 140 NRT. Plant height was significantly less for the 105 NRT compared to the 0, 70, and 140 NRT. No differences in plant height were observed between the 35 and 105 NRT (Table 4). At cutout, there were no differences in plant height when comparing the four varieties or the five NRT (Table 5).

Total nodes at pinhead square for FM 840B2F was significantly higher compared to the other three varieties. There were no differences in total nodes between PHY 375WRF, ST 4498B2F, and DP 141B2F. No differences in total nodes were observed between the five NRT (Table 6). For total nodes at first bloom, there was a significant variety by NRT interaction (Table 7). Total nodes at cutout for FM 840B2F was significantly higher compared to other three varieties. There were no differences in total number of nodes at cutout between PHY 375WRF and DP 141B2F. ST 4498B2F had significantly less nodes at cutout compared to the other three varieties. There were no differences in total number of nodes at cutout between the five NRT (Table 8).

Differences in percent canopy cover at peak bloom were not significant for the four varieties or the five NRT (Table 9).

Number of days to cutout was significantly higher for PHY 375WRF and FM 840B2F compared to ST 4498B2F and DP 141B2F. Number of days to cutout was significantly higher for DP 141B2F compared to ST 4498B2F. There were no differences in the number of days to cutout between the 70, 105, and 140 NRT. Number of days to cutout was significantly higher for the 70 and 105 NRT compared to the 0 NRT. No differences in number of days to cutout were observed between the 0, 35, and 140 NRT (Table 10).

No differences in pounds of lint per acre were observed between DP 141B2F and ST 4498B2F. Pounds of lint per acre for DP 141B2F was significantly higher compared to PHY 375WRF and FM 840B2F. For the five NRT, no differences in pounds of lint per acre were found (Table 11).

Number of boll per plant at harvest for DP 141B2F was significantly higher compared to PHY 375WRF and FM 840B2F. There were no differences in number of bolls at harvest between DP 141B2F and ST 4498B2F. Number of bolls per plant at harvest was significantly higher for the 140 NRT compared to the 0 and 35 NRT. There were no differences in number of bolls per plant at harvest between the 70, 105, and 140 NRT. No differences in number of bolls per plant at harvest were found between the 0, 35, 70, and 105 NRT (Table 12).

Percent seed nitrogen content at harvest was significantly higher for PHY 375WRF compared to the other three varieties. No differences in percent seed nitrogen content were found between FM 840B2F, ST 4498B2F, and DP 141B2F. Percent seed nitrogen content was not significant when comparing the five NRT (Table 13).

Table 1. Residual soil NO_3N levels in lbs/acre, San Patricio County, Texas, 2008.

Depth (inches)	NO_3-N (lbs /acre)
0-6	6
6-12	18
12-24	10
24-36	10
36-48	10
Total	54

Table 2. Final plant population (1,000), San Patricio County, Texas, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F=.6311
0	48.00	37.75	36.25	33.00	38.75 a
35	48.00	36.00	39.50	34.75	39.56 a
70	48.25	40.25	36.50	37.50	40.63 a
105	49.75	41.00	39.25	30.25	40.06 a
140	45.00	38.75	41.75	36.50	40.50 a
Pr>F=<.0001	47.80 a	38.75 b	38.65 b	34.40 c	

Table 3. Plant height (cm) at pinhead square, San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .0303
0	13.2	14.0	14.7	15.2	14.28 a
35	11.8	12.8	13.1	14.9	13.11 ab
70	12.0	12.7	13.7	15.5	13.48 ab
105	10.6	13.1	11.3	14.6	12.38 b
140	11.8	14.0	13.4	15.9	13.77 a
Pr>F= .0019	11.87 c	13.33 b	13.22 b	15.21 a	

Table 4. Plant height (cm) at first bloom, San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .0426
0	59.1	54.8	62.5	64.1	60.11 a
35	55.3	55.1	62.0	60.3	58.17 ab
70	61.6	57.1	59.3	62.5	60.11 a
105	60.6	52.1	58.2	59.1	57.46 b
140	57.9	56.8	60.8	63.1	59.64 a
Pr>F= .0014	58.89 b	55.16 c	60.56 ab	61.80 a	

Table 5. Plant height (cm) at cutout (NAWF=5), San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .9067
0	69.8	62.8	69.1	71.6	68.32 a
35	66.8	66.4	67.0	70.9	67.76 a
70	70.8	64.9	62.7	73.3	67.92 a
105	66.5	62.3	64.4	74.5	66.89 a
140	68.7	68.1	65.9	70.6	68.31 a
Pr>F= .0753	68.53 a	64.88 a	65.80 a	72.17 a	

Table 6. Total nodes at pinhead square, San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .1317
0	8.5	9.0	8.2	8.2	8.48 a
35	8.1	8.9	7.7	8.0	8.16 a
70	8.2	8.8	8.2	8.0	8.29 a
105	7.5	9.1	7.5	8.0	8.01 a
140	8.1	9.0	7.8	8.4	8.33 a
Pr>F= .0015	8.06 b	8.96 a	7.89 b	8.12 b	

Table 7. Total nodes at first bloom, San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .0212
0	17.8	18.3	17.0	17.4	17.59 a
35	17.7	18.9	16.2	16.7	17.35 ab
70	18.3	19.1	16.5	16.9	17.69 a
105	17.4	18.0	16.3	16.8	17.12 b
140	17.3	19.4	16.5	16.9	17.49 a
Pr>F= <.0001	17.67 b	18.74 a	16.47 d	16.92 c	

Table 8. Total nodes at cutout (NAWF=5), San Patricio County, TX, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .3474
0	19.8	21.0	18.6	19.3	19.7 a
35	20.0	22.1	18.7	19.6	20.08 a
70	20.2	20.5	18.5	19.4	19.61 a
105	20.1	20.7	18.8	19.8	19.86 a
140	20.2	21.5	18.3	19.3	19.81 a
Pr>F= .0004	20.04 b	21.17 a	18.58 c	19.48 b	

Table 9. Percent canopy cover at peak bloom, San Patricio County, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .8378
0	54.6	53.7	59.9	59.7	56.96 a
35	50.7	56.2	60.8	56.4	55.98 a
70	54.4	55.5	57.9	59.9	56.91 a
105	54.2	55.5	58.8	60.1	57.14 a
140	54.0	57.0	61.4	59.7	58.01 a
Pr>F= .1254	53.56 a	55.58 a	59.74 a	59.14 a	

Table 10. Number of days to cutout (NAWF=5), San Patricio County, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F=.0382
0	86.0	83.0	80.5	84.3	83.44 c
35	86.3	85.8	81.3	83.5	84.19 bc
70	88.3	89.3	79.8	85.8	85.75 ab
105	90.0	86.5	81.5	86.3	86.06 a
140	90.3	88.0	80.3	82.0	85.13 abc
Pr>F= <.0001	88.15 a	86.5 a	80.65 c	84.35 b	

Table 11. Pounds of lint per acre, San Patricio County, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .2293
0	1215	1057	1298	1250	1205 a
35	1091	1138	1370	1344	1236 a
70	1260	1018	1063	1374	1179 a
105	1152	968	1199	1330	1162 a
140	1154	1155	1372	1360	1260 a
Pr>F= .0069	1174 bc	1067 c	1260 ab	1332a	

Table 12. Number of bolls per plant at harvest, San Patricio County, Texas, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .0483
0	9.7	7.9	9.8	10.1	9.34 b
35	8.9	9.4	10.5	10.3	9.76 b
70	10.2	8.9	10.9	10.3	10.08 ab
105	10.3	8.9	10.4	10.7	10.06 ab
140	10.2	9.7	10.3	12.8	10.74 a
Pr>F= .0046	9.86 b	8.93 c	10.37 ab	10.84 a	

Table 13. Percent seed nitrogen content at harvest, San Patricio County, Texas, 2008.

Lbs. N/Acre	PHY 375WRF	FM 840B2F	ST 4498B2F	DP 141B2F	Pr>F= .4997
0	3.4	3.3	3.3	3.8	3.42 a
35	4.0	3.3	3.2	3.2	3.43 a
70	3.6	3.0	3.1	3.2	3.24 a
105	3.7	3.0	3.3	3.5	3.37 a
140	3.8	3.1	3.1	2.8	3.22 a
Pr>F= .0091	3.71 a	3.13 b	3.19 b	3.31 b	

Summary

Differences in percent canopy cover at peak bloom were not significant for the four varieties or the five NRT (Table 9).

Number of days to cutout was significantly higher for PHY 375WRF and FM 840B2F compared to ST 4498B2F and DP 141B2F. Number of days to cutout was significantly higher for DP 141B2F compared to ST 4498B2F. There were no differences in the number of days to cutout between the 70, 105, and 140 NRT. Number of days to cutout was significantly higher for the 70 and 105 NRT compared to the 0 NRT. No differences in number of days to cutout were observed between the 0, 35, and 140 NRT (Table 10).

Pounds of lint per acre for DP 141B2F was significantly higher compared to PHY 375WRF and FM 840B2F. No differences in pounds of lint per acre were observed between DP 141B2F and ST 4498B2F. For the five NRT, no differences in pounds of lint per acre were found (Table 11). The 0 NRT produced 1205 pounds of lint per acre on 54 pounds of residual NO_3-N (Tables 11, 1). Based our recommendation that it takes 50 pounds of nitrogen to produce a bale of cotton, therefore we had enough residual nitrogen to produce only 540 pounds of lint. Therefore, 66.5 pounds of nitrogen would have to come from mineralization and irrigation water to meet the nitrogen requirements of the additional 665 pounds of lint per acre.

Number of boll per plant at harvest for DP 141B2F was significantly higher compared to PHY 375WRF and FM 840B2F. There were no differences in number of bolls at harvest between DP 141B2F and ST 4498B2F. Number of bolls per plant at harvest was significantly higher for the 140 NRT compared to the 0 and 35 NRT. There were no differences in number of bolls per plant at harvest between the 70, 105, and 140 NRT. No differences in number of bolls per plant at harvest were found between the 0, 35, 70, and 105 NRT (Table 12).

Future research will possibly need to include the calculation of differences in seed size, including and evaluating an older conventional variety, and nitrogen content of plant biomass at first open boll.

The implementations of this study would not have been possible without the financial support of Cotton Incorporated and to Clarence Chopelas for providing the land.