IMPROVING NITROGEN MANAGEMENT FOR SUBSURFACE DRIP-IRRIGATED-COTTON IN ARIZONA

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Abstract

Declining surface irrigation water availability has been a fact of life in the American Southwest since 2000. Surface-irrigated cotton land is steadily being converted to subsurface drip irrigation (SDI) to increase water use efficiency (WUE). Nitrogen use efficiency (NUE) is assumed to be greater with SDI vs. surface irrigation, but research to tailor N fertilizer management in SDI cotton is lacking. The objectives of this study were to evaluate a pre-plant soil profile NO_3 test algorithm with a canopy reflectance approach in terms of yield and N use efficiency for SDI cotton in AZ. The N x water study was conducted with SDI cotton in Maricopa, AZ. We also constructed water balances to assess leaching and we measured N_2O emissions using chambers. Water use and lint yields were similar to those from recent Arizona N management studies using surface -and overhead sprinkler irrigation. The canopy reflectance-based N rate was 141 lb N/ac, compared to 156 lb N/ac for the soil test algorithm, with similar lint yields of 1400 lb/ac in both treatments. A maximum of 6 % of irrigation and rain were estimated to have deep leached below the 7ft. root zone. Unique to SDI, N_2O emissions were low and not different between N-fertigated and zero-N plots. Nitrogen recovery efficiency from N fertigations (24 events) in the plant at first open boll was maximum at 81 % for soil test N at 100 % ET replacement.

Introduction

Following water, N fertilizer is the main constraint to cotton production in the western USA. Canal infrastructure in Arizona means basin, flood, and furrow irrigation are still the pre-dominant choices of irrigation methods. However, recovery efficiency of ground-based N applications in furrow-irrigated cotton are low, ranging from 15 to 34 % (Bronson, 2008; Bronson et al., 2013). With declining water resources in the lower Colorado River basin since 2000 (Scanlon et al., 2016), and competition from growing urban areas, there is renewed interested in subsurface drip irrigation (SDI) systems. However, N management research and recommendations in the far Western US are lacking for SDI. Canopy reflectance-based N management in SDI in Texas resulted in reduced N fertilizer use, without hurting lint yields (Bronson et al., 2011). We see the need for improved and updated N fertilizer management recommendations for 4-bale/acre cotton yield goal based on a 36-inch pre-plant soil NO_3-N test. Additionally, we wanted to compare soil test-based N management for full and deficit SDI and with canopy reflectance based N management (full irrigation only).

Objectives:

1. Compare lint yields and NUE soil test-based N fertilizer management with canopy reflectance-based urea ammonium nitrate (UAN)-N management approach in SDI cotton.
2. Compare lint yields and NUE with full and deficit irrigation in SDI cotton.
3. Construct N balances for SDI cotton, i.e. quantify total N uptake, recovery N use efficiency, NO_3 leaching, and N_2O losses.

Materials and Methods

In March, 2016, pre-plant soil sampling to 7 ft. for NO_3 was done on four samples per plot on a Casa Grande sandy loam in Maricopa, AZ. Cotton 'Deltapine 1549 B2XF' was planted on 12 April, 2016 in plots that were 8, 40-inch-rows wide by 330 feet. Nitrogen fertilizer treatments included:

Nitrogen treatment	Irrigation level
1. Soil test-based N†	100
2. Reflectance-based N‡	100
3. Zero-N	100
4. Soil test-based N†	75
5. Zero-N	75

† Based on lint yield goal of 4.0 bale/ac, and a 200 lb N/ac N requirement, minus 0 - 36 in. soil NO_3-N and estimated irrigation input of 20 lb N/ac (estimated 40 inch irrigation of 2 ppm NO_3-N water).
‡ Applications start out at 50 % treatment no. 1, subsequent applications based on NDRE relative to treatment no. 1.

Nitrogen fertilizer as UAN was fertigated in 24 doses between first square and mid bloom. The experimental design was a completely randomized block, with three replicates. Canopy reflectance was measured every week from first square to first open boll using two Crop Circle ACS-470 active sensors. Several vegetative indices were calculated including NDVI, CCCI, and NDRE. NDRE was used for reflectance-based N treatments. Surface flux of N_2O was measured weekly for 16 weeks during the season using 4-qt vented chambers and gas chromatography. Biomass and total N uptake was determined plants on 2 m of row at first open boll. Nitrogen recovery efficiency, physiological N use efficiency and agronomic use efficiency were calculated. Lint and mature seed yields were machine harvested in October. Mature cotton seed N were determined from grab samples at the four DGPS points per plot and the percentage of seed N to total N uptake calculated.

Soil moisture to 72 inches was determined every week with a neutron probe and the water balance was calculated with irrigation amounts, rain and estimated ET (Maharjan et al., 2014). Nitrous oxide emissions data was analyzed by date, and with date as an effect, with a mixed model using SAS (SAS, 2013). Replicate was considered random, and N treatment, date, and date by N treatment were considered fixed. Since N_2O data often has a log-normal distribution, the statistical analysis was also conducted using PROC GLIMMIX with a log distribution.

Results and Discussion

First open boll biomass yields were high at 13,000 lb/ac for soil test N, with 100 % irrigation. Final lint yields were lower than expected, due to many level-two heat stress days in 2016 that led to early green boll shedding. At 100 % irrigation, reflectance-based N management yields were similar to soil test-based N management (~ 1400 lb lint/ac, Table 1) with 15 lb N/ac fertilizer savings. Soil test N management with the water stress irrigation treatment only yielded 16 % less than the 100 % ET soil test N treatment, although the irrigation was 25 % less (30 % less without the germinating irrigation).

Recovery efficiency (RE) of fertigated N was high in this system, ranging from 60- 81%. The highest RE of 81% was achieved with full irrigation and the 156 lb N/ac, soil test-based N management. These high REs were similar to those reported for SDI cotton in Texas (Bronson et al. 2011).

Nitrous oxide emissions were low and not affected by fertilizer (data not shown). In previous studies, the "emission factor" (percentage of added N fertilizer emitted as N_2O-N) for surface and overhead sprinkler-irrigated cotton averaged about 0.5% (Bronson et al., 2013; Bronson et al., 2015). In this study with SDI and near daily N fertigation over 6 weeks, the emission factor was zero. Deep percolation of irrigation plus rain was only 0-6 % in this sub-surface drip system (Table 2). This compares with 14 to 21 % losses at this site with surface irrigation (Bronson et al., 2013). This first year study shows the strong potential of efficient N and water use efficiency, with small losses from the system.

Table 1. Lint yield, seed yield, N uptake and N use efficiencies as affected by N management and irrigation level in subsurface drip-irrigated ‘DP 1549 B2XF’ cotton, Maricopa, AZ 2016

Nitrogen treatment	Irr. level	Fert. rate	Biomass yield	Lint yield	Total N uptake	Recovery efficiency	Agron. N use efficiency	Internal N use efficiency
	in.	lb N/ac	lb/ac	lb/ac	lb N/ac	%	lb lint/lb N fert.	lb N/bale
Soil test-based N	35.3	156	13,307 a	1358 a	186 a	81 a	3.5 a	65 a
Reflectance-based N	35.3	141	11,726 b	1412 a	151 b	67 a	4.2 a	52 b
Zero-N	35.3	0	5635 d	816 d	59 c	-	-	32 c
Soil test-based N	26.5	156	8898 c	1136 b	140 b	59 a	3.2 a	58 ab
Zero-N	26.5	0	5207 d	640 c	49 c	-	-	34 c

Table 2. Water balances† as affected by N management and irrigation level in subsurface drip-irrigated ‘DP 1549 B2XF’ cotton, Maricopa, AZ 2016.

N treat.	Irrigation level‡	ET	Rain	Irrigation	Change soil storage (0-7 ft)	Deep perc	Deep perc (% of irrigation and rain)
	------------------------------------- inches---------------------------------						
Soil test-based N	35.3	-34.0	1.2	32.0	-3.9	2.1	6.4
Reflectance-based N	35.3	-34.0	1.2	32.0	-3.3	1.5	4.6
Zero-N	35.3	-34.0	1.2	32.0	-0.3	-1.5	0
Soil test-based N	26.5	-27.6	1.2	23.2	-4.3	1.1	4.6
Zero-N	26.5	-27.6	1.2	23.2	-2.1	-1.1	0

†Covers 120 days.
‡ Includes irrigation for germination before neutron probe tube installation.

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