SPOON-FED NITROGEN AND PHOSPHORUS MANAGEMENT FOR SUBSURFACE DRIP IRRIGATED COTTON (*GOSSYPIUM HIRSUTUM*)

J. Burke, K. Lewis
Texas A&M AgriLife Research

ABSTRACT

Subsurface drip irrigation (SDI) is becoming a popular option for maximizing the water use efficiency of cotton (*Gossypium hirsutum*), especially in semi-arid environments of the Midsouth and Western United States. Applying fertilizers through SDI provides an opportunity to prescriptively apply nutrients at peak nutrient demand which could minimize loss and increase uptake, but the application timing needs to be better understood. The objective of this study was to develop nitrogen (N) and phosphorous (P) fertigation strategies using SDI that increases nutrient use efficiency (NUE) and cotton lint yield. Two cotton varieties were grown to understand the impact of cotton development on nutrient uptake: DeltaPine (DP) B2XF 2143 (late-maturing variety) and DP B2XF 2020 (mid-maturing variety). Nitrogen was applied as urea ammonium nitrate (UAN) at three or nine respective timings for a maximum of 168 kg N ha^{-1}, and P was applied as phosphoric acid (PA) at one, three, or nine respective timings for a maximum of 50 kg P ha^{-1}. Cotton lint yield was determined, and the cotton plants were partitioned into their physiological components of stems, leaves, burrs, seed, and lint at first open boll. Each component was analyzed for nutrient composition using Inductively Coupled Plasma Optical Emission spectroscopy following nitric acid digestion. There was no difference between cotton varieties on cotton lint yield. Cotton lint yields were greatest with nine N and one P application timings. Generally, nine N applications resulted in greater lint yield compared to three timings; however, one application of P generated a greater amount of cotton lint compared to three or nine timings. Calcareous soils are common in semi-arid environments, and P adsorbs calcium and magnesium, making them unavailable for cotton uptake. A single application of P likely allows for P reversion throughout the cotton growing season, which provides for increased plant uptake. For N, greater applications of N probably minimized losses from denitrification and immobilization. Results demonstrate that prescriptive N fertilizer applications produce greater lint yield and reduce nutrient losses compared to greater quantities applied at fewer frequencies. Phosphorus is best applied as a single application for the greatest lint production.

INTRODUCTION

Subsurface drip irrigation (SDI) is becoming a popular option for maximizing the water use efficiency of cotton (*Gossypium hirsutum*), especially in semi-arid environments of the Midsouth and Western United States. In the Texas High Plains, where underground water resources from the Ogallala Aquifer are rapidly declining, there is increased adoption of water conservation technologies like center pivot and drip irrigation. In addition to increased water efficiency, drip irrigation also allows for more precise fertilization through fertigation with the application directly in the plant root zone. Applying fertilizers through SDI provides an opportunity to prescriptively apply nutrients at peak nutrient demand which could minimize loss and increase uptake. Still, the application frequency and timing are poorly understood. The objective of this study was to develop nitrogen (N) and phosphorous (P) fertigation strategies using SDI that increase nutrient use efficiency (NUE) and cotton lint yield.

MATERIALS AND METHODS

Cotton was planted at the Texas A&M AgriLife Research and Extension Center in Lubbock, TX. The Center includes a recently installed SDI system with 67 zones that allows the flexibility and control to apply nutrients through fertigation to each zone precisely. Plots were four rows wide (40” spacing) by 68 ft long. Treatments were arranged as a split-plot design with four replications. Main plots were designated to variety and fertility treatments were assigned to split plots. The cotton varieties consisted of DeltaPine (DP) 2143 B2XF NR and 2020 B2XF planted at 53,000 seeds acre^{-1}. The fertility treatments consisted of 150 lb N A^{-1} as 32-0-0 at three or nine respective timings; and 45 lb P A^{-1} applied as phosphoric acid at one, three, or nine respective timings (Table 1).

Table 1. Application schedule for the 2022 growing season.

Applic: 1	Applic: 3	Applic: 9
7-Jun	7-Jun	7-Jun
		17-Jun
	24-Jun	24-Jun
		1-July
	8-July	8-July
		18-July
		29-July
		12-Aug
		26-Aug

Soil samples were collected on 17 March 2022 from each plot and analyzed by Ward Laboratories (Kearny, NE, USA) for residual nitrate (NO_3) and ammonium (NH_4), and P, potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), sodium, iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), and boron (B) concentrations and soil pH and electrical conductivity. Cotton (DP 2143 and DP 2020) was planted on 27 May 2022. Fertilizer was applied via fertigation on 7, 16, 24 June, 8, 15, 18, 29 July, and 12, 26 August 2022 (Table 1).

At first open boll (3 October 2022), two 1-m rows of cotton plants were destructively sampled from each plot and separated into leaves, stems, burs/bracts, seed, and lint to determine the mineral concentration and determine nutrient uptake. Dry weights were collected, and samples were ground for analysis. Each component is in the process of being analyzed for mineral composition using Inductively Coupled Plasma Optical Emission spectroscopy following nitric acid digestion at Water’s Agricultural Laboratories in Camilla, GA. We are waiting on the results. Cotton lint yield was determined from mechanical harvesting on 12 December 2022. Harvested samples were ginned on a scaled gin at Texas A&M AgriLife Research and Extension in Lubbock, TX. For High Volume Instrument analysis, ginned lint samples were sent to the Fiber and Biopolymer Research Institute (Texas Tech University, Lubbock, TX).

All statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc., Raleigh, NC, USA). Data analysis was conducted using a generalized linear mixed model. (PROC GLIMMIX) with variety and fertility application treated as the fixed effect and replication as the random effect. Normality was determined using the Shapiro–Wilk test, and all data were normally distributed. Means of treatment effects were compared within variety using Fisher’s least significant difference (LSD) at $p < 0.05$.

RESULTS AND DISCUSSION

There were no differences between cotton varieties on cotton lint yield, although DP 2143 generally outperformed DP 2020 (Figure 1). With DP 2020 and three N fertilizer applications, cotton lint yield was greater with zero, one, and three P applications than with nine applications. When N was applied in nine equal applications, lint yields were greater with one P application compared to the no P control and three applications. Regardless of variety, fewer P applications generally generated more cotton lint than three or nine applications.

Calcareous soils are common in semi-arid environments, and P adsorbs to and precipitates with calcium (and magnesium), making it unavailable for cotton uptake (Table 2). A single application of P likely allows for more significant P movement to plant roots via diffusion and desorption throughout the cotton growing season, which provides for increased plant uptake. Nine P applications may be causing antagonistic effects with zinc and possibly other micronutrients. Past work has demonstrated greater P uptake with nine applications even though lint yield was reduced. This leads us to hypothesize an antagonistic effect of increased P uptake reducing the uptake of other essential elements. Results demonstrate that prescriptive N fertilizer applications result in greater lint yield and minimize nutrient losses compared to greater quantities applied at greater frequencies. For N, greater applications of N likely minimized losses from denitrification and immobilization.

SUMMARY

Results suggest that fewer applications and larger doses of P fertilizer fertigated during the growing season result in greater lint yield regardless of cotton variety. The frequency and dose of N fertilizer did not appear to influence cotton lint production. Given the limited amount of information generated from a single site year, recommendations cannot be made. Additional research is being conducted and will be available in late 2023.

Table 2. Soil characteristics of the research plot at the Texas A&M AgriLife Research and Extension Center in Lubbock, TX, to a 36-inch depth.

Depth	pH	EC	NO_3N	P	K	Ca	Mg	S	Na	Fe	Zn	Mn	Cu
		umhos/cm	-----------	-----------	-----------	-----------	-----------	ppm	-----------	-----------	-----------	-----------	-----------
0-6"	7.74	523	14	22	322	2344	528	38	64	4.3	0.21	10.2	0.73
6-12"	8.09	421	13	6	258	2840	672	29	73	3.3	0.15	5.5	0.67
12-24"	8.19	458	9	5	249	4723	707	28	98	5.0	0.13	4.4	0.85
24-36"	8.00	781	35	11	201	4707	477	65	167	4.1	0.12	4.3	0.87
Average	8.00	546	18	11	257	3653	596	40	101	4.2	0.15	6.1	0.78

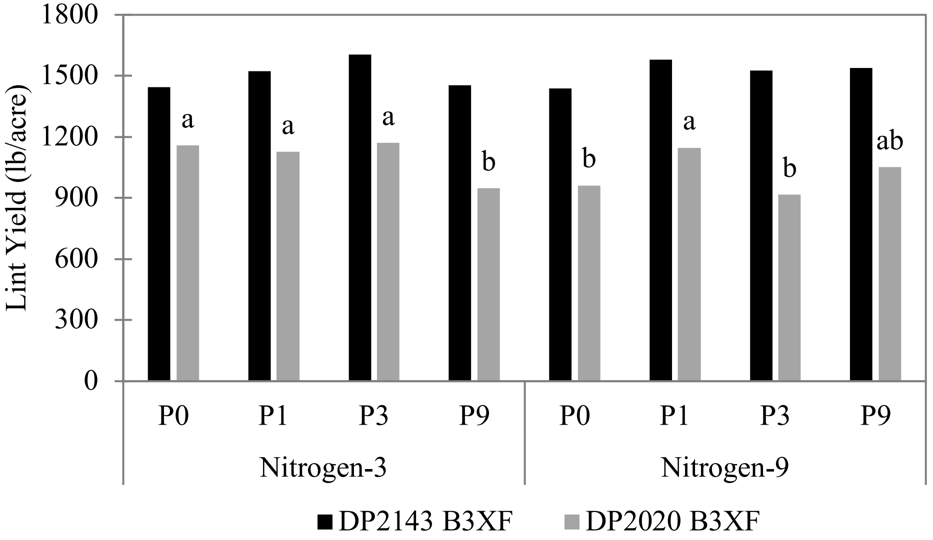

Figure 1. Cotton lint yields for two varieties, two nitrogen fertilization timings, and four phosphorus (P) fertilization timings at the Texas A&M AgriLife Research and Extension Center in Lubbock, TX. Letters represent significant differences between phosphorus fertilization frequency within cotton variety and nitrogen application frequency. Differences were only determined for DP 2020 B3XF but not DP 2143 B3XF.