NITROGEN MANAGEMENT IN CONSERVATION SYSTEMS TO INCREASE USE EFFICIENCY AND COTTON PRODUCTION

Joseph A. Burke, Texas A&M AgriLife Research, Lubbock, TX, joseph.burke@ag.tamu.edu, 806-746-6101

Katie L. Lewis, Texas A&M AgriLife Research, Lubbock, TX

ABSTRACT

Conservation management practices like no-tillage and cover crops have the potential to reduce wind erosion and stimulate ecosystem service, but lingering doubts regarding nutrient immobilization and water usage may limit their adoption on the Texas High Plains. A study was initiated at the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) in Lamesa, TX to examine the impact of supplemental nitrogen (N) fertilization on cotton yields and nitrogen use efficiency (NUE) in two cotton cropping systems. The continuous cotton cropping systems included: 1) conventional tillage, winter fallow (CC), and 2) conservation tillage with rye cover (CCRC). The N fertilizer treatments included: 1) farm practice, 2) additional N applied preplant, 3) additional N applied at emergence plus three weeks, and 4) additional N applied at pinhead square plus two weeks. Results indicate cotton lint yield and NUE were greater following a rye cover crop compared to monoculture cotton when additional N was applied preplant or at emergence plus three weeks in both cropping years. Applying additional N at pinhead square plus two weeks resulted in a significant reduction in yield and the lowest NUE in both years.

INTRODUCTION

The semi-arid Texas High Plains is one of the largest cotton producing regions in the world and contributes a significant amount to the regional economy; however, the extreme environmental conditions of the region can lead to wind erosion. Conservation management practices, like no-tillage and cover crops, can reduce wind erosion and stimulate ecosystem services. The use of these practices can result in yield deficit which might be caused by reduced water availability or nutrient immobilization (Lewis et al., 2018; Burke et al., 2019). Cover crops production can range from 1798 to 4654 lb dry matter A^{-1} on the Texas High Plains which results in substantial amounts of organic materials for microbes to decompose. Questions remain whether the decomposition of this organic material will align with peak cotton nutrient demands. The purpose of this research was to determine if and when supplement N applications in cotton cropping systems can reduce the yield drag associated with conservation management practices.

MATERIALS AND METHODS

A trial was initiated in 2018 to evaluate the effect of N fertilizer application timing on lint yield of cotton (DP 1522 B2XF) following a rye cover crop/conservation tillage (CCRC), and in a conventional tillage/winter fallow system (CC). The N treatments were replicated within each cropping system, and included: 1) check, AG-CARES practice (120 lb N A^{-1} applied via fertigation); 2) additional 30 lb N A^{-1} applied at preplant; 3) additional 30 lb N A^{-1} applied three weeks after emergence; and, 4) additional 30 lb N A^{-1} applied at pinhead square plus 2 weeks. The source of the N was urea ammonium nitrate (UAN, 32-0-0). All subsequent N fertilizer applications were knifed injected. Cotton in this trial was planted on 16 May 2018 and 19 May 2019, defoliated on 3 October 2018 and October 2019, and harvested 17 November 2018 and 18 November 2019. Statistical analyses for all measurements were performed using SAS version 9.3 software (SAS Institute Inc.). Analysis of variance was conducted for all parameters using a generalized linear mixed model (PROC GLIMMIX). Means of treatment effects were compared within sample time using Fisher's least significant difference (LSD) at $P < 0.05$. Nitrogen use efficiency was calculated as:

$$Nitrogen\ use\ efficiency\ (lb\ lint\ lb\ N^{-1}) = \frac{lint\ yield\ (lb\ lint\ A^{-1}) - check\ lint\ yield\ (lb\ lint\ A^{-1})}{Nitrogen\ applied\ (lb\ N\ A^{-1})}$$

RESULTS AND DISCUSSION

In 2018, cotton lint yields ranged from 605 to 808 lb lint A^{-1} and 683 to 975 lb lint A^{-1} for CC and CCRC systems, respectively (Table 1). For the CC system, a preplant application of 30 lb N A^{-1} resulted in significantly greater yield compared to the other treatments, while an additional application of N at emergence plus three weeks resulted in significantly greater cotton lint yield in the CCRC system. As with lint yield, NUE was greatest following a preplant application in the CC system and emergence plus three weeks in the CCRC system. In the CC system, the later application of 30 lb N A^{-1} at pinhead square plus two weeks resulted in decreased NUE compared to the check or farm practice. Cotton lint yields and NUE were greater in the CCRC system compared to the CC.

In 2019, cotton lint yields ranged from 776 to 872 lb lint A^{-1} and 913 to 1118 lb lint A^{-1} for CC and CCRC systems, respectively (Table 2). For the CC system, there were no significant differences between treatments and NUE was generally reduced with supplemental N fertilization except following a preplant application of N. Cotton lint yields and NUE were greater in the CCRC system compared to CC. For the CCRC system, cotton lint yield was greatest with the preplant application followed by emergence plus three weeks compared to the farmer practice and pinhead square plus two weeks. Nitrogen use efficiency in CCRC was improved in the preplant and emergence plus three weeks applications compared to the pinhead square plus two weeks application.

The addition of rye cover increased lint yield compared to CC with the addition of supplemental N in 2018, but increased yield regardless of N application in 2019. The 2018 cropping season was initially warmer than average but had adequate rainfall during the cropping season, while the 2019 cropping season began with adequate rainfall, but nearly no precipitation during the growing season. The rye cover may increase soil moisture storage which could explain the yield increases in 2019 even under limited precipitation.

Table 1. 2018 cotton lint yield and nitrogen use efficiency (NUE) of two cropping systems in Lamesa, TX. Mean values with the same letter within year are not significantly different at $P < 0.05$.

Nitrogen Management	**Cont. Cotton (CC)**	**CC, Rye Cover**
	----------------Lint yield (lb A^{-1})---------------	
Farm Practice (120 lb N/A)	641 bc	683 c
Preplant (+30 lb N/A)	808 a	830 b
Emerg + 3 wks (+30 lb N/A)	686 b	975 a
PHS + 2 wks (+30 lb N/A)	605 c	786 bc
P-value	0.001	0.009
	--------NUE, over check (lb lint lb N^{-1})------	
Farm Practice (120 lb N/A)	---	---
Preplant (+30 lb N/A)	5.59 a	4.90 b
Emerg + 3 wks (+30 lb N/A)	1.52 b	9.73 a
PHS + 2 wks (+30 lb N/A)	-1.18 c	3.44 b
P-value	0.0001	0.009

Table 2. 2019 cotton lint yield and nitrogen use efficiency (NUE) of two cropping systems in Lamesa, TX. Mean values with the same letter within year are not significantly different at $P < 0.05$.

Nitrogen Management	Cont. Cotton (CC)	CC, Rye Cover
	-----------------Lint yield (lb A^{-1})----------------	
Farm Practice (120 lb N/A)	845	924 b
Preplant (+30 lb N/A)	872	1118 a
Emerg + 3 wks (+30 lb N/A)	790	1001 ab
PHS + 2 wks (+30 lb N/A)	776	913 b
P -value	0.208	0.005
	--------NUE, over check (lb lint lb N^{-1})-------	
Farm Practice (120 lb N/A)	---	---
Preplant (+30 lb N/A)	0.90	6.47 a
Emerg + 3 wk (+30 lb N/A)	-1.85	2.57 ab
PHS + 2 wks (+30 lb N/A)	-2.30	-0.38 b
P -value	0.121	0.021

CONCLUSIONS

The inclusion of a rye cover crop into a cotton monoculture system will result in the need for supplemental N fertilization to reduce the yield drag associated with N immobilization. Timing of that application is essential to increase yield, as our results indicate supplemental N fertilization preplant or at emergence plus three weeks will significantly increase yield compared to the control in conservation management systems. Traditional extension recommendations suggest supplemental N fertilization should be applied later in the growing season, generally around pinhead square, but our results indicate that would be too late in the growing season to see the benefit. Questions remain regarding the benefits of supplemental N fertilization in conventional cotton cropping systems without a cover crop. Additional research regarding the economics of these supplemental N fertilizations should be evaluated to determine if economic benefits exist given the yield increases.

ACKNOWLEDGEMENTS

This work was partially supported by Texas State Support – Cotton Incorporated and the Texas A&M AgriLife Strategic Initiative Fellowship in Water and Soil Health. The authors are grateful to Dustin Kelley, and Drs. Lewis and Keeling Research Groups for their assistance.

WORKS CITED

Lewis, K.L., J.A. Burke, W.S. Keeling, D.M. McCallister, P.B. DeLaune, and J.W. Keeling. Soil benefits and yield limitations of cover crop use in Texas High Plains Cotton. Agron. J. 110:1616-1623.

Burke, J.A., K.L. Lewis, G.L. Ritchie, J. Moore-Kucera, P.B. DeLaune, and J.W. Keeling. Temporal variability of soil carbon and nitrogen in cotton production on the Texas High Plains. Agron. J. 111:2218-2225.