NUTRIENT CYCLING FOLLOWING COVER CROP TERMINATION IN TEXAS COTTON PRODUCTION

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ABSTRACT

The Southern High Plains (SHP) region of Texas is one of the largest cotton-producing regions in the United States. Climatic conditions and wind erosion hinder cotton production, but attempts have been made to adopt conservation management practices like cover crops and crop rotations to limit these effects. Conservation management practices can reduce a soil's susceptibility to wind erosion, but their adoption has been limited on the SHP due to producers' concerns regarding yield reductions. Previous research in the region has shown that the yield reduction is likely not caused by water usage but by nitrogen (N) availability. This study sought to evaluate the impact of cropping system management and N fertilization on cotton lint yield and gross margins. A field experiment was implemented in 2014 and the observations presented here were from 2018-2020 at the Agricultural Complex for Advanced Research and Extension Systems (Ag-CARES) in Lamesa, TX. Cropping systems consisted of 1) continuous cotton, conventional tillage, winter fallow (CC); 2) continuous cotton, no-tillage, rye cover crop (CCRC); and 3) cotton-wheat-fallow rotation (CWR). Nitrogen fertilization strategies consisted of 1) farmer's practices (FP, 120 lb N acree^{-1}); 2) farmer's practice plus 30 lb N acre^{-1} applied at preplant (PPN, 150 lb N acre^{-1}); 3) farmer's practice plus 30 lb N acre^{-1} applied at post-emergence plus two weeks (PEN, 150 lb N acre^{-1}); and 4) farmer's practice plus 30 lb N acre^{-1} applied at pinhead square plus two weeks (PHSN, 150 lb N acre^{-1}). Results indicated significant increases with the adoption of conservation cropping systems (CCRC and CRW) and N applied at PPN or PEN compared to the CC system with the greatest increases in yield in the CWR system regardless of N fertilization strategy. Gross margins followed a similar trend. Supplemental N fertilization did not benefit cotton lint yield in the CWR rotation. These results indicate that microbes have adequate time to mineralize the organic material following wheat harvest and before cotton planting 11 months later in the fallow period. However, the increase in cotton lint yield with N applications earlier in the growing season with the CCRC system indicates that immobilization of inorganic N by microbes during cover crop decomposition can potentially limit yield in this system. Adopting conservation management practices will rely on adequate nutrient management to maintain yields and minimize the potential yield gap.

INTRODUCTION

Texas annually produces approximately 40% of the annual U.S. cotton crop, making it the largest cotton-producing state (USDA-NASS, 2017). In the Texas High Plains, where most of the state's cotton is produced, limited rainfall and extreme spring winds can severely impact production. Cotton producers can reduce their susceptibility to wind erosion with no-tillage and cover crops. However, producers are concerned that cover crops will compete for limited soil water and reduce cotton yields. Prior research near Lamesa, TX, shows that cover crop water use is likely not the principal factor causing the yield decline in conservation cropping systems (Burke et al., 2021; 2022). Instead, N immobilization by the cover crops is likely causing the cotton yield reductions. Altering N fertilization timing to earlier in the growing season provides an opportunity to minimize the impact of N immobilization. This experiment aimed to determine the impact of N fertilization timing on cotton lint yield following a cover crop.

MATERIALS AND METHODS

Site description and experimental design

The study was arranged as a split-plot design replicated three times with cropping system serving as the main plot and nitrogen fertilization timing serving as the subplot. Cropping systems were demonstrated near Lamesa, TX at the Agricultural Complex for Advanced Research and Extension Systems (Ag-CARES), a cooperative research site between the Texas A&M AgriLife Research and Extension Center in Lubbock, TX and the Lamesa Cotton Growers. The cropping system treatments included: 1) continuous cotton, conventional tillage, winter fallow (CC); 2) continuous cotton, no-tillage, with a rye (*Secale cereal* L.) cover crop (CCRC); and 3) a cotton-wheat (*Triticum aestivum*) -fallow rotation (CWF). The cropping systems were established in 2014 and have been continuous since then. Cotton was planted in May and harvested between October and November of each year. In the CCRC system, the rye cover was planted following cotton harvest and terminated prior to cotton planting in late-March to mid-April. In CWF, wheat was harvested following cotton harvest and then harvested in June. Following wheat harvest, the remaining stubble remained in the field until cotton planting the following year.

The nitrogen fertilizer treatments included: 1) farmer practice (FP) which consisted of 120 lb of N applied at four equal applications during the growing season through fertigation; 2) FP + 30 lb N applied approximately two weeks prior to cotton plant (PPN); 3) FP + 30 lb N applied three weeks after cotton emergence (PEN); and 4) FP + 30 lb N applied at two weeks after cotton reach pinhead square (PHSN). All N fertilizer was applied as 32-0-0.

Calculations and statistical analysis

Analysis of variance for all parameters was calculated using a randomized complete split-plot design with three replications (PROC GLIMMIX, SAS 9.4, 2015). Means of treatment effects were compared among treatments using Fisher's least significant difference (LSD) at alpha level = 0.05 for all analyses.

RESULTS AND DISCUSSION

Cotton Production

There was a significant increase in cotton lint yield with the adoption of cover crops and crop rotations compared to the CC system (Table 1). On average, there was a 23.3 and 50.4% increase in lint yield with the CCRC and CWR systems compared to CC, respectively. In the CCRC system, there was an 18% yield increase with the PPN and PEN fertilization strategies, indicating earlier applications following a cover crop resulted in more cotton lint. The same trend was not observed in the CWF system, indicating that supplemental N did not increase cotton lint yield compared to the FP at any application timing. The increases in the CCRC system were likely caused by the supplemental N fertilization aiding in the decomposition of the cover crop residues and minimizing potential N immobilization by soil microbes. The current Texas A&M AgriLife Extension Service fertilization recommendation following cover crops is an additional 30 lb of N/acre applied at PHSN. This recent study shows that N application timing would be too late to see maximum benefit in our systems.

Table 1. Average cotton production (2018-2020) in different cropping systems and nitrogen fertilization strategies. Continuous cotton, conventional tillage, winter fallow (CC); continuous cotton, no-tillage, rye cover crop (CCRC); cotton-wheat-fallow rotation (CWF); farmer's practice (FP); preplant (PPN); post-emergence (PEN); pinhead square (PHSN); and average (AVG).

Cropping system	**Nitrogen fertilization strategy**				
	FP	**PPN**	**PEN**	**PHSN**	
	Lint yield (lint acre^{-1})				AVG
CC	723	787	715	683	727
CCRC	806	938	965	857	891
CWF	1,134	1,032	1,117	1,064	1,087
AVG	888	919	932	868	

Gross Margins

Gross margins followed a similar pattern as cotton production, where there were 65.5 and 77.1% increases in potential profits with the CCRC and CWF systems compared to CC, respectively. The greatest increases with N fertilization strategies were at PPN and PEN for the CCRC system. The cost of supplemental N did not decrease potential profits in any of the CCRC systems. Conversely, supplemental N decreased profitability in the CWF systems compared to CC.

Table 2. Gross margins (2018-2020) in different cropping systems and nitrogen fertilization strategies. Continuous cotton, conventional tillage, winter fallow (CC); continuous cotton, no-tillage, rye cover crop (CCRC); cotton-wheat-fallow rotation (CWF); farmer's practice (FP); preplant (PPN); post-emergence (PEN); pinhead square (PHSN); and average (AVG).

Cropping system	**Nitrogen fertilization strategy**				
	FP	**PPN**	**PEN**	**PHSN**	

			Gross margins ($ acre^{-1})		AVG
CC	434	489	441	420	336
CCRC	489	591	608	536	556
CWF	609	575	610	587	595
AVG	511	552	553	514	

CONCLUSIONS

Cover cropping is an important tool in conservation agriculture, but the consequences of their use are poorly understood, especially in semi-arid ecoregions. This has likely impacted the broadscale adoption of cover cropping. We have demonstrated that cover crop biomass remains relatively recalcitrant throughout a cotton growing season and can potentially immobilize inorganic N in cotton following cover crop termination. Further understanding of the N dynamics following cover crop termination in semi-arid cropping systems is essential to reducing producers concerns and maximizing their utility in cotton production. Future studies should examine the timing of N fertilizer applications in conservation management systems for synergistic nutrient availability, productivity, and sustainability.

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