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

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Abstract

Conservation management practices have the potential to reduce wind erosion and stimulate ecosystem services, but lingering concerns regarding water-use and nutrient immobilization may limit their adoption on the Texas High Plains. Two studies were initiated in Lamesa, TX to determine the impact of conservation management practices on water availability and nutrient immobilization. The first, compared three continuous cotton (*Gossypium hirsutum*) cropping systems: 1) conventional tillage, winter fallow (CT), 2) no-tillage with rye cover (R-NT), and 3) no-tillage with a mixed species cover. The second, compared a conventional tillage, winter fallow (CC) system to a conservation tillage with rye cover (CCRC) system under different N management systems: 1) farm practice, 2) additional N applied preplant, 3) additional N applied at emergence plus 3 weeks, and 4) additional N applied at pinhead square plus 2 weeks. Initial results indicated cover crops do not limit water availability compared to CT and can enhance in-season water availability. Additional results suggest supplemental N fertilization applied preplant can increase yield compared to the other N fertilization strategies. Additional research is needed to see if the trend in supplemental N fertilization is consistent during years with variable precipitation.

Introduction

Conventional tillage practices and monoculture crop production on the semi-arid Texas High Plains where water resources from the limited Ogallala Aquifer have led to concerns about diminishing soil health. The extensive use of these practices can contribute to wind erosion; however, wind erosion potential can be significantly reduced with the adoption of conservation management practices like cover crops and no-tillage. Cotton producers are concerned with the affect cover crops might have on water storage and nutrient availability which could reduce yields on their subsequent cotton crop.

Materials and Methods

Site description and experimental design

Management practices being demonstrated include: 1) conventional, winter fallow; 2) reduced tillage (no-till) - rye (*Secale cereal* L.) cover crop; and, 3) reduced tillage (no-till) – mixed species cover crop. Mixed cover crop species included hairy vetch (*Vicia villosa* Roth), radish (*Raphanus sativus* L.), winter pea (*Pisum sativum* L.), and rye. Conventional tillage and reduced tillage with rye cover crop treatments were established in 1998 and the mixed species cover was seed in 2014 in 8 of 16 rows of the rye cover crop plots. In 2019, each plot was split into 8-row plots to include a nematode resistant cotton variety (DP 1747 NR B2XF). Cover crops were planted using a no-till drill on 2 December 2014, 4 November 2015, 12 December 2016, 17 November 2017, 4 December 2018, and 21 November 2019 and were chemically terminated 10 April 2015, 11 March 2016, 3 April 2017, 27 March 2018, and 9 April 2019 using Roundup PowerMAX (32 oz/acre). Prior to termination, above ground biomass of cover crops were harvested from a 1 m^2 area to calculate herbage mass (dry weight basis), nitrogen (N) uptake, and C:N ratios. Soil core samples were collected following cover crop termination each year to a depth of 24 inches from each plot and analyzed for total C and N, organic C, nitrate-N, Mehlich III extractable macronutrients, and sodium (Na), and pH and electrical conductivity (EC). Additional samples were collected at this time to a 6-inch depth and analyzed using the Soil Health Test. After soil sampling, cotton (DP 1321 B2RF) was planted 13 May 2015, 24 May 2016, 5 May 2017, (DP 1646 B2XF) 15 May 2018, and 19 May 2019 (DP 1747 NR B2XF and DP 1646 B2XF) at a seeding rate 53,000 seed/acre. Cotton was harvested on 28 October 2015, 22 November 2016, 7 November 2017, 19 November 2018, and 28 October 2019. After cotton harvest the no-till plots were drilled with cover.

A second trial was initiated in 2018 to evaluate the effect of N fertilizer application time on lint yield of cotton (DP 1522 B2XF) following a rye cover crop (CCRC), in rotation with wheat, 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 (described above); 2) additional 30 lb N/A applied at preplant; 3) additional 30 lb N/A applied three weeks after emergence; and, 4) additional 30 lb N/A applied at pinhead square plus 2 weeks. This research serves as preliminary data to help explain yield reductions following a rye cover crop. Cotton in this trial was defoliated on 3 October 2018 and October 2019, and harvested 17 November 2018 and November 2019. Soil moisture measurements were collected via neutron attenuation with access tubes installed within each plot to a depth of approximately 140 cm. Measurements were taken at 20-cm increments every two weeks throughout the year beginning in March 2015 unless rainfall inhibited our ability to get into the field.

Calculations and statistical analysis

Analysis of variance for all parameters was calculated using a randomized complete block 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 = 0.05 for all analyses.

Results and Discussion

Long-term soil health management system

Cotton lint yield ranged from 725 to 1,236 kg lint ha^{-1} from 2015-2019 (Fig. 1). There were no significant differences between treatments in 2015, 2018, and 2019, but significant differences in 2016 and 2017. In both 2016 and 2017, CT yielded significantly greater lint compared to R-NT, but not M-NT. The differences in yield are most likely due to cover crop biomass production, as 2016 and 2017 saw greater than 4,000 kg of biomass produced by the rye cover (Fig. 2). The variability in cotton yield with following conservation management practices causes concerns for west Texas cotton producers considering no-till and cover crop adoption.

Cotton producers concerns with the adoption of conservation management practices center around limited moisture or nutrient immobilization following cover crop termination. While cover crops do utilize soil moisture for growth during the conventional fallow period, they more rapidly replenish soil moisture during spring rainfall or irrigation events and capture more soil moisture during the active cotton growth season compared to the conventional tillage, winter fallow system following termination (Fig. 4.). It does not appear that there is limited water availability following cover crop termination prior to planting or during the cotton growing season.

Cover crop herbage production ranged from 2,015 to 5,217 kg herbage ha^{-1} from 2015-2019 (Fig. 2). Significant differences between R-NT and M-NT existed in 2015, 2017, and 2019, but did not exist in 2016 and 2018. In 2015 and 2017, R-NT produced significantly greater biomass than M-NT, but the trend was reversed in 2019. The reversal was most likely to due to a poor-quality variety of rye used in the M-NT plots in 2019. The increase in biomass production has also resulted in significant increases in SOC for the R-NT and M-NT plots compared to CT (Fig. 3). Fertilization practices were originally developed for conventional tillage, winter fallow cotton production systems and with the adoption of conservation management practices like cover crops and no-tillage, cotton fertilization practices need to be reevaluated. The increase in C from the cover crop biomass must be balanced with additional N fertilization. If the C is not balanced with additional N, then immobilization would occur as the microbes will outcompete the cotton for N.

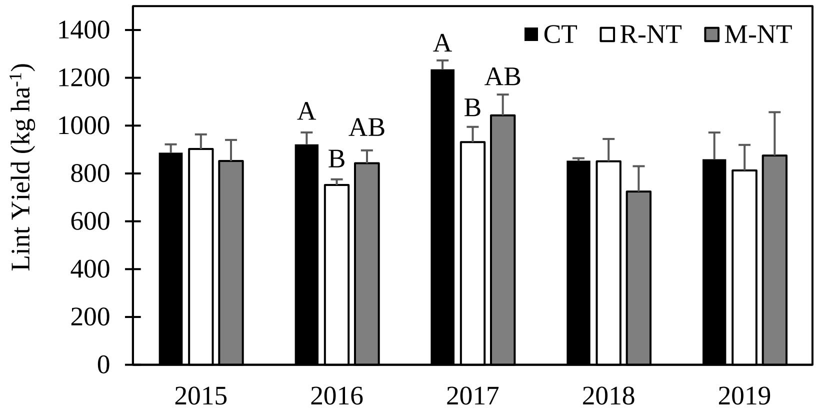

Figure 1. Cotton lint yield from 2015 – 2019 under different management practices. Conventional tillage winter fallow, no-tillage mixed cover, and no-tillage rye cover are denoted as CT, M-NT, and R-NT, respectively. Mean concentrations followed by the same letter within year are not different at *P*<0.05 by Fisher's protected LSD. The vertical bars represent the standard error of the mean.

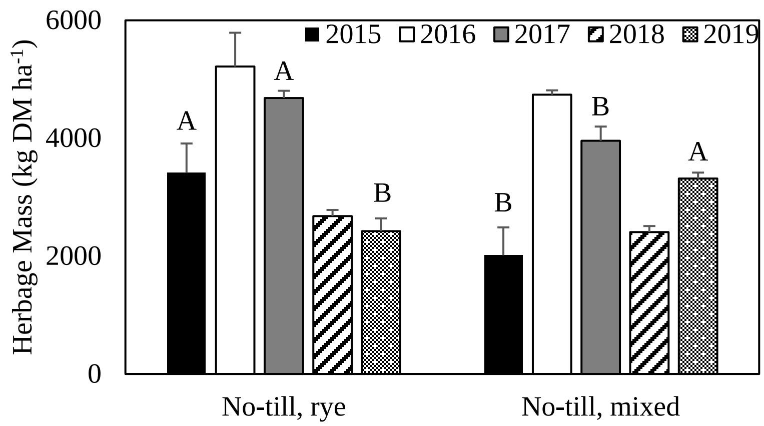

Figure 2. Cover crop herbage mass production for rye and a mixed species cover from 2015 – 2019. Mixed species cover included hairy vetch (*Vicia villosa* Roth), Austrian winter field pea (*Pisum sativum* L.), rye (*Secale cereal*) and radish (*Raphanus sativus* L.). Mean concentrations followed by the same letter within year are not different at *P*<0.05 by Fisher's protected LSD. The vertical bars represent the standard error of the mean.

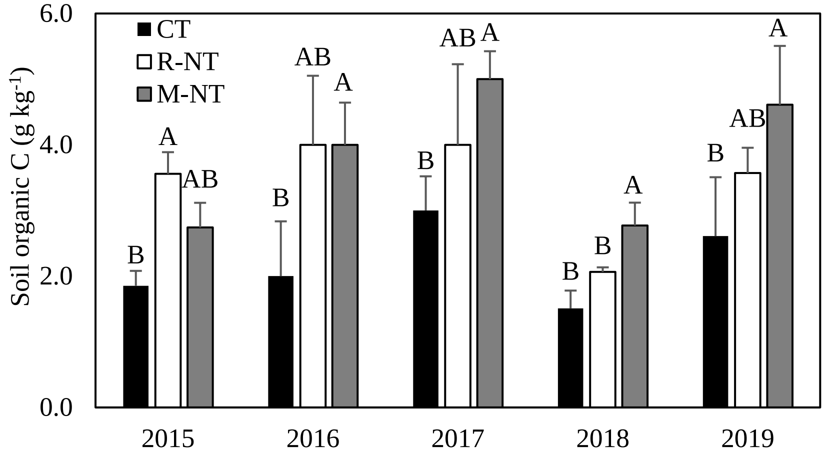

Figure 3. Soil organic C under different management practices. Mean concentrations followed by the same letter within year are not different at *P*<0.05 by Fisher's protected LSD. The vertical bars represent the standard error of the mean. Conventional tillage winter fallow, no-tillage mixed cover, and no-tillage rye cover are denoted as CT, M-NT, and R-NT, respectively.

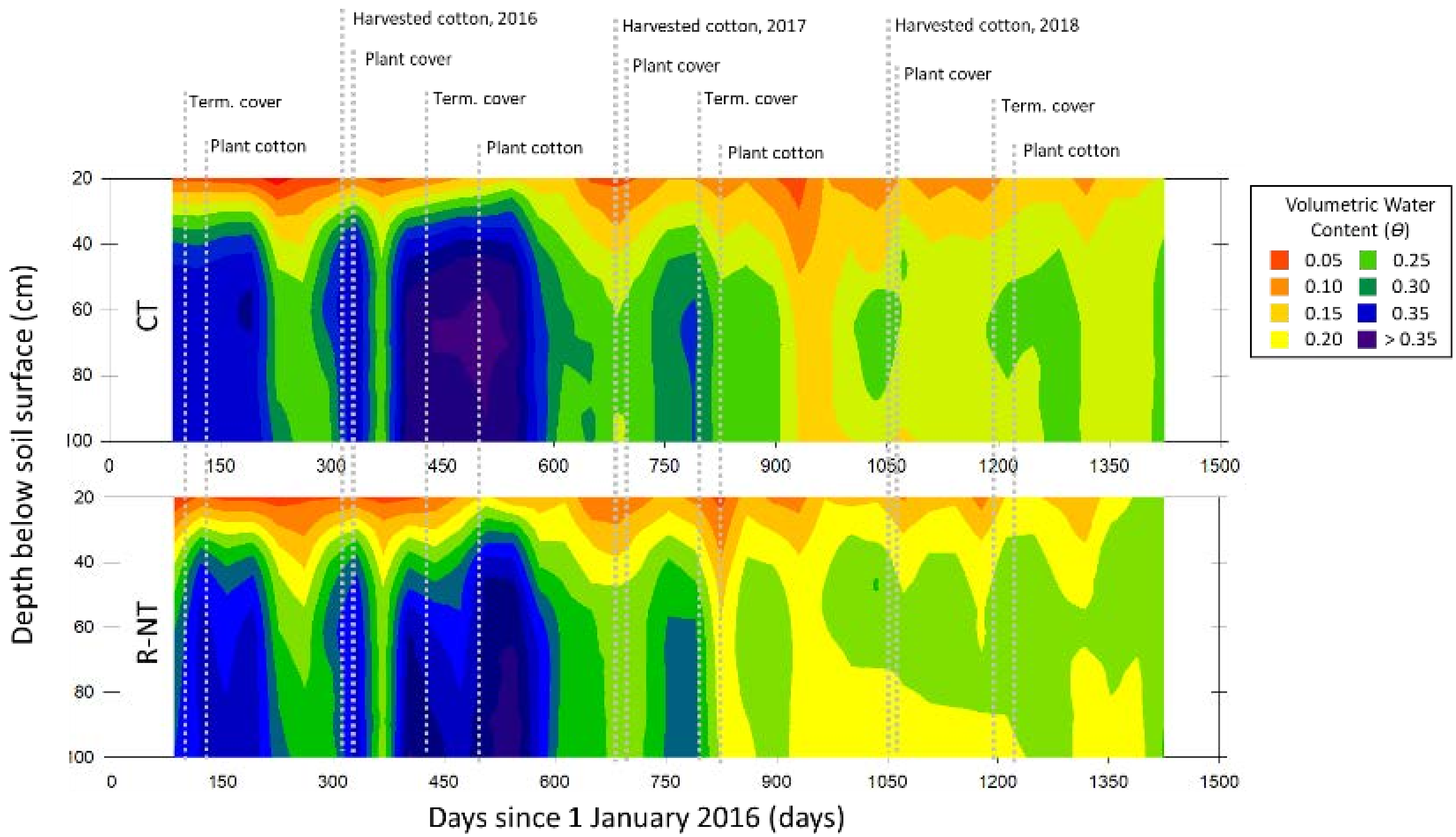

Figure 4. Soil moisture at depth in 20-cm increments to 100 cm below the soil surface beginning 1 January 2016 between conventional tillage, winter fallow and no-tillage, rye cover. Agronomic management practices were overlaid for simplicity. Conventional tillage winter fallow and no-tillage rye cover are denoted as CT and R-NT, respectively.

Nitrogen fertilization in conservation management systems

Cotton lint yields were generally greater in CCRC than CC in 2018 and 2019 (Fig. 5, 6). Under CC in 2018, additional N applied preplant resulted in significantly greater yield compared to the other N fertilization practices. However, under CCRC, additional N applied at emergence plus 3 weeks resulted in the greatest yield followed by a preplant addition of N. In 2019, there was no difference in yield following different N management practices for CC. In CCRC, the addition of N preplant resulted in significantly greater yield compared to the other treatments. The addition of N preplant in comparison to the traditional farm practice and supplement N applied later in the season is most likely due to the amount of N needed to decompose the additional C from the cover crop or residual cotton biomass from the previous season.

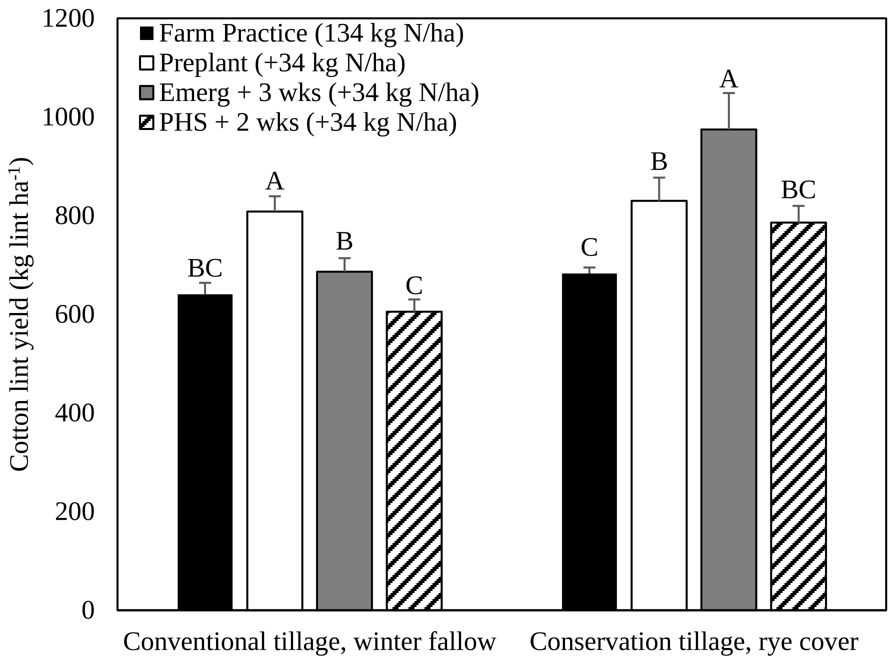

Figure 5. Cotton lint yield from harvest 2018 following different N application timings. Mean concentrations followed by the same letter within year are not different at *P*<0.05 by Fisher's protected LSD. The vertical bars represent the standard error of the mean. Additional 34 kg N/ha applied three weeks after emergence, and additional 34 kg N/ha applied at pinhead square plus 2 weeks are denoted as Emerg + 3 wks, and PHS + 2 wks, respectively.

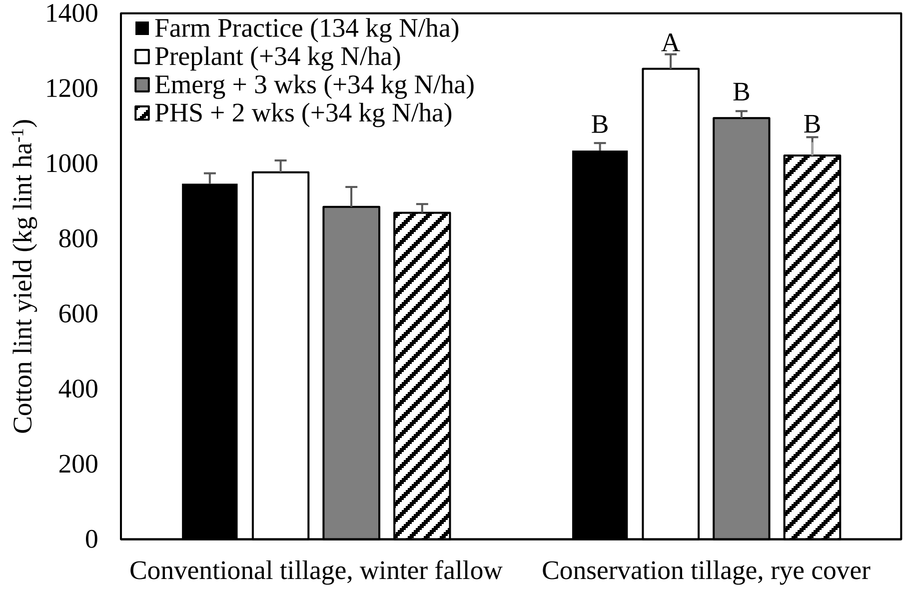

Figure 6. Cotton lint yield from harvest 2019 following different N application timings. Mean concentrations followed by the same letter within year are not different at $P<0.05$ by Fisher's protected LSD. Note what each of the abbreviations means. The vertical bars represent the standard error of the mean. Additional 34 kg N/ha applied three weeks after emergence, and additional 34 kg N/ha applied at pinhead square plus 2 weeks are denoted as Emerg + 3 wks, and PHS + 2 wks, respectively.

Conclusion

Conservation management practices reduce a soils susceptibility to wind erosion, but farmers have concerns regarding their potential to reduce yields from water use and N immobilization. Evidence does not support that water is limited yield following a winter cover crop but increase C production from the cover supports the idea of N immobilization potential reducing cotton yields in conservation systems. These studies highlight the important of supplemental N fertilization following cover crop termination and prior to planting cotton as a way to not only decrease yield loss potential, but to yield greater lint than from traditional fertilizer applications. Additional research is needed to better understand if these yield benefits can be replicated in dryland cropping systems.

Acknowledgements

This research was partially supported by Cotton Incorporated and the Texas A&M AgriLife Strategic Initiative Assistantship in Water and Soil Health. We thank Dustin Kelley, Ray White, Brice Delong, and Justin Spradley for their assistance.