IMPACT OF TILLAGE, COVER CROPPING AND NITROGEN TIMING ON SOIL CARBON AND NITROGEN DYNAMICS IN TEXAS SOUTHERN HIGH PLAINS COTTON

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ABSTRACT

Cover cropping and no tillage are the most common conversation practices in the Texas Southern High Plains (TSHP) region. However, less than a quarter of cultivated acres in the region utilize these practices. Concerns over cover crop nutrient and water use, yield decline and increased cost are common barriers to adoption for TSHP producers, despite potential benefits such as reduced wind erosion and increased soil organic matter. For these conservation practices to be successful, adjustments in other management practices may be necessary to account for factors such as increased nitrogen (N) demand of cover crops. Adjustment of N application timing could compensate for this by supplying more N earlier in the season to offset N immobilization during cover crop decomposition. Here, we investigate the impact of N rate and timing on soil carbon (C) and N dynamics in conventionally tilled-winter fallow, no-till-winter fallow and no-till with wheat cover cotton (*Gossypium hirsutum*) cropping systems. Our results indicate that splitting N between pre-plant and in-season side dress application positively impact cotton yield, while no-till with wheat cover did not negatively impact cotton yield and significantly increased soil organic carbon seven years after implementation. Our data adds to the varying results for cover cropping in the region, having increased cotton lint yield in this case, but resulting in no difference or reduced yield in other cases. When attempting to implement cover crops or no-till in their operations, producers should consider benefits and drawbacks to conservation practices for their specific circumstance. However, adjustments in other practices, such as N management could be necessary for successful implementation on their farm.

INTRODUCTION

Conservation practices in semi-arid environments can have varied effects on cotton production. Low rainfall and relatively low inherent soil fertility in the semi-arid TSHP has led to low adoption rates of conservation practices due to concerns over cover crop water use and nutrient availability. Previous research has indicated conservation practices generally have a negative or neutral impact on cotton lint yields but contribute positively to other parameters such as soil organic C (SOC) (Lewis et al., 2018). Although reduced yields are a potential drawback to conservation practices, increasing SOC can provide benefits such as increased water storage, soil stability and a slow-release nutrient source (Gregorich et al., 1994; Lehmann et al., 2020; Weil & Magdoff, 2004), which may provide system benefits after medium to long term implementation. Nitrogen management may mitigate some negative effects associated with the implementation of conservation practices, such as nutrient immobilization from cover crop decomposition, by compensating for immobilization during decomposition through additional N application up front or apply N after immobilization has slowed.

MATERIALS AND METHODS

To investigate the impact of N timing in conservation and conventional cotton systems in the TSHP, a study was conducted at the Texas A&M AgriLife Research and Extension Center in Lubbock, TX during the 2021 and 2022 growing seasons. Systems included no-till cotton with wheat cover crop, no-till cotton with winter fallow and conventionally tilled cotton with winter fallow, with no-till and conventionally tilled systems representing conservation and conventional practices, respectively. Nitrogen was applied at 168 kg per hectare (0 kg per hectare for control) at the following application timings: 100% preplant (PP), 100% side-dressed in-season (SD), 40% preplant and 60% side-dressed in-season (SPLIT) and 100% preplant with N stabilizer (PPS). System and N treatments had been in place for 4 years prior to 2021. Study design was a randomized complete block arranged as a split-plot. Plots were 4 rows (1 m spacing) by 15 m in length. The main-plot was the tillage regimes with N timing as the split plot. Cotton variety DP 2143 was planted at 133K seeds per ha. Soil samples were collected prior to cotton planting each year and analyzed for nitrate-N, total N and SOC to a depth of 30 cm.
Data were analyzed using proc glimmix in SAS ver 9.4 and significance level α=0.05.

RESULTS AND DISCUSSION

Soil Nitrogen

Total profile soil NO_3-N was not significant between systems in 2021, however at the 20-30 cm depth CT was significantly greater than NT and NTW (Figure 1a.) Total profile N was also not significant in 2021, however NTW was significantly greater than CT and NT (Figure 1b.). In 2022 both total profile N and NO_3-N were significant, with CT having significantly greater NO_3-N than NT and NTW (Figure 1c.), and NTW having significantly greater TN than CT and NT (Figure 1d.). In 2022, data was also analyzed by N treatment. There were few differences among TN, with SD NTW having significantly greater profile TN than all other system/N combinations (Figure 2b.). There were several differences among N treatments in terms of total profile NO_3-N. Side-dress was significantly greater than all other N treatments for CT and NT systems, however was only different from control in the NTW system (Figure 2a.).

Inorganic N was likely greatest in the CT system because there were no cover crops to scavenge residual N over winter. However, it was likely that organic N from wheat cover in the NTW system contributed to greater total profile N in 2022, as well as TN at 20-30 cm in 2021.

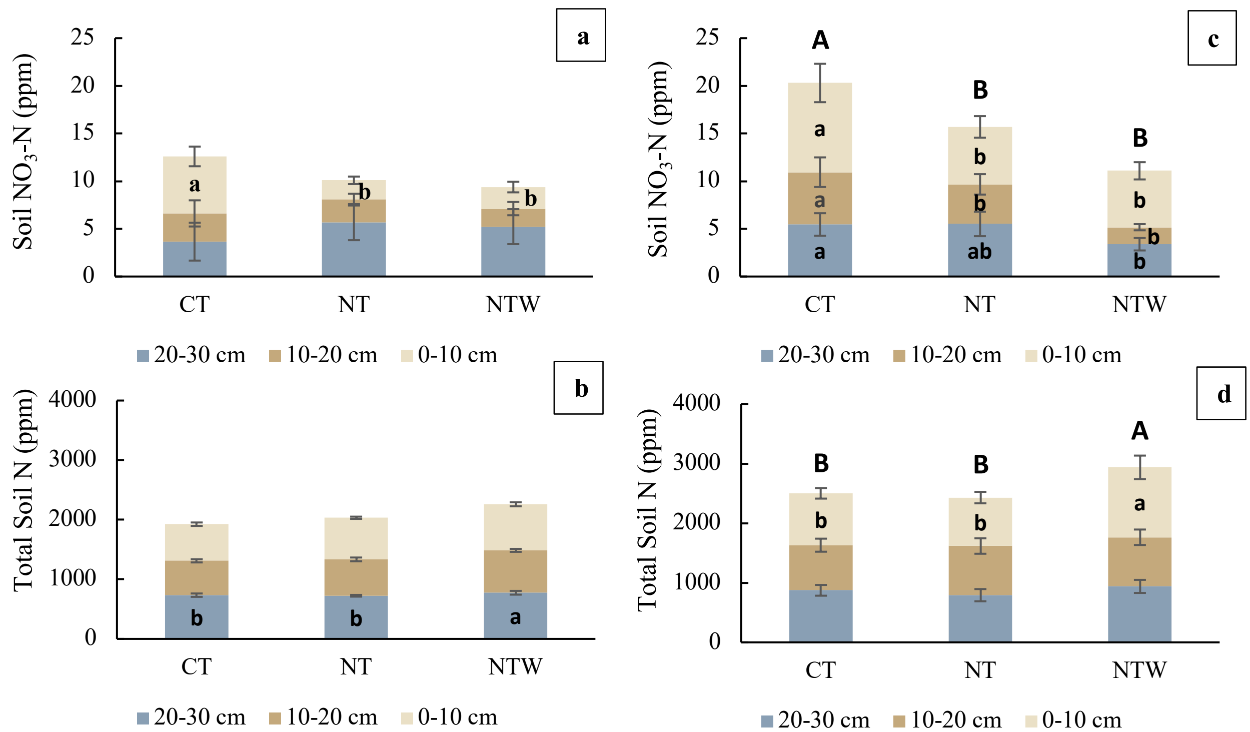

Figure 1. Soil NO_3-N and TN at 0-10, 10-20 and 20-30 cm depths in 2021 (a & b, respectively) and 2022 (c & d, respectively) averaged by system. Bars with different capital letters are different for the total profile within year ($p<0.05$), while bar segments with lower case letters are different within depth and year. Error bars are standard errors.

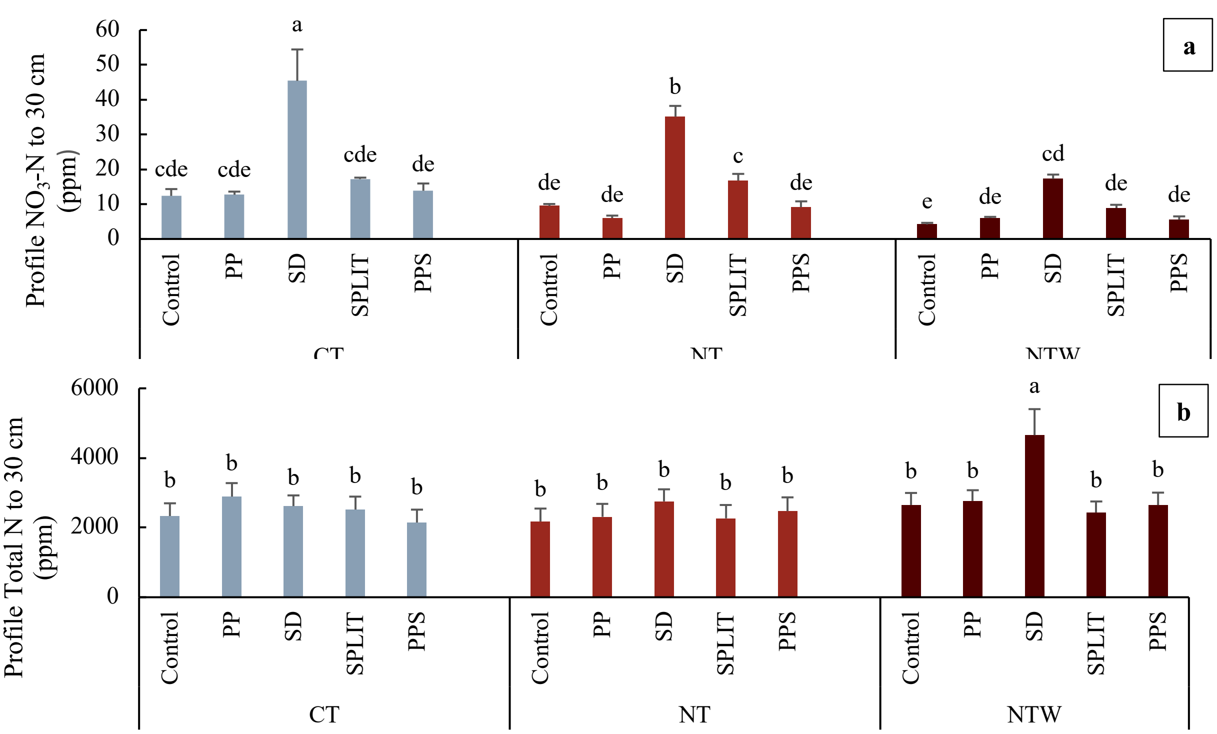

Figure 2. Profile NO_3-N (a) and total N (b) in 2022 averaged by N fertilization within system. Bars with different letters are significantly different ($p<0.05$). Error bars are standard errors.

Soil Carbon

Soil organic was significantly different between systems at 0-10 and 10-20 cm depths in 2021 (Figure 3.), representing 4 years after system implementation. At the upper depth NTW was significantly greater than CT and NT, however at the lower depth NTW was only different from CT. NTW was likely greater due to input from wheat cover crop biomass. Carbon dioxide emissions were slightly greater in the CT system compared to NT (data not show) which likely contributed to differences in SOC decomposition at the upper depth.

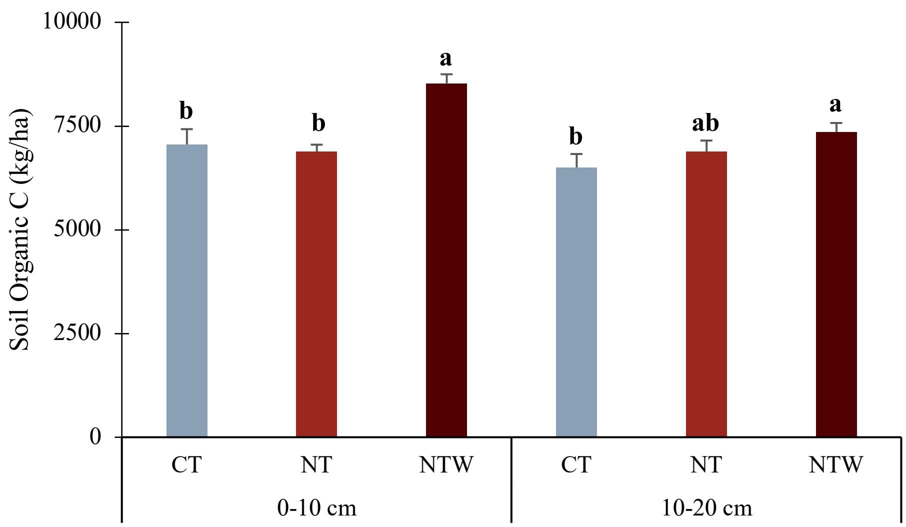

Figure 3. Soil organic carbon by system at 0-10 and 10-20 cm in 2022. Bars with different letters are significantly different ($p<0.05$) within depth. Error bars are standard errors.

Yield

System effects were only significant in 2021 with NT and NTW having significantly higher yields than CT (Figure 1a). Although this study was irrigated, drought in 2022 likely negated any differences between yields (Figure 1b). In 2021, residual soil organic N may have been mineralized late in the season, allowing for additional in season N and helping to increase cotton yield.

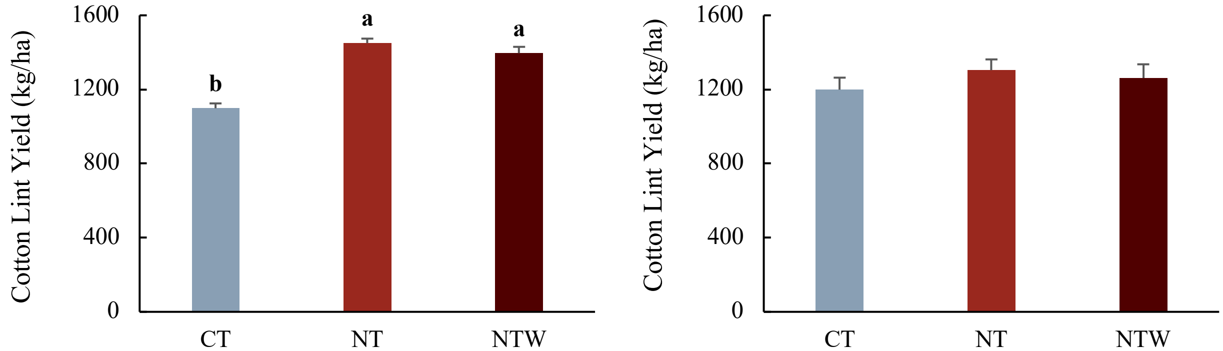

Figure 4. Cotton lint yield by system in 2021 (a) and 2022 (b). Bars with different letters are significantly different within year ($p<0.05$). Error bars are standard errors.

CONCLUSIONS

Here, we investigated the effect of cropping system and N timing on cotton yield and soil N and C parameters. Although NTW and NT reduced NO_3-N, they either increased or had no effect on cotton lint yield and SOC. In 2021, these conservation practices increased yield compared to CT, while in 2022 NTW increased TN compared to CT. This demonstrates that conservation practices can have positive impacts on cotton production in the TSHP, however other studies have demonstrated the potential for negative effects. Producers should make decisions based on their operation and production goals when considering the implementation of conservation practices in semi-arid regions such as the TSHP.

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