NUTRIENT CYCLING FOLLOWING COVER CROP TERMINATION IN TEXAS COTTON PRODUCTION

Joseph A. Burke and Katie L. Lewis
Texas A&M AgriLife Research, Lubbock, TX
joseph.burke@ag.tamu.edu (806) 746-6101

Jamie L. Foster
Texas A&M AgriLife Research, Corpus Christi, TX

ABSTRACT

Cotton producers on the Texas High Plains (THP) have not readily adopted conservation practices such as no-tillage and cover crops due to concerns regarding water availability and its subsequent impact on the proceeding cotton (*Gossypium hirsutum* L.) crop. However, prior research in the THP has shown that soil water availability was greater with the inclusion of cover crops compared to conventionally tilled cotton. A study was initiated into an existing experiment at the Agricultural Complex for Advanced Research and Extension Systems near Lamesa, TX. The objective of the study was to determine the decomposition rate and nutrient cycling potential of cover crops following termination. Treatments included: 1) conventional tillage, winter fallow (CT); 2) no-tillage, rye (*Secale cereal* L.) cover crop (NTR); and 3) no-tillage, mixed species cover crop (NTM). Mixed cover crop species included 10% hairy vetch (*Vicia villosa* Roth), 7% radish (*Raphanus sativus* L.), 33% winter pea (*Pisum sativum* L.), and 50% rye, by weight. Litterbags were installed at field-scale into the plots following cover crop termination on 27 March 2020 and collected periodically at 4, 8, 16, 32, 64, and 128 days after termination (DAT) during the growing season to determine biomass decomposition. Soil samples were collected along with the litterbags to determine inorganic nitrogen (N) fractions (nitrate and ammonium) and soil protein concentrations. Results indicated that approximately 75% of the terminated cover crop biomass was persistent in the field 128 days after termination. Soil N followed similar trends to biomass decomposition indicating that N may not immediately be available to the cotton crop following a cover crop in this semi-arid ecoregion. Soil protein and inorganic N concentrations peaked 8 and 16 DAT, respectively, before steadily decreasing for the rest of the study period. These results suggest N immobilization may serve as a viable culprit to the yield reductions observed following cover crops in Texas High Plains cotton production.

INTRODUCTION

Texas is the largest cotton producing state and annually produces approximately 40% of the US cotton crop (USDA-NASS, 2017). Within Texas, the High Plains region produces a majority of that cotton, but THP production can be significantly impacted by limited rainfall and wind erosion. 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 demonstrated that cover crop water use is likely not the principal factor causing the yield decline in conservation cropping systems (Burke et al., 2021).

Instead, it is likely that N immobilization by microorganisms mineralizing the cover crops is causing cotton yield reductions. The objective of this experiment was to determine cover crop biomass decomposition rates and N cycling following cover crop termination.

MATERIALS AND METHODS

Site description and experimental design

Management practices 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, and included: 1) conventional tillage, winter fallow; 2) no-tillage, rye (*Secale cereal* L.) cover crop; and 3) no-tillage, mixed species cover crop. Mixed cover crop species included hairy vetch (*Vicia villosa* Roth, 10%), radish (*Raphanus sativus* L. 7%), winter pea (*Pisum sativum* L., 33%), and rye (50%, by weight). Conventional tillage and no-tillage with a rye cover crop were established in 1998 and a mixed species cover was seeded in 2014 by splitting the 32 row plots into 16 rows within the rye cover crop plots. Cover crops were planted using a no-till drill on 21 November 2019 and were chemically terminated 27 March 2020 using Roundup PowerMAX (32 oz/acre). Prior to termination, above ground biomass of cover crops were harvested from a 9 ft^2 area to calculate herbage mass (dry weight basis), N uptake, and C:N ratios. Biomass from an additional 9 ft^2 sampling area was collected and transferred to 6- x 8-cm nylon litterbags at field scale to simulate decomposition *in-situ*. Litterbags were installed in triplicate into the single or mixed species cover crop plots on 27 March 2020 and collected at 4, 8, 16, 32, 64, and 128 DAT. At each collection date, soil samples were collected from directly beneath the litterbags to a depth of 6 inch and analyzed for soil proteins, nitrate, and ammonium (NO_3^- & NH_4^+). Cotton (DP 1646 B2XF) was planted on 19 May 2019 at a seeding rate 53,000 seeds $acre^{-1}$. Cotton was harvested on 31 October 2020. After cotton harvest the no-till plots were drilled with their respective cover crops.

Calculations and statistical analysis

Biomass decomposition was calculated by applying a natural log curve to the average of the litterbag weights by treatment remaining at a specific collection date following cover crop termination. Total inorganic N was calculated as the sum of NO_3^- and NH_4^+. Potential N availability was calculated by multiplying the amount of biomass produced by the percent N of the biomass. 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 level = 0.05 for all analyses.

RESULTS AND DISCUSSION

Biomass production and decomposition

There were no differences in biomass production, N concentration, potential N, and C:N ratio between the two cover crop systems (Table 1). Cover crop biomass production was consistent with results reported by Lewis et al. (2018) which reported to potentially reduce cotton lint yields. Hypothetically, if 100% of the biomass were to decompose within a given growing season, approximately 126-128 lb N A^{-1} would be available for the subsequent cotton crop. However, decomposition was limited following cover crop termination in 2020, resulting in ~78% biomass remaining 128 DAT (Fig. 1). These results indicate that only 28 lb N A^{-1} would be available for cotton growth during the entire 2020 growing season. This limited biomass mineralization could have resulted in N limitations as soil microorganisms immobilized N to complete their cellular functions.

Table 1. Cover crop biomass production, nitrogen (N) concentration, potential N, and C:N ratio of rye and mixed species cover crops terminated in 2020.

Cover crop	Biomass (lb A^{-1})	N (%)	Potential N (lb A^{-1})	C:N Ratio
Rye	4,131	3.1	128.0	13.3
Mixed	4,068	3.1	126.2	13.3

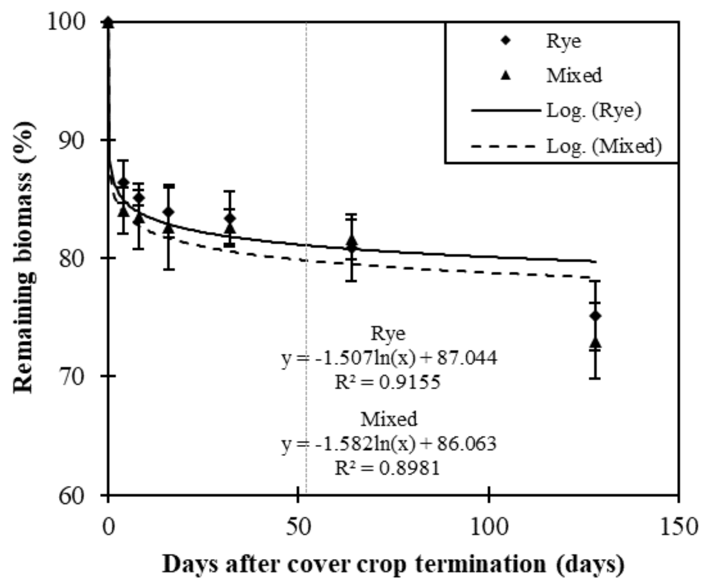

Figure 1. Biomass decomposition following rye and mixed species cover crop termination in 2020. The vertical dashed line represents cotton planting date.

Nutrient cycling

Following cover crop termination, soil inorganic N levels remained constant 0-8 DAT before increasing at 16 DAT (Fig. 2A). This increase in inorganic N at 16 DAT follows increases in soil proteins 8 DAT (Fig. 2B). Following termination, proteins are one of the first products to be released from the biomass, as those proteins are mineralized by soil microbes, they release soil inorganic N resulting in the increase in soil N observed at 16 DAT. After the peak at 8 DAT, soil protein levels decreased throughout the rest of the cotton growing season. Soil inorganic N levels were similar between 16 and 32 DAT, but significantly increased at 64 DAT. The increase in NO_3^--N and inorganic N observed at 64 DAT is likely due to N fertilization shortly after cotton planting. These results indicate that there is likely N immobilization early in the growing season following cover crop termination.

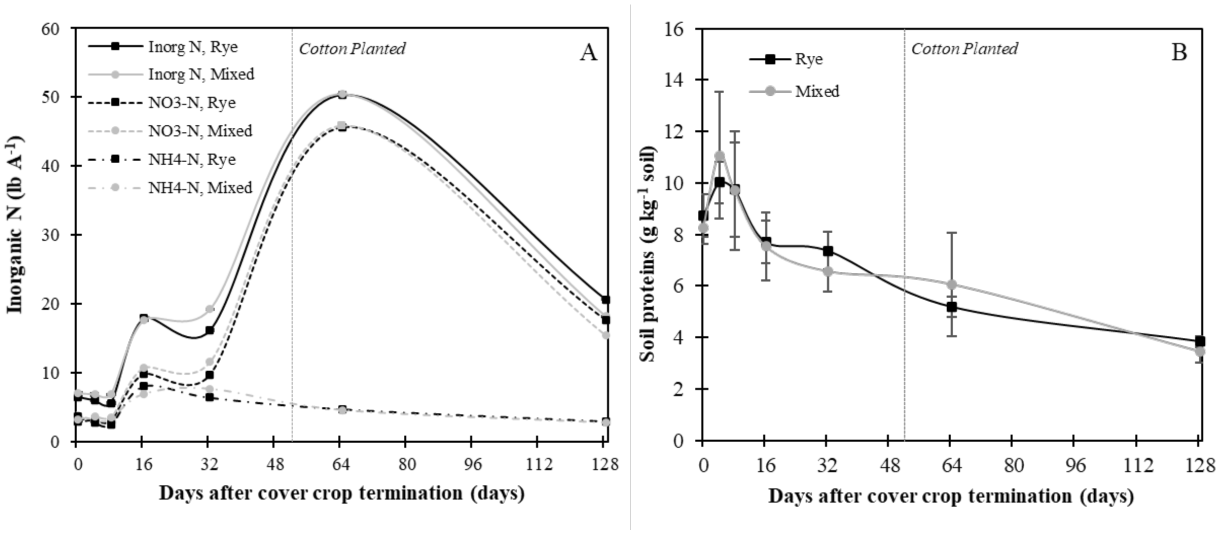

Figure 2. A) Inorganic nitrogen (N) consisting of nitrate (NO_3^--N) and ammonium (NH_4^+-N), and B) soil protein dynamics following rye and mixed species cover crop termination. The dashed vertical lines represent cotton planting.

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 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.

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 thank Dustin Kelley, and Drs. Lewis and Keeling Research Groups for their assistance.

REFERENCES

Burke, J.A., K.L. Lewis, G.L. Ritchie, P.B. DeLaune, J.W. Keeling, V. Acosta-Martinez, J.M. Moore, and T. McLendon. 2021. Net positive soil water content following cover crops with no tillage in irrigated semi-arid cotton production. Soil Till. Res. 208: 104869.

Lewis, K.L., J.A. Burke, W.S. Keeling, D.M. McCallister, P.B. DeLaune, and J.W. Keeling. 2018. Soil benefits and yield limitations of cover crop use in Texas High Plains cotton. Agron. J. 110: 1616-1623.

USDA-NASS. 2017. U.S. Department of Agriculture, National Agricultural Statistical Service, 2016 state agriculture overview: Texas. USDA-NASS. Washington, DC. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=TEXAS (accessed 24 Nov. 2017).