NITROGEN DYNAMICS FOLLOWING COVER CROPS IN TEXAS HIGH PLAINS COTTON

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Abstract

Adoption of conservation management practices by Texas High Plains cotton producers is limited by concerns regarding the impacts of cover cropping and no-tillage on their subsequent cash crop. One of these concerns focuses on the impact of cover crop biomass production on nitrogen (N) availability following cover crop termination. A study was initiated in Lamesa, TX to determine the impact of cover crop makeup on biomass decomposition and N cycling following termination in semi-arid cotton production. Treatments 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), radish (*Raphanus sativus* L.), winter pea (*Pisum sativum* L.), and rye. Litterbags were installed at field-scale into the plots following cover crop termination on 27 March 2020 and collected periodically during the growing season to determine biomass decomposition, inorganic N fractions, and soil protein concentrations. Results indicate more than 75% of the terminated cover crop biomass was persistent in the field 128 days after termination (DAT). Soil protein and inorganic N concentrations peaked 8 and 16 DAT, respectively, before steadily decreasing during the growing season. Soil N followed similar trends to biomass decomposition indicating that N may not immediately be available to the cotton cash crop following a cover crop in this semi-arid ecoregion. Further research is necessary to better understand the relationship between cover crop biomass mineralization and N cycling.

Introduction

Conservation management practices such as no-tillage and cover cropping have grown in popularity along with interest in sustainable agricultural production. Cover crops and no-tillage have been shown to increase nutrient cycling potential and water storage during the cropping season (Burke et al., 2019; 2021). Despite their benefits, adoption of conservation management practices is limited, especially in semi-arid regions. Commonly, producers' express concerns regarding cover crop water usage, costs, and N immobilization following termination. Previous studies have examined the economics and water usage of cover crops (Lewis et al., 2018; Burke et al., 2021). In this study, we sought to determine the rate of cover crop biomass decomposition following termination in a semi-arid long-term cotton cropping system.

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), 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 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 (0.84 kg active ingredient ha^{-1}). Prior to termination, above ground biomass of cover crops were harvested from a 1 m^2 area to calculate herbage mass (dry weight basis), N uptake, and C:N ratios. Biomass from an additional 1 m^2 sampling area was collected and transferred to 15- x 20-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 15 cm and analyzed for soil proteins, nitrate, and ammonium (NO_3^- &

NH_4^+). Cotton (DP 1646 B2XF), *Gossypium hirsutum*, was planted on 18 May 2020 at a seeding rate 21,500 seed hectare^{-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

Cover crop aboveground biomass production N content, and potentially available N were similar between the two treatments (Table 1). The mixed species cover biomass was dominated by rye with little growth of Austrian winter pea, hairy vetch, and radish despite the fact that rye only represented 50% of the mixed species cover seeding weight. This fact highlights the ability to reduce NRCS recommended seeding rates for the Texas High Plains Region without sacrificing the benefit of biomass production. The potentially available N from total mineralization of the cover crop biomass could provide significant amounts of N to the cotton cash crop. However, cover crop mineralization is limited by biotic and abiotic factors that impede decomposition and the subsequent release of N. Often, limited soil N causes microbes to immobilize available N inhibiting potential plant uptake.

Table 1. Cover crop biomass production, nitrogen (N) composition, and potentially available N of two cover crops grown at Ag-CARES in 2020. There was no significant difference in any parameter between cover crops.

Cover crop	Biomass (kg ha^{-1})	N (%)	Potential N (kg ha^{-1})
Rye	4,630	3.1	143.5
Mixed	4,560	3.0	136.8

Biomass decomposition (Fig. 1) followed similar trends for both single and mixed species cover crop treatments. There was rapid decomposition of the biomass at 4 DAT (approximately 15% of the total biomass) and the decomposition rate slowed to a nearly constant level around 8 DAT. This rapid loss of biomass likely resulted from the decomposition of low molecular weight compounds that have smaller C:N, like proteins and soluble carbon compounds. Cotton was planted at 48 DAT when more than 80% of the cover crop biomass was remaining in the field. This remaining biomass can protect emerged cotton seedlings from blowing dust and mulch the soil surface limiting evaporation. This remaining biomass might also cause microbes to immobilize limited inorganic soil N and impair early growth. After 128 DAT, approximately 75% of the biomass was remaining in both cover crop treatments. The slowing of biomass decomposition likely resulted from greater C:N of structural components like cellulose and lignin. This lingering biomass can immobilize soil N and impact cash crop growth during key physiological growth stages. Further research is necessary to understand N immobilization potential during the growing season so cotton producers can account for it in their fertility programs.

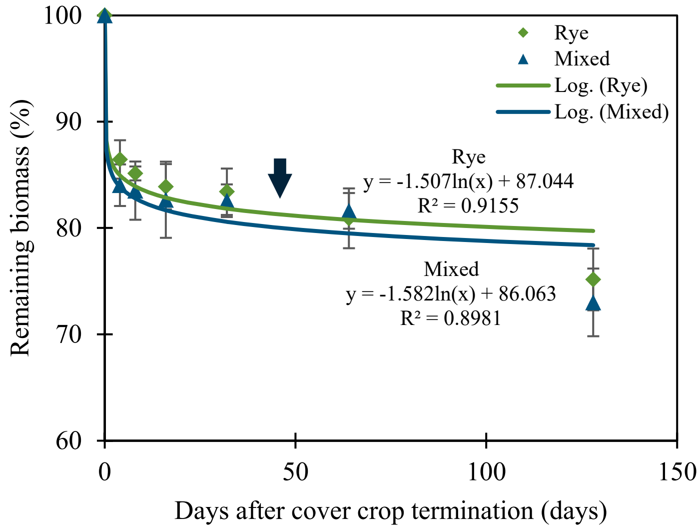

Figure 1. Cover crop biomass decomposition rate over time following termination on 27 March 2020 at AG-CARES, Lamesa, TX. Arrow indicates cotton planting date. There was no significant difference in decomposition rate between cover crops.

Soil protein concentrations peaked at 4 DAT immediately following cover crop termination and steadily decreased throughout the rest of the study and were not different between cover crop treatments (Fig. 2A). Soil proteins consist of organic N compounds resulting from the microbial degradation of soil organic materials, like cover crop biomass. An increase in soil proteins immediately following cover crop termination likely resulted from the decomposition of low molecular weight compounds like proteins which would increase the protein concentrations in the soil. The steady decline in soil proteins throughout the study follows a similar trend to the reduced decomposition of cover crop biomass. Inclusion of soil protein concentrations into biomass decomposition studies might be a useful tool in understanding biomass recalcitrance *in situ*.

Soil inorganic N concentrations were consistent following cover crop termination until 16 DAT when an initial peak was observed (Fig. 2B). Interestingly, this peak followed a similar peak observed in soil proteins at 8 DAT. This likely resulted from mineralization of organic N forms into inorganic NH_4^+ and nitrification of NH_4^+ into NO_3^-. This observation is further strengthened because NH_4^+ concentrations followed a similar trend as soil proteins, albeit delayed. Soil NO_3^- concentrations significantly increased at 64 DAT following the application of urea ammonium-nitrate (UAN, 32-0-0) fertilizer through fertigation. Following the fertilizer applications, it is impossible to separate the NO_3^--N associated with the fertilizer and that resulting from nitrification of mineralized cover crop biomass, a limitation of the current study.

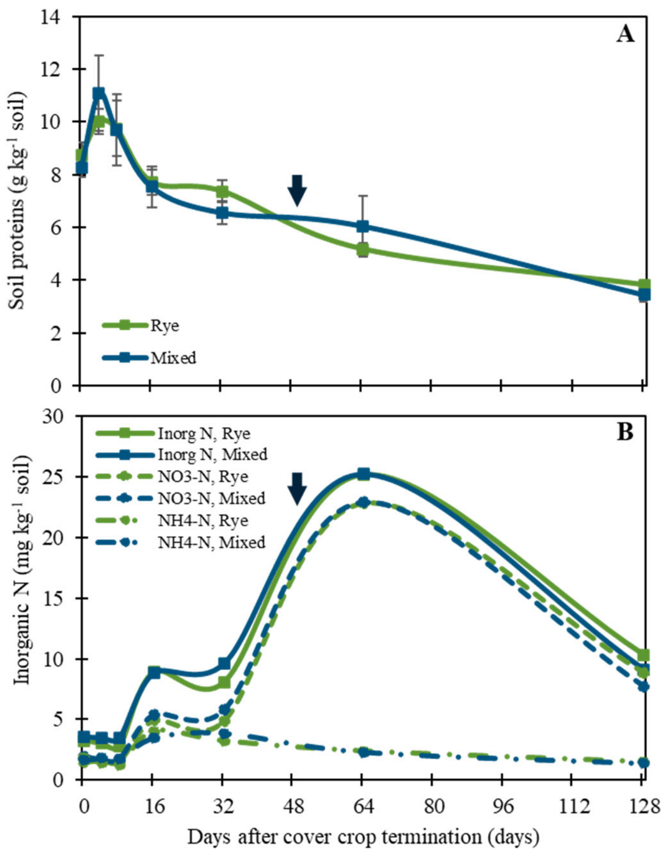

Figure 2. Soil protein (A) and Inorganic N (B) changes following cover crop termination at Ag-CARES in 2020. There was no significant difference in any parameter between cover crops. Arrows indicate cotton planting date.

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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