NITROGEN AVAILABILITY FOLLOWING COVER CROPS IN TX CROPPING SYSTEMS

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ABSTRACT

Cover crops have been heavily promoted to improve soil health and function in US agricultural productions systems. Within semi-arid environments, interest in cover crops continues to grow although several concerns hinder adoption. As soil water use by cover crops is often a chief concern, nutrient availability to subsequent crops is also a concern. The objective of this study was to measure soil chemical and biological properties following various cover crops in a continuous cotton system under rainfed conditions. The study was conducted at the Texas A&M AgriLife Chillicothe Research Station with the following treatments: 1) conventional till; 2) no-till; and no-till with the following cover crops, 3) Austrian winter pea; 4) hairy vetch; 5) crimson clover; 6) wheat; and 7) multi-species mixture. Pea and vetch cover crops resulted in greater N accumulation and lower C:N ratios in the herbage mass. Soil nitrate was greater for Austrian winter pea and hairy vetch 6 weeks after termination compared to other treatments. Soil nitrate was not different between grass cover crop treatments and non-cover crop treatments. Trends for soil respiration were similar as observed with soil nitrate. Soil respiration in the upper 10 cm was greater for pea compared to non-cover crop treatments for each date Initial results found that N availability following cover crops was greater for legume cover crops and grass cover crops did not immobilize N in continuous cotton systems that received no inorganic fertilizer applications.

INTRODUCTION

Cover crops and crop rotation have been shown to enhance soil fertility, soil organic matter, and soil structure. Identification of cover crops that can be successfully established and terminated in time for nutrients to be available at key time points in crop growth cycles is critical for maximizing yields and reducing input costs. A global meta-analysis indicated that non-leguminous cover crops substantially reduced nitrate leaching into freshwater systems by 56% (Thapa et al., 2018). Furthermore, nonlegume-legume cover crop mixtures reduced nitrate leaching as effectively as nonlegumes and significantly more than legume cover crops. Seman-Varner et al. (2017) suggested that a legume cover crop may effectively scavenge poultry litter nitrogen in low nitrogen systems and result in increased residual nitrogen availability over time. As cover crops may affect the availability of nitrogen, research has shown that cover crops can have detrimental effects on subsequent cash crop yields in semi-arid environments (Nielsen et al., 2016; Holman et al., 2018). In the Texas Rolling Plains, research has shown that cover crops have not negatively affected cotton lint yields (DeLaune et al., 2012; DeLaune et al., 2020). Hence, research is warranted to better understand nutrient cycling in adverse climatic conditions that are common across the US Great Plains. The objective of this study was to measure soil chemical and biological properties following cover crops in a continuous cotton system in the Texas Rolling Plains.

MATERIALS AND METHODS

A study was initiated in Fall 2011 at the Texas A&M AgriLife Chillicothe Research Station near Chillicothe, TX. Historically, the study area had been under conventional tillage with various field crops. Results for this paper are based upon sampling in Spring 2017. Evaluated treatments included: 1) conventional tillage (CT); 2) no-till (NT); and NT with the following cover crops, 3) Austrian winter field pea (pea); 4) hairy vetch (vetch); 5) crimson clover (clover); 6) wheat; and 7) multi-species mixture (mix). Plots were 8 rows wide (1 m row spacing) and 12 m long and arranged in a randomized complete block design with four replicates. Conventional tillage consisted of an offset disc used in the fall and winter followed by bedding of rows. One in-season cultivation was conducted using a sweep plow. After cotton harvest in 2016, cover crops were planted using a NT drill 22 November 2016. Seeding rates for cover crops were 39.2 kg ha^{-1} for pea, 33.6 kg ha^{-1} for wheat and mix, and 22.4 kg ha^{-1} for clover and vetch. The mix consisted of 13.4 kg ha^{-1} cereal rye, 10.1 kg ha^{-1} wheat, 6.7 kg ha^{-1} pea, and 3.4 kg ha^{-1} vetch. Cover crops were chemically terminated on 20 April 2017. Cotton was planted on 30 May 2017 using a four-row vacuum planter.

Soil samples were collected 0 (20 April), 3 (9 May), and 6 (30 May) weeks after cover crop termination. Soil samples were collected using a 2.54 cm diameter soil core sampler at depths of 0-10 and 10-20 cm. Air dried soil was passed through a 2 mm sieve for analysis. A total of 2 g soil was extracted with 20 mL of 1N KCL. After 1 hr of shaking at 160 oscillations per minute, the extract was filtered through Whatman No. 42 filter paper into 20 mL plastic scintillation vials. The filtrate was analyzed using a Skalar flow analyzer for ammonium and nitrate (Keeney and Nelson, 1982; Dorich and Nelson, 1983). Mineralizable carbon (evolved CO_2, soil respiration) was determined as outlined by Franzluebbers (2016). A subset of soil samples was passed through a 4.75 mm sieve and 100 g of soil was weighed into a graduated glass bottle. Water was added to achieve 50% water-filled pore space. A 0.5 M NaOH alkali trap (10 mL) and a vial containing 10 mL of DI water to sustain humidity was added to the bottle, which was then placed in a 1 L glass jar and sealed for 72 hrs. After the incubation period, 0.5 N HCl was used to titrate the alkali solution to determine the amount of carbon dioxide evolved.

RESULTS AND DISCUSSION

Cover Crop Biomass

Clover produced less biomass than all other treatments (Table 1). Pea produced greater biomass than clover and wheat. There were no differences among wheat, mix, and vetch. Nitrogen accumulated in the above ground biomass was significantly greater for pea and vetch (Table 1). There were no differences in N accumulation among clover, wheat, and mix. The ratio of C:N is a good indicator of nitrogen mineralization potential (Wagger et al., 1998). A high quality residue may be defined as having a C:N value below 25 to 30, whereas greater values indicate a low quality residue. Adding legumes to the mix did not change the C:N ratio compared to wheat, as the mix was dominated by rye.

Table 1. Cover crop biomass production and above ground nitrogen accumulation at Chillicothe Research Station in 2017. Different letters represent significant difference at $P<0.05$.

	Biomass (kg ha^{-1})	C:N	N Accumulation (kg ha^{-1})
Clover	342c	16.4b	7.6b
Wheat	1766b	38.9a	17.4b
Mix	2491ab	38.9a	27.8b
Vetch	2950ab	11.1b	111.8a
Pea	3148a	14.1b	93.7a

Nutrient Cycling

Adding legume cover crops can provide nitrogen to the subsequent cash crop as well as stimulate the microbial biomass, which improves crop nutrition and soil structure (Crews and Peoples, 2004). Therefore, the use of cover crops with high quality biomass is required to increase soil nitrogen supply. At cover crop termination and 3 weeks after termination, nitrate concentrations in the upper 10 cm of the soil did not differ among treatments (Figure 1A and 1B). However, pea had greater soil nitrate concentrations than all other treatments in the upper 10 cm 6 weeks after termination (Figure 1C). Vetch had greater soil nitrate concentrations in the upper 10 cm than CT at 6 weeks after termination. Trends were similar for the 10-20 cm depth, where soil nitrate concentrations were numerically greater for pea and vetch than other treatments. Soil nitrate concentrations at the 0-10 cm depth were significantly greater than all other treatments except the mix (Figure 1F). These results correspond with the nitrogen accumulation and C:N ratios observed in the cover crop biomass. As nitrogen accumulation was greater for pea and vetch, higher soil nitrate concentrations were also observed just prior to cotton planting. Although C:N ratios for wheat and mix were greater than the level expected for nitrogen immobilization to occur, soil nitrate concentrations did not differ between these treatments and the non-cover crop treatments CT and NT.

Inorganic nutrient availability alone does not offer a complete assessment of soil fertility or of soil biological influences on important soil properties and processes that affect crop yield and environmental quality (Franzluebbers, 2016). Franzluebbers (2016) proposed that soil testing could be elevated to a more complete evaluation of soil fertility and health with the adoption of a test for biological activity by using the flush of CO_2 during 1 to 3 day following rewetting of dried soil and incubation period to measure soil respiration. Trends were similar for soil respiration as observed with soil nitrate (Figure 2). The concentration of CO_2 evolved was numerically higher for pea than all treatments for each date and depth (Figure 2). These levels were significantly greater for pea than CT and NT for all dates and depths except for six weeks after cover crop termination in the 10-20 cm depth (Figure 2F). Vetch produced more evolved CO_2 after pea. In general, the amount of CO_2 evolved decreased with time after cover crop termination, which could be a result of much drier conditions over time since the cover crops were terminated leading to reduced microbial activity. Water extractable organic nitrogen, thought to be an essential substrate for microorganisms, had a strong positive correlation with evolved CO_2 ($R=0.62$, $P<0.0001$; data no shown).

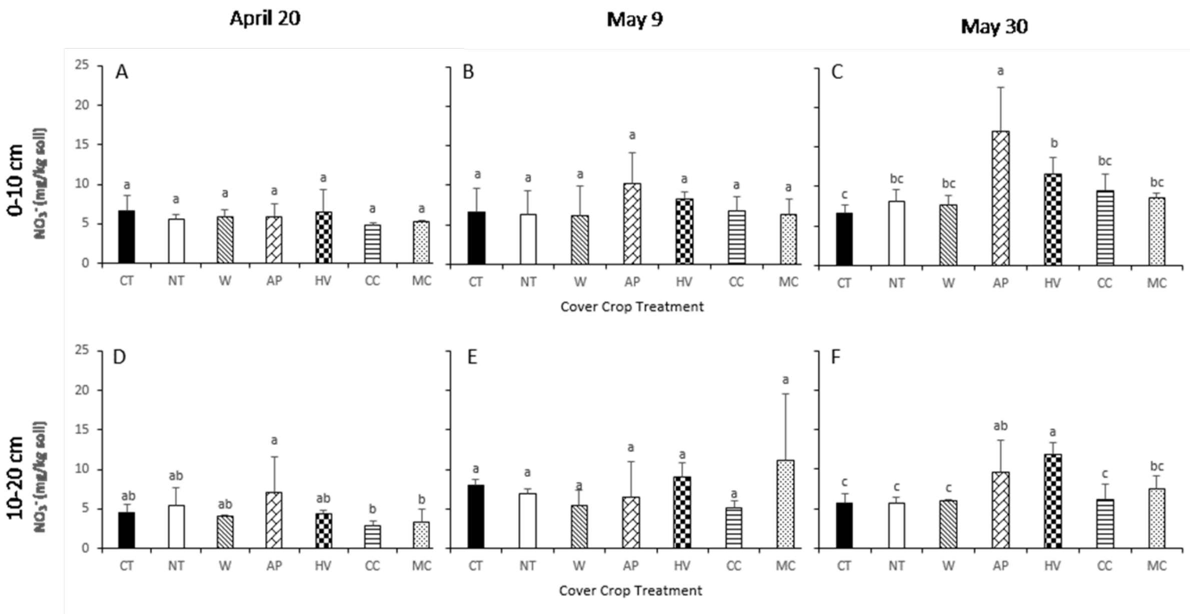

Figure 1. Soil nitrate as affected by tillage and cover crop treatments. Samples represent 0-10 cm from A) April 20, B) May 9, and C) May 30 and 10-20 cm from D) April 20, E) May 9, and F) May 30. Statistical significance within each date and depth denoted by different letters ($P < 0.05$). CT = conventional till; NT = no-till; W = winter wheat; AP = Austrian winter pea; HV = hairy vetch; CC = crimson clover; MC = mixed species cover.

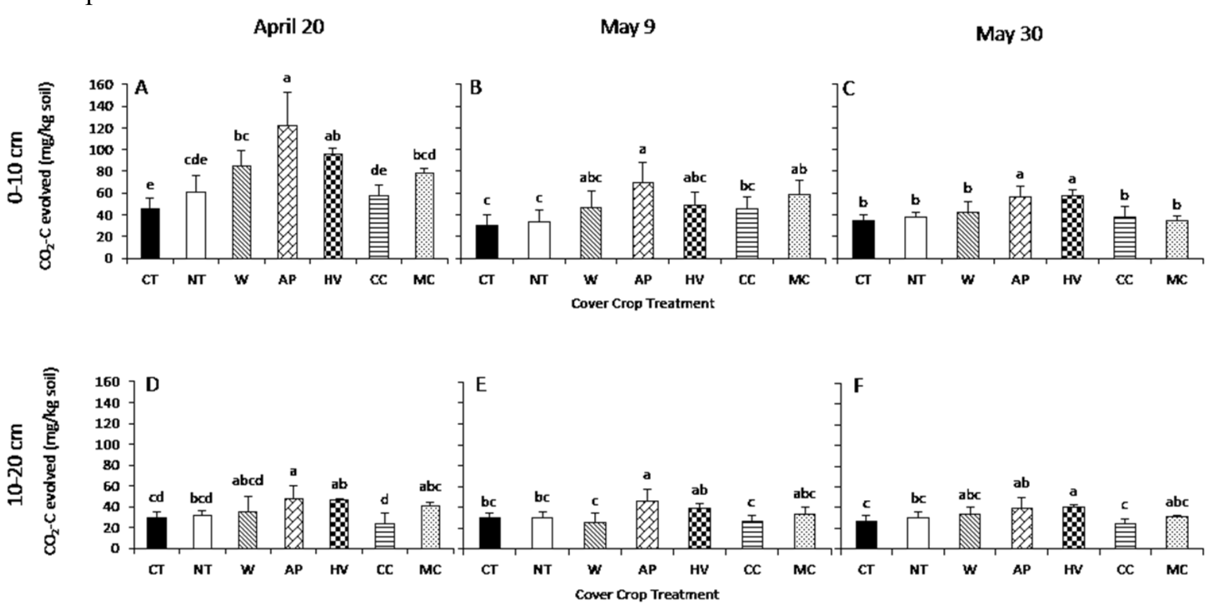

Figure 2. Soil respiration as affected by tillage and cover crop treatments. Samples represent 0-10 cm from A) April 20, B) May 9, and C) May 30 and 10-20 cm from D) April 20, E) May 9, and F) May 30. Statistical significance within each date and depth denoted by different letters ($P < 0.05$). CT = conventional till; NT = no-till; W = winter wheat; AP = Austrian winter pea; HV = hairy vetch; CC = crimson clover; MC = mixed species cover.

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