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Soil Properties' Response to Wheat and Corn Stubble Residue Management in Louisiana

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SOIL PROPERTIES' RESPONSE TO WHEAT AND CORN STUBBLE RESIDUE
MANAGEMENT IN LOUISIANA

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Abstract

Crop residue plays an important role in improving soil fertility. Crop residue affects soil biological and chemical properties by increasing soil organic matter, nutrient status and availability, and microbial activity. The degree of the effects of crop residue on soil fertility depends on the crop residue management practice. Samples were collected in 2014 in wheat (*Triticum spp.*) stubble and corn (*Zea mays*) stubble residue. A second soil sample collection under wheat stubble residue was taken in 2015 in the prescribed fire and no-till sections. A total of 342 soil samples (0-2.5cm) were collected across conventional tillage, no-till, and prescribed fire treatments of wheat stubble and corn stubble residue located on the Macon Ridge Research Station in Winnsboro, LA. Samples were collected pre-management (0 hr) and at 1, 24, 168, 720, and 4320 hr intervals post-management and analyzed for soil chemical (macronutrients and soil organic matter) and biological (microbial community structure and enzyme activities) properties. In 2015, additional samples were taken in wheat stubble residue 6 hrs and 168 hrs (1 week) post-management. Additional samples were collected in corn stubble residue 6 hrs post-management. Prescribed fire increased NO_3^--N relative to no-till and conventional tillage in wheat stubble. Prescribed fire increased β-glucosidase activity relative to conventional tillage but was similar to β-glucosidase activity observed in no-till. Short term changes in organic matter, nutrients, and enzyme activity were observed in prescribed fire, no-till, and conventional tillage. Shifts in microbial communities were observed in wheat stubble residue with Gram negative, total bacteria, and actinomycetes

dominating the prescribed fire soil and abundance of arbuscular mycorrhizal fungi, saprophytic fungi, and fungi:bacteria dominated no-till and conventional tillage soil. The effects of management practices on microbial community structure was unable to be determined in corn stubble residue based on the fatty acid profiles tested in this study. While prescribed fire increased NO_3^--N and β-glucosidase activity, similarities between management were observed in NH_4^+-N, soil organic matter, and N-acetyl-β-D-glucosaminidase activity. Therefore, further research needs to be done in order to determine the most efficient crop residue management practice to optimize soil fertility.

Chapter 1. Introduction

1.1 Crop Residue in Agriculture

Crop residues are materials left in an agricultural field after the crop has been harvested including stalks and stubble, leaves and seed pods. Crop residue plays an important role in maintaining soil fertility by improving soil chemical, biological, and physical properties (Singh and Rengel, 2007). Crop residue effects soil physical properties by decreasing the risk of soil erosion, improving soil water holding capacity, and conserving soil moisture and temperature. Soil chemical properties affected by crop residue includes nutrient status and availability, soil pH, and soil organic matter.

Crop residues sustain and increase soil organic matter by slowly decomposing, building up organic matter in the 0-7.5 cm soil depth. The increase in soil organic matter leads to an increase in meso and macrofauna populations and activities, microbial diversity, and C and nutrients in microbial biomass (García-Orenes et al., 2003). Soil organisms are important for soil fertility and perform vital functions in the soil. Soil microorganisms enhance soil fertility due to their involvement in the cycling of nutrients like C and N by decomposing the organic matter entering the soil (Gougoulias et al., 2014). The mineralization and immobilization from the microbial activity contributes to an increase in nutrient status and availability. Certain soil microorganisms such as mycorrhizal fungi can also increase the availability of mineral nutrients to plants (Marschner and Dell, 1994). Different microbial groups produce different soil enzymes which are involved in C cycling in soil. Therefore, shifts in the microbial community

composition have important implications for soil fertility. β-glucosidase, for example, is important for decomposition of the labile fraction of plant tissue (Madejon et al., 2003). N-acetyl-β-D-glucosaminidase catalyzes the hydrolysis of chitin (Ekenler and Tabatabai, 2004).

Crop residue plays an important role in soil C and N storage. Crop residue is the main source of soil C in agricultural systems (Schmatz et al, 2017) and contains nutrients that affect the dynamics of soil C and N in the soil. Crop residue contains all mineral nutrients; however, the amount of nutrients depends on the type of crop (Singh and Rengel, 2007; Table 1.1). In Louisiana, wheat and corn stubble are commonly used as crop residues. Wheat and corn stubble residue have high C:N ratios (<24:1) increasing the resistance to microbial decomposition (USDA NRCS 1977). Wheat stubble is less dense than corn stubble; therefore, wheat has a higher surface area and has the potential to break down at a faster rate than corn. The amount of nutrients in the crop residue control the rate of decomposition and formation of microbial biomass (de Bruijn and Butterbach-Bahl 2010). However, it is difficult to determine the amount of nutrients that crop residue releases into the soil at a given time due to complex processes controlling residue decomposition and nutrient release (Singh and Rengel, 2007). The effects of crop residue on the soil's physical, biological, and chemical properties depends on the crop residue management practice, such as prescribed fire, tillage, or no-till. Therefore, determining the best crop residue management practice is essential to soil fertility.

Table 1.1 Crop residue nutrient content.

Crop Residue	Nutrient Content[1] (kg tonne^{-1})			
	N	P_2O_5	K_2O	S
Wheat	5	1.5	15.5	1
Corn	5.5	2	11	0.5

[1] Based on Table from Gelderman et al., 2011

1.2 Prescribed Fire Management Practice

Prescribed fire is an intentional application of fire, set under controlled conditions to achieve specific objectives (Merrill and Alexander, 1987). Prescribed fire controls excess crop residue providing an ease of tillage to obtain an efficient seedbed for planting and decreases incidence of disease where crop residues can be a host for pathogens (Singh and Rengel, 2007).

Fire influences soil chemical (macronutrients and soil organic matter) and biological (microbial community structure and enzyme activities) processes (Singh and Rengel, 2007). The effects are a result of burn severity, which consists of peak temperatures and duration of the fire. Low (up to 250°C) to moderate (250°C- 500°C) severity fires, such as most of those prescribed in forest management promotes renovation of the dominant vegetation through elimination of undesired species and transient increase of pH and available nutrients. No irreversible ecosystem change occurs, but the enhancement of hydrophobicity can render the soil less able to soak up water and more prone to erosion. Severe (500°C and up) fires, such as wildfires, can cause negative effects on soil such as significant removal of organic matter, deterioration of both structure and porosity, considerable loss of nutrients through volatilization, ash entrapment in smoke columns, leaching and erosion, and marked alteration of

both quantity and specific composition of microbial and soil-dwelling invertebrate communities (Certini, 2005).

Prescribed fire has been found to increase pH of soil. Following a Mediterranean forest fire, the incorporation of ash into the soil and the complete oxidation of the soil organic matter increased pH of the soil (Alcaniz et al, 2016). . Available phosphorous (P) also increased after a prescribed fire event due to the combustion of vegetation, the incorporation of ash into the soil and the mineralization of organic P. Total nitrogen (N), calcium (Ca^{2+}) and magnesium (Mg^{2+}) levels increased post-fire due to the high volatilization temperatures of these nutrients, the formation of ash from the combustion of organic matter and its incorporation into the soil (Alcaniz et al, 2016). In Spartina patens-dominated tidal marshes, fire caused organic matter decomposition, which released plant nutrients, thereby stimulating increased biomass production, leading to a net organic matter increase (Cahoon et al, 2004). In natural grasslands in southern India, burning stimulated soil enzyme activities in the surface layer due to the increase in the population of soil microorganisms, brought about by the relative increase in nutrients and organic matter observed in the burned area together with favorable moisture and temperature, following grass fire in natural grasslands in southern India (Senthilkumar et al, 1997).

Soil heating alters soil organic matter and increases nutrient availability, therefore affecting subsequent microbial growth. In a China wetland, prescribed fire increased microbial metabolism in the post-burned soil through influencing soil microbial composition and activity. Fire increased carbon (C) mineralization

rates due to increased organic C and N contents in the burned soils in the China wetland and improved quality of substrate for microbial growth and possibly increased labile compounds, which all stimulates microbial growth (Zhoa et al., 2012). In a coniferous forest, fire affects nutrient availability by modifying microbial community structure due to the heating of the soil (Perry et al, 1984). Increases in soil temperature from fire contributes to increases in soil inorganic N pools through increased microbial activity and N mineralization rates in grasslands (Augustine et al 2014).

1.3 No-Till vs. Conventionally Tilled Management Practices

No-till is a conservation practice that leaves the crop residue undisturbed from harvest through planting (Singh and Rengel, 2007). No-till protects against erosion and controls soil moisture due to the vegetative cover remaining on the surface. Soil stays cooler until a little later in the spring and summer because of the insulating layer of crop residue. (Carefoot et al., 1990; Cox et al., 1990). In Alberta, soil temperature was lower in the spring up to a 10 cm depth in no-till than conventional tillage (Nyborg and Malhi, 1989; Malhi and O'Sullivan, 1990). Organic matter decomposition rate is reduced in cooler soils; therefore, the nutrients in the crop residue is released slowly (Carefoot et al., 1990). The slow release of nutrients in crop residue in cooler soils reduces the amount of nutrients readily available to the crop.

Tillage incorporates crop residue into the soil, which leaves the soil surface bare and without cover protection leaving the soil vulnerable to wind and water erosion. One advantage of conventional tillage is that the needed

machinery is widely available and the techniques are well-known. Soils that are tilled typically warm faster in the spring than those with less tillage; therefore, organic matter decomposes rapidly releasing nutrients that are readily available for the crop (Nyborg and Malhi, 1989; Malhi and O'Sullivan, 1990). Conventional tillage can increase porosity and loosen soil, allowing for good air exchange and root growth, but tillage also destroys soil structure (Busari et al., 2015).

No-till has enhanced soil qualities relative to tillage management. Since no-till practices leave crop residue on the surface, soil chemical and biological processes are influenced at the upper depth (0-7.5 cm) of the soil. Leaving crop residues on the soil surface protects soils from wind and water erosion by buffering the soil against forces of raindrop impact and wind shear (Lal 2005; Unger and McCalla 1980). Leaving crop residues on the soil surface reduces water evaporation in the top few inches of the soil conserving soil moisture. Tillage has been found to have lower soil organic matter content than no-till soils. The accumulation of crop residue in no-till soils results in a higher amount of organic matter. When there is an enrichment in soil organic matter, there is an increase abundance of microorganisms, such as of fungi, bacteria, arbuscular mycorrhizal fungi, and actinobacteria (Reji et al., 2012). The changes in microbial communities could be due to favorable environmental conditions in no-till soils, such as high organic matter and nutrients which also increases enzymatic activity (Melero et al., 2011; Acosta-Martínez et al., 2008; Alvear et al., 2005). Conventional tillage systems had a lower amount of soil organic C and total N than no-till practices in a continuous corn system on a Decatur silt loam soil (Reji

et al., 2012). No-till practices increased total C and N relative to conventionally tilled practices in a continuous corn, corn-soybean, and corn-soybean-wheat-Cowpea systems (Aziz et al., 2013). Total C also kept decreasing over time in the tilled soil. Tillage has lower inorganic N than no-till soils (Busari et al., 2015). Tillage increases leaching rate due to soil structure deterioration, which could explain the lower inorganic N content.

Since crop residue management practices have different impacts on soil, determining the best management practice is important to maximize crop residue's effectiveness on soil fertility. The objective of this study was to determine the impacts of prescribed fire, no-till, and conventional tillage on soil chemical and biological properties in wheat stubble residue and corn stubble residue. We hypothesized that prescribed fire will increase inorganic N concentration, soil enzyme activity, and soil organic matter relative to no-till and tilled management enhancing soil fertility in wheat and corn stubble residue.

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Chapter 2. Soil Properties' Response to Wheat Stubble and Corn Stubble Residue Management in Louisiana

2.1 Introduction

Crop residue plays an important role in soil fertility. Crop residue increases soil organic matter (SOM) and contributes to C and N storage. Soil organisms are influenced by crop residue due to the SOM increase providing C as an energy source. Soil microorganisms are involved in C and N cycling by producing enzymes and decomposing the organic matter entering the soil improving soil fertility. β-glucosidase is an enzyme that is important for decomposition of the labile fraction of plant tissue (Madejon et al., 2003). N-acetyl-β-D-glucosaminidase is an enzyme that catalyzes the hydrolysis of chitin (Ekenler and Tabatabai, 2004). Crop residue enhance soil fertility by providing an optimal environment for microbial activity, SOM decomposition, and nutrient release. However, the efficiency of crop residue on soil chemical and biological properties is based on the management practice (prescribed fire, no-till, and conventional tillage).

There is little research on prescribed fire as a crop residue management practice. However, prescribed fire has been proven beneficial to soils in forests, wetlands, and grasslands (Alcaniz et al., 2016; Augustine et al., 2014; Senthilkumar et al., 1997; Zhoa et al., 2012;). Prescribed fire can control excess crop residue providing an ease of tillage and decrease incidence of disease. Prescribed fire increased nutrient availability due to the formation of ash from the combustion of organic matter and its incorporation into the soil in a

Mediterranean forest (Alcaniz et al., 2016). Prescribed fire increased soil

inorganic N pools due to increased microbial activity and N mineralization rates a

semiarid grassland (Augustine et al., 2014). Prescribed fire increased soil

enzyme activity due to the increase in the population of soil microorganisms in a

natural grassland in India (Senthilkumar et al., 1997). Prescribed fire increased

soil microbial activity due to increased nutrient availability in a northeastern China

wetland (Zhoa et al., 2012).

No-till is a conservation practice that leaves the crop residue undisturbed

on the soil's surface (Singh and Rengel, 2007). Since no-till practices leave crop

residue on the surface, soil chemical and biological processes are influenced at

the upper depth (0-7.5 cm) of the soil. Leaving crop residue on the surface of the

soil protects against wind and water erosion and controls soil moisture. Soil stays

cooler until a little later in the spring and summer because of the insulating layer

of crop residue, which could reduce organic matter decomposition rate (Carefoot

et al., 1990; Cox et al., 1990). When organic matter decomposes slowly, the

nutrients in the crop residue are released gradually reducing the amount of

nutrients available to the crop.

Conventional tillage incorporates crop residue into the soil leaving the soil

surface bare and without cover protection making the soil vulnerable to wind and

water erosion. Soils that are tilled typically warm faster in the spring than those

with less tillage; therefore, organic matter decomposes rapidly releasing nutrients

that are readily available for the crop (Nyborg and Malhi, 1989; Malhi and

O'Sullivan, 1990). Tillage has been found to have lower soil organic matter

content than no-till soils. The accumulation of crop residue in no-till soils results in a higher amount of organic matter. When there is an enrichment in soil organic matter, there is an increase abundance of microorganisms, such as of fungi, bacteria, arbuscular mycorrhizal fungi, and actinobacteria (Reji et al., 2012). Tilled soils had lower enzymatic activity than no till soils in response to shifts in availability of organic substrates, soil moisture, soil temperature, soil aeration and constitution of soil flora and fauna (Acosta-Martínez et al., 2008; Alvear et al., 2005; Melero et al., 2011). Conventional tillage systems had a lower amount of soil organic C and total N than no-till practices in a continuous corn system on a Decatur silt loam soil (Reji et al., 2012). No-till practices increased total C and N relative to conventionally tilled practices in a continuous corn, corn-soybean, and corn-soybean-wheat-Cowpea systems (Aziz et al., 2013). Tillage has lower inorganic N than no-till soils (Busari et al., 2015). Tillage deteriorates soil structure increases leaching rate, which could explain the lower inorganic N content.

While there are advantages and disadvantages to each management practice, it is important to determine the crop residue management practice that maximizes the benefits of crop residue on soil fertility. The objective of this study was to determine the impacts of prescribed fire, no-till, and conventional tillage on soil physical, chemical, and biological properties in wheat stubble residue and corn stubble residue. We hypothesized that prescribed fire will increase inorganic N concentration, soil enzyme activity, and soil organic matter relative to no-till and tilled management enhancing soil fertility in wheat and corn stubble residue.

2.2 Materials and Methods

2.2.1 Site Description

The experiment was conducted at the Macon Ridge Research Station in Winnsboro, LA. The soil type was a Gigger-Gilbert complex (12% sand, 73% silt, 16% clay in wheat stubble; 10% sand, 78% silt, 12% clay in corn stubble). The Gigger soil series is classified as fine-silty, mixed, active, thermic Typic Fragiudalfs. The Gilbert soil series is classified as fine-silty, mixed, active, thermic Typic Glossaqualfs. The average precipitation in Winnsboro was 1451 mm and average high temperature is 24°C and the average low is 11°C. The wheat (*Triticum spp.*) stubble and corn (*Zea mays*) stubble fields are 0.4 ha each and are separated into no-till, tilled, and prescribed fire sections. For the wheat stubble field, soybeans were planted 14 days after the management event. For the corn stubble field, corn was planted 24 hrs post-management and 269 kg ha^{-1} of N was applied 2 weeks after the corn was planted.

2.2.2 Soil Sampling

A total of 342 soil samples (0-2.5 cm) were collected across tilled (n=86), no-till (n=128), and prescribed fire (n=128) management practices of wheat stubble and corn stubble residue. Samples were collected in 2014 in wheat stubble and corn stubble residue. A second soil sample collection under wheat stubble residue was taken in 2015 in the prescribed fire and no-till sections. Samples were collected from all plots pre-management and at intervals of 1 hr, 24 hrs, 720 hrs (30 days), and 4320 hrs (6 months) post-management. In 2015, additional samples were taken in wheat stubble residue 6 hrs and 168 hrs (1

week) post-management. Additional samples were collected in corn stubble residue 6 hrs post-management. Due to technical failure, the 4320 hrs post-management wheat stubble residue samples in 2014 were unable to be processed. The soil samples were passed through a 2 mm sieve and placed in plastic bags and immediately stored in a 4°C freezer. A portion of the soil samples were air dried prior to analysis. Samples were analyzed for soil chemical (macronutrients and soil organic matter) and biological (microbial community structure and enzyme activity) properties.

2.2.3 Soil Physical Properties

Particle size analysis was determined using the modified hydrometer method as described in Grossman and Reinsch (2002). Briefly, 50 grams of air dried sieved soil was placed into plastic bottles with 10 mL of 10% sodium hexametaphosphate to facilitate the dispersion of soil particles. The bottles were then filled halfway with DI water and placed on a shaker for 4 hrs. After shaking, the soil solution is transferred into a 1 L graduated cylinder and adjusted to 1L volume with DI water. The soil particles in the cylinder were carefully mixed and a hydrometer was immediately inserted in order to calculate sand content, and temperature was recorded. After 24 hrs, another hydrometer and temperature reading was made without mixing in order to calculate clay content. Silt was calculated based on sand and clay content. Temperature (°C) was used to correct for variation in water viscosity by adjusting the hydrometer readings by adding 0.36 to every degree that exceeds 20°C. The USDA textural triangle was used to determine soil texture.

2.2.4 Soil Chemical Properties

2.2.4.1 Soil Organic Matter

Soil organic matter was determined by the weight loss-on-ignition method (Nelson and Sommers, 1996). Briefly, air dried soil samples were oven-dried at 105°C overnight, cooled in a desiccator, and weighed. The samples were then ignited at 400°C for 24 hrs in a muffle furnace. After ignition, samples were again weighed to determine loss-on-ignition. Soil organic matter was then estimated according to the equation: %SOM = (%LOI*0.7) – 0.23 as recommended in the Cornell Soil Health Assessment Training Manual (Gugino et al, 2009).

2.2.4.2 Inorganic Nitrogen

Inorganic nitrogen (NO_3^--N & NH_4^+-N) was measured using potassium chloride (KCl) extraction (Mulvaney, 1996). One gram of air dried soil was added to 10 mL of 2 M KCl and was placed in the shaker for one hr. After shaking, samples were filtered through Whatman 42 filter paper. To determine NO_3^--N concentration, 200 µL of Vanadium (III) solution was added to a 96-well plate and then 40 µL of filtrate was added and incubated in the dark at 37°C for one hr. After incubation, the absorbance was read at 540 nm using a spectrophotometer. To determine NH_4^+-N, 100 µL of salicylate solution was added to a 96-well plate and then 40 µL of filtrate was added and lastly 100 µL of bleach solution was added. The 96-well plate was then incubated in the dark for 50 minutes at room temperature. After incubation, the absorbance was read at 650 nm using a spectrophotometer. The concentration of inorganic nitrogen was determined based on a standard curve.

2.2.5 Soil Biological Properties

2.2.5.1 β-Glucosidase Enzyme Activity

β-glucosidase enzyme activity was assessed by the p–nitrophenol method (Tabatabai, 1994). Briefly, 0.5 gram of air dried soil samples were used to determine β-glucosidase enzyme activity measured as μmol p-nitrophenol kg^{-1} h^{-1}. Soil samples were placed in three 50 mL Erlenmeyer flasks. Two of the flasks were replicates and one flask was the control. For the replicates, 2 mL of Modified Universal Buffer, pH 6, and 0.5 mL of 0.05 M p-Nitrophenyl-β-D-glucoside (PNG) solution were added. The controls only received 2 mL of Modified Universal Buffer, pH 6; therefore, no PNG solution was added. The flasks were then incubated at 37°C for one hr and then 0.5 mL of 0.5 M CaCl2 and 2 mL 0.1 M Tris (hydroxylmethyl) aminomethane (THAM), pH 12, were added to all flasks. The controls then received 0.5 mL of PNG solution. The soil suspension was filtered through Whatman 2 filter paper and 200 μL aliquots of each sample were pipetted into three wells in a 96-well plate. The 96-well plate was placed in an EON spectrophotometer (BioTek, Vermont), and the yellow color filtrate intensity was measured at 420 nm and concentration of p-nitrophenol was determined based on a standard curve.

2.2.5.2 N-acetyl-β-D-glucosaminidase (NAGase)

Air dried soil samples were used to determine N-acetyl-β-D-glucosaminidase enzyme activity measured as μmol p-nitrophenol kg^{-1} h^{-1} described by the p–nitrophenol method (Tabatabai, 1994). A half gram of each soil sample was placed in three 50 mL Erlenmeyer flasks. Two flask were for

replicates, and one flask was for the control. For the replicates, 2 mL of 0.1 *M* Acetate buffer pH 5.5 and 0.5 ml of 10 mM p-Nitrophenyl-N-acetyl-B-D-glucosaminide (pNNAG) solution were added. The controls received 2 mL of 0.1 *M* Acetate buffer pH 5.5 but no pNNAG solution. The flasks were then incubated at 37°C for one hr and then 0.5 mL of 0.5 *M* CaCl2 and 2 mL 0.1 *M* THAM pH 12 were added to all flasks. The controls then received 0.5 mL of pNNAG solution. The soil suspension was then filtered through Whatman 2 filter paper and then 200 µL aliquots of each sample were pipetted into three wells in a 96-well plate. The yellow color filtrate intensity was measured at 420 nm via an EON spectrophotometer (BioTek, Vermont), and concentration of p-nitrophenol was determined based on a standard curve.

2.2.5.3 Soil Microbial Community Structure

Soil microbial community structure was determined using individual fatty acid methyl esters as biomarkers per the ester-linked fatty acid ethyl ester (EL-FAME) analysis described by Schutter and Dick (2000). The EL FAME extraction procedure occurred in three steps: methylation, neutralization, and extraction. Three grams of field moist soil was measured and 15 mL of the methylation reagent, 0.2 *M* potassium hydroxide in methanol was added. The samples were then incubated at 37°C for one hr in a water bath while being vortexed every 15 minutes. The samples were cooled at ambient temperature and 3 mL of 1.0 *M* acetic acid was added to neutralize pH. After the neutralization process, 3 mL of hexane was added and centrifuged at 2200 rpm for 5 minutes in order to separate EL-FAMEs into the organic phase. The organic phase was then

transferred into a separate test tube and concentrated with N_2 gas to evaporate the hexane. The samples were analyzed on an Agilent 7890B gas chromatograph (California) with a silica packed 0.2 mm x 25 m Agilent J&W Ultra Inert column, flame ionization detectors, and oven program of 190 ºC to 285 ºC in 10 ºC increments.

The concentration of FAME (nmol g-[1] soil) were calculated using the 19:0 internal standard and relative abundance (mol%) was calculated by dividing each FAME by the total sum of all identified EL-FAMEs in a sample. Identified EL-FAMEs are named by the number of C atoms, a colon, and the number of double bonds followed by the position of the first double bond from the methyl (w) end. Notations include cyclic (cyclo), cis (c), and iso and anteiso branched EL-FAMEs. Biomarkers included: 17:0 10-methyl, 18:0 10-methyl, 16:0 10-methyl for actinomycetes (Frostegard et al., 1993; Zelles, 1997) ; 16:1 w5c for arbuscular mycorrhizal fungi (AMF) (Paul and Clark, 1988; Pennanen et al., 1996); 18:1 w9c, 18:2 w6c, 18:3 w6c (6,9,12), and 20:1 w9c for saprophytic fungi (Paul and Clark, 1988; Zelles, 1997; Frostegard et al., 1993; Madan et al., 2002); 16:1 w9c, 16:1 w7c, 17:0 cyclo, 19:0 cyclo w6c, 18:1 w7c, 18:1 w5c, 19:1 w6c, and 19:0 cyclo for Gram-negative bacteria (Zelles and Bai, 1994; Ratledge and Wilkinson, 1988; Frostegard et al., 1993; Laczko et al., 1997); and 14:0 iso, 15:0 iso, 15:0 anteiso, 16:0 iso, 16:0 anteiso, 17:0 iso, 17:0 anteiso, 17:1 w9c, and 18:0 for Gram-positive bacteria (Morgan and Winstanley, 1997; White et al., 1998; Laczko et al., 1997; Frostegard et al., 1993; Ratledge and Wilkinson, 1988; Pennanen et al., 1996; O'Leary and Wilkinson, 1988).

2.2.6 Data Analysis

Basic analysis of variance (ANOVA) was used to compare across residue management treatments (prescribed fire, tillage, and no-till). In the case of wheat stubble, if no year effect was observed, samples were pooled across years. R was used for multivariate data and all statistics (R Core Team, 2013). LSD for mean separation was from the agricolae package (de Mendiburu, 2017). Non-metric distance based multivariate analysis for FAME data was done using the capscale command in the vegan package (Oksanen et al., 2017). Vectors were done using the envfit function of the vegan package.

2.3 Results and Discussion

2.3.1 Treatment Effects on Soil Organic Matter

In wheat stubble residue, a treatment by sample time interaction occurred for soil organic matter concentrations (Table 2.1). Soil organic matter increased in 1 hr post-prescribed fire and again at 24 hrs post-prescribed fire decreasing to pre-prescribed fire levels at 168 hrs post-prescribed fire. Prescribed fire soil contained the most soil organic matter 24 hrs post-management and 4320 hrs post-management relative to no-till and tilled (Fig. 2.1). A year by time interaction was observed possibly due to variations in time of sampling between years (Table 2.1; Fig. 2.2).

In corn stubble residue, an interaction between treatment and sample time was observed for soil organic matter (Table 2.2). Soil organic matter was highest in prescribed fire soil relative to no-till and tilled soils up to 720 hrs post-management. Soil organic matter increased 1 hr post-prescribed fire and

remained higher than pre-prescribed fire levels 4320 hrs post-prescribed fire (Fig.

2.3).

Table 2.1. ANOVA p-values for soil organic matter in wheat stubble residue as affected by treatment, sampling time, year, and their interactions.

Source	Soil Organic Matter
Treatment	<0.0001
Sample time	NS[1]
Year	NS
Treatment x Sample time	0.0399
Treatment x Year	NS
Sample time x Year	0.0001
Treatment x Sample time x Year	NS

[1]Not Significant at 0.05 level

Fig. 2.1. Soil organic matter concentration in samples from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within treatments over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)
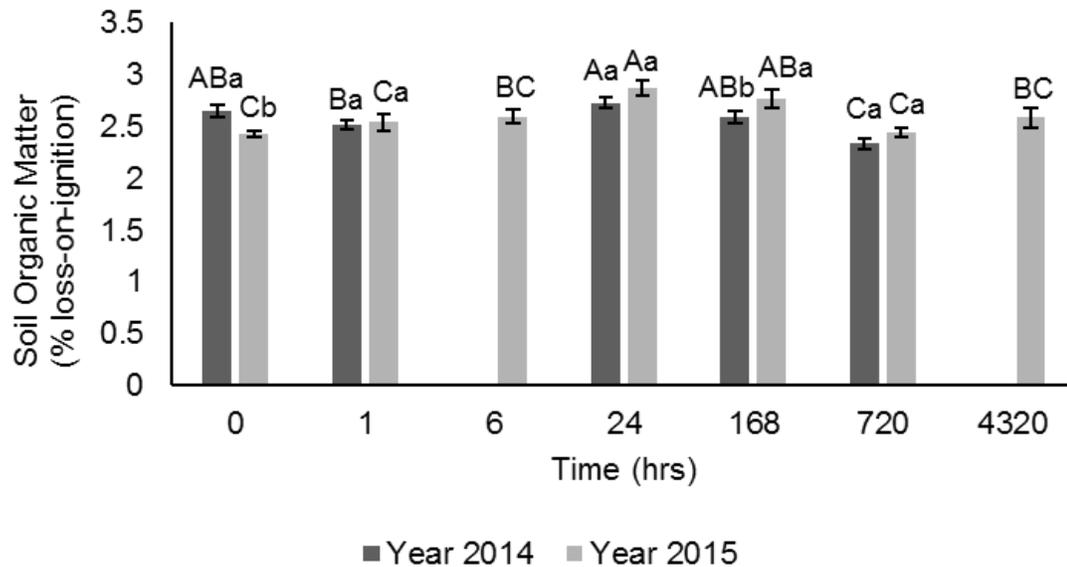
Fig. 2.2. Soil organic matter concentration in samples collected year 2014 and 2015 from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within years over time. Different lowercase letters indicate significant differences within time between years. (α=0.05)

Soil organic matter increased in the prescribed fire soils in wheat and corn stubble residue relative to tilled and no-till soils. The increase in soil organic matter after a prescribed fire event was also observed in Spartina patens-dominated tidal marshes where fire caused organic matter to decompose releasing plant nutrients and stimulating increases in biomass production leading to a net organic matter increase (Cahoon et al, 2004). The increase in soil organic matter could also be due to the incorporation of anthropogenic charcoal (biochar) from the crop residue into the soil due to the prescribed fire event influencing C cycling (Alexis et al., 2012; Alcaniz et al., 2016; Wiechmann et al., 2015). Biochar is C-rich and nitrogen-depleted increasing resistance to microbial degradation (Wiechmann et al., 2015). The increase in soil organic matter 4320

hrs post-management is likely due to vegetation changes such has an increase

in plant biomass.

Table 2.2. ANOVA p-values for soil organic matter in corn stubble residue as affected by treatment, sampling time, and their interactions.

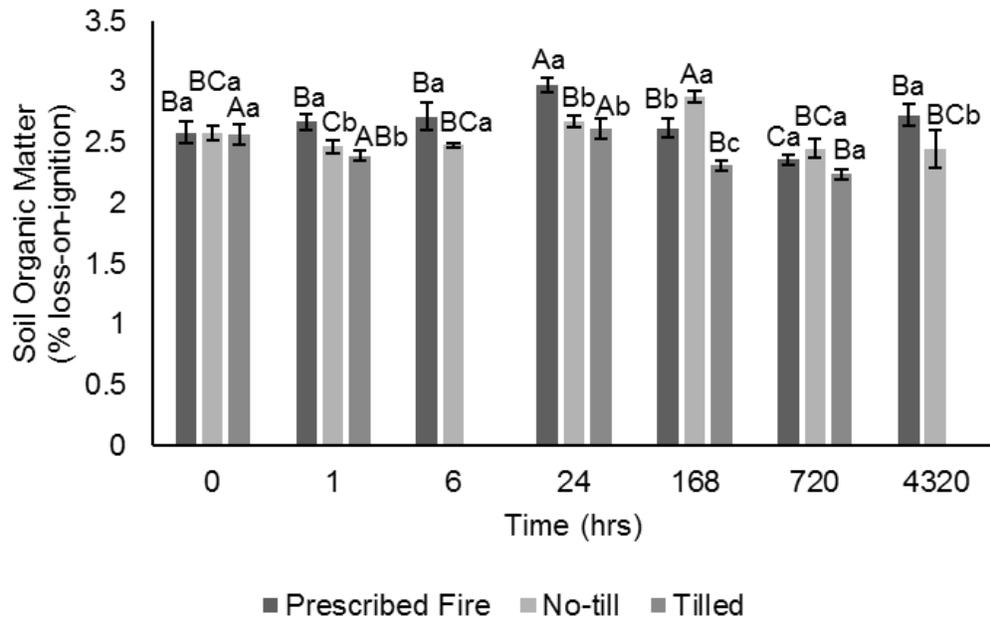| Source	Soil Organic Matter
Treatment	<0.0001
Sample time	NS[1]
Treatment x Sample time	0.0033

[1]Not Significant at 0.05 level
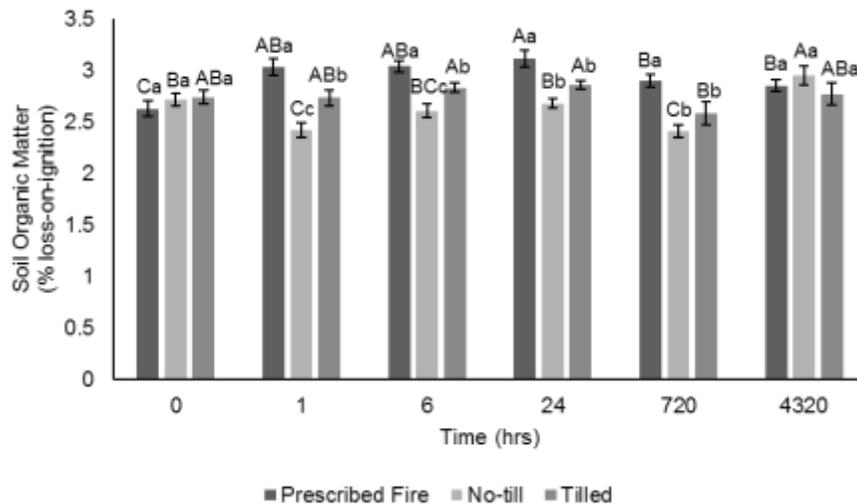
Fig. 2.3. Soil organic matter concentration in samples from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of corn residue. Different uppercase letters indicate significant differences within treatment over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)

2.3.2 Changes in Inorganic Nitrogen as a Result of Treatment Effects

In wheat stubble residue, a treatment effect and a year effect was

observed for NO_3^--N (Table 2.3). Nitrate-N was highest in prescribed fire soils

relative to no-till and tilled soils (Fig. 2.4). The increase in NO_3^--N in prescribed

fire soil could be due to increased microbial activity and N mineralization rates

(Augustine et al., 2014). There was no difference in NO_3^--N in tilled and no-till soils. Nitrate-N was higher in year 2014 than year 2015 possibly due to abiotic factors or variations in sampling times (Fig. 2.5).

Table 2.3. ANOVA p-values for nitrate-N in wheat stubble residue as affected by treatment, sampling time, year, and their interactions.

Source	Nitrate-N
Treatment	0.0135
Sample time	NS[1]
Year	<0.0001
Treatment x Sample time	NS
Treatment x Year	NS
Sample time x Year	NS
Treatment x Sample time x Year	NS

[1]Not Significant at 0.05 level
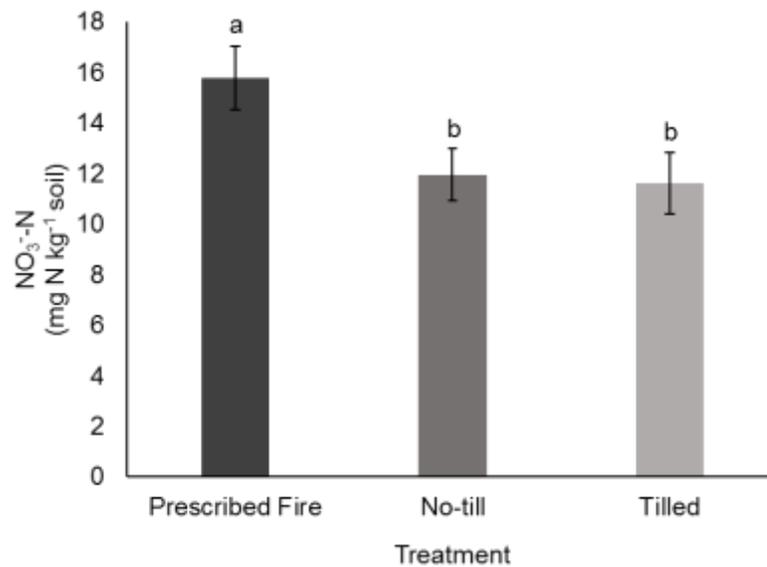
Fig. 2.4. Nitrate-N (NO_3^--N) concentration in samples averaged over time from pre- (0 hrs) to 4320 hrs (6 months) post-management in prescribed fire, no-till, and conventionally tilled treatments in wheat residue. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)

Fig. 2.5. Nitrate-N (NO_3^--N) concentration in samples averaged over time from pre- (0 hrs) to 4320 hrs (6 months) post-prescribed fire and across prescribed fire, no-till, and conventionally tilled treatments in wheat residue. Different lowercase letters indicate significant differences within time and treatments between years. (α=0.05)

There was an interaction between treatment and sample time observed for NH_4^+-N in wheat stubble residue (Table 2.4). Ammonium-N increased 24 hrs post-management and decreased to minimum levels 720 hrs post-management and increased to maximum levels 4320 hrs post-management (Fig. 2.6). Since soybeans were planted 14 days after the fire event, the decrease in NH_4^+-N at 720 hrs post-prescribed fire could be due to nutrient uptake by the plant. The maximum increase in NH_4^+-N 4320 hrs post-management could be a result of the conversion of organic N to inorganic N by the soybeans. Tilled soil had highest amount of NH_4^+-N relative to no-till and prescribed fire soils 24 hrs post-management (Fig. 2.6). A year by time interaction was observed potentially due to variations in time of sampling between years (Table 2.4; Fig. 2.7). The spike in NH_4^+-N at 4320 hrs post-management is possibly due to vegetation changes.

Table 2.4. ANOVA p-values for ammonium-N in wheat stubble residue as affected by treatment, sampling time, year, and their interactions.

Source	Ammonium-N
Treatment	NS[1]
Sample time	<0.0001
Year	NS
Treatment x Sample time	0.0001
Treatment x Year	NS
Sample time x Year	0.0010
Treatment x Sample time x Year	NS

[1]Not Significant at 0.05 level
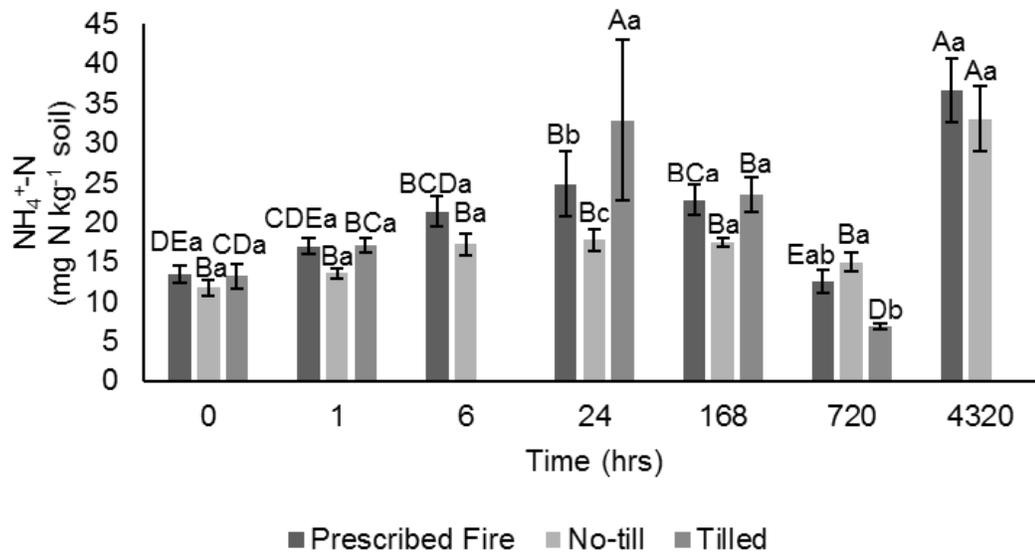
Fig. 2.6. Ammonium-N (NH_4^+-N) concentration in samples collected year 2014 and 2015 from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within treatment over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)
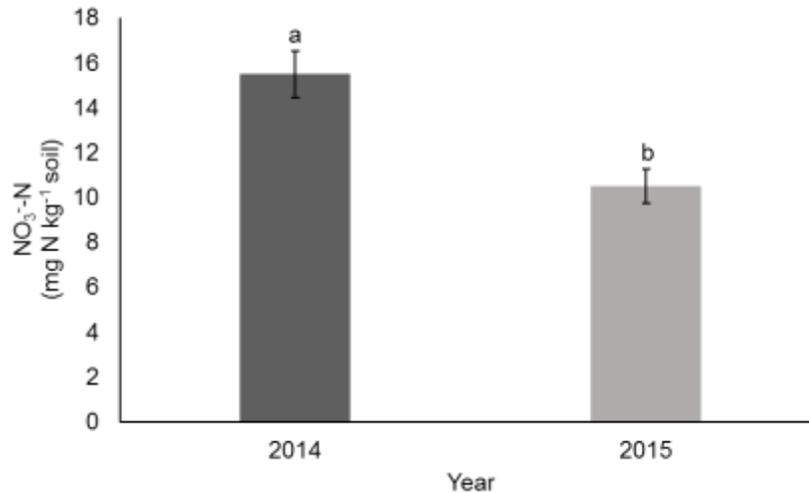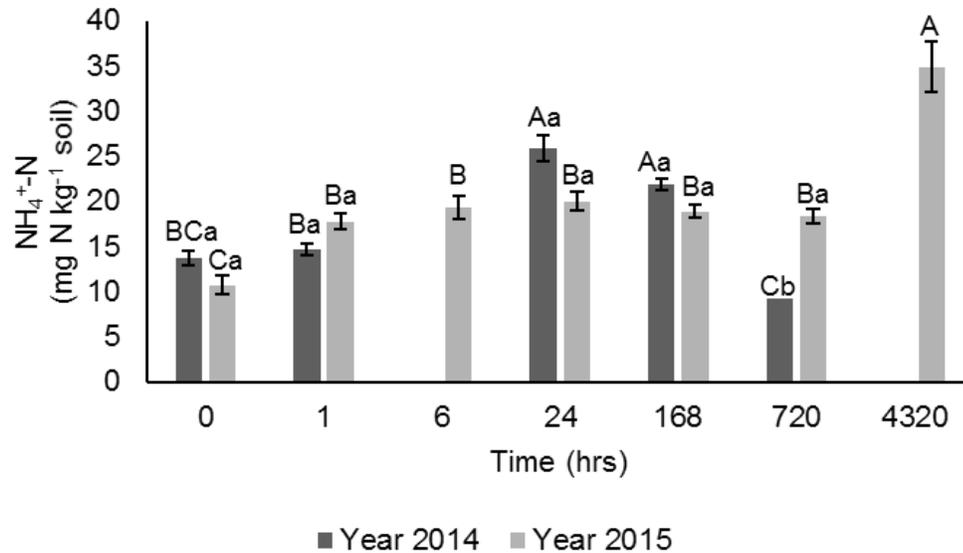
Fig. 2.7. Ammonium-N (NH_4^+-N) concentration in samples collected year 2014 and 2015 from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within years over time. Different lowercase letters indicate significant differences within time between years. (α=0.05)

In corn stubble residue, a sampling time effect was observed for NO_3^--N (Table 2.5). Nitrate-N decreased 1 hr post-management and recovered to pre-management levels 720 hrs post-management (Fig. 2.8). The decrease in NO_3^--N 1 hr and up to 720 hrs post-management could be due to abiotic factors such as rainfall and temperature since there was no treatment effect. An interaction between treatment and sample time was observed for NH_4^+-N (Table 2.5). Ammonium-N decreased 1 hr post-management and increased in the tilled soil 24 hrs post-tillage. NH_4^+-N recovered to pre-management levels in no-till soil 720 hrs post-management. NH_4^+-N increased to its maximum 4320 hrs post-prescribed fire. NH_4^+-N increased drastically in the prescribed fire and no-till soils 720 hrs post-management (Fig. 2.9). Nitrogen fertilizer was applied 14 days after

the management event which could explain the drastic increase in NH_4^+-N 720

hrs post-management.

Table 2.5. ANOVA p-values for inorganic N (nitrate-N and ammonium-N) in corn stubble residue as affected by treatment, sampling time, and their interactions.

Source	Nitrate-N	Ammonium-N
Treatment	NS[1]	0.0064
Sample time	0.0208	<0.0001
Treatment x Sample time	NS	<0.0001

[1]Not Significant at 0.05 level

Fig. 2.8. Nitrate-N (NO_3^- -N) concentration in samples averaged over treatments of prescribed fire, no-till, and tilled management practices in year 2014 and 2015 at pre- (0 hrs) and up to 4320 hrs (6 months) post-management of corn residue. Different uppercase letters indicate significant differences within treatments over time. (α=0.05)
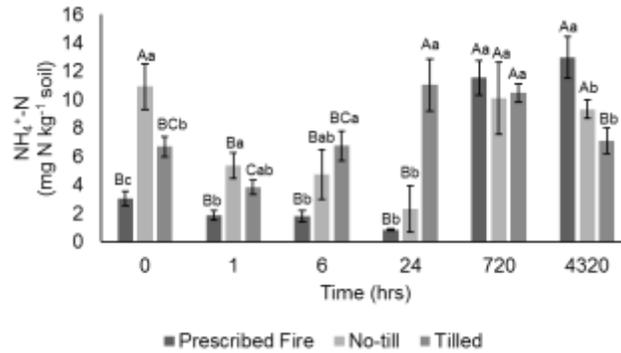
Fig. 2.9. Ammonium-N (NH_4^+-N) concentration in samples from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of corn residue. Different uppercase letters indicate significant differences within treatment over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)

2.3.3 Soil Enzyme Activity Response to Treatments

In wheat stubble residue, a treatment effect and sampling time effect was observed for β-glucosidase activity (Table 2.6). Tilled soil had the lowest β-glucosidase activity relative to no-till and prescribed fire (Fig. 2.10). β-glucosidase activity decreased 1 hr post-management and increased to maximum activity at 4320 post-management (Fig. 2.11). The increase in β-glucosidase activity 4320 hrs post-management could be in response to the increased amount of biomass at the surface due to plant growth.

Table 2.6. ANOVA p-values for in β-glucosidase activity in wheat stubble residue as affected by treatment, sampling time, year, and their interactions.

Source	β-glucosidase
Treatment	<0.0001
Sample time	<0.0001
Year	NS[1]
Treatment x Sample time	NS
Treatment x Year	NS
Sample time x Year	NS
Treatment x Sample time x Year	NS

[1]Not Significant at 0.05 level
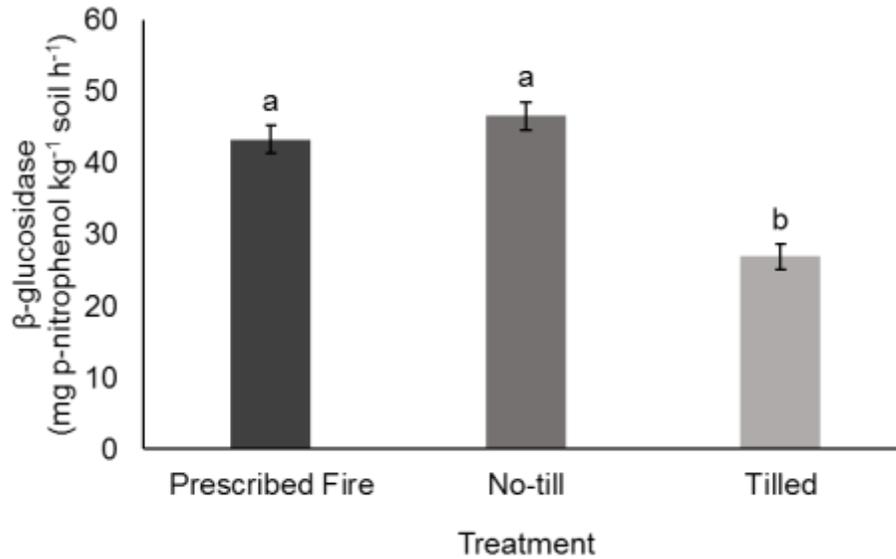
Fig. 2.10. β-glucosidase activity in samples averaged over time from pre- (0 hrs) to 4320 hrs (6 months) post-management in prescribed fire, no-till, and conventionally tilled treatments in wheat residue. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)

In corn stubble residue, an interaction was observed between treatment and sampling time for β-glucosidase activity (Table 2.7). β-glucosidase activity decreased 6 hrs post-prescribed fire and recovered to pre-prescribed fire levels 24 hrs post-prescribed fire.
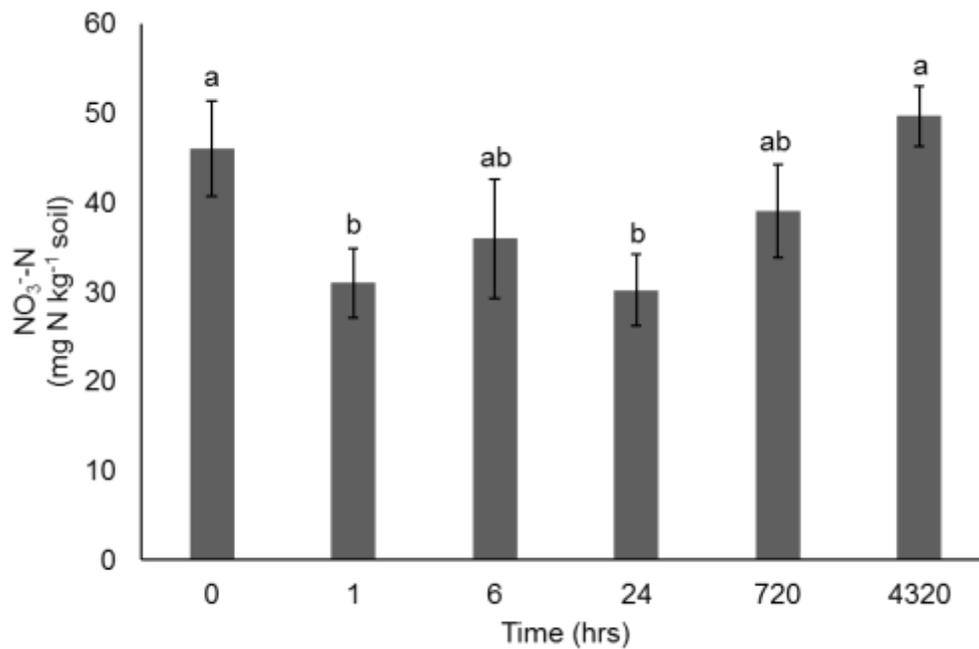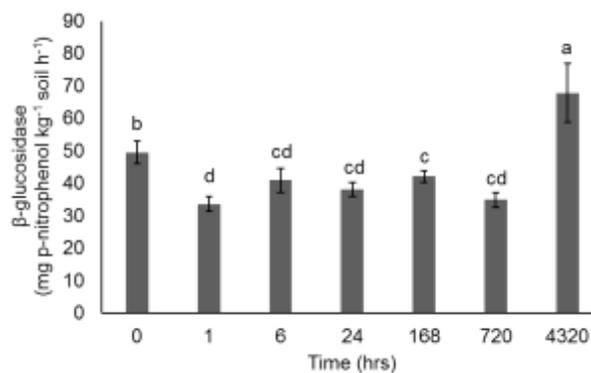

Fig. 2.11. β-glucosidase activity concentration in samples averaged over treatments of prescribed fire, no-till, and tilled management practices at pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within treatments over time. (α=0.05)

β-glucosidase activity decreased in no-till soils 24 hrs post-management and recovered to pre-management levels at 4320 hrs post-management (Fig. 2.12). The recovery of β-glucosidase activity 4320 hrs post-management could be in response to more corn biomass at the surface. Tilled soil had the lowest β-glucosidase activity before the management event and 4320 hrs post-management (Fig. 2.12).

Tillage incorporates crop residue into the soil, which could explain the decrease in β-glucosidase activity in tilled soil at the surface layer (0-2.5 cm) relative to no-till and prescribed fire soil. Results were similar to those reported by Bergstrom et al. (2000) that indicated tillage had a lower amount of β-glucosidase activity at 0-7.5 cm depth relative to no-till soil. These results are also comparable to that shown previously where tilled soils contained lower enzymatic activity than no till soils in response to shifts in availability of organic substrates, in soil moisture, soil temperature, soil aeration and constitution of soil flora and fauna (Melero et al., 2011; Acosta-Martínez et al., 2008; Alvear et al., 2005).

Table 2.7. ANOVA p-values for in β-glucosidase activity in corn stubble residue as affected by treatment, sampling time, and their interactions.

Source	β-glucosidase
Treatment	NS[1]
Sample time	NS
Treatment x Sample time	0.0106

[1]Not Significant at 0.05 level

Fig. 2.12. β-glucosidase activity in samples from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of corn residue. Different uppercase letters indicate significant differences within treatment over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)

In wheat stubble residue, an interaction between treatment and sampling time was observed (Table 2.8). No-till soil had the highest amount of NAGase activity up to 720 hrs post-management. Since no-till leaves crop residue undisturbed on the soil surface, there is a more stable pool of extracellular enzymes because the soil environment is less oxidizing than in tilled soil which could explain the higher amount of NAGase activity in the no-till soil (Melero et al., 2009; Trasar-Cepeda et al., 2008). Prescribed fire and no-till soil had similar NAGase activity 4320 hrs post-management. NAGase activity increased to its maximum 4320 hrs post-management possibly due to vegetative changes (Fig. 2.13). A year by time interaction was observed potentially due to variations in time of sampling between years (Table 2.8; Fig. 2.14).

Table 2.8. ANOVA p-values for in N-acetyl-β-D-glucosaminidase activity in wheat stubble residue as affected by treatment, sampling time, year, and their interactions.

Source	N-acetyl-β-D-glucosaminide
Treatment	<0.0001
Sample time	0.0035
Year	0.0208
Treatment x Sample time	0.0002
Treatment x Year	NS[1]
Sample time x Year	<0.0001
Treatment x Sample time x Year	NS

[1]Not Significant at 0.05 level

In corn stubble residue, a sample time effect was observed for NAGase activity (Table 2.9). NAGase increased 1 hr post-management and returned to pre-management levels 720 hrs post-management. NAGase increased to maximum activity at 4320 hrs post-management (Fig. 2.15). The increase in soil enzyme activity 4320 hrs post-management could be in response to increased amount of biomass at the surface.
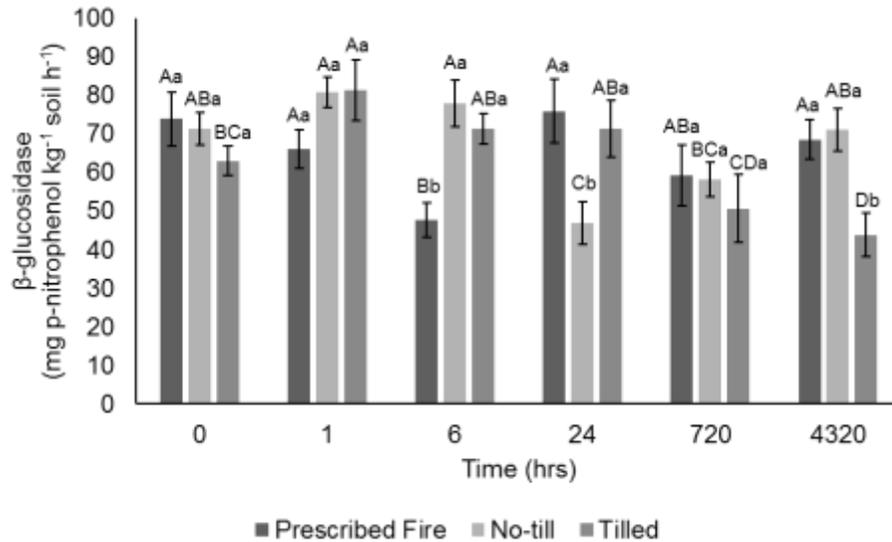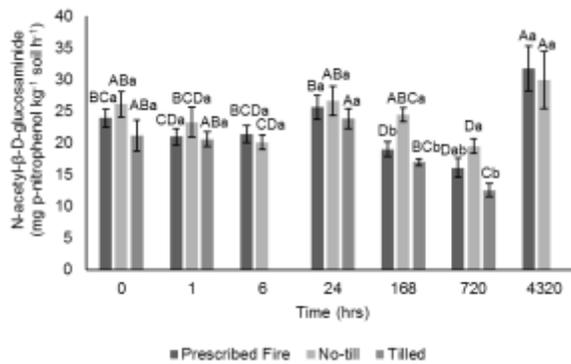

Fig. 2.13. N-acetyl-β-D-glucosaminidase (NAGase) activity in samples from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within treatments over time. Different lowercase letters indicate significant differences within time between treatments. (α=0.05)
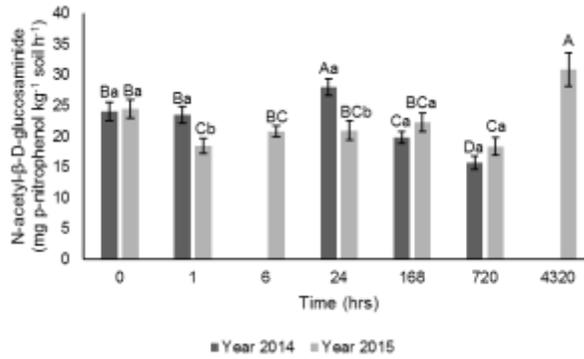
Fig. 2.14. N-acetyl-β-D-glucosaminidase (NAGase) activity in samples collected year 2014 and 2015 from prescribed fire, no-till, and conventionally tilled treatments pre- (0 hrs) and up to 4320 hrs (6 months) post-management of wheat residue. Different uppercase letters indicate significant differences within years over time. Different lowercase letters indicate significant differences within time between years. (α=0.05)

Table 2.9. ANOVA p-values for in N-acetyl-β-D-glucosaminidase activity in corn stubble residue as affected by treatment, sampling time, and their interactions.

Source	N-acetyl-β-D-glucosaminide
Treatment	NS[1]
Sample time	<0.0001
Treatment x Sample time	NS

[1]Not Significant at 0.05 level
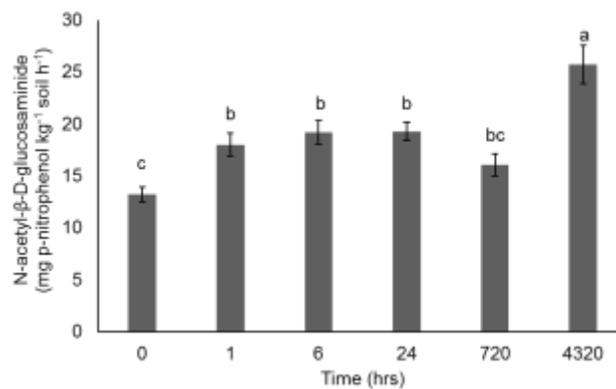
Fig. 2.15. N-acetyl-β-D-glucosaminidase (NAGase) activity in samples averaged over treatments of prescribed fire, no-till, and tilled management practices at pre- (0 hrs) and up to 4320 hrs (6 months) post-management of corn residue. Different uppercase letters indicate significant differences within treatments over time. (α=0.05)

2.3.4 Soil Microbial Community Structure as a Result of Treatment Effects

In wheat stubble residue, there were no differences in absolute abundance of FAMEs; however, a treatment effect and a time effect was observed for relative abundance of FAMEs. Therefore, total FAMEs did not increase between treatments or across time, but different microbial groups shifted in abundance relative to treatments and over time. Prescribed fire soil had a relative abundance of Gram negative, total bacteria, and actinomycetes. No-till and tilled soils had similar microbial communities with a relative abundance of AMF, saprophytic fungi, and fungi:bacteria (Fig. 2.16).

Fig. 2.16. Distance based redundancy analysis (db RDA) plot derived from fatty acid profiles from samples collected in 2014 wheat stubble residue under tilled (green triangles), no-till (red circles), and prescribed fire treatments (black circles). Vectors in the bi-plot overlay were constructed from a matrix containing taxonomic groups. (mGMp = Gram positive bacteria; mGMn = Gram negative bacteria; mAMF = Arbuscular mycorrhizal fungi; S. Fungi = Saprophytic Fungi)

Prescribed fire can modify microbial community structure due to the heating of the soil which could explain the different microbial communities in prescribed fire soil relative to tilled and no-till (Perry et al., 1984). Pre-management (0 hrs) and 1 hr post-management had a relative abundance of saprophytic fungi, fungi:bacteria, and Gram negative bacteria. There was a shift in microbial community structure 24 hrs post-management where there was a relative abundance of AMF. At 168 hrs post-management, the microbial community shifted to a relative abundance of Gram positive bacteria. At 720 hrs post-management, the microbial community shifted to a relative abundance of total bacteria (Fig. 2.17). Since there was no interaction between treatment and sampling time, the shifts in microbial community structure over time could be the result of abiotic factors such as rainfall, temperature, and time of day.
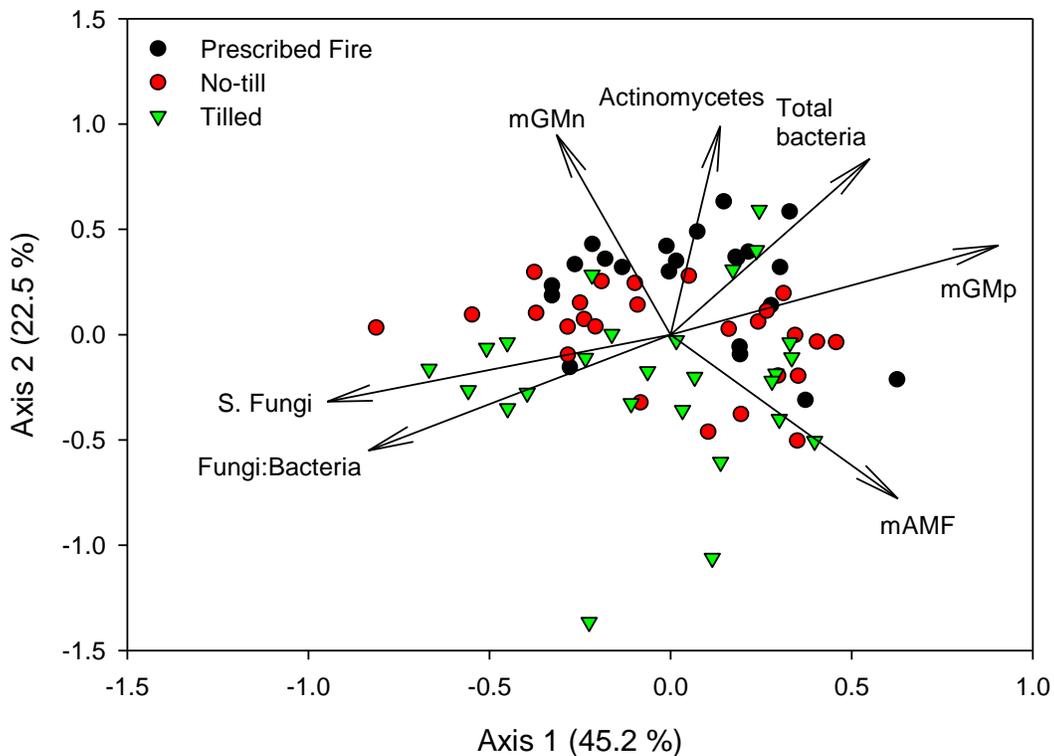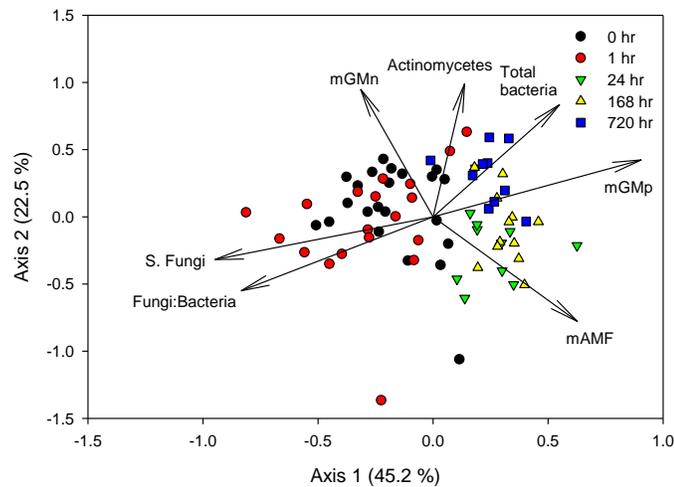

Fig. 2.17. Distance based redundancy analysis (db RDA) plot derived from fatty acid profiles from samples collected in 2014 wheat stubble residue from tilled, no-till, and prescribed fire treatments at pre- (0 hrs) and up to 720 hrs (30 days) post-management. Pre are black circles, 1 hr is red circles, 24 hrs are green triangles, 168 hrs are gold triangles, and 720 hrs are blue squares. Vectors in the bi-plot overlay were constructed from a matrix containing taxonomic groups. (mGMp = Gram positive bacteria; mGMn = Gram negative bacteria; mAMF = Arbuscular mycorrhizal fungi; S. Fungi = Saprophytic Fungi)

In corn stubble residue, there was a time effect observed for total abundance of FAMEs (Table 2.10). Total FAMEs increased 1 hr post-management then decreased 6 hrs post-management. This trend was observed in Gram positive bacteria, Gram negative bacteria, actinomycetes, total bacteria, and saprophytic fungi. AMF was not affected by time but was more abundant in no-till soil (3.32 nmol g^{-1} in no-till; 2.31 nmol g^{-1} in prescribed fire; 1.99 nmol g^{-1} in tilled) possibly due to the soil being undisturbed. Inorganic N decreased 1 hr-post management which could be explained by the increase in total FAMEs. Since corn stubble has a high C:N ratio, microorganisms could be consuming the N in order to breakdown the residue 1 hr-post management favoring immobilization (Hoorman and Islam 2010). An increase in total FAMEs has the potential to increase soil enzyme activity by producing enzymes for C and N cycling, which could explain the increase in NAGase activity 1 hr post-management (Burns and Wallenstein 2010).

Table 2.10. Total abundance of FAMEs in corn stubble residue as affected by time.

FAMEs[1]	0 hr[2]	1 hr	6 hrs	720 hrs
	nmol g^{-1}			
Total FAMEs	87.20 ab[3]	100.30 a	78.17 bc	64.36 c
Gram Postive Bacteria	10.31 ab	11.55 a	9.38 b	7.03 c
Gram Negative Bacteria	5.05 ab	6.12 a	4.56 b	3.98 b
Actinomycetes	5.61 ab	6.12 a	4.86 bc	4.36 c
Total Bacteria	20.98 ab	23.79 a	18.80 bc	15.37 c
Saprophytic Fungi	13.63 ab	15.95 a	12.06 b	10.52 b

[1]Fatty Acid Methyl Esters

[2]Hours after management

[3]Different lower case letters indicate significant differences within microbial groups across sampling time ($p \leq 0.05$).

A treatment by time interaction occurred for relative abundance of FAMEs in corn stubble residue. No-till soil had an abundance of AMF, Gram negative bacteria, and saprophytic fungi at 6 hrs and 720 hrs post-management (Fig. 2.18). Microbial community structure could not be determined pre-management and 1 hr post-management in the no-till soil. Microbial community structure could not be determined in the tilled soil (Fig. 2.19). There was an abundance of Gram positive bacteria and total bacteria pre-prescribed fire and 1 hr post-prescribed fire (Fig. 2.20). Microbial community structure could not be determined 6 hrs and 720 hrs post-prescribed fire.

Fig. 2.18. Distance based redundancy analysis (db RDA) plot derived from fatty acid profiles from samples collected in corn stubble residue from no-till treatment at pre- (0 hrs) and up to 720 hrs (30 days) post-management. Pre are black circles, 1 hr is red circles, 6 hrs are green triangles, and 720 hrs are gold triangles. Vectors in the bi-plot overlay were constructed from a matrix containing taxonomic groups. (mGMp = Gram positive bacteria; mGMn = Gram negative bacteria; mAMF = Arbuscular mycorrhizal fungi; S. Fungi = Saprophytic Fungi)

While microbial community structure can be determined in prescribed fire, no-till, and tilled treatments, variation was observed in corn stubble residue over time that was not associated with the fatty acid profiles that were tested. These variations could be due to abiotic factors, such as temperature, rainfall, and sampling time. Another explanation for the variations could be that there are other fatty acid profiles present in the soil that were not tested. Therefore, further research needs to be done in order to determine crop residue management effects on microbial community structure over time.

Fig. 2.19. Distance based redundancy analysis (db RDA) plot derived from fatty acid profiles from samples collected in corn stubble residue from tilled treatment at pre- (0 hrs) and up to 720 hrs (30 days) post-management. Pre are black circles, 1 hr is red circles, 6 hrs are green triangles, and 720 hrs are gold triangles. Vectors in the bi-plot overlay were constructed from a matrix containing taxonomic groups. (mGMp = Gram positive bacteria; mGMn = Gram negative bacteria; mAMF = Arbuscular mycorrhizal fungi; S. Fungi = Saprophytic Fungi)
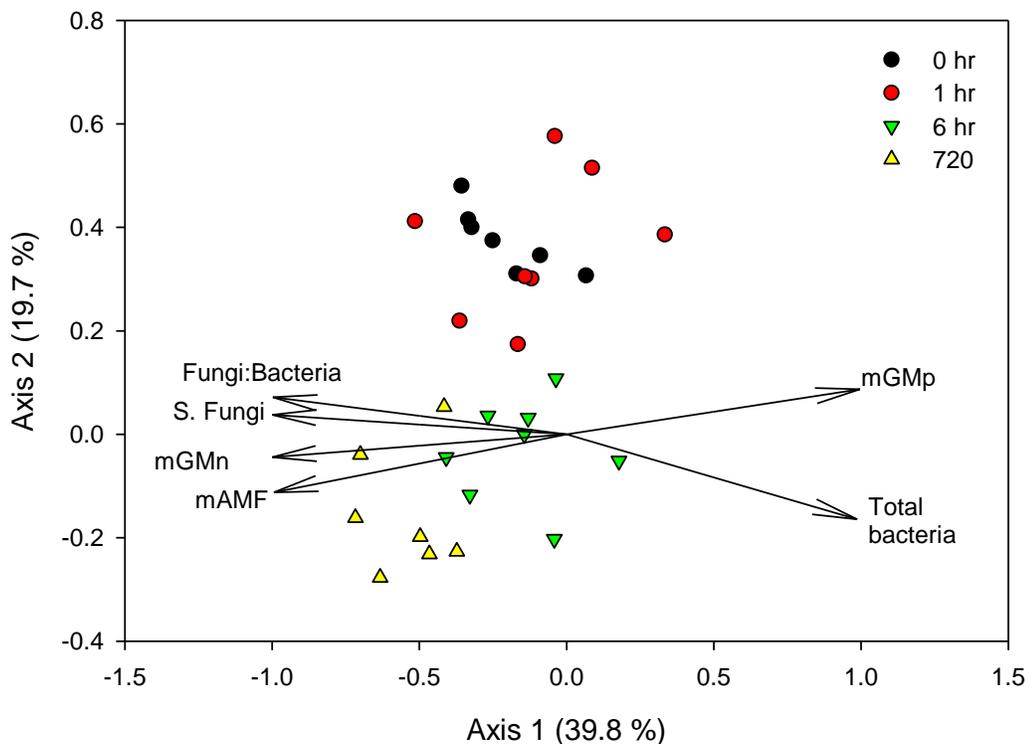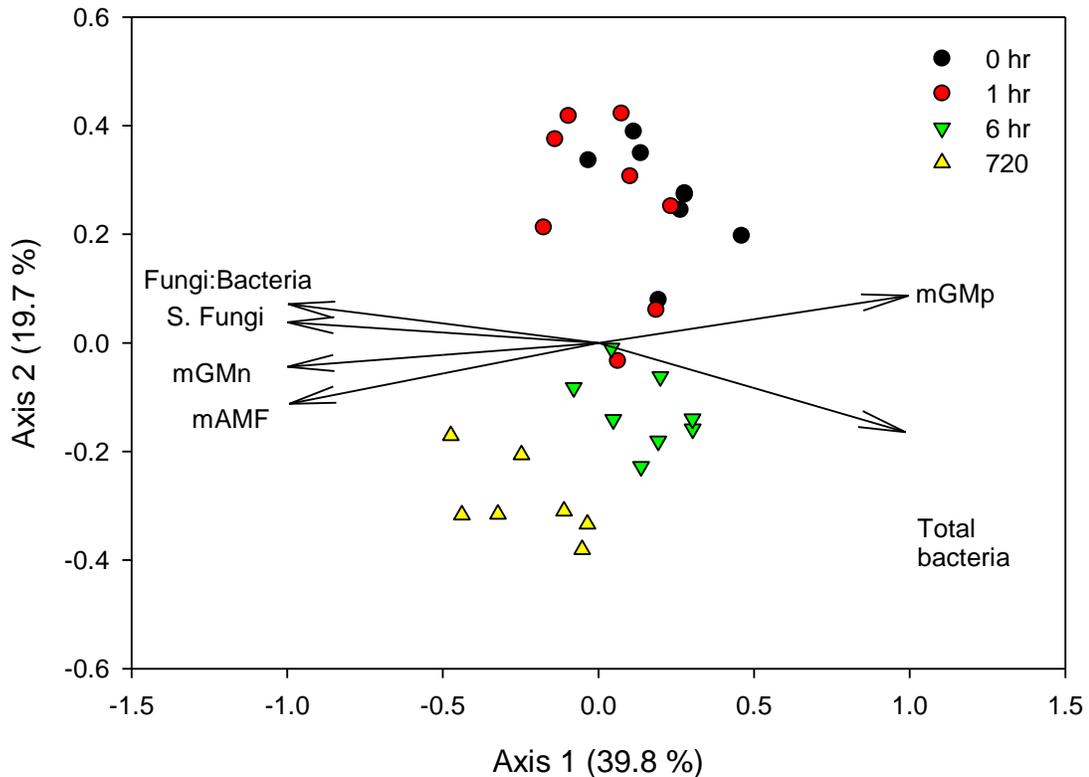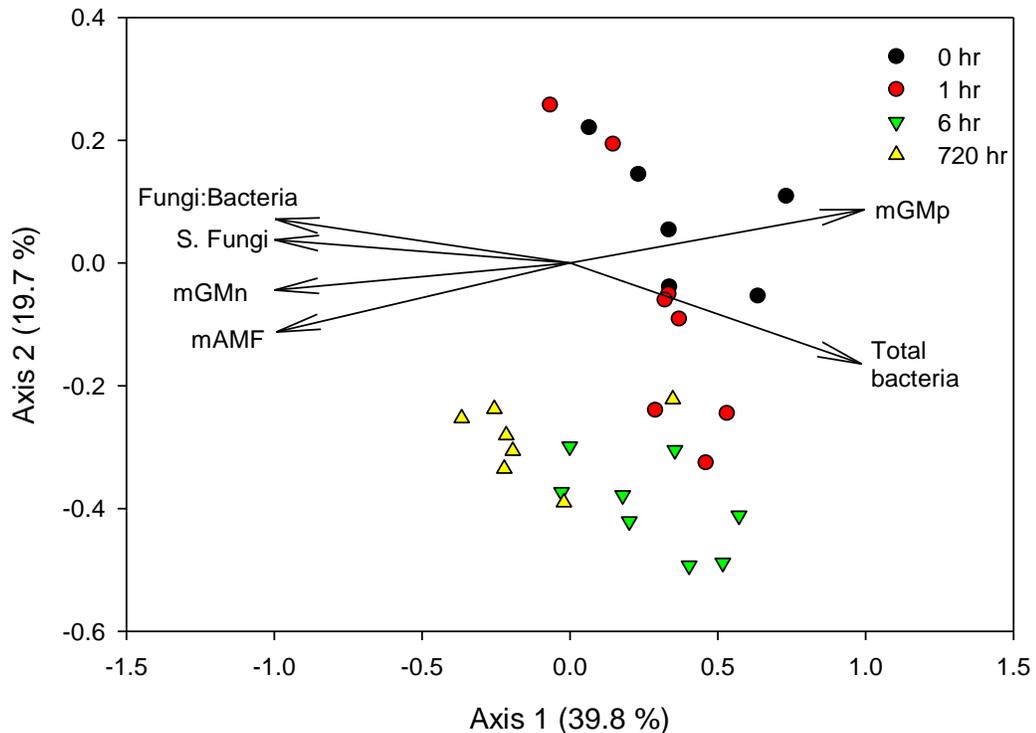
Fig. 2.20. Distance based redundancy analysis (db RDA) plot derived from fatty acid profiles from samples collected in corn stubble residue from prescribed fire treatment at pre- (0 hrs) and up to 720 hrs (30 days) post-management. Pre are black circles, 1 hr is red circles, 6 hrs are green triangles, and 720 hrs are gold triangles. Vectors in the bi-plot overlay were constructed from a matrix containing taxonomic groups. (mGMp = Gram positive bacteria; mGMn = Gram negative bacteria; mAMF = Arbuscular mycorrhizal fungi; S. Fungi = Saprophytic Fungi)

2.4 Conclusions

The effects of prescribed fire, no-till, and conventional tillage on soil biological and chemical properties in wheat and corn stubble residue were determined by this study. Short term changes in organic matter, nutrients, and enzyme activity were observed for prescribed fire, no-till, and conventional tillage in wheat and corn stubble residue. Prescribed fire increased nitrate-N relative to no-till and conventional tillage in wheat stubble residue. β-glucosidase activity was lowest in conventional tillage in wheat stubble residue. In wheat stubble

residue, prescribed fire soil had an abundance of Gram negative, total bacteria, and actinomycetes. No-till and tilled soils had similar microbial communities with an abundance of AMF, saprophytic fungi, and fungi:bacteria. There were shifts in microbial communities over time from abundance of saprophytic fungi, fungi:bacteria, and Gram negative bacteria pre-management and 1 hr post-management to an abundance of AMF 24 hr post-management to an abundance of Gram positive bacteria 168 hrs post-management to an abundance of total bacteria 720 hrs post-management. The effects of the crop residue management practices on microbial community structure over time was unable to be determined based on the fatty acid profiles tested in this study in corn stubble residue. Further research needs to be done in order to determine the most efficient crop residue management practice to optimize soil fertility in wheat and corn stubble residue in Louisiana.

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Chapter 3. Conclusions

Crop residues have been proven beneficial in improving soil fertility. However, crop residue management practices impact the effectiveness of crop residue on soil biological and chemical properties. With little research done on prescribed fire as a crop residue management practice, we established this study in order to determine the effects of prescribed fire, no-till, and conventional tillage on soil organic matter, nutrients, soil enzyme activity, and soil microbial community structure in wheat and corn stubble residue. Prescribed fire increased NO_3^--N relative to no-till and conventional tillage in wheat stubble, which aligned with our hypothesis. Prescribed fire also increased β-glucosidase activity relative to conventional tillage but was similar to β-glucosidase activity observed in no-till. Short term changes in organic matter, nutrients, and enzyme activity were observed in prescribed fire, no-till, and conventional tillage. Shifts in microbial communities were observed in wheat stubble residue with of Gram negative, total bacteria, and actinomycetes dominating the prescribed fire soil and abundance of AMF, saprophytic fungi, and fungi:bacteria dominated no-till and conventional tillage soil. We were unable to determine effects of management practices on microbial community structure on corn stubble residue based on the fatty acid profiles we tested. While prescribed fire increased NO_3^--N and β-glucosidase activity, similarities between management practices were observed in NH_4^+-N, soil organic matter, and NAGase activity. Therefore, further research needs to be done in order to determine the most efficient crop residue management practice to optimize soil fertility.

Vita

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