GREENHOUSE GAS EMISSIONS, SOIL MOISTURE AND TEMPERATURE DYNAMICS WITH DIFFERENT COVER CROPS IN ORGANIC COTTON

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Abstract

Cover crops are important components of organic crop production systems. Cover crops can suppress weed pressure and provide additional soil fertility in organic cropping systems. Cover crops also have the potential to sequester C and reduce greenhouse gas (GHG) emissions. A study was conducted in 2020 at the Texas A&M University research farm near College Station, Texas to investigate the effects of winter cover crops on GHG emissions, and soil moisture and temperature dynamics in conventionally tilled organic cotton (*Gossypium hirsutum L.*) system. Cover crop treatments were winter pea (*Pisum sativum*), mustard (*Brassica rapa*), oats (*Avena sativa L.*), winter mix (mixture of winter pea, mustard and oats) and control (no-cover weed free). Greenhouse gas samples were collected weekly using static chambers during the cotton growing season and analyzed for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) concentrations. Soil moisture and temperature were monitored continuously during the cotton growing season. Data showed higher soil moisture in oats and winter mix cover crop plots compared to other treatments. Soil temperature was not affected by cover crop treatments. Relative higher residues of oats and winter mix cover crop contributed greater CO_2 emissions compared to the single species cover crops. Mix species of cover crops had greater N_2O and CH_4 emissions indicating greater microbial activity and diversity in mix species compared to single species. Continuation of the study for two more years would help to understand the effects of different types of cover crops to the overall cropping system and selection of proper management practices.

Introduction

Texas is the top cotton producing state in the U.S. and organic cotton acreage is growing each year in the state (USDA-NASS, 2021). Maintaining soil fertility and weed control are major challenges in organic crop production. Many organic farmers still rely on tillage and row cultivations for weed management. In recent years, cover cropping has emerged as an important component of organic farming for controlling weeds and improving soil fertility. A well-planned cover crop system along with manure application has been shown to improve soil fertility in long-term organic cropping systems (Birkhofer et al., 2008).

Majority of the cotton fields in Texas have low soil organic matter (Bronson et al., 2004). This is in part due to the relatively small amount of crop residue left in the field following the harvest of cotton. In addition, agricultural producers in this region traditionally have opted for conventional tillage, which leads to soil disturbance, increased emissions of GHGs, and less carbon sequestration. Inclusion of cover crops as a low-input crop have the potential to store more carbon in the soil as organic matter, reduce GHG emissions and increase overall cotton yield (Abdalla et al., 2019; Nouri et al., 2019).

The GHG emissions from organically managed cotton fields in Texas are not well quantified. Limited information is available on the effects of different cover crops on soil moisture and temperature dynamics in organic cotton system. In this study, we investigated how cover crops are affecting soil moisture, soil temperature and GHG emissions in conventionally tilled organic cotton in south-central Texas.

Materials and Methods

Study Site and Treatments

The study was conducted at the Texas A&M University research farm near College Station, Texas (33.55°N, 96.43°W) located on the Brazos River floodplain in southcentral Texas, USA (Fig. 1). The climate is humid subtropical with a mean annual precipitation of 1018 mm, annual average minimum air temperature of 15°C, and maximum of 27°C (Menefee et al., 2020). The soil at the site is classified as Weswood silty clay loam (fine-silty, mixed, superactive, thermic Udifluventic Haplustepts) with 23 % sand, 39 % silt, and 38 % clay in the top 30 cm of the profile (Soil Survey Staff, 2021).

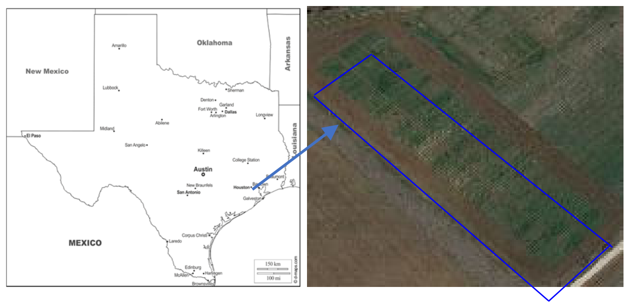

Figure 1: Study site near College Station, Texas.

The experimental design was randomized complete block design (RCBD) with five cover crop treatments and four replications. Cover crop treatments included legume, brassica and cereal single cover crop treatments and a mix of all three species. Legume cover crop treatment was winter pea. Mustard was planted as brassica cover crop and, oats were planted as cereal cover crop. Winter mix contained all three cover crops. Control treatment was kept weed-free with no cover crop. The seeding rate of the cover crops were 56 kg ha^{-1} for winter pea, 5.5 kg ha^{-1} for mustard, 78 kg ha^{-1} for oats and 46 kg ha^{-1} for winter mix in a ratio of 10:1:14 of winter pea, mustard and oats, respectively. All cover crops were planted on November 4, 2019 and terminated on March 26, 2020 with a roller crimper. Poultry litter was applied at a rate of 2.98 Mg ha^{-1} two weeks prior to cotton planting on May 20, which supplied 125 kg ha^{-1} N. Cotton was planted on June 2, 2020. Row spacing was 1 m. Individual plot size was 15.24 m × 3.05 m. Cotton was harvested on October 29, 2020.

Soil Moisture and Temperature

Soil moisture and temperature were monitored using multi-parameter soil temperature and moisture sensors (Model CS655, Campbell Scientific Inc, Logan, UT). Sensors were installed vertically to measure soil temperature at 5 cm depth and soil volumetric water content (VWC) from 5-17 cm depth. Sensors were programmed to collect measurements at 5 sec intervals using a datalogger (Model CR1000, Campbell Scientific Inc, Logan, UT).

Greenhouse Gas Emissions

Greenhouse gas emissions were measured using static chamber technique following the USDA-ARS GRACEnet protocol (Parkin and Venterea, 2010). The size of the anchors used were 0.73 m × 0.35 m. The anchors were installed in between two crop rows as shown in fig 2. Gas sampling was done at weekly intervals during the cotton growing season but was delayed by 2-3 days in case of heavy rain. The samples were collected at 00-, 10-, 20- and 30-min intervals after closing the chamber lid. Samples (20 ml) were drawn using air-tight syringes and stored in 10 ml evacuated vials before measuring GHG concentrations using a gas chromatograph. Flux rates were calculated from the slope of curve by plotting gas flux against time.

Figure 2: Greenhouse gas samples collection from the chambers in the field.

Results and Discussion

Figure 1 presents half-hourly VWC data throughout the growing season. During the soil dry-down period after precipitation and irrigation, cotton plots with oats cover crop residues retained more soil moisture in the topsoil compared to other treatments (Fig-3). Control plots with no cover crop residues had the lowest VWC. Previous studies also indicated improvements in soil moisture retention with cover crops that produced slowly-decomposing residues (Blanco-Canqui and Ruis, 2020). Figure 4 presents half-hourly soil temperature data during the cotton growing season from control plots plotted against soil temperature from cover crop treatment plots. Comparison of each cover crop treatment to control showed no significant difference in soil temperature at 5 cm depth (Fig. 4A-D).

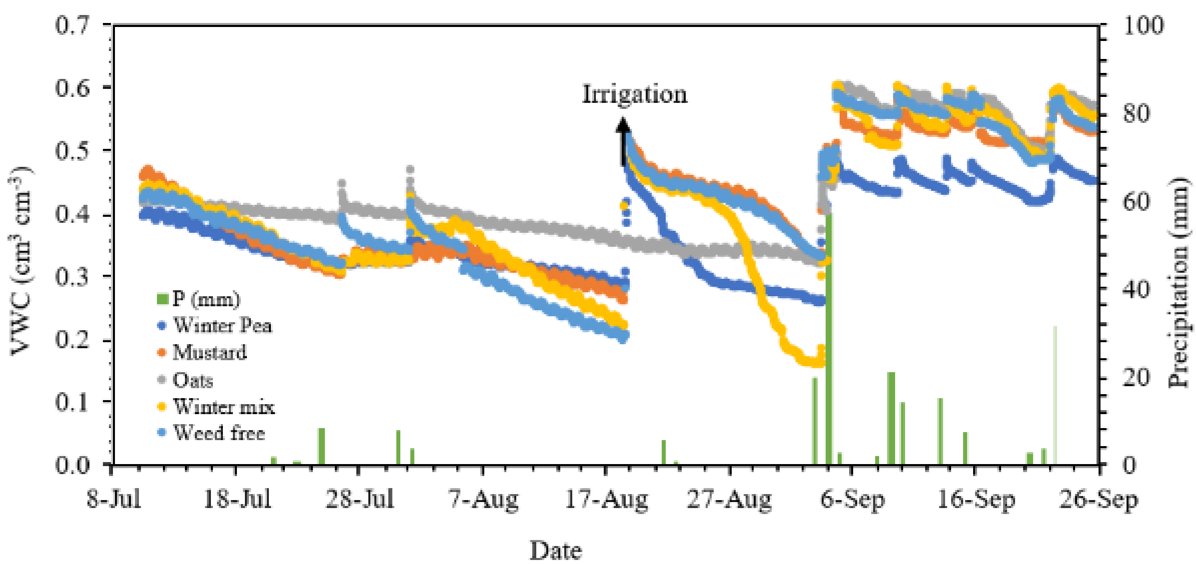

Figure 3: Volumetric water content (VWC) in response to different cover crop treatments and precipitation (P) events throughout the cotton growing season.

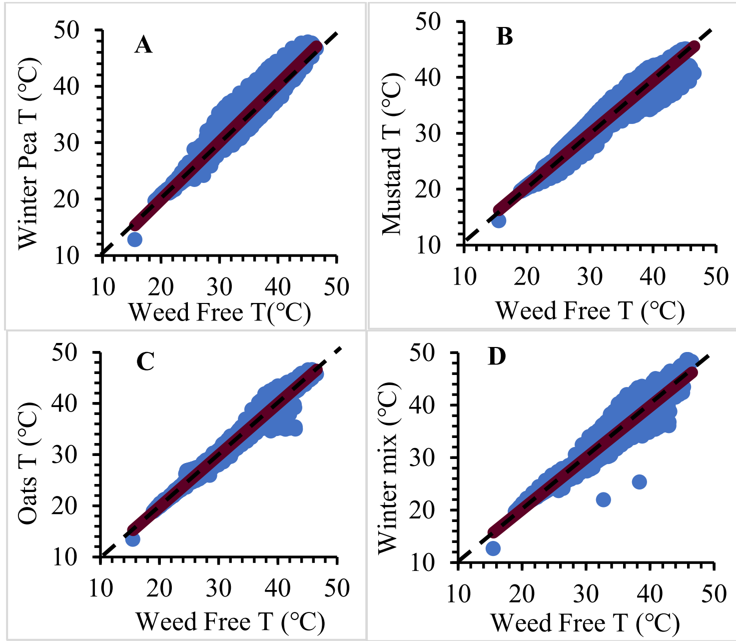

Figure 4: Effects of winter pea (A), mustard (B), oats (C) and winter mix (D) on soil surface temperature compared to weed free. Bold red line represents the regression line and dashed line is the one-to-one ratio.

Figure 5 presents GHG emissions dring the cototn growing season. Cotton plots that has winter mix residues had higher CO_2 emissions compared to the single species cover crop treatments and control. This higher CO_2 emisison could be due to balanced C and N availability from mix species of cover crops for microbial activity in soils (Fig. 5A). Plots with mix species residues and control had higher N_2O emissions compared to the single species cover crops (Fig. 5B). This finding supports the fact that availability of mineralizable C from non-legumes and high N content of legumes stimulates the nitrifier and denitrifier activity causing increased N_2O emisison (Kaye and Quemada, 2017; Mitchell et al., 2013). CH_4 emissions were negligible but mix species showed comparatively higher emission which could be because of the higher biomass and better availability of mineralizable C (Fig. 5C).

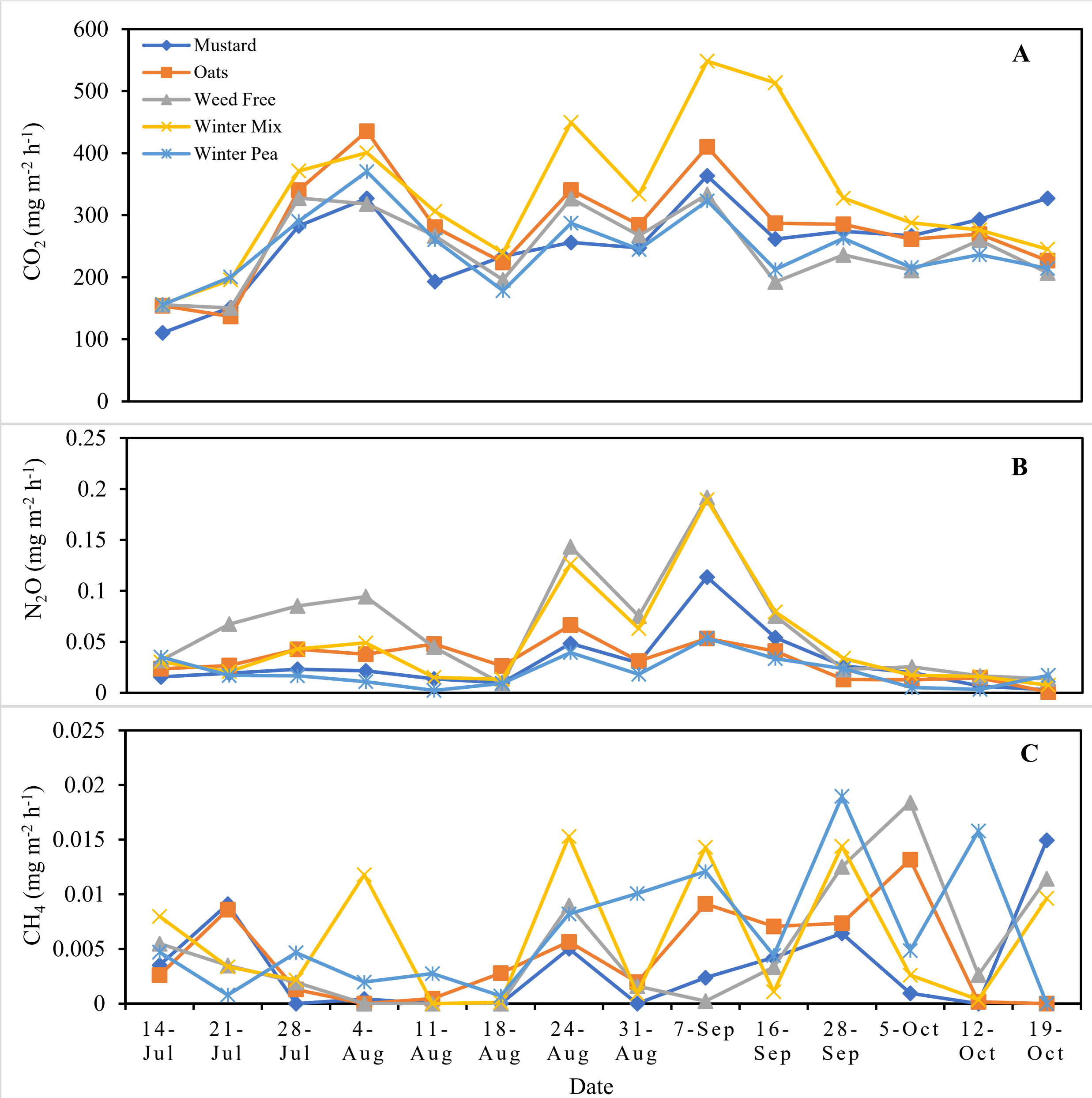

Figure 5: Fluxes of CO_2 (A), N_2O (B) and CH_4 (C) in response to different cover crops during the cotton growing period.

Conclusions

This study showed efficiency of oats residues in retaining higher soil moisture during the cotton growing period. All cover crop treatments had similar topsoil temperature. Mix species of cover crops stimulated soil respiration leading to higher CO_2 emissions. Favorable C:N ratio and availability of mineralizable C of mix species cover crops lead to higher N_2O emissions compared to single species cover crops. CH_4 emissions were very negligible but higher residues and balanced C and N availability lead to comparatively higher CH_4 emission in plots that had mix species cover crop residues.

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