Effects of Different Cover Crops and Tillage on Greenhouse Gas Emissions in Soil Incubation

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Introduction

- Decomposition of cover crops (CC) after termination stimulates microbial activity and can increase the greenhouse gas (GHG) emissions.
- Tillage following CC termination accelerate the decomposition process and may promote the GHG emissions (Abdalla et al., 2014).
- Different cover crops like legumes, brassica, cereal and mix species of CC with residues incorporated or surface applied to the soil may have differential effects on GHG emission.
- However, the carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) emissions after cover crop termination and incorporation into the soil is not adequately studied.
- Soil incubation simulating the field condition of CC residues and tillage may help understand the GHG emission dynamics in a cover crop incorporated cropping system.

Research Hypotheses

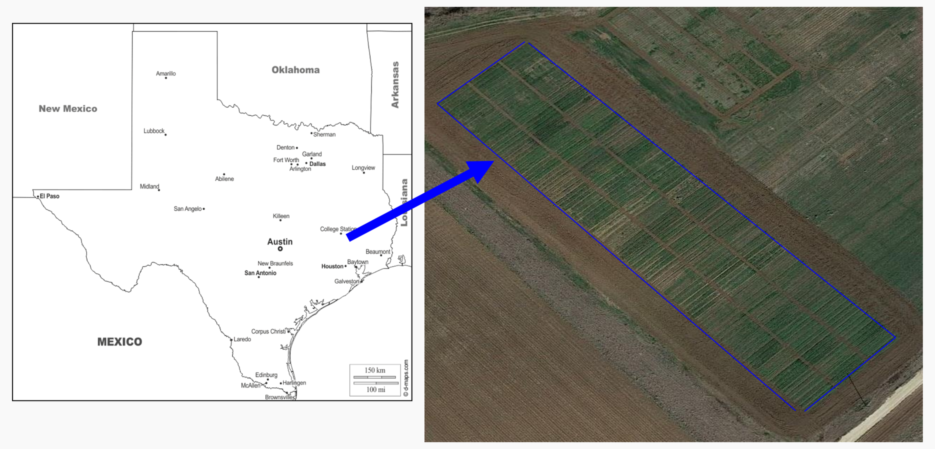
- Mix species of CC may have higher CO_2 emissions and legume CC would have higher N_2O emissions compared to other CC and no CC treatments.
- Soil incorporation of residues may lead to higher GHG emission compared to surface applied.

Objectives

1. To investigate the effects of CC residues on CO_2, N_2O and CH_4 emissions during incubation of soil core samples collected from an organic cotton field at 29°C.
2. To study different residue management effects (surface applied or soil incorporated) on GHG emissions during the incubation.

Methods

Study Site in College Station, Texas



- Study Site: Near College Station, Texas (33.55ºN, 96.43ºW).
- Climate: Humid subtropical.
- Cropping System: Organic cotton with CC
- Exp. Design: Split plot design with two tillage treatments as main plots and six CC treatments as subplots in three replications.

Treatments

Tillage (Main plots)	Cover crops (Sub-plots)	Seeding rate (kg ha^{-1})
Conventional (incorporated)	Winter pea (*Pisum sativum*)	56
	Mustard (*Brassica rapa*)	5.5
	Oats (*Avena sativa L.*)	78
Surface applied	Winter mix (mix of all three)	46
	Weed free (no cover crop)	--
	Weedy (no CC and no weed control)	--

- CC residues were applied just before soil incubation at the rates as in field.
- Poultry litter was applied at a rate of 2.98 Mg ha^{-1} (0.77 g per soil core).
- Soils were stirred for conventional tilled plots and surface applied to mimic no-tillage.

Soil Sampling and Incubation

- Undisturbed soil core samples were collected from each plot after CC termination.
- Core size: 5.72 cm inner diameter, 10.2 cm height (Fig-1).
- Soil samples were placed in 250 ml cups and were stored in refrigerator at <4° C until incubation.
- Incubation jars: Inner volume of 946 ml with air-tight lids (Fig-2).
- Soil water adjustment: 60% WHC.
- Incubation temperature: 29°C.

Fig 1: Bulb planter used for undisturbed soil sampling.

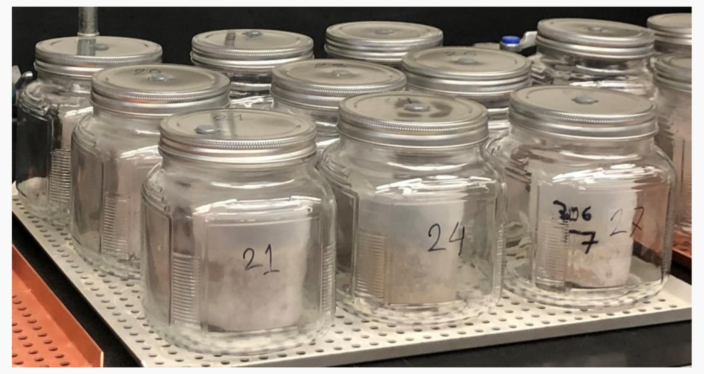


Fig 2: Soils inside the airtight jar for incubation.

Greenhouse Gas Emissions

- Sampling days: 0, 1, 2, 4, 6, 10, 14, 22, 30, 45 days of incubation.
- Sampling time: 0 and 4 hours after closing the lids.
- Gas samples were stored in 12 ml evacuated vials.
- Samples were analyzed for CO_2, N_2O and CH_4 concentration using a gas chromatograph.

Results and Discussion

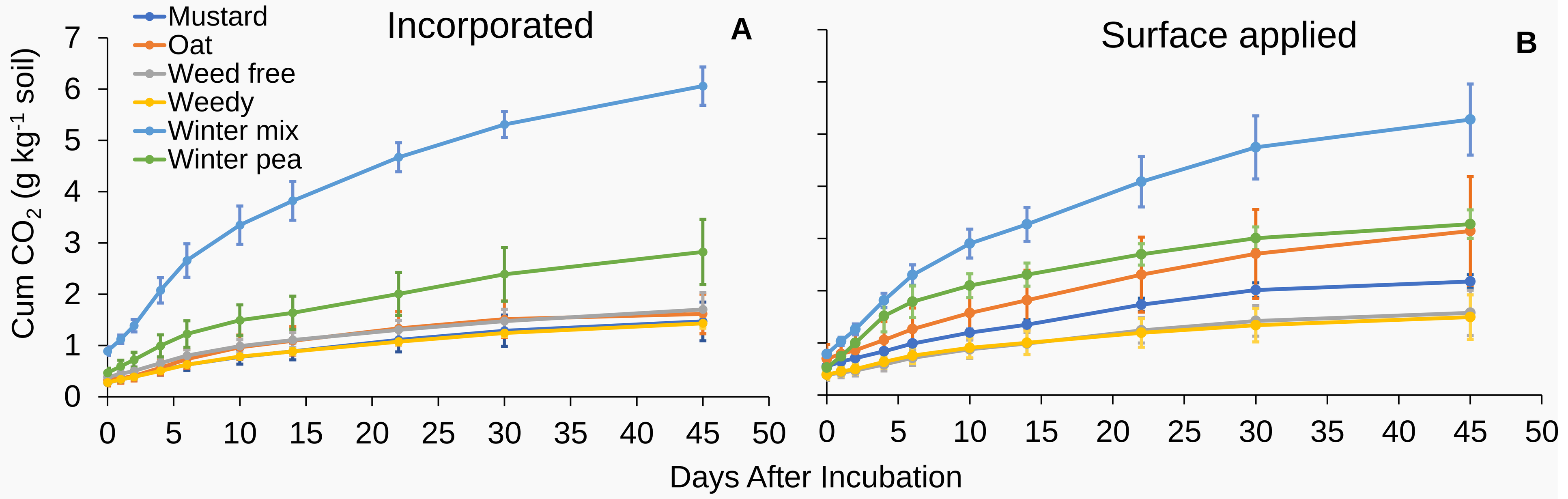


Fig 3: Cumulative CO_2 emissions (g kg^{-1} soil) in response to different CC treatments of incorporated (A) and surface appied (B) residues.

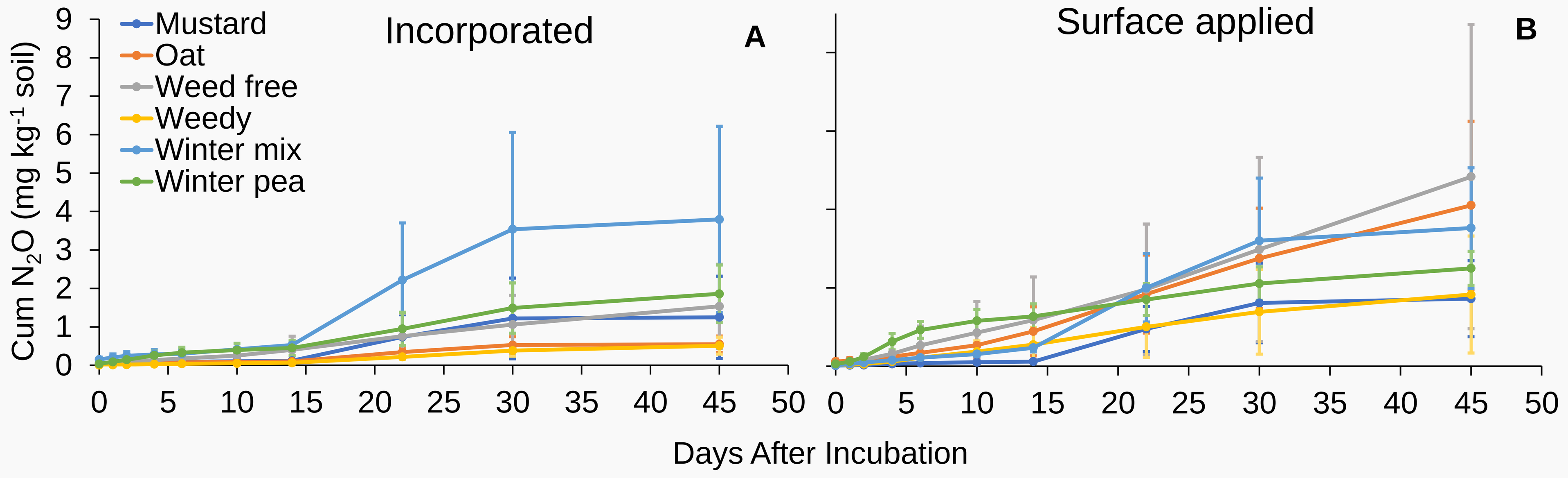


Fig 4: Cumulative N_2O emissions in response to different CC treatments of incorporated (A) and surface applied (B) residues.

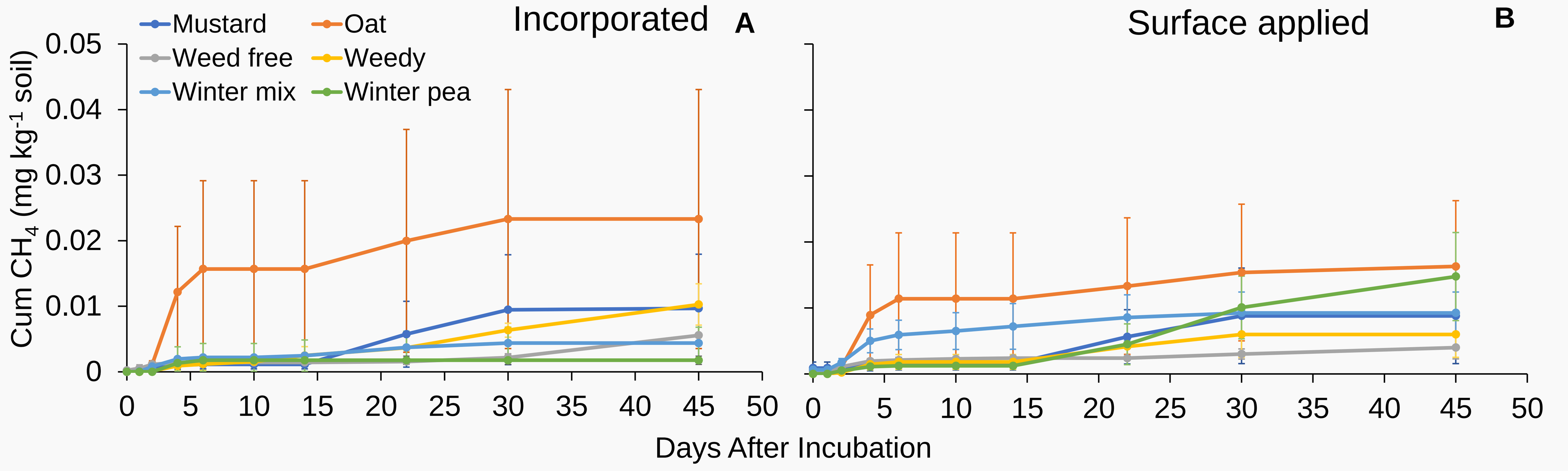


Fig 5: Cumulative CH_4 emissions in response to different CC treatments of incorporated (A) and surfaced (B) residues.

- Winter mix had significantly higher cumulative CO_2 emissions in both soil incorporated and surface applied treatments indicating higher microbial activity and soil respiration. This could be promoted due to the balanced C:N ratio of cereal and legume CC residues (Fig-3).
- When incorporated, emission from oats treatment was similar to no CC treatments which shows that oats residues were more persistent than other CC residues (Fig-3). However, when surface applies, oats had similar CO_2 emission as legume CC treatment.
- Winter mix had higher cumulative N_2O emissions while residues were incorporated compared to other CC treatments, but no difference was observed in surface applied residues of CC (Fig-4). This result indicates the mix species while incorporated into the soil stimulated nitrifiers and denitrifiers' activity compared to other CC and control. Surprisingly, single species legume CC didn't have any effect on N_2O emissions which is opposite of our hypothesis.
- Oats had higher cumulative CH_4 emissions when residues were incorporated but no observable difference were observed in surface applied (Fig-5). This indicates an influence of oats residue in regulating CH_4 emissions which need further investigation (Haque et al., 2013). Overall CH_4 emissions were negligible and residue incorporation didn't differ from surfaced treatment in terms of CH_4 emission.

Conclusions

- Balanced C and N availability from mix species CC stimulated the microbial activity and increased CO_2 emissions in both residue management. Legume CC had higher CO_2 emissions while residues were mixed into the soil.
- Mix species CC treatment when residues were incorporated had higher N_2O emissions. Low C:N ratio legume CC treatment didn't increase N_2O emissions compared to no CC treatments.
- Oats residues increased CH_4 emissions when incorporated with soil but overall CH_4 emissions were very negligible and no difference among CC treatments were found in surface applied treatments.

References

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