Greenhouse gas emissions in no-till vegetable production

Wolters, B.R., Collins, D.P., Fortuna, A.M., Cogger, C.G., Bary, A.
[1]Washington State University, [2]North Dakota State University

Introduction

Soils are major a source of CO_2 emissions in agriculture and conventional tilling increases these emissions. No-till farming practices can reduce the amount of CO_2 emitted from the soil and sequester more carbon in the soil, reducing atmospheric CO_2 concentrations and improving soil quality. Organic vegetable production relies heavily upon tillage to incorporate residues, prepare the seedbed, and control weeds. Using no-till farming could reduce the amount of CO_2 emissions from organic vegetable production.

Objective

- Compare CO_2 emissions in fully tilled and no-till system

Design of Field Experiments

- Organic Reduced Tillage Experiment at WSU Puyallup Research and Education Center was established in 2011
- The two treatments analyzed for CO_2 are part of a larger experiment with five treatments (Figure 1):
  - All plots were tilled and planted with cover crops in fall and rolled or flailed in spring
  - Spader was used on fully tilled plots and planting aid on no-till plots
  - Planting aid (Figure 2) disturbs soil 5 cm wide and 10 cm deep
  - Vegetable crops include broccoli, squash, and green beans
- Treatments measured in this study:
  - Flail + spader + squash (fully tilled)
  - Roll + planting aid + squash (no-till)

Sq	Br	Bn	Sq	Br	Bn	Sq	Br	Bn	Sq	Br	Bn	Sq	Br	Bn
flailing + no-till			flailing + zone till			flailing + complete till			roll/crimp + zone till			roll/crimp + no-till.		

Figure 1. Puyallup Organic Reduced Tillage Experiment
***One of four replicates*. SQ=squash; BR= broccoli; BN = beans. Shaded treatments were evaluated for greenhouse gas emissions.**

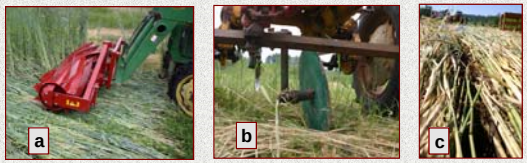

Figure 2. The reduced tillage plots in the Organic Reduced Tillage Experiment were managed by terminating cover crops with a roller/crimper (a) then opening soil for transplanting with a custom tool (b) that leaves a 5 cm wide by 10 cm deep swath (c).

Measuring Trace Gas Flux

Figure 3. CO_2 was measured with an infrared gas analyzer on In-row and Out of row chambers.

- CO_2 was measured with an infrared gas analyzer (IRGA) on In-Row and Out of Row chambers
  - Licor LI-700 with tubing to circulate air through IRGA and back to the chamber
  - Dynamic closed cell system: chambers are open to the atmosphere except during the measurement period for a 2 minute period while chamber was closed
  - Licor LI-7000 IRGA with tubing to circulate chamber air through the IRGA and back to the chamber
- Measured immediately before tillage, 3 times on the day of tillage, and 1, 3, 7, and 14 days after tillage.
- All green plants were removed from within chambers but residues were left
- Soil temperature and chamber air temperature were monitored
- Chamber area: 29.2cm x 49.5 cm, average volume 22.6 L
- Chamber design was similar to the GRACEnet protocol with an extra port was to allow gas to be recirculate (http://www.ars.usda.gov/research/Gracenet)

Results

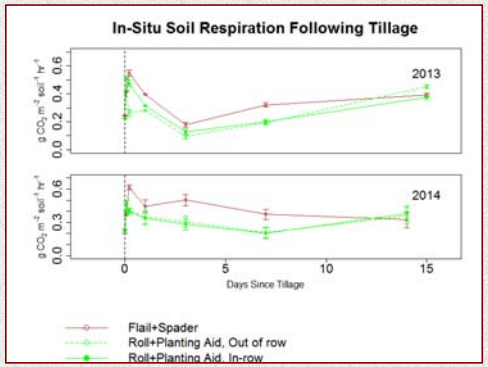

Figure 5. In-situ soil respiration (g CO_2 m^{-2} hr^{-1}) by day following tillage in 2013 and 2014. Error bars represent the standard error of the mean of each day and the dashed gray line is time of tillage.

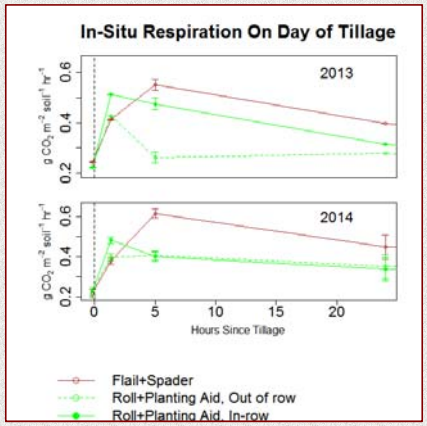

Figure 6. In-situ soil respiration (g CO_2 m^{-2} hr^{-1}) by hours on the day of tillage. Error bars represent standard error of the mean of each day and the dashed gray line is time of tillage.

- Year (p value <0.0001), day in 2013 (p value = 0.04) and day in 2014 (p value <0.001) were significant
- Emissions on each day was considered individually

- 2013
  - Tillage was significant on days 1 (p=0.05), 3 (p<0.001) and 7 (p<0.001)
  - Tillage is not significant before tillage (P=0.735) and on day 0 at 5 hours (p=0.105)
  - Treatment*Zone interaction on day 0 & 14
    - On day 0 at 80 minutes, zone is not significant in tilled (p=0.361) or no-till (p=0.169)
    - On day 14, zone effect was notable no-till (=0.0514) but not in tilled (p=0.52)

- 2014
  - Tillage was significant on days 1, (p=0.0152), 3(p<0.0001), 7 (p<0.0001)
  - Tillage was not significant on day -1 (p=0.579), 0 (p=0.1665) and 14 (p=0.366)

Conclusions

- For the first 7 days, CO_2 emission were higher in fully tilled plots than in the no-till plots
- Emissions are highest on Day 0
- CO_2 emissions in both zones (In-Row and Out of Row) were similar within the full till treatment. The In-row zone occasionally produced higher emissions but was not consistently different, in the no-till treatment

This research is supported by grants from the Organic Transitions Project of the National Institute of Food and Agriculture, USDA, and Western Sustainable Agriculture Research and Education