TILLAGE AND NITROGEN MANAGEMENT EFFECTS ON SOIL ORGANIC CARBON POOLS

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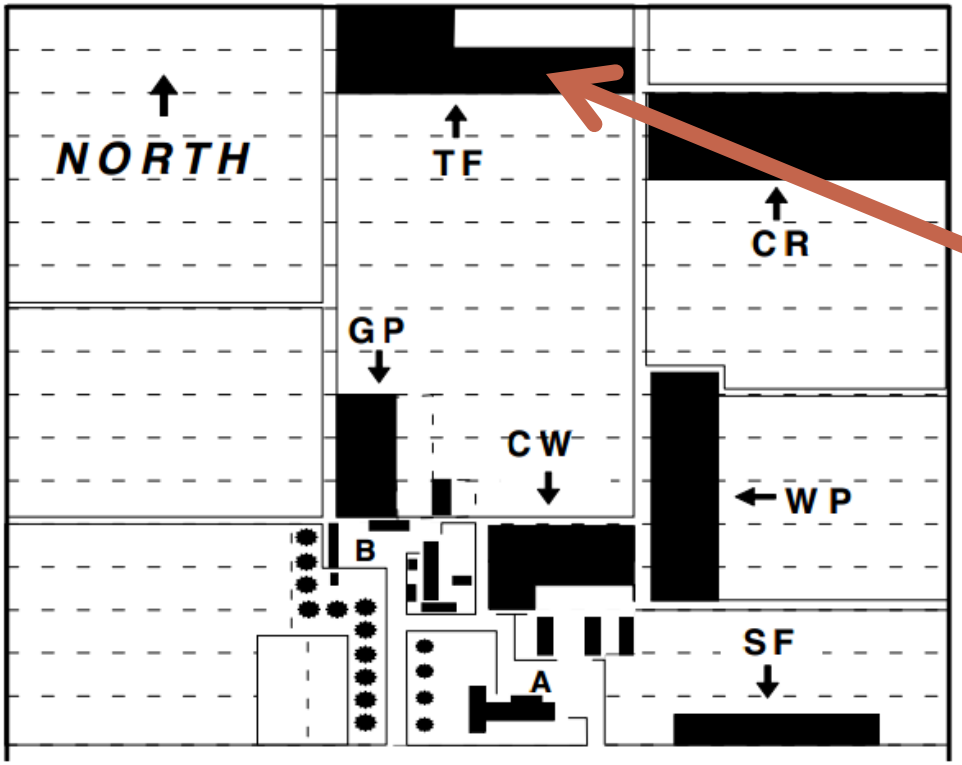
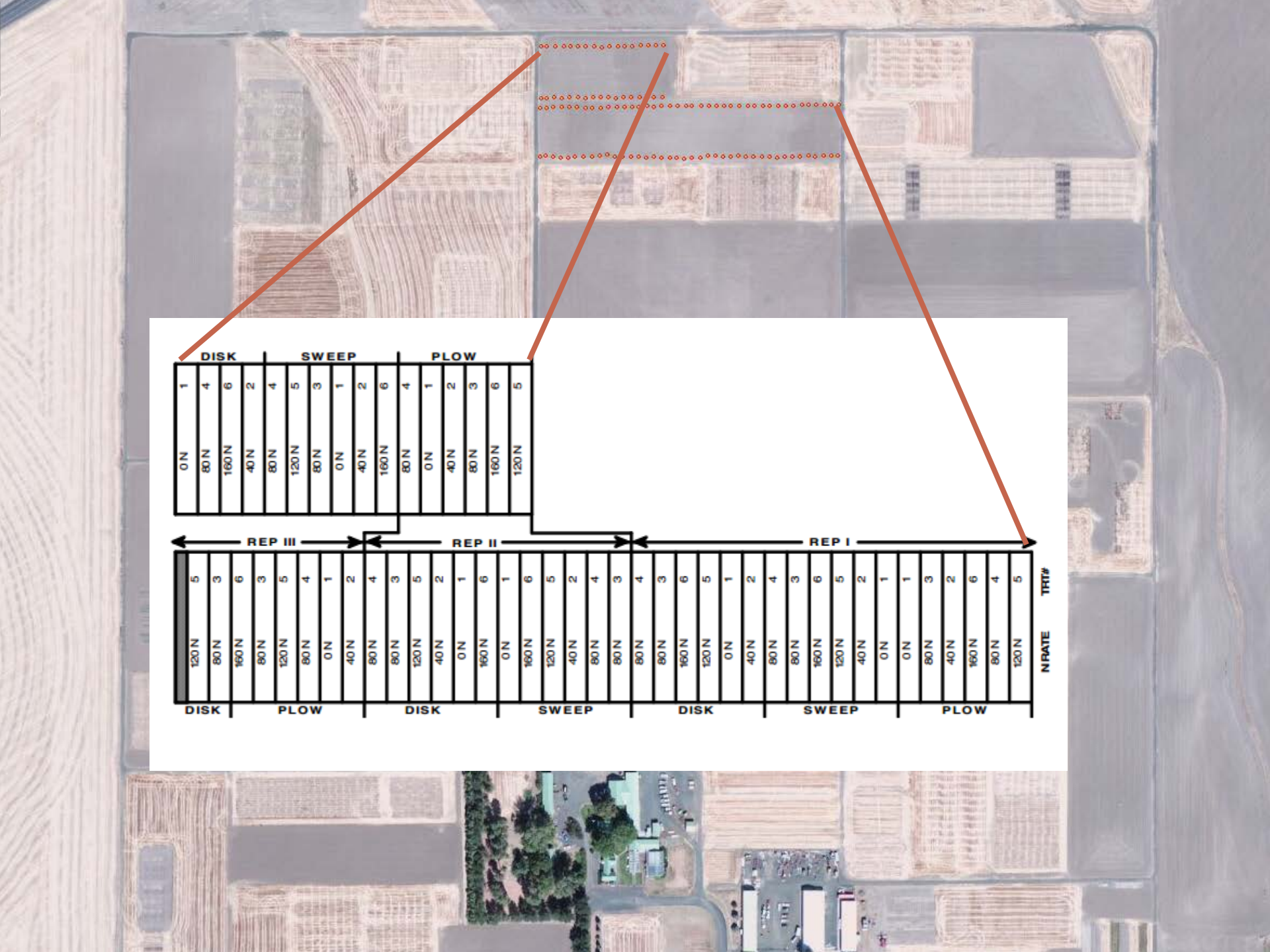
USDA
Agricultural
Research Center
ARS and OSU



A. USDA-ARS facilities. B. OSU facilities.

Table 1 . Identification and location of long-term research experiments at Pendleton

Year Initiated	Symbol	Experiment Name	Treatment Variables
1931	GP	Grass Pasture	None
1931	CW	Continuous Cereal	Fertility
1931	CR	Residue Management	Nitrogen, Manure, Burning
1940	TF	Tillage-Fertility	Tillage, Fertility
1963	WP	Wheat-Pea	Tillage, Fertility 1991-99
1982	SF	No-till Wheat	Nitrogen


DISK
SWEEP
PLOW
1 4 6 2
0 N 80 N 160 N 40 N
4 5 3 1 2 6
80 N 120 N 80 N 0 N 40 N 160 N
4 1 2 3 6 5
80 N 0 N 40 N 80 N 160 N 120 N
REP III
REP II
REP I
5 3 6 3 5 4 1 2
120 N 80 N 160 N 80 N 120 N 80 N 0 N 40 N
4 3 5 2 1 6
80 N 80 N 120 N 40 N 0 N 160 N
1 6 5 2 4 3
0 N 160 N 120 N 40 N 80 N 80 N
4 3 6 5 1 2
80 N 80 N 160 N 120 N 0 N 40 N
4 3 6 5 2 1
80 N 80 N 160 N 120 N 40 N 0 N
1 3 2 6 4 5
0 N 80 N 40 N 160 N 80 N 120 N
TRT#
N RATE
DISK
PLOW
DISK
SWEEP
DISK
SWEEP
PLOW

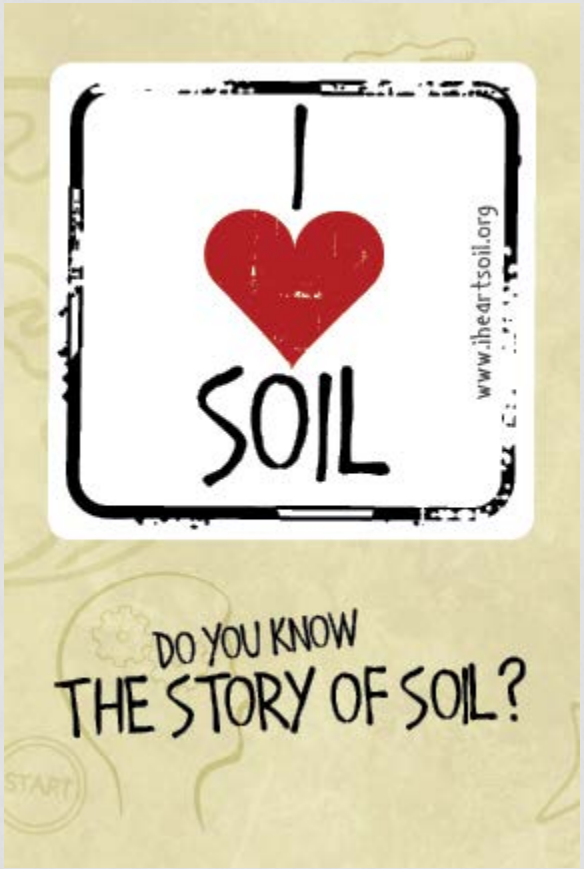
MY PROJECT

- How do soil organic carbon pools (SOC) change with tillage and soil fertility management practices in wheat-fallow systems?

- Samples taken at 10cm depth
- N applied at 0lbs/ac and 80lbs/ac
- Tillage practices:
  - moldboard plow
  - offset disc
  - subsurface sweep

THIS IS IMPORTANT TO ME

- Soil is much more than *dirt*
- Everything is built on soil
- "Civilization itself rests upon the Soil." -Thomas Jefferson



(SSSA, 2011)

THIS IS IMPORTANT TO THE EARTH

- Soil can be either a source or sink for carbon
- 3 times more carbon is stored in the soil than in the atmosphere
- Cultivation of grassland caused a significant loss of carbon
  - destroys permeant soil cover
  - repeated tillage drives CO_2 loss
- Changing climate exacerbates SOC depletion

(NASA, 2002)

LITERATURE REVIEW

- Identification of the factors that regulate soil respiration can help predict ecosystem responses to climate change (Ahn et al., 2009).
- Cropping system, tillage practices, and residue management are significant variables that control the quantity, quality, and placement of organic matter within the soil (Franzluebbers & Stuedemann, 2008).
- With reduced or no-tillage practices, soils have greater potential to sequester and retain C. (Machado et al., 2006).

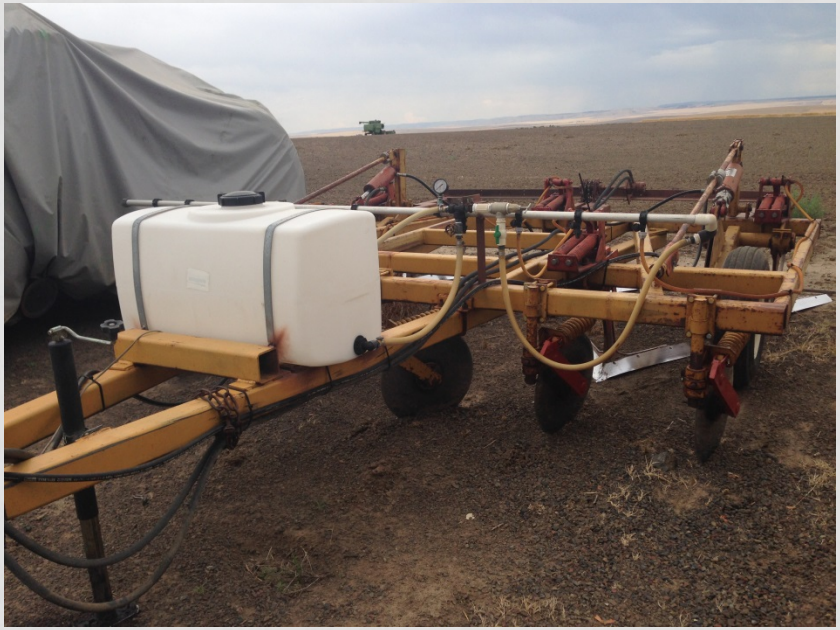
LITERATURE REVIEW

- The total soil organic C changes slowly with management (Sainju et al., 2011).
- Particulate organic C (POC) is a coarse fraction SOC that decomposes in less than a decade and is sensitive to changes in management practices (Cabardella and Elliott, 1992).
- Potentially mineralizeable organic C (PMC) is chemically active, and could better reflect changes in soil organic matter than total SOC (Sainju et al., 2011).
- POC provides substrates for microorganisms and influences soil aggregation (Cabardella and Elliott, 1992).

EXPERIMENT ONE

MEASURING PARTICULATE ORGANIC CARBON (POC)

UNDERSTANDING TILLAGE



Subsurface Sweep

- Leave more than 30% crop residue
- Tilled to 6 inches

UNDERSTANDING TILLAGE

Moldboard Plow

- Soil is completely inverted
- No remaining surface residue
- Tilled to 9 inches

UNDERSTANDING TILLAGE

Offset Disc

- Soil and crop residue are mixed
- Tilled to 6 inches

SOIL PREPARATION

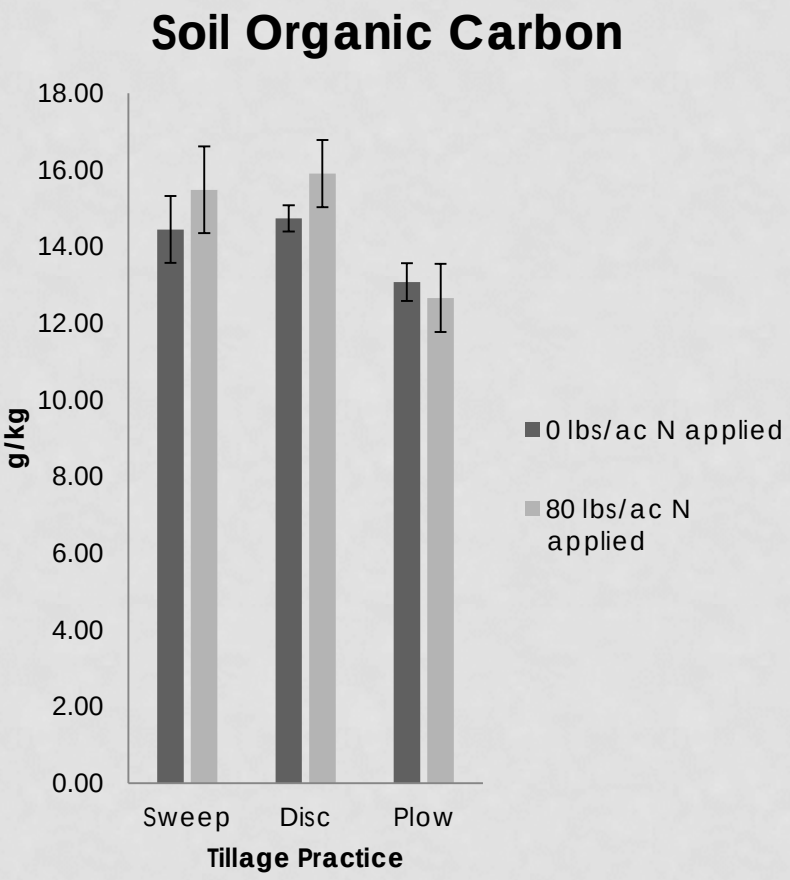
Already completed:

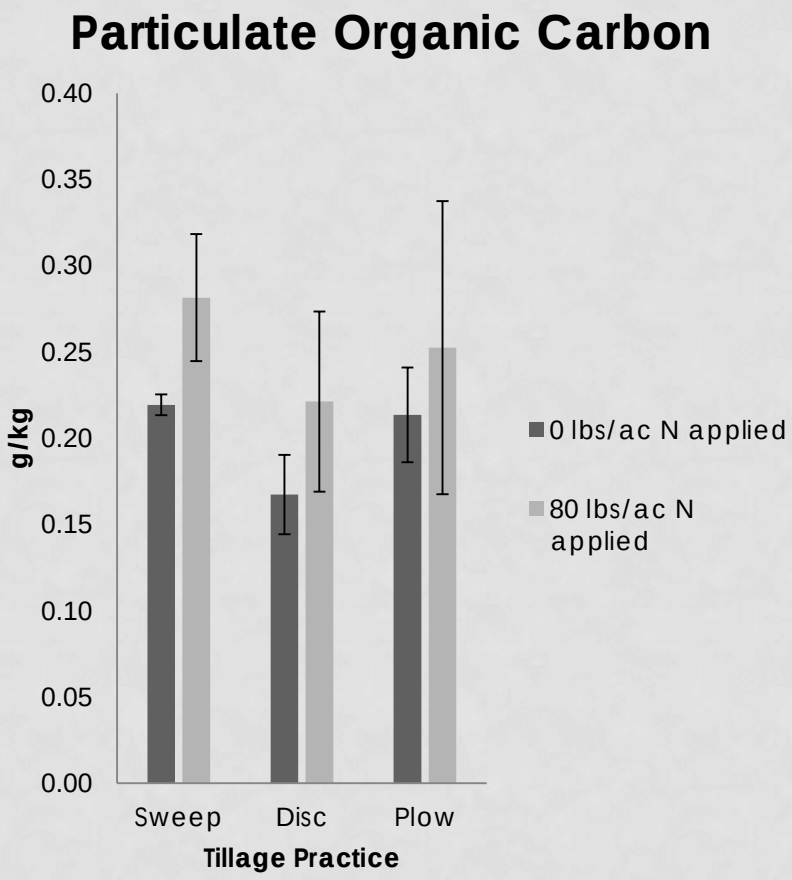
- Samples collected in 2010
- Total C measured
- Particulate organic matter was removed from the soil:
  - Soil was treated with $(NaPO_3)_6$ and 0.053 mm sieved with DI water and then oven dried (Cambardella et al., 1992)

My responsibility:

- Ground soil samples
- 25-28mg samples in tin cups for dry combustion C:N analyzer
- **POC=Total C-Results**

RESULTS


Soil Organic Carbon
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
g/kg
Sweep
Disc
Plow
Tillage Practice
0 lbs/ac N applied
80 lbs/ac N applied


Particulate Organic Carbon
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
g/kg
Sweep
Disc
Plow
Tillage Practice
0 lbs/ac N applied
80 lbs/ac N applied

EXPERIMENT TWO

MEASURING POTENTIALLY MINERALIZEABLE ORGANIC CARBON(PMC)

COLLECTING SAMPLES

COLLECTING SAMPLES

- Grass pasture has not been tilled since 1931
- Used soil probe tractor to collect samples

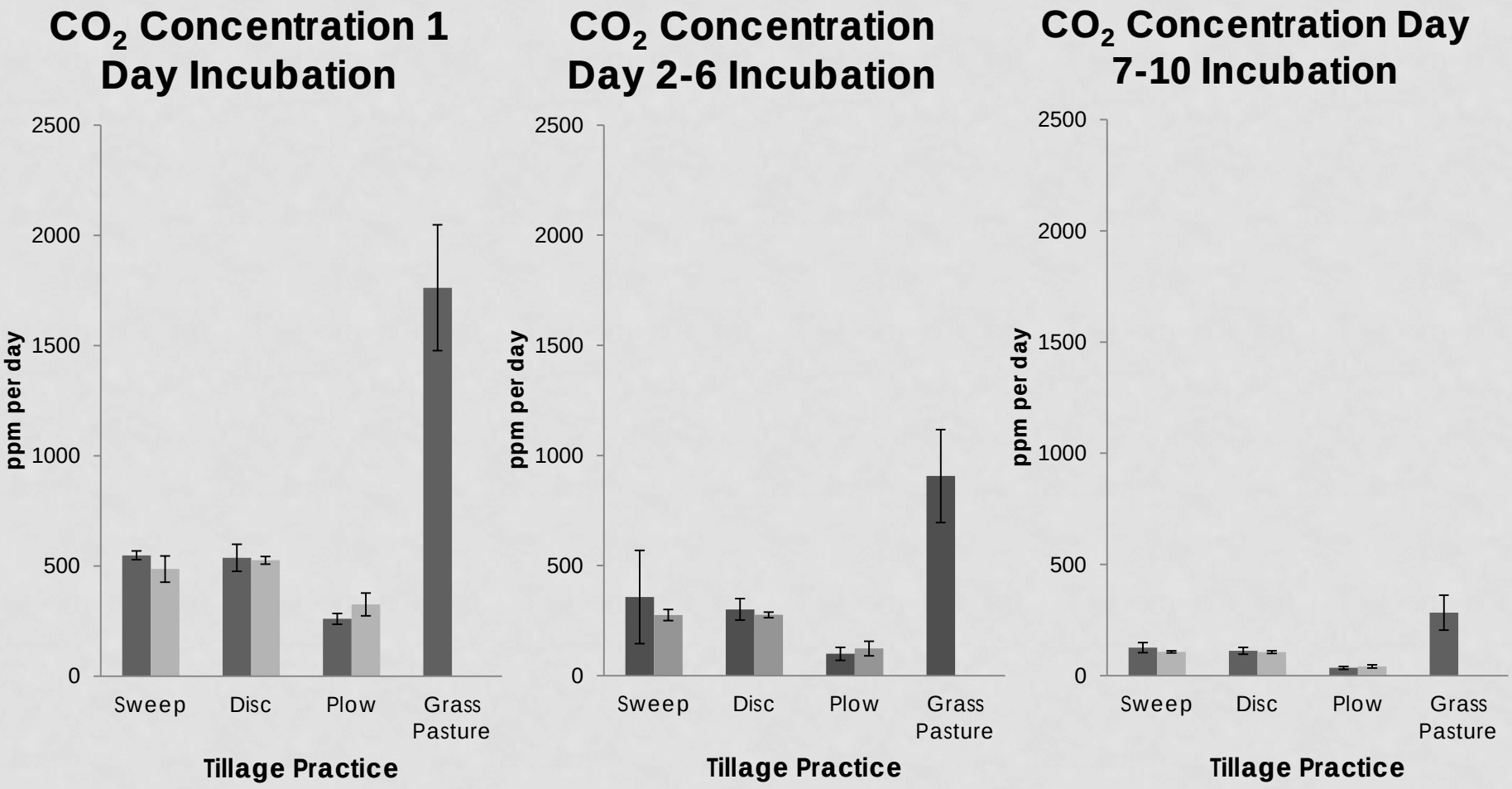
SOIL PREPARATION

- Weighed samples and then oven dried to calculate gravimetric moisture
- Used to calculate field capacity (FC), 23% moisture
- 50ml beakers were filled with ~22g soil and brought to FC

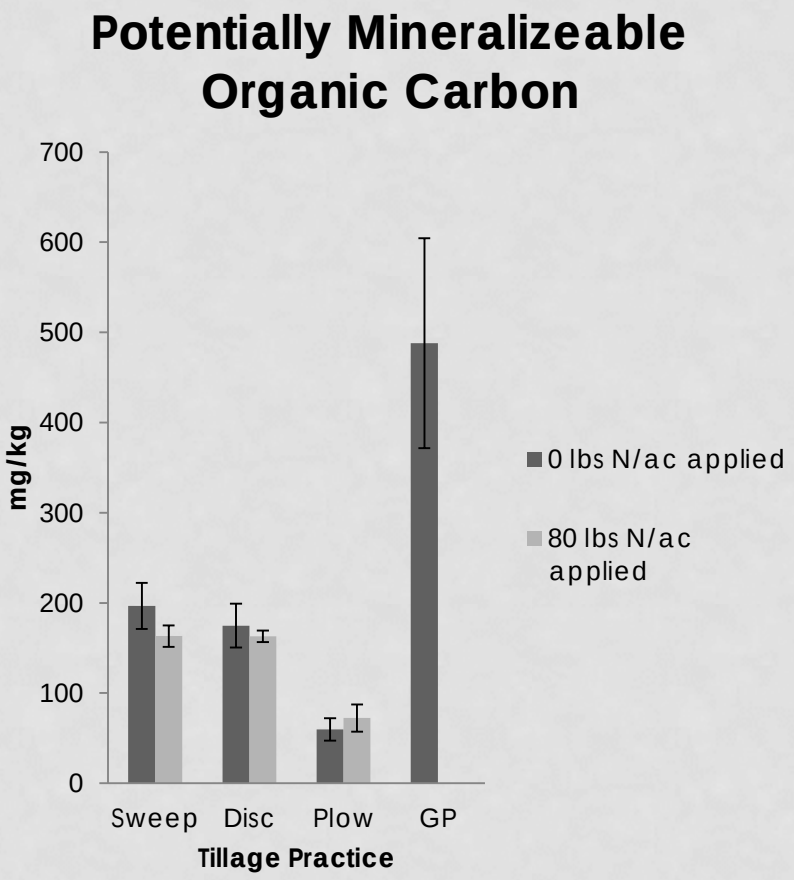
COLLECTING DATA

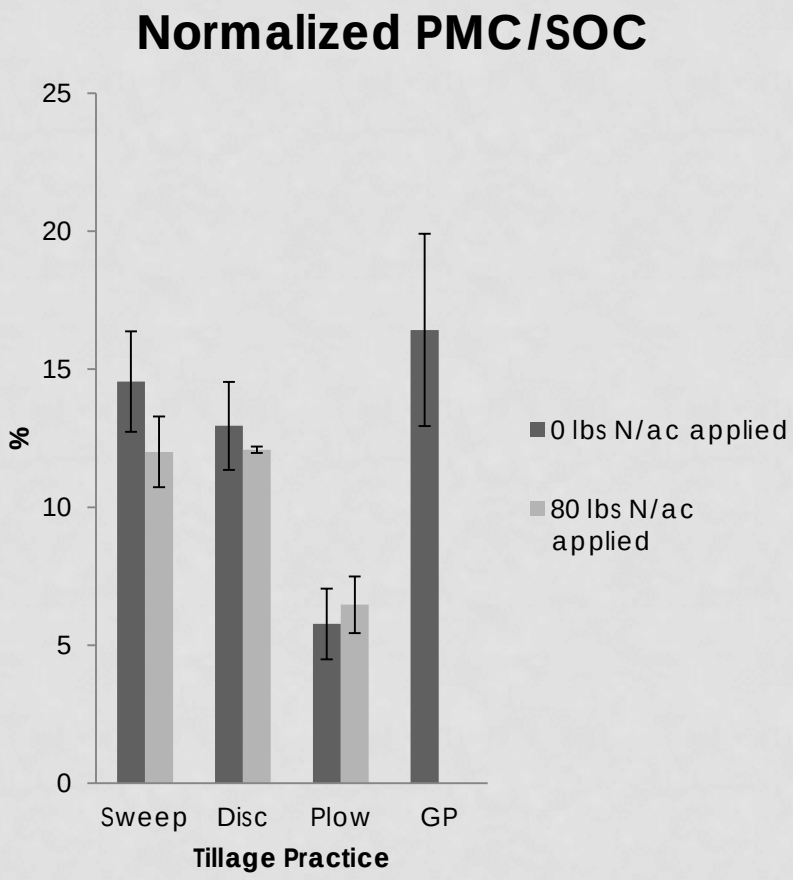
- Placed in 1 L mason jars and stored in dark cabinet to incubate
- CO_2 was extracted using a syringe on day 1, 6, and 10
- Measured using a gas chromatograph

RESULTS


0 lbs/ac N applied
80 lbs/ac N applied
CO_2 Concentration 1 Day Incubation
CO_2 Concentration Day 2-6 Incubation
CO_2 Concentration Day 7-10 Incubation
ppm per day
2500
2000
1500
1000
500
0
Sweep
Disc
Plow
Grass Pasture
Tillage Practice

RESULTS


Potentially Mineralizeable Organic Carbon
700
600
500
400
300
200
100
0
mg/kg
Sweep
Disc
Plow
GP
Tillage Practice
0 lbs N/ac applied
80 lbs N/ac applied


Normalized PMC/SOC
25
20
15
10
5
0
%
Sweep
Disc
Plow
GP
Tillage Practice
0 lbs N/ac applied
80 lbs N/ac applied

CONCLUSIONS

- Grass pastures store the largest amount of soil organic carbon, and would lose the most with disturbance.
- Tillage practice has the largest impact on soil's ability to retain carbon pools.
- Synthetic N fertilizer has little effect on overall soil carbon retention
- PMC content was least in the most disturbed system, plow.
- In the top 10cm, disc tillage could cause more POC decomposition than we originally thought.

WHAT DOES THIS MEAN FOR CLIMATE CHANGE?

- We are losing a significant amount of stored organic carbon to the atmosphere as CO_2 when we till, whether it be sweep, disc, or plow.
- If we convert from pasture to croplands we are going to lose even more carbon.
- If we convert from plowed cropland to grass pasture, we could potentially store 3 times the amount of total organic carbon in the soil.
- Adding nitrogen back to the soil isn't going to solve all the organic matter problems.
- **We still have a lot to learn about soil's role in climate change mitigation.**

REFERENCES

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