The role of wetting vs. drying

on SOM destabilization

Kaizad F. Patel

updated: 2021-01-29

Objectives

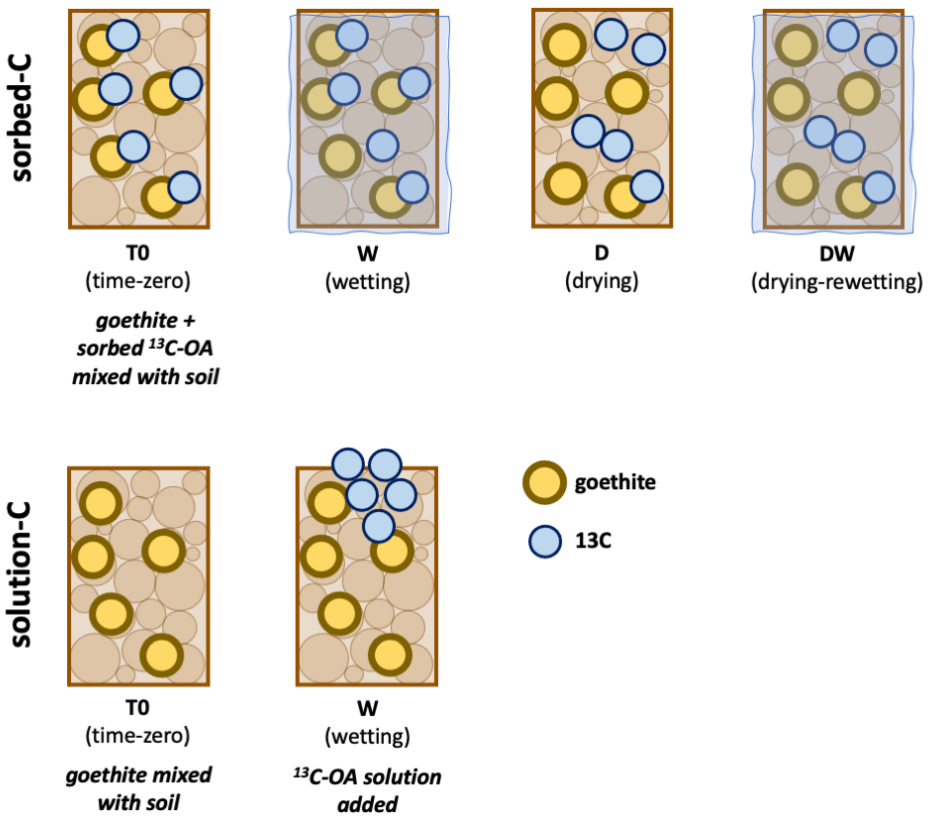
To partition biochemical and physicochemical protection/destabilization mechanisms for soil C by their sensitivities to wetting and drying.

Hypotheses

1. drying and wetting processes destabilize C via different mechanisms: desorption and cell lysis (drying), vs. increased hydrologic connectivity and improved spatial access to substrate (wetting).
    - under conditions of drying, desorption of C from clay-sorbed substrate will result in [lag and release] of desorption/respiration. vs. cell lysis means we will have a pulse of more 12C vs. the newly added 13C
2. drying will have a stronger effect on soil C destabilization, compared to wetting
    - drying will have a higher ratio of 13/12C because the respiration will be more destabilization vs. wetting/access to native soil C.

Experiment

60 g field-moist Palouse soil (~58 g oven-dry equivalent) in pint size Mason jars
labelled substrate (13C-oxalic acid, 18.66 % enriched) was added to the soil, in adsorbed or solution form.

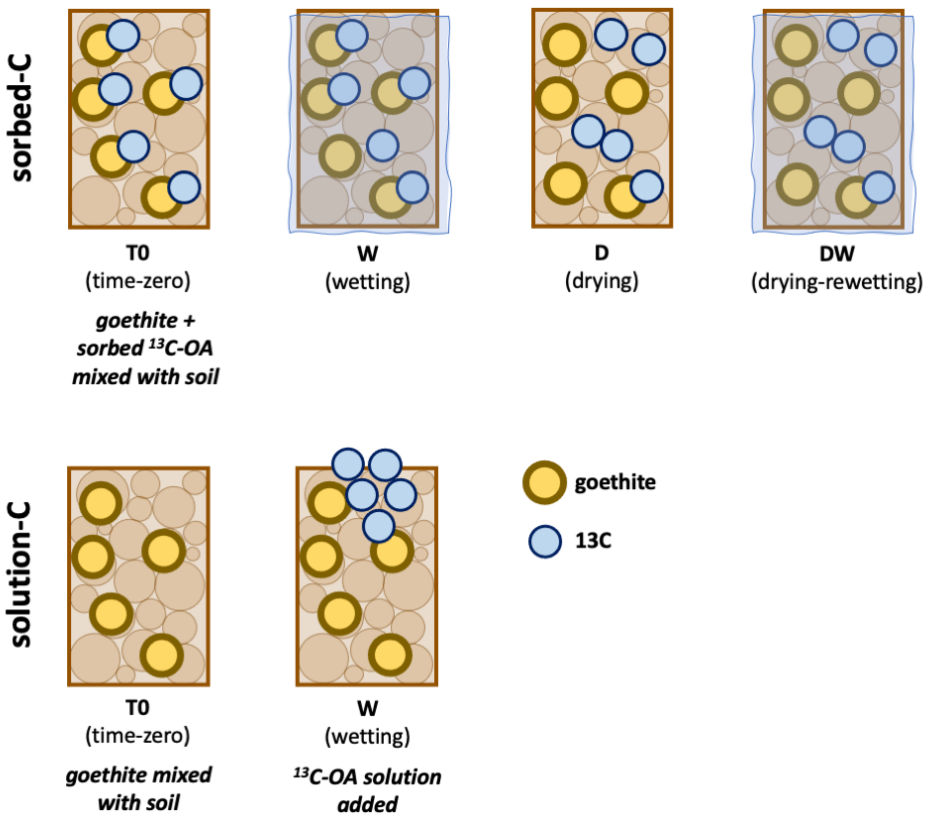


adsorbed-C:

- 20 mL of labelled OA solution mixed with 5 g goethite; rinsed 3x; labelled goethite resuspended in 5 mL water; added as paste to soil units
- The soil was subjected to one of the following treatments, after which the jars were sealed:
    1. time-zero: jars sealed as soon as goethite was added
    2. wetting: 20 mL water added
    3. drying: soil allowed to air-dry until constant weight
    4. drying-rewetting: soil allowed to dry, then rewet with 20 mL water
- The jars were sealed for 48 hours.

Experiment

60 g field-moist Palouse soil (~58 g oven-dry equivalent) in pint size Mason jars
labelled substrate (13C-oxalic acid, 18.66 % enriched) was added to the soil, in adsorbed or solution form.



solution-C:

- a parallel experiment was performed as a control for priming effects of the added OA
- 5 g goethite mixed with soil; 16 mL of labelled OA solution added to the soil-goethite mixture
- The soil was subjected to one of the following treatments, after which the jars were sealed:
    1. time-zero: goethite mixed with soil
    2. wetting: 16 mL 13C-OA solution added
- The jars were sealed for 48 hours.

Analyses

1. **respiration**: headspace samples were collected after the 48-hr incubation. analyzed for CO2 and 13C-CO2
    - LI-7810 (LI-COR), LGR
2. **WEOC** (water extractable organic C): organic carbon extracted and analyzed for C content and 13C
    - extracts were dried to powder and analyzed as solid samples
    - VarioIsotope Cube/Isoprime precisION IRMS (Elementar)
3. **total soil C**: soil was dried and analyzed for C and 13C content
    - VarioIsotope Cube/Isoprime precisION IRMS (Elementar)

sorbed-C

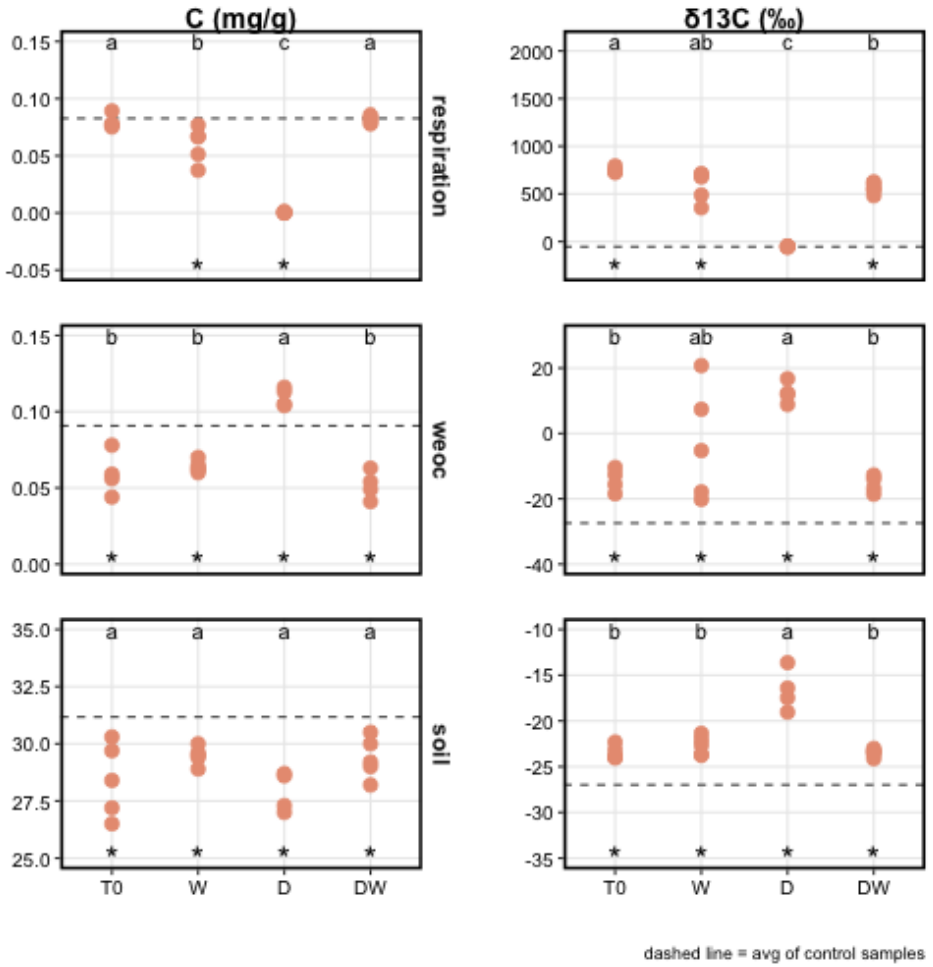


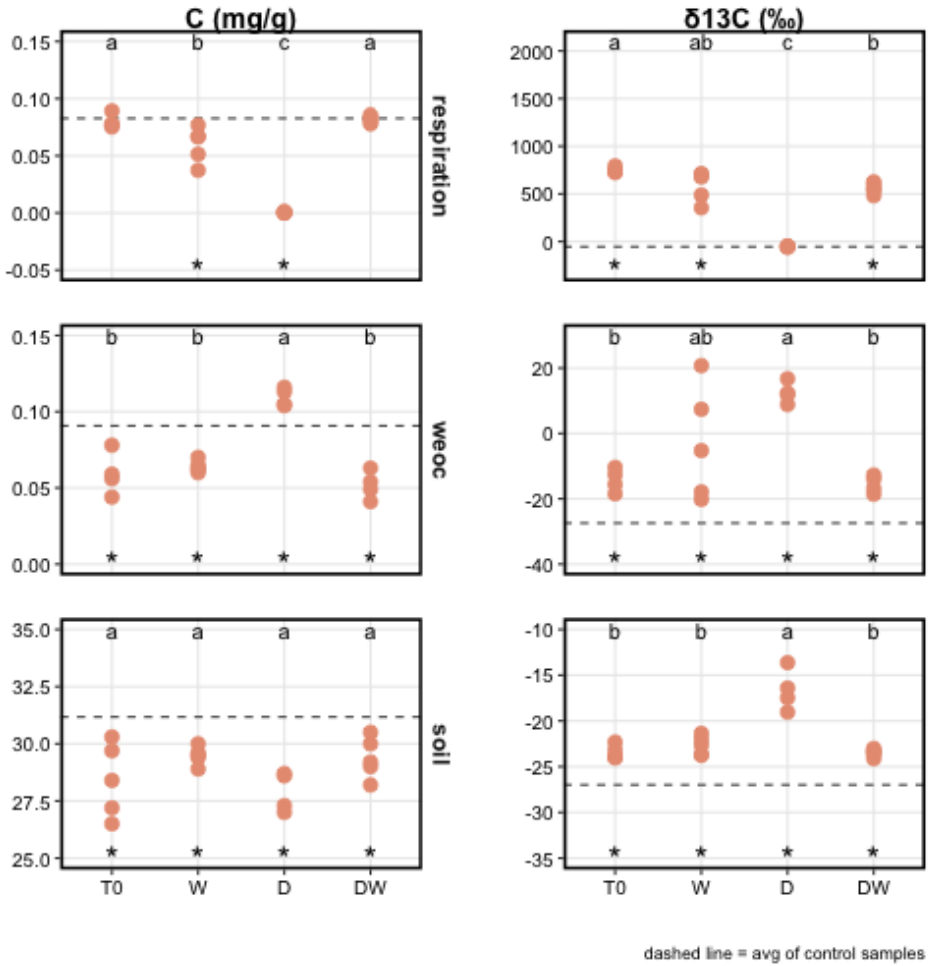
Figure Caption

C concentrations and d13C values (relative to Vienna Pee Dee Belemnite) for T0 (time-zero), W (wetting), D (drying), and DW (drying-rewetting) treatments.

Different letters denote significant differences across treatments.

Asterisks denote significant differences from the unlabelled control samples (dashed line).

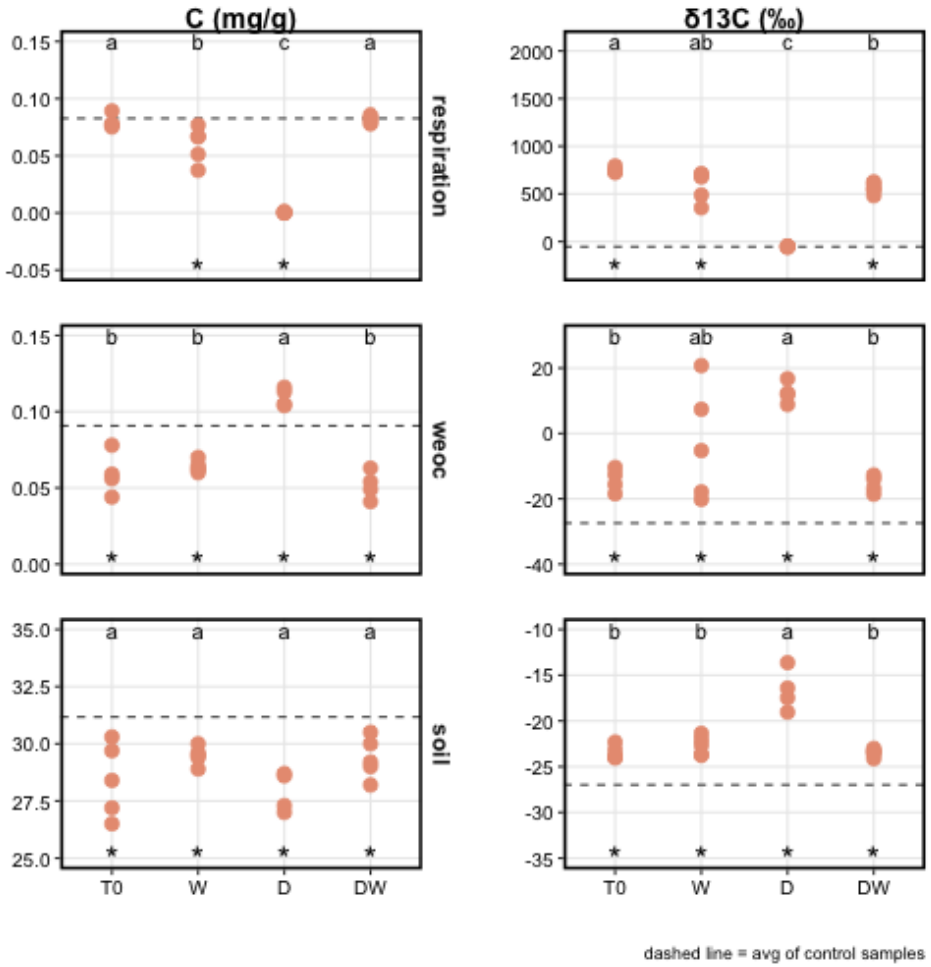
sorbed-C



respiration

- C amendment did not increase respiration
- however, the CO2 evolved was significantly enriched throughout (except for D, which had almost no respiration)
  - thus, the added OA did contribute to the CO2 evolved, but did not increase overall CO2 evolved
  - respiration in these soils is not C limited?
  - no priming effect?
  - perhaps low microbial load, so low respiration potential
  - *even adding oxalic acid in solution form did not increase CO2 significantly, see solution-C slides*

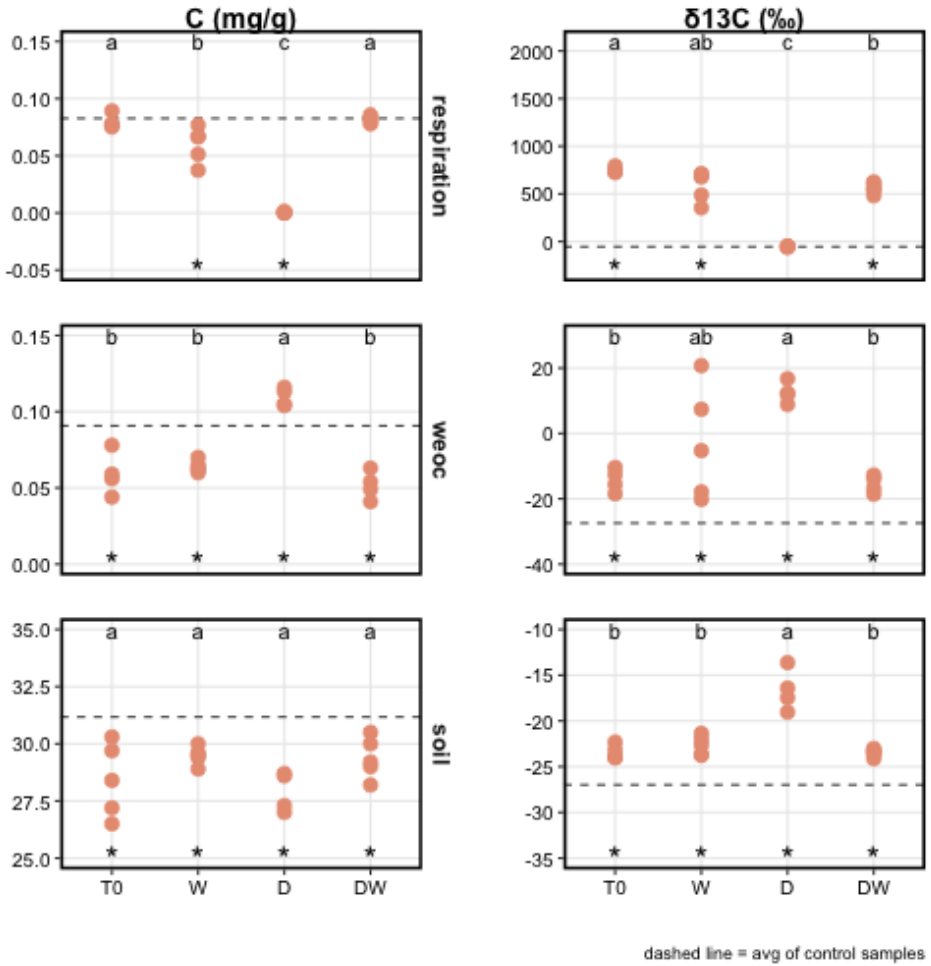
sorbed-C



respiration

- simply mixing the labelled clay with the soil did not change the amount of CO2 evolved (T0).
- wetting decreased the evolved CO2 by 0.05 mg C/g.
  - negative priming as the oxalic acid was released?
  - high moisture suppressed respiration?
  - lag effect?

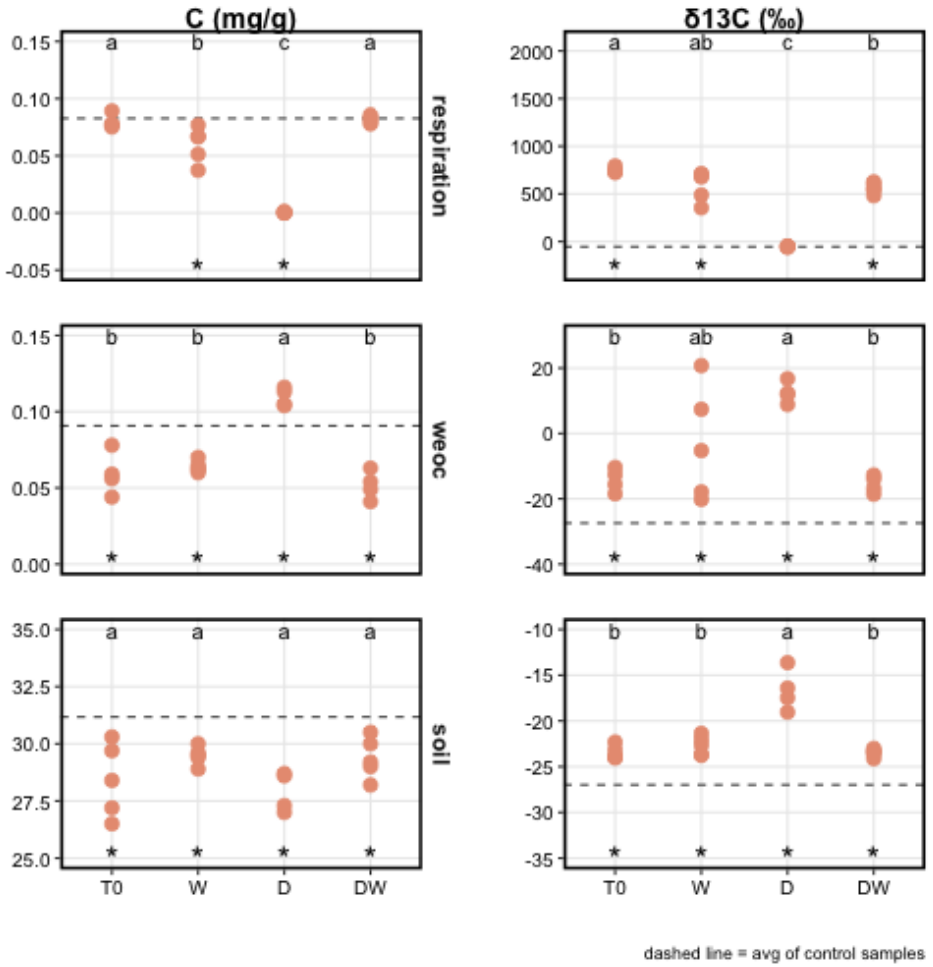
sorbed-C



respiration

- CO2 enrichment did not differ between W and DW samples.
  - *we expected DW > W*
  - W and DW mobilized C equally?
- but more CO2 was evolved after DW, compared to W
  - drought effects: destabilization of C, microbial necromass/osmolytes

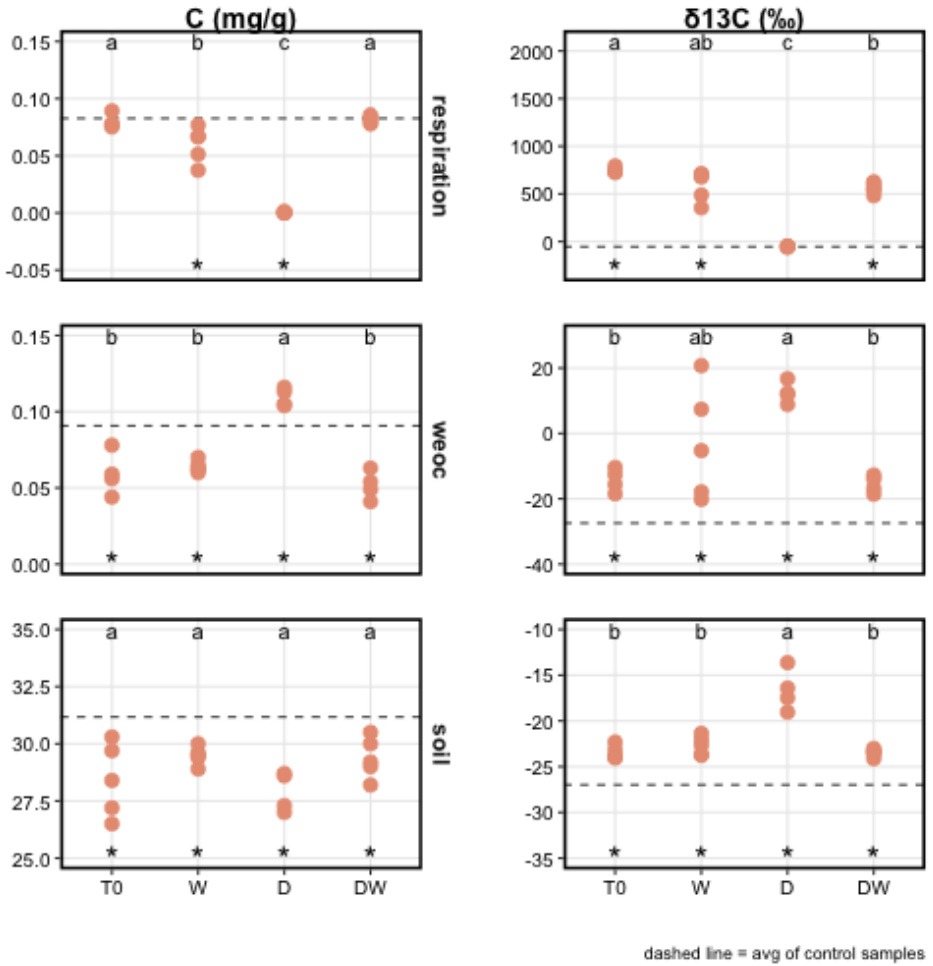
sorbed-C



WEOC

- WEOC concentrations were lower than control for all except D
  - because the C was consumed for respiration? (*inconsistent with resp data*)
- D had the greatest WEOC concentrations
  - (a) desorption of C, (b) microbial necromass/osmolytes, and/or (c) C was not respired and therefore accumulated

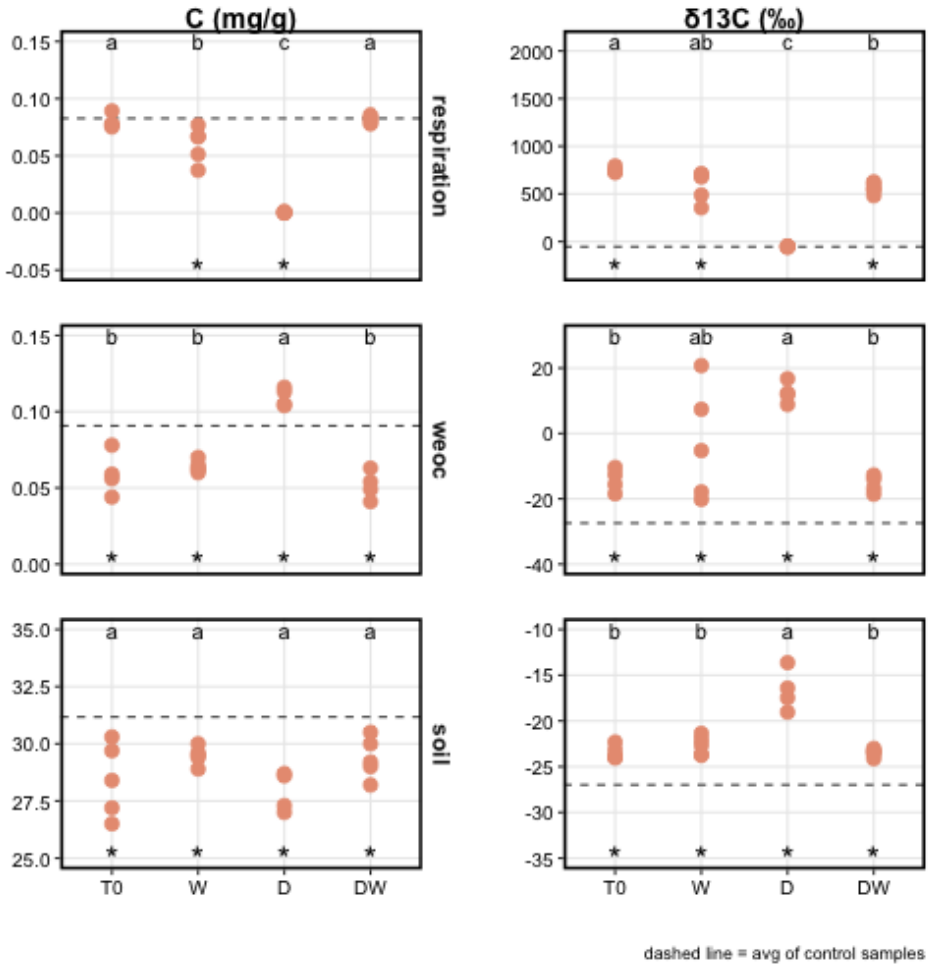
sorbed-C



WEOC

- WEOC was enriched throughout
- W and D were the most enriched
    - because both wetting and drying processes destabilized C
- note: W and D had similar enrichment, but W had lower WEOC concentrations. So less 13C was destabilized by wetting?
    - also: mass balance slide shows T0 and W had similar 13C, and D had increased 13C. So drying destabilized more C than W?

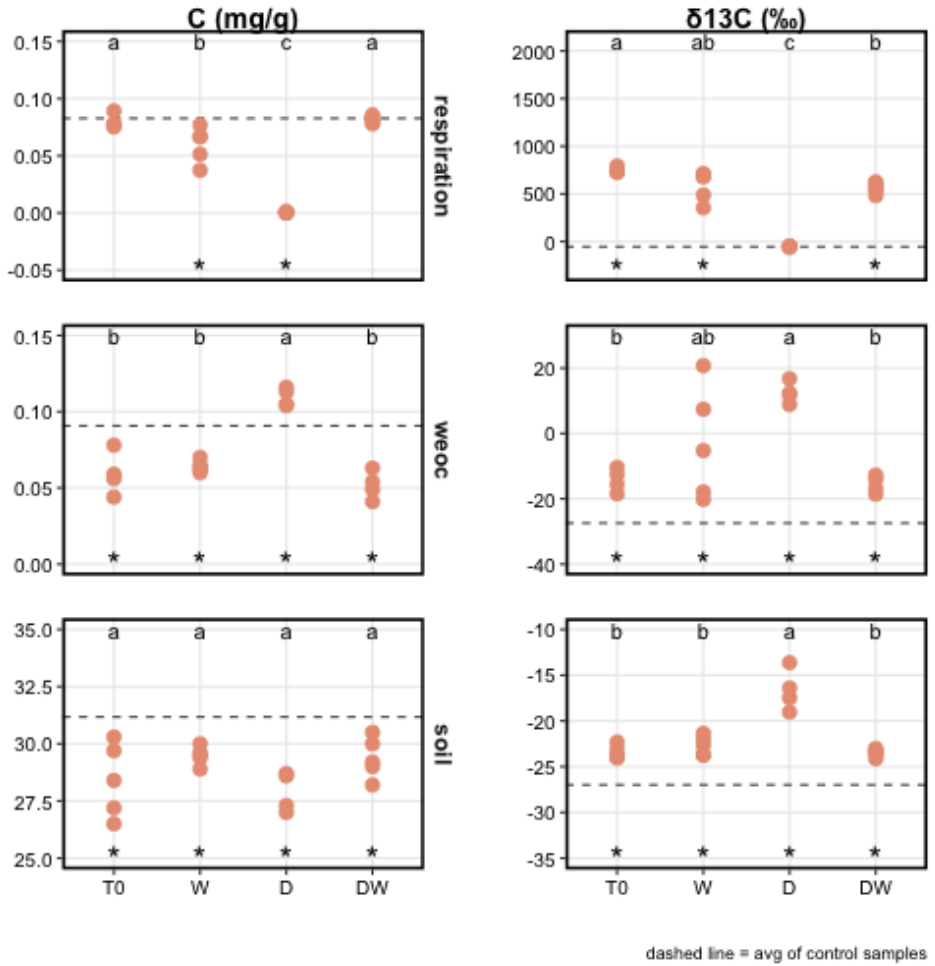
sorbed-C



WEOC

- W had greater variability than D (STATS)
  - preferential wetting patterns?
  - "weaker/non-uniform destabilization" than drying?

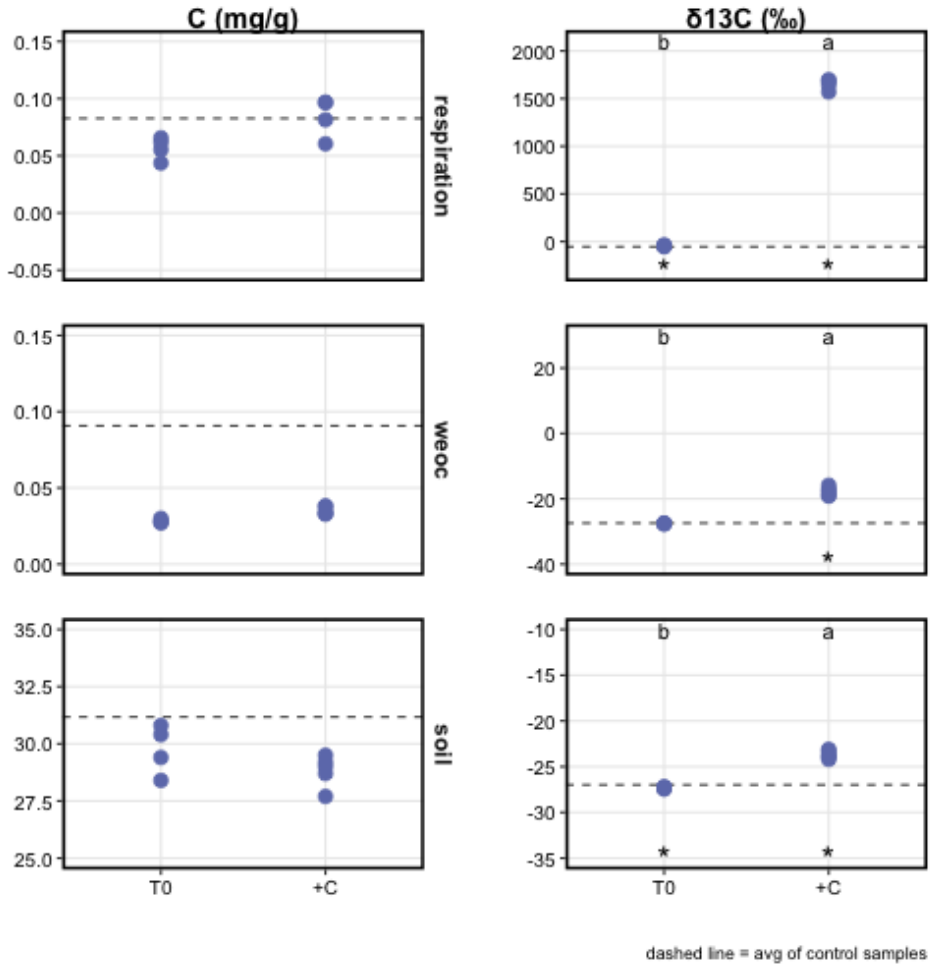
sorbed-C



soil C

- soil C concentrations were lower than control for all
    - because the C was consumed for respiration? (*inconsistent with resp data*)
- soil C was enriched for all,
- with greatest enrichment in D
    - ???
    - accumulation of unrespired C?
    - but D also had the lowest C concentrations (non-sig), and 13C ug/g was similar to T0 (see mass balance slide)

solution-C

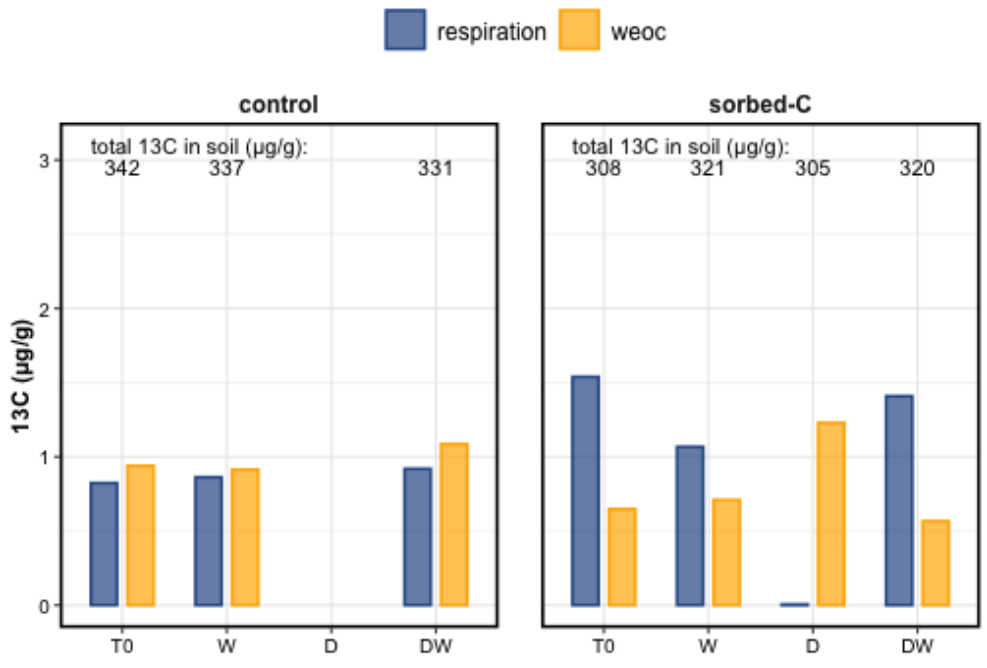


T0 = goethite mixed with soil

+C = 13C-OA added in solution form

- respiration, WEOC, and soil were all enriched after addition of soluble 13C-oxalic acid
- respiration: more enriched from solution-C (1648 ‰) compared to sorbed-C (586 ‰)
    - OA was more available in solution form than in adsorbed form
- but despite increased OA contribution, overall CO2 evolved did not increase.

Mass Balance: sorbed-C



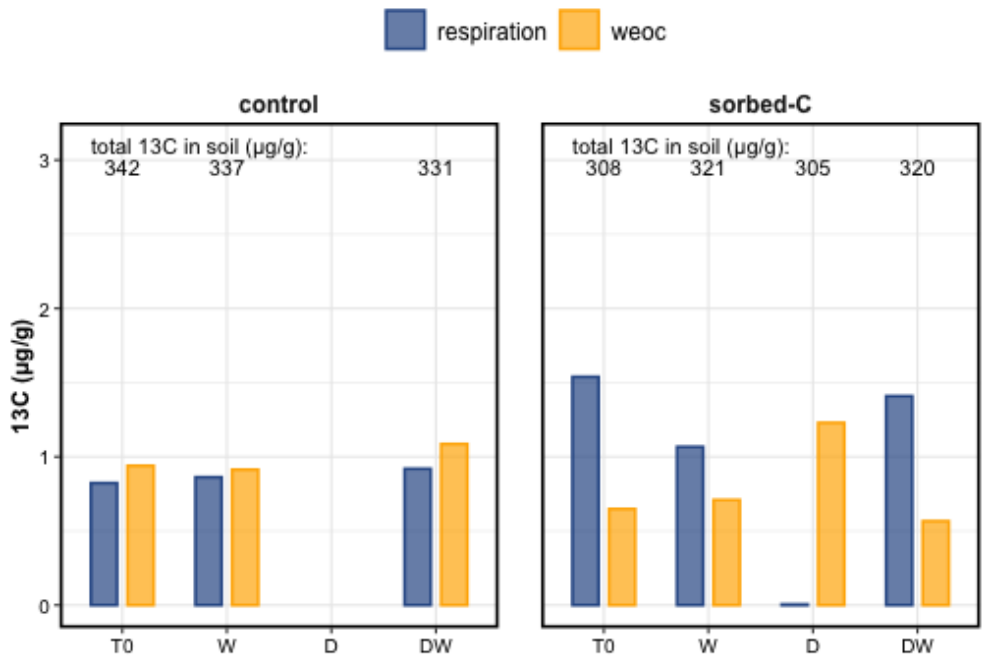
493 µg (7.72 µg/g) 13C was added in sorbed form.

13C µg/g in sorbed-C soils compared to control soils:

	resp	soil	weoc
T0	+0.716	-34.1	-0.291
W	+0.205	-15.6	-0.204
D	NA †	NA †	NA †
DW	+0.490	-11.3	-0.520

† no control samples

Mass Balance: sorbed-C



isotope retention

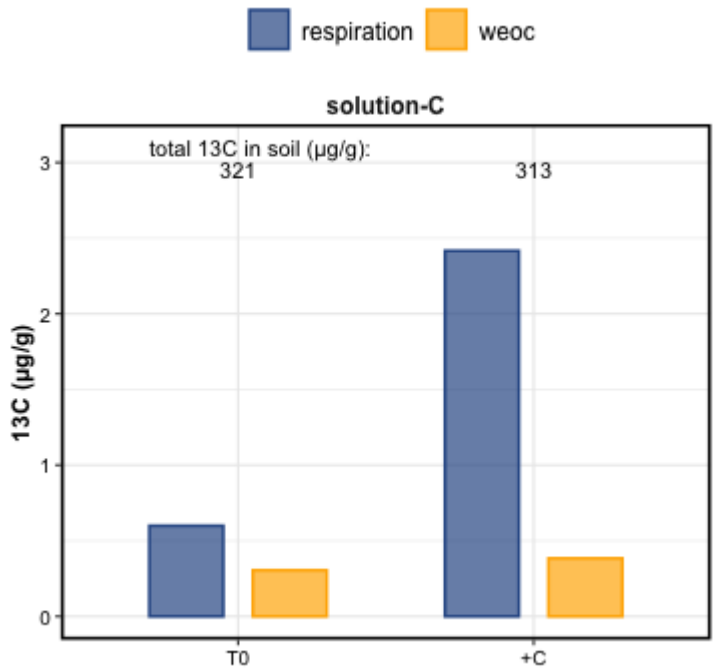
493 µg (7.72 µg/g) 13C was added in sorbed form.

But the treated soils showed decreased 13C values. (???)

comparing added 13C with (resp + soil) difference, there is a missing piece of 13C

- methane? no, because CH4 production was very, very low, and did not change with treatment/OA addition.

Mass Balance: solution-C



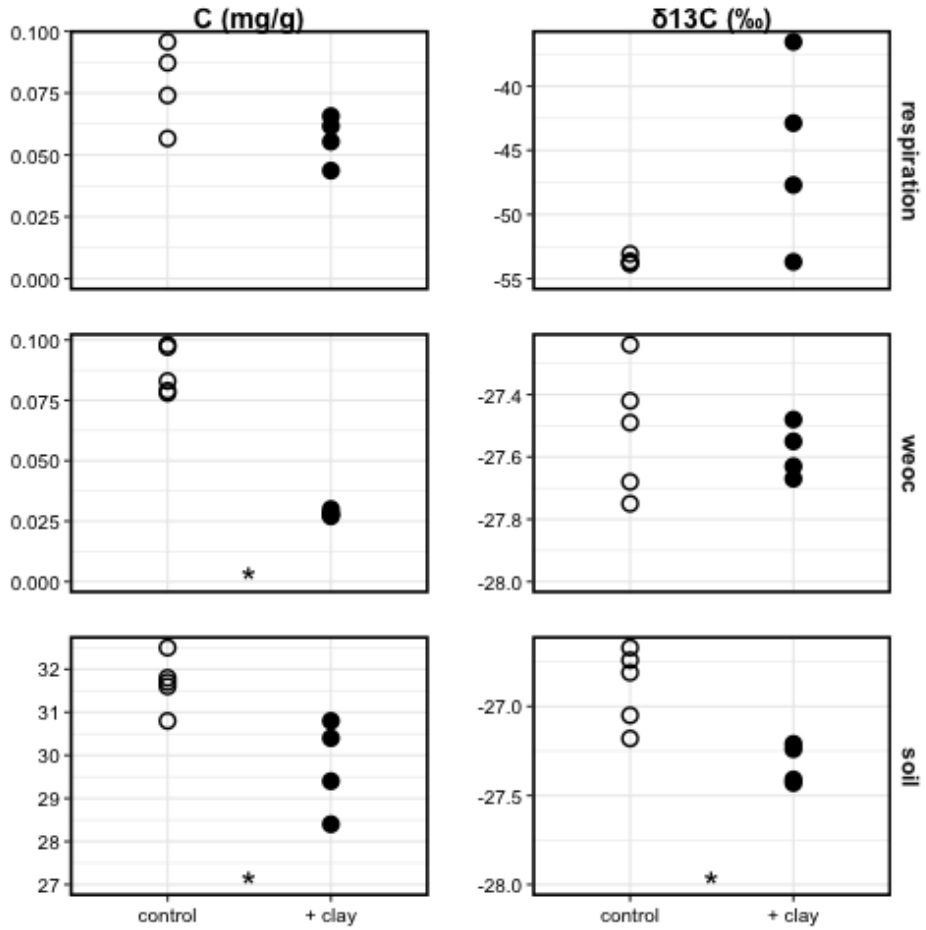
417 ug (6.54 ug/g) 13C was added as solution

- very little change in WEOC-13C
- some increase in resp-13C
- decrease in soil-13C
  SO WHERE DID THE 13C GO???

13C µg/g in +C compared to T0 (time zero):

	resp	soil	weoc
+C	+1.82	-8	+0.08

extra: How did clay addition influence C?



We compare time-zero of control (soil only) with time-zero of solution-C treatment (soil + goethite)

- respiration did not change significantly, but enrichment was more variable
  - ???
- weoc decreased, but enrichment did not change
  - previously available sorbed onto goethite
- soil C decreased, as did enrichment
  - ???

Conclusions

- wetting did not destabilize much sorbed-C
- drying released more sorbed-C than wetting

MAJOR QUESTIONS

1. do we use δ13C or C13 mass (mass balance) to determine extent of destabilization?
2. missing 13C?

Session Info

Date run: 2021-01-29

Slides prepared using xaringan

```
## R version 4.0.2 (2020-06-22)
## Platform: x86_64-apple-darwin17.0 (64-bit)
## Running under: macOS Catalina 10.15.7
##
## Matrix products: default
## BLAS:   /System/Library/Frameworks/Accelerate.framework/Versions/A/Frameworks/vecLib.framework/Versions/A/libBLAS.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.0/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] agricolae_1.3-3 patchwork_1.1.1 outliers_0.14   PNWColors_0.1.0
##  [5] drake_7.13.0    forcats_0.5.0   stringr_1.4.0   dplyr_1.0.2
##  [9] purrr_0.3.4     readr_1.4.0     tidyr_1.1.2     tibble_3.0.4
## [13] ggplot2_3.3.3   tidyverse_1.3.0
```