

# Supplementary Material for ‘Winter Cover Cropping Effects on Soil Water-Holding Capacity Vary by Site’

Nichols et al. 2021

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## Supplemental material S1. Map of sites

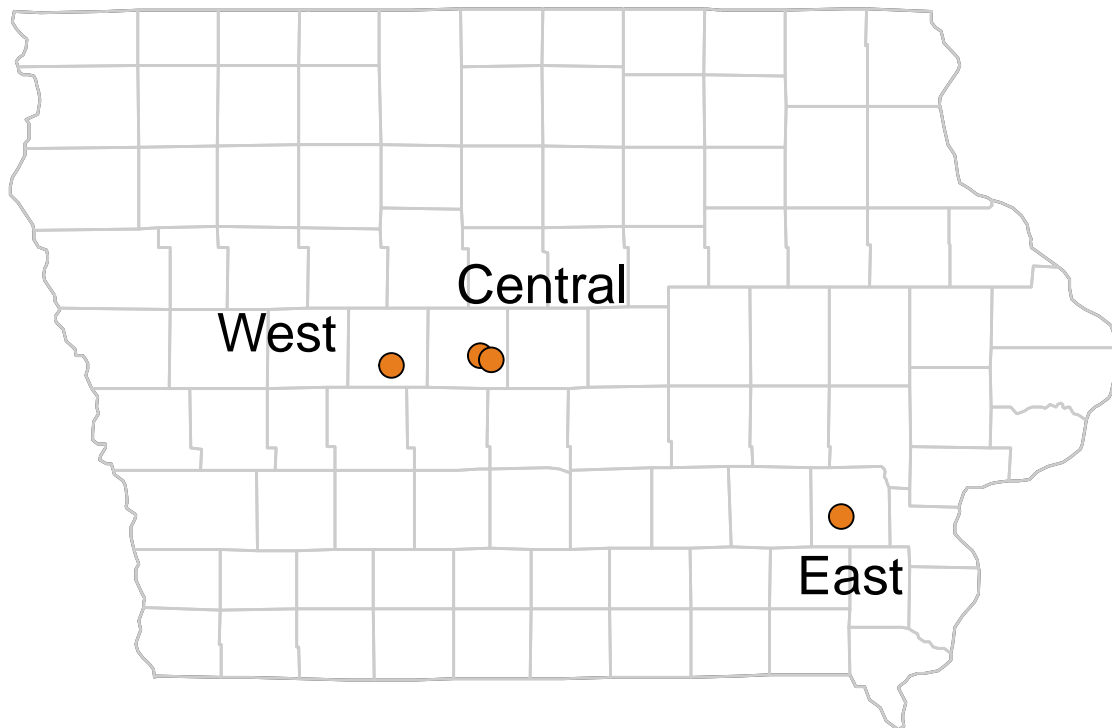


Figure 1: Map of site locations in Iowa



## Supplemental material S2. General Site Management Summary

Table 1: General Site Description

| Site Description | General Location           | Treatment Description  | Year of Initiation | Crop Planted in 2019 | Number of Treatment Replicates | Sampled in 2019 |
|------------------|----------------------------|--|--------------------|----------------------|--------------------------------|-----------------|
| Central Grain    | Boyd Farm, Boone, field 44 | maize/soybean grain rotation, with and without rye cover crop        | 2009               | maize                | 5                              | Y               |
|                  | Boyd Farm, Boone, field 42 | maize/soybean grain rotation, with and without rye cover crop        | 2009               | soy                  | 5                              | Y               |
| Central Silage   | Boyd Farm, Boone, field 44 | maize silage/soybean grain rotation, with and without rye cover crop | 2002               | maize silage         | 5                              | Y               |
|                  | Boyd Farm, Boone, field 42 | maize silage/soybean grain rotation, with and without rye cover crop | 2002               | soy                  | 5                              | N               |
| West             | Jefferson, IA              | maize/soybean grain rotation, with and without rye cover crop        | 2008               | maize                | 4                              | Y               |
| East             | Washington, IA             | maize/soybean grain rotation, with and without rye cover crop        | 2009               | soybeans             | 4                              | Y               |

Table 2: 2018-2019 Herbicide Use

| Site Description | Herbicides Used in 2018 Growing Season  | Herbicides Used in Fall 2018 | Herbicides Used in Spring 2019   |
|------------------|---|------------------------------|--|
| Central Grain    | glyphosate 1 week before soybean planting   | none                         | glyphosate 1 week before maize planting; metalochlor, atrazine, and mesotrione at planting                           |
| Central Grain    | glyphosate 1 week before maize planting; metalochlor, atrazine, and mesotrione at planting  | none                         | glyphosate 1 week before soybean planting  |
| Central Silage   | glyphosate 1 week before soybean planting   | none                         | glyphosate 1 week before maize planting; metalochlor, atrazine, and mesotrione at planting                           |
| Central Silage   | glyphosate 1 week before maize planting; metalochlor, atrazine, and mesotrione at planting  | none                         | glyphosate 1 week before soybean planting  |
| West             | glyphosate before planting; glyphosate and fluthiacet-methyl at planting  | none                         | glyphosate before planting; glyphosate and fluthiacet-methyl at planting   |
| East             | glyphosate and acetochlor before planting (April 15), atrazine, acetochlor at planting (May 14); acetochlor and glyphosate after planting (June 15) | none                         | chlorimuron-ethyl, flumioxazin, pyroxasulfone, and glyphosate before planting, dicamba and acetochlor after planting |

Table 3: General Management

| Site Description | General<br>Herbicide<br>Regime  | General<br>Date of<br>Cover<br>Crop Ter-<br>mination | General<br>Date of<br>Crop<br>Planting | Inorganic<br>Fertilizer<br>Used | Organic<br>Fertilizer<br>Used   | Tillage<br>Used |
|------------------|---|--|--|---------------------------------|---|-----------------|
| Central Grain    | burndown,<br>residual<br>herbicide at<br>maize planting   | 15-Apr   | 26-Apr                                 | Y                               | NA  | N               |
| Central Grain    | burndown,<br>residual<br>herbicide at<br>maize planting   | 25-Apr   | 5-May                                  | Y                               | NA  | N               |
| Central Silage   | burndown,<br>residual<br>herbicide at<br>maize planting   | 15-Apr   | 26-Apr                                 | Y                               | NA  | N               |
| Central Silage   | burndown,<br>residual<br>herbicide at<br>maize planting   | 25-Apr   | 5-May                                  | Y                               | NA  | N               |
| West             | burndown,<br>pre-emergent<br>herbicide  | 1-May  | 10-May                                 | Y                               | chicken or<br>turkey<br>manure  | N               |
| East             | burndown,<br>residual<br>herbicide at<br>planting,<br>another<br>application on<br>maize at ~V6 | 1-May  | 5-May                                  | Y                               | liquid<br>swine,<br>~3000<br>gal/ac<br>every other<br>year to<br>entire field | N               |

Cover crop biomass production over past 10 years of trials

Table 4: Historical cover crop biomass production (Mg/ha) by trial

| trial          | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2019 | 2018 |
|----------------|------|------|------|------|------|------|------|------|------|------|
| Central_grain  | 0.86 | 0.28 | 1.37 | 0.25 | 0.47 | 0.61 | 2.22 | 2.76 | 1.29 | NA   |
| Central_silage | 1.59 | 1.72 | 3.32 | 1.26 | 0.91 | 1.76 | 4.23 | 2.21 | 2.05 | NA   |
| East_grain     | 2.11 | 1.46 | 0.00 | 0.92 | 0.00 | 0.36 | 0.51 | 7.30 | 0.30 | 0.19 |
| West_grain     | 2.11 | 0.21 | 1.33 | 0.00 | 0.00 | 0.04 | 0.45 | 0.63 | 0.00 | 0.09 |

## Supplemental material S3. Statistical summaries

### Clay, silt, and sand components

Table 5: Statistical analysis of cover crop effect on clay

| site_sys       | respvar | cc     | no     | contrast | est_diff | diff_se | diff_pval |
|----------------|---------|--------|--------|----------|----------|---------|-----------|
| Central_grain  | clay    | 27.740 | 28.000 | cc - no  | -0.260   | 0.186   | 0.164     |
| Central_silage | clay    | 28.751 | 29.895 | cc - no  | -1.144   | 0.208   | <0.001    |
| East_grain     | clay    | 31.730 | 34.606 | cc - no  | -2.876   | 0.208   | <0.001    |
| West_grain     | clay    | 27.349 | 29.511 | cc - no  | -2.162   | 0.208   | <0.001    |

Table 6: Statistical analysis of cover crop effect on silt

| site_sys       | respvar | cc     | no     | contrast | est_diff | diff_se | diff_pval |
|----------------|---------|--------|--------|----------|----------|---------|-----------|
| Central_grain  | silt    | 39.772 | 40.399 | cc - no  | -0.627   | 0.206   | 0.003     |
| Central_silage | silt    | 41.313 | 40.793 | cc - no  | 0.520    | 0.230   | 0.025     |
| East_grain     | silt    | 55.552 | 55.557 | cc - no  | -0.005   | 0.230   | 0.983     |
| West_grain     | silt    | 41.896 | 44.728 | cc - no  | -2.831   | 0.230   | <0.001    |

Table 7: Statistical analysis of cover crop effect on sand

| site_sys       | respvar | cc     | no     | contrast | est_diff | diff_se | diff_pval |
|----------------|---------|--------|--------|----------|----------|---------|-----------|
| Central_grain  | sand    | 32.486 | 31.600 | cc - no  | 0.886    | 0.299   | 0.003     |
| Central_silage | sand    | 29.811 | 29.233 | cc - no  | 0.578    | 0.335   | 0.085     |
| East_grain     | sand    | 12.715 | 9.837  | cc - no  | 2.877    | 0.335   | <0.001    |
| West_grain     | sand    | 30.506 | 25.610 | cc - no  | 4.896    | 0.335   | <0.001    |

### Soil organic matter

Table 8: Statistical analysis of cover crop effect on organic matter, with and without sand covariate

| cov  | site_sys       | respvar | cc    | no    | contrast | est_diff | diff_se | diff_pval |
|------|----------------|---------|-------|-------|----------|----------|---------|-----------|
| none | Central_grain  | om      | 2.360 | 2.480 | cc - no  | -0.120   | 0.051   | 0.02      |
| none | Central_silage | om      | 2.640 | 2.416 | cc - no  | 0.224    | 0.057   | <0.001    |
| none | East_grain     | om      | 3.575 | 3.675 | cc - no  | -0.100   | 0.057   | 0.082     |
| none | West_grain     | om      | 2.750 | 2.975 | cc - no  | -0.225   | 0.057   | <0.001    |
| sand | Central_grain  | om      | 3.034 | 3.066 | cc - no  | -0.032   | 0.082   | 0.696     |
| sand | Central_silage | om      | 3.049 | 2.772 | cc - no  | 0.278    | 0.088   | 0.002     |
| sand | East_grain     | om      | 2.290 | 2.105 | cc - no  | 0.185    | 0.093   | 0.048     |
| sand | West_grain     | om      | 3.228 | 2.968 | cc - no  | 0.260    | 0.096   | 0.007     |

## Soil bulk density

Table 9: Mean bulk density (g/cm<sup>3</sup>) by trial

| site_name | sys_trt | crop_trt | cc_trt | bulkden_mean | bulkden_sd |
|-----------|---------|----------|--------|--------------|------------|
| Central   | grain   | soy      | cc     | 1.42         | 0.08       |
| Central   | grain   | soy      | no     | 1.37         | 0.07       |
| Central   | silage  | soy      | cc     | 1.46         | 0.06       |
| Central   | silage  | soy      | no     | 1.44         | 0.07       |
| East      | grain   | soy      | cc     | 1.44         | 0.05       |
| East      | grain   | soy      | no     | 1.49         | 0.04       |
| West      | grain   | corn     | cc     | 1.57         | 0.14       |
| West      | grain   | corn     | no     | 1.47         | 0.21       |

Table 10: Statistical analysis of cover crop effect on bulk density, with and without sand covariate

| cov  | site_sys       | respvar | cc    | no    | contrast | est_diff | diff_se | diff_pval |
|------|----------------|---------|-------|-------|----------|----------|---------|-----------|
| none | Central_grain  | bd      | 1.422 | 1.374 | cc - no  | 0.048    | 0.010   | <0.001    |
| none | Central_silage | bd      | 1.464 | 1.436 | cc - no  | 0.028    | 0.011   | 0.012     |
| none | East_grain     | bd      | 1.437 | 1.488 | cc - no  | -0.050   | 0.011   | <0.001    |
| none | West_grain     | bd      | 1.573 | 1.472 | cc - no  | 0.101    | 0.011   | <0.001    |
| sand | Central_grain  | bd      | 1.309 | 1.275 | cc - no  | 0.033    | 0.013   | 0.011     |
| sand | Central_silage | bd      | 1.395 | 1.386 | cc - no  | 0.010    | 0.014   | 0.483     |
| sand | East_grain     | bd      | 1.653 | 1.752 | cc - no  | -0.098   | 0.015   | <0.001    |
| sand | West_grain     | bd      | 1.493 | 1.473 | cc - no  | 0.020    | 0.015   | 0.188     |

## Soil moisture (%vol) at saturation

Table 11: Statistical analysis of cover crop effect on soil water at saturation, with and without sand covariate

| cov  | site_sys       | term   | contrast  | estimate | std.error | df     | statistic | adj.p.value | param      |
|------|----------------|--------|-----------|----------|-----------|--------|-----------|-------------|------------|
| sand | Central_grain  | cc_trt | cc effect | -0.013   | 0.008     | 26.000 | -1.688    | 0.103       | saturation |
| sand | Central_silage | cc_trt | cc effect | 0.004    | 0.008     | 26.000 | 0.510     | 0.614       | saturation |
| sand | East_grain     | cc_trt | cc effect | 0.011    | 0.009     | 26.000 | 1.271     | 0.215       | saturation |
| sand | West_grain     | cc_trt | cc effect | -0.007   | 0.009     | 26.000 | -0.729    | 0.473       | saturation |
| none | Central_grain  | cc_trt | cc effect | -0.016   | 0.008     | 13.050 | -1.959    | 0.072       | saturation |
| none | Central_silage | cc_trt | cc effect | 0.002    | 0.009     | 14.068 | 0.246     | 0.809       | saturation |
| none | East_grain     | cc_trt | cc effect | 0.002    | 0.009     | 13.050 | 0.228     | 0.823       | saturation |
| none | West_grain     | cc_trt | cc effect | -0.022   | 0.009     | 13.050 | -2.430    | 0.030       | saturation |



## Soil moisture (%vol) at field capacity (-100 cm water)

Table 12: Statistical analysis of cover crop effect on soil water at field capacity, with and without sand covariate

| cov  | site_sys       | term   | contrast  | estimate | std.error | df     | statistic | adj.p.value | param          |
|------|----------------|--------|-----------|----------|-----------|--------|-----------|-------------|----------------|
| sand | Central_grain  | cc_trt | cc effect | -0.002   | 0.006     | 26.000 | -0.430    | 0.671       | field capacity |
| sand | Central_silage | cc_trt | cc effect | 0.012    | 0.006     | 26.000 | 2.041     | 0.052       | field capacity |
| sand | East_grain     | cc_trt | cc effect | -0.002   | 0.006     | 26.000 | -0.353    | 0.727       | field capacity |
| sand | West_grain     | cc_trt | cc effect | 0.012    | 0.007     | 26.000 | 1.835     | 0.078       | field capacity |
| none | Central_grain  | cc_trt | cc effect | -0.004   | 0.005     | 13.044 | -0.800    | 0.438       | field capacity |
| none | Central_silage | cc_trt | cc effect | 0.012    | 0.006     | 14.005 | 2.242     | 0.042       | field capacity |
| none | East_grain     | cc_trt | cc effect | -0.007   | 0.006     | 13.044 | -1.317    | 0.211       | field capacity |
| none | West_grain     | cc_trt | cc effect | 0.003    | 0.006     | 13.044 | 0.597     | 0.561       | field capacity |

## Fitted parameters a and n

Table 13: Table of 'a' Gardener parameter estimate

| site_sys       | cc_trt | rep | estimate | std.error |
|----------------|--------|-----|----------|-----------|
| Central_grain  | cc     | 1   | 0.043    | 0.010     |
|                |        | 2   | 0.025    | 0.006     |
|                |        | 3   | 0.015    | 0.012     |
|                |        | 4   | 0.021    | 0.010     |
|                |        | 5   | 0.002    | 0.001     |
|                | no     | 1   | 0.020    | 0.010     |
|                |        | 2   | 0.025    | 0.009     |
|                |        | 3   | 0.010    | 0.005     |
|                |        | 4   | 0.013    | 0.007     |
|                |        | 5   | 0.041    | 0.014     |
| Central_silage | cc     | 1   | 0.028    | 0.014     |
|                |        | 2   | 0.030    | 0.013     |
|                |        | 3   | 0.011    | 0.008     |
|                |        | 4   | 0.015    | 0.011     |
|                |        | 5   | 0.044    | 0.013     |
|                | no     | 1   | 0.049    | 0.029     |
|                |        | 2   | 0.046    | 0.014     |
|                |        | 3   | 0.048    | 0.014     |
|                |        | 4   | 0.016    | 0.007     |
|                |        |     |          |           |
| East_grain     | cc     | 1   | 0.100    | 0.027     |
|                |        | 2   | 0.180    | 0.046     |
|                |        | 3   | 0.054    | 0.022     |
|                |        | 4   | 0.085    | 0.024     |
|                |        | 1   | 0.088    | 0.022     |
|                | no     | 2   | 0.080    | 0.028     |
|                |        | 3   | 0.073    | 0.026     |
|                |        | 4   | 0.080    | 0.024     |
|                |        | 5   | 0.092    | 0.029     |
|                |        |     |          |           |
| West_grain     | cc     | 1   | 0.007    | 0.008     |
|                |        | 2   | 0.026    | 0.006     |
|                |        | 3   | 0.039    | 0.016     |
|                |        | 4   | 0.032    | 0.015     |
|                | no     | 1   | 0.013    | 0.013     |
|                |        | 2   | 0.029    | 0.012     |
|                |        | 3   | 0.051    | 0.017     |
|                |        | 4   | 0.102    | 0.017     |

Table 14: Table of 'n' Gardener parameter estimate

| site_sys       | cc_trt | rep | estimate | std.error |
|----------------|--------|-----|----------|-----------|
| Central_grain  | cc     | 1   | 0.987    | 0.079     |
|                |        | 2   | 1.099    | 0.073     |
|                |        | 3   | 1.106    | 0.219     |
|                |        | 4   | 1.086    | 0.141     |
|                |        | 5   | 1.468    | 0.198     |
|                | no     | 1   | 0.999    | 0.154     |
|                |        | 2   | 1.007    | 0.110     |
|                |        | 3   | 1.291    | 0.139     |
|                |        | 4   | 1.264    | 0.153     |
|                |        | 5   | 0.949    | 0.112     |
| Central_silage | cc     | 1   | 0.813    | 0.158     |
|                |        | 2   | 0.850    | 0.137     |
|                |        | 3   | 1.006    | 0.220     |
|                |        | 4   | 1.173    | 0.212     |
|                |        | 5   | 0.639    | 0.116     |
|                | no     | 1   | 0.923    | 0.197     |
|                |        | 2   | 0.705    | 0.108     |
|                |        | 3   | 0.614    | 0.121     |
|                |        | 4   | 1.041    | 0.125     |
|                |        | 5   | 0.772    | 0.104     |
| East_grain     | cc     | 2   | 0.817    | 0.115     |
|                |        | 3   | 0.994    | 0.140     |
|                |        | 4   | 0.740    | 0.105     |
|                |        | 1   | 0.651    | 0.099     |
|                |        | 2   | 0.973    | 0.133     |
|                | no     | 3   | 0.880    | 0.131     |
|                |        | 4   | 0.880    | 0.110     |
|                |        | 5   | 0.737    | 0.116     |
|                |        | 1   | 1.009    | 0.305     |
|                |        | 2   | 0.834    | 0.071     |
| West_grain     | cc     | 3   | 0.488    | 0.175     |
|                |        | 4   | 0.997    | 0.145     |
|                |        | 1   | 1.039    | 0.268     |
|                |        | 2   | 0.970    | 0.133     |
|                | no     | 3   | 0.837    | 0.110     |
|                |        | 4   | 0.743    | 0.064     |

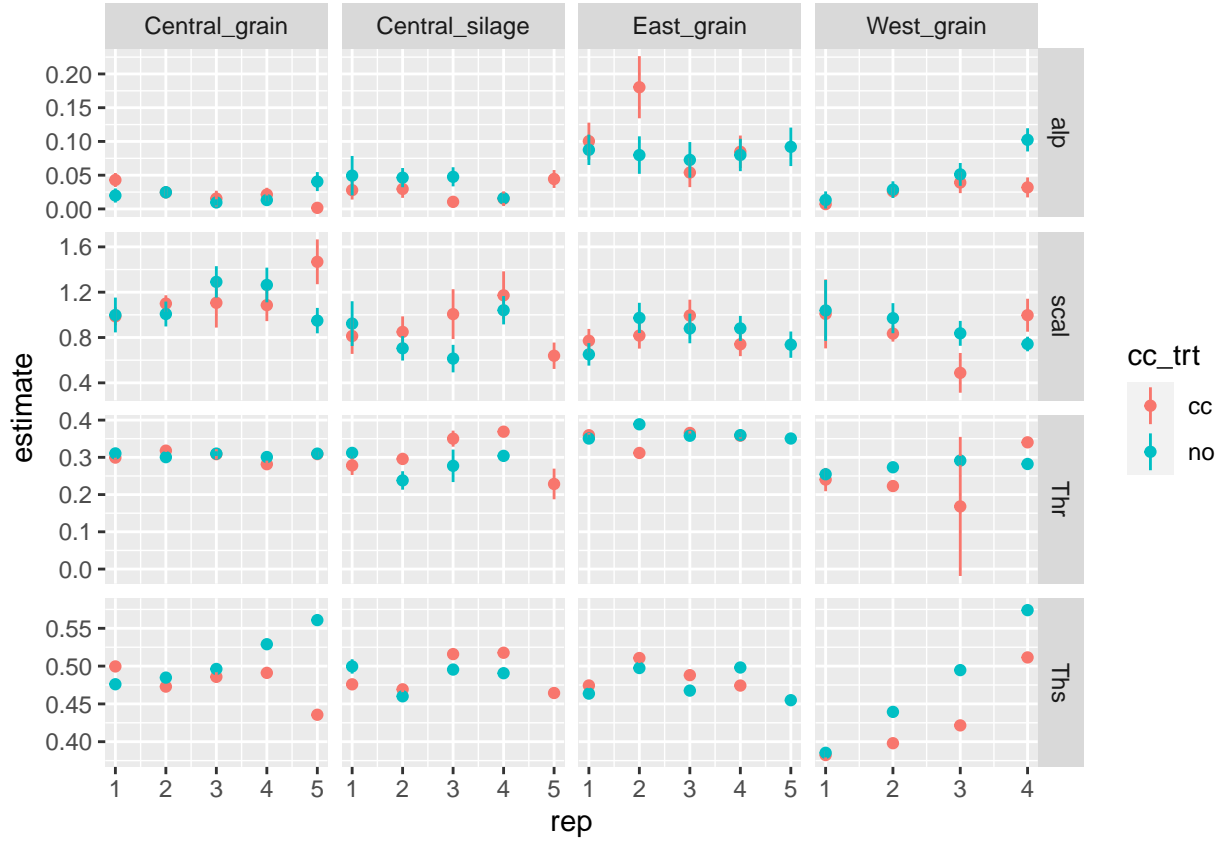


Figure 2: Non-linear model fitted parameters

## Macro-pore percentages

Table 15: Table of macropores estimates and comparisons

| site_sys       | cc_trt | estimate | df     | conf.low | conf.high | contrast | est_diff | pval_diff |
|----------------|--------|----------|--------|----------|-----------|----------|----------|-----------|
| Central-grain  | cc     | 0.589    | 26.228 | 0.518    | 0.660     | cc - no  | -0.029   | 0.606     |
|                | no     | 0.618    | 26.228 | 0.547    | 0.689     | cc - no  |          |           |
| Central-silage | cc     | 0.535    | 26.228 | 0.464    | 0.606     | cc - no  | -0.051   | 0.403     |
|                | no     | 0.586    | 26.989 | 0.506    | 0.665     | cc - no  |          |           |
| East-grain     | cc     | 0.731    | 26.989 | 0.651    | 0.811     | cc - no  | 0.019    | 0.750     |
|                | no     | 0.712    | 26.228 | 0.641    | 0.783     | cc - no  |          |           |
| West-grain     | cc     | 0.478    | 26.989 | 0.399    | 0.558     | cc - no  | -0.127   | 0.053     |
|                | no     | 0.605    | 26.989 | 0.525    | 0.685     | cc - no  |          |           |

Supplemental material S4. Detailed soil texture results

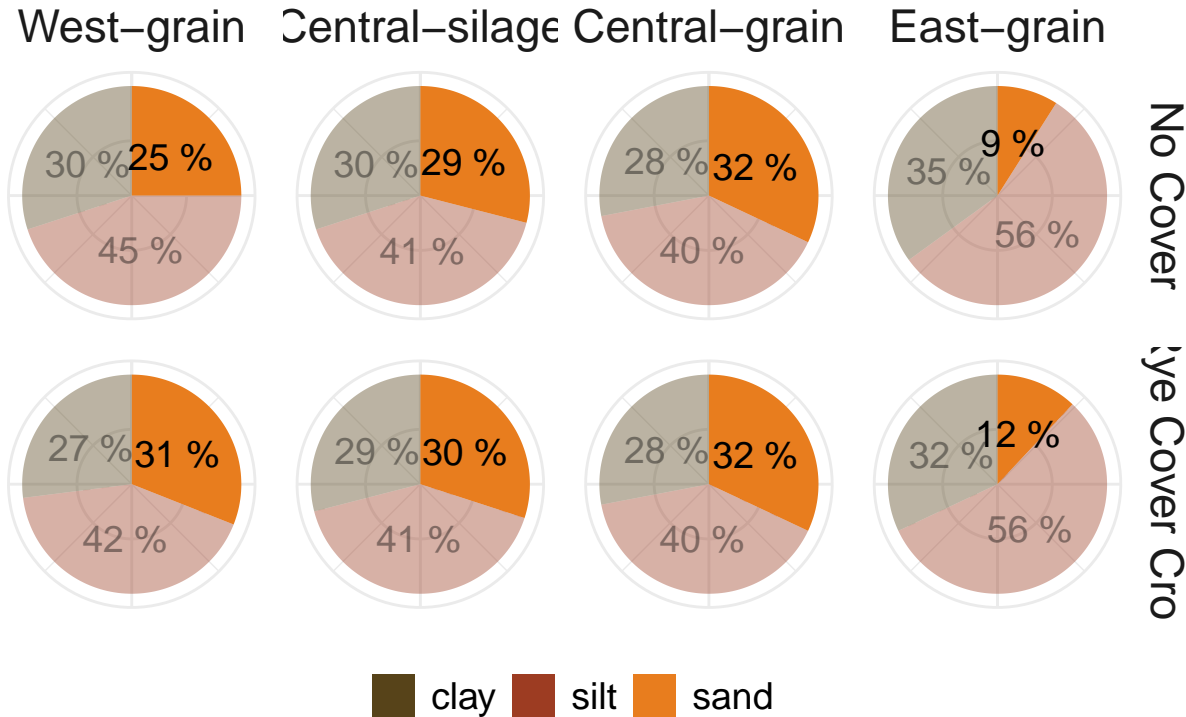


Figure 3: Soil texture components varied by trial and cover crop treatment, with the cover cropped plots having significantly more sand bolded orange color, and significantly less clay at the West-grain and East-grain trials both, commercial fields

Table with values:

Table 16: Table of values

| site_sys       | cc_trt | clay | sand | silt | tot | sig_sand_diff |
|----------------|--------|------|------|------|-----|---------------|
| Central-grain  | cc     | 0.28 | 0.32 | 0.40 | 1   | No            |
|                | no     | 0.28 | 0.32 | 0.40 | 1   |               |
| Central-silage | cc     | 0.29 | 0.30 | 0.41 | 1   | Yes           |
|                | no     | 0.30 | 0.29 | 0.41 | 1   |               |
| East-grain     | cc     | 0.32 | 0.12 | 0.56 | 1   | Yes           |
|                | no     | 0.35 | 0.09 | 0.56 | 1   |               |
| West-grain     | cc     | 0.27 | 0.31 | 0.42 | 1   | Yes           |
|                | no     | 0.30 | 0.25 | 0.45 | 1   |               |

Table 17: Table of sand statistics

| site_sys       | respvar | cc     | no     | contrast | est_diff | diff_se | pval   |
|----------------|---------|--------|--------|----------|----------|---------|--------|
| Central_grain  | sand    | 32.486 | 31.600 | cc - no  | 0.886    | 0.299   | 0.003  |
| Central_silage | sand    | 29.811 | 29.233 | cc - no  | 0.578    | 0.335   | 0.085  |
| East_grain     | sand    | 12.715 | 9.837  | cc - no  | 2.877    | 0.335   | <0.001 |
| West_grain     | sand    | 30.506 | 25.610 | cc - no  | 4.896    | 0.335   | <0.001 |