

# Supplementary Material for ‘Long-term use of cover crops reduces weed seedbanks’

*Nichols et al. 2020*

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

Table 3: General Management

| Site Description | General<br>Herbicide<br>Regime  | General<br>Date of<br>Cover Crop<br>Termination | 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               |
|                  | 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               |
|                  | 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               |

## Field wet soil amounts

Table 4: Wet Soil Weights Immediately After Sampling

| site  | cc_trt | rep | soilwt_g | notes               |
|-------|--------|-----|----------|---------------------|
| BC    | no     | 1   | 6718.3   | sampled 4/8, 12-6pm |
|       | rye    | 1   | 6936.2   | sampled 4/8, 12-6pm |
|       | no     | 2   | 6838.6   | sampled 4/8, 12-6pm |
|       | rye    | 2   | 5965.2   | sampled 4/8, 12-6pm |
|       | no     | 3   | 6260.4   | sampled 4/8, 12-6pm |
|       | rye    | 3   | 6136.0   | sampled 4/8, 12-6pm |
|       | no     | 4   | 5554.9   | sampled 4/9         |
|       | rye    | 4   | 6312.7   | sampled 4/9         |
|       | no     | 5   | 5866.2   | sampled 4/9         |
|       | rye    | 5   | 5981.1   | sampled 4/9         |
| Bcsil | rye    | 1   | 6340.0   | sampled 4/16, 2-6pm |
|       | no     | 1   | 5800.0   | sampled 4/16, 2-6pm |
|       | rye    | 2   | 5990.0   | sampled 4/16, 2-6pm |
|       | no     | 2   | 6100.0   | sampled 4/16, 2-6pm |
|       | no     | 3   | 6245.5   | sampled 4/8         |
|       | rye    | 3   | 6160.2   | sampled 4/8         |
|       | no     | 4   | 6240.2   | sampled 4/8         |
|       | rye    | 4   | 6007.5   | sampled 4/8         |
|       | no     | 5   | 6682.9   | sampled 4/8         |
|       | rye    | 5   | 6045.7   | sampled 4/8         |
| BS    | rye    | 1   | 6068.7   | sampled 4/9         |
|       | no     | 2   | 6240.3   | sampled 4/9         |
|       | rye    | 2   | 5950.5   | sampled 4/9         |
|       | no     | 3   | 5885.7   | sampled 4/9         |
|       | rye    | 3   | 5734.1   | sampled 4/9         |
|       | no     | 4   | 6213.3   | sampled 4/9         |
|       | rye    | 4   | 5968.2   | sampled 4/9         |
|       | no     | 5   | 6175.8   | sampled 4/9         |
|       | rye    | 5   | 6050.4   | sampled 4/9         |
| East  | no     | 1   | 5349.6   | sampled 4/6, 8-5pm  |
|       | rye    | 1   | 5460.6   | sampled 4/6, 8-5pm  |
|       | no     | 2   | 5235.5   | sampled 4/6, 8-5pm  |
|       | rye    | 2   | 5055.2   | sampled 4/6, 8-5pm  |
|       | no     | 3   | 5211.1   | sampled 4/6, 8-5pm  |
|       | rye    | 3   | 4991.7   | sampled 4/6, 8-5pm  |
|       | no     | 4   | 5401.6   | sampled 4/6, 8-5pm  |
|       | rye    | 4   | 5163.9   | sampled 4/6, 8-5pm  |
| West  | no     | 1   | 6314.0   | sampled 4/17, 9-2pm |
|       | rye    | 1   | 6401.0   | sampled 4/17, 9-2pm |
|       | no     | 2   | 5841.0   | sampled 4/17, 9-2pm |
|       | rye    | 2   | 5543.0   | sampled 4/17, 9-2pm |
|       | no     | 3   | 5698.0   | sampled 4/17, 9-2pm |
|       | rye    | 3   | 5947.0   | sampled 4/17, 9-2pm |
|       | no     | 4   | 6057.0   | sampled 4/17, 9-2pm |
|       | rye    | 4   | 5989.0   | sampled 4/17, 9-2pm |

# Statistical Results

## Linear models on seedbank density

Values are presented for the models run with the full dataset (XX\_full) and with the outlier removed (XX\_out-rm)

Table 5: Contrasts using full dataset (full) and dataset with outlier removed (out-rm)

| model        | site_sys       | level1 | level2 | estimate | std.error | z.ratio | p.value |
|--------------|----------------|--------|--------|----------|-----------|---------|---------|
| pois_out-rm  | Central_grain  | no     | rye    | -0.32    | 0.26      | -1.22   | 0.22    |
|              | Central_silage | no     | rye    | 0.95     | 0.35      | 2.66    | 0.01    |
|              | West_grain     | no     | rye    | 0.71     | 0.42      | 1.68    | 0.09    |
|              | East_grain     | no     | rye    | 0.42     | 0.41      | 1.03    | 0.31    |
| pois_full    | Central_grain  | no     | rye    | -0.32    | 0.27      | -1.19   | 0.24    |
|              | Central_silage | no     | rye    | 0.95     | 0.37      | 2.58    | 0.01    |
|              | West_grain     | no     | rye    | 0.36     | 0.4       | 0.91    | 0.37    |
|              | East_grain     | no     | rye    | 0.43     | 0.43      | 1       | 0.32    |
| binom_out-rm | Central_grain  | no     | rye    | -0.33    | 0.26      | -1.27   | 0.2     |
|              | Central_silage | no     | rye    | 1.02     | 0.34      | 2.99    | 0       |
|              | West_grain     | no     | rye    | 0.71     | 0.41      | 1.72    | 0.09    |
|              | East_grain     | no     | rye    | 0.45     | 0.4       | 1.12    | 0.26    |
| binom_full   | Central_grain  | no     | rye    | -0.33    | 0.26      | -1.23   | 0.22    |
|              | Central_silage | no     | rye    | 1.03     | 0.35      | 2.92    | 0       |
|              | West_grain     | no     | rye    | 0.28     | 0.39      | 0.71    | 0.48    |
|              | East_grain     | no     | rye    | 0.45     | 0.41      | 1.09    | 0.27    |

Table 6: Estimates using full dataset (full) and dataset with outlier removed (out-rm)

| model        | site_sys       | cc_trt | estimate | std.error | asympt.LCL | asympt.UCL |
|--------------|----------------|--------|----------|-----------|------------|------------|
| pois_out-rm  | Central_grain  | no     | 2.97     | 0.23      | 2.52       | 3.42       |
|              |                | rye    | 3.29     | 0.23      | 2.85       | 3.73       |
|              | Central_silage | no     | 4.3      | 0.3       | 3.72       | 4.88       |
|              |                | rye    | 3.35     | 0.3       | 2.76       | 3.95       |
|              | West_grain     | no     | 6.02     | 0.34      | 5.35       | 6.69       |
|              |                | rye    | 5.31     | 0.39      | 4.55       | 6.07       |
| pois_full    | East_grain     | no     | 3.32     | 0.36      | 2.62       | 4.03       |
|              |                | rye    | 2.9      | 0.36      | 2.19       | 3.61       |
|              | Central_grain  | no     | 2.97     | 0.24      | 2.5        | 3.43       |
|              |                | rye    | 3.29     | 0.23      | 2.83       | 3.74       |
|              | Central_silage | no     | 4.29     | 0.31      | 3.69       | 4.9        |
|              |                | rye    | 3.35     | 0.31      | 2.74       | 3.96       |
| binom_out-rm | West_grain     | no     | 6.02     | 0.35      | 5.33       | 6.71       |
|              |                | rye    | 5.66     | 0.36      | 4.97       | 6.36       |
|              | East_grain     | no     | 3.32     | 0.37      | 2.6        | 4.05       |
|              |                | rye    | 2.9      | 0.38      | 2.16       | 3.63       |
|              | Central_grain  | no     | 3.11     | 0.23      | 2.67       | 3.55       |
|              |                | rye    | 3.44     | 0.23      | 3          | 3.88       |
| binom_full   | Central_silage | no     | 4.45     | 0.29      | 3.87       | 5.02       |
|              |                | rye    | 3.42     | 0.3       | 2.84       | 4.01       |
|              | West_grain     | no     | 6.03     | 0.33      | 5.37       | 6.68       |
|              |                | rye    | 5.32     | 0.38      | 4.58       | 6.06       |
|              | East_grain     | no     | 3.43     | 0.36      | 2.73       | 4.13       |
|              |                | rye    | 2.98     | 0.36      | 2.28       | 3.69       |
| pois_out-rm  | Central_grain  | no     | 3.11     | 0.23      | 2.65       | 3.57       |
|              |                | rye    | 3.43     | 0.24      | 2.97       | 3.9        |
|              | Central_silage | no     | 4.44     | 0.3       | 3.85       | 5.04       |
|              |                | rye    | 3.42     | 0.31      | 2.81       | 4.02       |
|              | West_grain     | no     | 6.04     | 0.35      | 5.35       | 6.72       |
|              |                | rye    | 5.76     | 0.36      | 5.06       | 6.46       |
| binom_out-rm | East_grain     | no     | 3.42     | 0.37      | 2.69       | 4.15       |
|              |                | rye    | 2.98     | 0.37      | 2.24       | 3.71       |

## Biomass metrics

Table 7: Cover crop biomass metrics, 10-year time frame

| site_sys       | nabov1 | nabov2 | ccbio_mean | ccbio_med | ccbio_var | ccbio_max | ccbio_stab | ccbio_2019 |
|----------------|--------|--------|------------|-----------|-----------|-----------|------------|------------|
| Central_grain  | 4      | 2      | 1.03       | 0.74      | 0.77      | 2.76      | 0.85       | 1.29       |
| Central_silage | 9      | 4      | 2.04       | 1.74      | 1.02      | 4.23      | 0.5        | 2.05       |
| West_grain     | 2      | 1      | 0.45       | 0.14      | 0.46      | 2.11      | 1.5        | 0          |
| East_grain     | 3      | 2      | 1.32       | 0.43      | 4.89      | 7.3       | 1.68       | 0.3        |

Table 8: Cover crop biomass metrics, 5-year time frame

| site_sys       | nabovel | nabove2 | ccbio_mean | ccbio_med | ccbio_var | ccbio_max | ccbio_stab | ccbio_2019 |
|----------------|---------|---------|------------|-----------|-----------|-----------|------------|------------|
| Central_grain  | 3       | 2       | 1.72       | 1.76      | 0.91      | 2.76      | 0.55       | 1.29       |
| Central_silage | 4       | 3       | 2.56       | 2.13      | 1.27      | 4.23      | 0.44       | 2.05       |
| West_grain     | 0       | 0       | 0.24       | 0.09      | 0.08      | 0.63      | 1.16       | 0          |
| East_grain     | 1       | 1       | 1.73       | 0.36      | 9.71      | 7.3       | 1.8        | 0.3        |

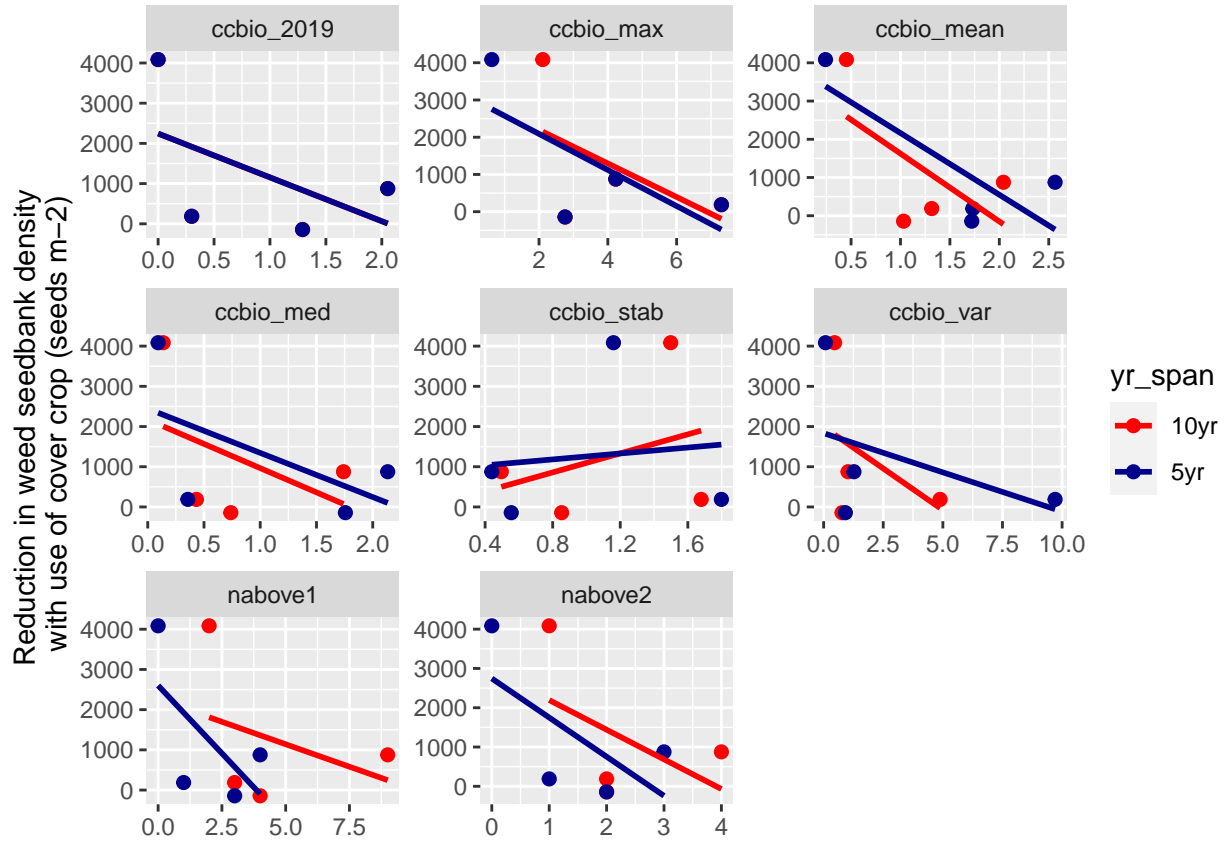


Figure 1: Absolute change in seedbank density vs. cover crop biomass metrics



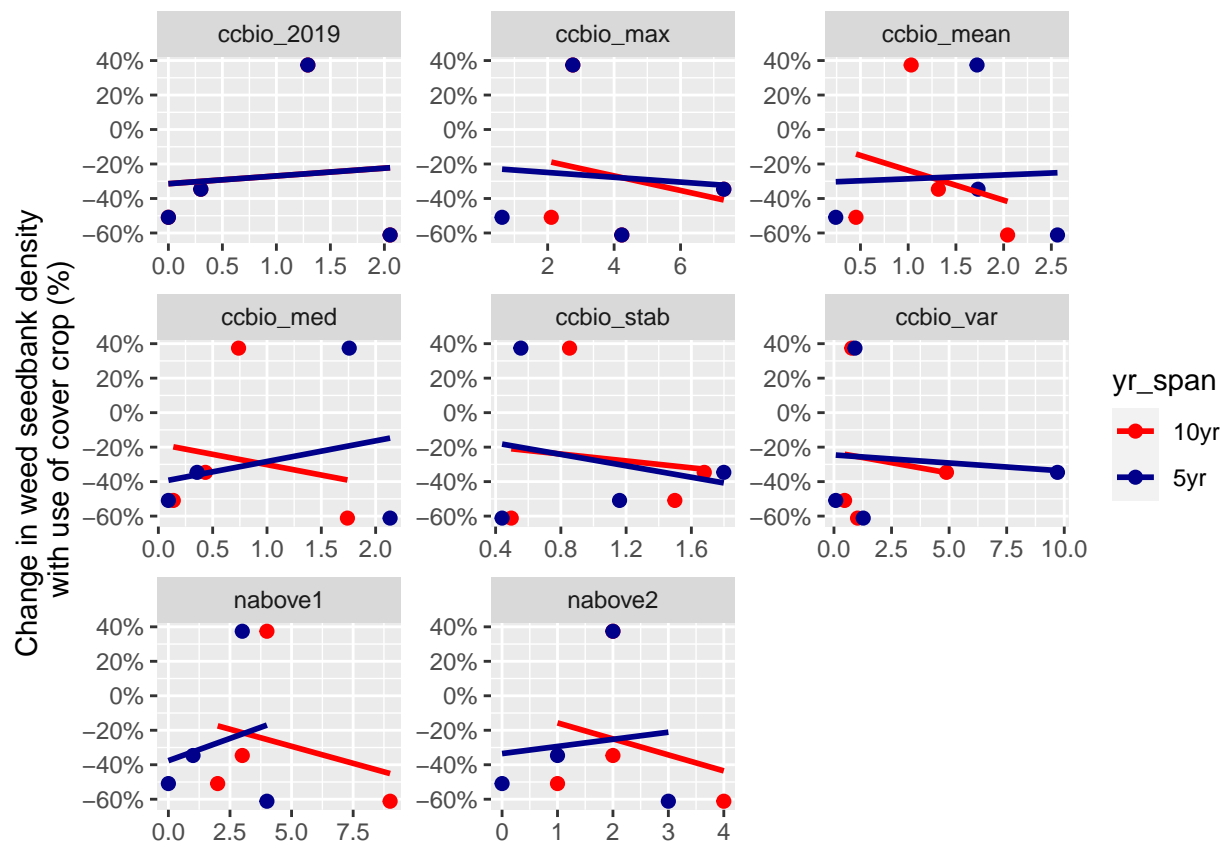


Figure 2: Relative change in seedbank density vs. cover crop biomass metrics

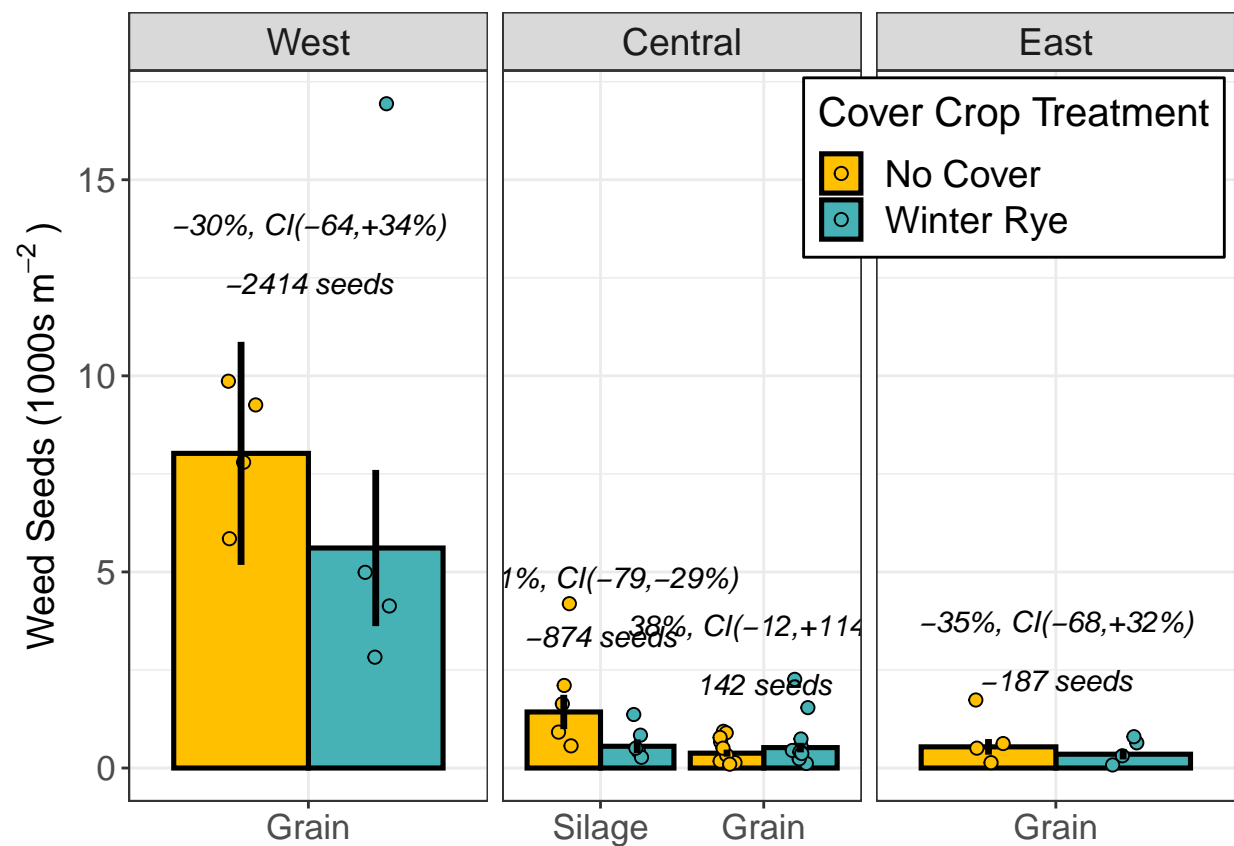


Figure 3: Manuscript fig. 2 using full dataset

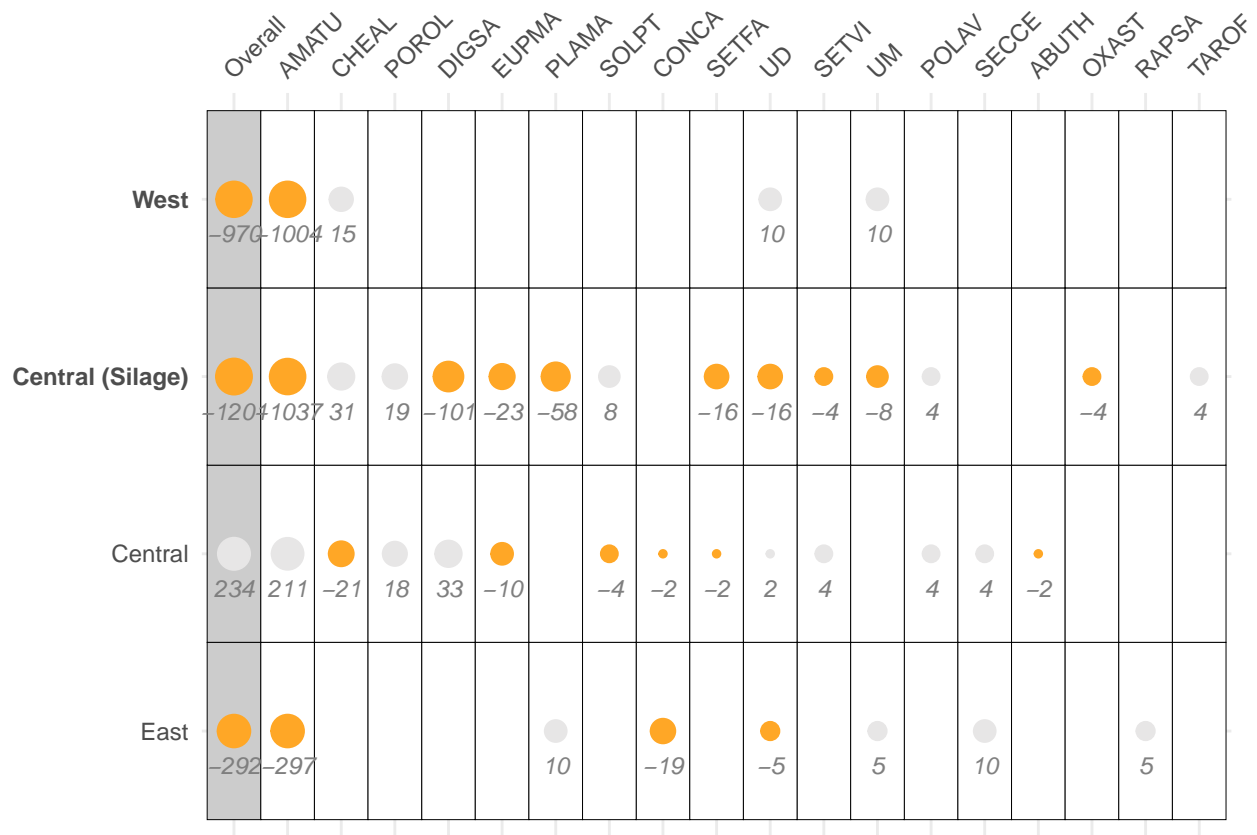


Figure 4: Manuscript fig. 3 using full dataset

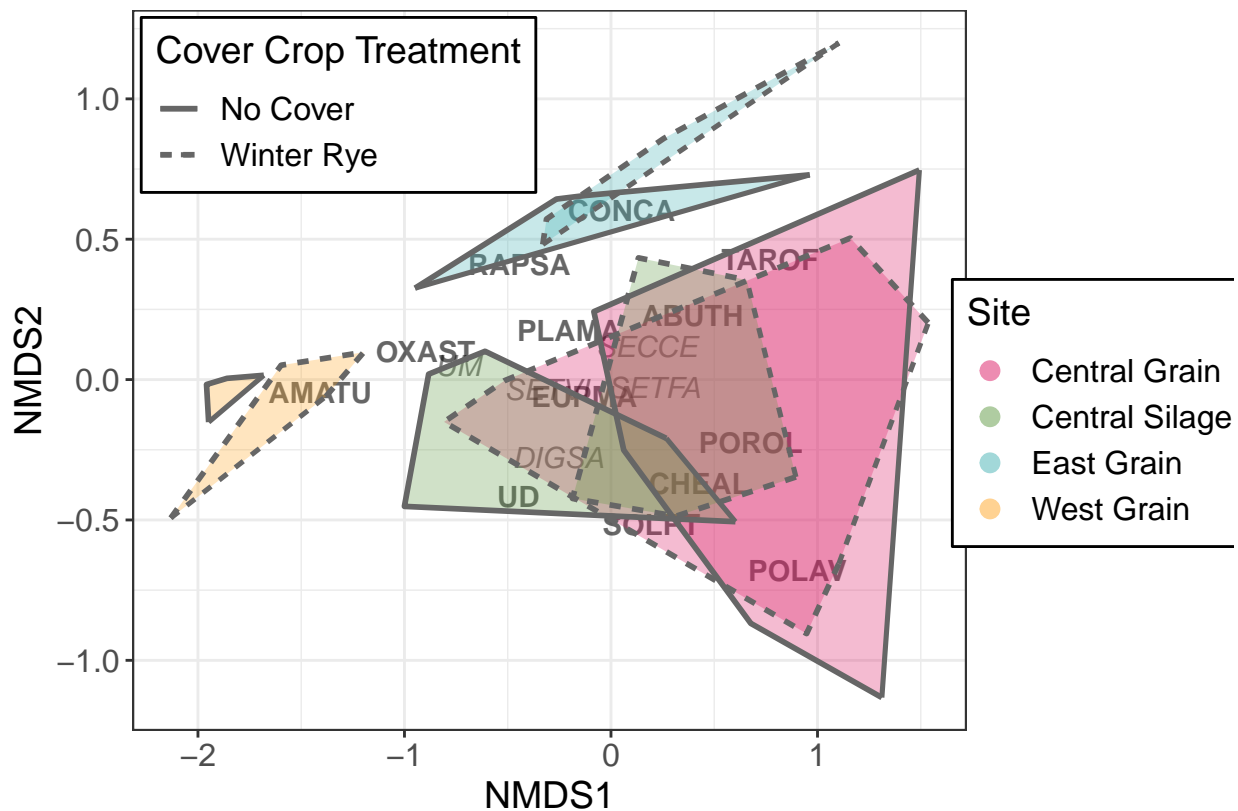


Figure 5: Manuscript fig. 4 using full dataset

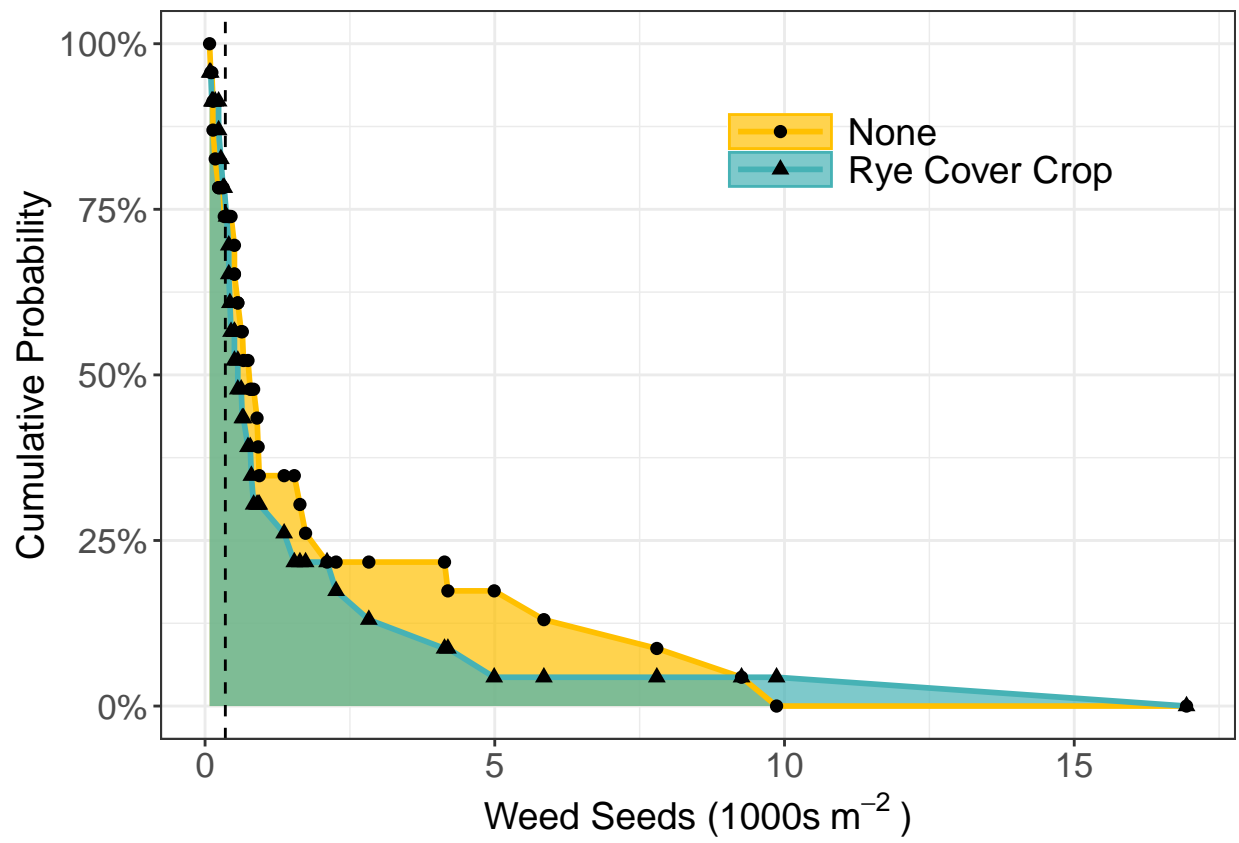


Figure 6: Manuscript fig. 5 using full dataset