Incorporation of Small Grain and Cover Crop in a Corn-Soybean Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0933053202101
County: Dodge
Tillage: No-till
Reps: 8 (4 per area)

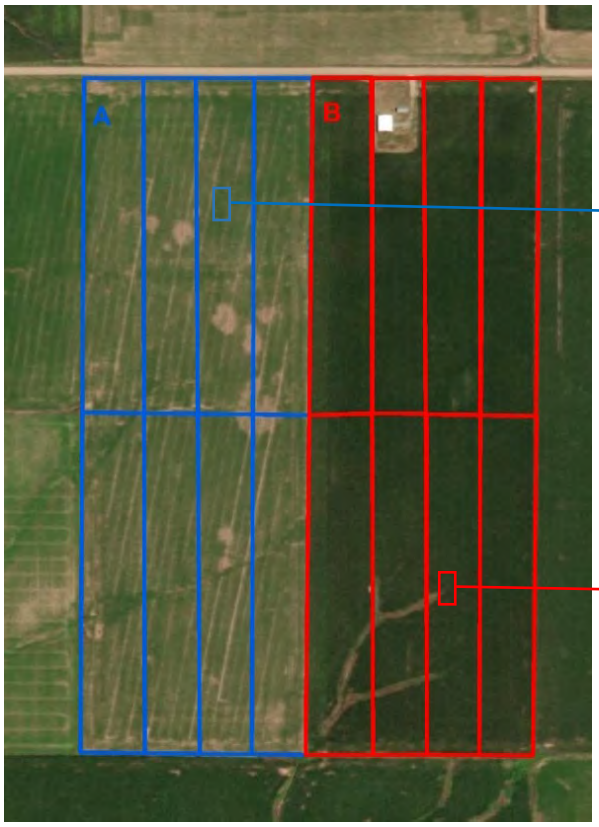
Soil Type: Belfore silty clay loam 0-2% slope; Moody silty clay loam 2-6% slopes
Irrigation: None

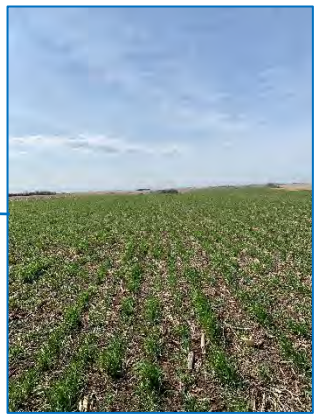
Introduction

This study is being conducted on a soil health demonstration field as part of the Nebraska USDA Natural Resources Conservation Service's (NRCS) Soil Health Initiative, and involves the farmer, the Nebraska On-Farm Research Network, and the USDA-NRCS. The traditional crop rotation for this producer is a corn and soybean crop rotation with a cover crop following soybeans and no-till residue management. There is interest in intensifying the cropping system by incorporating a cool-season cash crop such as winter wheat and increasing the amount of time living plants are growing in the field. The two treatments, a check and an intensified system, were used in this five-year study (2017-2022). The check treatment is a corn and soybean rotation with a cover crop following corn and soybeans. The intensive cropping system is a corn, soybean, small grain rotation with cover crop following each cash crop. Both phases of the rotation (corn-soybean) are present each year in this field. The field was divided into two portions (Figure 1).

- Area A primarily consists of Moody silty clay loam, 2 to 6 percent slopes and Nora silty clay loam, 6 to 11 percent slopes, eroded
- Area B primarily consists of Belfore silty clay loam, 0 to 2 percent slopes

The results here are presented over the five years for each of these areas of the field.





Intensified system. Picture taken on April 22, 2020.

Intensified system. Picture taken on May 5, 2020.

Sub-field area A (Moody and Nora silty clay loam)

Year 1 – Soybeans (2017 Crop)

Planting Date: 5/10/17
Harvest Date: 10/17/17
Population: 140,000
Row Spacing (in): 15
Variety: Channel® 2617
Fertilizer: 147.03 lb/ac MESZ® on 11/6/16
Herbicides: ***Burndown:*** 44 oz/ac Roundup® on 4/12/17 ***Pre:*** Sonic® and Hel-Fire® on 4/22/17 ***Post:*** 32 oz/ac Roundup® & AMS on 6/3/17; 32 oz/ac Roundup®, Flexstar®, Section® Three, and Zaar® on 6/25/17

In year one, cereal rye was planted October 10, 2016. Cover crop terminated April 12, 2017. Soybeans were planted across both, check and intensive plots, on May 10, 2017 and harvested on October 17, 2017. In 2017, soybeans had no difference in yield following check or intensive system.

Table 1. 2017 soybean moisture, yield, and net return for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Check	12.9 A*	61.3 A	545 A
Intensive System	12.1 B	64.2 A	571 A
P-Value	0.0331	0.127	0.153

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.90/bu soybeans in both treatments.

Year 2 – Corn and Wheat (2018 Crop)

Corn
Planting Date: 5/7/18
Harvest Date: 11/1/18
Herbicides: ***Pre:*** 42 oz/ac Roundup® 4/28/18

Wheat
Planting Date: 10/16/17
Harvest Date: 8/6/18
Population: 75 lb/ac
Hybrid: Certified SY Wolf
Herbicides: ***Pre:*** 32 oz/ac Roundup® prior to wheat planting

In year two, following soybean harvest October 2017, in the check plots a cover crop mix of 30 lbs/ac rye, 3.5 lbs/ac radish, 5lbs/ac hairy vetch, 1lbs/ac crimson clover was drilled on October 18, 2017. This cover crop mix was terminated on April 28, 2018, with a 42 oz/ac Roundup® burndown application, then corn was planted on May 7, 2018, and harvested on November 1, 2018. In the intensive system plots, wheat was planted on October 16, 2017, and harvested on August 6, 2018. As this was the first time the farmer had planted or harvested wheat, it was not successful as far as weed control and harvest yield. A post-harvest application of Roundup® was applied. No measurements were made on wheat yields in the intensive system strips.

Table 2. 2018 corn and wheat moisture and yield for check and intensive system treatments.

Treatment	Crop	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	Corn	14.5	181.4	546.4
Intensive System	Wheat	-	-	

†Bushels per acre corrected to 15.5% (corn) and 13.5% (wheat) moisture.
‡Marginal net return based on $3.23/bu corn and $25/ac cost for cover crop seed and $14.40 drilling for check treatment.

Year 3 – Soybeans (2019 Crop)

Planting Date: 5/14/19
Harvest Date: 10/14/19
Population: 140,000
Row Spacing (in): 7
Variety: Channel® 2617
Herbicides: ***Burndown:*** 42 oz/ac Roundup® on 4/23/19 ***Pre:*** Zidua®, Roundup® and Zaar® on 5/10/19 ***Post:*** 31 oz/ac Roundup®,11 oz/ac Sinister®, Zaar®, 74.85 oz/ac FirstRate®, and 39.85 oz/ac Warrant® on 7/1/19
Insecticide: 3.99 oz/ac Artic® 3.2 EC on 7/20/19

In year three, 20 lbs/ac rye, 2lbs/ac radishes, 0.5lbs/ac African cabbage, 8 lbs/ac winter pea, 5 lbs/ac common vetch, 3 lbs/ac sunnhemp, 5 lbs/ac buckwheat, 10lbs/ac spring oats cover crop mix was drilled on August 7, 2018, following wheat (intensive plots) and 65 lbs/ac rye drilled on November 7, 2018 following corn (check plots) harvest. All plots were sprayed on April 23, 2019 prior to soybean planting. Soybeans were planted on May 14, 2019 and harvested on October 14, 2019. In 2019, soybean yield was higher in the check plots compared to intensive system plots.

Table 3. 2019 soybean moisture and yield for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	13.1 B*	49.1 A	371 A
Intensive System	13.3 A	46.7 B	329 B
P-Value	0.0471	0.087	0.0096

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $35/ac cost for cover crop seed for intensive treatment, $12.5/ac cost for cover crop seed for check treatment and $14.40 drilling for drilling cost.

Year 4 – Corn (2020 Crop)

Planting Date: 4/28/20
Harvest Date: 10/14/20
Population: 29,000
Row Spacing (in): 30
Hybrid: Channel® 217-41 DroughtGard® VT2P RIB Complete, DEKALB® DKC62-98 VT2P RIB
Herbicides: ***Pre:*** 32 oz/ac Roundup PowerMAX® with AMS on 4/23/20 burndown; 1.5 qt/ac Harness® Xtra®, 3 oz/ac Balance® Flexx, 1.3 qt/ac Roundup PowerMAX® on 4/30/20 ***Post:*** 16 oz/ac ZAAR®, 32 oz/ac Roundup®, 3 oz/ac Laudis®, and 8 oz/ac atrazine on 6/11/20
Seed Treatment: BAS250
Fertilizer: 176 lb/ac MESZ®, 12-40-0-10S-1Zn, 50 lb/ac 0-0-60 Potash applied on 12/26/19; 421 lb/ac UAN 32-0-0 on 4/30/20
Cumulative Rainfall (in): 25

In year four, 3-way mix cover crops (35 lb/ac winter rye, 2 lb/ac rapeseed, and 1 lb/ac red clover) were drilled on October 15, 2019, following soybean harvest on both plots (intensive and check). Cover crop was terminated on April 23, 2020. Then corn was planted on April 28, 2020, and harvested on October 14, 2020. Corn planted in the intensive system had higher yield than the check strips. These observations are in agreement with the crop vigor analysis (NDVI) that showed higher values in the intensive system strips, during the growing season.

Table 4. 2020 cover crop biomass, green cover, corn moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 22, 2020, prior to termination.

	Cover crop Biomass (lb/ac)	Green cover (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)	Corn NDVI on Jul 28, 2020
Check	602 A*	10.55 A	14.7 A	183 B	602 B	0.450 B
Intensive System	507 A	7.28 B	14.3 A	202 A	668 A	0.462 A
P-Value	0.2160	0.0031	0.168	0.00413	0.00115	0.00113

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
Green cover determined using the Canopeo measurement tool.
‡Marginal net return based on $3.51/bu corn, $25/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 5 – Soybeans (2021 Crop)

Planting Date: 5/13/21
Harvest Date: 10/5/21
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Brevant® 269EE
Herbicides: ***Burndown:*** 30.55 oz/ac Roundup PowerMAX® on 4/26/21 ***Pre:*** 8.02 oz/ac 2,4-D LV6, 6 oz/ac Zidua® Pro, and 16 oz/ac Zaar® on 4/26/21 ***Post:*** AMS, CVA® Elite HSCOG, Liberty®, Outlook®, and Resource® on 7/2/21
Seed Treatment: seed was pre-treated prior to planting, products used are for early season insect control to help with germination, actual products used are unknown
Foliar Insecticides: Leverage® 360 on 8/3/21
Foliar Fungicides: Masterlock®and Delaro® on 8/3/21
Cumulative Rainfall (in): 40

In year five, a VNS cereal rye cover crop (65 lb/ac) was drilled on November 4, 2020, following corn harvest on all plots (intensive and check). Cover crop was chemically terminated on April 26, 2021. Then soybeans were planted on April 13, 2021, and harvested on October 5, 2021.

Table 5. 2021 cover crop biomass, green cover, soybean moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 22, 2020.

	Cover Crop Biomass (lbs/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac) †	Marginal Net Return‡ ($/ac)
Check	131 A*	4.94 A	14.4 A	82 A	943 A
Intensive System	102 A	4.77 A	13.7 A	83 A	955 A
P-Value	0.374	0.872	0.5606	0.4022	0.402

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
Green cover determined using the Canopeo measurement tool.
‡Marginal net return based on $11.80/bu soybean, $12.75/ac cost for cover crop seed and $14.40 drilling for both treatments.

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2019, 2020 and 2021.

Table 6. Soil physical, chemical, and biological properties for check and intensive system treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 14, 2020)*						
Check	0.015 A*	24.5 A	1.21 A	41.9 A	3.67 A	12.6 A
Intensive System	0.480 A	23.5 A	1.06 A	42.5 A	3.92 A	15.2 A
P-Value	0.551	0.3471	0.315	0.500	0.678	0.272
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 6, 2019)*						
Check	1.84 A	26.8 A	1.06 A	39.92 A	3.12 A	14.9 B
Intensive System	3.20 A	25.8 A	1.06 A	39.95 A	3.00 A	18.5 A
P-Value	0.2692	0.591	0.869	0.718	0.638	0.0721
2020 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2020)*						
Check	1.36 A	28.7 A	1.14 A	44.1 A	2.94 A	17.8 B
Intensive System	3.46 A	28.7 A	1.14 A	44.0 A	2.94 A	18.6 A
P-Value	0.117	0.969	0.992	0.781	1.00	0.055
2021 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2021)*						
Check	4.66 A	29.3 A	1.15 A	46.0 A	3.06 A	20.3 B
Intensive System	5.83 A	30.5 A	1.09 A	45.8 A	3.00 A	21.5 A
P-Value	0.824	0.625	0.276	0.693	0.896	0.0923

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.
Soil assessment was not completed in 2018 as it was originally planned for every other year interval.
*Values with the same letter are not significantly different at a 90% confidence level.

Sub-field Area B (Belfore silty clay loam)

Year 1 – Corn (2017 Crop)

Planting Date: 5/6/17
Harvest Date: 10/28/17
Population: 38,000
Row Spacing (in): 30”
Hybrid: Channel® 213-19 VT2 Rib
Herbicides: ***Pre:*** 8.02 oz/ac 2-4D burndown on 04/05/17, 44 oz Roundup® with Firezone® burndown on 04/12/17 ***Post:*** 32 oz Roundup® – spot spray on 06/03/17
Seed Treatment: VT2PRIB
Fertilizer: 147.03 lb/ac MESZ, 12-40-0-10S-1Zn, on 11/09/2016, 443.65 lb/ac UAN 32-0-0 on 05/09/2017

In year one, cover crop (35 lbs/ac winter rye) was drilled across both, check and intensive plots, on October 4, 2016, following soybean harvest. The cover crop was terminated on April 12, 2017. Corn was planted on May 6, 2017, and harvested on October 28, 2017. In 2017, there was no difference in corn yield and moisture between the check or intensive system.

Table 1. 2017 corn moisture, yield, and net return for check and intensive system treatments.

	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	16.4 A*	190 A	571 A
Intensive System	16.5 A	196 A	589 A
P-Value	0.346	0.326	0.412

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
‡Marginal net return based on $3.15/bu corn, $12.50/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 2 – Soybeans (2018 Crop)

In year two, following corn harvest in 2017, cover crop (50 lbs/ac of winter rye) was drilled on November 7, 2017, in the check and intensive plots. The cover crop was terminated on April 25, 2018. Soybeans were planted in both treatment strips on May 9, 2018, and harvested on October 20, 2018. In 2018, there was no difference in soybean yield between the check or intensive system.

Table 2. 2018 soybean moisture and yield, for check and intensive system treatments.

	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	11.5 A*	54.2 A	368 A
Intensive System	11.4 B	56.9 A	388 A
P-Value	0.0972	0.2136	0.476

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
‡Marginal net return based on $7.40/bu soybean, $18.50/ac cost for cover crop seed and $14.40 drilling for both treatments.

Year 3 – Corn and Wheat (2019 Crop)

Corn
Planting Date: 5/12/2019
Harvest Date: 11/1/2019
Population: 29,000
Row Spacing (in): 30
Hybrid: Channel® 212-48 VT Double Pro RIB
Herbicides: ***Burndown:*** 42 oz/ac Roundup® 4/23/19 ***Post:*** Harness®, Balance® Flexx, Laudis®, and StrikeLock®
Fertilizer: 162 lb/ac MESZ® on 4/19/19, 442.40 lb/ac 32-0-0 on 5/11/19

Wheat
Planting Date: 10/22/2018
Harvest Date: 7/26/2019
Herbicides: Huskie® on 5/15/19
Fungicide: 21.3 oz/ac Caramba® on 6/10/19
Fertilizer: MESZ on 4/19/19; potash, 20-0-0, 34-0-0, and 367.50 lb/ac lime top-dressed on 4/13/19

In year three, in the check plots, following soybean harvest, cover crops were drilled on October 24, 2018. The cover crop planted was a mix of 35 lbs/ac rye, 2 lbs/ac rapeseed, and 1 lbs/ac red clover. Cover crop was terminated on April 23, 2019, then corn was planted on May 12 and harvested on November 1, 2019. In the intensive system plots, wheat was planted following soybean harvest on October 22, 2018. Wheat was harvested and the straw was baled and removed on July 30, 2019 (intensive system plots).

Table 3. 2019 corn and wheat moisture and yield for check and intensive system treatments.

Treatment	Crop	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	Corn	17.5	167.2	606.4
Intensive System	Wheat	11.7	48.2	174.9

†Bushels per acre corrected to 15.5% (corn) and 13.5% (wheat) moisture.
‡Marginal net return based on $3.83/bu corn, $19.50/ac cost for cover crop seed and $14.40 drilling (check treatment) and $3.63/bu wheat (intensive treatment).

Year 4 – Soybeans (2020 Crop)

Planting Date: 5/6/20
Harvest Date: 9/27/20
Population: 140,000
Row Spacing (in): 15
Variety: Mycogen® 289E Enlist E3™
Herbicides: ***Pre:*** 16 oz/ac ZAAR™, 6 oz/ac Zidua® PRO, 43.98 oz/ac Roundup PowerMAX® on 5/13/20 ***Post:*** 31.5 oz/ac Liberty®, 7.25 oz/ac Section® Three, 5.90 oz/ac Superb® HC, 45 oz/ac Warrant®, 2 oz/ac Resource® on 6/26/20
Seed Treatment: Acceleron® E-007 SAT
Cumulative Rainfall (in): 25

In year four, an 8-way cover crop mix (20 lb/ac cereal rye, 2 lb/ac radish, 3 lb/ac sunhemp, 5 lb/ac African cabbage, 8 lb/ac winter pea, 5 lb/ac common vetch, 5 lb/ac buckwheat, and 10 lb/ac spring oats) was drilled on August 3, 2019 following wheat harvest (intensive system plots) and 65 lb/ac cereal rye cover crop was drilled on September 29 following corn harvest (check plots). The cover crops were terminated on May 13, 2020. Prior to cover crop termination, soybeans were planted on May 6, 2020, and harvested on September 27, 2020. Soybean planted in the check system had a higher yield than the intensive system strips. These observations are in agreement with the crop vigor analysis (NDVI) that showed higher values in the check strips.

Table 4. 2020 crop biomass and green cover, soybean moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on May 5, 2020.

	Cover crop Biomass (lbs/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)	Soybean NDVI on Jul 28, 2020
Check	358 B*	10.7 B	13.5 A	35.7 A	313 A	0.451 A
Intensive System	896 A	22.1 A	12.5 A	34.7 B	280 B	0.426 B
P-Value	0.0048	0.0196	0.00498	0.00887	0.00012	0.0463

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture.
Green cover using the Canopeo measurement tool.
‡Marginal net return based on $9.50/bu soybean, $12.50/ac cost for cover crop seed and $14.40 drilling (check treatment) and $35.0/ac cost for cover crop seed and $14.40 drilling (intensive treatment).

Year 5 – Corn (2021 Crop)

Planting Date: 4/30/21
Harvest Date: 10/17/21
Seeding Rate: 31,000
Row Spacing (in): 30
Hybrid: Channel® 210-79 DGVT2
Herbicides: ***Burndown:*** 32 oz/ac Roundup PowerMAX® and 8.07 oz/ac Destiny® HC on 4/24/21 ***Pre:*** 3.2 oz/ac Balance® Flexx, 1.5 qt/ac Harness® Xtra 6.0, and 19.04 oz/ac NutriSphere-N® HV on 5/6/21
Seed Treatment: Channel® Protexus® and Acceleron®
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 176 lb/ac of MESZ and 176 lb/ac potash on 12/16/20; 150 lb N/ac as 32% UAN on 5/6/21
Cumulative Rainfall (in): 40

In year five, a 3-way cover crop mix (35 lb/acre cereal rye, 2 lb/ac rapeseed and 1 lb/ac red clover) was drilled on September 29, 2020, in the check and intensive plots. Cover crop was chemically terminated in late April 2021 prior to planting corn on April 30, 2021. Corn was harvested on October 17, 2021.

Table 5. 2021 cover crop biomass, green cover, corn moisture and yield for check and intensive system treatments. Cover crop biomass and green cover measured on April 17, 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	736 A*	38.9 A	14.4 A	222 A	1128 A
Intensive System	779 A	43.2 A	14.4 A	230 A	1168 A
P-Value	0.836	0.420	0.820	0.311	0.311

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15.5% moisture.
Green cover using the Canopeo measurement tool.
‡Marginal net return based on $5.20/bu corn, $22.0/ac cost for cover crop seed and $14.40 drilling for both treatments.

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2019, 2020 and 2021.

Table 6. Soil physical, chemical, and biological properties for check and intensive system treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2017 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 14, 2020)*						
Check	1.424 A*	24.8 A	1.04 A	43.5 A	3.17 A	16.7 A
Intensive System	1.449 A	24.8 A	1.07 A	42.8 A	3.17 A	16.3 A
P-Value	0.12567	0.968	0.614	0.510	1.0000	0.802
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 6, 2019)*						
Check	2.42 A	27.4 A	1.10 A	39.88 A	4.00 A	18.5 A
Intensive System	7.90 A	25.5 A	1.13 A	39.90 A	3.88 A	19.0 A
P-Value	0.223	0.251	0.602	0.718	0.895	0.252
2020 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2020)*						
Check	22.1 A	26.1 A	1.21 A	44.2 A	3.38 A	20.1 A
Intensive System	16.7 A	26.4 A	1.15 A	44.4 A	3.00 A	20.2 A
P-Value	0.748	0.784	0.177	0.628	0.377	0.792
2021 *(2 samples per treatment replication, n=8 per treatment; samples collected on Nov. 3, 2021)*						
Check	0.815 A	29.0 A	1.20 A	46.4 A	2.88 A	21.4 A
Intensive System	2.762 A	27.8 A	1.27 A	46.2 A	2.81 A	22.4 A
P-Value	0.202	0.303	0.42	0.726	0.909	0.133

[1]Soil respiration (Modified Solvita burst).

[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

Soil assessment was not completed in 2018 as it was originally planned for every other year interval.

*Values with the same letter are not significantly different at a 90% confidence level.

Summary:

- Incorporating a cool-season cash crop such as winter wheat in a corn-soybean rotation resulted in a decrease (1 – 2.4 bu/acre) or neutral effects in soybean yields.
- Incorporating a cool-season cash crop such as winter wheat in a corn-soybean rotation resulted in a increase (20 bu/ac) or neutral effects in corn yields.
- Trends of increased total soil health scores over time were observed in both intensive system treatment areas and check treatment areas.