Incorporation of Winter Terminated and Winter Hardy Cover Crop in a Corn-Soybean-Wheat Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0656127202101
County: Nemaha
Reps: 12 (4 per area)
Tillage: No-till
Irrigation: None

Introduction

This study is being conducted on a soil health demonstration farm 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. Two treatments, winter terminated cover crops and winter hardy cover crops, were used in this five-year study (2016-2021), this is the final year of this study. This study did not have a no cover crop control. The crop rotation is corn, soybean, and wheat, with all three crops present each year. The field was divided into three portions so that all phases of the crop rotation were present each year (Figure 1).

- Area A primarily consists of Judson silt loam, 2 to 6 percent slopes
- Area B primarily consists of Judson silt loam, 0 to 2 percent slopes
- Area C primarily consists of Ackmore silt loam, occasionally flooded.

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

Winter hardy mix (left) and winter terminated mix (right). Picture taken on April 2nd, 2020.

Sub-field area A (Judson silt loam, 2 to 6 percent slopes)

Year 1 – Corn (2017 Crop)

Planting Date: 4/11/17
Harvest Date: 9/19/17
Population: 33,000
Row Spacing (in): 30
Hybrid: Pioneer P0636AM
Herbicides: ***Pre:*** 64 oz/ac FulTime®, 16 oz/ac Range Star®, and 3.2 oz/ac ABSORB 100 ***Post:*** 32 oz/ac Buccaneer® 5 Extra, 2 oz/ac Bellum™, and 3.2 oz/ac N-Tense™
Seed Treatment: PPST 250
Foliar Fungicides: 8 oz/ac Quilt Xcel®
Fertilizer: 12-40-60-10-1-1 dry and 175 lb N/ac as UAN 32% spring pre-plant, and 1 gal/ac NResponse™ foliarly applied
Cumulative Rainfall (in): 20

In year one, cover crops were drilled on September 29, 2016. The winter terminated treatment was a mix of oats, turnips, and common rapeseed, whereas the winter hardy treatment consisted of cereal rye, turnips, and common rapeseed. For uniformity, both cover crop mixes were sprayed with glyphosate on April 12, 2017. This terminated the winter hardy treatment and controlled weeds and brassicas, which had overwintered in the winter terminated cover crop treatment. In 2017, corn planted after winter terminated cover crops had a higher yield, higher test weight, and was drier than the winter hardy cover crops (Table 1). There were no differences in harvest stand counts for the corn following the winter terminated and winter hardy cover crops (Table 1). The corn following the winter hardy mix was three days slower to tassel than the corn following the winter terminated mix (Figure 1).

Table 1. 2017 corn stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/acre)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated	30,355 A*	54 A	18.0 B	183 A	546.97 A
Winter Hardy	30,023 A	52 B	19.1 A	168 B	498.00 B
P-Value	0.802	0.0209	0.0034	0.0003	0.0003

*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 and $30.07 cost for cover crop seed and drilling in both treatments.

Figure 1. Corn crop following winter hardy and winter terminated cover crops. Picture taken on July 7, 2017.

Year 2 – Soybeans (2018 Crop)

Planting Date: 5/7/18
Harvest Date: 9/17/18
Row Spacing (in): 15
Variety: Pioneer® 24T19R
Herbicides: ***Pre:*** 6 oz/ac Sonic®, 16 oz/ac generic Dual, 16 oz/ac 2,4-D 6#, 8 oz/ac Absorb 100, and 16 oz/ac Buccaneer 5 Extra® on 4/17/18 ***Post:*** 16 oz/ac Shafen Star, 8 oz/ac Clethodim 2EC, 32 oz/ac Buccaneer 5 Extra®, 8 oz/ac Absorb 100, and 4 oz/ac N-Tense™ on 6/16/18
Seed Treatment: PPST 2030
Foliar Insecticides: 3.84 oz/ac Lambda-Cy 1 EC aerial applied on 7/26/18
Foliar Fungicides: 10.5 oz/ac Azoxyprop Xtra aerial applied on 7/26/18
Fertilizer: 1 gal/ac NResponse™ on 6/16/18; 1 gal/ac Kugler KS2075 (20% N, 7.5% P, 5% S) aerial applied on 7/26/18
Cumulative Rainfall (in): 27

In year two, cover crops were drilled on August 1, 2017. The winter terminated treatment was a mix of 30 lb/ac oats, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 17, 2018. Soybeans planted after winter terminated cover crops had a higher yield, lower test weight, and higher net return than the winter hardy cover crops (Table 2).

Table 2. 2018 soybean stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight	Moisture (%)	Soybean Yield† (bu/ac)	Marginal Net Return‡ ($/ac)
Winter Terminated	120,744 A*	56 B	11.3 A	65 A	452.80 A
Winter Hardy	120,246 A	56 A	11.2 A	59 B	410.75 B
P-Value	0.872	0.096	0.200	0.002	0.002

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 13% moisture for soybeans.
‡Marginal net return based on $7.40/bu soybean, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 3 – Wheat (2019 Crop)

In year three, wheat was planted following soybean harvest. No measurements were made on wheat yields in the winter terminated and winter hardy cover crop strips.

Year 4 – Corn (2020 Crop)

Planting Date: 4/8/20
Harvest Date: 9/15/20
Population: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P0589AM
Herbicides: ***Pre:*** 1 lb/ac Atrazine, 40 oz/ac Resicore®, 32 oz/ac glyphosate, 1 qt/100 gal N-Tense on 4/2/20
Post: 40 oz/ac Resicore®, 32 oz/ac glyphosate, and 1 qt/100 gal N-Tense
Fertilizer: NPSZ starter fertilizer (10 lb N/ac, 40 lb N/ac, 40 lb N/ac, 6 lb S/ac, and 2 lb Zn/ac); 150 lb N/ac as 32% UAN, 46 lb N/ac as urea side-dress
Cumulative Rainfall: 25”

In year four, cover crops were drilled on August 1, 2019. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 17, 2019 and removed on December 12, 2019. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2, 2020. In previous years, corn and soybeans in this portion of the field yielded lower when they followed the winter hardy cover crop. This was not the case this year. In 2020, there were no differences in corn population, moisture, test weight, yield, or net return (Table 3).

Table 3. 2020 corn stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	31,556 A*	53 A	21.1 A	213 A	719.79 A
Winter Hardy Cover Crop	30,352 A	53 A	20.9 A	208 A	701.16 A
P-Value	0.182	0.704	0.330	0.212	0.173

*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 $3.51/bu corn, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 5 – Soybeans (2021 Crop)

Planting Date: 4/25/21
Harvest Date: 9/21/21
Seeding Rate: 140,000
Row Spacing (in): 15
Variety: Pioneer® P27A17X
Herbicides: ***Pre:*** 6 oz/ac Authority® First, 16 oz/ac metolachlor, 16 oz/ac 2,4D LV 6, 16 oz/ac Buccaneer 5 Xtra®, and 6.4 oz/ac Absorb 100 ***Post:*** 32 oz/ac Enlist One®, 40 oz/ac glufosinate, 2 qt/100 gal Cornbelt® EN-Pack™, 2 lb/ac AMS, and 1 lb/ac DriGuard

Fertilizer: 11-40-60-6-2
Cumulative Rainfall: 23”

In year five, cover crops were drilled in September, 2020, after corn harvest. The winter terminated treatment was a mix of 30 lb/ac oats, 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac rye, 3 lb/ac turnips 3 lb/ac radishes. Cattle were put out on the cover crop on November 7, and removed December 11, 2020. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 10, 2021. In 2021, there were also no differences in soybean population, moisture, test weight, yield, or net return (Table 4).

Table 4. 2021 soybean stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	123,236 A*	11.0 A	67 A	758 A
Winter Hardy Cover Crop	123,974 A	10.9 A	66 A	751 A
P-Value	0.925	0.695	0.727	0.808

*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 $11.80/bu soybean, $21.30/ac for winter terminated cover crop seed, $18.30/ac for winter hardy cover crop seed, and $14.40/ac for drilling cost.

Multi-Year Soil Health Assessment (2016 to 2021)

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

Table 5. Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016)*						
Winter hardy	1.30	-	1.22	59	-[3]	19.5
Winter terminated	1.12	-	1.32	59	-	20.8
2018 *(2 composite samples collected for all replications of a treatment, samples collected on Oct. 31, 2018)*						
Winter hardy	0.932	27.5 A	1.22 A	50.1 A	-	18.5
Winter terminated	0.743	24.7 A	1.26 A	50.6 A	-	18.5
P-Value	-	0.406	0.341	0.500		-
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019)*						
Winter hardy	0.631 A	29.5 A	1.28 A	48.4 A	4.12 A	20.2 A
Winter terminated	2.259 A	28.1 A	1.20 A	49.7 A	4.38 A	21.4 A
P-Value	0.338	0.594	0.433	0.350	0.604	0.186
2020 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020)*						
Winter hardy	2.52 A	15.6 A	1.24 A	57.4 A	3.25 A	22.4 A
Winter terminated	4.85 A	15.7 A	1.25 A	57.9 A	3.00 A	22.5 A
P-Value	0.337	0.772	0.862	0.767	0.182	0.391
2021 *(1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021)*						
Winter hardy	3.433 A	24.5 A	1.22 A	40.0 A	3.00 A	21.2 A
Winter terminated	0.567 A	21.7 A	1.26 A	40.2 A	2.75 A	21.4 A
P-Value	0.226	0.392	0.695	0.886	0.495	0.761

[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.
[3]No test was completed in 2016 for soil moisture and 2016 and 2018 for Soil Respiration.
*Values with the same letter are not significantly different at a 90% confidence level.

Sub-field area B (Judson silt loam, 0 to 2 percent slopes)

Year 1 – Soybeans (2017 Crop)

Planting Date: 4/30/17
Harvest Date: 9/20/17
Population: 175,000
Row Spacing (in): 15
Variety: Pioneer 24T19R
Herbicides: ***Pre:*** 5 oz/ac Sonic®, 2 oz/ac Blanket® 4F, 14 oz/ac 2,4-D LV, and 3.2 oz/ac ABSORB 100 ***Post:*** 32 oz/ac Buccaneer® 5 Extra, 16 oz/ac Flexstar®, 6.4 oz/ac Clethodim®, 3.2 oz/ac ABSORB 100, and 10.5 oz/ac AzoxyProp Xtra
Cumulative Rainfall (in): 20

In year one, cover crops were drilled on September 29, 2016. The winter terminated treatment was a mix of oats, turnips, and common rapeseed, whereas the winter hardy treatment consisted of cereal rye, turnips, and common rapeseed. For uniformity, both cover crop mixes were sprayed with glyphosate on April 12, 2017. This terminated the winter hardy treatment and controlled weeds and brassicas, which had overwintered in the winter terminated cover crop treatment. In 2017, soybeans had no difference in yield, test weight, moisture, or net return following the winter terminated and winter hardy cover crops (Table 6).

Table 6. 2017 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	102,178 A*	56 A	10.6 A	62 A	518.84 A
Winter Hardy Cover Crop	102,178 A	56 A	10.6 A	61 A	516.42 A
P-Value	1	0.4886	1	0.7345	0.735

*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 soybean and $30.07 cost for cover

Year 2 – Wheat (2018 Crop)

In year two, following soybean harvest in 2017, wheat was planted in this area. No yield measurements were collected for the winter terminated and winter hardy cover crop strips.

Year 3 – Corn (2019 Crop)

Planting Date: 4/10/19
Harvest Date: 9/19/19
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P0688AM™
Herbicides: ***Pre:*** 40 oz/ac Resicore®, 32 oz/ac Buccaneer® 5 EXTRA, 16 oz/ac Detonate® on 4/2/19 ***Post:*** 3.2 oz/ac Meso Star and 32 oz/ac Buccaneer® 5 EXTRA on 6/5/19
Foliar Insecticides: 3.84 oz/ac Lambda-Cyhalothrin 1 EC on 7/28/19 aerial applied
Foliar Fungicides: 6.4 oz/ac AzoxyProp Xtra on 6/5/19 with herbicide; 10.5 oz/ac AzoxyProp Xtra on 7/28/19 aerial applied
Fertilizer: 150 lb/ac NPSZ (18 lb/ac N, 67.5 lb/ac P, 7.5 lb/ac S, and 1.5 lb/ac Zn), 75 lb/ac potash, and 7 lb/ac boron 15% on 2/5/19; 150 lb N/ac as 32% UAN on 4/2/19; 6.4 oz/ac N-TENSE™ on 6/5/19; 46 lb N/ac as 46% urea on 6/27/19
Cumulative Rainfall (in): 35

In year three, following wheat harvest, cover crops were drilled on August 1, 2018. The winter terminated treatment was a mix of 30 lb/ac oats and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye and 1 lb/ac turnip. Cattle grazed the cover crop from November 1 to November 26. For uniformity,

both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2, 2019. In 2019, there were no differences in corn population, moisture, test weight, yield, or net return (Table 7).

Table 7. 2019 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plans/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	29,952 A*	57 A	17.7 A	217 A	805.04 A
Winter Hardy Cover Crop	29,429 A	57 A	17.8 A	214 A	792.55 A
P-Value	0.207	0.552	0.891	0.277	0.216

*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 $3.83/bu corn, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 4 – Soybeans (2020 Crop)

Planting Date: 5/7/20
Harvest Date: 9/23/20
Population: 145,000
Row Spacing (in): 15
Variety: Pioneer® P27A17X
Herbicides: ***Pre:*** 6 oz/ac Authority® First, 16 oz/ac Me-Too-Lachor™, 16 oz/ac Dicamba HD®, and 6.4 oz/ac Absorb 100 ***Post:*** 32 to 40 oz/ac Buccaneer® 5 EXTRA, 16 oz/ac Battle Star®, 7 oz/ac Clethodim, 1 qt/100 gal Absorb 100, and 1 qt/100 gal N-TENSE™
Fertilizer: NPSZ starter fertilizer (10 lb N/ac, 40 lb N/ac, 40 lb N/ac, 6 lb S/ac, and 2 lb Zn/ac)
Cumulative Rainfall: 35”

In year four, cover crops were drilled September 27, 2019. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 17, 2019, and removed December 12, 2019. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 23, 2020. There were no differences in soybean stand counts, yield, moisture, test weight, or net return between the winter terminated and winter hardy cover crop (Table 8). However, aerial imagery normalized difference vegetation index (NDVI) analysis showed higher values for soybean in the winter terminated strips (Figures 2A and 2B). Even though yields were not different, soybeans following winter hardy cover crops were not as large or canopied as soybeans following winter terminated cover crop.

Table 8. 2020 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	127,187 A*	56 A	12.6 A	76 A	694.02 A
Winter Hardy Cover Crop	117,338 A	56 A	12.8 A	73 A	669.34 A
P-Value	0.179	0.527	0.268	0.452	0.419

*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 $9.50/bu soybean, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

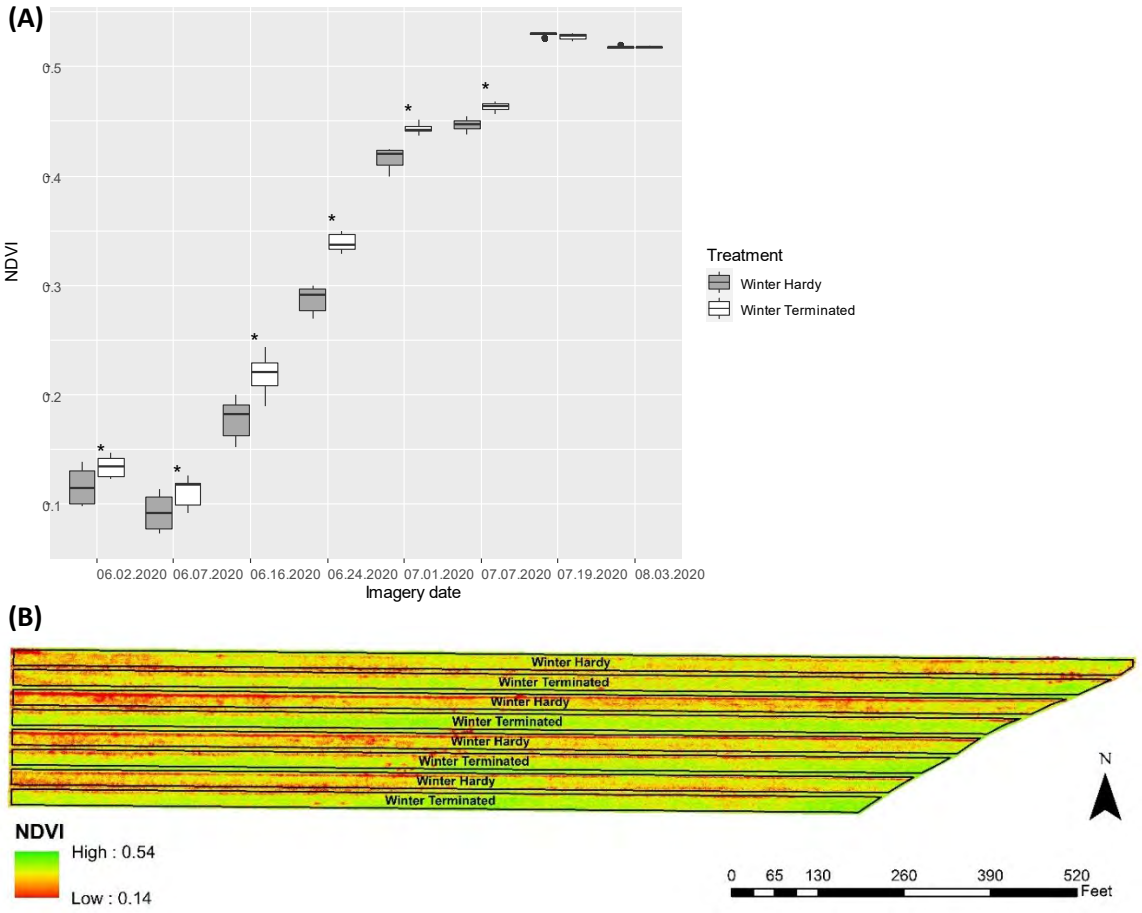

Figure 2. (A) Normalized difference vegetation index (NDVI) values from aerial imagery for the soybean crop following winter hardy and winter terminated cover crops. Asterisk (*) within each date indicates significant difference ($p < 0.10$) between treatments at a 90% confidence level. (B) Aerial imagery from July 1 displayed as soybean normalized difference vegetation index (NDVI). Strips with winter hardy and winter terminated cover crop are indicated.

Year 5 – Wheat (2021 Crop)

In year five, following soybean harvest in 2020, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Multi-Year Soil Health Assessment (2016 to 2021)

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

Table 9. Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2016 *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016)*						
Winter hardy	1.30	-	1.22	59	-[3]	19.5
Winter terminated	1.12	-	1.32	59	-	20.8
2018 *(2 composite samples collected for all replications of a treatment; samples collected on Oct. 31, 2018)*						
Winter hardy	0.86 A	29.4 A	1.20 A	49.0 A	-	18.5 A
Winter terminated	1.71 A	26.5 A	1.38 A	49.5 A	-	18.0 A
P-Value	0.350	0.777	0.113	0.500		0.5
2019 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019)*						
Winter hardy	0.72 A	22.6 A	1.19 A	48.83 A	2.88 A	19.5 A
Winter terminated	0.62 A	26.4 A	1.26 A	48.98 A	2.38 A	19.5 A
P-Value	0.599	0.195	0.284	0.638	0.308	1.000

Table 1 Continued

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2020 *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020)*						
Winter hardy	10.87 A	13.3 A	1.29 A	58 A	2.62 B	18.5 A
Winter terminated	7.59 A	15.2 A	1.29 A	58 A	3.00 A	17.6 A
P-Value	0.2560	0.605	0.928	1.000	0.0577	0.628
2021 *(1 samples per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021)*						
Winter hardy	4.72 A	21.3 A	1.39 A	39.9 A	3.25 A	21.1 A
Winter terminated	1.88 A	19.2 A	1.35 A	39.7 A	2.38 A	21.1 A
P-Value	0.527	0.139	0.492	0.789	0.0689	0.275

[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.

[3]No test was completed in 2016 for soil moisture and 2016 and 2018 for Soil Respiration.

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

Sub-field area C (Ackmore silt loam, occasionally flooded)

Year 1 – Wheat (2017 Crop)

In year one, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Year 2 – Corn (2018 Crop)

Planting Date: 4/17/18
Harvest Date: 9/14/18
Row Spacing (in): 30
Hybrid: Pioneer® 0363AM
Herbicides: ***Pre:*** 3 qt/ac FulTime® NXT, 16 oz/ac 6# 2,4-D, and 16 oz/ac Buccaneer 5 Extra® on 4/4/18 ***Post:*** 3 oz/ac Bellum™, 32 oz/ac Buccaneer 5 Extra®, and 3.2 oz/ac N-Tense™ on 6/4/18
Seed Treatment: PONCHO®/VOTiVO®
Foliar Insecticides: 3.84 oz/ac Lambda-Cy 1EC aerial applied on 7/7/18; 3.84 oz/ac Lambda-Cy 1 EC aerial applied on 7/26/18
Foliar Fungicides: 6 oz/ac AzoxyProp Xtra on 6/4/18; 10.5 oz/ac AzoxyProp Xtra aerial applied on 7/7/18; 10.5 oz/ac AzoxyProp Xtra aerial applied on 7/26/18
Fertilizer: 150 lb/ac N as 32% UAN on 4/4/18; 1 gal/ac NResponse™ on 6/4/18; 82.8 lb/ac N as Urea on 6/11/18; 1 gal/ac Kugler KQ-KRN™ (28% N) aerial applied on 7/7/18;1 gal/ac Kugler KS2075 (20% N, 7.5% P, 5% S) aerial applied on 7/26/18
Cumulative Rainfall: 27”

In year two, cover crops were drilled August 1, 2017. The winter terminated treatment was a mix of 30 lb/ac oats, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye, 1.5 lb/ac canola/rapeseed, and 1 lb/ac turnip. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 4, 2018. There were no differences in corn yield, moisture, test weight, harvest stand counts, or net return between the winter terminated or winter hardy cover crop treatment (Table 10).

Table 10. 2018 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plans/ac)	Test Weight (lb/bu)	Moisture (%)	Corn Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	29,710 A*	56 A	20.7 A	243 A	759.43 A
Winter Hardy Cover Crop	29,515 A	56 A	20.9 A	240 A	748.71 A
P-Value	0.677	0.226	0.516	0.281	0.283

*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 $3.23/bu corn, $12.48/ac winter terminated cover crop seed mix, $12.45/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 3 – Soybeans (2019 Crop)

Planting Date: 4/26/19
Harvest Date: 9/26/19
Seeding Rate: 140,000
Row Spacing (in): 30
Variety: Pioneer® P23A32X
Herbicides: ***Pre:*** 6 oz/ac Sonic®, 24 oz/ac Metalica, 16 oz/ac 2,4-D LV6, and 32 oz/ac Buccaneer® 5 Extra with 6.4 oz/ac Absorb 100 on 4/9/19 ***Post:*** 16 oz/ac Metalica, 16 oz/ac Shafen Star, 8 oz/ac SeCURE EC, and 32 oz/ac Buccaneer® 5 Extra with 9.6 oz/ac Absorb 100 on 6/19/19
Foliar Insecticides: 3.84 oz/ac Lambda-Cyhalothrin 1 EC aerial applied on 8/15/19
Foliar Fungicides: 10.5 oz/ac AzoxyProp Xtra aerial applied 8/15/19
Fertilizer: 100 lb/ac NPSZ (12 lb/ac N, 45 lb/ac P, 5 lb/ac S, and 1 lb/ac Zn) and 100 lb/ac potash on 2/5/19
Cumulative Rainfall: 35”

In year three, cover crops were drilled September 15, 2018. The winter terminated treatment was a mix of 30 lb/ac oats and 1 lb/ac turnip. The winter hardy treatment consisted of 30 lb/ac cereal rye and 1 lb/ac turnip. Cattle were put out on the cover crop on November 1 and removed November 26. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 9, 2019. There were no differences in soybean yield, moisture, test weight, or net return between the winter terminated and winter hardy cover crop. Soybean stand counts taken at harvest were lower for the soybean following winter hardy cover crop (Table 11).

Table 11. 2019 soybean stand counts, test weight, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	100,519 A*	56 A	12.6 A	84 A	652.21 A
Winter Hardy Cover Crop	93,884 B	56 A	12.9 A	86 A	670.35 A
P-Value	0.099	0.629	0.447	0.693	0.719

*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, $12/ac winter terminated cover crop seed mix, $13.80/ac winter hardy cover crop seed mix, and $14.40/ac drilling cost.

Year 4 – Wheat (2020 Crop)

In year four, following soybean harvest in 2019, wheat was planted in this area. No yield measurements were made for the winter terminated and winter hardy cover crop strips.

Year 5 – Corn (2021 Crop)

Planting Date: 4/13/21
Harvest Date: 9/20/21
Seeding Rate: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1089AM
Herbicides: ***Pre:*** 40 oz/ac Resicore®, 16 oz/ac Buccaneer 5 Xtra®, 4 oz/ac Cornbelt® N-TENSE™, and 1 lb/ac DriGuard ***Post:*** 40 oz/ac Resicore®, 32 oz/ac Buccaneer 5 Xtra®, 4 oz/ac Cornbelt® N-TENSE™, and 1 lb/ac DriGuard
Foliar Fungicides: 10.5 oz/ac Azoxyprop Xtra on 8/4/21
Fertilizer: 180-40-60-6-2, 120 lb N/ac as 32% UAN with herbicide application
Cumulative Rainfall: 23”

In year five, cover crops were drilled in September, 2020 after soybean harvest. The winter terminated treatment was a mix of 30 lb/ac oats and 3 lb/ac turnips and radishes. The winter hardy treatment consisted of 30 lb/ac cereal rye and 3 lb/ac turnips and radishes. Cattle were put out on the cover crop on November 7, and removed on Decmber 10, 2020. For uniformity, both cover crop mixes were sprayed with herbicide to terminate the cover crops on April 2nd, 2021. In 2021, there were no differences in corn population, moisture, test weight, yield, or net return (Table 12).

Table 12. 2021 corn stand counts, test weight, moisture, yield, and net return for winter hardy and winter terminated cover crop treatments.

	Stand Count (plants/ac)	Moisture (%)	Corn Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Winter Terminated Cover Crop	30,629 A*	15.3 A	221 A	1,115 A
Winter Hardy Cover Crop	30,023 A	15.1 A	218 A	1,100 A
P-Value	0.664	0.150	0.275	0.356

*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 $5.20/bu corn, $21.30/ac for winter terminated cover crop seed mix, $18.30/ac for winter hardy cover crop seed mix, and $14.40/ac for drilling cost.