Incorporation of Cover Crop in an Irrigated Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 5-year summary report

Study ID: 0914093202101
County: Howard
Reps: 7
Tillage: No-till
Soil Type: Holdrege silty clay loam 7-11% slopes, eroded
Irrigation: Pivot

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. Two treatments are being evaluated in this five-year study: a cover crop mix and a no-cover crop check. The prescribed plot management was maintained throughout the project timeline (2017-2021).

Year 1 – Corn (2017 Crop)

In year one, cover crops were drilled after corn harvest in 2016. The cover crop mix was kale, trophy rape, purple turnips, forage collards, hairy vetch, and rye. Cover crop that did not winter terminate were terminated with herbicides on May, 2017. Soybeans were planted on May 26, 2017, and harvested on October 15, 2017. No yield measurements were available representing the cover crop and no cover crop strips due to the harvest angle.

Year 2 – Corn (2018 Crop)

In year two, following soybean harvest in October, 2017, a cover crop mix of 33 lbs/ac cereal rye, 0.8 lbs/ac turnip, 1.6 lbs/ac canola, 0.6 lbs/ac African cabbage, 0.5 lbs/ac forage collards, 1.1 lbs/ac sunflower, 1.6 lbs/ac hairy vetch, 1.1 lbs/ac radish, 1 lbs/ac safflower and 1 lbs/ac winter lentil was drilled. The cover crop that did not winter terminate was terminated with herbicides in May, 2018. Corn was planted after cover crop termination, on May 7, 2018 and harvested on September 11, 2018. Corn experienced hail damage on August 16, 2018. No yield measurements were available representing the cover crop and no cover crop strips.

Year 3 – Soybeans (2019 Crop)

Planting Date: 5/16/19
Harvest Date: 9/30/19
Seeding Rate: 180,000
Row Spacing (in): 30
Variety: AgriGold® G2405RX
Herbicides: ***Pre:*** 25 oz/ac BroadAxe®XC and 48 oz/ac Gramoxone® SL ***Post:*** 12.8 oz/ac Engenia® and 32 oz/ac Buccaneer® 5 Extra
Foliar Insecticides: 2 oz/ac Warrior II with Zeon Technology®
Fertilizer: 108 lb/ac 11-52-0, 87 lb/ac 0-0-22-22 S11 Mg, and 23 lb/ac 98% lime
Cumulative Rainfall (in): 33

In year three, the cover crop mix was Barkant turnips, African cabbage, impact forage collards, dwarf Essex rapeseed, eco-till radish, peredovick sunflowers, finish safflowers, VNS hairy vetch, viceray lentils, and rye. The cover crop was seeded after corn harvest on September 21, 2018. Cover crops that did not winter terminate were terminated with herbicides on May 14, 2019. Soybeans were planted on May 16 in 30" row spacing and harvested on September 30, 2019. Soybeans experienced damage from heavy thistle caterpillar infestations. Aerial imagery and normalized difference vegetation index (NDVI) analysis showed soybeans following the no cover crop treatments had greater leaf senescence and were more mature (Figure 1). Due to visual differences observed in imagery and crop senescence, additional grain quality samples were collected. The treatments did not result in differences in soybean moisture, yield, or net return (Table 1). Yield data was compiled by the treatment area.

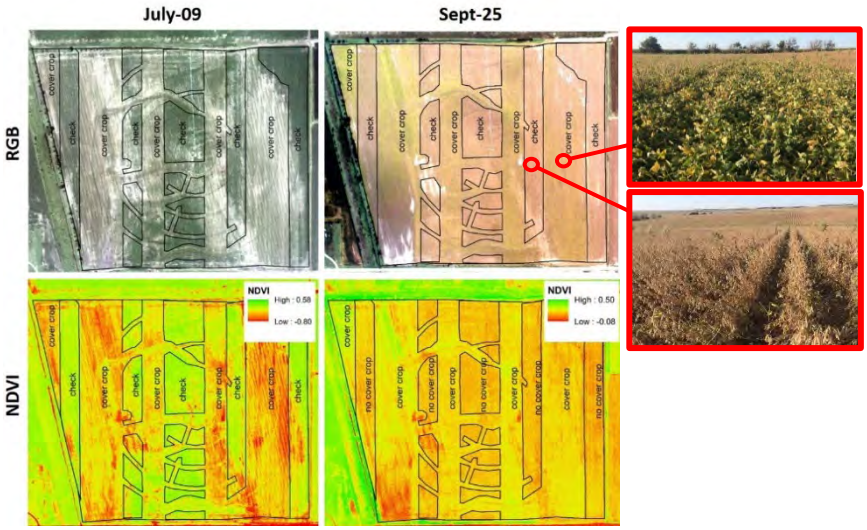

Figure 1. Aerial imagery from July 9 (left) and September 25 (right) displayed as true color (top) and normalized difference vegetation index (NDVI) (bottom). Strips with cover crop and no cover crop are indicated. Far-right inset images are pictures taken on September 26 in cover crop and no cover crop treatments.

Table 1. 2019 soybean yield, yield components, oil, moisture, and marginal net return for cover crop mix and no cover crop treatments.

	Pods/ plant	Grain/ plant	Linoleic (%)	Saturated fat (%)	Protein (%)	Oil (%)	Fiber (%)	Moisture (%)	Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	48.5 A	103 A	6.7 A	10.6 A	34.0 A	19.6 A	4.9 A	15.0 A	67.9 A	549.67 A
Cover Crop Mix	49.9 A	107 A	6.6 A	11.1 A	35.1 A	19.2 A	4.8 A	16.8 A	69.5 A	524.69 A
P-Value	0.897	0.771	0.880	0.397	0.385	0.175	0.178	0.210	0.779	0.605

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $24/ac cover crop seed, and $14.40 drilling.

Year 4 – Cereal Rye (2020 Crop)

Planting Date: 10/9/19
Harvest Date: 7/23/20
Seeding Rate: 72 lb/ac
Row Spacing (in): 7.5
Variety: Rye
Fertilizer: 117 lb/ac 11-52-0, 86 lb/ac lb K-mag, 27 lb/ac pell lime, 2 lb/ac 36% zinc
Irrigation: Pivot, Total: 6" on cover crops
Cumulative Rainfall (in): 23

In year four, following soybean harvest, cereal rye for grain/seed was drilled across both cover crop and no cover crop treatments on October 9, 2019, and harvested on July 23, 2020. Yield was compiled by the treatment area. There were no differences in rye test weight, moisture, yield, and marginal net return between the treatments.

Table 2. 2020 rye moisture, yield, and net return for cover crop mix and no cover crop treatments.

	Moisture (%)	Rye Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Check	14.5 A	40.9 A	246 A
Cover Crop Mix	14.5 A	42.4 A	255 A
P-Value	0.965	0.35144	0.35144

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre corrected to 15% moisture.
‡Marginal net return based on $6.01/bu cereal rye. Costs of cover crop drilled after rye harvest were not included on the analysis.

Year 5 – Corn (2021 Crop)

Planting Date: 4/26/21
Harvest Date: 10/25-10/29
Seeding Rate: 31,000
Row Spacing (in): 30
Hybrid: AgriGold® A6652VT2RIB
Herbicides: ***Pre:*** 2 qt/ac Lexar® EZ, 8 oz/ac DiFlexx™, 32 oz/ac Durango® DMA on 5/4/21 ***Post:*** 10 oz/ac Diflexx™ and 32 oz/ac Durango® DMA on 6/18/21
Foliar Fungicides: 10.5 oz/ac Quilt Xcel® on 7/22/21
Fertilizer: 117 lb/ac 11-52-0, 85 lb/ac K-Mag®, 3 lb/ac of Zinc, 26 lb/ac of Pel-lime applied by variable rate on 4/1/21; 60 gal/ac UAN, 2 gal/ac Thio-Sul® on 5/4/21
Irrigation: Pivot, Total: 12"
Cumulative Rainfall (in): 27
In year five, cover crop mix (winter rye, radish, rapeseed, turnips, kale, lentils, Austrian winter peas, and vetch) was seeded after rye harvest in July. Cover crops that did not winter terminate were terminated with herbicides in April, 2021. Cover crop biomass was measured on April 15 (1224 lb/ac). Check strips had volunteer rye throughout the field (biomass = 1520 lb/ac). Corn was planted on April 26, and harvested on October 25-29, 2021. Yield data was compiled by treatment area. The treatments did not result in differences in corn moisture and yield (Table 3).

In addition to soil health assessment and yield results, weed biomass and density in the cover crop and check treatments were measured in 2021, five years after experimental plots were established. No differences in the seedbank were observed and the composition of the most abundant species was similar between the treatments. Despite no differences in the seedbank, early season weed biomass measured in the field was significantly reduced by the cover crop treatment. This reduction did persist later in the growing season.

Table 3. 2021 corn moisture, yield, net return and cover crop biomass and green cover for the cover crop mix and check treatments. Cover crop biomass measured on April 15 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Yield (bu/acre)	Marginal Net Return ($/acre)
Check	1520 A	43.4 A	18.5 B	222 A	1156 A
Cover Crop Mix	1224 A	33.4 B	18.6 A	217 A	1089 B
P-Value	0.1012	0.01465	0.0640	0.1194	0.0099

*Values with the same letter are not significantly different at a 90% confidence level.
†Yield values are from cleaned yield monitor data. Bushels per acre adjusted to 15.5% moisture.
‡Marginal net return based on $5.20/bu corn, $24/ac cover crop seed, and $14.40 drilling.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and number of species identified for cover crop mix and check treatments. Seedbank was collected on April 15, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from collection date until November 1, 2021, with two periods of drying and resifting soil to stimulate new germination flushes. Seedlings were identified by species and counted to quantify the size and composition of the soil seedbank. Total number of weeds, pigweeds, grasses, and other broadleaves are reported in weeds per m^2, which was determined from the number of emerged seedlings.

	Total weeds (weeds/m^2)†	Species Identified	Pigweeds (weeds/m^2)	Grasses (weeds/m^2)	Broadleaves (weeds/m^2)
Check	3415 A*	12.5 A	869 A	1404 A	1792 A
Cover Crop Mix	2580 A	15.2 A	581 A	666 A	1526 A
P-Value	0.344	0.296	0.492	0.137	0.715

† Total weeds, pigweeds, grasses, and broadleaves are estimated in weeds/m^2, which is derived from the number of seedlings that emerged from the soil seedbank.
*Values with the same letter are not significantly different at a 90% confidence level.

Table 5. Weed seedbank species composition for top five most abundant species in cover crop mix and check treatments. Seedbank was collected April 15, 2021, and permitted to freely germinate in the greenhouse until November 1, 2021.

Check – Species	Percentage of Seedbank	Cover Crop Mix – Species	Percentage of Seedbank
Green foxtail	24.8%	Common lambsquarters	27.0%
Common woodsorrel	20.3%	Green foxtail	18.1%
Common lambsquarters	15.4%	Redroot pigweed	14.2%
Common waterhemp	11.8%	Common woodsorrel	9.4%
Redroot pigweed	8.3%	Marestail	9.1%

Table 6. In-season measurements were taken for weed density, pigweed density, and weed biomass at early (at crop emergence and before post-emergence herbicide application) and late season (before canopy closure and 4+ weeks after post-emergence herbicide application) for cover crop and check treatments. Measurements are reported in weeds per m^2 and grams of biomass per m^2.

	Early Season Weed Density (weeds/m^2)	Early Season Pigweed Density (weeds/m^2)	Early Season Weed Biomass (g/m^2)	Late Season Weed Density (weeds/m^2)	Late Season Pigweed Density (weeds/m^2)	Late Season Weed Biomass (g/m^2)
Check	38.7 A*	3.25 A	0.454 A	29.8 A	19.5 A	0.423 A
Cover Crop	29.2 A	22.0 A	0.028 B	17.7 A	10.6 A	0.263 A
P-Value	0.749	0.104	0.0720	0.562	0.973	0.726

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

Multi-Year Soil Health Assessment (2017 to 2020)

Baseline and soil health measures were collected in 2017, 2018, 2019, 2020, and 2021.

Table 7. Soil physical, chemical, and biological properties for cover crop and no cover crop 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=7 per treatment; samples collected on Nov. 16, 2017)*						
Check	7.07 A*	24.1 A	1.08 A	48.3 A	5.04 A	12.8 A
Cover Crop Mix	13.11 A	26.7 A	1.11 A	48.6 A	4.79 A	12.9 A
P-Value	0.446	0.525	0.457	0.724	0.391	0.750
2018 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 28, 2018)*						
Check	-	30.1 A	1.19 A	48.5 A	-	13.8 A
Cover Crop Mix	-	31.3 A	1.21 A	48.8 A	-	14.5 A
P-Value	-	0.422	0.654	0.799	-	0.286
2019 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 29, 2019)*						
Check	0.59 A	21.51 A	1.16 A	47.71 A	3.64 A	14.1 B
Cover Crop Mix	0.62 A	23.33 A	1.15 A	46.69 A	4.43 A	16.0 A
P-Value	0.781	0.616	0.817	0.521	0.297	0.00205
2020 *(1 sample per treatment replication, n=7 per treatment; samples collected on Oct. 8, 2020)*						
Check	36.1 A	10.1 A	1.04 A	54.3 A	3.83 A	18.6 B
Cover Crop Mix	33.7 A	11.6 A	1.09 A	53.3 A	3.42 A	20.3 A
P-Value	0.886	0.138	0.396	0.497	0.259	0.0212

Table 7 Continued.

Treatment	Infiltration (in/hr)	Soil moisture (%)	Bulk density (g/cm^3)	Soil temp. (F)	Soil respiration[1]	Total soil health score[2]
2021 *(1 sample per treatment replication, n=7 per treatment; samples collected on Nov. 30, 2021)*						
Check	0.985 A	24.0 B	1.34 A	43.4 A	3.05 A	18.9 B
Cover Crop Mix	0.499 A	26.8 A	1.34 A	43.4 A	3.12 A	20.4 A
P-Value	0.37	0.0196	0.986	0.9738	0.845	0.00327

[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.

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

Summary:

- This project included a field-wide conversion to and application of no-till management beginning in 2017.
- Incorporating cover crops in a corn-soybean-small grain rotation resulted in neutral effects on corn, soybean, and small grain yields.
- Total soil health score was higher in the cover crop strips in 2019 and 2020. There is also a trend of increases in soil health scores over time.
- No differences in the seedbank were detected in the treatments. Early-season weed biomass was significantly reduced by the cover crop treatment, but no effects were observed on weed density.