Incorporation of Cover Crop in an Irrigated Corn-Soybean-Small grain Rotation
NRCS Soil Health Management Demonstration Field 4-year summary report

Study ID: 0708077202101
County: Greeley
Reps: 6
Tillage: No-till
Soil Type: Hersh fine sandy loam 3-6% slopes; Gates silt loam 6-11% slopes; Gates silt loam 11-17% slopes
Irrigation: Pivot

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, a no cover crop check and a cover crop mix, were applied and the treatment areas were maintained throughout the four-year study time frame (2018-2021).

Year 1 – Corn (2018 Crop)

In crop year one, a cover crop mix including cereal rye, forage collards, purple top turnips, rapeseed, and kale was drilled following soybean harvest on October 23, 2017, on the cover crop treatment areas. Following cover crop termination, corn was planted on May 9, 2018. The corn was harvested on November 15, 2018. The weigh wagon yield measurements were not analyzed for the check and cover crop mix treatments areas.

Year 2 - Soybeans (2019 Crop)

Planting Date: 5/15/19
Harvest Date: 10/16/19
Seeding Rate: 140,000
Row Spacing (in): 30
Variety: Asgrow® AG21X7
Herbicides: ***Pre:*** 5.0 oz/ac Zidua® PRO, and 32 oz/ac Roundup® on 5/5/19 ***Post:*** 22 oz/ac FeXapan®, and 32 oz/ac Roundup® on 6/28/19
Seed Treatment: Vault® SP inoculant
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 40 lb P/ac, 40 lb K/ac on 6/8/19

In crop year two, the cover crop was drilled following corn harvest on November 17, 2018, on the cover crop treatment areas. The cover crop mixture was comprised of 50 lbs/ac cereal rye, 1 lbs/ac forage collards, 1 lbs/ac turnips, 1 lbs/ac rapeseed, and 1 lbs/ac kale. Soybeans were planted green into the cover crop on May 15, 2019. The cover crop was terminated on June 1, 2019, with a herbicide application. Cover crops were 10" tall at the time of termination. Soybeans were harvested in November 2019. The year was very wet with 21" of rain from planting to August 26, 2019. There were no differences in soybean yield, moisture, or test weight between the cover crop treatment and no cover crop check (Table 1). Marginal net return was lower for the cover crop treatment due to the additional cost of cover crop seed and drilling (Table 1).

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

	Test Weight (lb/bu)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
No Cover Crop	57 A*	10.0 A	55 A	444.82 A
Cover Crop Mix	57 A	9.9 A	54 A	397.26 B
P-Value	0.180	0.530	0.514	0.010

*Values with the same letter are not significantly different at a 90% confidence level.
†Bushels per acre adjusted to 13% moisture.
‡Marginal net return based on $8.10/bu soybean, $25/ac cover crop seed cost, and $14.40/ac for drilling.

Year 3 – Cereal Rye (2020 Crop)

Planting Date: 11/1/19
Harvest Date: 7/25/20
Seeding Rate: 110 lb/ac
Row Spacing (in): 7.5
Variety: Rye (VNS)
Herbicides: ***Pre:*** None ***Post:*** None
Seed Treatment: None
Foliar Insecticides: None
Foliar Fungicides: None
Fertilizer: 20 lb/ac N as 32% UAN and 10 lb/ac S as thiosulfate through the pivot
Irrigation Total: 6"

In crop year three, following soybean harvest, cereal rye (VNS), for grain/seed production, was drilled in November, 2019, and harvested between July 13-July 25, 2020. There were no differences in rye test weight, moisture, yield, and marginal net return between the treatments (Table 2). Multiple rain and wind events in late July delayed/interrupted harvest, and the last wind storm flattened the rye on the east half of the field. The farmer had to combine one way going east to west across the treatment strips. This destroyed the yield sampling process. Farmer was only able to collect yield data on 3 of the 6 treatment strips.

Table 2. 2020 cereal rye (VNS) test weight, moisture, yield, and net return for cover crop mix and no cover crop treatments.

	Test Weight (lb/bu)	Moisture (%)	Rye Yield (bu/acre)†	Marginal Net Return‡ ($/ac)
Check	53.70 A*	12.4 A	42.2 A	253 A
Cover Crop Mix	53.77 A	12.4 A	40.0 A	240 A
P-Value	0.7538	1.0000	0.1993	0.1993

*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 ($20/ac) were not included on the analysis.

Year 4 – Soybeans (2021 Crop)

Planting Date: 5/8/21
Harvest Date: 10/16/21
Seeding Rate: 100,000
Row Spacing (in): 15
Variety: Asgrow® 27X01
Previous Crop: Soybean
Herbicides: ***Pre:*** 12 oz/ac 2,4-D LV6 and 6 oz/ac Fierce® on 4/28/21 ***Post:*** 22 oz/ac XtendiMax® on 6/25/21
Seed Treatment: Vault® IP and Acceleron®
Fertilizer: 75 lb/ac MAP 11-52-0 and 50 lb/ac potash on 4/24/21
Note: White mold in lower areas of the field
Irrigation Total: 9"

In crop year four, following rye harvest, cover crops were drilled in August, 2020. The cover crop mix consisted of oats, sorghum, pearl millet, radish, forage collards, rapeseed, buckwheat, mustard, sunn hemp, mung bean, winter pea, and soybean. The cover crop was chemically terminated on April 28, 2021. Biomass was measured April 12, 2021, and on average was 1,074 lb/ac for both the cover crop and the check treatments (Table 3). Check strips had volunteer rye growing. Soybeans were planted on May 8, 2021, and harvested on October 16, 2021. There were no differences in soybean yield and marginal net return between the treatments (Table 3).

In addition to soil health assessment (Table 7) and crop yield results, weed biomass and density in the cover crop and check treatments were measured in 2021, four years after experimental plots were established. A significant increase in the proportion of pigweeds in the seedbank occurred in the cover crop treatment (Table 4). The check seedbank was primarily dominated by green foxtail whereas the cover crop seedbank had a

relatively even distribution of the top 5 most abundant species (Table 5). No differences in weed density or biomass occurred between the two treatments, despite the large number of pigweed seeds in the cover crop seedbank (Table 6).

Table 3. 2021 soybean yield, moisture, marginal net return and biomass and "green cover" measurements for the cover crop treatments and volunteer rye in the no cover crop treatment areas. Cover crop biomass and green cover were measured on April 12th, 2021.

	Cover crop biomass (lb/ac)	Green cover (%)	Moisture (%)	Soybean Yield (bu/ac)†	Marginal Net Return‡ ($/ac)
Check	1021 A*	24.1 A	11.53 B	70.9 A	837 A
Cover Crop Mix	1127 A	24.5 A	11.62 A	73.1 A	822 A
P-Value	0.454	0.918	0.0925	0.1553	0.378

*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 $11.80/bu soybean, $25/ac cover crop seed cost, and $14.58/ac for drilling.
Green cover assessed using the Canopeo measurement tool.

Table 4. Total number of weeds, pigweeds, grasses, broadleaves, and number of species identified for cover crop mix and check treatments. Seedbank was sampled on April 16, 2021, by collecting twenty soil cores to a depth of 10 cm for each replication per treatment area. Collected soil was put in the greenhouse and weed seedlings were permitted to freely germinate from the 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	1599 A*	15.2 A	65 B	1075 A	785 A
Cover Crop Mix	1308 A	15.5 A	242 A	803 A	454 A
P-Value	0.501	0.928	0.0504	0.142	0.212

† 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 the cover crop mix and check treatments. Seedbank was collected on April 16, 2021, and permitted to freely germinate in the greenhouse until November 1st, 2021.

Check – Species	Percentage of Seedbank	Cover Crop Mix – Species	Percentage of Seedbank
Green foxtail	52.9%	Smooth crabgrass	24.0%
Marestail	17.1%	Redroot pigweed	13.8%
Field pennycress	15.3%	Marestail	11.7%
Yellow foxtail	6.90%	Palmer amaranth	8.94%
Eastern black nightshade	5.21%	Large crabgrass	8.38%

Table 6. Weed density, pigweed density, and weed biomass at early (at crop emergence and before post-emergence herbicide application) and late (before canopy closure and 4+ weeks after post-emergence herbicide application) season for cover crop mix and check treatments.

	Early Season Weed Density (weeds/m^2)	Early Season Weed Biomass (g/m^2)	Late Season Weed Density (weeds/m^2)	Late Season Weed Biomass (g/m^2)
Check	27.3 A*	0.280 A	15.7 A	0.840 A
Cover Crop Mix	3.56 A	0.009 A	1.40 A	0.007 A
P-Value	0.375	0.227	0.520	0.103

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

Multi-Year Soil Health Assessment (2017 to 2021)

Baseline and soil health measures were collected in 2017, 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=6 per treatment; samples collected on Oct. 18, 2019)*						
Check	5.19 A*	22.7 A	1.32 A	51.2 A	2.96 A	14.0 A
Cover Crop Mix	7.23 A	20.3 A	1.34 A	51.5 A	3.03 A	13.8 A
P-Value	0.682	0.374	0.726	0.352	0.854	0.6302
2019 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 22, 2019)*						
Check	2.03 A	13.25 A	1.41 A	44.16 B	2.44 A	12.9 A
Cover Crop Mix	6.45 A	14.56 A	1.27 A	46.06 A	2.86 A	13.3 A
P-Value	0.267	0.488	0.179	0.098	0.296	0.477
2020 *(1 sample per treatment replication, n=6 per treatment; samples collected on Oct. 20, 2020)*						
Check	6.32 A	20.1 A	1.28 A	47.0 A	2.57 A	13.9 B
Cover Crop Mix	5.19 A	18.2 A	1.34 A	47.1 A	2.64 A	16.8 A
P-Value	0.7222	0.4355	0.3813	0.8661	0.9255	0.0001
2021 *(1 sample per treatment replication, n=6 per treatment; samples collected on Dec. 1, 2021)*						
Check	4.88 A	15.1 A	1.70 A	43.8 A	1.69 A	14.2 B
Cover Crop Mix	6.25 A	16.5 A	1.74 A	44.4 A	1.90 A	16.5 A
P-Value	0.695	0.4574	0.5904	0.11343	0.5126	0.020

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (averaged from 1-3; 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 cover crop in a corn-soybean-small grain rotation resulted in neutral effects on soybean and small grain yields.
- Total soil health score was higher in the cover crop treatment area in 2020 and 2021.
- No differences in weed density or biomass were observed in 2021, four years after the treatment strips were established.