

Effects of Grazing Cover Crops in a Three-Year Non-irrigated Rotation *4-year summary report*

Study ID: 0720129202001
County: Nuckolls

Soil Type: Hastings silt loam 0-1% slope
Reps: 4

Introduction

In rainfed systems, adding cover crops into the rotation can decrease crop yields if precipitation is limited; however, the use of cover crops for forage may offset monetary costs while retaining soil benefits. This study evaluated three treatments: grazed cover crop (or stubble, depending on the year of crop rotation), non-grazed cover crop, and non-grazed wheat stubble. This is a three-year, no-till crop rotation of wheat, corn, and soybean, with cover crops planted in the cover crop treatments following the wheat crop only. Watermark™ Soil Moisture Sensors were installed to determine treatment impacts for each growing season.

Year 1 (2017 crop)

In year one of the study, cover crop treatments were planted on August 14, 2016, following wheat harvest and consisted of a mix of winter peas, spring triticale, oats, collards, and purple top turnip. Cover crop biomass measured on October 19, 2016, was 3,401 lb/ac and consisted mainly of grass and turnip (Table 1).

Table 1. Cover crop composition (% of biomass on DM basis).

Grass	53.5%
Winter Pea	1.5%
Collards	8.7%
Turnip Tops	20.9%
Turnip Bottoms	14.5%
Other	0.9%

The grazed treatment was grazed in the fall of 2016. Starting in November 2016, 28 (1,100 lb) first-calf heifers grazed 9.6 acres for 22 days, resulting in the cover crop carrying 2.4 animal unit months (AUM)/ac. Post-grazing 2,177 lb/ac of biomass were still present. Baseline soil samples were collected in April 2017, prior to planting corn (Table 2).

Table 2. Soil analysis taken prior to corn planting in April 2017.

	-----0 to 8 inches-----				
	Soil pH	OM %	Nitrate-N ppm	Nitrogen lb N/A	
Cover Crop – Non-grazed	5.52 A	3.1 A	5.4 B	9.3 B	
Cover Crop/Stubble – Grazed	5.68 A	3.1 A	7.3 B	12.6 B	
Stubble – Non-grazed	5.40 A	3.1 A	12.9 A	24.5 A	
P-Value	0.38	0.90	0.01	<0.01	
	-----0 to 4 inches-----				
	Solvita CO ₂ -C (ppm)	Total Biomass (ng/g)	Total Bacteria Biomass (ng/g)	Total Fungi Biomass (ng/g)	Diversity Index
Cover Crop – Non-grazed	133 A	4,225 A	2,187 A	351 A	1.44 A
Cover Crop/Stubble – Grazed	161 A	3,927 AB	2,142 A	333 A	1.44 A
Stubble – Non-grazed	128 A	3,046 B	1,605 A	306 A	1.5 A
P-Value	0.19	0.09	0.12	0.90	0.90

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

During March through May 2017, prior to planting corn, the cover crop treatments were around 35% depletion (the typical trigger point for irrigation on these soil types), whereas the wheat stubble treatments remained near field capacity (full soil moisture profile). Corn was planted in 2017 across all treatments. In May 2017, 8" of rain recharged the soil profile and all treatments had a full 4' soil moisture profile at the beginning of June. Therefore, the cover crop treatments did not result in lower beginning moisture, which could limit yield potential. The grazed treatments began to show greater soil moisture depletion than the ungrazed treatments as time progressed. In June 2017, it was observed that the grazed treatments had concentrations of Palmer amaranth where the cattle created trails walking along the electric fence; Palmer amaranth was controlled with dicamba herbicide. For the 2017 corn crop, no significant yield differences occurred (Table 3). Corn yield where the cover crop was planted and not grazed (213 bu/ac) did not differ from where it was grazed (211 bu/ac).

Table 3. 2017 corn yield results.

	Stand Count (plants/ac)	Moisture (%)	Test Weight	Corn Yield (bu/ac) [†]
Cover Crop—Non-grazed	22,500 A	15.0 A	61 A	213 A
Cover Crop/Stubble—Grazed	22,167 A	14.9 A	61 A	211 A
Stubble—Non-grazed	22,500 A	15.2 A	61 A	218 A
P-Value	0.952	0.129	0.267	0.141

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

[†]Bushels per acre corrected to 15.5% moisture for corn.

Year 2 (2018 crop)

In year two of the study, following corn harvest in the fall of 2017, no cover crops were planted. In the previously established grazed cover crop treatment, 11 bulls grazed on the corn stalks (9.6 acres) for 18 days. The two previously non-grazed treatments remained non-grazed. Soybeans were planted in 2018 across all treatments. In August, the grazed treatment showed greater moisture stress than the non-grazed treatments (Figure 1).



Figure 1. August 3, 2018, image with grazed treatment (cover crop in 2016 and stubble in 2017) showing greater moisture stress.

Table 4. 2018 soybean yield results.

	Stand Count (plants/ac)	Test Weight	Moisture (%)	Soybean Yield† (bu/ac)
Cover Crop—Non-grazed	120,750 A*	55 A	10.7 B	50 A
Cover Crop/Stubble—Grazed	120,500 A	55 A	11.0 A	40 B
Stubble—Non-grazed	117,750 A	55 A	10.6 C	52 A
P-Value	0.629	0.397	0.0002	0.0004

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

†Bushels per acre corrected to 13% moisture for soybeans.

For the 2018 soybean crop, there were no differences in test weight or stand counts between the three treatments (Table 4). Grain moisture was significantly higher for the grazed cover crop treatment, followed by the non-grazed cover crop treatment, then the non-grazed wheat stubble. Yield of the non-grazed treatments was 10-12 bu/ac higher than for the grazed cover crop treatment.

Year 3 (2019 crop)

Following soybean harvest in October of 2018, Overland wheat was planted on October 22, 2018, at a seeding rate of 120 lb/ac and row spacing of 7.5". The field received 10 gal/ac 10-34-0 at planting and 80 lb N/ac as a spring topdress application. Wheat was harvested on July 26, 2019, and yield and grain moisture were recorded. For the 2019 wheat crop, there was no difference in test weight or yield (Table 5). Grain moisture was slightly different with the grazed cover crop treatment being wetter than the ungrazed wheat stubble treatment. The wet 2019 season delayed wheat harvest to July 26, 2019. The cover crop was planted on September 4, 2019, due to the rain and wet field. Three-year follow-up soil analysis for nutrient and soil health (Table 6) were taken August 5, 2019 (following wheat harvest and prior to planting cover crops).

Table 5. 2019 wheat yield results.

	Test Weight (lb/bu)	Moisture (%)	Wheat Yield (bu/ac)†
Cover Crop – Non-grazed	59 A*	10.3 AB	84 A
Cover Crop/Stubble – Grazed	59 A	10.4 A	84 A
Stubble – Non-grazed	59 A	10.2 B	83 A
P-Value	0.483	0.067	0.613

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

†Bushels per acre adjusted to 13% moisture.

Table 6. Three-year follow up soil analysis taken prior to cover crop planting August 5, 2019.

	-----0 to 8 inches-----					
	Soil pH	OM %	Nitrate-N ppm	Nitrogen lb N/A		
Cover Crop – Non-grazed	5.7 A*	3.3 A	6.6 A	16.0 A		
Cover Crop/Stubble – Grazed	5.5 AB	3.2 A	6.3 A	15.0 A		
Stubble – Non-grazed	5.5 B	3.1 A	6.0 A	14.5 A		
P-Value	0.090	0.105	0.395	0.390		
-----0 to 4 inches-----						
	Solvita CO ₂ -C (ppm)	Total Biomass (ng/g)	Total Bacteria Biomass (ng/g)	Total Fungi Biomass (ng/g)	Diversity Index	Soil Health Calculation
Cover Crop – Non-grazed	59	2860	1073	183	1.06	10.00
Cover Crop/Stubble – Grazed	44	3498	1524	298	1.44	7.87
Stubble – Non-grazed	63	2760	1287	198	1.30	9.69
-----4 to 8 inches-----						
Cover Crop – Non-grazed	31	906	353	4	0.94	5.89
Cover Crop/Stubble – Grazed	29	1526	569	53	1.22	5.53
Stubble – Non-grazed	21	977	354	12	1.06	4.65

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

3-Year Soil Physical Properties Changes

Sampling for soil physical properties including bulk density was completed on August 5, 2019. Neither cover crops nor grazing had a significant effect on soil bulk density in the top 2 inches. The average bulk density for the grazed cover crops was 1.08 g/cm³, for ungrazed cover crops was 1.09 g/cm³, and the ungrazed wheat stubble was 1.06 g/cm³. There was no effect of grazing or cover crop in the 2-4" depth of soil. The average bulk density for the soil in the 2-4" depth was 1.31 g/cm³ for the grazed cover crop treatment, 1.28 g/cm³ for the ungrazed cover crop treatment, and 1.28 g/cm³ for the ungrazed wheat stubble treatment.

Soil cone index value is a measurement of how easy it is to penetrate the soil. Figure 2 shows no significant effect on soil cone index value at any of the soil depths. The ungrazed cover crop tended to have a lower soil cone index value, but it was not significantly different from the other two treatments.

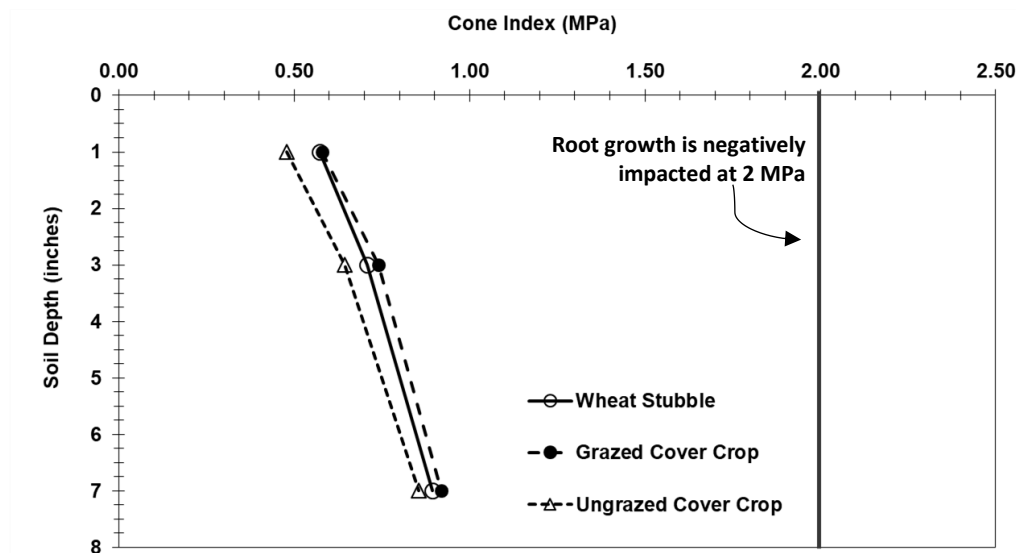
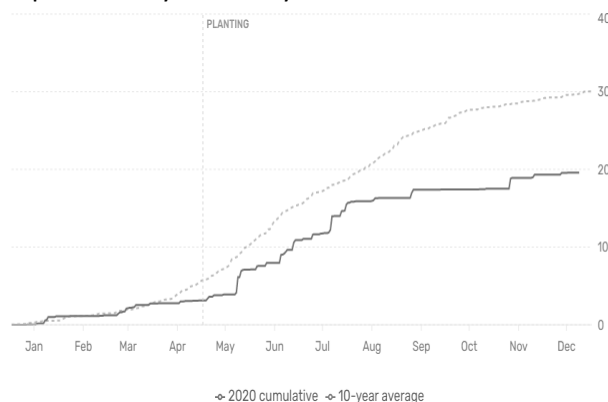


Figure 2. Three-year follow up soil cone index values by treatment taken August 5, 2019. The line on the far right represents where root growth is negatively impacted, because roots are no longer able to easily penetrate through the soil.

Year 4 (2019 Cover Crop and 2020 Corn)

Following wheat harvest, 20 ton/ac manure was applied, then a cool-season cover crop was planted on 9/3/19. Cover crop contained 10 lb/ac winter peas, 25 lb/ac winter triticale, 25 lb/ac black oats, 1.3 lb/ac collards, and 1.3 lb/ac turnip. Nine bulls grazed the cover crop for 23 days and only 8.66 AUM were achieved (much less than the 19.03 AUM in 2016) due to the wet fall, late planting, and minimal growth. Cover crop was 8" at time of termination by 32 oz Roundup®, 8 oz/ac dicamba, 0.5 lb/ac atrazine, and 4 oz/ac Balance® Flexx on 3/20/20. Manure application on a wet field resulted in deep ruts. This may have impacted corn emergence and stand counts the following spring.

For the corn crop, 190 lb/ac N as anhydrous ammonia was applied on 3/15/20. Pioneer® P1244 was planted no-till on 5/1/20 at a seeding rate of 25,000 seeds/ac in 30" rows. Six gallons of starter fertilizer (10-34-0) was



applied in-furrow at planting. Post-emergent herbicides included 0.5 lb/ac atrazine, 30 oz/ac DiFlexx® DUO, and 32 oz/ac of Roundup. On 8/20/20, Headline AMP® at 10 oz/ac was applied for southern rust. Harvest occurred on 10/13/20. All treatments had a full soil moisture profile at the beginning of the 2020 growing season. By the end of August, all treatments had reached 50% depletion (Figure 3). There were no differences amongst treatments for stand counts, percent stalk rot, percent moisture, and test weight. The corn in the ungrazed wheat stubble yielded more than the cover crop treatments (Table 7). Economic analysis can be viewed in Table 8. This study will continue for two more years.

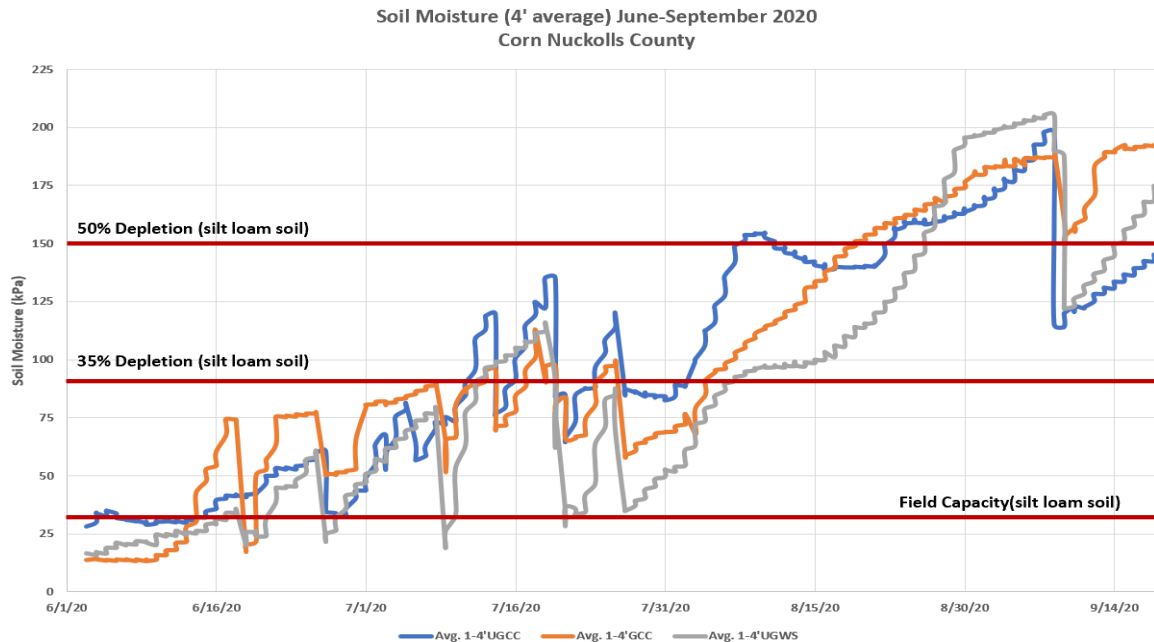


Figure 3. Soil moisture depletion for June-September 2020 corn in Nuckolls County. All treatments began the season with soil moisture at or above field capacity. The ungrazed cover crop (UGCC) and grazed cover crop (GCC) treatments reached 50% depletion by mid-August with the ungrazed wheat stubble (UGWS) reaching 50% depletion toward the end of August.

Table 7. 2020 corn yield results.

	Stand Count (plants/ac)	Stalk Rot (%)	Moisture (%)	Test Weight	Corn Yield (bu/ac)†
Cover Crop—Non-grazed	16,875 A	0 A	13.8 A	60.125 A	215 B
Cover Crop/Stubble—Grazed	18,000 A	0 A	13.58 A	60.3 A	216 B
Stubble—Non-grazed	18,125 A	2.5 A	13.6 A	60.2 A	227 A
P-Value	0.4355	0.454	0.2648	0.9201	0.0057

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

†Bushels per acre corrected to 15.5% moisture for corn.

Multi-Year Economic Analysis (2016 cover crop to 2020 corn crop)

2016 Cover Crop: Cost for spraying wheat stubble was \$18/ac. Costs for the non-grazed cover crop treatments were \$46.64/ac (\$28.64/ac for seed and \$18/ac for drilling). Costs for grazed cover crop treatments were \$61.94/ac (\$46.64/ac for the cover crop seed and planting, \$5/ac for fencing, and \$10.30/ac for water). Water cost was calculated assuming hauling water (1,000 gal) 15 miles every two days at \$2 per loaded mile and \$6 per \$1,000 gal. Costs for the grazed cover crop treatments equaled \$30.97/AUM (animal unit months). Value of the forage is estimated to be \$84.80/ac (based on rental rates of \$53/pair/month [1.25 AUMs] or \$42.40 AUM).

2017 Corn: The economic analysis had no input differences for any of the treatments for corn production. UNL Corn Budget 21 (EC872, 2017 Nebraska Crop Budgets, revised Nov. 2016) was the closest that fit this operation, so a total cost/ac of \$459.60/ac and a market year average price of \$3.15/bu was used. In the previously established grazed cover crop treatment, cattle grazed on the corn stalks. A \$5/ac cornstalk rental rate value was assessed to this 9.6 acre area. This rate assumes water, fencing, and the care of the animals.

2018 Soybean: The inputs were the same for the soybeans planted into all the previous treatments. UNL Budget 56 (EC872, 2018 Nebraska Crop Budgets, revised Nov. 2017) was used, which states a \$315.82/ac total cost. A market year average price of \$7.40/bu was used.

2019 Wheat: The inputs were the same for the wheat planted into all the previous treatments. UNL Budget 70 (EC872, 2019 Nebraska Crop Budgets, revised Nov. 2018) was used which stated a \$247.04/ac total cost. A market year average price of \$3.65/bu was used.

2019 Cover Crop: Cost for spraying the wheat stubble was \$18 (\$9/ac application and \$9/ac herbicide cost). Costs for the non-grazed cover crop treatments were \$49.42/ac (\$31.42/ac for seed and \$18/ac for drilling). Costs for grazed cover crop treatments were \$64.00/ac (\$49.42/ac for the cover crop seed and planting, \$5/ac for fencing, and \$9.58/ac for water). Water cost was calculated based on hauling water (5.75 water trips at \$16/trip, which included cost of water).

Costs for the grazed cover crop treatments equaled \$54.78/AUM ($49.42 \times 9.6 = 474.43 / 8.66 \text{AUM}$ from what was grazed = 54.78). Value of the forage was estimated to be \$84.80/ac (based on rental rates of \$53/pair/month [1.25 AUMs] or \$42.40 AUM). Forage production was limited in the fall of 2019 compared to 2016 due to a wet summer that delayed wheat harvest, which, in turn, delayed cover crop planting. A cool fall led to less growth. Only 8.66 AUM was achieved with the 2019 cover crop compared to 19.03 AUM with the 2016 cover crop.

2020 Corn: The economic analysis had no input differences for any of the treatments for corn production. UNL Corn Budget 23 (EC872, 2020 Nebraska Crop Budgets, revised Nov. 2019) was the closest that fit this operation, so a total cost/ac of \$452.10 and a market year average price of \$3.51 was used. In the previously established grazed cover crop treatment, cattle grazed on the corn stalks. A \$5/ac cornstalk rental rate value was assessed to this 9.6 acre area. This rate assumes water, fencing, and the care of the animals.

Table 7. Three crop year economic analysis summary of this study.

	2016 Cover	2017 Corn	2018 Soy	2019 Wheat	3-Year Total
Cover Crop—Non-grazed	-\$46.64	\$211.35	\$54.18	\$59.56	\$278.45
Cover Crop/Stubble—Grazed	\$22.86	\$210.05	-\$19.82	\$59.56	\$272.65
Stubble—Non-grazed	-\$18.00	\$227.10	\$68.98	\$55.91	\$333.99

	2019 Cover	2020 Corn	2021 Soy	2022 Wheat	6-Year Total
Cover Crop—Non-grazed	-\$49.42	\$304.23	TBD	TBD	\$533.26
Cover Crop/Stubble—Grazed	\$20.80	\$311.13	TBD	TBD	\$604.58
Stubble—Non-grazed	-\$18.00	\$342.99	TBD	TBD	\$658.98

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