SNAPSHOT OF CROP NUTRIENT BALANCE WITH USE OF A RYE COVER CROP IN A CORN-SOYBEAN ROTATION UNDER TILE DRAINAGE IN EASTERN SOUTH DAKOTA

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ABSTRACT

The purpose of this study was to evaluate the effect of using a winter rye cover crop within a corn/soybean rotation (rye seeded every fall and burned down each spring) on drainage water quality, crop nutrient status, and grain yield. A three year study was conducted (corn/soybean/corn) starting in 2018 at Beresford, South Dakota, towards this end. There were two treatments in the study, rye cover crop and control (no cover crop), laid out in a randomized complete block design with six replications. Rye biomass and nutrient content were measured near the time of termination of the rye cover crop. Yield differences between treatments were minor. There were trends for greater shoot K levels in the cover crop plots; however, it was not clear if that was an effect of the rye cover crop or an artifact of initial soil K levels being slightly higher in the cover crop plots.

INTRODUCTION

Interest in tile drainage has increased dramatically in eastern South Dakota over the last 15 years. This is due to a complex combination of factors including a long-term trend for increased rainfall, increased crop yields and land value, and economics that favor use of simple rotations lacking perennials or forage sequences. Nationally, concern has grown about the effect of loss of nutrients, particularly nitrate, from fields in drainage systems and its effect on downstream water quality. One simple tool that is practical and within our reach to ameliorate these problems is use of a winter rye cover crop. In order to obtain initial estimates of the effect of a rye cover crop on soil and water quality, and on crop yield and shoot nutrient balance, a replicated study was undertaken where rye was grown every season as a cover crop for three seasons while drainage water, soil quality and crop yields were monitored.

MATERIALS AND METHODS

Winter rye was sown after grain harvest and compared to a no cover crop control in a set of 12 paired plots (six replications) for three seasons in a corn/soybean rotation on a no-till field at the SDSU Southeast Research Farm in Beresford, South Dakota from 2018 through 2020. Detailed results from the water and soil quality aspects of this study are reported in Bawa et al (2021). The shoot nutrient content of the rye cover crop was determined by taking three crop cuts (15 by 22.5") from each plot near the time of burndown herbicide application. Corn and soybean shoot nutrient contents were measured mid-season and near physiological maturity by clipping 6' of row from each plot, determining whole sample fresh weight and immediately chipping a subsample of 3 or more plants for determination of dry matter percentage and to obtain a sample for nutrient analysis. Dried plant samples were sent to Ward Labs (Kearney, Nebraska) for analysis of N by combustion analysis and other nutrients using ICP methods. Yields were measured using a small plot combine (4 rows by 180') in each plot.

RESULTS AND DISCUSSION

Initial soil test values are given in Table 1 and soil K levels (according to the Haney test) over the course of the study are shown in Figure 1. In the first two years of the study, there was a tendency for a small yield bump associated with the use of the rye cover crop (Table 2). In 2018, the corn yield trend ($P < 0.10$) was for a 3.5 bu/ac gain in the rye cover crop plots versus the control plots. In 2019, there was a small, but statistically significant ($P < 0.05$), yield bump of 2.9 bu/ac in soybean yield associated with use of a rye cover crop. In 2020 there was no discernable effect or trend in the plot data on corn yield ($P=0.62$). Even where there appeared to be positive trends on yield in 2018 and 2019, the magnitude of the effect was small. In the years when corn was the grain crop (2018 and 2020), rye biomass was minimal (240 lb/ac in 2018, and 131 lb/ac in 2020 - dry matter basis) because there was not much of a window for growth before the rye was terminated ahead of corn planting. In the year with soybean as a grain crop (2019), the rye had more opportunity to grow and put on biomass (1030 lb/ac dry matter) before the grain crop was seeded.

Pooled analysis across sample dates showed greater microbially active C in the cover crop plots (average of 63.4 vs. 56.2 % for the cover crop and control treatments, respectively ($P<0.05$)), and trends for slightly higher soil organic matter and Haney soil health scores in the cover crop plots, but these latter points were inconsistent (Fig. 2). It appears that the cover crop practice may have to be continued longer than a three year period in order to observe consistent differences in soil health measurements. Measurements of shoot nutrient balance showed a trend for greater K and Zn levels in the cover crop plots (Table 3). Differences in shoot K levels were not significant in the first season of the study, but did show some significant effects in the second and third seasons of the study. Soil K levels tended to be greater in the cover crop plots over the course of the study from beginning to end (Table 1 and Fig. 1). Further work is needed to sort out whether a rye cover crop may contribute to K uptake in the following corn or soybean crop, or if this observation was an artifact of previous differences in soil K levels between plots.

REFERENCES

Bawa A, MacDowell R, Bansal S, McMaine J, Sexton P, Kumar S. Responses of leached nitrogen concentrations and soil health to winter rye cover crop under no-till corn–soybean rotation in the northern Great Plains. J Environ Qual. 2021; 1–12. https://doi.org/10.1002/jeq2.20294

Table 1. Soil organic matter, Olsen P, K, pH, EC, and Zn from a composite sample taken before the trial started in October of 2017, and average of samples taken from each plot midway through the study in June of 2019. All of these samples were analyzed at the SDSU Soil Testing Lab. Potassium measurement was based on a procedure using an ammonium acetate extract.

Treatment	Date	Organic Matter	Olsen P	K	pH	Salts 1:1	Zinc
		(%)	(ppm)	(ppm)		(mmho/cm)	(ppm)
Composite	10/16/17	5.0	14.9	302	6.6	0.8	1.1
Control	6/4/19	4.9	19.3	258	7.1	0.7	1.1
Rye cover crop	6/4/19	4.9	18.1	266	6.6	0.6	1.3

Note: 'Available K' in the graph below is from the Haney soil test procedure.

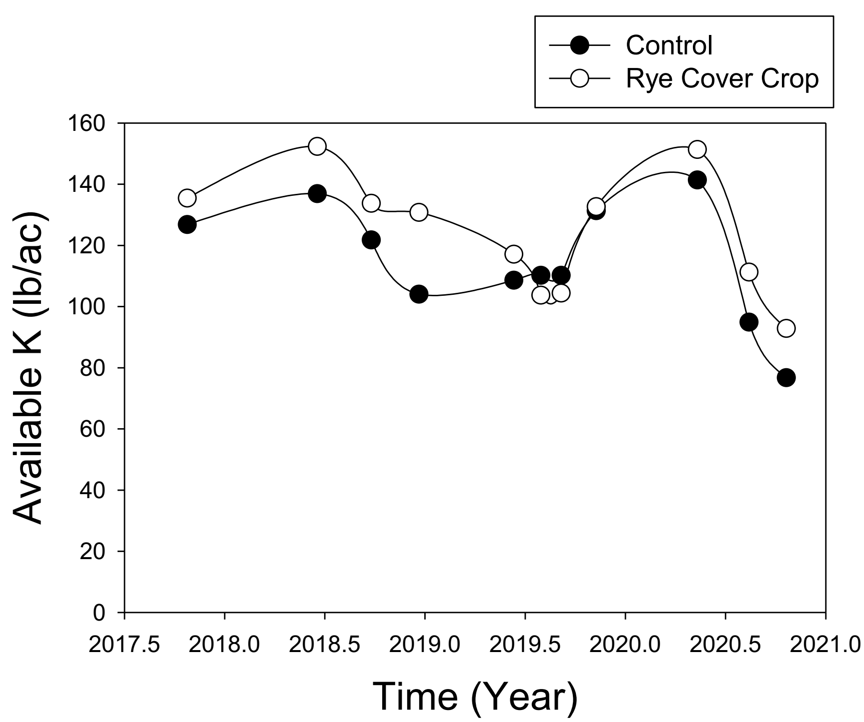

Figure 1. Average levels of available K, as measured from the Haney soil test, from plots raised with and without a rye cover crop in a replicated study at the SDSU Southeast Research Farm in Beresford, South Dakota. The rye cover crop was planted in the fall after grain harvest and terminated in the spring before planting the next grain crop in each year of the study (fall 2017 through 2020). According to this soil test, the cover crop and control plots averaged 124, and 115 lb/ac of available K per acre, respectively, over the course of the study.

Table 2. Average stand, grain moisture, test weight, and yield for corn and soybean plots raised with and without a rye cover crop in a replicated study at the SDSU Southeast Research Farm in Beresford, South Dakota in 2018 (corn), 2019 (soybean), and 2020 (corn).

2018 Corn Treatment	Stand	Moisture	Test Wt.	Yield
	(plants/ac)	(%)	(lb/bu)	(bu/ac)
Rye Cover Crop	33109	19.4	56.4	207.3
Control	33405	19.5	56.4	203.8
Mean	*33257*	*19.5*	*56.4*	*205.6*
CV (%)	*5.6*	*2.3*	*1.3*	*1.5*
P-value	*NS*	*NS*	*NS*	*P < 0.10*

2019 Soy Treatment	Height	Stand	100-Seed Wt.	Moisture	Test Wt.	Yield
	(in)	(plt/ac)	(g)	(%)	(lb/bu)	(bu/ac)
Rye cover crop	32.4	98155	19.3	12.3	55.0	61.3
Control	30.8	102221	18.7	12.6	55.7	58.4
Mean	*31.6*	*100188*	*19.0*	*12.5*	*55.4*	*59.8*
CV (%)	*2.2*	*6.3*	*1.1*	*4.3*	*1.4*	*3.2*
P-value	*< 0.01*	*NS*	*< 0.01*	*NS*	*NS*	*<0.05*

2020 Corn Treatment	Stand	100-Seed Wt.	Moisture	Test Wt.	Yield
	(plt/ac)	(g)	(%)	(lb/bu)	(bu/ac)
Control	26136	29.6	11.9	58.7	182
Rye Cover Crop	26862	29.4	12.1	58.9	179
mean	*26500*	*29.5*	*12*	*58.8*	*180.3*
CV (%)	*9.4*	*5.4*	*2.0*	*1.0*	*5.2*
P-value	*NS*	*NS*	*NS*	*<0.02*	*NS*

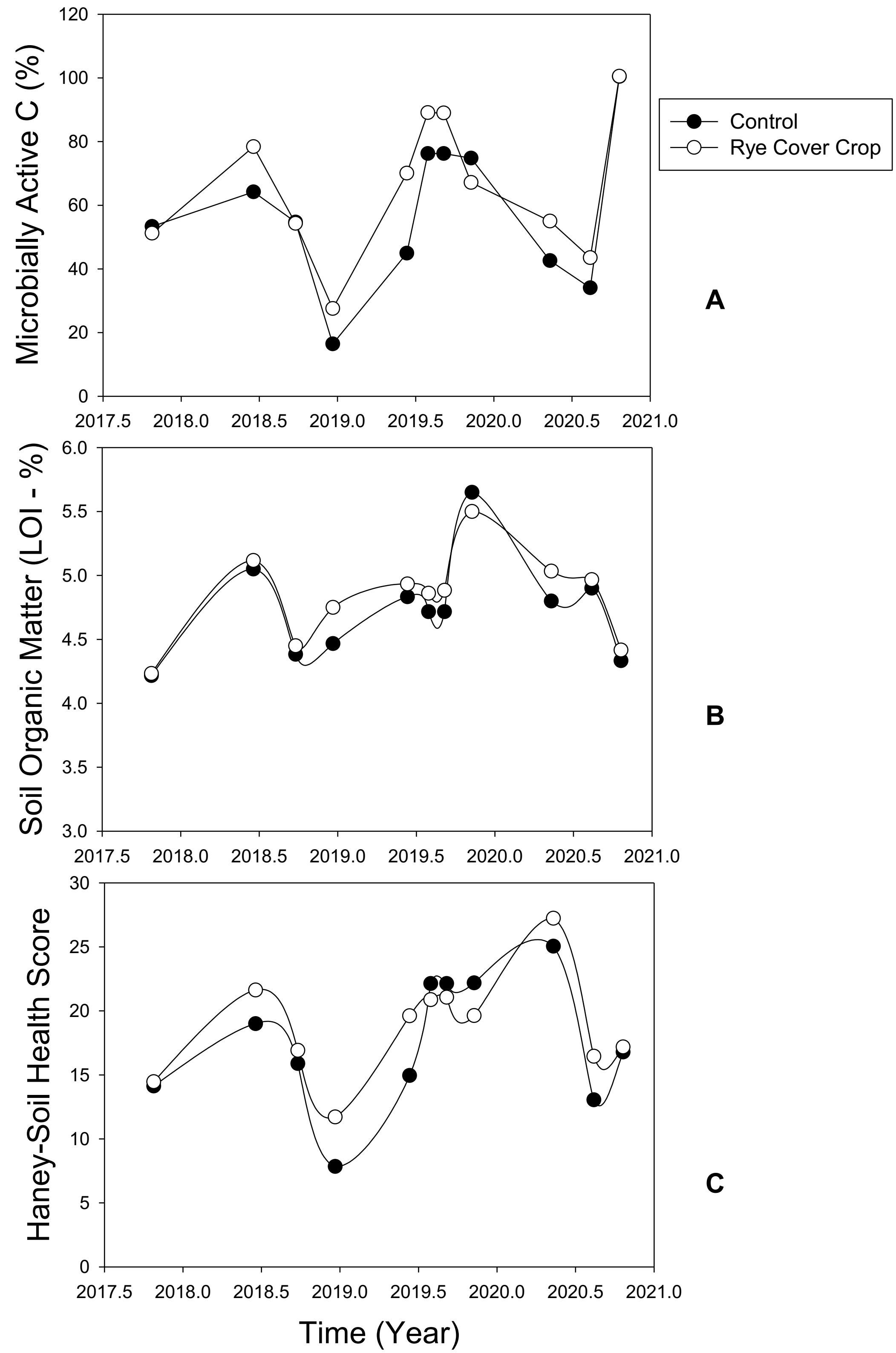

Fig. 2. Microbially active C (A - as measured in the Haney soil test), soil organic matter (B), and the Haney soil health score (C) at different sample times in a study comparing plots that had a rye cover crop versus those that did not over a three year period at the Southeast Research Farm in Beresford, South Dakota.

Table 3. Average whole shoot nutrient content of rye cover crops, and the following corn and soybean crops, as measured in a study conducted at the Southeast Research Farm in Beresford, South Dakota between 2018 and 2020.

Date	Cover Crop	Material	Biomass	[N]	N Content	[P]	P Content	[K]	K Content	[S]	S Content	[Zn]	Zn Content
			(lb/ac)	(%)	(lb/ac)	(%)	(lb/ac)	(%)	(lb/ac)	(%)	(lb/ac)	(ppm)	(lb/ac)
5/24/18	Rye c.c.	RYE	240	3.91	9	0.69	1.7	4.28	10	0.38	0.9	40.0	0.009
7/3/18	Control	CORN	2823	2.52	71	0.30	8.5	3.74	107	0.19	5.5	29.8	0.084
7/3/18	Rye c.c.	CORN	3203	2.58	83	0.30	9.7	4.10	130	0.19	6.1	32.0	0.103
		P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
9/24/18	Control	CORN	21499	1.13	243	0.17	36.1	1.01	218	0.14	29.7	26.8	0.578
9/24/18	Rye c.c.	CORN	22929	1.14	260	0.18	40.9	1.06	243	0.14	33.1	28.0	0.636
		P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	***<0.10***
6/4/419	Rye c.c.	RYE	1029	1.55	16	0.40	4.1	2.74	28	0.18	1.8	18.0	0.018
7/30/19	Control	SOY	3809	3.22	122	0.29	11.2	2.53	97	0.22	8.2	30.8	0.119
7/30/19	Rye c.c.	SOY	4520	3.17	144	0.29	13.1	2.60	118	0.21	9.3	38.0	0.185
		P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
9/6/19	Control	SOY	13050	3.11	406	0.26	33.9	1.73	225	0.19	25.2	20.7	0.270
9/6/19	Rye c.c.	SOY	14097	3.08	434	0.25	35.9	1.87	264	0.19	26.4	21.8	0.306
		P-value	NS	NS	NS	NS	NS	NS	**<0.05**	NS	NS	NS	**<0.10**
5/11/20	Rye c.c.	RYE	131	6.01	8	0.52	0.8	4.31	6	0.40	0.5	41.0	0.006
8/12/20	Control	CORN	13913	1.39	193	0.17	24.2	1.11	154	0.15	20.7	35.8	0.487
8/12/20	Rye c.c.	CORN	13647	1.40	191	0.18	24.3	1.25	170	0.14	19.3	35.8	0.490
		P-value	NS	NS	NS	NS	NS	**<0.05**	**<0.10**	NS	NS	NS	NS
9/18/20	Control	CORN	16761	0.97	163	0.12	20.3	0.98	164	0.11	19.1	25.5	0.429
9/18/20	Rye c.c.	CORN	17944	0.97	174	0.12	21.4	1.09	195	0.11	19.1	23.8	0.427
		P-value	**<0.10**	NS	NS	NS	NS	NS	**<0.05**	NS	NS	NS	NS