Demonstrating Cover Crop Mixtures on Iowa Farmland: Management, Soil Health, and Water Quality Benefits

RFR-A2079

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Introduction

Iowa landowners and farmers increasingly are seeing the value of single species cover crops. In theory, cover crop mixtures have the same advantages as diverse species ecosystems like prairies. The most important advantage would be greater and more stable total plant growth. Mixing species with complimentary features can take advantage of multiple niches and environmental conditions in space, weather, time, and seasons.

The project's goal is to evaluate management techniques that will increase growth and improve the overall environmental benefits of cover crops in improving soil health and reducing nutrient losses.

Materials and Methods

Cover crop plots were established at six ISU Research and Demonstration sites in fall 2013. In fall 2016, the project continued at four sites, and three sites were seeded for the eighth year in 2020.

The plots compare three treatments–single species, mixture, and no cover crop. Each treatment is replicated four times at each site in both corn and soybean, for a total of 24 plots at each farm. The plots range from 6 to 12 rows wide and all are 50 ft in length. Before corn, the single species is oats and the mixture contains oats, hairy vetch, and radish. Before soybean, the single species is rye and the mixture contains rye, rapeseed, and radish. For all sites and all years, spring and fall cover crop biomass, and cash crop yield data were collected to evaluate the establishment of the cover crops and potential yield impacts. Late spring nitrate was collected at all sites from 2015 to 2017. At five of the sites, water quality samples were collected using suction lysimeters.

Results and Discussion

Corn grain yields were not statistically affected by the treatments (Table 1). Only in 1 of 32 site-years was a corn yield difference found. That was Crawfordsville in 2016 where the no cover and cover crop mixture yielded more than the single species oat cover crop. Soybean grain yields were not statistically different in 28 of 32 site-years (Table 2). Late spring soil nitrate samples were taken in the first three years and were not statistically different within any site-year in corn plots (where the cover crop rarely over-wintered). Late spring soil nitrate-nitrogen was significant in 7 of 16 site-years in soybean plots. In each of those site-years, the no cover treatment had higher soil nitrate-nitrogen.

Total fall biomass dry matter ahead of corn was significant between treatments in 3 of 32 site-years and were found in southern Iowa where the cover crop mixture had greater biomass compared with the single species oat cover crop (Table 3). Typically, no cover crops survived over winter ahead of corn, but there are a few exceptions. In 2018 and 2019

at Lewis, hairy vetch survived over winter and yielded more than 500 lb/acre. In 2020, both some oats and hairy vetch survived through the winter at Lewis. In the fall, oats were the highest percentage of biomass in the mixture plots in 20 of the 26 site-years with measurable biomass (Table 4). Radish was the second highest percentage of biomass in 21 of 26 site-years. The radish cover crop did noticeably better at Crawfordsville and Lewis, which are both warmer sites.

Difference in total fall biomass dry matter ahead of soybean was significant in 6 of 26 site-years with measurable biomass (Table 5). In 5 of the 6 site-years, the single species cereal rye cover crop had more biomass than the cover crop mixture treatment. Total spring biomass was significantly higher in the single species plots in 6 of 26 site-years. In the fall, rye was the highest percentage of biomass in the mixture plots in 24 of 26 site-years (Table 6). As seen in the mixture plots ahead of corn, radish did very well at Lewis, the warmer site.

Iowa soils are highly vulnerable to nitrate losses between April and June when nitrogen mineralization exceeds the cash crop demands. Spring (April to June) had the highest lysimeter nitrate concentrations and fall had the lowest. Rye statistically reduced average spring nitrate in soil water at every site compared with no cover.

The rye mixture and oats single species statistically reduced average spring soil water nitrate at three sites compared with no cover. The spring nitrate readings were much higher in corn than soybean. In some cases, lysimeter readings were taken shortly after sidedress application.

The presence of a cover crop (mix or single species) statistically reduced annual lysimeter nitrate concentration significantly when averaged over all sites. In soybean, rye significantly decreased nitrate concentration by 61 percent compared with no cover. During cover crop growth (planting in August to termination in May), all treatments had lysimeter readings average below 10 mg/L, including the no cover plots (Table 7).

Acknowledgements

This project is funded by USDA-NRCS through a National Conservation Innovation Grant, The Leopold Center for Sustainable Agriculture, and Iowa Department of Agriculture and Land Stewardship. Partners on the project include Iowa Learning Farms under the leadership of Jacqueline Comito, Practical Farmers of Iowa, NRCS, and Conservation Districts of Iowa, and Iowa Cover Crop Working Group.

Table 1. Corn grain yield and late spring nitrate-nitrogen concentration for a no cover control, single species (oats), and cover crop mixture (oats, radish, hairy vetch) at six locations across Iowa.[1]

		Corn yield							Late spring nitrate test		
Location	**Treatment**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2015**	**2016**	**2017**
		bu/ac							ppm		
Sutherland	No cover	187.2	228.9	235.7					40.4	8.9	
	Single	186.1	218.7	233.1					32.1	8.4	
	Mix	192.5	226.8	235.7					39.1	10.2	
	Pr > F	0.702	0.506	0.925					0.823	0.105	
Kanawha	No cover	145.1	214.0	213.1	220.8	162.3	171.2	170.2	42.0	23.9	26.7
	Single	141.9	209.4	216.6	233.6	163.4	169.1	179.0	46.6	21.0	29.6
	Mix	148.5	211.1	212.2	229.0	167.2	177.4	174.2	44.0	19.8	29.9
	Pr > F	0.605	0.698	0.787	0.246	0.842	0.481	0.3914	0.797	0.497	0.216
Nashua	No cover	161.6	244.7	211.3	227.2	208.2	233.9	196.5	47.1	9.8	8.7
	Single	170.1	246.3	205.7	231.1	206.6	232.9	196.5	54.5	9.5	9.3
	Mix	167.3	246.4	208.3	224.9	207.4	236.3	199.1	45.7	9.7	8.1
	Pr > F	0.660	0.871	0.676	0.568	0.951	0.777	0.902	0.929	0.973	0.627
Lewis	No cover	227.6	238.4	212.3	223.2	212.3	242.4	216.2	5.5	14.6	12.4
	Single	216.3	245.0	219.8	208.5	209.5	246.8	205.8	6.0	21.3	12.8
	Mix	220.0	257.4	223.5	208.0	215.3	232.1	207.2	7.0	13.3	14.6
	Pr > F	0.499	0.365	0.691	0.227	0.758	0.357	0.609	0.126	0.460	0.834
Chariton	No cover	211.2	231.2	193.5					23.5	18.6	
	Single	221.2	231.6	199.0					29.6	23.2	
	Mix	232.3	234.4	195.6					34.8	28.4	
	Pr > F	0.531	0.963	0.942					0.410	0.566	
Crawfordsville	No cover	221.2	234.3	216.1a	234.24	207.6			64.3	9.6	9.9
	Single	212.2	239.5	198.0b	221.26	198.8			61.3	8.3	12.8
	Mix	209.5	237.1	215.6a	227.90	200.5			59.4	8.7	11.1
	Pr > F	0.506	0.395	0.018	0.523	0.633			0.730	0.555	0.058

[1]Values within the same row and variable sharing a letter are not statistically different (P = 0.05).

Table 2. Soybean grain yield and soil nitrate for a no cover control, single species (winter cereal rye), and cover crop mixture (winter cereal rye, rapeseed, radish) at six locations across Iowa.[1]

		Soybean yield							Soil nitrate test		
Location	**Treatment**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2015**	**2016**	**2017**
		bu/ac							ppm		
Sutherland	No cover	61.5a	70.4a	81.8					12.8	6.7	
	Single	57.9b	63.7b	79.5					12.6	5.3	
	Mix	58.9b	68.0ab	79.3					16.3	4.9	
	Pr > F	0.002	0.041	0.419					0.197	0.093	
Kanawha	No cover	36.8	55.7	62.5	59.1	45.7b	48.6	61.5	5.5a	6.7a	6.9a
	Single	42.1	48.9	58.9	56.6	51.3a	50.2	64.5	3.7b	4.4b	6.0b
	Mix	44.9	53.4	63.2	59.8	51.9a	49.0	62.8	4.3ab	4.6b	5.6b
	Pr > F	0.244	0.225	0.207	0.630	0.037	0.863	0.483	0.047	0.023	0.012
Nashua	No cover	70.9	75.8	69.1	64.6	68.8	69.8	70.7	7.4	7.2a	8.1a
	Single	71.4	75.4	66.2	61.7	67.5	70.8	69.2	5.3	5.2b	5.4b
	Mix	71.0	74.1	66.2	62.9	68.1	69.7	70.3	4.5	6.4ab	5.6b
	Pr > F	0.954	0.550	0.373	0.193	0.742	0.584	0.442	0.089	0.040	0.001
Lewis	No cover	79.2	76.3	73.9	64.0	51.3a	81.8	76.7	6.9	5.8	6.7
	Single	77.4	72.3	74.1	62.9	44.3b	75.9	71.9	7.9	4.7	8.2
	Mix	78.7	72.5	73.1	63.4	44.7ab	74.2	70.9	8.3	5.6	7.5
	Pr > F	0.864	0.541	0.978	0.974	0.071	0.204	0.395	0.231	0.198	0.181
Chariton	No cover	74.6	58.9	95.4					7.9	6.1	
	Single	71.7	51.5	97.2					5.9	4.2	
	Mix	73.6	48.9	98.2					6.0	5.1	
	Pr > F	0.771	0.435	0.452					0.538	0.115	
Crawfordsville	No cover	62.9	57.9	50.0	70.4	63.6			7.4	7.7a	10.6a
	Single	63.4	57.5	47.3	60.2	62.9			4.0	6.3ab	6.5b
	Mix	62.1	59.9	41.4	65.9	62.0			4.5	5.2b	6.0b
	Pr > F	0.911	0.624	0.112	0.100	0.661			0.301	0.037	0.012

[1]Values within the same row and variable sharing a letter are not statistically different (P = 0.05).

Table 3. Cover crop biomass growth for single species (oats), and cover crop mixture (oats, radish, hairy vetch) ahead of a corn cash crop at six locations across Iowa.*

Site-year	Fall growth			Spring growth		
	Single	Mix	Pr>F	Single	Mix	Pr>F
	lb/acre			lb/acre		
Crawfordsville 2015	0.1b	28.3a	0.006	0	0.0	
Crawfordsville 2016[a]	400.4	286.2	0.088	21.8	351.0	0.077
Crawfordsville 2017	1232.7b	1662.4a	0.002	0	0.0	
Crawfordsville 2018	9.2	16.2	0.124	0	0.0	
Kanawha 2015	303.9	261.5	0.578	0	0	
Kanawha 2016	158.9	110.8	0.238	0	0	
Kanawha 2017	353.4	311	0.377	0	0	
Kanawha 2018	131	87.7	0.346	0	0	
Kanawha 2019	291.3	290.1	0.970	0	0	
Kanawha 2020	10.4	4.7	0.084	0	0	
Lewis 2015	112.2	300.9	0.056	0	0.0	
Lewis 2016	243.1	335.1	0.178	0	0	
Lewis 2017	820.5	708.8	0.371	0	0	
Lewis 2018[b]	338.9	404.3	0.121	0	517.1	<0.0001
Lewis 2019[b]	607.9	510.1	0.374	0	512.6	0.003
Lewis 2020[b]	235.6	180.5	0.097	49.55	96.36	0.1807
Chariton 2015	<0.1	<0.1	.	0	0	
Chariton 2016	22.7b	71.4a	0.037	0	0.0	
Nashua 2015	267.1	363.6	0.168	0	0.0	
Nashua 2016[a]	372.9	361.5	0.852	0	247.2	0.002
Nashua 2017	593.9	621.9	0.660	0	0.0	
Nashua 2018	112.3	133.3	0.579	0	0.0	
Nashua 2019	41.6	220.8	0.336	0	0.0	
Nashua 2020	10.8	13.5	0.476	0	0	
Sutherland 2015	453.3	575.7	0.160	0	0.0	
Sutherland 2016	644.4	605.8	0.760	0	0.0	

[a]Spring growth at Crawfordsville in 2016 was both delayed germination of oats in some plots and hairy vetch surviving over winter.

[b]Spring growth at Lewis in 2018–2020 was hairy vetch surviving over winter.

*Values within the same row and variable sharing a letter are not statistically different (P = 0.05).

Table 4. Make-up of mixture in plots ahead of corn. Seeding rates were oats at 52 lb/acre, hairy vetch at 10 lb/acre, and radish at 4 lb/acre.

Site-year	Fall growth			Spring growth	
	Oats	Radish	Hairy vetch	Oats	Hairy vetch
	lb/acre			lb/acre	
Crawfordsville 2015	5.9	5.1	17.3		
Crawfordsville 2016	196.2	65.5	24.5	188.7	162.3
Crawfordsville 2017	981.5	529.1	151.8		
Crawfordsville 2018	10.2	<0.1	5.9		
Kanawha 2015	225.7	24.8	10.9		
Kanawha 2016	93.8	12.7	4.4		
Kanawha 2017	270.6	11.5	28.8		
Kanawha 2018	75.5	10.6	1.67		
Kanawha 2019	206.7	51.4	32		
Kanawha 2020	4.7	<0.1	<0.1		
Lewis 2015	183.8	88.4	28.8		
Lewis 2016	254.9	61.5	18.72		
Lewis 2017	575.8	104.8	28.12		
Lewis 2018	352.3	48.1	3.9		517.1
Lewis 2019	336.6	132.2	41.3		512.6
Lewis 2020	148.2	26.1	6.2	35.83	60.5
Chariton 2015	<0.1	<0.1	<0.1		
Chariton 2016	12.8	41.1	17.5		
Nashua 2015	307.4	40.8	15.4		
Nashua 2016	281.4	61.8	18.4	74.07	173
Nashua 2017	581.0	25.4	15.4		
Nashua 2018	107.9	18.6	6.8		
Nashua 2019	218.0	2.0	0.8		
Nashua 2020	10.9	0.1	2.6		
Sutherland 2015	490.9	53.6	31.2		
Sutherland 2016	426.5	125.7	53.6		

Table 5. Cover crop biomass growth for single species (winter cereal rye), and cover crop mixture (winter cereal rye, rapeseed, radish) ahead of a soybean cash crop at six locations across Iowa from 2015-2019.[1]

Site-year	Fall growth			Spring growth		
	Single	Mix	Pr>F	Single	Mix	Pr>F
	lb/acre			lb/acre		
Crawfordsville 2015	80.4	33.9	0.090	850.3a	318.9b	0.014
Crawfordsville 2016	362.6	268.1	0.271	1634.8	1126.1	0.059
Crawfordsville 2017	233.6	168.5	0.492	5544.0	4382.2	0.152
Crawfordsville 2018	6.3	7.7	0.239	346.7a	104.3b	0.012
Kanawha 2015	199.7	144.8	0.086	4372.6	3711.2	0.106
Kanawha 2016	130.1a	67.9b	0.005	2186.6	1847.5	0.597
Kanawha 2017	455.8a	325.2b	0.024	3677.3b	4389.2a	0.046
Kanawha 2018	67.01a	34.6b	0.028	2564.9	1378.7	0.068
Kanawha 2019	194.0	167.5	0.132	2782.7	3136.5	0.501
Kanawha 2020	4.8	4.2	0.757	318.5	188.0	0.067
Lewis 2015	471.0	319.9	0.180	823.5	593.0	0.159
Lewis 2016	365.9a	228.5b	0.020	1368.9	1399.7	0.928
Lewis 2017	752.2b	965.2a	0.002	813	479	0.055
Lewis 2018	54.1	57.8	0.697	2117.5	1008.1	0.060
Lewis 2019	236.2	257.1	0.565	1950.7a	927.9b	0.001
Lewis 2020	35.5a	11.1b	0.013	160.7	131.8	0.488
Chariton 2015	93.0	98.4	0.834	1450.3	868.1	0.203
Chariton 2016	149.3	187.4	0.558	750.3	596.9	0.449
Nashua 2015	187.1	173.4	0.678	2197.2a	1430.0b	0.002
Nashua 2016	76.3	66.9	0.774	1613.9	905.6	0.153
Nashua 2017	126.8	124.7	0.896	2842.6	2036.8	0.081
Nashua 2018	24.7	16.7	0.249	392.1a	165.0b	0.030
Nashua 2019	14.9	18.8	0.596	830.8	832.2	0.996
Nashua 2020	12.3	10.1	0.362	823.7	636.9	0.288
Sutherland 2015	102.2	111.3	0.626	2615.0a	1542.9b	0.025
Sutherland 2016	761.4	602.0	0.157	2615.8	2169.2	0.360

[1]Values within the same row and variable sharing a letter are not statistically different (P = 0.05).

Table 6. Make-up of mixture in plots ahead of soybean. Seeding rates were rye at 32 lb/acre, rapeseed at 2.5 lb/acre, and radish at 3.5 lb/acre.

Site-year	Fall growth				Spring growth	
	Rye	Rapeseed	Radish	Brassica[a]	Rye	Rapeseed
	lb/acre				lb/acre	
Crawfordsville 2015	30.6			3.2	318.9	
Crawfordsville 2016	211.5	18.9	37.7		1126.1	
Crawfordsville 2017	46.8	4.8	117		4382.2	
Crawfordsville 2018	3.1			4.5	104.3	
Kanawha 2014				8	54.5	
Kanawha 2015	107.9	12.9	24		3711.2	
Kanawha 2016	47.5	4	20.4		1847.5	
Kanawha 2017	317.1				4389.2	
Kanawha 2018	23.8			10.7	1378.7	
Kanawha 2019	124.8			42.6	3136.5	
Kanawha 2020	3.8			0.3	188.0	
Lewis 2015	184.3	97.1	38.5		593	
Lewis 2016	169.1	16.1	43.3		1399.7	
Lewis 2017	328.2	66.2	570.9		479	
Lewis 2018	32.3			25.4	1008.1	
Lewis 2019	122.0			134.9	927.9	
Lewis 2020	8.9			2.3	131.8	
Chariton 2015	85.2			13.1	868.1	
Chariton 2016	46.5	38.2	102.6		596.9	
Nashua 2015	127.9	18.5	27		1430	
Nashua 2016	47.9			19	876.5	29.1
Nashua 2017	92.1			32.5	2036.8	
Nashua 2018	7.2			9.5	165.0	
Nashua 2019	11.9	2.6	4.3		832.2	
Nashua 2020	9.2			0.9	636.9	
Sutherland 2015	55.2	22.5	33.6		1542.9	
Sutherland 2016	412.2	26.1	163.6		2169.2	

[a]Rapeseed and Radish were sometimes hard to distinguish and were counted together as Brassica.

Table 7. Suction lysimeter nitrate-N values in mg/L averaged over all years.[1]

Timeframe	Site	Crop	No cover	Mix	Single
			lysimeter nitrate-N mg/L[2]		
Annual 2014-2017	All	Corn	13.1a	10.8b	10.5b
Annual 2014-2017	All	Soybean	7.0a	4.3b	3.2c
Spring	All	Corn	15.9a	12.8b	12.2b
Spring	All	Soybean	9.6a	5b	3.7c
Cover crop growth (planting to termination)	All	Oats (radish, hairy vetch)	5.6a	3.9ab	3.4b
Cover crop growth (planting to termination)	All	Rye (rapeseed, radish)	8.0a	4.8b	3.4c
Spring 2014-2017	Crawfordsville	Corn	17.8a	15.4a	20.7a
Spring 2014-2017	Kanawha	Corn	17.1a	17.5a	17.7a
Spring 2014-2015	Lewis	Corn	17.4a	17.7a	13b
Spring 2014-2016	Chariton	Corn	27.8a	11.1b	11.1b
Spring 2014-2017	Nashua	Corn	11.8a	11.2a	7.8b
Spring 2014-2017	Crawfordsville	Soybean	12.1a	11a	5.3b
Spring 2014-2017	Kanawha	Soybean	7.9a	2b	2.1b
Spring 2014-2015	Lewis	Soybean	11.5a	15.3a	5.9b
Spring 2014-2016	Chariton	Soybean	9.8a	2.5b	2.4b
Spring 2014-2017	Nashua	Soybean	9a	5.7b	6b

[1]The three treatments were no cover, mix, and single cover crop species. Before corn, the single species treatment is oats and the mixture is oats, hairy vetch, and radish. Before soybean, the single species treatment is winter cereal rye and the mixture is rye, rapeseed, and radish.
[2]Values within the same row sharing a letter are not statistically different (P = 0.05).