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

RFR-A1867

Mark Licht, assistant professor
Department of Agronomy
Liz Juchems, conservation outreach specialist
Iowa Learning Farms
Matthew Helmers, professor
Emily Waring, PhD student
Agricultural and Biosystems Engineering
Sarah Carlson, Midwest cover crop research coordinator
Practical Farmers of Iowa

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. The project was continued in fall 2016 at four sites and three sites were seeded for the sixth year in 2018.

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, spring and fall cover crop biomass, late spring nitrate-nitrogen, and cash crop yield data were collected to evaluate the establishment of the cover crops and potential yield impacts. 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 26 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. Late spring nitrate samples were not statistically different within any site-year. Total fall biomass dry matter was significant in 2 of 17 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). Cover crop biomass from 2015 can be found in the previous farm progress reports at https://lib.dr.iastate.edu/farmprogressreports/vol2017/iss1/9/.

Soybean grain yields were not statistically different in 22 of 26 site-years (Table 2). June soil nitrate-nitrogen was significant 7 of 16 site-years. In each of those site-years, the no cover treatment had higher soil nitrate-nitrogen. Difference in total fall biomass dry matter was significant in 4 of 19 site-years (Table 4). In 3 of the 4 site-years, the single species cereal rye cover crop had more biomass than the cover crop mixture treatment.

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 nitrate concentrations and fall had the lowest. Rye statistically reduced average spring nitrate at every site compared with no cover. The rye mixture and oats single species statistically reduced average spring 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 averaging below 10 mg/L, including the no cover plots (Table 5).

Acknowledgements

This project is funded by USDA-NRCS through a National Conservation Innovation Grant and the Leopold Center for Sustainable Agriculture. Partners on the project include Iowa Learning Farms under the leadership of Jacqueline Comito, Practical Farmers of Iowa, NRCS, 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**	**2015**	**2016**	**2017**
		bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	ppm	ppm	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	0.7018	0.5055	0.9250			0.8234	0.1053	
Kanawha	No cover	145.1	214.0	213.1	220.8	162.3	42.0	23.9	26.7
	Single	141.9	209.4	216.6	233.6	163.4	46.6	21.0	29.6
	Mix	148.5	211.1	212.2	229.0	167.2	44.0	19.8	29.9
	Pr > F	0.6054	0.6981	0.7868	0.2460	0.8416	0.7973	0.4966	0.2164
Nashua	No cover	161.6	244.7	211.3	227.2	208.2	47.1	9.8	8.7
	Single	170.1	246.3	205.7	231.1	206.6	54.5	9.5	9.3
	Mix	167.3	246.4	208.3	224.9	207.4	45.7	9.7	8.1
	Pr > F	0.6598	0.8712	0.6760	0.5676	0.9511	0.9287	0.9727	0.6273
Lewis	No cover	227.6	238.4	212.3	223.2	212.3	5.5	14.6	12.4
	Single	216.3	245.0	219.8	208.5	209.5	6.0	21.3	12.8
	Mix	220.0	257.4	223.5	208.0	215.3	7.0	13.3	14.6
	Pr > F	0.4986	0.3654	0.6909	0.2273	0.7582	0.1256	0.4595	0.8338
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	0.5307	0.9629	0.9418			0.4102	0.5663	
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	0.5057	0.3945	**0.0175**	0.5227	0.6332	0.7300	0.5546	0.0581

[1]Statistically significant site-years are denoted by bold font.

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**	**2015**	**2016**	**2017**
		bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	ppm	ppm	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	**0.0021**	**0.0407**	0.4186			0.1971	0.0928	
Kanawha	No cover	36.8	55.7	62.5	59.1	**45.7b**	**5.5a**	**6.7a**	**6.9a**
	Single	42.1	48.9	58.9	56.6	**51.3a**	**3.7b**	**4.4b**	**6.0b**
	Mix	44.9	53.4	63.2	59.8	**51.9a**	**4.3ab**	**4.6b**	**5.6b**
	Pr > F	0.2437	0.2251	0.2068	0.6303	**0.0366**	**0.0470**	**0.0234**	**0.0119**
Nashua	No cover	70.9	75.8	69.1	64.6	68.8	7.4	**7.2a**	**8.1a**
	Single	71.4	75.4	66.2	61.7	67.5	5.3	**5.2b**	**5.4b**
	Mix	71.0	74.1	66.2	62.9	68.1	4.5	**6.4ab**	**5.6b**
	Pr > F	0.9536	0.5498	0.3732	0.1929	0.7423	0.0886	**0.0397**	**0.0006**
Lewis	No cover	79.2	76.3	73.9	64.0	**51.3a**	6.9	5.8	6.7
	Single	77.4	72.3	74.1	62.9	**44.3b**	7.9	4.7	8.2
	Mix	78.7	72.5	73.1	63.4	**44.7ab**	8.3	5.6	7.5
	Pr > F	0.8640	0.5405	0.9775	0.9741	**0.0706**	0.2313	0.1975	0.1809
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	0.7712	0.4354	0.4515			0.5382	0.1152	
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	0.9110	0.6238	0.1123	0.1050	0.6612	0.3011	**0.0367**	**0.0117**

[1]Statistically significant site-years are denoted by bold font.

Table 3. Fall cover crop biomass growth for a no cover control, single species (oats), and cover crop mixture (oats, radish, hairy vetch) ahead of a corn cash crop at six locations across Iowa.[1]

Location	Treatment	2016				2017				2018			
		Total biomass	Oats	Radish	Vetch	Total biomass	Oats	Radish	Vetch	Total biomass	Oats	Radish	Vetch
		lb biomass/acre											
Sutherland	Single	644.4	644.4										
	Mix	623.6	426.5	125.7	71.4								
	Pr > F	0.7597	0.1123										
Kanawha	Single	158.9	158.9			353.4	353.4			291.3	**291.3**		
	Mix	127.9	93.8	16.8	17.3	311	270.6	11.5	28.8	290.1	**206.7**	51.4	32
	Pr > F	0.2369	0.0979			0.3773	0.1256			0.9703	**0.0197**		
Nashua[2]	Single	372.9	372.9			593.9	593.9			41.6	41.6		
	Mix	367.6ł	281.3	61.8	24.4	621.9	581	25.4	15.4	220.8	218	2	0.74
	Pr > F	0.8521	0.1887			0.6599	0.8144			0.3362	0.3436		
Lewis	Single	243.1	243.1			820.5	**820.5**			607.9	**607.9**		
	Mix	335.1	254.9	61.5	18.7	708.8	**575.8**	104.8	28.1	510.1	**336.6**	132.2	41.3
	Pr > F	0.1782	0.8515			0.3707	**0.0336**			0.3738	**0.0202**		
Chariton	Single	**22.7**	22.7										
	Mix	**81.5**	17	41.1	23.3								
	Pr > F	**0.0371**	0.1431										
Crawfordsville[3]	Single	400.4	**400.4**			**1232.7**	**1232.7**						
	Mix	286.2	**196.1**	65.5	24.5	**1662.4**	**981.5**	529.1	151.8				
	Pr > F	0.0878	**0.0086**			**0.0021**	**0.0241**						

[1]Statistically significant site-years are denoted by bold font.

[2]In Nashua 2016, there was some oat (74.1 lb/ac) and hairy vetch (173.1 lb/ac) biomass due to spring germination and growth.

[3]In Crawfordsville 2016, there was some oat (single, 43.5 lb/ac; mix, 251.6 lb/ac) and hairy vetch (mix, 162.3 lb/ac) biomass due to spring germination and growth.

Table 4. Cover crop biomass growth for a no cover control, 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 in 2015.

		2016				2017				2018			
Location	**Treatment**	**Total fall biomass**	**Fall brassica[2]**	**Fall rye**	**Spring rye**	**Total fall biomass**	**Fall brassica[3]**	**Fall rye**	**Spring rye**	**Total fall biomass**	**Fall brassica[4]**	**Fall rye**	**Spring rye**
		lb biomass/acre											
Sutherland	Single	761.4		**761.4**	2615.8								
	Mix	680	267.8	**412.2**	2169.2								
	Pr > F	0.1563		**0.0133**	0.3601								
Kanawha	Single	**130.1**		**130.1**	2186.6	**455.8**		**455.8**	**3677.3**	193.4.0		**194**	2564.9
	Mix	**85**	37.5	**47.5**	1847.5	**327.7**	10.6	**317.1**	**4389.2**	167.4	42.6	**124.8**	1378.7
	Pr > F	**0.0052**		**0.0052**	0.5969	**0.0236**		**0.018**	**0.0464**	0.1308		**0.0002**	0.0683
Nashua	Single	76.3		76.3	1613.9	126.8		126.8	2842.6	14.9		14.9	**392.1**
	Mix	66.8	19	47.9	876.5	124.6	32.5	92.1	2036.8	18.8	6.9	11.9	**165.03**
	Pr > F	0.7717		0.4045	0.1283	0.8911		0.0691	0.0813	0.5955		0.6741	**0.0298**
Lewis	Single	**365.9**		**365.9**	1368.9	**752.2**		**752.2**	813	236.2		**236.2**	2117.5
	Mix	**244.5**	75.4	**169.1**	1399.7	**965.2**	637	**328.2**	479	257	134.9	**122.1**	1344.1
	Pr > F	**0.0199**		**0.0035**	0.9284	**0.0023**		**0.0001**	0.0547	0.5664		**0.0048**	0.1133
McNay	Single	149.3		149.3	750.3								
	Mix	187.4	140.8	46.5	596.9								
	Pr > F	0.558		0.1321	0.4491								
Crawfordsville	Single	362.6		362.6	1634.8	233.6		233.6	5544				**346.7**
	Mix	286.8	75.3	211.5	1126.1	173.2	126.4	46.8	4382.2				**138.97**
	Pr > F	0.2712		0.0008	0.0593	0.4916		0.062	0.1517				**0.0309**

[1]Statistically significant site-years are denoted by bold font.

[2]Sutherland and McNay 2016, radish 1.5 times and 2.5 times, respectively, greater than rapeseed otherwise quantities are roughly the same. Nashua 2016, had 58.2 lb/ac of spring rapeseed biomass from spring germination and growth.

[3]Lewis and Crawfordsville 2017, radish was 8.6 times and 12.5 times, respectively, greater than rapeseed whereas there was no rapeseed identified at Kanawha and Nashua.

[4]In 2018, Kanawha, Nashua, and Lewis had rapeseed and radish quantities the same.

Table 5. Cover crop suction lysimeter nitrate-N values in mg/L averaged over all years.[1]

Timeframe	Site	Crop	No cover[2]	Mix[2]	Single[2]
				mg/L	
Annual 2014-2017	All	Corn	13.1a	10.8b	10.5b
Annual 2014-2017	All	Soybeans	7.0a	4.3b	3.2c
Spring	All	Corn	15.9a	12.8b	12.2b
Spring	All	Soybeans	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	Soybeans	12.1a	11a	5.3b
Spring 2014-2017	Kanawha	Soybeans	7.9a	2b	2.1b
Spring 2014-2015	Lewis	Soybeans	11.5a	15.3a	5.9b
Spring 2014-2016	Chariton	Soybeans	9.8a	2.5b	2.4b
Spring 2014-2017	Nashua	Soybeans	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).