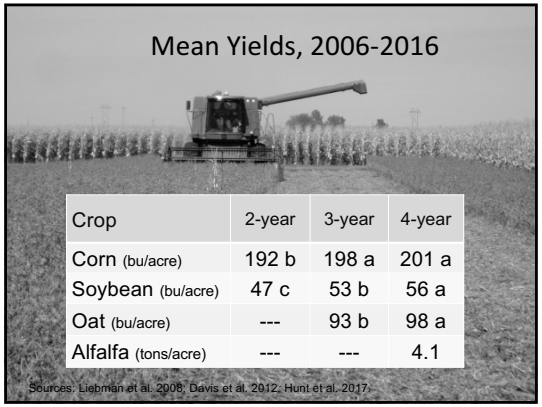
Mean annual mineral N fertilizer and herbicide use, 2006-2016

	N fertilizer			Herbicides		
Rotation	2-year	3-year	4-year	2-year	3-year	4-year
	lb N/acre			lb a.i./acre		
Corn	152	29	24	1.18	0.06	0.06
Soybean	2	2	2	1.45	0.10	0.10
Oat	--	2	2	--	0	0
Alfalfa	--	--	2	--	--	0
Rotation av.	77	11	7	1.32	0.05	0.04
Reduction		-86%	-91%		-96%	-97%

Mean Yields, 2006-2016



Crop	2-year	3-year	4-year
Corn (bu/acre)	192 b	198 a	201 a
Soybean (bu/acre)	47 c	53 b	56 a
Oat (bu/acre)	---	93 b	98 a
Alfalfa (tons/acre)	---	---	4.1

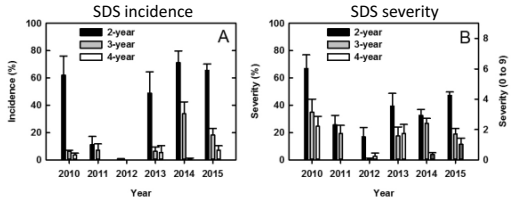
Sources: Liebman et al. 2008; Davis et al. 2012; Hunt et al. 2017.

Mean weed biomass in 2006-2016 was low in the corn and soybean phases of each system. Weed growth was greater in oat and alfalfa phases.

Crop phase	2-year: Corn-Soybean	3-year: Corn-Soybean-Oat/Red Clover	4-year: Corn-Soybean-Oat/Alfalfa-Alfalfa
		lb/acre	
Corn	2 b	13 a	8 ab
Soybean	3 b	18 a	7 b
Oat/legume	---	68 a	64 a
Alfalfa	---	---	52

Within rows, means followed by different letters are significantly different.

Large reduction in soybean sudden death syndrome in longer rotations



Leandro et al. (in press)

Soil Quality Indicators in Corn

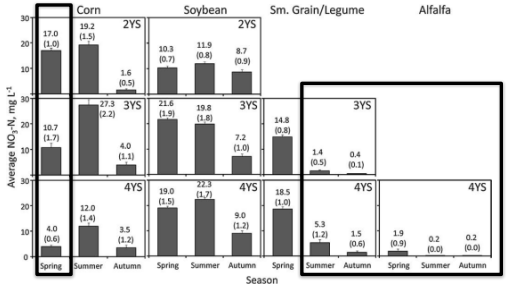
(0-20 cm)

Rotation	Particulate organic matter carbon	Microbial biomass carbon	Potentially mineralizable nitrogen
	mg POM-C cm^{-3} soil	µg C g^{-1} soil	mg PMN cm^{-3} soil
2-year	1.90 b	312.6 b	31.2 b
3-year	2.31 a	388.7 ab	40.4 a
4-year	2.19 a	472.2 a	37.3 ab

Soil managed with longer rotations had more POM-C, greater microbial biomass, and higher PMN.

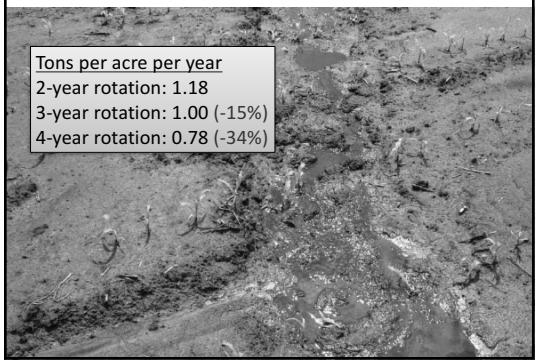
Sources: Lazicki et al., 2016; King and Hofmockel, 2017

Mean NO_3-N concentrations in water samples collected under each cropping system, 2004-2011



Tomer & Liebman (2014)

Estimated Sheet and Rill Erosion (RUSLE2)

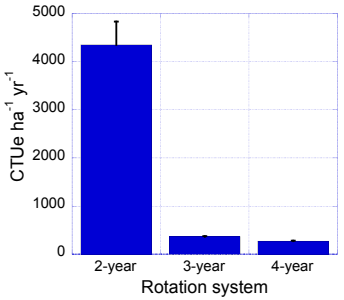


Fossil Energy Inputs [GJ ha^{-1} yr^{-1}], 2008-2014

	2-Year Rotation	3-Year Rotation	4-Year Rotation
Fuel for Operations	2.6	2.0	1.8
Fertilizer	5.5	0.9	0.9
Herbicide	0.4	0.3	0.2
Seed Production	0.3	0.3	0.3
Grain Drying	1.5	1.0	0.8
Total Energy Costs	**10.3**	**4.5**	**3.9**

About 0.6 barrels of oil equivalent = about 25 gallons diesel equivalent per acre

Freshwater ecotoxicological potential of herbicides in contrasting rotations, 2008-2016, USEtox model



Hunt et al. 2017

Labor and economics, 2008-2016

	Rotation		
	2-year	3-year	4-year
Labor inputs (hr/acre)	0.7 c	1.2 b	1.4 a
Gross returns ($/acre)	688 a	610 b	638 b
Costs of production (with labor, but not land, $/acre)	353 a	253 c	277 b
Profits (returns to land and management, $/acre)	335 a	357 a	361 a

Diversity → greater labor requirements, lower gross returns, lower costs, similar profits

Hunt et al. 2017 and unpublished data