Purdue Agronomy
crop, soil, and environmental sciences

2018

Long-term Tillage Study Year 44

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Cover photo: Terry West planting with John Deere tractor and J.D. model 1780 6-row planter. (2014 to present)

Inset cover photo: Don Griffith planting with Ford 8000 tractor and Allis-Chalmers planter (1975 through 1978).

Don Griffith planting with Ford 8000 tractor and a Buffalo-Till planter on ridges. (1970's)

Introduction

Early evaluation of reduced tillage systems in the Midwest centered on well-drained and/or erosive soils. Due to reduced water erosion and savings in soil moisture, systems leaving 70% or more of the soil surface covered with residue often increased yield potential on these soils. These findings could not be generalized, however, to the dark silty clay loam soils of the Eastern Corn Belt where soil moisture and erosion were less severe problems.

Beginning in 1975, a range of tillage systems have been compared annually on Chalmers silty clay loam soil (4% OM) at the Purdue Agronomy Center for Research and Education (ACRE) in West-central Indiana. Our goals are to determine long-term yield potential of the different systems and to determine changes in soil characteristics and crop growth that could be associated with yield differences. Plow, chisel, ridge-till (discontinued in 2008) strip-till, and no-till systems are compared for continuous corn, corn following soybeans, soybeans following corn, and continuous soybeans. There are 4 replications; individual plots are 30-feet wide and 150-feet long.

Terry West planting with Ford 8000 tractor and a J.D. model 7000 planter (1979 through 1996)

Soil and Crop Management

Cultural practices have been relatively consistent since the study began. Plowing and chiseling were done in the fall with 1 disking and/or 1 or 2 field cultivation passes for spring seedbed preparation. For the ridge system, ridges were made at the time of inter-row cultivation in corn and after harvest in soybeans. (The ridge system was replaced with strip-till for 2010 and beyond.) Row width for corn is 30-inches. Both moldboard and chisel plowed corn plots were also inter-row cultivated until 2008. No-till has never been inter-row cultivated. Row width for soybeans was 30-inches for soybeans in all treatments from 1975 to 1994. Starting in 1995, soybeans were drilled in 7.5-inch rows for plow, chisel and no-till treatments, but the ridge treatment remained at 30-inches. Due to the threat of soybean rust disease, all soybean treatments were switched back to 30-inch rows starting in 2005. We concluded that the mechanical damage to plants during possible fungicide application(s) most likely would have greatly reduced yield in the harvest area of drilled soybeans. Soybean plots have not been inter-row cultivated since 2004.

Hiniker ridge-till cultivator used through 2008.

Starter fertilizer was used for all corn plots (except in 2010), but not for soybeans. Placement was 2-inches to the side and 2-inches below the seed. The nitrogen source for corn was anhydrous ammonia through 2000 (either pre-plant or side-dress) and liquid UAN (28%) (always side-dress applied) starting in 2001. Total nitrogen applied generally exceeded 180 lbs/acre of actual N. Phosphorus, potassium and lime were surface-applied as needed.

Corn planting dates ranged from April 5 to May 31 and soybean dates from April 25 to June 21; however, all tillage treatments were planted on the same day each year. One-inch fluted, 2-inch fluted or bubble coulters were used ahead of planter disk openers from 1975 to 1996. Starting in 1997, no coulters were used ahead of disk openers as per planter manufacturer recommendation; however, tined row cleaners were used in no-till corn treatments. For ridge planting, horizontal disks were used to scrape ridges at planting from 1980 to 1996 and then we switched to planter-mounted, double-vertical disks in 1997. Strip-till, which replaced ridge-till in 2010, was accomplished with a Remlinger brand toolbar equipped with row cleaners, a shank set for 8-inches deep, and concave disks to catch soil from the shank and deposit it on the shank track.

Burndown herbicides were applied to control existing vegetation when needed. Pre-emergence herbicides were applied with the planting pass from 1975 through 1996. Starting in 1997, pre-emergence herbicides were applied after planting in a separate operation. Post-applied herbicides were used for weed escapes. Where needed, plots were hand weeded to ensure that weed control did not limit yield. Insecticides were applied at planting for corn rootworm control until 2008 when we switched to genetically modified corn hybrids. Chemical control for cutworms, stalk borers, bean leaf beetle, rodents, and spider mites was applied as needed.

The ridge-till treatment was discontinued after harvest in the fall of 2008. These plots were chisel plowed and disked to destroy the ridges after fall harvest and then strip-tilled in March of 2009. Heavy rains in April and May of 2009 leveled the strips to the point of being unrecognizable. We decided to use 2009 as a set-up year and to field cultivate once more before planting in 2009. Strips were successfully established in the fall of 2009 with 2010 becoming the first data year for strip-till.

Fourteen corn hybrids and 19 soybean varieties have been used during the 44 years of this project.

Case-IH 5240 tractor and model 955 Cyclo planter (1997 through 2013).

Researchers Involved

Dr. Jerry V. Mannering, Harry Galloway and Donald R. Griffith initiated the experiment in 1975 and continued to direct it until their respective retirements in 1989, 1980, and 1995. Terry D. West has managed the experiment from 1979 until present. Dr. Tony J. Vyn became involved in 1998, after moving from Canada where he had been involved in tillage research for 20 years.

Numerous faculty and graduate students have conducted research on this experiment over the years. Most of the efforts were directed towards soil physical properties (Drs. Mannering, Kladivko and Steinhardt), soybean diseases (Drs. Abney and Westphal), corn and soybean production (Griffith and Dr. Swearingin), agricultural engineering (Dr. Parsons), soil microbiology (Drs. Nakatsu, Turco and Brouder), soil fertility (Dr. Mengel) and entomology (Bledsoe).

Planting with John Deere 1780 planter, 2013 to present

Table 1. Planting dates for corn and soybean, Long-term Tillage Study, ACRE.

	Year	Corn	Soybean		Year	Corn	Soybean
1	1975	5/2	5/6	23	1997	4/29	5/16
2	1976	4/29	5/10	24	1998	5/14	5/18
3	1977	5/10	5/6	25	1999	5/12	5/21
4	1978	5/3	5/19	26	2000	4/26	5/24
5	1979	5/9	5/17	27	2001	5/2	5/10
6	1980	5/5	5/15	28	2002	5/29	5/29
7	1981	5/22	5/28	29	2003	5/23	5/27
8	1982	4/30	5/11	30	2004	4/29	6/4
9	1983	5/10	5/12	31	2005	4/19	5/5
10	1984	5/2	5/14	32	2006	4/29	5/31
11	1985	4/25	5/16	33	2007	5/5	5/7
12	1986	4/29	5/28	34	2008	5/1	5/28
13	1987	5/5	5/7	35	2009*	5/23 (6/25)	5/27
14	1988	4/26	5/12	36	2010	4/19	5/30
15	1989	4/25	5/12	37	2011	5/12	5/12
16	1990	4/26	5/21	38	2012	4/5	4/25
17	1991	5/10	5/16	39	2013	5/15	5/17
18	1992	5/5	5/8	40	2014	4/24	5/23
19	1993	5/11	5/12	41	2015	5/23	5/22
20	1994	5/22	5/17	42	2016	4/20	5/23
21	1995	5/22	6/1	43	2017	4/24	4/25
22	1996	5/31	6/21	44	2018	5/1	5/1

*All corn plots were replanted due to herbicide application error.

The Journal of Production Agriculture article titled “Effect of Tillage and Rotation on Agronomic Performance of Corn and Soybean: Twenty-Year Study on Dark Silty Clay Loam Soil” gives a detailed report of this research project. This article can be found in volume 9, no. 2, page 241 to 248, 1996.

Don Griffith at field day stop.

Jerry Mannering educating a youngster.

Terry West, Tony Vyn, and Alicia West.

Table 2. Soil test results based on composite samples, Long-term Tillage Study, ACRE, Summer 2018.

Rotation	Tillage	Soil OM 0-2"	Soil OM 2-4"	Soil OM 4-8"	Soil OM 8-12"	Soil OM Mean*	Soil pH 0-2"	Soil pH 2-4"	Soil pH 4-8"	Soil pH 8-12"	Soil pH Mean*	Soil P 0-2"	Soil P 2-4"	Soil P 4-8"	Soil P 8-12"	Soil P Mean*	Soil K 0-2"	Soil K 2-4"	Soil K 4-8"	Soil K 8-12"	Soil K Mean*
												ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
BB	Plow	3.9b	3.9ab	3.8ab	3.3	3.8b	7.2	7.3a	7.3a	7.1a	7.3a	61b	61ab	60a	29a	61a	214b	212	220a	174a	215
	Chisel	3.9b	3.7b	3.6ab	3.1	3.7b	7.3	7.3a	7.0ab	7.0ab	7.2a	79a	72.5a	41b	19b	64a	267ab	247	195ab	155ab	236
	Strip-till	3.8b	3.6b	3.5b	3.1	3.6b	7.2	7.1b	6.8bc	6.3c	7.0b	78ab	73.8c	23c	12b	48b	267ab	199	147c	128b	204
	No-till	4.6a	4.2a	4.0a	3.2	4.2a	7.2	7.1b	6.6c	6.6bc	6.9b	94a	52.8bc	33bc	12b	60a	300a	223	158bc	129b	227
	Average	4.0	3.8	3.7	3.2	3.7	7.2	7.2	6.9	6.7	7.0	78	58	39	18	48	262	220	180	146	202
	LSD	*0.3*	*0.5*	*0.5*	*0.6*	*0.4*	*0.2*	*0.2*	*0.3*	*0.4*	*0.2*	*17*	*14.0*	*17*	*9.5*	*10*	*61*	*71*	*45*	*29*	*54*
BC	Plow	4.1c	4.3b	4.1b	3.4b	4.2c	7.2a	7.2a	7.2a	7.2a	7.2a	51b	49bc	40	22	47b	202b	220	212a	170	211
	Chisel	4.8b	4.6a	4.1b	3.2b	4.5b	7.2a	7.2a	7.1a	6.9a	7.2a	85a	66ab	37	14	63ab	313ab	227	181b	136	240
	Strip	4.9b	4.5a	4.2b	3.3b	4.5b	7.1b	6.8b	6.2b	6.2b	6.7b	96a	72a	48	22	72a	365a	235	176b	140	259
	No-till	5.9a	4.5a	4.6a	3.8a	5.0a	7.2a	6.6c	6.1b	6.3b	6.6c	81a	44c	31	18	52b	401a	222	166b	142	263
	Average	4.9	4.5	4.2	3.4	4.3	7.2	6.9	6.6	6.6	6.8	78	57	39	19	48	320	226	184	147	219
	LSD	*0.6*	*0.2*	*0.3*	*0.3*	*0.3*	*0.1*	*0.2*	*0.3*	*0.4*	*0.2*	*26*	*17*	*22*	*14*	*19*	*126*	*70*	*26*	*37*	*68*
CB	Plow	4.0c	4.1b	3.9b	3.2b	4.0b	7.2a	7.3a	7.2a	7.2a	7.2a	45b	65.5	44	21	51	227b	229	220a	166	226
	Chisel	4.8b	4.8a	4.0ab	3.6ab	4.6a	7.0b	7.1ab	7.0a	6.8b	7.0b	77a	76.8	36	21	63	301ab	273	200ab	162	258
	Strip	5.5a	4.7ab	4.4a	3.8a	4.8a	7.0b	7.0b	6.4b	6.2c	6.8c	87a	64.8	43	22	65	371a	255	178ab	138	268
	No-till	5.7a	4.7ab	4.2ab	3.4ab	4.9a	7.1ab	6.5c	5.9c	6.1c	6.5d	86a	63.8	32	12	60	363a	226	159b	133	249
	Average	5.0	4.6	4.1	3.5	4.3	7.1	7.0	6.6	6.6	6.8	74	68	39	19	50	316	246	189	149	225
	LSD	*0.6*	*0.6*	*0.4*	*0.4*	*0.4*	*0.2*	*0.2*	*0.2*	*0.3*	*0.1*	*24*	*38*	*15*	*14*	*24*	*107*	*78*	*59*	*41*	*71*
CC	Plow	4.0b	4.1	4.1	3.5ab	4.1c	7.0	7.1a	7.1a	7.0a	7.1a	48c	49	46	31	48	208c	237ab	228a	184a	224b
	Chisel	4.6b	4.4	3.9	3.3b	4.3bc	7.0	7.1a	6.8a	6.6b	7.0a	69bc	64	40	19	58	335b	269ab	203a	149b	269ab
	Strip	5.6a	4.6	4.2	3.8a	4.8ab	7.1	6.7b	6.1b	6.2c	6.6b	77b	65	36	19	59	441a	230b	156b	147b	276ab
	No-till	6.4a	4.5	4.3	3.6ab	5.0a	7.1	6.6b	6.1b	6.1c	6.6b	101	58	42	18	67	414a	302a	203a	144b	306a
	Average	5.1	4.4	4.1	3.5	4.3	7.1	6.9	6.5	6.5	6.7	74	59	41	55	49	350	259	197	156	241
	LSD	*0.8*	*0.5*	*0.6*	*0.4*	*0.6*	*0.1*	*0.3*	*0.4*	*0.3*	*0.2*	*22*	*21*	*28*	*19*	*21*	*69*	*71*	*46*	*30*	*56*

Average of 4 replications. *Mean is 0-8"

Table 2 continued. Soil test results based on composite samples, Long-term Tillage Study, ACRE, Summer 2018.

Rotation	Tillage	Soil Ca 0-2"	Soil Ca 2-4"	Soil Ca 4-8"	Soil Ca 8-12"	Soil Ca Mean*	Soil Mg 0-2"	Soil Mg 2-4"	Soil Mg 4-8"	Soil Mg 8-12"	Soil Mg Mean*	Soil CEC 0-2"	Soil CEC 2-4"	Soil CEC 4-8"	Soil CEC 8-12"	Soil CEC Mean*	Sulfur 0-2"	Sulfur 2-4"	Sulfur 4-8"	Sulfur 8-12"	Sulfur Mean*
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm						ppm	ppm	ppm	ppm	ppm
BB	Plow	3291a	3291a	3323	3396	3301a	888a	885a	893	921a	888a	24.5a	24.4a	24.7	25.1	24.5a	5.3	4.3b	5.8ab	4.0	5.1b
	Chisel	3079a	3221a	3338	3312	3212a	835ab	855ab	878	891a	856ab	23.1a	23.9a	24.7	24.6	23.9ab	5.8	5.5ab	4.3c	4.8	5.2b
	Strip-till	2770b	3001b	3153	2966	2975b	790b	804b	820	767b	795c	20.9b	22.3b	24.3	24.6	22.5b	5.8	6.0a	5.3bc	5.3	5.7ab
	No-till	3031ab	3088ab	3204	3373	3108ab	824ab	832ab	835	848ab	830bc	22.8ab	23.0b	25.8	26.4	23.9ab	6.3	5.8a	7.0a	3.8	6.3a
	Average	3043	3150	3254	3262	3177	826	844	856	857	846	22.8	23.4	24.9	25.2	24.1	5.8	5.4	5.6	4.4	5.6
	LSD	*282*	*216*	*327*	*569*	*204*	*91*	*58*	*75*	*120*	*57*	*2.0*	*1.5*	*2.6*	*3.8*	*1.5*	*1.3*	*1.5*	*1.5*	*1.9*	*1.1*
BC	Plow	3429a	3339a	3421a	3546	3396a	949	914b	945a	952a	936a	25.6	25.0b	25.6c	26.1	25.4b	6.0b	6.3b	5.8b	4.3bc	6.0b
	Chisel	3210ab	3386a	3489a	3286	3361a	958	983a	957a	888a	966a	24.9	25.7ab	26.0bc	24.7	25.5b	7.0ab	7.0b	6.5b	3.3c	6.8a
	Strip	3236ab	3345a	3230b	3159	3270a	939	1000a	884b	786b	941a	25.0	26.7a	27.9a	27.0	26.5a	7.3a	9.3a	9.8a	6.0a	8.8b
	No-till	3134b	3119	3017c	3252	3090b	882	862b	793c	749b	846b	24.1	25.5b	26.7b	26.1	25.4b	7.8a	9.0a	9.3a	5.3ab	8.7a
	Average	3252	3297	3289	3311	3287	932	940	894	844	902	24.9	25.7	26.5	26.0	25.8	7.0	7.9	7.8	4.7	7.6
	LSD	*228*	*195*	*138*	*400*	*148*	*84*	*56*	*52*	*90*	*49*	*1.5*	*1.0*	*1.1*	*2.6*	*.09*	*1.1*	*1.0*	*2.5*	*1.7*	*1.1*
CB	Plow	3174	3285	3298b	3447	3252	882b	936	913b	954ab	910b	23.8b	24.9b	24.7b	25.7b	24.5b	4.8c	6.3b	5.0c	5.0b	5.3b
	Chisel	3367	3383	3710a	3722	3487	997a	992	1063a	996a	1017a	26.1a	26.0b	28.3a	28.3ab	26.8a	6.8bc	6.5b	6.3b	4.5b	6.5b
	Strip	3189	3386	3142b	3512	3329	946a	987	963ab	901bc	965ab	25.1ab	26.2ab	28.9a	29.3a	26.7a	9.5a	8.0ab	9.0a	6.8a	8.8a
	No-till	3244	3304	3241b	3476	3263	954a	962	872b	837c	929b	25.2ab	27.9a	29.3a	29.3a	27.4a	8.5ab	9.3a	9.3a	5.3b	9.0a
	Average	3243	3339	3415	3539	3384	945	969	953	922	947	25.1	26.2	27.8	28.2	26.8	7.4	7.5	7.4	5.4	7.4
	LSD	*281*	*295*	*291*	*347*	*241*	*65*	*91*	*101*	*77*	*77*	*1.9*	*1.8*	*2.3*	*2.8*	*1.7*	*2.4*	*2.0*	*1.1*	*1.1*	*1.5*
CC	Plow	3034	3144	3301	3327	3160	894	949ab	962a	980a	935	23.3	24.2	25.3	25.4b	24.3	6.3	6.3b	6.5c	6.0	6.3b
	Chisel	2883	3121	3218	3162	3074	875	995a	935a	888b	935	22.7	24.7	25.5	25.3b	24.3	7.3	7.3b	7.0bc	4.5	7.2b
	Strip	2919	3015	3049	3176	2994	916	947ab	833b	821bc	898	23.5	24.7	26.6	27.1ab	24.9	8.0	9.5a	9.3ab	6.5	8.9a
	No-till	3014	3013	2985	3263	3004	921	912b	836b	794c	889	23.9	25.9	27.2	27.9a	25.7	8.0	9.8a	10.3a	6.0	9.3a
	Average	2962	3073	3138	3232	3101	901	951	891	871	904	23.3	24.9	26.1	26.4	25.2	7.4	8.2	8.3	5.8	7.9
	LSD	*306*	*161*	*329*	*282*	*197*	*60*	*63*	*74*	*83*	*50*	*2.0*	*2.2*	*2.1*	*2.2*	*1.5*	*2.0*	*2.0*	*2.5*	*2.6*	*1.6*

Average of 4 replications. *Mean is 0-8”

Table 2 continued. Soil test results based on composite samples, Long-term Tillage Study, ACRE, Summer 2018.

		Zinc					Manganese					Iron					Boron				
Rotation	Tillage	0-2”	2-4”	4-8”	8-12”	Mean*	0-2”	2-4”	4-8”	8-12”	Mean*	0-2”	2-4”	4-8”	8-12”	Mean*	0-2”	2-4”	4-8”	8-12”	Mean*
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
BB	Plow	1.4c	1.4b	1.4a	0.9	1.4b	26	26	27a	18a	26	117	118	119ab	92	118	0.8b	0.7	0.8a	0.7a	0.8ab
	Chisel	1.9ab	1.8a	1.5b	0.8	1.6a	28	28	15ab	13b	23	113	114	94c	69	107	1.9ab	0.9	0.7ab	0.6a	0.8ab
	Strip-till	1.7b	1.4b	1.4c	0.7	1.4b	28	21	13b	11b	20	103	108	106bc	88	106	1.b9	0.7	0.6b	0.4b	0.7b
	No-till	2.1a	1.5b	1.5ab	0.7	1.6a	24	14	10b	12b	16	115	110	129a	74	118	1.a1	0.8	0.7ab	0.6a	0.9a
	Average	1.7	1.5	1.5	0.8	1.5	26	22	16	14	21	112	113	112	81	112	0.9	0.8	0.7	0.6	0.8
	LSD	*0.3*	*0.3*	*0.2*	*0.2*	*0.1*	*9*	*15*	*12*	*4*	*11*	*16*	*20*	*18*	*26*	*13*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*
BC	Plow	1.6b	1.5	1.5	0.9	1.5b	22	24a	23a	20a	23a	150a	151	149ab	104	150	0.9b	0.8	0.8a	0.8a	0.8
	Chisel	2.3b	1.9	1.9	0.7	1.8ab	23	19a	15b	13b	19a	140a	144	118b	65	134	0.9ab	0.9	0.7ab	0.6b	0.8
	Strip	2.6b	1.9	1.9	0.9	2.0ab	19	13b	9c	10b	14b	149a	165	172a	92	162	0.9ab	0.7	0.6c	0.4c	0.8
	No-till	4.0a	2.4	2.4	2.4	2.8a	21	11b	8c	8b	13b	116b	147	155ab	96	139	1.2a	0.8	0.7b	0.6b	0.9
	Average	2.6	1.9	1.9	1.2	2.0	21	17	14	13	17	139	152	149	89	146	1.1	0.8	0.7	0.6	0.8
	LSD	*1.4*	*1.2*	*1.1*	*1.9*	*1.2*	*5*	*6*	*5*	*6*	*5*	*22*	*33*	*50*	*48*	*31*	*0.3*	*0.2*	*0.1*	*0.1*	*0.1*
CB	Plow	1.4c	1.5b	1.5b	1.0	1.5c	25a	26a	27a	22a	26a	124b	145	146ab	105	138	0.8b	0.8	0.8	0.6	0.8
	Chisel	2.2bc	2.1b	2.1ab	1.1	2.0bc	19b	19a	12b	11b	17b	137ab	139	122b	88	132	0.9b	0.9	0.8	0.6	0.8
	Strip	4.0a	2.9a	2.9a	1.0	3.0a	24a	18ab	10b	9b	17b	143a	143	160a	120	149	1.0ab	0.9	0.6	0.5	0.8
	No-till	3.7ab	2.0b	2.0ab	1.0	2.4ab	20b	9b	7b	8b	12b	119b	153	156a	90	142	1.2a	0.8	0.7	0.6	0.9
	Average	2.8	2.1	2.1	1.0	2.2	22	18	14	12	18	130	145	146	101	140	1.0	0.8	0.7	0.6	0.8
	LSD	*1.5*	*0.6*	*0.4*	*0.3*	*0.8*	*2*	*9*	*7*	*4*	*6*	*18*	*23*	*29*	*41*	*19*	*0.2*	*0.1*	*0.2*	*0.2*	*0.1*
CC	Plow	1.5c	1.6	1.6	1.2	1.5b	26	29a	30a	24a	28a	185a	191a	198a	143a	191a	0.7c	0.8	0.7	1.6ab	0.7b
	Chisel	1.9c	1.8	1.8	0.8	1.7b	27	26a	19b	14b	24b	161ab	169ab	150b	92b	160b	0.7c	0.7	0.7	0.4b	0.7b
	Strip	2.7b	1.9	1.9	1.0	2.0b	29	17b	12c	9b	19c	166ab	178ab	174ab	124ab	173ab	0.9b	0.7	0.7	0.6a	0.8a
	No-till	4.0a	2.0	2.0	0.9	2.4a	26	18b	12c	11b	18c	155b	155b	169ab	106ab	160b	1.1a	0.7	0.6	0.5ab	0.8a
	Average	2.5	1.8	1.8	1.0	1.9	27	22	18	14	22	167	173	173	116	171	0.8	0.7	0.7	0.5	0.7
	LSD	*0.7*	*0.5*	*0.3*	*0.4*	*0.5*	*5*	*4*	*6*	*5*	*3*	*27*	*34*	*39*	*45*	*31*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*

Average of 4 replications. *Mean is 0-8”

Table 3. Soil nitrogen results based on composite samples, Long-term Tillage Study, ACRE, Summer 2018.

		6/??/2018				8/??/2018			
		Nitrate		Ammonium		Nitrate		Ammonium	
Rotation	Tillage	0-12”	12-24”	0-12”	12-24”	0-12”	12-24”	0-12”	12-24”
		ppm	ppm						
CB	Plow								
	Chisel								
	Strip								
	No-till								
	Average								
	LSD								
CC	Plow								
	Chisel								
	Strip								
	No-till								
	Average								
	LSD								

Average of 4 replications.

2018 Field Practices

Primary tillage included the use of an International Harvester 5-furrow 18-inch bottom semi-mounted moldboard plow on the plow treatments. A DMI 7-shank coulter-chisel plow equipped with 4-inch twisted chisel points on 15-inch centers and a Danish-tine sweep leveling bar was used for the chisel treatment. We strip-tilled with a Remlinger 6-row unit set to 8" deep. Secondary tillage for plow and chisel was accomplished with a John Deere field cultivator with trailing, double rolling crumblers. Plow and chisel plots were field cultivated once.

Corn was planted in 30-inch rows with a John Deere 1780 6-row planter. Smooth coulters opened a slots for starter fertilizer placement. We used unit-mounted row cleaners to clear the row area of residue when no-till planting into corn and soybean residue. Following corn the new rows were planted between the old rows, not beside.

Nitrogen was side dressed at a depth of 3 to 4 inches with a DMI NutriPlacr 2800 7-knife liquid nitrogen applicator equipped with 1 coulter per knife. The outside knives (#1 and #7) delivered 1/2 rate and, after the first pass through the plots, an outside knife was placed back in the previous outside knife track to give a full rate. The north 60-feet of the west 6 rows received zero side-dressed N. These plots are designated as A, B, C, and D as shown below.

Zero N "B"	240 N "D"
180 N "A"	240 N "C"

North

Long-term Tillage Plots, 2017.

Soybeans were planted with the John Deere 1780 planter in 30-inch rows in all treatments. Herbicides were applied by ACRE staff with a 10-foot 3-point hitch mounted sprayer. Following corn the new rows were planted between the old rows, not beside. Following soybeans the new rows were planted on the old soybean rows.

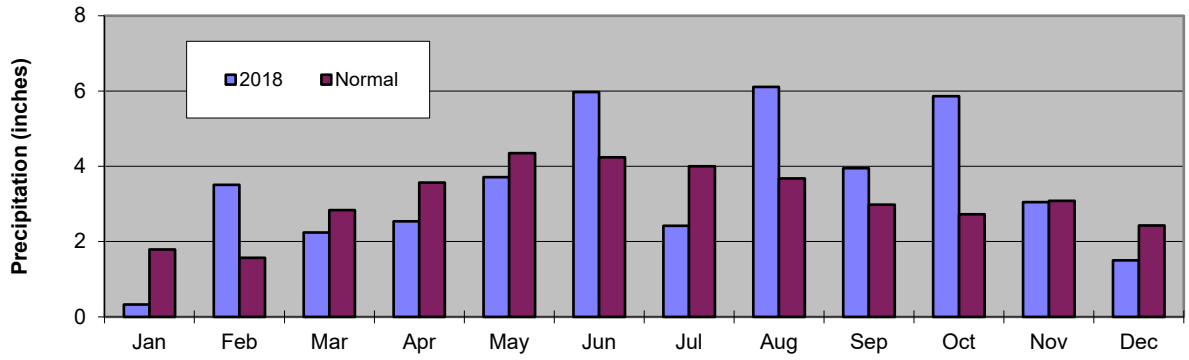
All corn plots were harvested with the Torbert/Tuinstra Kincaid 8XP combine equipped with a 2-row corn head. All soybean plots were harvested with Casteel's Kincaid 8XP combine.

Table 4. Cultural Practices Used 2018				
Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	4/30	Field cultivate once on chisel and plow plots.	4/30	Field cultivate once on chisel and plow plots.
Hybrid/Variety planted	5/1	Pioneer P1197 AMXT (113-day) Row cleaners on c/b and c/c strip-till and no-till. Shifted no-till c/c to west 15".	5/1	Pioneer P34T07R2 Round-up Ready Group 3.4. Row cleaners on c/b and c/c strip-till and no-till.
Seeding rate		34,000 seeds/ac		140,000 seeds/ac
Starter fertilizer/planter		20 gal/acre of 10-34-0		None
Insecticide/planter		None		None
Weed control		Pre-emergence:		Burndown:
	?	Roundup PowerMax 28 oz/ac	?	Roundup PowerMax 28 oz/ac
		2,4-D 16 oz/ac		Dual II Magnum 1.8 pt/ac
		Class Act 1 gal/100 water		Scepter 2.8 oz/ac
		Interlock 2-4 oz/100 water		Class Act 1 gal/100 water
		Post-emergence:		Interlock 2-4 oz/100 water
	?	Roundup 32 oz/ac		Post-emergence:
		Callisto 3 oz/ac	?	Roundup 28 oz/ac
		Class Act 1 gal/100 water		Class Act 1 gal/100 water
		Interlock 2-4 oz/100 water		Interlock 2-4 oz/100 water
Nitrogen fertilizer, sidedressed	5/21	Subplot A: 180 lbs N as UAN (28%) Subplot B: zero N Subplot C: 240 lbs N as UAN (28%) Subplot D: 240 lbs N as UAN (28%)		None
Harvest		Two-row harvest according to plot length with Kincaid combine.		Two-row harvest with Kincaid combine.
Fall fertilizers:		None		None
Lime		None		None
Primary tillage	11/14	Fall plow on plow treatment	11/14	Fall plow on plow treatment
	10/25	Fall chisel on chisel treatment	10/25	Fall chisel on chisel treatment
	10/25	Strip-till: shifted rows when following corn, no shift when following soybeans	10/25	Strip-till: shifted rows when following corn, no shift when following soybeans

Weather and soil conditions in 2018

March through August rainfall was below average (Fig. 1). An excellent window of opportunity existed in mid to late April for planting. Soil conditions were good for secondary tillage in the plow and chisel treatments leaving a satisfactory seedbed. The no-till treatment in both continuous and rotation corn planted very nicely. Strip-till also planted extremely well and did appear to be drier than no-till. Rain on May 3-4 of 0.4" provided great conditions for seed germination and emergence. Another shower of 0.94" on May 15-16 kept crops growing. Crops never lacked for water during the growing season. A dry and hot period in mid-September hastened plant maturity. A very wet October made harvesting difficult and fall tillage nearly impossible. A narrow window of good soil conditions for tillage occurred in the 3rd week. A wet early November also made tillage difficult, with moldboard plowing done when soil surface was frozen allowing for good traction.

Figure 1. Monthly precipitation for 2018 compared to normal, ACRE.



Anhydrous ammonia applicator, 1975 through 2000.

UAN application, 2001 through 2018.

Stand, growth, and yield -- Corn.

Establishing a uniform stand can be difficult in no-till continuous corn. The corn residue is thickest on the old row and we have observed seeds planted in contact with residue, not in contact with soil, when planting on the row. Variable seed depth and inconsistent contact with the soil can result in non-uniform germination, reducing yield potential. Therefore, we shifted no-till corn after corn rows 6-inches (enough to clear the planter gauge wheels) to the side of previous year's rows from 1995 thru 2010. By shifting the new rows, we wanted to gain more uniform seeding depth, improve seed to soil contact, achieve more uniform seedling emergence, and stay out of the compacted wheel tracked row centers. We achieved these goals in 14 of the 15 years. Since 2011 we have planted the no-till continuous corn 15-inches from the old row (i.e. row middles) rather than on or beside the old row. As in 2011, 2012 and 2013 the corn residue was so thick and tough that it would not flow under and through the planter. It seems that today's hybrids have tougher stalks that do not decay sufficiently through the winter months. These tough stalks along with increased planting populations leave too much residue for our equipment to handle.

Table 5. Agronomic performance of corn as affected by tillage and rotation, subplot A (180 lb/ac N rate), 2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	31406	20.9a	99.9ab	15.6b	220.9a
	Chisel	31469	18.9a	99.8b	16.0b	204.9ab
	Strip-till	31344	18.5a	102.8a	16.2b	206.4ab
	No-till	31656	15.1b	102.2ab	17.4a	203.6b
	LSD at 5%	951	3.0	2.9	0.8	16.0
Soybean	Plow	31406	22.9	102.7	15.9b	256.1
	Chisel	32313	22.6	103.1	16.2b	246.8
	Strip-till	30250	23.7	102.6	17.0a	243.7
	No-till	31875	21.1	99.6	16.9a	247.4
	LSD at 5%	2834	2.9	6.4	0.6	20.0

†Average of 4 replications.
‡Within rotations, data followed by the same letter are not significantly different according to the GLM procedure (P= .05).

Table 6. Corn Yield Response to Tillage and Rotation, subplot A (180 lb/ac N rate), 2018†.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	256.1	- - -	220.9	- - -	16
Chisel	246.8	96	204.9	93	20
Strip-till	243.7	95	206.4	93	18
No-till	247.4	97	203.6	92	22

†Average of 4 replications.

Table 7. Agronomic performance of corn as affected by tillage and rotation, subplot C/D (240 lb/ac N rate), 2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 6 weeks	Height 8 weeks	Spad 1	Spad 2	Harvest moisture	Yield @15.5%
		ppa	in	in	in			%	bu/ac
Corn	Plow	32000	21.6a	56.2a	95.3b	52.1	51.4	15.8c	235.2a
	Chisel	31375	21.0a	53.3a	101.0ab	52.9	51.4	16.0c	227.5ab
	Strip-till	30875	18.7b	50.9a	104.7a	51.7	49.8	16.5b	219.2b
	No-till	31375	17.4b	39.8b	101.7ab	51.1	49.5	17.8a	227.3ab
	LSD at 5%	1809	2.0	8.5	6.6	5.7	4.2	0.4	11.1
Soybean	Plow	30000	22.7	50.1b	100.3c	52.9	52.6	16.4b	257.9a
	Chisel	32250	22.6	57.9a	102.6bc	53.1	51.6	16.5b	258.9a
	Strip-till	31000	23.4	52.8ab	105.0ab	52.1	54.2	16.8b	259.9a
	No-till	31625	22.0	54.5ab	106.6a	54.7	51.8	17.6a	249.0b
	LSD at 5%	4238	2.2	7.1	2.8	3.0	3.9	0.8	8.8

†Average of 4 replications.
‡Within rotations, data followed by the same letter are not significantly different according to the GLM procedure (P= .05).

Table 8. Corn Yield Response to Tillage and Rotation, subplot C/D (240 lb/ac N rate), 2018†.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	257.9	- - -	235.2	- - -	10
Chisel	258.9	100	227.5	97	14
Strip-till	259.9	101	219.2	93	19
No-till	249.0	97	227.3	97	10

†Average of 4 replications.

Almaco/John Deere combine used for corn harvest 2004-2011.

Kincaid combine used for corn harvest, 2012-2018.

Stand, growth, and yield -- Soybeans.

From 1995 through 2004 we drilled the plow, chisel, and no-till treatments at 7.5-inch row spacing, while the ridge treatment was planted at 30-inch row spacing. In 2005, we went back to 30-inch rows for all treatments. This was due to the threat of soybean rust disease. In order to spray fungicides if an outbreak occurred, the mechanical damage to drilled rows of the "sacred" harvest area would have severely impacted the yields. Any damage to 30-inch rows would be minimal, so we switched to the 30-inch rows. Also, we have continued 30-inch rows to facilitate other research projects. Soil samples taken in 1999 and 2002 confirmed the presence of Soybean Cyst Nematodes (SCN) in many of the plots. To reduce the negative impact of SCN on yield potential we have planted SCN resistant varieties since 2000.

Table 9. Agronomic performance of soybean as affected by tillage and rotation, 2018. †

Previous Crop	Tillage	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	in	in	%	bu/ac
Corn	Plow	135762	7.1a	19.3a	11.2	67.7a
	Chisel	133584	6.2b	17.5ab	11.1	64.0ab
	Strip-till	133584	6.0b	15.5ab	11.4	62.6ab
	No-till	138666	4.8c	14.0b	11.1	54.8b
	LSD at 5%	11085	0.8	3.9	0.5	9.6
Soybean	Plow	138666	7.1a	18.1a	11.3	68.1a
	Chisel	139029	6.7b	17.4ab	11.4	67.9a
	Strip-till	138303	6.2ab	16.7ab	11.3	64.6ab
	No-till	140481	5.7b	15.4b	11.3	60.7b
	LSD at 5%	12267	1.3	2.3	0.2	4.2

†Average of 4 replications.
‡Within rotation, data followed by the same letter are not significantly different according to GLM (P= .05).

Table 10. Soybean Yield Response to Tillage and Rotation, 2018†.

Tillage	Soybean/Corn		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	67.7	- - -	68.1	- - -	-1
Chisel	64.0	95	67.9	100	-6
Strip-till	62.6	92	64.6	95	-3
No-till	54.8	81	60.7	89	-10

†Average of 4 replications.

Table 11. Analysis of variance summary, tillage data, 2018.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield bu/ac
	----------Significance Level----------				
			Corn		
Tillage	NS	0.01	0.01	0.01	0.08
Previous crop	NS	0.02	NS	NS	0.01
Tillage x previous crop	NS	NS	NS	0.06	0.01
			Soybean		
Tillage	NS	0.01	0.01	NS	0.01
Previous crop	0.19	NS	NS	NS	0.01
Tillage x previous crop	NS	NS	NS	NS	NS

Soybean harvest with IH 93 combine, 1980.

Soybean harvest with Kincaid combine, 2016.

Gary Steinhardt and Dave Gehring taking soil penetrometer measurements, 1997.

Power tools that did the work! CaseIH 5240, John Deere 8345R, and a Ford 8000 operated by Terry D. West.

Long-term Yields

Results from this study provide insight into long-term yield potential of corn and soybean with different tillage systems on dark prairie soils of the Central and Northern Corn Belt. While equipment, cultivars, and seeding rates were changed periodically, tillage treatments were not altered during first 34-years of this 44-year continuing experiment.

Both tillage system and rotation influenced stand, growth and yield of corn and soybean in these studies. In continuous corn, tillage system also influenced grain moisture. With planting conditions similar to those in this study, the following conclusions appear to be justified:

1. Both corn and soybean yields are greater in rotation than in continuous cropping for all tillage systems (Tables 12 and 13). The positive response to rotation is greatest for no-till corn. However, within the 3 tilled treatments (plow, chisel, and ridge) soybean yields increased more (percent basis) with rotation than did corn yields.
2. When corn follows corn, yields with chiseling and ridging may be reduced slightly (3% or less) compared with plowing. No-till continuous corn yield on dark, poorly drained soil is likely to be reduced, compared to yields with other systems, and the yield reduction may increase with time when planted on the old row (Fig. 2). Part, but not all, of the yield loss prior to 1995 may be due to reduced stand or non-uniform plant emergence. Since planting beside old row starting in 1995, the yield gap has been reduced.
3. When corn follows soybean, yields with plow and chisel are likely to be about the same. Yields from the ridge system may be slightly better (3%) than plow and chisel. No-till corn yields may be slightly reduced (2%) compared to plow and chisel, but the relative yields of no-till change little with time (Fig. 3). Yield reductions with no-till corn are not due to lower plant populations.
4. No-till soybean yields are likely to be reduced slightly, compared with plowing, but yield differences may be reduced with time (Fig. 4 and 5). No-till soybean yield reductions are likely to be less frequent when grown in narrow rows (note the yield responses from 1995 to 2004), but no-till yields can be similar to those after plowing even in 30-inch row widths (note the yield responses in 1990-94, and again in 2005-08). We acknowledge that variety selection plays a large role in the relative yield responses of soybean to wide row widths and to no-till systems. However, soil-borne disease incidence was not the highest in long-term no-till for the pathogens evaluated (see earlier sections).
5. Tables 14 and 15 shows corn yields for the last 10 growing seasons. This table reflects increased seeding rates; genetic trait stacked corn, and improved corn genetics over time.
6. Tables 16 and 17 shows soybean yields for the last 10 growing seasons.
7. Tables 18 and 19 give corn data since the inclusion of strip-till as a tillage treatment. (10-years)
8. Tables 20 and 21 give soybean data since the inclusion of strip-till as a tillage treatment. (10-years)

Table 12. Corn Yield Response to Tillage and Rotation, 1975-08.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	182.0	- - -	175.1	- - -	4
Chisel	183.2	101	170.2	97	8
Ridge*	187.3	103	172.2	98	9
No-till	178.3	98	151.6	87	18

*1980 to 2008

Table 13. Soybean Yield Response to Tillage and Rotation, 1975-08.

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	53.9	- - -	48.9	- - -	10
Chisel	51.8	96	47.0	96	10
Ridge*	52.4	97	46.5	95	13
No-till	51.6	96	47.4	97	9

*1980 to 2008

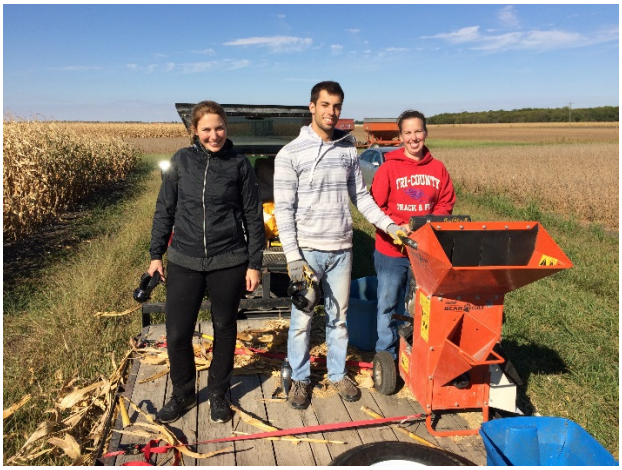
Table 14. Agronomic performance of corn as affected by tillage and rotation, last 10-years, 2009-2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	33021a	17.8a	76.1a	18.6c	208.2a
	Chisel	32763a	17.0b	72.6b	19.3b	198.4b
	No-till	32088b	15.5c	66.9c	20.9a	196.4b
	LSD at 5%	430	0.6	2.1	0.6	5.9
Soybean	Plow	32942	18.4b	78.4a	18.9b	225.5a
	Chisel	33083	19.2a	80.1a	18.7b	221.1ab
	No-till	32854	17.5c	75.2b	19.9a	219.5b
	LSD at 5%	397	0.7	1.8	0.3	5.2

†Average of 3 replications.
‡Within rotations, data followed by the same letter are not significantly different according to the GLM procedure (P= .05).

Table 15. Corn Yield Response to Tillage and Rotation, last 10 years, 2009-2018.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	225.5	- - -	208.2	- - -	8
Chisel	221.1	98	198.4	95	11
No-till	219.5	97	196.4	94	12



Corn biomass harvesting for nutrient analysis, directed by Alicia West (in red hoodie).

Table 16. Agronomic performance of soybean as affected by tillage and rotation, last 10-years, 2009-2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	In	in	%	bu/ac
Corn	Plow	136924a	9.3a	26.5a	12.2	59.9a
	Chisel	131261b	8.5b	24.8b	12.1	58.1b
	No-till	130922b	7.8c	22.9c	12.2	58.2ab
	LSD at 5%	3431	0.7	0.3	0.2	1.7
Soybean	Plow	136367	9.6a	26.7a	12.1	58.7ab
	Chisel	134116	9.0b	25.7b	12.2	59.3a
	No-till	136052	8.6c	24.3c	12.2	56.8b
	LSD at 5%	3323	0.4	0.8	0.2	1.9

†Average of 3 replications.
‡Within rotations, data followed by the same letter are not significantly different according to the GLM procedure (P= .05).

Table 17. Soybean Yield Response to Tillage and Rotation, last 10 years, 2009-2018. †

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	59.9	- - -	58.7	- - -	2
Chisel	58.1	97	59.3	101	-2
No-till	58.2	97	56.8	97	2

†Average of 3 replications.

Table 18. Agronomic performance of corn as affected by tillage and rotation, 2010-2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	33120a	15.7a	72.9a	18.5c	206.1a
	Chisel	32806a	14.7b	68.9b	19.2b	195.9bc
	Strip-till	32931a	15.7a	68.4b	19.3b	201.5ab
	No-till	32171b	13.3c	62.8c	20.9a	194.4c
	LSD at 5%	416	0.6	2.3	0.6	6.1
Soybean	Plow	33130	16.2b	74.9a	18.9b	225.1a
	Chisel	33204	16.9ab	76.6a	18.5c	220.0ab
	Strip-till	32884	17.0a	75.8a	19.1b	223.3ab
	No-till	32944	15.1c	71.1b	19.8a	219.2b
	LSD at 5%	522	0.7	1.9	0.3	5.4

†Average of 3 replications.
‡Within rotations, data followed by the same letter are not significantly different according to the GLM procedure (P= .05).

Table 19. Corn Yield Response to Tillage and Rotation, 2010-2018. †

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	225.1	- - -	206.1	- - -	9
Chisel	220.0	98	195.9	95	12
Strip-till	223.3	99	201.5	98	11
No-till	219.2	97	194.4	94	13

†Average of 3 replications.

Table 20. Agronomic performance of soybean as affected by tillage and rotation, 2010-2018. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	In	in	%	bu/ac
Corn	Plow	137564a	8.9a	26.2a	12.1	59.4
	Chisel	131514b	8.3b	24.6b	12.0	57.8
	Strip-till	134364ab	8.5b	25.0b	12.1	58.4
	No-till	131164b	7.5c	22.6c	12.1	57.7
	LSD at 5%	4173	0.4	0.9	0.2	1.8
Soybean	Plow	136622	9.2a	26.4a	12.0	58.2a
	Chisel	134821	8.7b	25.4ab	12.1	58.7a
	Strip-till	137456	8.5b	24.5bc	12.2	57.6ab
	No-till	136219	8.3b	23.9c	12.2	56.2b
	LSD at 5%	4447	0.4	1.0	0.2	1.9

†Average of 3 replications.
‡Within rotation, data followed by the same letter are not significantly different according to GLM (P= .05).

Table 21. Soybean Yield Response to Tillage and Rotation, 2010-2018. †

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	59.4	- - -	58.2	- - -	2
Chisel	57.8	97	58.7	101	-2
Strip-till	58.6	99	57.6	99	2
No-till	57.7	97	56.2	97	3

†Average of 3 replications.

Strip-tilling with Remlinger toolbar, 2012.

Monitor on left is for controlling tractor autosteer.

Figure 2. Continuous Corn Yields, ACRE, 1975-2018.

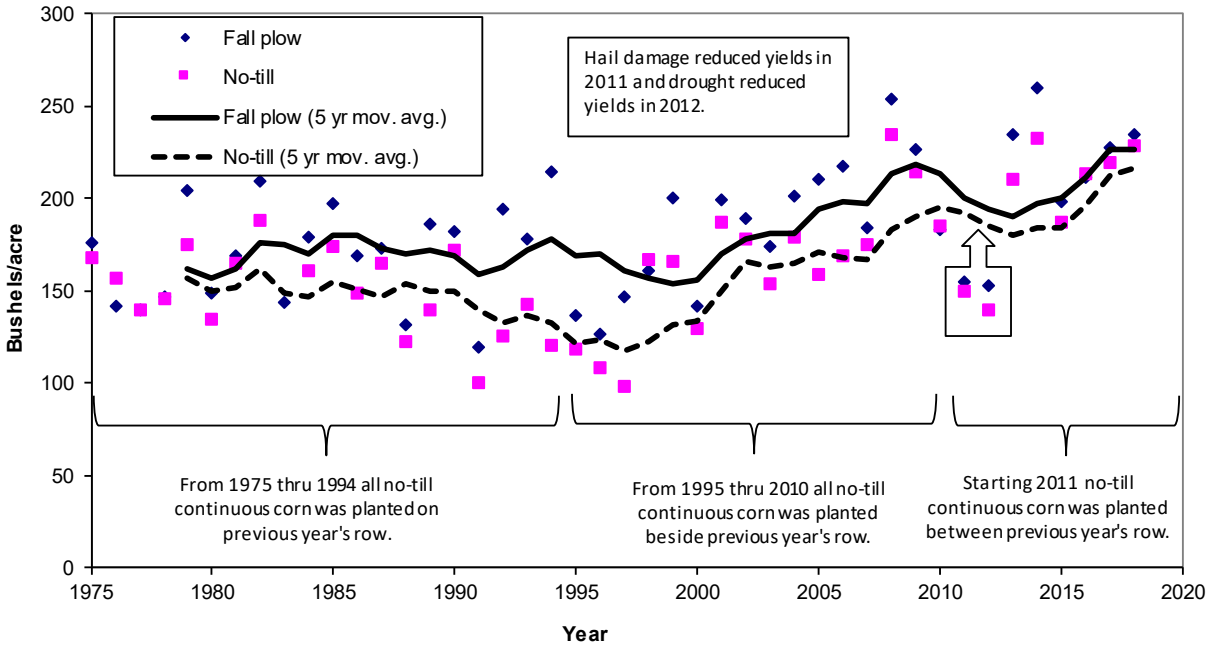


Figure 3. Corn Yields After Soybeans, ACRE, 1975-2018.

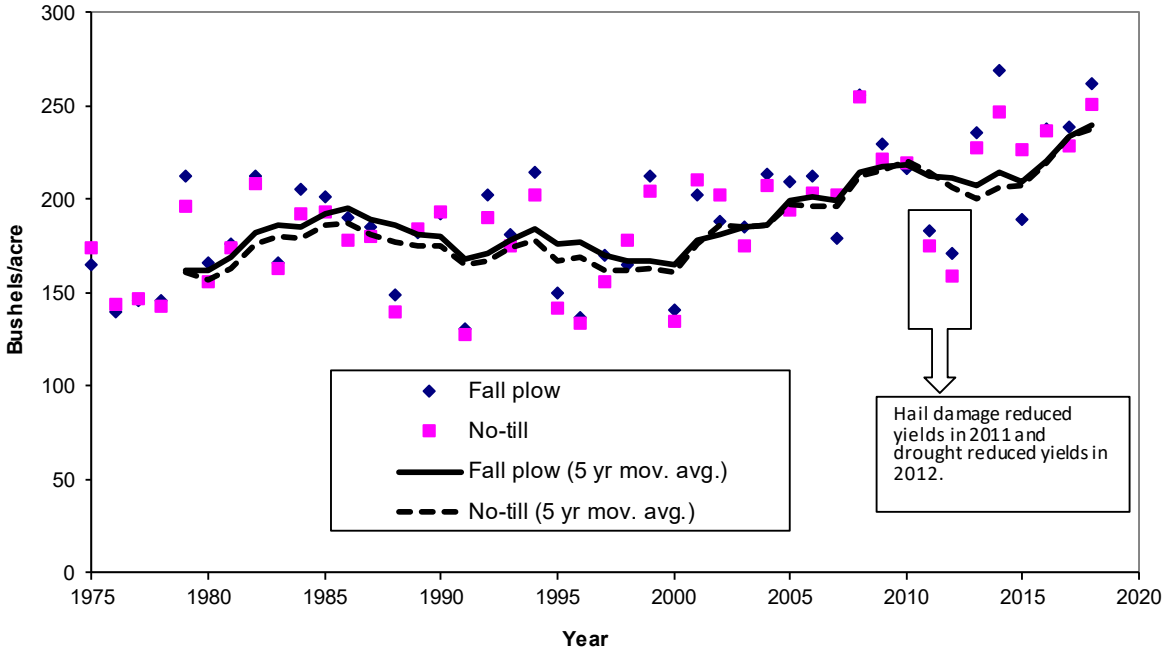


Figure 4. Continuous Soybean Yields, ACRE, 1975-2018.

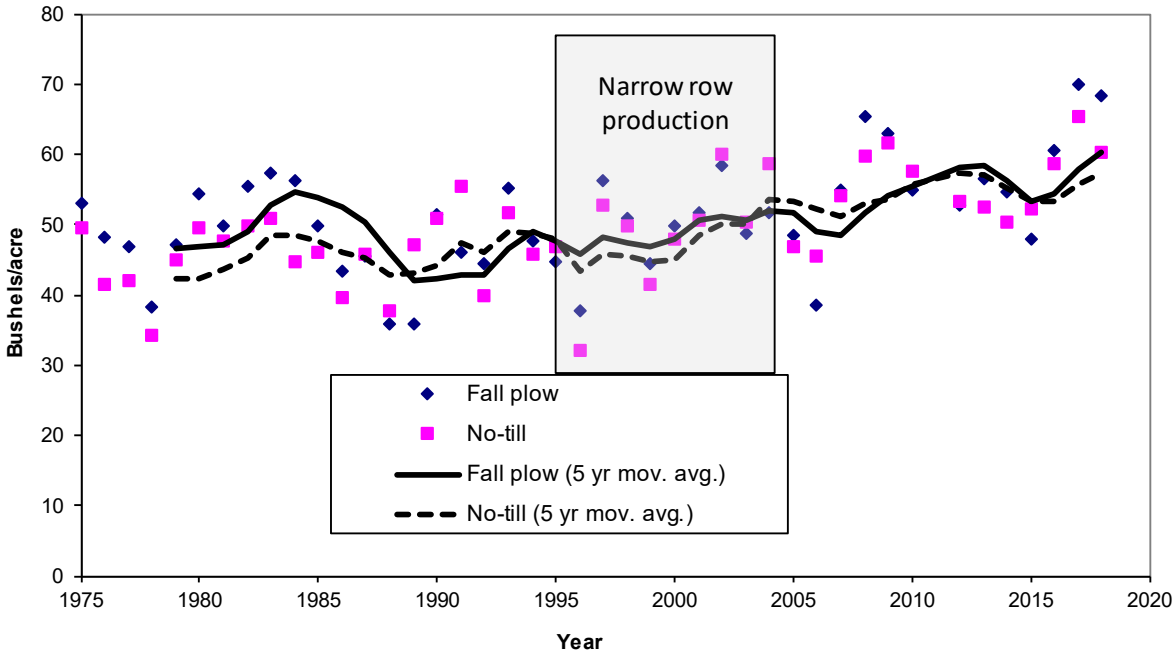
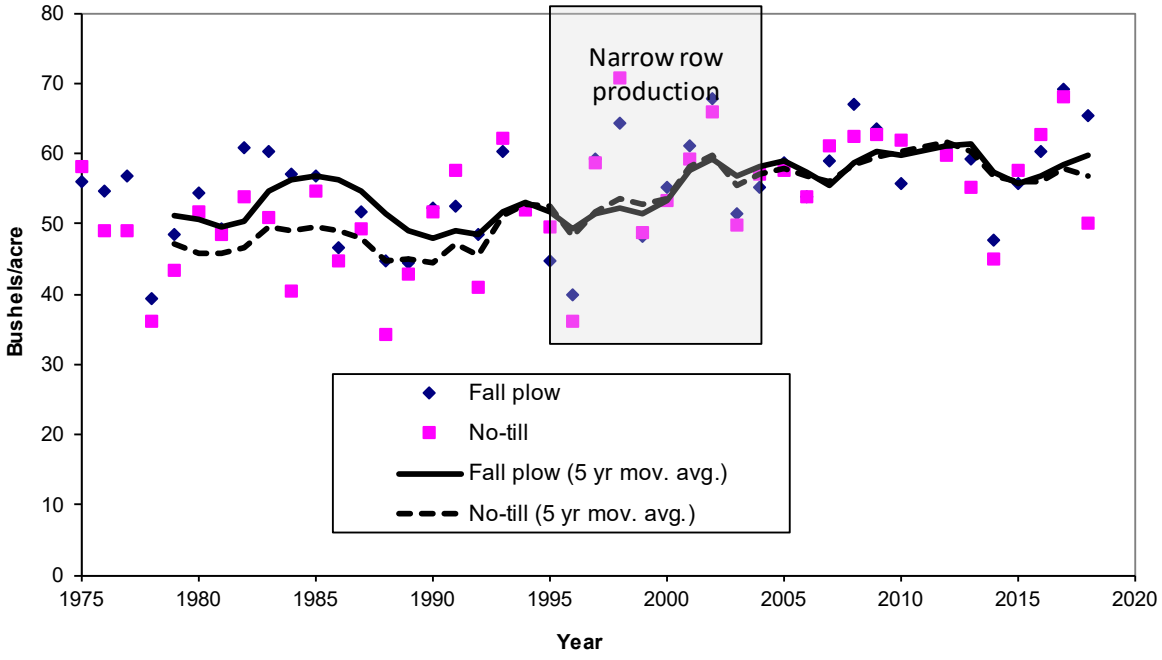


Figure 5. Soybean Yields After Corn, ACRE, 1975-2018.



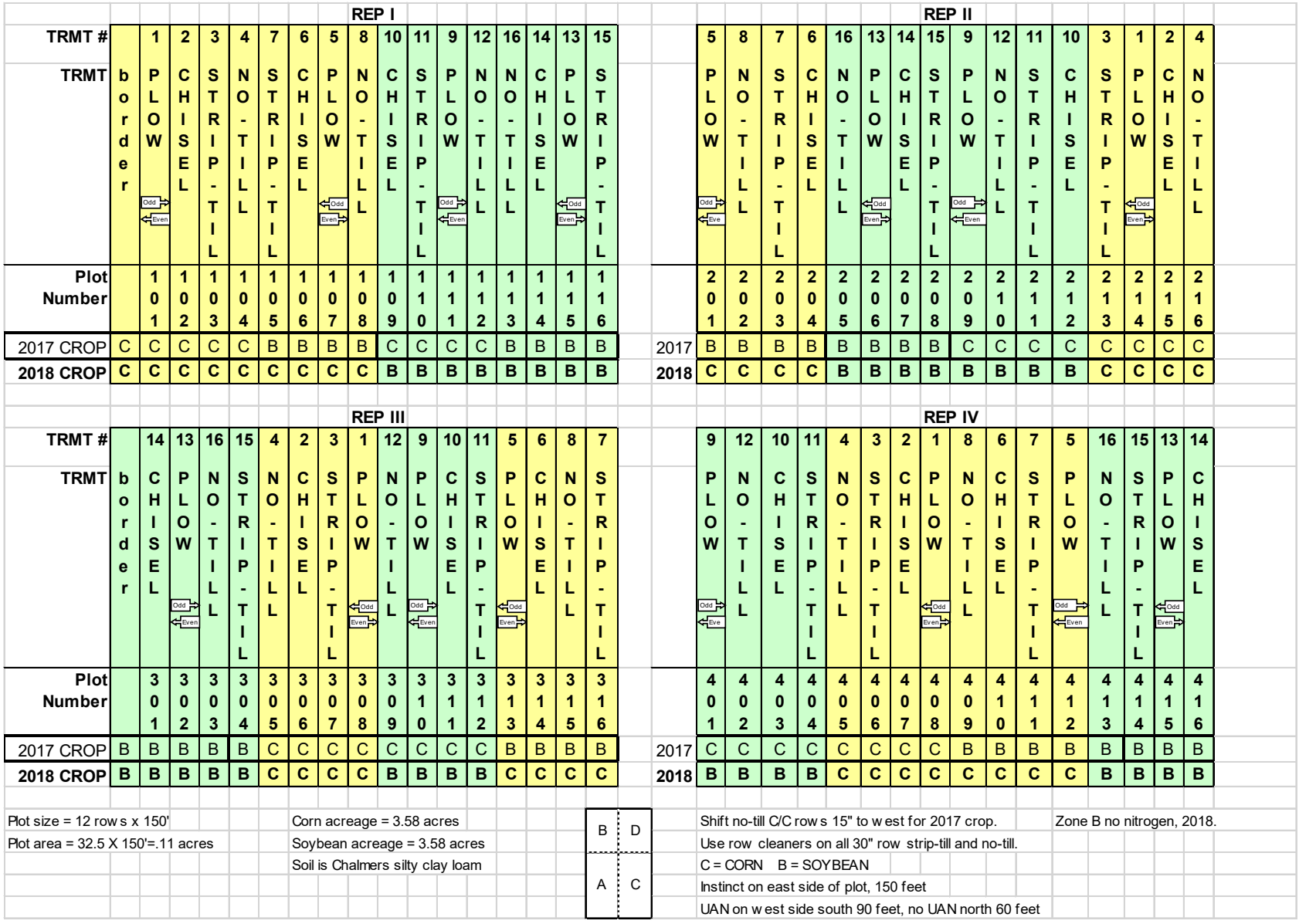


Figure 6. Plot map for 2018.

Table 23. Corn yield summary, bu/a., Long-term Tillage Study, ACRE, Purdue University, West Lafayette, IN, USA. 1975-2018[1]

Previous Crop	Tillage	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Corn	Fall Plow	175.8	142.3	139.9	146.8	204.4	149.3	169.0	209.2	144.2	179.5	197.6	169.5	173.5	131.8	186.3	182.3	119.5	194.3	178.7	214.7	136.7	126.5	147.1	161.3
	Fall Chisel	164.6	148.1	132.7	144.7	190.2	136.0	170.9	190.4	139.3	178.8	183.9	167.6	172.8	141.9	182.8	177.8	124.1	192.6	173.4	202.9	124.0	122.0	141.7	163.9
	Ridge-till	----	----	----	----	----	142.6	166.6	189.0	148.6	173.8	185.6	161.7	172.9	135.0	180.8	188.2	130.0	189.6	176.1	208.4	132.8	121.4	145.3	173.0
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	No-till	168.0	156.8	139.5	146.1	174.7	134.4	164.6	188.8	83.7	161.2	174.2	149.1	164.6	122.9	140.1	172.6	100.3	126.0	142.8	120.6	118.2	108.9	98.8	166.6
	CC Average	169.5	149.1	137.4	145.9	189.8	140.6	167.8	194.4	128.9	173.3	185.3	162.0	170.9	132.9	172.5	180.2	118.5	175.6	167.8	186.7	127.9	119.7	133.2	166.2
Soybeans	Fall Plow	165.5	140.1	145.4	145.4	212.2	166.0	176.4	212.4	166.4	205.3	201.6	190.3	185.1	149.2	181.9	192.8	130.9	202.6	181.5	214.6	149.5	136.9	170.6	164.6
	Fall Chisel	176.9	140.9	149.3	140.2	206.0	159.4	170.3	209.1	170.7	197.1	192.6	190.0	174.9	143.1	195.5	195.3	137.5	205.2	191.9	227.1	143.2	140.1	174.2	159.1
	Ridge-till	----	----	----	----	----	164.2	173.6	216.6	176.8	198.3	208.0	190.5	177.7	150.4	192.5	197.5	145.0	199.1	184.7	219.2	142.5	134.8	167.7	182.9
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	No-till	174.5	144.0	146.6	142.8	196.8	155.8	174.6	208.9	163.4	192.8	193.3	178.5	180.4	139.4	184.6	193.5	127.5	190.6	175.0	202.4	141.7	133.4	155.8	178.7
	CB Average	172.3	141.7	147.1	142.8	205.0	161.4	173.7	211.7	169.3	198.4	198.9	187.3	179.5	145.5	188.6	194.8	135.2	199.4	183.3	215.8	144.2	136.3	167.1	171.3
	Annual Avg.	170.9	145.4	142.2	144.3	197.4	151.0	170.7	203.0	149.1	185.9	192.1	174.7	175.2	139.2	180.6	187.5	126.8	187.5	175.5	201.2	136.1	128.0	150.1	168.8

Previous Crop	Tillage	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009[2]	2010	2011[3]	2012	2013	2014	2015	2016	2017	2018[4]	75-18 Avg.	80-08 Avg.	10-18 Avg.	09-18 Avg.
Corn	Fall Plow	200.5	142.3	199.6	189.0	174.1	201.3	210.4	217.2	184.6	254.3	227.1	183.6	154.6	152.5	235.2	260.4	198.5	211.7	227.6	234.7	182.7	177.4	206.5	208.6
	Fall Chisel	190.1	142.1	194.1	190.9	173.6	198.2	200.3	211.3	182.7	238.7	221.0	187.2	154.7	152.7	216.9	241.4	174.5	217.0	210.7	229.2	177.1	172.7	198.3	200.5
	Ridge-till	188.1	138.2	199.4	190.6	173.1	189.3	177.7	187.1	187.2	241.8	----	----	----	----	----	----	----	----	----	----	----	172.2	----	----
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	194.8	159.3	158.6	221.3	236.0	199.5	208.4	223.8	221.8	----	----	202.6	----
	No-till	166.2	129.8	187.4	177.9	153.7	179.0	159.2	169.2	174.9	235.1	214.6	185.5	149.8	140.3	211.0	232.5	187.1	213.4	219.4	228.7	162.2	150.7	196.4	198.2
	CC Average	186.2	138.1	195.1	187.1	168.6	192.0	186.9	196.2	182.3	242.5	220.9	187.8	154.6	151.1	221.1	242.6	189.9	212.6	220.4	228.6	175.0	168.3	201.0	203.0
Soybeans	Fall Plow	212.5	140.8	202.3	187.9	185.1	213.2	209.6	212.6	179.0	256.5	229.8	216.4	182.8	170.8	235.5	269.1	189.3	238.1	238.6	261.8	191.3	185.4	222.5	223.2
	Fall Chisel	218.3	137.8	193.8	202.5	181.5	209.1	207.3	213.5	207.1	262.0	230.8	222.4	179.4	178.1	228.6	252.6	213.2	228.7	231.4	263.4	192.1	186.5	222.0	222.9
	Ridge-till	204.6	139.3	201.3	207.9	181.5	207.3	201.0	212.4	199.6	255.6	----	----	----	----	----	----	----	----	----	----	----	187.3	----	----
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	228.5	173.8	176.4	228.8	254.2	213.1	239.7	244.9	260.8	----	----	224.5	----
	No-till	204.0	134.4	210.5	202.5	175.3	207.1	193.9	203.7	202.6	254.7	221.8	220.1	175.5	159.4	227.7	247.3	226.7	236.6	228.8	251.1	187.7	181.3	219.2	219.5
	CB Average	209.9	138.1	202.0	200.2	180.8	209.2	202.9	210.6	197.1	257.2	227.5	221.9	177.9	171.2	230.1	255.8	210.6	235.8	235.9	259.3	191.0	185.2	222.0	222.6
	Annual Avg.	198.1	138.1	198.6	193.7	174.7	200.6	194.9	203.4	189.7	249.8	225.0	204.8	166.2	161.1	225.6	249.2	200.2	224.2	224.2	243.9	182.9	176.7	211.1	213.0

1. Average of 3 replications.
2. No yield for ridge-till or strip-till due to transition year.
3. Hail damage reduced yields.
4. Subplot "D" with 240 lbs N/acre.

Table 24. Soybean yield summary, bu/a., Long-term Tillage Study, ACRE, Purdue University, West Lafayette, IN, USA. 1975-2018[1]

Previous Crop	Tillage	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[2]	1996	1997	1998
Corn	Fall Plow	56.1	54.7	56.8	36.9	48.4	54.4	49.2	60.7	60.4	57.1	56.9	46.5	51.7	44.6	44.4	52.2	52.5	48.5	60.4	52.1	44.8	40.0	60.2	64.4
	Fall Chisel	58.1	51.5	56.0	43.0	49.5	54.6	46.2	54.7	57.3	54.2	53.7	46.4	49.6	38.6	44.2	48.1	55.2	44.3	59.3	50.6	51.4	38.6	58.2	59.3
	Ridge-till	----	----	----	----	----	55.0	47.6	60.3	56.9	47.5	54.2	46.0	50.7	39.9	44.9	49.2	56.5	40.1	55.1	49.8	49.5	33.9	54.8	59.0
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	No-till	58.0	48.9	49.1	32.3	43.3	51.8	48.4	53.7	51.0	40.4	54.5	44.7	49.3	34.3	42.7	51.8	57.6	40.9	62.1	51.9	49.6	36.2	59.0	70.6
	BC Average	55.2	51.6	54.9	37.8	47.9	54.0	47.9	57.3	56.4	49.8	54.8	45.9	50.3	39.3	44.1	50.3	55.4	43.5	59.2	51.1	48.8	37.2	58.1	63.3
Soybeans	Fall Plow	52.9	48.2	46.8	38.2	47.1	54.3	49.7	55.5	57.4	56.3	49.9	43.3	45.4	35.8	35.9	51.4	46.0	44.4	55.1	47.7	44.5	37.5	55.7	51.0
	Fall Chisel	51.9	45.7	44.3	37.8	48.1	50.7	42.8	52.9	54.9	49.9	49.7	42.0	43.2	35.4	35.5	47.6	48.8	40.3	47.3	46.0	43.1	34.8	51.2	47.4
	Ridge-till	----	----	----	----	----	48.1	45.6	53.1	56.0	49.6	43.3	42.3	47.5	34.9	40.4	50.2	49.4	37.6	50.7	45.6	39.3	32.4	40.8	45.1
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	No-till	49.4	41.5	41.9	34.2	44.9	49.5	46.8	49.9	50.8	44.6	46.0	39.5	45.9	37.7	47.0	50.8	55.3	39.9	51.7	45.8	46.8	32.1	52.2	49.8
	BB Average	51.2	45.3	44.1	36.4	46.7	50.6	46.2	52.8	54.8	50.1	47.2	41.8	45.5	35.9	39.7	50.0	49.9	40.6	51.2	46.3	43.4	34.2	50.0	48.3
	Annual Avg.	54.4	48.4	49.2	37.1	46.9	52.3	47.0	55.1	55.6	49.9	51.0	43.8	47.9	37.6	41.9	50.2	52.7	42.0	55.2	48.7	46.1	35.7	54.0	55.8

Previous Crop	Tillage	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009[3]	2010	2011[4]	2012	2013	2014	2015	2016	2017	2018	75-18 Avg.	80-08 Avg.	10-18 Avg.	09-18 Avg.
Corn	Fall Plow	48.1	55.3	61.0	67.8	51.4	55.1	58.7	53.8	58.8	67.0	63.5	55.6	----	60.9	59.1	47.7	55.8	60.3	69.1	65.4	54.9	54.4	59.2	59.7
	Fall Chisel	47.9	53.3	53.2	63.5	49.9	52.4	51.7	43.1	55.3	64.3	60.5	51.6	----	59.7	58.3	42.6	53.3	59.7	70.7	63.0	52.8	51.7	57.4	57.7
	Ridge-till	49.0	55.1	59.3	62.9	50.6	54.5	60.1	54.1	61.2	61.6	----	----	----	----	----	----	----	----	----		----	52.4	----	----
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	56.5	----	59.2	59.9	41.0	60.3	59.1	70.1	57.2	----	----	57.9	----
	No-till	48.8	53.3	59.2	65.9	49.7	57.1	59.5	53.2	61.0	62.3	62.7	61.9	----	59.7	55.2	44.9	57.7	62.8	68.0	50.2	52.5	52.4	57.6	58.1
	BC Average	48.5	54.2	58.2	65.0	50.4	54.8	57.5	51.1	59.1	63.8	62.2	56.4	----	59.9	58.1	44.0	56.8	60.5	69.5	58.9	53.3	52.7	58.0	58.5
Soybeans	Fall Plow	44.3	49.9	51.8	58.4	48.6	51.6	48.4	38.6	54.9	65.4	63.0	55.0	----	52.7	56.4	54.6	47.8	60.6	69.9	68.3	50.9	49.3	58.2	58.7
	Fall Chisel	43.1	43.4	51.2	57.3	49.1	52.2	49.3	43.3	54.0	63.1	64.1	59.0	----	55.4	57.1	52.6	50.8	60.4	66.5	65.6	49.6	47.2	58.4	59.0
	Ridge-till	36.8	40.5	49.5	58.3	46.6	54.0	48.4	50.0	56.8	55.6	----	----	----	----	----	----	----	----	----		----	46.5	----	----
	Strip-till	----	----	----	----	----	----	----	----	----	----	----	56.8	----	53.1	55.0	52.9	53.8	58.2	67.4	62.1	----	----	57.4	----
	No-till	41.6	48.0	50.6	60.1	50.4	58.7	46.8	45.6	54.1	59.6	61.7	57.6	----	53.2	52.6	50.3	52.1	58.6	65.4	60.3	49.3	48.2	56.3	56.9
	BB Average	41.4	45.4	50.8	58.6	48.7	54.1	48.2	44.4	54.9	60.9	62.9	57.1	----	53.6	55.3	52.6	51.1	59.5	67.3	64.1	49.6	47.8	57.6	58.2
	Annual Avg.	45.0	49.8	54.5	61.8	49.5	54.5	52.9	47.7	57.0	62.4	62.5	56.8	----	56.7	56.7	48.3	54.0	60.0	68.4	61.5	51.5	50.3	57.8	58.3

1. Average of 3 replications.
2. Prior to 1995 and after 2004, all soybean treatments were planted in 30-inch rows. From 1995 thru 2004, plow chisel, and no-till soybean treatments were drilled at 7.5-inches with thr ridge-till treatment remaining on 30-inch rows.
3. No yield for ridge-till or strip-till due to transition year.
4. Hail damage reduced yields.