

Manhattan, KS: Crop Rotations and Tillage Interactions - J.L. Havlin and D. Peterson

I. Site Location

- A. Geographic: 12 km SW of Manhattan, KS, 39° 07' N, 96° 37' W
- B. Administration: Department of Agronomy, Kansas State University
- C. Contact persons: John L. Havlin, Dr. Dallas Peterson

II. Site Description

The area is characterized by flat landscape, with soils developed in deep alluvium along river and creek terraces. Elevation is 314 m above sea level. Native vegetation consists of western wheat grass, blue grama, dropseed, and sedges. The experimental area is located on a Muir silt loam (fine-silty, mixed, mesic Pachic Haplustoll) with 8% sand, 66% silt, and 26% clay (0-15 cm). The soil is well drained and the profile depth is approximately 1.5 m over Kansas River alluvium. The field was in annual grain crop production under conventional, full tillage cultivation from the 1900's to the beginning of the experiment.

III. Experimental Design

A. Experiment initiated in spring, 1974

B. Treatments (1974-1993):

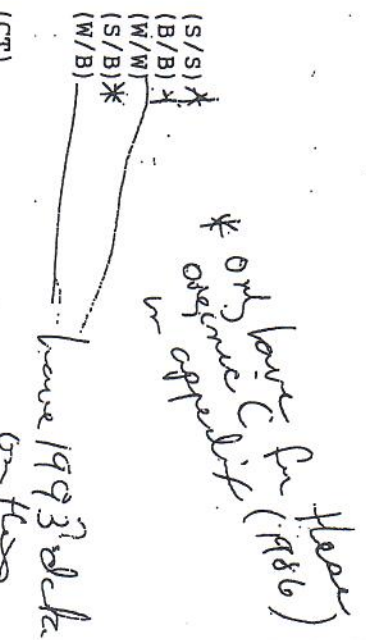
1. Crop rotations:
 - ✓a. Continuous grain sorghum
 - ✓b. Continuous soybean
 - ✓c. Continuous winter wheat
 - ✓d. Grain sorghum/soybean
 - ✓e. Winter wheat/soybean
2. Tillage:
 - ✓a. Conventional tillage - chisel plow, disk, cultivate (CT)
 - ✓b. Reduced tillage - chisel plow, herbicides (RT)
 - ✓c. No tillage, herbicides (NT)

C. Statistical design:

Split block design with four replicates. Main plots are rotation treatments and subplots are tillage treatments, with tillage randomized within each rotation. Subplots are 6.1 m wide and 18.3 m long. (Each crop is produced each year, thus there are 7 rotation treatments.)

IV. Management Schedule

Planting dates were between May 1 and 20 for soybean, May 15 and June 5 for grain sorghum, and September 25 and October 15 for winter wheat. Harvest dates were between September 25 and October 10 for soybean, October 10 and 25 for grain sorghum, and June 25 and July 10 for winter wheat. All plots received a surface broadcast application of 134 kg ha⁻¹ of NH₄NO₃ and 123 kg ha⁻¹ of (NH₄)₂P₂O₅ before planting, which represents



~~1986~~ ~~CT~~ ~~RT~~ ~~NT~~

67 kg N ha⁻¹ and 25 kg P ha⁻¹. After application, the fertilizer was incorporated with a disk in the CT treatments, but not in the RT and NT plots. The CT plots were tilled as needed using a disk, field cultivator, and spring tooth harrow. A rotary tiller was used prior to planting in the CT and RT plots. Maximum tillage depth was 15 to 20 cm.

V. Soil Properties

A. Means of crop rotations, across tillage treatments in 1981.

Date	Treatment	Depth (cm)	pH		OM	P	K
			g kg ⁻¹				
1981	W/W	0-5	5.2		25	0.140	0.609
		5-10	5.4		22	0.106	0.431
		10-15	5.6	5.5	20	0.072	0.318
		15-20	5.8		19	0.053	0.287
		20-25	6.0		17	0.035	0.288
		25-30	6.2		17	0.030	0.280
	W/B	0-5	5.6		26	0.164	0.489
		5-10	5.6	5.6	22	0.108	0.367
		10-15	5.6		20	0.073	0.315
		15-20	5.7		19	0.056	0.302
		20-25	6.0		18	0.036	0.300
		25-30	6.1		17	0.027	0.290
B/B	0-5	5.7		23	0.152	0.360	
	5-10	5.8	5.8	21	0.069	0.256	
	10-15	5.8		21	0.036	0.210	
	15-20	5.8		20	0.023	0.220	
	20-25	6.1		19	0.014	0.229	
	25-30	6.1		18	0.011	0.226	
S/B	0-5	5.7		28	0.137	0.443	
	5-10	5.8		25	0.073	0.311	
	10-15	5.7	5.8	23	0.044	0.247	
	15-20	5.8		22	0.032	0.233	
	20-25	6.0		20	0.018	0.237	
	25-30	6.2		18	0.014	0.230	
S/S	0-5	5.9		29	0.145	0.414	
	5-10	5.9		24	0.063	0.287	
	10-15	5.9	5.9	22	0.036	0.232	
	15-20	5.9		21	0.023	0.213	
	20-25	6.2		20	0.013	0.232	
	25-30	6.3		18	0.009	0.231	

overall mean S, P

B. Means of tillage treatments, across rotations in 1981.

Date	Treatment	Depth (cm)	pH	OM		P	K
				g kg ⁻¹			
1981	NT	0-5	5.5	30	0.156	0.473	
		5-10	5.6	23	0.086	0.343	
		10-15	5.7	21	0.057	0.276	
		15-20	5.8	20	0.040	0.255	
		20-25	6.0	19	0.027	0.265	
		25-30	6.1	18	0.021	0.240	
	RT	0-5	5.7	27	0.143	0.471	
		5-10	5.7	23	0.084	0.337	
		10-15	5.7	21	0.056	0.268	
		15-20	5.8	20	0.039	0.252	
		20-25	6.0	19	0.027	0.256	
		25-30	6.1	18	0.020	0.252	
CT	0-5	5.6	25	0.136	0.464		
	5-10	5.7	22	0.080	0.322		
	10-15	5.7	21	0.053	0.268		
	15-20	5.9	19	0.037	0.261		
	20-25	6.1	19	0.026	0.263		
	25-30	6.2	18	0.020	0.255		

C. Means for conventional and no-till treatments by rotation, in 1986.

BD = 1.40 RD = 1.38 (199d)

Date	Treatment	Depth (cm)	Organic C		Organic N	
			g kg ⁻¹		g kg ⁻¹	
1986	B/B Cont. Soybean	0-2.5	11.4	14.3	1.09	1.26
		2.5-7.5	11.3	11.3	1.04	1.02
		7.5-15	11.0	11.0	1.00	1.03
		15-30	9.6	10.0	0.90	0.94
		0-2.5	12.5	18.6	1.14	1.56
		2.5-7.5	12.3	13.0	1.14	1.14
	B/S Soybean/Soybean	7.5-15	11.6	11.9	0.99	1.07
		15-30	10.4	10.3	0.88	0.88
		0-2.5	14.1	19.8	1.20	1.68
		2.5-7.5	13.6	12.5	1.18	1.12
		7.5-15	12.6	11.6	1.13	1.03
		15-30	11.0	10.6	0.99	0.96
S/S Cont. Soybean	0-2.5	14.1	19.8	1.20	1.68	
	2.5-7.5	13.6	12.5	1.18	1.12	
	7.5-15	12.6	11.6	1.13	1.03	
	15-30	11.0	10.6	0.99	0.96	
	0-2.5	14.1	19.8	1.20	1.68	
	2.5-7.5	13.6	12.5	1.18	1.12	

Organic N (g/m²)

BBB-CT 0-15 : 2.16
BBB-CT 15-30 : 1.89

NT 0-15 : 2.17
NT 15-30 : 1.95

412

Analytical Methods: Organic C determined by dry combustion (LECO auto-analyzer) and total N by salicylic acid-H₂SO₄ digestion. Inorganic N was subtracted from total N to determine organic N. Extractable P was determined using Bray 1-P method and K was extracted with NH₄OAc. Organic matter was determined by dichromate oxidation and pH was measured in 1:1 soil:water.

Bulk densities in selected samples in the spring of 1994 were 1.40 g cm⁻³ in the no-till and 1.38 g cm⁻³ in the conventional till treatments (0-20 cm depth). There were no apparent rotation effects on bulk density.

VI. Yields

A. Grain sorghum and winter wheat yields at 12% moisture.

Date	S/S (sorghum)			W/W (wheat)			S/B (sorghum)			W/B (wheat)		
	CT	RT	NT	CT	RT	NT	CT	RT	NT	CT	RT	NT
1975	4.77	5.46	5.15	2.84	2.59	2.57	4.89	4.71	5.30	3.00	3.14	3.06
1976	7.43	7.77	7.03	2.66	2.51	1.71	4.17	4.18	5.06	2.57	2.66	2.44
1977	2.55	2.50	1.97	1.43	1.95	0.67	2.40	2.36	2.27	1.23	1.19	1.26
1978	5.79	5.24	4.51	3.58	4.00	3.28	3.52	4.17	5.12	4.04	4.00	3.87
1979	6.24	6.36	5.60	2.98	2.28	0.14	6.56	6.54	7.62	2.42	2.57	2.63
1980	2.72	3.06	2.35	3.10	2.76	3.15	1.35	1.97	3.36	3.76	3.94	3.84
1981	7.66	7.46	7.18	0.72	1.59	0.67	7.97	6.30	8.86	0.73	0.82	0.71
1982	6.74	7.35	7.61	2.78	1.48	1.53	7.30	7.05	8.23	3.58	2.84	3.22
1983	4.60	3.90	4.52	1.74	1.80	1.80	4.33	4.47	5.17	1.73	1.71	1.73
1984	5.58	5.05	5.63	1.07	1.21	0.65	5.71	4.84	6.27	2.75	2.89	2.74
1985	5.37	5.30	5.34	3.72	3.67	3.79	6.39	6.27	6.86	3.35	3.55	3.45
1986	6.37	6.72	6.81	1.34	0.80	0.40	6.96	5.77	7.43	2.06	1.98	1.86
1987	6.79	6.70	6.66	2.76	2.94	2.72	7.01	8.29	8.02	3.26	3.42	3.21
1988	4.28	4.28	3.93	4.03	3.81	3.39	3.46	3.36	3.49	2.39	2.78	2.67
1989	3.59	3.57	3.53	2.54	1.48	0.80	5.42	5.23	6.07	0	0	0
1990	6.02	5.74	5.78	3.33	3.27	3.27	5.28	5.75	6.88	3.79	4.18	3.98
1991	3.67	4.80	6.40	4.03	3.50	1.75	3.71	4.82	6.85	3.16	3.23	3.29
1992	8.28	7.65	7.21	4.02	4.27	2.24	4.77	6.08	8.03	4.03	4.08	4.23

Mg ha⁻¹

B. Soybean yields at 15% moisture.

Date	Rotation			Rotation		
	B/B	S/B	W/B	B/B	S/B	W/B
	CT	RT	NT	CT	RT	NT
1975	2.88	3.12	3.02	3.67	3.66	3.59
1976	0.77	1.11	0.99	1.36	1.54	1.63
1977	2.97	2.99	2.99	3.50	3.85	3.61
1978	0.18	0.21	0.26	0.57	0.82	0.72
1979	0.93	0.93	1.69	0.99	1.32	2.09
1980	1.05	1.07	1.20	1.00	1.06	2.84
1981	1.95	1.52	2.18	2.05	1.94	0.84
1982	2.21	1.76	2.50	2.42	2.24	2.82
1983	0.67	0.74	0.91	0.76	0.91	3.10
1984	1.40	1.81	1.59	1.85	1.68	1.20
1985	1.54	1.32	1.56	1.51	1.86	1.92
1986	3.15	3.05	3.41	3.60	3.66	2.25
1987	3.19	3.13	3.12	3.30	3.11	3.68
1988	0.48	0.44	0.71	1.25	1.43	3.01
1989	0.60	0.66	0.81	0.91	0.81	1.67
1990	1.03	1.08	0.86	1.16	1.63	1.11
1991	0.36	0.44	0.26	0.26	0.28	2.02
1992	1.87	1.86	1.70	2.91	2.87	0.35
						3.36

VII. Climate averages (1960-1990).

Mean Monthly	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max. temperature (°C)	3.2	6.9	12.5	19.9	25.2	30.1	33.2	32.4	27.6	21.7	12.6	6.2
Min. temperature (°C)	-8.6	-5.6	-0.8	6.2	11.9	17.3	20.0	19.1	13.8	7.3	0.0	-5.4
Precipitation (cm)	2.1	2.4	5.3	7.1	11.4	13.4	10.1	8.1	10.3	7.3	3.7	2.3