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Wheat and Grain Sorghum in Four-Year Rotations

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Abstract
In recent years, cropping intensity has increased in dryland systems in western Kansas. The traditional wheat-fallow system is being replaced by wheat-summer crop-fallow rotations. Is more intensive cropping feasible with concurrent increases in no-till? Objectives of this research were to quantify soil water storage, crop water use, and crop productivity of 4-year and continuous cropping systems.

Keywords
four-year rotations, wheat and grain sorghum rotations, dryland rotation systems

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Wheat and Grain Sorghum in Four-Year Rotations

A. Schlegel, J. Holman, and C. Thompson

Summary
In 1996, an effort began to quantify soil water storage, crop water use, and crop productivity on dryland systems in western Kansas. Research on 4-year crop rotations with wheat and grain sorghum was initiated at the Southwest Research-Extension Center near Tribune, KS. Rotations were wheat-wheat-sorghum-fallow (WWSF), wheat-sorghum-sorghum-fallow (WSSF), and continuous wheat (WW). Soil water at wheat planting averaged about 9 in. following sorghum, which is about 3 in. more than the average for the second wheat crop in a WWSF rotation. Soil water at sorghum planting was only about 1 in. less for the second sorghum crop compared with sorghum following wheat. Grain yield of recrop wheat averaged about 80% of the yield of wheat following sorghum. Grain yield of continuous wheat averaged about 60% of the yield of wheat grown in a 4-year rotation following sorghum. Generally, wheat yields were similar following one or two sorghum crops. Similarly, average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages ~65% of the yield of the first sorghum crop.

Introduction
In recent years, cropping intensity has increased in dryland systems in western Kansas. The traditional wheat-fallow system is being replaced by wheat-summer crop-fallow rotations. Research was conducted to better understand if more intensive cropping is feasible with concurrent increases in no-tillage. Objectives of this research were to quantify soil water storage, crop water use, and crop productivity of 4-year and continuous cropping systems.

Experimental Procedures
Research on 4-year crop rotations with wheat and grain sorghum was initiated in 1996 at the Tribune unit of the Southwest Research-Extension Center. Rotations were WWSF, WSSF, and WW. No-tillage was used for all rotations except for the first two years where reduced tillage was used for wheat following sorghum. Available water was measured in the soil profile (0 to 6 ft) at planting and harvest of each crop. The center of each plot was machine harvested after physiological maturity, and yields were adjusted to 12.5% moisture.

Results and Discussion

Soil Water

The amount of available water in the soil profile (0 to 6 ft) at wheat planting varied greatly from year to year (Figure 1). In 2017, available soil water was greater for wheat following sorghum and for wheat following wheat compared to the long-term average. Soil water was similar following fallow after either one or two sorghum crops and averaged about 9 in. across the 21-year study period. Water at planting of the second wheat crop in a WWSF rotation was generally less than at planting of the first wheat crop, except in 1997 and 2003. Soil water for the second wheat crop averaged more than 3 in. (or about 40%) less than that for the first wheat crop in the rotation. Continuous wheat averaged about 0.8 in. less water at planting than the second wheat crop in a WWSF rotation.

Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2) and available water at sorghum planting was greater than the long-term average. Soil water was similar following fallow after either one or two wheat crops and averaged about 8 in. over 22 years. Water at planting of the second sorghum crop in a WSSF rotation was generally less than that at planting of the first sorghum crop. Averaged across the entire study period, the first sorghum crop had about 1.3 in. more available water at planting than the second crop.

Grain Yields

In 2017, wheat yields were severely decreased by an infestation of wheat streak mosaic virus (Table 1). Averaged across 21 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 80% of first-year wheat crop in WWSF. Before 2003, recrop wheat yielded about 70% of first-year wheat. Wheat yields following two sorghum crops are 2 bu/a greater than following one sorghum crop. In most years, continuous wheat yields have been similar to recrop wheat yields, but in several years (2003, 2007, 2009, and 2014), recrop wheat yields were considerably greater than continuous wheat yields.

Sorghum yields in 2017 for all rotations were the highest recorded in the study. Sorghum yields were 64 to 72 bu/a greater than the long-term average (Table 2). Sorghum yields were similar following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop yields were 81% of the first sorghum crop in 2017, which is greater than the long-term average of about 65%.

Table 1. Wheat response to dryland crop rotation, Tribune, KS, 1997–2017

	Rotation					ANOVA (P > F)		
Year	Wssf[1]	Wwsf	wWsf	WW	LSD 0.05	Rotation	Year	Year × rotation
	---------------------------- bu/a ----------------------------							
1997	57	55	48	43	8	0.017		
1998	70	64	63	60	12	0.391		
1999	74	80	41	43	14	0.001		
2000	46	35	18	18	10	0.001		
2001	22	29	27	34	14	0.335		
2002	0	0	0	0	---	---		
2003	29	27	66	30	14	0.001		
2004	5.7	6.1	0.4	0.5	1.6	0.001		
2005	45	40	41	44	10	0.690		
2006	28	26	7	2	8	0.001		
2007	75	61	63	41	14	0.004		
2008	40	40	5	6	5	0.001		
2009	37	39	50	24	15	0.029		
2010	63	60	29	23	9	0.001		
2011	25	22	25	17	8	0.152		
2012	14	20	10	9	15	0.380		
2013	0	0	0	0	---	---		
2014	51	45	31	12	18	0.004		
2015	49	36	24	24	12	0.001		
2016	78	77	58	52	12	0.001		
2017	20	20	4	6	4	0.001		
Mean	39a	37b	29c	23d	2	0.001	0.001	0.001

[1]W = wheat; S = sorghum; capital letters denote current year's crop.
Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow (WWSF), and continuous wheat (WW).
ANOVA = analysis of variance.
LSD = least significant difference.

Table 2. Grain sorghum response to crop rotation, Tribune, KS, 1996–2017

	Rotation				ANOVA (P>F)		
Year	wSsf[1]	wsSf	wwSf	LSD 0.05	Rotation	Year	Year × rotation
	---------------------- bu/a ----------------------						
1996	58	35	54	24	0.117		
1997	88	45	80	13	0.001		
1998	117	100	109	12	0.026		
1999	99	74	90	11	0.004		
2000	63	23	67	16	0.001		
2001	68	66	73	18	0.673		
2002	0	0	0	---	---		
2003	60	41	76	18	0.009		
2004	91	79	82	17	0.295		
2005	81	69	85	20	0.188		
2006	55	13	71	15	0.001		
2007	101	86	101	9	0.008		
2008	50	30	57	12	0.005		
2009	89	44	103	53	0.080		
2010	98	52	105	24	0.004		
2011	119	47	105	34	0.005		
2012	0	0	0	---	---		
2013	105	98	100	23	0.742		
2014	91	5	84	29	0.001		
2015	125	82	124	22	0.005		
2016	134	98	139	10	0.001		
2017	147	119	157	15	0.002		
Mean	84a	55b	85a	4	0.001	0.001	0.001

[1]W = wheat; S = sorghum; capital letters denote current year's crop.
Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).
ANOVA = analysis of variance.
LSD = least significant difference.

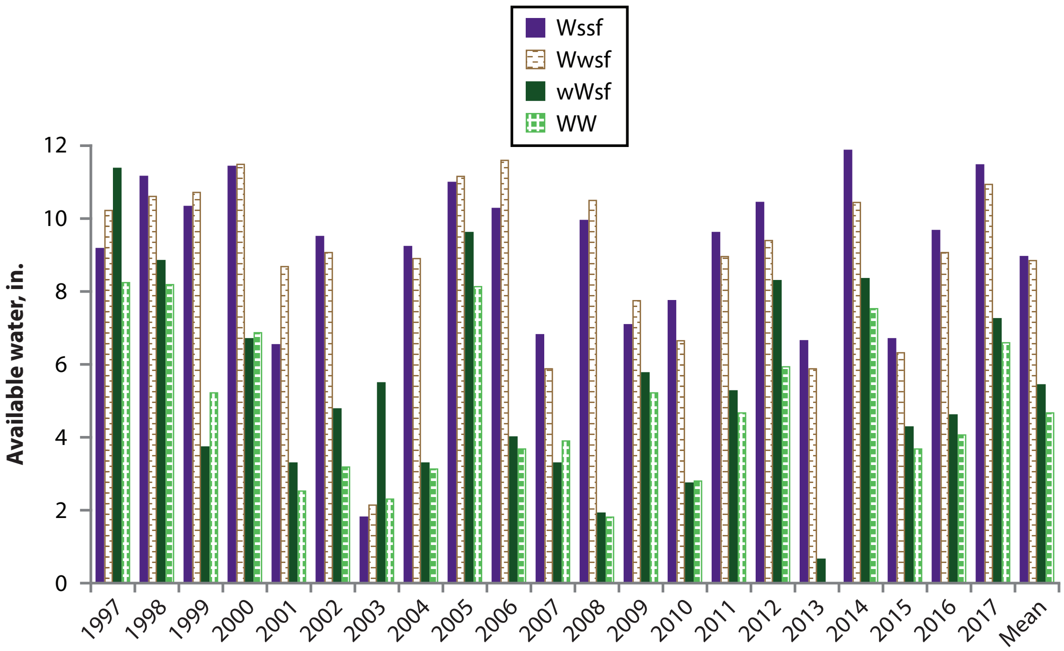

Figure 1. Available soil water in 6-ft profile at planting of wheat in several rotations at Tribune, KS, 1997–2017. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow (WWSF), and continuous wheat (WW).

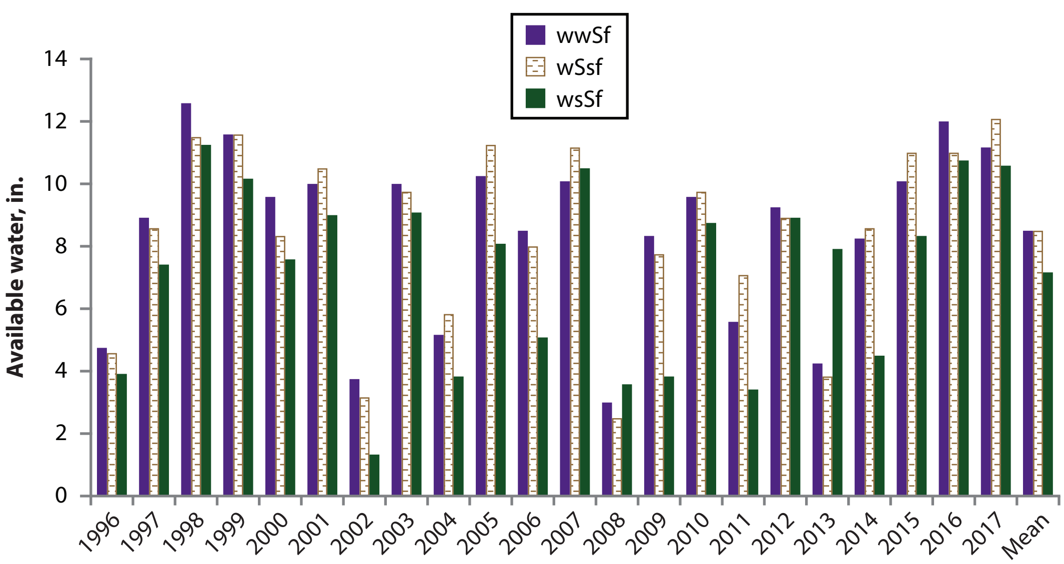

Figure 2. Available soil water in 6-ft profile at planting of sorghum in several rotations at Tribune, KS, 1996–2017. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).