

## Wheat and Grain Sorghum in Four-Year Rotations

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### 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 1.5 in. less for the second sorghum crop compared to sorghum following wheat. The 2019 grain yields of both wheat and grain sorghum in all rotations were much greater than the long-term average. Grain yield of recrop wheat averaged about 75% 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 2019, available soil water was greater for wheat following two sorghum crops than one sorghum crop, while normally they are similar. Soil water was less for WW than for the second wheat crop in WWSF. Available 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 approximately 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 in 2019 was greater than the long-term average. Soil water was similar following one or two wheat crops. 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 1.53 in. more available water at planting than the second crop.

### *Grain Yields*

In 2019, wheat yields in all rotations were much greater than the long-term average (Table 1). Averaged across 23 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 75% 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 many years, continuous wheat yields have been similar to recrop wheat yields. In other years (2003, 2007, 2009, 2014, and 2018), recrop wheat yields were considerably greater than continuous wheat yields. In 2019, continuous wheat yields were 8 bu/a less than recrop wheat yields (63 vs. 71 bu/a) and averaged 6 bu/a less than recrop wheat.

Sorghum yields in 2019 for all rotations were much higher than the long-term average yields (Table 2). This is the fifth year in a row of above average sorghum yields. Sorghum yields following wheat were about 47 bu/a greater than the long-term average. Recrop sorghum yields were 34 bu/a greater than the long-term average. Sorghum yields were similar following one or two wheat crops, which was consistent with the long-term average. The second sorghum crop yields were 68% of the first sorghum crop in 2019, which was similar to the long-term average of about 65%.

**Table 1. Wheat response to dryland crop rotation, Tribune, KS, 1997–2019**

Year	Rotation					ANOVA (P > F)		
	Wssf <sup>1</sup>	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		
2018	52	51	24	24	9	0.001		
2019	88	96	71	63	6	0.001		
Mean	42 a	40 b	31 c	25 d	2	0.001	0.001	0.001

<sup>1</sup>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, 1996–2019**

Year	Rotation				ANOVA (P > F)		
	wSsf <sup>1</sup>	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		
2018	125	64	137	13	0.001		
2019	134	91	137	15	0.001		
Mean	87 a	57 b	89 a	3	0.001	0.001	0.001

<sup>1</sup>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.

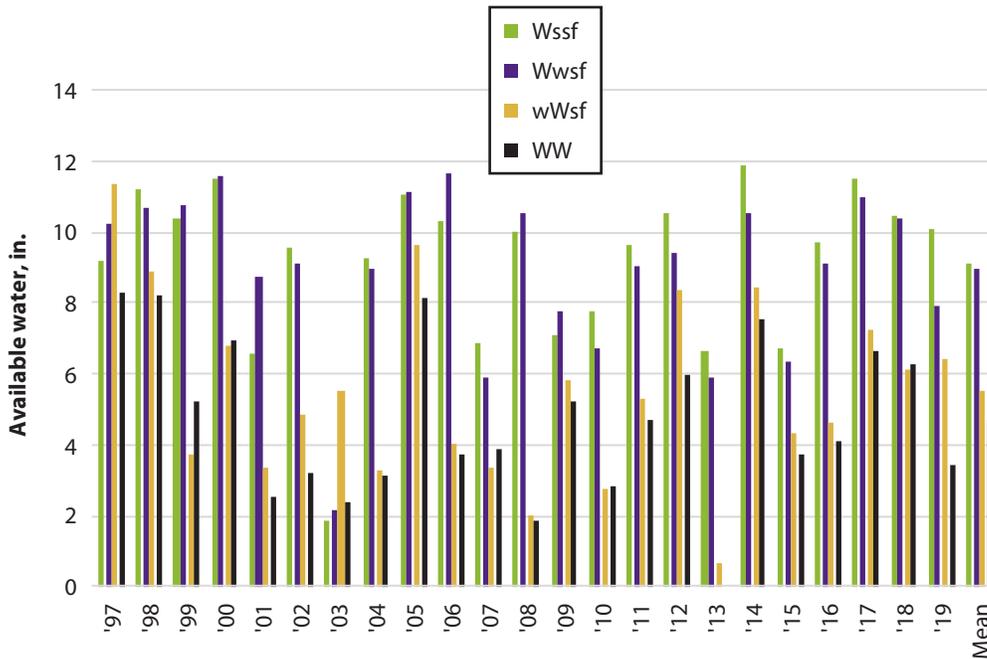


Figure 1. Available soil water in 6-ft profile at planting of wheat in four rotations at Tribune, KS, 1997–2019. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow (WWSF), and continuous wheat (WW).

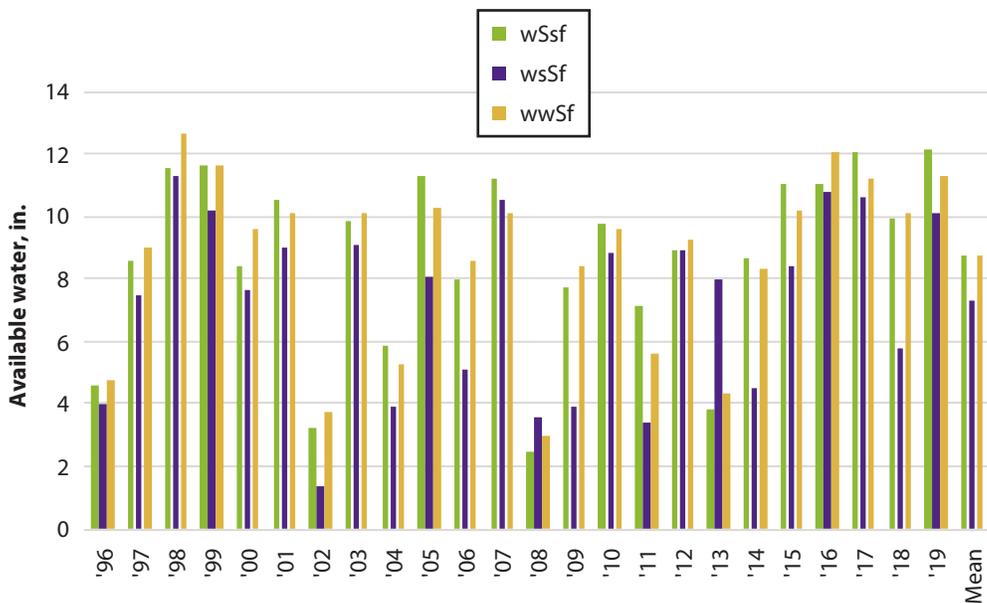


Figure 2. Available soil water in 6-ft profile at planting of sorghum in three rotations at Tribune, KS, 1996–2019. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).