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Lucas A. Haag
Kansas State University, lhaag@ksu.edu

Dewayne Bond
Kansas State University, dbond@ksu.edu

Amanda Burnett
Kansas State University, alburnett@k-state.edu

See next page for additional authors

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Authors

Lucas A. Haag, Dewayne Bond, Amanda Burnett, Jeffrey Slattery, and Alan Schlegel

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L.A. Haag, D. Bond, A. Burnett, J. Slattery, and A. Schlegel

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 9.1 in. following sorghum, which is about 3.8 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 with sorghum following wheat. Sorghum grain yield in 2022 was near average for first crop sorghum after wheat, above average for recrop sorghum, and below average for sorghum after recrop wheat. Wheat yields in 2022 were near zero due to hail. Wheat yields, when averaged across years, have been 2 bu/a greater following two sorghum crops than following one sorghum crop. Average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a WSSF rotation averages ~66% 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 has varied greatly from year to year (Figure 1). In 2022, available soil water at wheat planting was greater for wheat following sorghum than following wheat. Soil water was similar for WW and the second wheat crop in WWSF. 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 about 3.8 in. (or about 42%) 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 has varied greatly from year to year (Figure 2). Available water at sorghum planting in 2022 was less than the long-term average. Soil water was similar following one or two wheat crops. Averaged over the entire study, profile water at planting of the second sorghum crop in a WSSF rotation was generally about 83% of soil water for sorghum planted into wheat stubble. Averaged across the entire study period, the first sorghum crop had about 1.5 in. more available water at planting than the second crop.

Grain Yields

In 2022, wheat yields were reduced to near zero due to hail received immediately prior to harvest. Averaged across 25 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 were 2 bu/a greater than following one sorghum crop. In many years, continuous wheat yields have been similar to recrop wheat yields, but in several years (2003, 2007, 2009, 2014, and 2018), recrop wheat yields were considerably greater than continuous wheat yields. On average, continuous wheat yields were 5 bu/a less than recrop wheat.

Sorghum grain yield in 2022 was near average for first crop sorghum after wheat, above average for recrop sorghum, and below average for sorghum after recrop wheat (Table 2). Sorghum yields were similar following one or two wheat crops, which were consistent with the long-term average. The second sorghum crop yield in a WSSF rotation was 87% of the first sorghum crop in 2022, which were significantly above the long-term average of about 66%. Sorghum after two years of wheat in a WWSF rotation was abnormally below the yield of first year sorghum in a WSSF rotation, which generally produced similar yields.

While second crop sorghum has averaged about 66% of first crop sorghum, a wide range of relative yields has been observed over the 25-year study (Figure 3). There also appears to be a potential relationship between the relative yield of second crop sorghum and profile water at planting (Figure 4). In general, as profile water at planting increases, the average relative yields of recrop sorghum increase. Perhaps more importantly, the scatter in observed datapoints tightens at higher levels of profile water, e.g. yields become more stable as they are less reliant on in-season precipitation.

Table 1. Wheat response to dryland crop rotation, Tribune, KS, 1997–2022

	Rotation					ANOVA (P>F)
Year	Wssf[1]	Wwsf	wWsf	WW	LSD 0.05	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
2020	38	39	9	11	5	0.001
2021	68	68	50	53	11	0.008
2022	---	---	---	---	---	---
Mean	42 a	40 b	30 c	24 d	3	0.001

[1]W = wheat. S = sorghum. Capital letters denote current year's crop.
WSSF = wheat-sorghum-sorghum-fallow. WWSF = wheat-wheat-sorghum-fallow. WW = continuous wheat.
ANOVA = analysis of variance.
LSD = least significant difference.

Table 2. Grain sorghum response to crop rotation, Tribune, KS, 1996–2022

	Rotation				ANOVA (P>F)
Year	wSsf[1]	wsSf	wwSf	LSD 0.05	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
2020	94	64	98	20	0.001
2021	99	69	105	12	0.001
2022	84	73	62	28	0.234
Mean	88 a	58 b	89 a	5	0.001

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

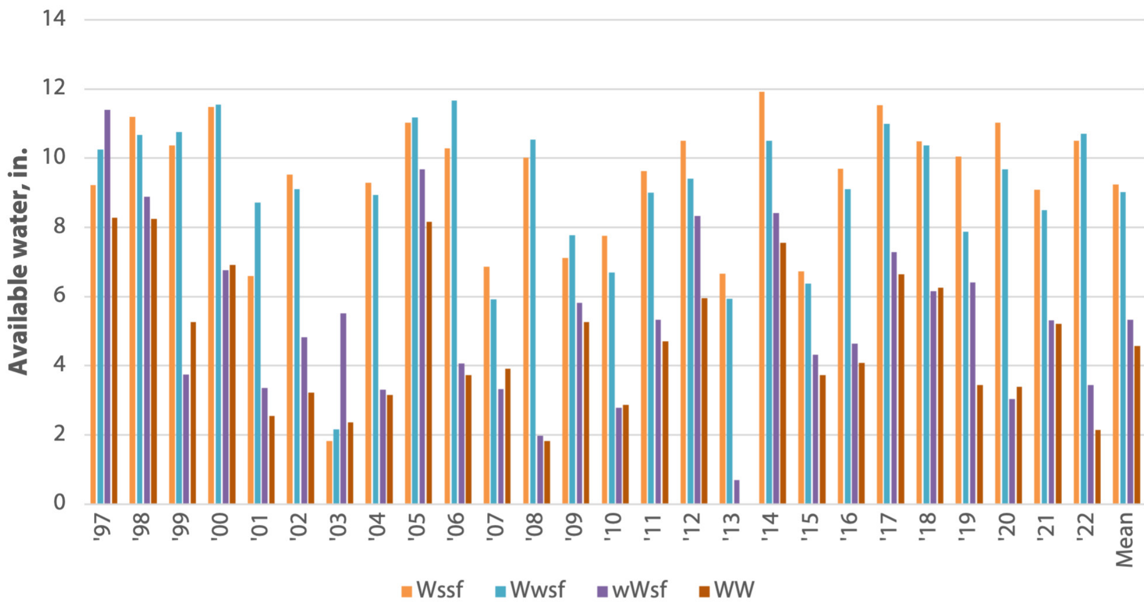

Figure 1. Available soil water in 6-ft profile at planting of wheat in several rotations at Tribune, KS, 1997–2020. Capital letter denotes current crop in rotation (W = wheat; S = sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow (WWSF), and continuous wheat (WW).

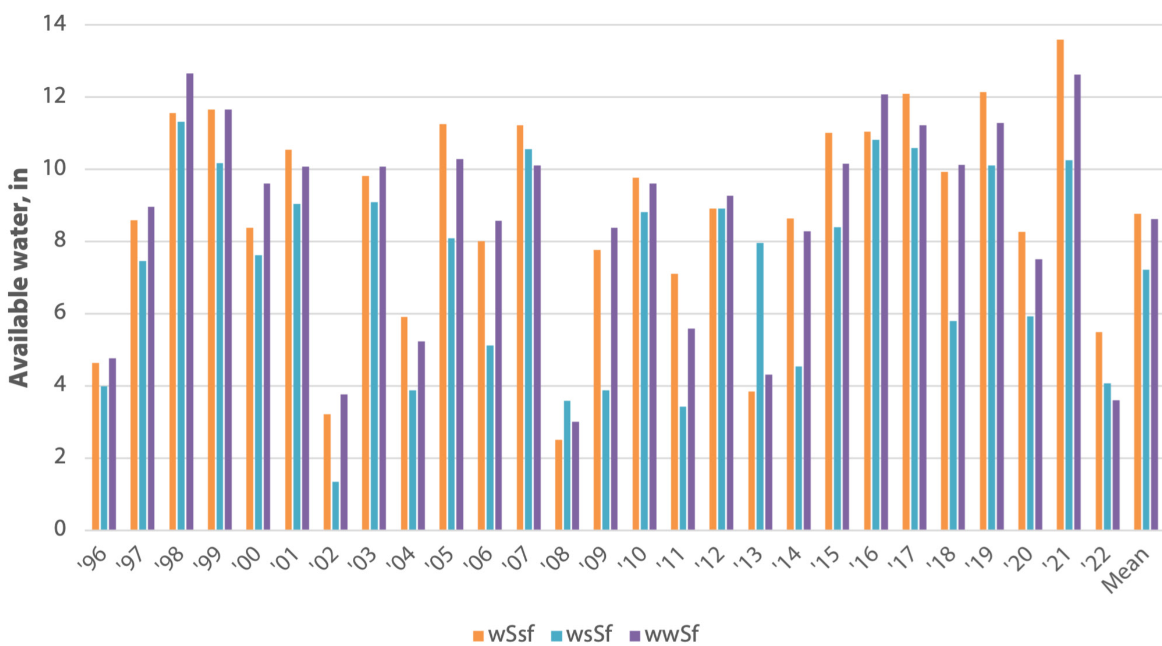

Figure 2. Available soil water in 6-ft profile at planting of sorghum in several rotations at Tribune, KS, 1996–2020. Capital letter denotes current crop in rotation (W = wheat; S = sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow (WWSF).

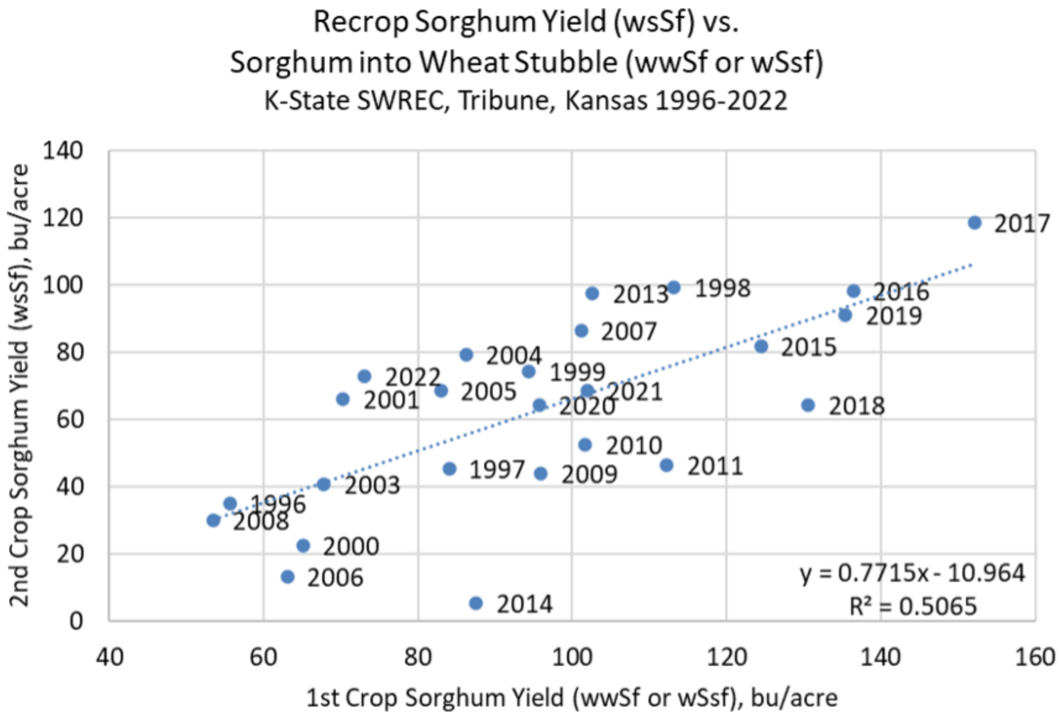

Figure 3. Grain yield of recrop sorghum as a function of first crop sorghum in the same year for sorghum at Tribune, KS, 1996–2022. WSSF = wheat-sorghum-sorghum-fallow. WWSF = wheat-wheat-sorghum-fallow.

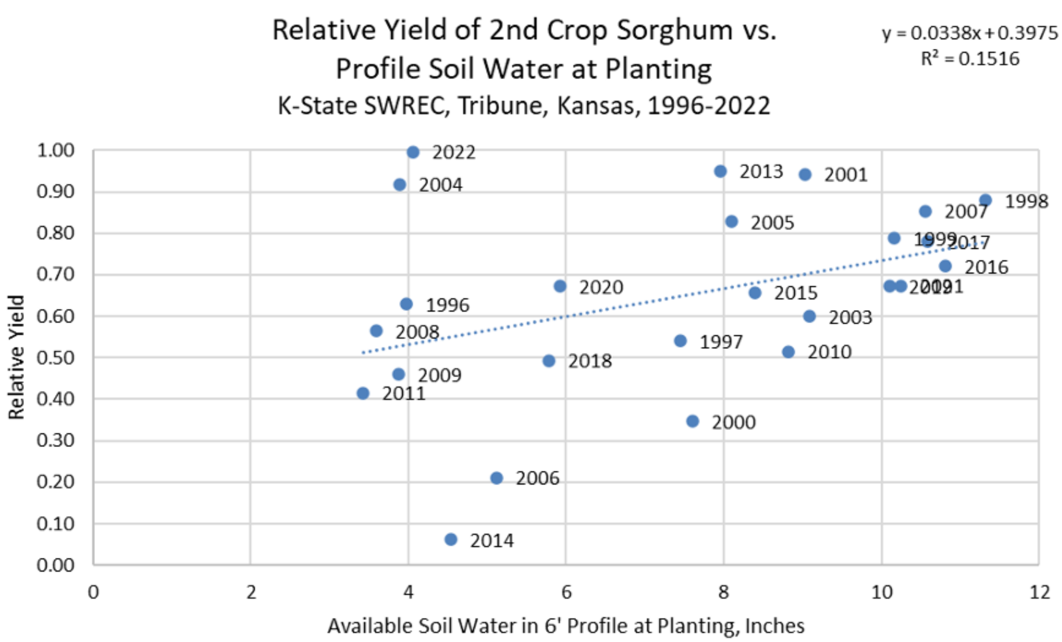

Figure 4. Relative grain yield of recrop sorghum compared to first crop sorghum as a function of profile available water at sorghum planting. Tribune, KS, 1996–2022.