

Large-Scale Dryland Cropping Systems

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Summary

This study was conducted from 2008–2019 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify whether more intensive cropping systems can enhance and stabilize production in rainfed cropping systems to optimize economic crop production, more efficiently capture and utilize scarce precipitation, and maintain or enhance soil resources and environmental quality. The crop rotations evaluated were continuous grain sorghum (SS), wheat-fallow (WF), wheat-corn-fallow (WCF), wheat-sorghum-fallow (WSF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCHF). All rotations were grown using no-tillage practices except for WF, which was grown using reduced-tillage. The efficiency of precipitation capture was not greater with more intensive rotations. Length of rotation had little effect on wheat yields. Corn and grain sorghum yields were about 45–50% greater when following wheat than when following corn or grain sorghum. Grain sorghum yields were about 45% greater than corn in similar rotations.

Introduction

The change from conventional tillage to no-tillage cropping systems has allowed for greater intensification of cropping in semi-arid regions. In the central High Plains, wheat-fallow (1 crop in 2 years) has been a popular cropping system for many decades. This system is being replaced by more intensive wheat-summer crop-fallow rotations (2 crops in 3 years). There has also been increased interest in further intensifying the cropping systems by growing 3 crops in 4 years or continuous cropping. This project evaluates several multi-crop rotations that are feasible for the region, along with alternative systems that are more intensive than 2- or 3-year rotations. The objectives are to 1) enhance and stabilize production of rainfed cropping systems using multiple crops and rotations, using best management practices to optimize capture and utilization of precipitation for economic crop production, and 2) enhance adoption of alternative rainfed cropping systems that provide optimal profitability.

Experimental Procedures

The crop rotations are 2-year (wheat-fallow [WF]); 3-year (wheat-grain sorghum-fallow [WSF] and wheat-corn-fallow [WCF]); 4-year (wheat-corn-sorghum-fallow [WCSF] and wheat-sorghum-corn-fallow [WSCHF]); and continuous sorghum [SS]. All rotations are grown using no-tillage (NT) practices except for WF, which is grown using reduced-tillage (RT). All phases of each rotation are present each year. Plot size is a minimum of 100 × 450 ft. In most instances, grain yields were determined by harvesting the center 60 ft (by entire length) of each plot with a commercial combine and determining grain weight with a weigh-wagon or combine yield monitor. Soil water was measured in 12-inch increments to 96 inches near planting and after harvest either gravimetrically (RT WF) or by neutron attenuation (NT plots).

Results and Discussion

Precipitation averaged 102% of normal (17.90 in.) across the 12-yr study period and was near normal (+/- 15%) in 8 out of 12 years with three wet years (>20% above normal) and one exceptionally dry year (42% of normal) (Figure 1). Fallow accumulation, fallow efficiency, and profile available water at wheat planting were greater with WF than all other wheat rotations (Table 1). The fallow efficiencies of the 3- and 4-yr NT rotations were only 54–68% of WF under RT. With more water available, crop water use was also greater with WF than with wheat in other rotations. There were no differences in available water at wheat planting or crop water use among the 3- and 4-yr rotations.

Fallow accumulation prior to corn planting and profile available soil water at planting was greater following wheat (WCF or WCSF) than following grain sorghum (WSCF) (Table 1). However, the fallow period following wheat was longer, resulting in low fallow efficiencies (~18%) following wheat and only 22% following sorghum. Similar to wheat, corn water use was greater with greater available soil water at planting. Grain sorghum responded similarly to corn, with greater fallow accumulation and soil water at planting (and greater crop water use) when following wheat than following corn or sorghum. Again, fallow efficiencies prior to grain sorghum were low (16–22%).

Wheat yields were greatly above normal in 2019 with yields exceeding 100 bu/a in the 3-yr rotations (Figure 2). The effect of cropping systems was not consistent across years, with WF sometimes in the highest yielding group and sometimes in the lowest yielding group. Averaged across the 12 years, cropping system had little effect (5 bu/a or less) on wheat yields.

Grain sorghum yields were very good in 2019 with yields greater than 100 bu/a when following wheat (Figure 3). Sorghum following corn produced 36 bu/a less yield than following wheat, and continuous sorghum yields were 14 bu/a greater than following corn. Average grain sorghum yields following wheat were approximately 50% greater than following corn or sorghum.

Similar to grain sorghum, corn yields were very good in 2019 (Figure 4) with all rotations yielding 90 bu/a or more. Corn yields following wheat in either the 3- or 4-yr rotations were always greater than corn yields following grain sorghum, except in 2015 where corn yields following sorghum (wsCf) were greater than wCf. On average, corn yields following wheat were about 45% greater than following grain sorghum.

When examining grain yields across crops, the greatest yields were produced by grain sorghum following wheat (either wSf or wScf) of >85 bu/a (Figure 5). These yields were about 45% greater than corn following wheat (wCf or wCsf). Sorghum yields following wheat were about 50% greater than sorghum following corn or sorghum (wcSf or SS), while corn yields following wheat (wCf or wCsf) were about 45% greater than following sorghum.

Acknowledgments

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Table 1. Fallow accumulation, fallow efficiency, profile (8 ft) available soil water at planting, and crop water use by wheat, corn, and grain sorghum in several crop rotations, Tribune, KS, 2008–2019

Crop	Rotation	Fallow accumulation	Fallow efficiency	Profile ASW at planting ²	Crop water use
		inch	%	----- inch -----	
Wheat	Wf ¹	6.82 a	28 a	9.88 a	18.55 a
	Wsf	3.12 bc	19 b	6.54 b	14.68 b
	Wcf	2.67 c	15 c	6.48 b	14.69 b
	Wscf	3.30 b	19 b	7.02 b	15.03 b
	Wcsf	3.20 b	18 b	6.51 b	14.71 b
LSD _{0.05}		0.49	2	0.58	0.51
Corn	wCf	2.65 a	18 b	6.14 a	14.09 a
	wCsf	2.60 a	18 b	6.08 a	14.05 a
	wsCf	1.62 b	22 a	5.18 b	13.19 b
LSD _{0.05}		0.33	3	0.53	0.34
Grain sorghum	wSf	2.57 b	16 c	6.13 b	13.54 b
	wScf	3.11 a	19 b	6.68 a	13.91 a
	wcSf	1.55 d	16 c	5.36 c	12.92 c
	SS	2.06 c	22 a	5.51 c	12.99 c
LSD _{0.05}		0.34	3	0.53	0.33

¹Wheat-fallow rotation is reduced-tillage; all other rotations are no-tillage. Means within a column with the same letter for the same crop are not statistically different at $P = 0.05$. The capital letter in the rotation denotes the crop phase of the rotation.

²Available soil water (ASW) in an 8 ft profile at planting.

W = wheat. F = fallow. S = sorghum. C = corn. SS = continuous grain sorghum.



Figure 1. Annual (2008–2019) and normal precipitation (1981–2010, last bar), Tribune, KS.

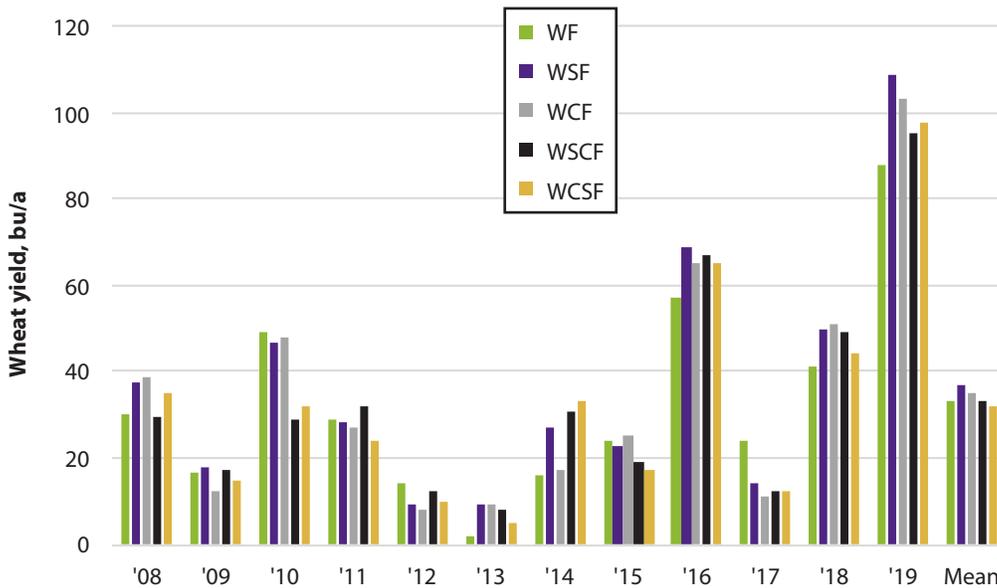


Figure 2. Wheat yields by cropping system, 2008–2019. Last set of columns are treatment means. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF).

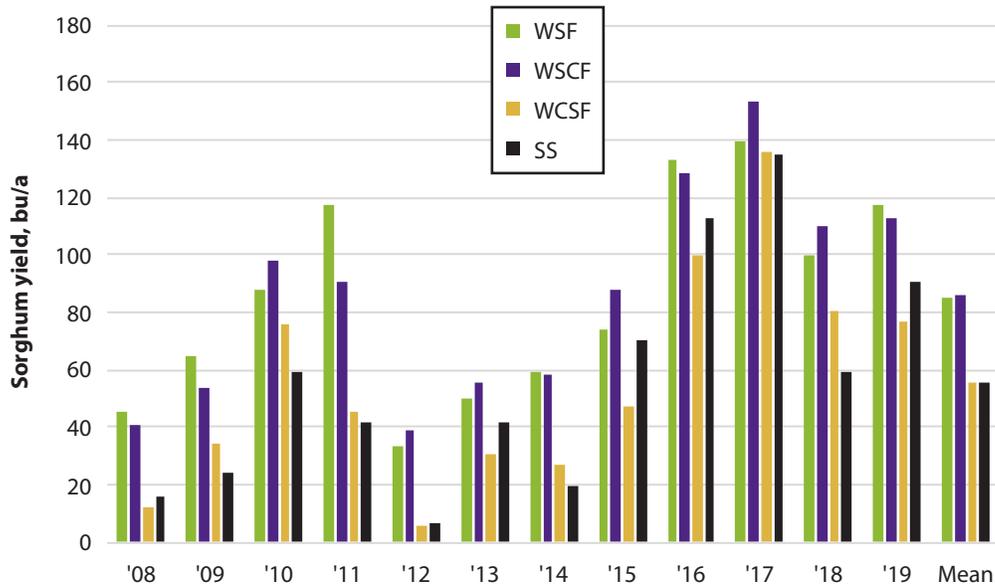


Figure 3. Grain sorghum yields by cropping system, 2008–2019. Last set of columns are treatment means. Wheat-sorghum-fallow (WSF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).

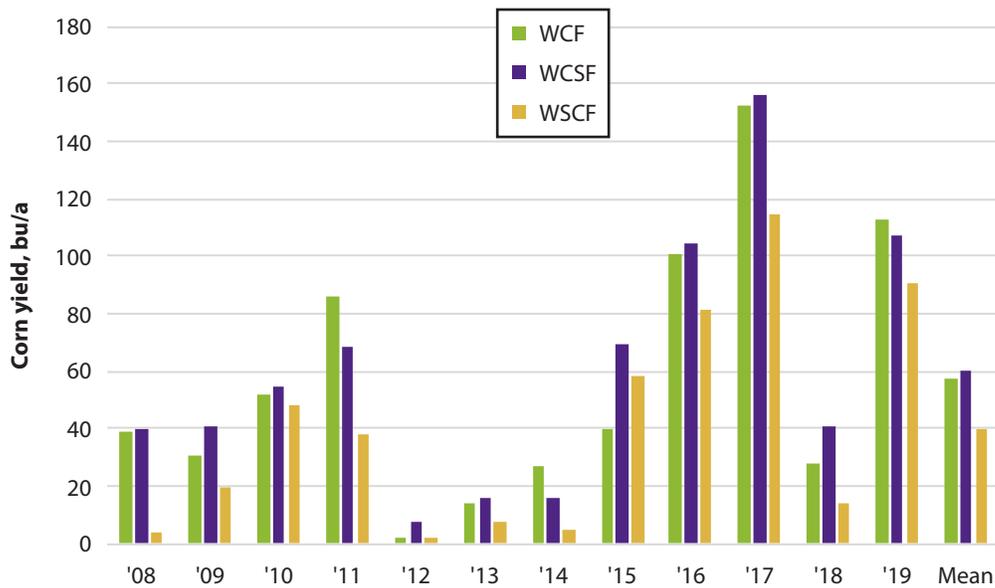


Figure 4. Corn yields by cropping system, 2008–2019. Last set of columns are treatment means. Wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WSCF), and wheat-sorghum-corn-fallow (WCSF).

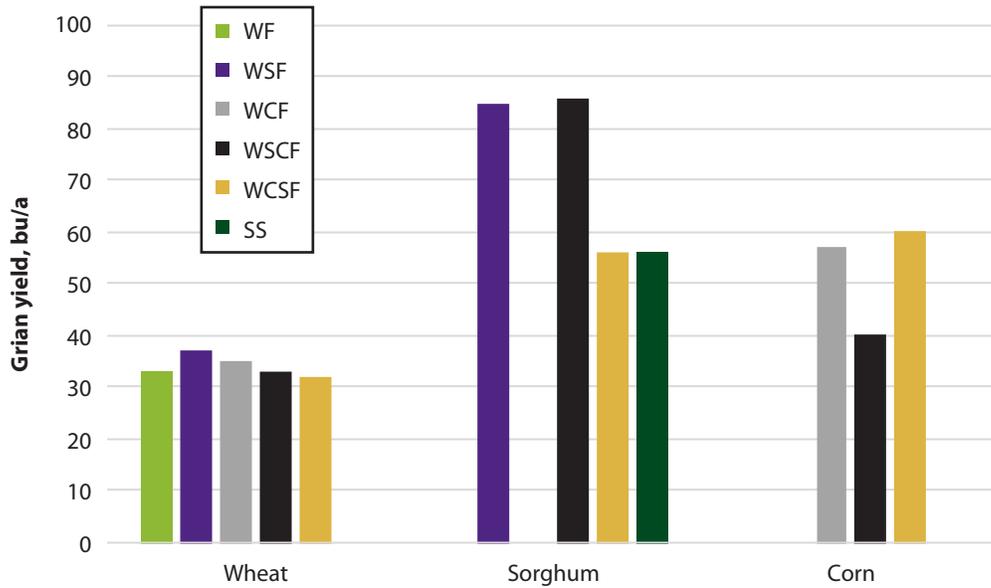


Figure 5. Average grain yields by cropping system, 2008–2019. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).