From: Agronomy Field Research 2009, Kansas Agric. Exp. Stn. Report of Progress 1017, April 2009

Ten Crop Sequences, Transition to No-Till

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Summary

Grain productivity and water use of 10 crop sequences, all including winter wheat, were compared for the period 2002 to 2007, which included a 3-year drought. Corn or grain sorghum feed grains were included in nine of the crop sequences; six of the sequences were cropped continuously by including an oilseed crop (spring canola, soybean, or sunflower). Principle trends in the study indicated that land and productivity varied with rainfall among years, wheat productivity benefited from summer fallow, grain sorghum productivity exceeded corn when limited by water, and continuous cropping increased the fraction of precipitation used by crop but reduced overall land productivity. Economic analysis revealed that net returns were similar for wheat/grain sorghum/fallow ($35/a) and wheat/fallow ($31/a); wheat/corn/fallow also gave positive net returns ($14/a), but economic returns were negative for other crop sequences. Net returns were significantly greater in 2005, 2006, and 2007 relative to previous drought years.

Introduction

Available water frequently limits productivity in semiarid cropping systems. The wheat/fallow system accumulates water over a 2-year period, producing a single wheat crop. Tillage provides weed control but often leaves soil exposed to evaporative and erosive forces. Frequently, more precipitation is lost to evaporation than used by a growing wheat crop. More intensive crop sequences use feed grains (corn, grain sorghum) and oilseeds (spring canola, soybean, sunflower) to reduce evaporative losses in fallow periods and increase crop access to precipitation. The objective of this study was to compare water use, grain yield, and biomass productivity for 10 cropping sequences.

Procedures

Crop management was intended to minimize evaporative loss of water, maximize grain productivity, and maximize soil water recharge. Full-season, adapted feed grain cultivars were planted at conventional periods; short-season oilseed cultivars were planted early in continuous cropping sequences to permit wheat planting following harvest. Cultural practices (Table 1) were modified at the beginning of each 3-year cycle to reflect technology advances.

Cropping sequences (Table 2) included 3-year cycles of wheat, feed grain (corn or grain sorghum), and oilseed (sunflower, soybean, canola) or fallow as well as wheat/fallow (2-year cycle) and wheat/corn/sunflower/fallow (4-year cycle). Each phase of a sequence was present each year in triplicate sets of plots. Thus, cropping sequences represent 1:2, 2:3, 3:4, and 3:3 (crop harvest:years in cycle) cropping intensities.

Crop water use was calculated from cumulative precipitation and change in soil profile water content from emergence to flowering to harvest (physiological maturity) crop stages. Yield components (stand, mid-vegetative, and harvest; flowering units; seed weight) and aboveground biomass were hand sampled at maturity. Grain yield was also measured by machine harvest with a plot combine (platform or corn header). For conditions with poor stands, yield potential was estimated from hand-harvested samples. Yields were adjusted to standard moisture content. Annualized crop water use, grain yield, or biomass, computed as the average among all phases (including fallow) of a given sequence, provided a uniform basis for comparing water use and land productivity among crop sequences.

An economic analysis of the relative profitability of the cropping systems was performed. Crop input cost estimates were developed from Table 2 by using recent crop budget guides from K-State Research and Extension, the University of Nebraska-Lincoln, and other sources when needed. Per-unit cost estimates of seed, fertilizer, herbicides, and insecticides were used. Current estimates of current field operation costs were taken from Kansas Agricultural Statistics. Field operation costs used in this analysis included those for plant/seeding; application of fertilizer, herbicides, and insecticides; tillage; and harvesting and hauling of grain. Grain prices for the 2002-2003 through 2007-2008 marketing years for wheat were gathered from USDA sources. Decisions of whether to include harvest costs in net returns for a particular year were made in the following manner: If revenue from crop (yield × grain price) was greater than or equal to total harvesting and hauling cost of the grain, costs were included. Returns over total harvesting cost were then applied toward covering the rest of the crop production costs. Conversely, if crop revenue was less than total harvesting costs, crop enterprise financial losses were minimized by assuming the crop was not harvested.

Results

The study was established in 2000; crops were planted into uniform wheat stubble. Thus, the 2002 harvest was the first year reflecting crop sequence effects for 3-year cycles. Two complete cycles of the 3-year sequences are represented by results from 2002 to 2007. Crop water use, grain yields, and biomass productivity are presented (Table 2) for each phase of the crop sequences, averaged over years. Annualized values represent the sum of each phase divided by number of years in the crop sequence. Some trends observed during these drought years include:

- Land productivity varied with rainfall among years.
- Wheat productivity benefited from summer fallow.
- Grain sorghum productivity exceeded corn productivity when limited by water.
- Continuous cropping increased the fraction of precipitation used by the crop.
- Stand establishment, timing, and amount of water limited oilseed productivity.

Annualized grain yield (averaged over a given sequence) was closely related to aboveground biomass produced by that crop sequence (Figure 1). Annualized productivity, averaged over all growing seasons, indicated that land productivity was greatest for the wheat/grain sorghum/fallow sequence. Land productivity for the wheat/corn/fallow sequence exceeded that of continuous cropping with grain sorghum and either spring canola or soybean.

Economic analysis revealed that net returns (Table 3) were similar for wheat/grain sorghum/fallow ($35/a) and wheat/fallow ($31/a). Wheat/corn/fallow also gave positive net returns ($14/a), but economic returns were negative for other crop sequences. Considering the drought conditions, the threshold for economic harvest was always met for wheat after fallow (Table 4) but was met only in 70% of the cases for wheat after oilseed (continuous cropping). The economic threshold for harvest was met for feed grains in 56 (corn) to 72% (grain sorghum) of cases but was met for oilseeds in only 17 to 19% of cases for the oilseed crop (when cropped continuously). Net returns were significantly greater in 2005, 2006, and 2007 relative to previous drought years (Figure 2).

Table 1. Typical crop cultural practices for crop sequence study, 2002-2007

Crop	Cultivar	Seeding	Fertilizer	Pesticide/Weed control
			lb/a	
Wheat	Jagger	90 lb/a	70 N 30 P	Starane 0.5 pt/a
Corn	CA 6920 Bt, Ottilie 5170RR, DKC50-20 RR2/YGCB	18,500 seeds/a	70 N 30 P	Roundup UM 24 oz/a
Grain sorghum	CA 737, DK-44	40,000 seeds/a	70 N 30 P	Roundup UM 24 oz/a[1] Starane 8 oz/a or Clarity 8 oz/a[2]
Canola	Hyola 401, Hyola 357RR	11 lb/a	70 N 30 P	Treflan 1.5 pt/a Gaucho seed treatment Capture 2EC 2.5 oz/a Roundup Ultra 16 oz/a[1]
Soybean	IA 1008, Macon, KS4704RR	175,000 seeds/a	70 N 30 P	Raptor 4 oz/a Roundup Ultra 16 oz/a
Sunflower	SF 187, Myc 8N429CL	18,000 seeds/a	70 N 30 P	Lorsban 15 2 lb/a Roundup RT 24 oz/a Beyond 4 oz/a Spartan 3 oz/a
Fallow, no-till	–	–	–	4X Roundup Ultra 16 oz/a[3]
Fallow, reduced till	–	–	–	4X undercut with sweep plow

[1] When weeds were present prior to planting.
[2] Broadleaf control, as needed.
[3] Ammonium sulfate was added (17 lb/100 gal first application, 10 lb/100 gal later applications) to Roundup Ultra fallow applications but not in tank mixes.

Table 2. Crop sequence effects on water use, biomass, and grain yields, 2002-2007

Rotation[1]	Wheat phase	Feed grain phase	Oilseed phase	Annualized[2]
	Crop water use			
	----------in.----------			
WW-C-Can	9.02	13.53	8.16	10.67
WW-C-Soy	8.84	12.80	12.99	11.52
WW-C-Sun	8.17	12.54	10.78	10.72
WW-C-Fal	12.85	13.74	0.00	8.77
WW-GS-Can	8.75	14.89	8.21	11.05
WW-GS-Soy	8.08	13.80	13.43	11.8
WW-GS-Sun	8.04	12.97	10.42	10.74
WW-GS-Fal	10.88	14.83	0.00	8.49
WW-Fal	10.98	0.00	0.00	5.49
WW-C-Sun-Fal	10.81	14.11	11.86	9.38
	Biomass yield			
	----------lb/a----------			
WW-C-Can	4137	4190	1550	3259
WW-C-Soy	3484	3846	1518	2920
WW-C-Sun	3060	4026	1763	2920
WW-C-Fal	6883	5428	0	4062
WW-GS-Can	3937	7130	1189	4044
WW-GS-Soy	3271	6879	1527	3854
WW-GS-Sun	3401	5787	1640	3573
WW-GS-Fal	6814	8100	0	4922
WW-Fal	6302	0	0	3151
WW-C-Sun-Fal	6306	5596	2565	3617

continued

Table 2. Crop sequence effects on water use, biomass, and grain yields, 2002-2007

Rotation[1]	Wheat phase		Feed grain phase		Oilseed phase		Annualized[2]
	Grain yield						
	lb/a	bu/a	lb/a	bu/a	bu/a	lb/a	lb/a
WW-C-Can	1096	18.3	1390	24.8		395	951
WW-C-Soy	984	16.4	1362	24.3	10.8	649	988
WW-C-Sun	697	11.6	1393	24.9		350	805
WW-C-Fal	2243	37.4	1997	35.7		0	1400
WW-GS-Can	968	16.1	2824	50.4		249	1333
WW-GS-Soy	851	14.2	2569	45.9	10.7	643	1341
WW-GS-Sun	761	12.7	1892	33.8		293	972
WW-GS-Fal	2240	37.3	3296	58.9		0	1827
WW-Fal	2435	40.6	0			0	1217
WW-GS[3]-Sun-Fal	1916	31.9	1845	32.9		671	1108

[1] WW = winter wheat (13% moisture basis, 60 lb/bu), C = corn (15.5% moisture basis, 56 lb/bu), Can = canola (10% moisture basis, cwt), Soy = soybean (13% moisture basis, 60 lb/bu), Sun = sunflower (10% moisture basis, cwt), Fal = fallow, GS = grain sorghum (12.5% moisture basis, 56 lb/bu).

[2] Annualized is the sum of the phases for a crop sequence divided by number of years in the crop sequence.

[3] Feed grain was corn in 2002.

Table 3. Average annual net returns for crop phase and annualized crop sequence for dryland crop sequences at Colby, KS, 2002-2007

	Average annual net returns[1]				
Crop sequence[2]	Wheat	Feed grain	Oilseed	Fallow	Annualized
	---$/a---				
W-F	88			(26)	31
W-C-F	72	17		(47)	14
W-GS-F	79	74		(47)	35
W-GS-Sun-F	57	7	(64)		(12)
W-C-OS	(5)	(11)	(79)		(32)
W-GS-OS	(8)	40	(80)		(16)

[1] Values in parentheses indicate negative net returns.

[2] W = winter wheat, F = fallow, C = corn, GS = grain sorghum, Sun = sunflower, OS = oilseed (average of canola, soybean, and sunflower response).

Table 4. Percentage of years when economic value of grain yields matched or exceeded harvest costs for crop phases of crop sequences at Colby, KS, 2002-2007

	Economic harvest		
Crop sequence[1]	Wheat	Feed grain	Oilseed
	---% ---		
W-F	100		
W-C-F	100	56	
W-GS-F	100	72	
W-GS-Sun-F	100	61	28
W-C-OS	69	52	19
W-GS-OS	70	61	17

[1] W = winter wheat, F = fallow, C = corn, GS = grain sorghum, Sun = sunflower, OS = oilseed (average of canola, soybean, and sunflower response).

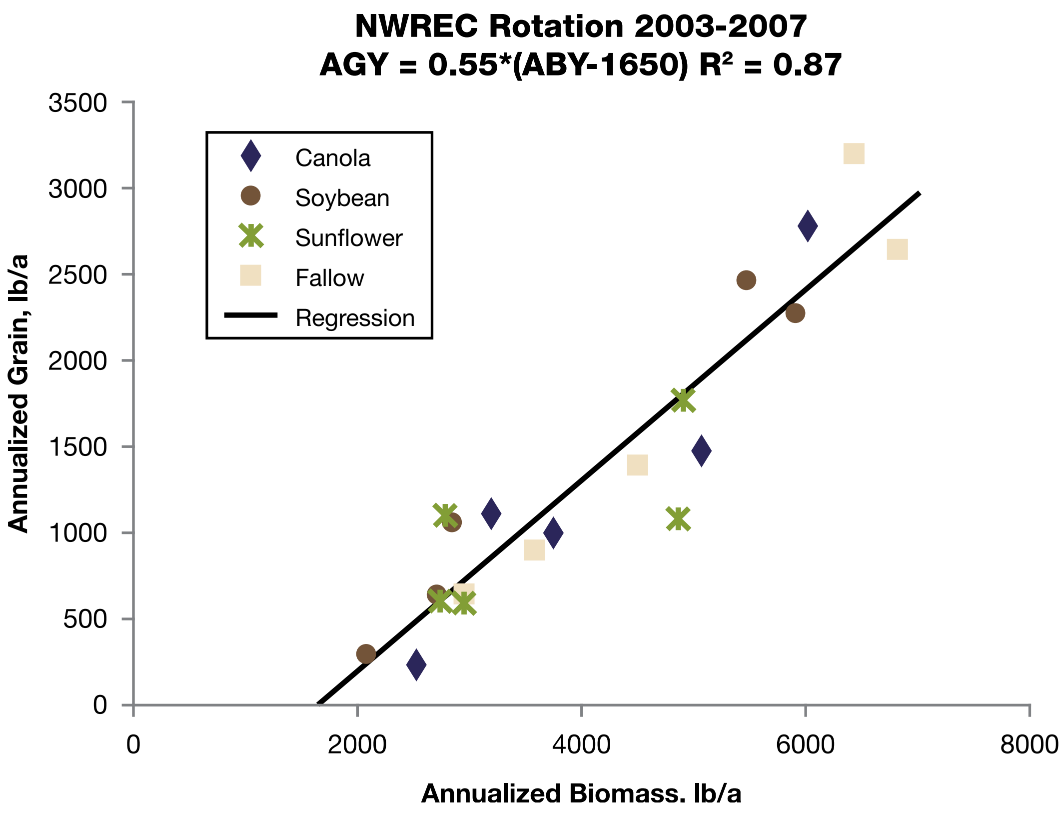

Figure 1. Annualized grain yield (average of crop phases within crop sequence) in relation to annualized aboveground biomass produced by that crop sequence.

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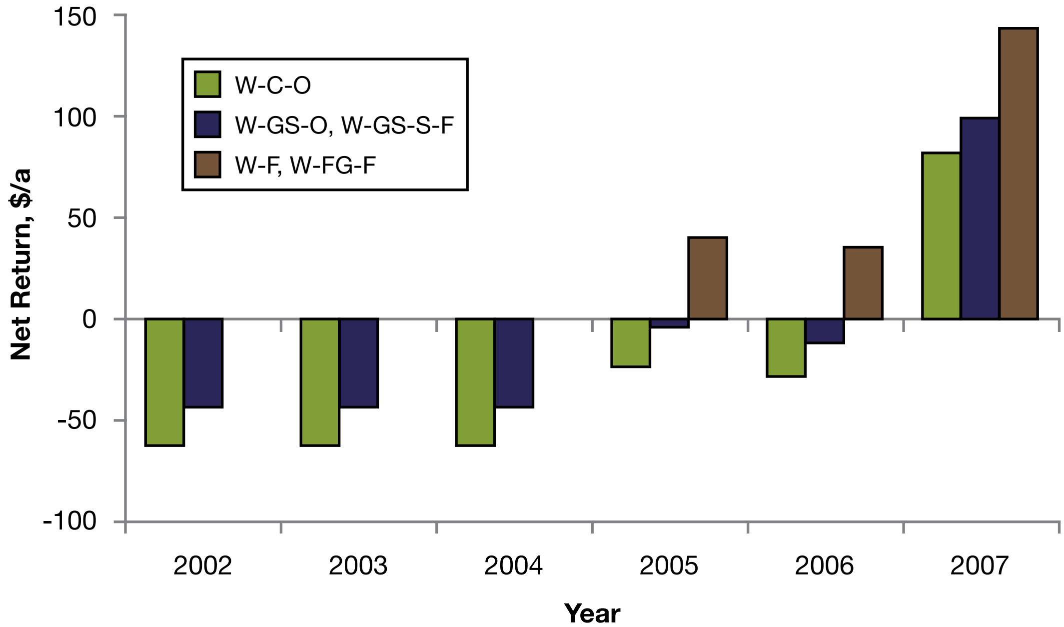

Figure 2. Net economic returns to crop sequences at Colby, KS, 2002-2007; Model of crop sequence and year effects.
W = winter wheat, C = corn, O = oilseed (average of canola, soybean, and sunflower response), GS = grain sorghum, S = sunflower, F = fallow, FG = feed grain.