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# Alternative Cropping Systems with Limited Irrigation

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## Cover Page Footnote

The project was funded in part by Western Kansas Groundwater Management District No. 1.

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## Summary

A limited irrigation study involving four cropping systems and evaluating four crop rotations was initiated at the Southwest Research-Extension Center near Tribune, KS, in 2012. The cropping systems were two annual systems (continuous corn [C-C] and continuous grain sorghum [GS-GS]) and two 2-year systems (corn-grain sorghum [C-GS]) and corn-winter wheat [C-W]). In 2016, corn yields were similar in all rotations, as were grain sorghum yields. This tended to agree with the 4-yr average yields, except for average grain sorghum yields being higher following corn than grain sorghum.

## Experimental Procedures

A crop rotation study under sprinkler irrigation at the Kansas State University Southwest Research-Extension Center near Tribune was initiated in the spring of 2012. The study evaluates four different crop rotations with a limited irrigation allocation. The rotations include 1- and 2-year rotations. The crop rotations are 1) continuous corn; 2) corn-winter wheat; 3) corn-grain sorghum; and 4) continuous grain sorghum (a total of 6 treatments). All rotations are limited to 10 inches of irrigation water annually. All crops are grown no-till, while other cultural practices (hybrid selection, fertility practices, weed control, etc.) are selected to optimize production. All phases of each rotation are present each year and replicated four times. Irrigations are scheduled to supply water at the most critical stress periods for the specific crops and limited to 1.5 inches/week. Soil water is measured at planting, during the growing season, and at harvest in 1-ft increments to a depth of 8 ft. Grain yields are determined by machine harvest. Nitrogen fertilizer (UAN) was surface applied (stream) in March to all crops (240 lb N/a for corn, 160 lb N/a for grain sorghum, and 120 lb N/a for wheat). Corn was planted on April 28, 2016, and harvested on September 15, 2016. Grain sorghum was planted on June 1, 2016, and harvested on October 20, 2016. Wheat was planted on September 29, 2015, and harvested on July 8, 2016.

## Results and Discussion

Weather conditions were good for crop production in 2016. Precipitation was above normal for April, July, August, and September. Open pan evaporation was 13% below normal from April through September. Corn yields in 2016 were similar for all rotations with a range of 174 to 186 bu/a (Table 1). Wheat yields in 2016 (82 bu/a) were greater than the multi-year average yield of 64 bu/a (Table 2). Grain sorghum yields were similar following corn or grain sorghum at about 150 bu/a. Averaged across four years, continuous grain sorghum yields were 10 bu/a less than following corn.

Available soil water at corn planting and harvest was similar for all rotations in 2016 (Table 3). Fallow efficiency was less following wheat than following either corn or grain sorghum. For wheat, available soil water at planting and harvest was greater than the 4-yr average (Table 4). The only difference observed with grain sorghum was more fallow accumulation for grain sorghum following corn than following grain sorghum. This was consistent with the average fallow accumulation for the past 4 years. Average crop water use was similar for all rotations for corn and both rotations with grain sorghum.

## Acknowledgment

The project was funded in part by Western Kansas Groundwater Management District No. 1.

**Table 1. Grain yield of three crops under limited irrigation as affected by rotation in 2016**

| Rotation | Corn | Wheat | Grain sorghum |
|---|---|---|---|
| | ---------- bu/a ---------- | | |
| Continuous corn | 174 | --- | --- |
| Continuous grain sorghum | --- | --- | 149 |
| Corn-wheat | 181 | 82 | --- |
| Corn-grain sorghum | 186 | --- | 154 |
| Least significant difference$_{(0.05)}$ | 17 | --- | 25 |

**Table 2. Grain yields of three crops under limited irrigation as affected by rotation across years 2013 - 2016**

| Rotation | Corn | Wheat | Grain sorghum |
|---|---|---|---|
| | ---------- bu/a ---------- | | |
| Continuous corn | 170b[1] | --- | --- |
| Continuous grain sorghum | --- | --- | 137b |
| Corn-wheat | 184a | 64 | --- |
| Corn-grain sorghum | 183a | --- | 147a |
| Least significant difference$_{(0.05)}$ | 12 | --- | 9 |

[1] Means within a column with the same letter are not statistically different at $P = 0.05$.

**Table 3. Profile available soil water, crop water use, and fallow accumulation for crop rotations under limited irrigation, Tribune, KS, 2016**

| | | Available water | | | | | |
|---|---|---|---|---|---|---|---|
| Crop | Rotation | Previous harvest | Planting | Harvest | Crop water use | Fallow accumulation | Fallow efficiency |
| | | inches | | | | | % |
| Corn | C-C | 10.03 | 16.15 | 14.85 | 28.72 | 6.13 | 63a [1] |
| | C-W | 10.74 | 15.27 | 15.94 | 26.75 | 4.53 | 31b |
| | C-GS | 10.28 | 15.10 | 15.27 | 27.24 | 4.82 | 72a |
| LSD $_{0.05}$ | | 4.14 | 2.78 | 3.95 | 2.57 | 2.18 | 21 |
| ANOVA (P > F) | | | | | | | |
| System | | 0.915 | 0.630 | 0.800 | 0.229 | 0.242 | 0.008 |
| Wheat | C-W | 9.58 | 9.58 | 12.69 | 19.59 | 0 | --- |
| ANOVA (P > F) | | | | | | | |
| System | | --- | --- | --- | --- | --- | --- |
| Grain sorghum | C-GS | 7.69b | 15.50 | 11.37 | 24.52 | 7.80a | 52 |
| | GS-GS | 10.57a | 15.54 | 11.32 | 24.61 | 4.97b | 41 |
| LSD $_{0.05}$ | | 1.86 | 1.38 | 1.46 | 1.24 | 2.70 | 21 |
| ANOVA (P > F) | | | | | | | |
| System | | 0.016 | 0.923 | 0.934 | 0.837 | 0.044 | 0.213 |

Note: All crops received ~10 inches of irrigation.
In season rainfall for corn (4/28/16 – 9/15/16) = 17.91 inches; grain sorghum (6/01/16 – 10/20/16) = 12.61 inches; and wheat (9/29/15 – 7/08/16) = 20.29 inches.
C = corn.
W = wheat.
GS = grain sorghum.
LSD = least significant difference.
ANOVA = analysis of variance.
[1] Means within a column with the same letter are not statistically different at $P = 0.05$.

**Table 4. Profile available soil water, crop water use, and fallow accumulation for crop rotations under limited irrigation across years, Tribune, KS, 2013-2016**

| | | Available water | | | | | |
|---|---|---|---|---|---|---|---|
| Crop | Rotation | Previous harvest | Planting | Harvest | Crop water use | Fallow accumulation | Fallow efficiency |
| | | inches | | | | | % |
| Corn | C-C | 10.51a [1] | 13.68a | 12.02a | 25.16 | 3.17ab | 36b |
| | C-W | 10.09ab | 13.71a | 12.13a | 25.08 | 3.62a | 24c |
| | C-GS | 9.21b | 11.89b | 10.20b | 25.19 | 2.68b | 53a |
| $LSD_{(0.05)}$ | | 1.19 | 1.00 | 1.14 | 0.99 | 0.56 | 8 |
| ANOVA (P > F) | | | | | | | |
| System | | 0.091 | 0.001 | 0.002 | 0.972 | 0.007 | 0.001 |
| Year | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| System × year | | 0.001 | 0.004 | 0.014 | 0.001 | 0.001 | 0.001 |
| Wheat | C-W | 10.41 | 10.41 | 10.76 | 20.01 | 0 | --- |
| ANOVA (P > F) | | | | | | | |
| System | | --- | --- | --- | --- | --- | --- |
| Year | | 0.001 | 0.001 | 0.003 | 0.001 | --- | --- |
| System × year | | --- | --- | --- | --- | --- | --- |
| Grain sorghum | C-GS | 8.08 | 12.55 | 10.64 | 23.31 | 4.47a | 39 |
| | GS-GS | 9.08 | 12.18 | 10.60 | 22.98 | 3.10b | 37 |
| $LSD_{(0.05)}$ | | 1.14 | 1.05 | 1.07 | 0.68 | 0.78 | 11 |
| ANOVA (P>F) | | | | | | | |
| System | | 0.082 | 0.462 | 0.937 | 0.314 | 0.002 | 0.818 |
| Year | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| System × year | | 0.001 | 0.009 | 0.787 | 0.123 | 0.001 | 0.392 |

Note: All crops received ~10 inches of irrigation each year.
C = corn.
W = wheat.
GS = grain sorghum.
LSD = least significant difference.
ANOVA = analysis of variance.

[1] Means within a column with the same letter are not statistically different at $P = 0.05$.