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# Wheat and Grain Sorghum in Four-Year Rotations

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# Wheat and Grain Sorghum in Four-Year Rotations


## Abstract

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 with sorghum following wheat. Grain yields of sorghum in 2020 in all rotations were near the long-term average. For wheat, grain yields in 2020 were similar after fallow following sorghum, but much less after wheat. 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; however, averaged across years, wheat yields were 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 ~65% of the yield of the first sorghum crop.



## Keywords

no-till, continuous cropping, wheat, grain sorghum

# 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 with sorghum following wheat. Grain yields of sorghum in 2020 in all rotations were near the long-term average. For wheat, grain yields in 2020 were similar after fallow following sorghum, but much less after wheat. 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; however, averaged across years, wheat yields were 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 ~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 2020, available soil water 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 in. (or approximately 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 2020 was similar to 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 1.5 in. more available water at planting than the second crop.

## *Grain Yields*

In 2020, wheat yields in both rotations following fallow were similar to the long-term average, while recrop or continuous wheat yields were much lower than the long-term average (Table 1). Averaged across 24 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; however, 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 6 bu/a less than recrop wheat.

Sorghum yields in 2020 were near the long-term average yields (Table 2). Sorghum yields were similar following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop yields were 67% of the first sorghum crop in 2020, which is similar to the long-term average of about 65%.

**Table 1. Wheat response to dryland crop rotation, Tribune, KS, 1997–2020**

| | Rotation | | | | | ANOVA (P > F) | | |
|---|---|---|---|---|---|---|---|---|
| Year | Wssf[1] | 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 | | |
| 2020 | 38 | 39 | 9 | 11 | 5 | 0.001 | | |
| Mean | 42 a* | 40 b | 30 c | 24 d | 2 | 0.001 | 0.001 | 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.
* Means within a row with the same letter are not statistically different at $P = 0.05$.

**Table 2. Grain sorghum response to crop rotation, Tribune, KS, 1996–2020**

| | Rotation | | | | ANOVA (P>F) | | |
|---|---|---|---|---|---|---|---|
| Year | wSsf[1] | 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 | | |
| 2020 | 94 | 64 | 98 | 20 | 0.001 | | |
| Mean | 88 a* | 57 b | 89 a | 3 | 0.001 | 0.001 | 0.001 |

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

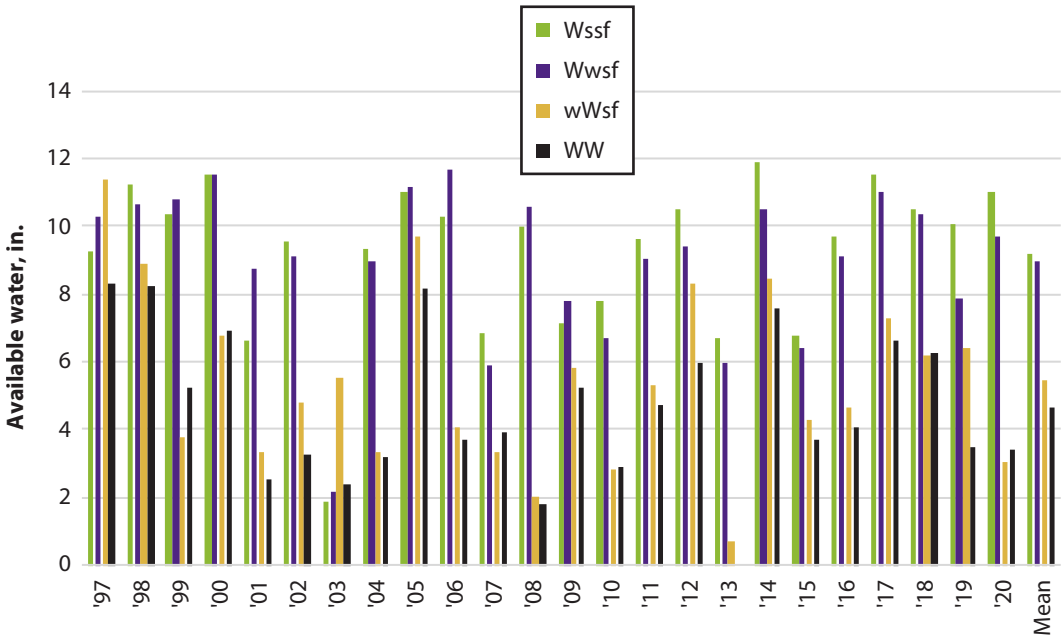


**Figure 1. Available soil water in 6-ft profile at planting of wheat in several rotations at Tribune, KS, 1997–2020. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF), wheat-wheat-sorghum-fallow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

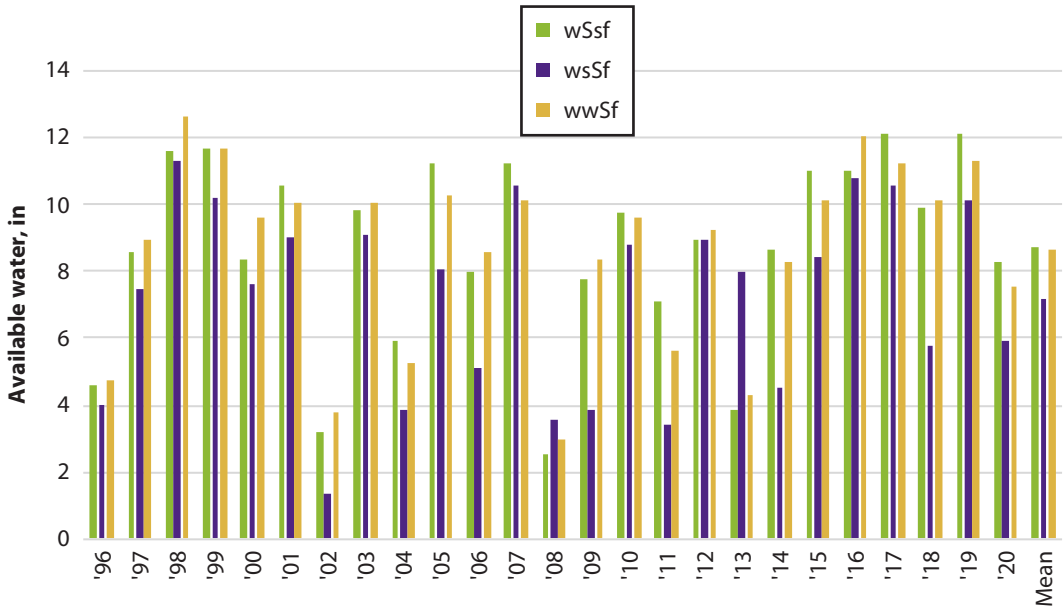


**Figure 2. Available soil water in 6-ft profile at planting of sorghum in several rotations at Tribune, KS, 1996–2020. Capital letter denotes current crop in rotation (W, wheat; S, sorghum). The last set of bars (Mean) is the average across years. Wheat-sorghum-sorghum-fallow (WSSF) and wheat-wheat-sorghum-fallow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