[Kansas Agricultural Experiment Station Research Reports](https://newprairiepress.org/kaesrr)

Volume 7
Issue 7 *Southwest Research-Extension Reports*

Article 5

2021

Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation

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Recommended Citation

Schlegel, A. and Burnett, A. (2021) "Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation," *Kansas Agricultural Experiment Station Research Reports*: Vol. 7: Iss. 7. https://doi.org/10.4148/2378-5977.8104

Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation

Abstract

This study was initiated in 1991 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify the effects of tillage intensity on precipitation capture, soil water storage, and grain yield in a wheat-sorghum- fallow rotation. Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. In 2020, available soil water at sorghum planting was greater for no-tillage (NT) than reduced tillage (RT), which was greater than conventional tillage (CT). For wheat there was a similar pattern as sorghum, with available soil water at wheat planting being in the order of NT > RT > CT. Averaged across the 20-year study, available soil water at wheat planting was similar for NT and RT and approximately 1 inch greater than CT. Average available soil water at sorghum planting was greater in the order RT = NT > CT. Averaged across the past 20 years, NT wheat yields were 5 bu/a greater than RT and 8 bu/a greater than CT. Averaged across the past 20 years, sorghum yields with long-term NT have been 58% greater than with short-term NT (79 vs. 50 bu/a).

Keywords

no-till, reduced tillage, available soil water, dryland cropping systems, fallow accumulation

Cover Page Footnote

The U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program partially supported this research project.

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Summary

This study was initiated in 1991 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify the effects of tillage intensity on precipitation capture, soil water storage, and grain yield in a wheat-sorghum-fallow rotation. Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. In 2020, available soil water at sorghum planting was greater for no-tillage (NT) than reduced tillage (RT), which was greater than conventional tillage (CT). For wheat there was a similar pattern as sorghum, with available soil water at wheat planting being in the order of NT > RT > CT. Averaged across the 20-year study, available soil water at wheat planting was similar for NT and RT and approximately 1 inch greater than CT. Average available soil water at sorghum planting was greater in the order RT = NT > CT. Averaged across the past 20 years, NT wheat yields were 5 bu/a greater than RT and 8 bu/a greater than CT. Averaged across the past 20 years, sorghum yields with long-term NT have been 58% greater than with short-term NT (79 vs. 50 bu/a).

Experimental Procedures

Research on different tillage intensities in a WSF rotation at the Tribune, KS, unit of the Southwest Research-Extension Center was initiated in 1991. The three tillage intensities in this study are conventional, reduced, and no-tillage. The CT system was tilled as needed to control weed growth during the fallow period. On average, this resulted in 4 to 5 tillage operations per year, usually with a blade plow or field cultivator. The RT system originally used a combination of herbicides (1 to 2 spray operations) and tillage (2 to 3 tillage operations) to control weed growth during the fallow period; however, in 2001, the RT system was changed to using NT from wheat harvest through sorghum planting (short-term NT) and CT from sorghum harvest through wheat planting. The NT system exclusively used herbicides to control weed growth during the fallow period. All tillage systems used herbicides for in-crop weed control.

Results and Discussion

Soil Water

The amount of available water in the soil profile (0–8 ft) at wheat planting varied greatly from year to year (Figure 1). In 2020, available soil water at wheat planting was greater with NT than RT and least with CT. Averaged across the 20-year study, available soil water at wheat planting was similar for RT and NT (~ 8 inches) and approximately 1 inch greater than CT. Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2). In 2020, available soil water at sorghum planting was greater with NT than RT and least with CT. On average, available soil water at sorghum planting was similar for NT and RT and about 1.5 inches greater than CT.

Grain Yields

Wheat yields in 2020 were near the long-term average (Table 1). Since 2001, wheat yields have been depressed in 11 of 20 years, primarily because of lack of precipitation, winterkill (2015), and disease (2017). Reduced tillage and NT increased wheat yields. On average, wheat yields were 8 bu/a higher for NT (30 bu/a) than CT (22 bu/a). Wheat yields for RT were 3 bu/a greater than CT even though both systems had tillage prior to wheat. Yields of NT were significantly less than CT or RT in only 1 of the 20 years.

Grain sorghum yields in 2020 were near the long-term average (Table 2). Sorghum yields were 70% greater with NT than RT (90 vs. 53 bu/a) while CT yields were the least (17 bu/a). The yield benefit from reducing tillage is greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 21 bu/a more than CT, whereas NT averaged 29 bu/a more than RT. For sorghum, both RT and NT used herbicides for weed control during fallow, so the difference in yield could be attributed to short-term compared with long-term NT. This yield benefit with long-term vs. short-term NT has been observed in most years since the RT system was changed in 2001. Averaged across the past 20 years, sorghum yields with long-term NT have been 58% greater than with short-term NT (79 vs. 50 bu/a).

Acknowledgment

The U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program partially supported this research project.

Table 1. Wheat response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 2001–2020

Year	Tillage			LSD (0.05)	ANOVA $(P > F)$		
	Conventional	Reduced	No-tillage		Tillage	Year	Tillage × year
	---------------------- bu/a ----------------------						
2001	17	40	31	8	0.002		
2002	0	0	0	---	---		
2003	22	15	30	7	0.007		
2004	1	2	4	2	0.001		
2005	32	32	39	12	0.360		
2006	0	2	16	6	0.001		
2007	26	36	51	15	0.017		
2008	21	19	9	14	0.142		
2009	8	10	22	9	0.018		
2010	29	35	50	8	0.002		
2011	22	20	20	7	0.649		
2012	0	1	5	1	0.001		
2013	0	0	0	---	---		
2014	10	11	18	12	0.336		
2015	10	9	9	9	0.966		
2016	72	85	82	18	0.239		
2017	13	12	12	9	0.970		
2018	46	48	64	4	0.001		
2019	78	98	109	14	0.004		
2020	29	31	33	9	0.565		
Mean	22 c*	25 b	30 a	2	0.001	0.001	0.001

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 tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 2001–2020

Year	Tillage			LSD	ANOVA *(P > F)*		
	Conventional	Reduced	No-tillage	(0.05)	Tillage	Year	Tillage × year
	---------------------- bu/a ----------------------						
2001	6	43	64	7	0.001		
2002	0	0	0	---	---		
2003	7	7	37	8	0.001		
2004	44	67	118	14	0.001		
2005	28	38	61	35	0.130		
2006	4	3	29	10	0.001		
2007	26	43	62	42	0.196		
2008	16	25	40	20	0.071		
2009	19	5	72	31	0.004		
2010	10	26	84	9	0.001		
2011	37	78	113	10	0.001		
2012	0	0	0	---	---		
2013	37	51	78	32	0.053		
2014	38	72	94	28	0.008		
2015	56	60	102	55	0.153		
2016	55	124	139	47	0.010		
2017	121	163	159	33	0.038		
2018	35	57	116	33	0.003		
2019	23	85	127	7	0.001		
2020	17	53	90	19	0.001		
Mean	29 c*	50 b	79 a	5	0.001	0.001	0.001

ANOVA = analysis of variance.
LSD = least significant difference.
* Means within a row with the same letter are not statistically different at $P = 0.05$.

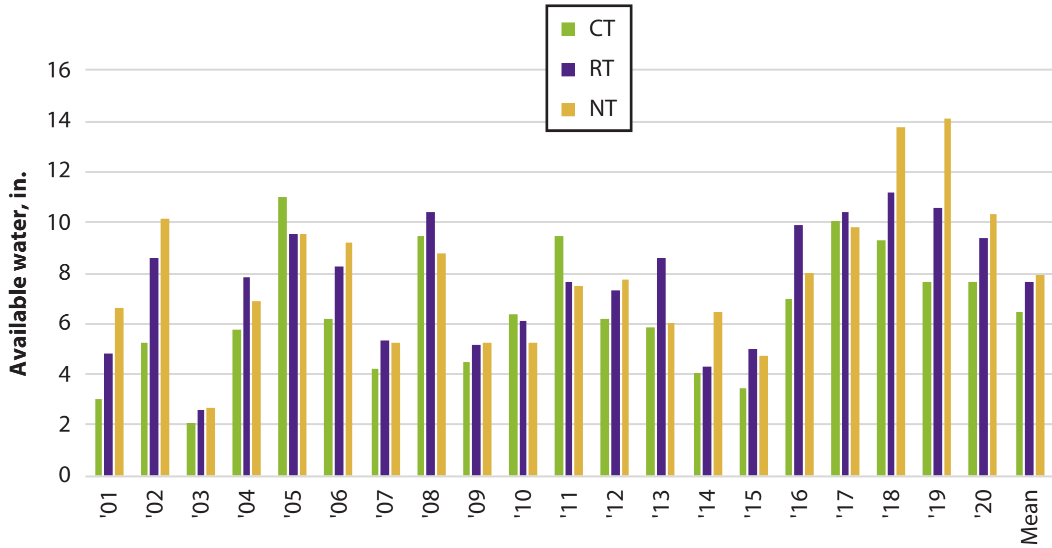

Figure 1. Available soil water in the 8-ft profile at planting of wheat in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2020. The last set of bars (Mean) is the average across years. CT = conventional tillage, RT = reduced tillage, NT = no-tillage.

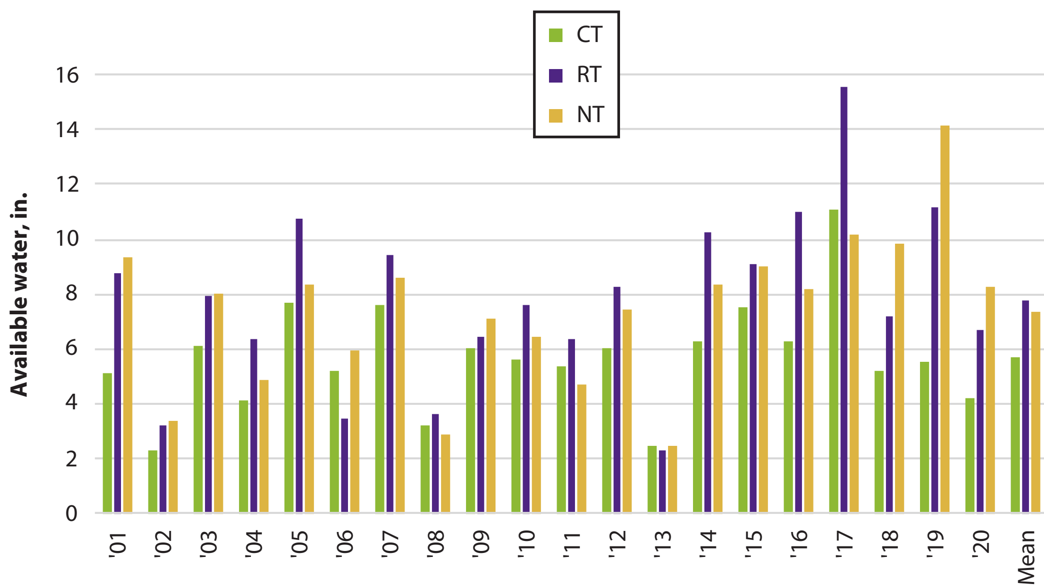

Figure 2. Available soil water in the 8-ft profile at planting of grain sorghum in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2020. The last set of bars (Mean) is the average across years. CT = conventional tillage, RT = reduced tillage, NT = no-tillage.