Kansas Agricultural Experiment Station Research Reports

Volume 9
Issue 6 *Western Kansas Agricultural Research*

Article 5

2023

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

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Recommended Citation

Haag, Lucas A.; Burnett, Amanda; Bond, Dewayne; Slattery, Jeffrey; and Schlegel, Alan (2023) "Tillage Intensity in a Long-Term Wheat-Sorghum-Fallow Rotation," *Kansas Agricultural Experiment Station Research Reports*: Vol. 9: Iss. 6. https://doi.org/10.4148/2378-5977.8489

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Funding Source

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 2022, 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 most recent 22 years of the study, available soil water at wheat planting was 0.60 inch greater for NT than RT and approximately 1.7 inches greater than CT. Average available soil water at sorghum planting was greater in the order RT=NT>CT averaging 7.9 inches for RT and NT and 5.9 inches for CT. Averaged across the past 22 years, NT wheat yields were 6 bu/a greater than RT and 10 bu/a greater than CT. Averaged across the past 22 years, sorghum yields with long-term NT have been 57% greater than with RT (82 vs. 52 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 (CT), reduced (RT), and no-tillage (NT). 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 2022, available soil water at wheat planting was greater with NT (15.3 inches) than RT (12.5 inches) and CT (13.9 inches). Across the 22-yr study, available soil water at wheat planting was greatest for NT (8.44 inches) followed by RT (7.85 inches), and CT (6.72 inches). Similar to wheat, the amount of available water in the soil profile at sorghum planting varied greatly from year to year (Figure 2). In 2022, available soil water at sorghum planting was greater with NT (7.8 inches) than RT (5.7 inches) and least with CT (5.3 inches). On average, available soil water at sorghum planting was similar for NT and RT and about 2 inches greater than CT.

Grain Yields

Wheat yields in 2022 were significantly reduced by hail damage and are not reported (Table 1). Since 2001, wheat yields have been depressed in 12 of 22 years, primarily because of lack of precipitation, winterkill (2015), viral disease (2017), and hail (2022). Reduced tillage and NT increased wheat yields. On average, wheat yields were 10 bu/a higher for NT (33 bu/a) than CT (23 bu/a). Wheat yields for RT were 4 bu/a greater than CT even though both systems had tillage prior to wheat. Yields of NT were significantly less than CT in only one year (2008) and RT in 2 of the 22 years (2001, 2008).

Grain sorghum yields in 2022 were slightly above the long-term average (Table 2). Sorghum yields were 60% greater with NT than RT (108 vs. 67 bu/a) while CT yields were the least (52 bu/a). The yield benefit from reducing or eliminating tillage was greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 20 bu/a more than CT, whereas NT averaged 30 bu/a more than RT. For sorghum, both RT and NT used herbicides for weed control in the wheat stubble post-harvest, and in both the RT and NT systems, the sorghum was "no-till" planted into wheat stubble. Using tillage in the summer-fallow period ahead of seeding wheat, while only reducing wheat yields in a minor way, subsequent sorghum yields were being significantly reduced. This yield benefit with long-term vs. short-term NT (RT) 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 57% greater than with RT (82 vs. 52 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, 2001–2022

	Tillage			---	ANOVA (P>F)
Year	**Conventional**	**Reduced**	**No-tillage**	**LSD (0.05)**	**Tillage**
	------------------------- 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
2021	48	61	88	15	0.002
2022*	---	---	---	---	---
Mean	23 c	27 b	33 a	2	<0.001

ANOVA = analysis of variance.
LSD = least significant difference.
*Wheat yields in 2022 were significantly reduced by hail damage and are not reported.

Table 2. Grain sorghum response to tillage in a wheat-sorghum-fallow rotation, Tribune, KS, 2001–2022

	Tillage			---	ANOVA (P>F)
Year	**Conventional**	**Reduced**	**No-tillage**	**LSD (0.05)**	**Tillage**
	------------------------- 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
2021	86	83	111	43	0.277
2022	52	67	108	35	0.020
Mean	33 c	52 b	82 a	6.4	<0.001

ANOVA = analysis of variance.
LSD = least significant difference.

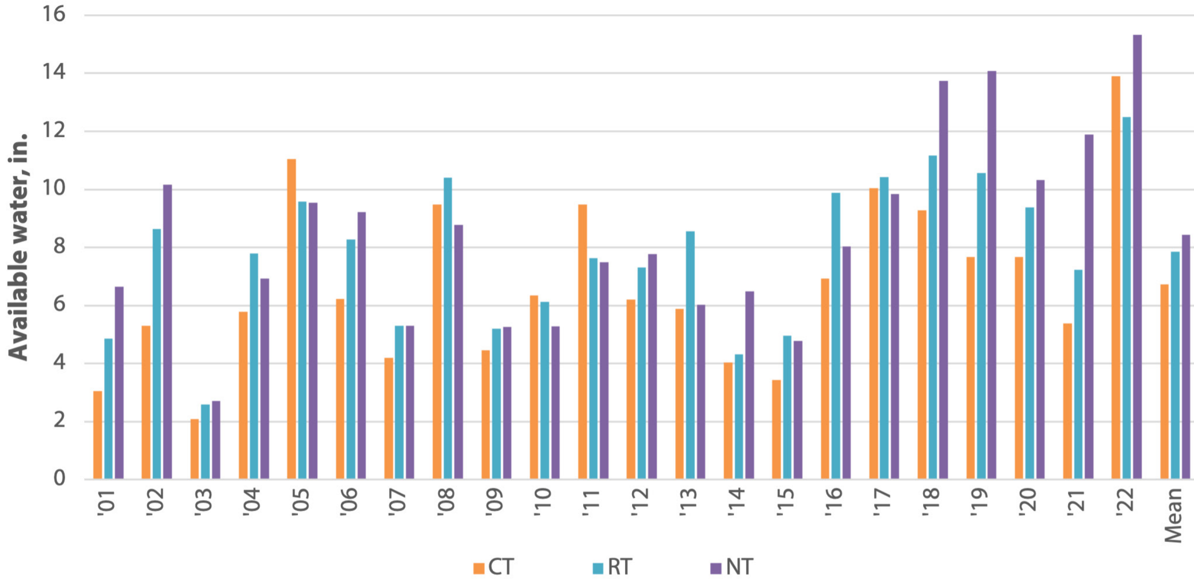

Figure 1. Available soil water in 8-ft profile at planting of wheat in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2022. The last set of bars (Mean) is the average across years. CT = conventional tillage. RT = reduced tillage. NT = no-tillage.

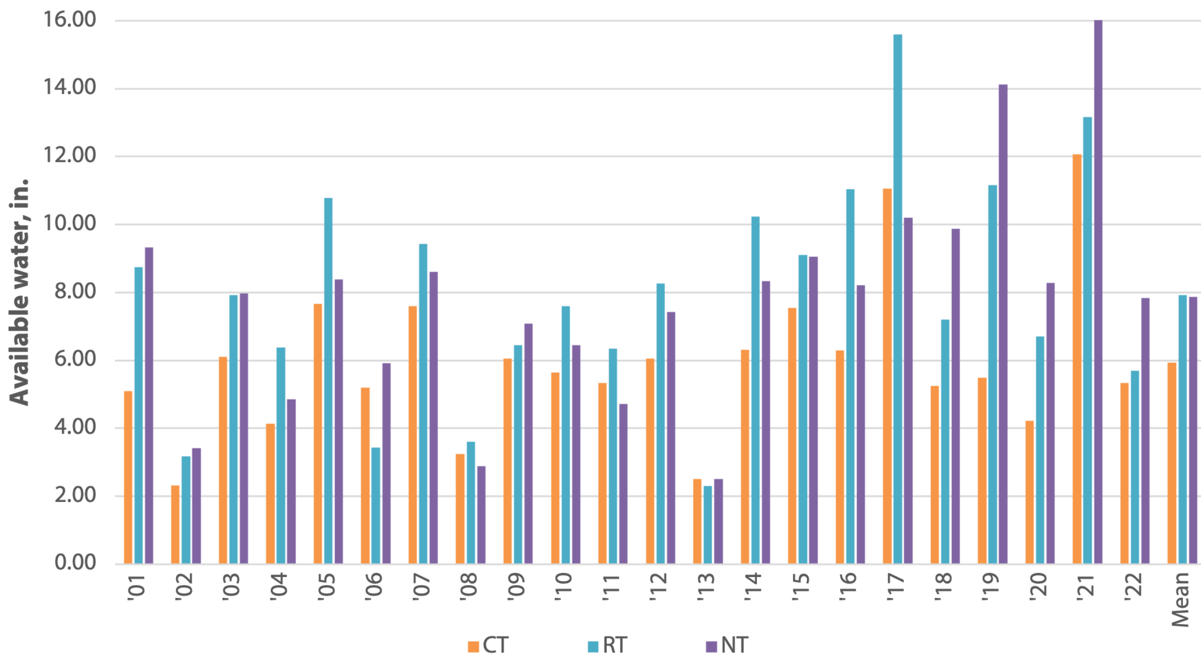

Figure 2. Available soil water in 8-ft profile at planting of grain sorghum in a wheat-sorghum-fallow rotation as affected by tillage intensity, Tribune, KS, 2001–2022. The last set of bars (Mean) is the average across years. CT = conventional tillage. RT = reduced tillage. NT = no-tillage.