IMPACT OF LONG-TERM NO-TILL ON CROP YIELD, ECONOMICS, AND SOIL PROPERTIES

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ABSTRACT

A study was initiated in west-central Kansas near Tribune to evaluate the long-term effects of tillage intensity on soil properties and grain yield in a wheat-sorghum-fallow (WSF) rotation. After 10-yr, water infiltration was 50% greater with no-till (NT) than either reduced tillage (RT) or conventional tillage (CT). Aggregate stability was also better following NT than RT or CT. Grain yields of wheat and grain sorghum increased with decreased tillage intensity. Averaged across 15-yr, yield of NT wheat was 4 bu/a greater than RT and 8 bu/a greater than CT. Average NT sorghum yields were 13 bu/a greater than RT and 34 bu/a greater than CT. For grain sorghum, in particular, the advantage of reducing tillage intensity has increased with time. Also for grain sorghum, there is a yield benefit from long-term no-till compared to short-term no-till. An economic analysis showed that CT was the least profitable system. Profitability was similar for both RT and NT at about $15/a/yr greater than CT.

INTRODUCTION

In recent years, tillage intensity has decreased in dryland systems in the Great Plains in an attempt to improve precipitation capture and reduce evaporation losses. The objectives of this study were to quantify the impact of reduced tillage practices on precipitation capture, soil properties, crop production, and profitability in a WSF rotation.

MATERIALS AND METHODS

Research on different tillage intensities in a WSF rotation at the K-State Southwest Research-Extension Center at Tribune was initiated in 1991 on land just removed from native sod. The three tillage intensities are CT, RT, and 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. The NT system used herbicides (primarily glyphosate) to control weed growth during the fallow period usually requiring 3-4 applications during each fallow period. Initially the RT system used a combination of herbicides (1 to 2 applications) and tillage (2 to 3 tillage operations) to control weed growth during the fallow period prior to each crop. In 2001, the RT system was changed to a combination of NT from wheat harvest through sorghum planting and CT from sorghum harvest to wheat planting. This did not change the overall number of tillage and herbicide applications for the rotation, but did change when they were performed. All tillage systems used herbicides for in-crop weed control. Plot size was 50 by 100 ft with four replications. All phases of the rotation were present each year.

Grain yield was determined by machine harvesting the center of each plot after physiological maturity. Profile soil water was measured near planting and after harvest of each crop to a depth of

8 ft. Water infiltration (steady-state) and wet-aggregate stability were measured in the summer (July) after 10 yr of the tillage treatments. Economic returns to land and management were calculated for each tillage system using enterprise budget techniques. Crop input costs for each tillage system were based on typical practices during the study and input prices from 2004, which are more representative of long-term average costs. Machinery costs were based on values reported in *Kansas Custom Rates* from Kansas Agricultural Statistics Service. Crop prices reflect average prices in southwest Kansas during the month of harvest.

RESULTS AND DISCUSSION

Water Infiltration and Aggregate Stability

Water infiltration was 50% greater with NT than other tillage treatments for all crop phases (Fig. 1). Infiltration tended to be greater in wheat stubble (wheat) than in growing stubble (sorghum) or sorghum stubble (fallow).

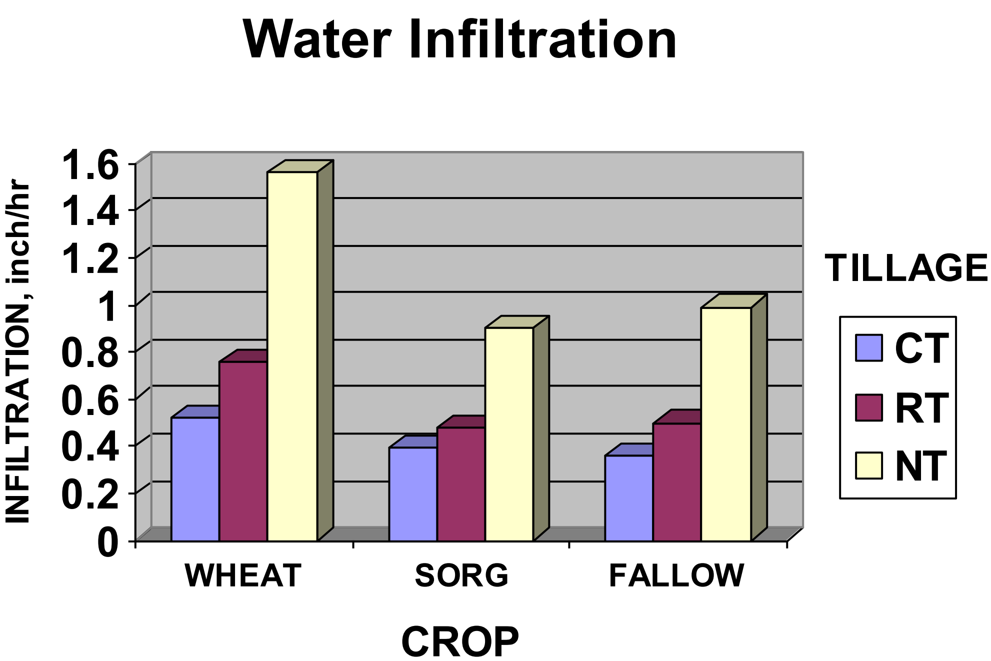

Figure 1. Steady-state water infiltration after 10-yr of different tillage intensities in a wheat-sorghum-fallow rotation, Tribune, KS.

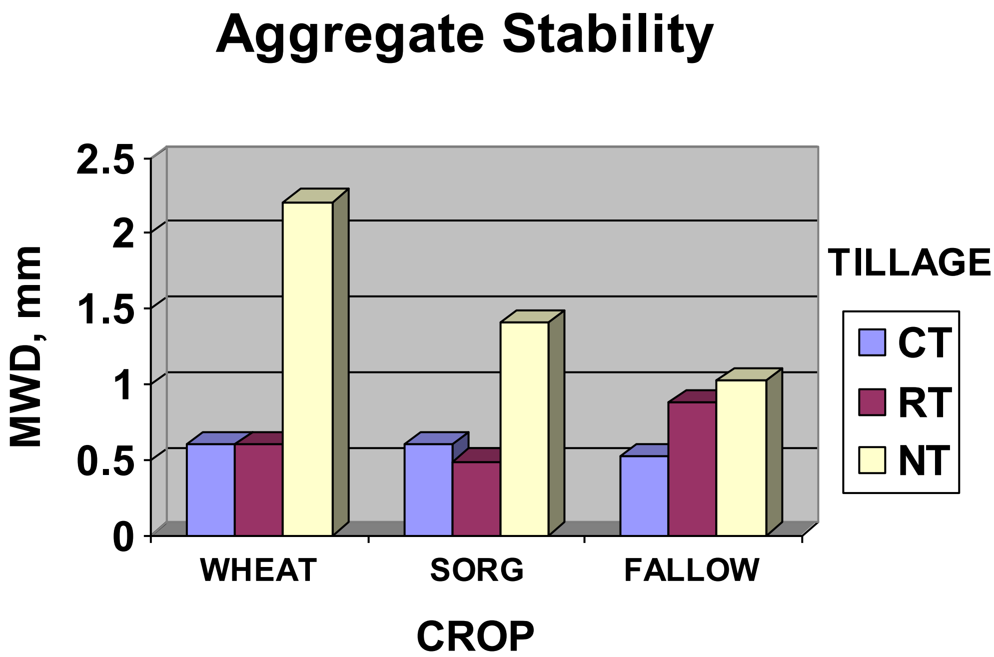

Figure 2. Aggregate stability (mean weight diameter) after 10-yr of different tillage intensities in a wheat-sorghum-fallow rotation compared to undisturbed sod, Tribune, KS.

Similar to water infiltration, aggregate stability (Mean Weight Diameter or MWD) was greater with NT than other tillage systems (Fig. 2). For this measurement, the larger the value the more stable the aggregates.

Soil Water

The amount of soil water accumulation during fallow (from harvest of previous crop to planting of current crop) varied widely among years for both crops (Fig. 3 and 4). In some years, there was a loss of stored soil water from harvest to planting while, in other years, fallow accumulation exceeded 10 inches. On average, CT was the least effective in accumulating soil water for both crops. Prior to wheat, fallow accumulation averaged 4.82 inches for CT compared with 5.66 inches for RT and 5.24 inches for NT. Somewhat surprising was the NT did not accumulate more water than RT. Fallow efficiency (amount of water accumulated during fallow divided by precipitation during fallow) ranged from less than 0 to more than 50% and averaged 26% for CT compared with 31% for RT and 28% for NT.

For sorghum, soil water accumulation from wheat harvest to sorghum planting averaged 3.92 inches for CT compared with 5.34 inches for RT and 4.93 inches for NT. Fallow efficiency was 22% for CT compared with 33% for RT and 29% for NT.

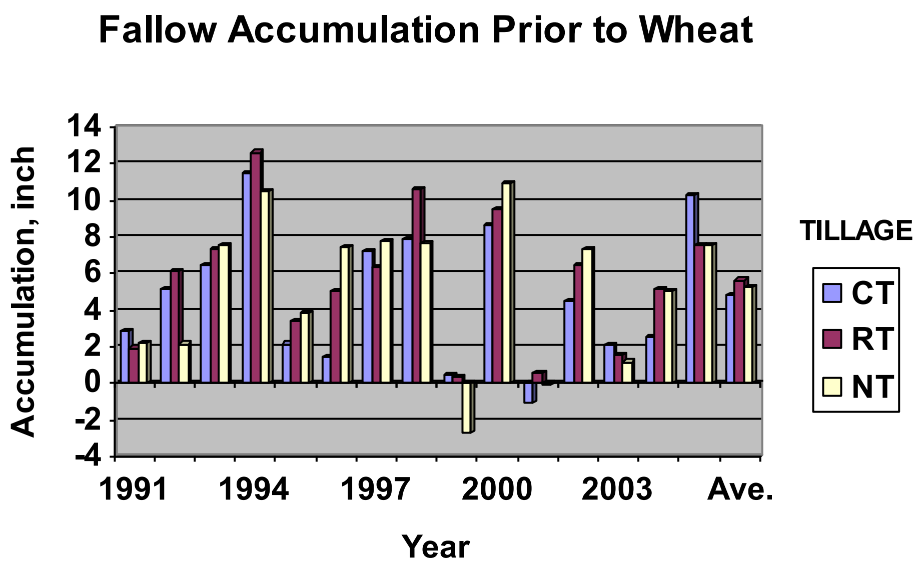

Figure 3. Soil water accumulation during fallow prior to wheat in a WSF rotation, 1991-2005, Tribune, KS.

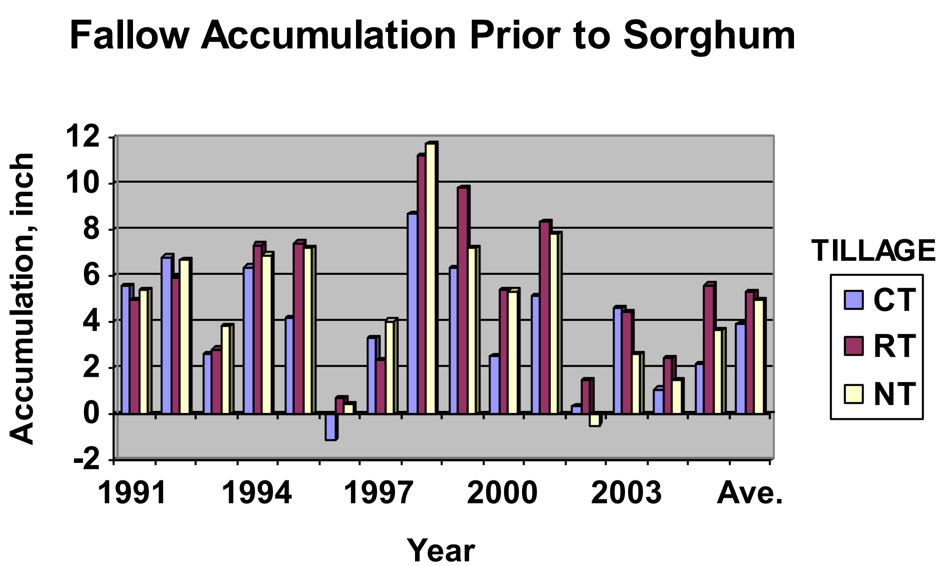

Figure 4. Soil water accumulation during fallow prior to sorghum in a WSF rotation, 1991-2005, Tribune, KS.

Grain Yield of Wheat and Grain Sorghum

Wheat yields increased when tillage intensity decreased. On average (1991-2005), wheat yields were 8 bu/a higher for NT (38 bu/acre) than for CT (30 bu/acre). Wheat yields for RT (34 bu/a) were 4 bu/a greater than CT. During the first 5-yr of the study, wheat yields were similar for CT and RT with NT yields 3 bu/a greater (Fig. 5). During the late1990's (1996-2000), NT yields were 5 bu/a greater than RT and 14 bu/a greater than CT. The two years with the lowest wheat yields (less than 5 bu/a) of the entire study occurred in the past 5 yr (2002 because of drought and 2004 because of mid-May freeze). Although average yields during this 5-yr period were very low, NT produced 6 bu/a more wheat than CT.

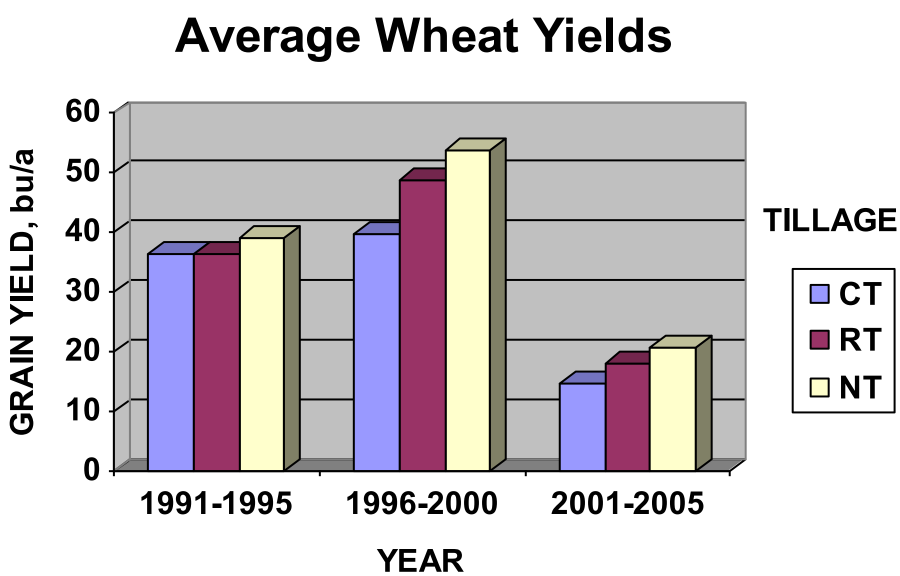

Figure 5. Average wheat yields as affected by tillage in a WSF rotation, Tribune, KS.

The yield benefit from reduced tillage was greater for grain sorghum than for wheat (Fig. 6). Grain sorghum yields for CT averaged 36 bu/ for the entire study period compared with 57 bu/a for RT and 70 bu/a for NT. The yield benefit from reduction in tillage has increased during the study. During the first 5-yr, sorghum yields were about 17 bu/a greater with RT or NT compared with CT. During the late 1990's with generally good growing conditions, CT sorghum averaged 57 bu/a compared with 88 bu/a for RT and 103 bu/a for NT. Similar to wheat, there have been two poor sorghum years since 2000 (2002 and 2003), however, the relative advantage to reduced tillage has increased. Averaged across the past 5-yr, NT sorghum yields were 56 bu/a for NT compared with 31 bu/a for RT and only 17 bu/a for CT. In 2004, NT sorghum yields were 118 bu/a compared with 67 bu/a for RT and 44 bu/a for CT.

In the past 5-yr, the RT system used a combination of no-till prior to sorghum and conventional tillage prior to wheat. So it is interesting that sorghum yields were 25 bu/a greater with NT than RT even though both were no-till planted. Apparently there is a yield benefit from long-term vs. short-term no-till.

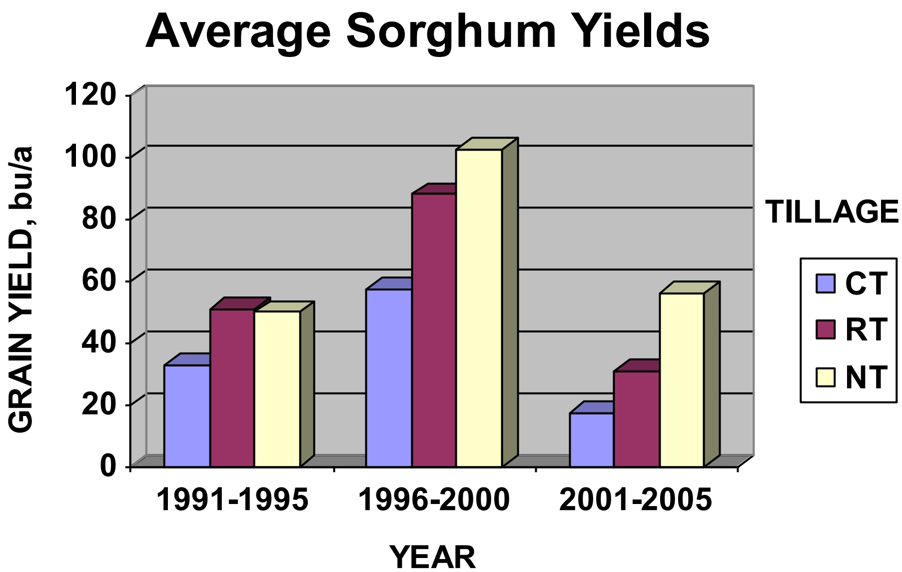

Figure 6. Average grain sorghum yields as affected by tillage in a WSF rotation, Tribune, KS.

Economics

Reflecting increased yields with reduced tillage, economic returns were higher for RT and NT rotations compared with CT. However, with 28% higher costs associated with NT wheat versus CT wheat and 54% higher costs for NT sorghum versus CT sorghum, returns for the NT rotation were only slightly higher than RT (Table 1). Considering individual crop returns, RT wheat had average returns of $24.12/ac, compared with $12.60/ac for CT wheat and $13.54/ac for NT wheat. NT sorghum had the highest average returns at $10.42/ac, compared with -$12.28/ac for CT sorghum and -$0.89 for RT sorghum.

Table 1. Average costs and returns per planted acre and average returns for a WSF rotation with different tillage intensities.

Tillage	CT	RT	NT
		Average costs per planted acre	
Wheat	$79.82	$80.84	$102.43
Grain sorghum	$87.46	$119.96	$134.49
		Average returns per planted acre	
Wheat	$12.60	$24.12	$13.54
Grain sorghum	-$12.28	-$0.89	$10.42
		Average returns per tillable acre	
WSF rotation	$0.21	$15.48	$15.97