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TILLAGE MANAGEMENT AND SPRINKLER-IRRIGATED CORN PRODUCTION

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INTRODUCTION

Tillage management strategies that leave greater amounts of residue on the soil surface are beneficial in sprinkler-irrigated corn production in terms of improving infiltration of both irrigation and rainfall, and in reduction of soil evaporative losses early in the growing season. Additionally, sometimes early season crop growth is delayed under higher residue conditions and this can result in the shifting of crop evapotranspiration to later in the season for higher residue treatments. This paper will discuss 4 years (2004-2007) of sprinkler-irrigated corn research under conventional, strip-tillage, and no tillage.

BRIEF DESCRIPTION OF PROCEDURES

The study was conducted under a center pivot sprinkler at the KSU Northwest Research-Extension Center at Colby, Kansas during the years 2004 to 2007. Corn was also grown on the field site in 2003 to establish baseline residue levels for the three tillage treatments. The study area had conventional tillage in 2003. The soil type was a medium textured, deep, well drained, silt loam soil. The region has an average annual precipitation of 19 inches with a summer pattern resulting in an average corn cropping season precipitation of 12 inches. The average seasonal total crop evapotranspiration (ETc) for corn in this region is 21 inches.

A corn hybrid of approximately 110-day relative maturity (Dekalb DCK60-191 in 2004 and DCK60-18 in 2005 through 2007) was planted in 30-inch spaced circular rows on May 8, 2004, April 27, 2005, April 20, 2006 and May 8, 2007, respectively. The two hybrids differ only slightly with the latter hybrid having an additional genetic modification of corn rootworm control. Three target seeding rates (26,000, 30,000 and 34,000 seeds/acre) were superimposed onto each tillage treatment in a complete randomized block design.

Irrigation was scheduled with a weather-based water budget, but was limited to the 3 treatment capacities of 1 inch every 4, 6, or 8 days (IC-4, IC-6 and IC-8, respectively). The weather-based water budget was constructed using data collected from a NOAA weather station located approximately 1800 ft. northeast of the study site.

The three tillage treatments [Conventional tillage (CT), Strip Tillage (ST) and No Tillage (NT)] were replicated in a Latin-Square type arrangement widths at three different radii (Figure 1). Planting was in the approximate same row location each year for the Conventional Tillage treatment to the extent that good farming practices allowed. The Strip Tillage and No-Tillage treatments were planted between corn rows from the previous year.

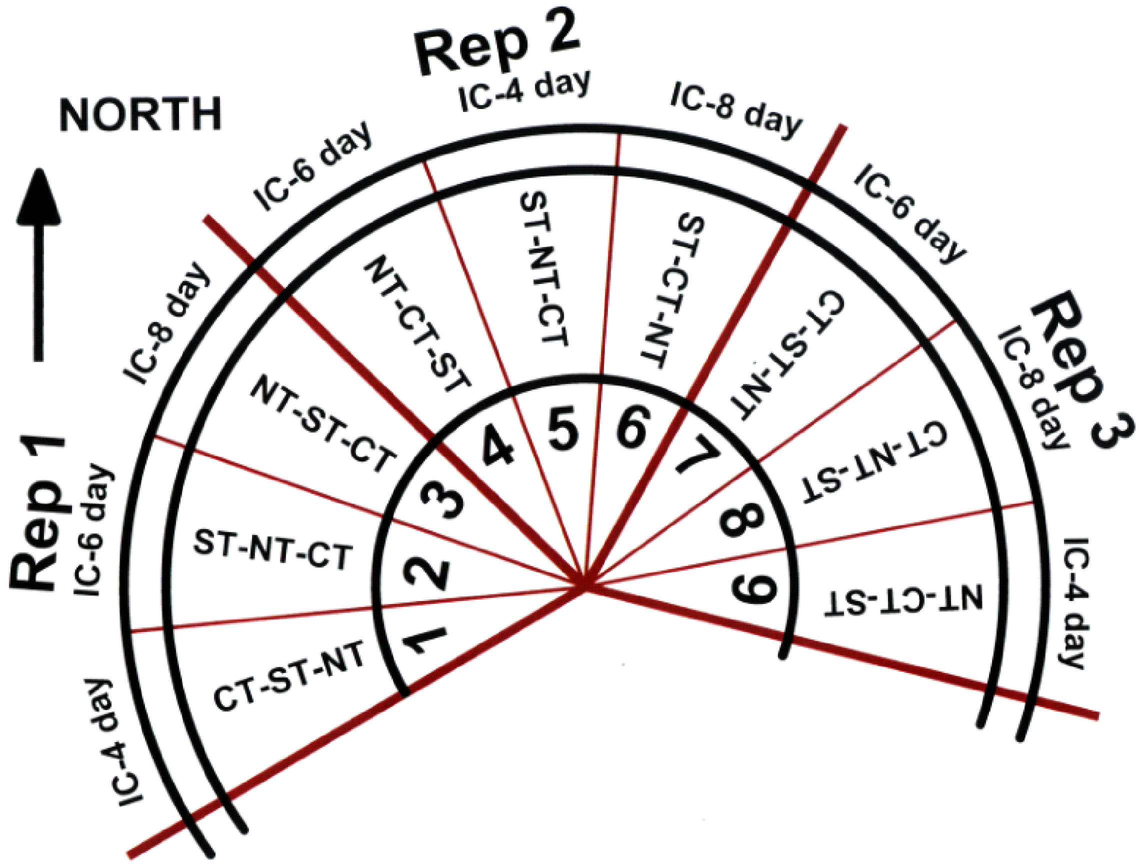

Figure 1. Physical arrangement of the irrigation capacity (IC-4 IC-6, or IC-8) for the nine different pie sectors and tillage treatments (CT, ST or NT) randomized within the outer sprinkler span.

Fertilizer N for all 3 treatments was applied at a rate of 200 lbs/acre. Phosphorus was applied with the starter fertilizer at planting at the rate of 45 lbs/acre P_2O_5. Weekly to bi-weekly soil water measurements were made in 1 ft. increments to an 8 ft. depth with a neutron probe. All measured data was taken near the center of each plot. Corn yield was measured in each of the 81 subplots at the end of the season by hand harvesting the ears from a 20 ft. section of one corn row near the center of each plot. Water use and water productivity (i.e., grain yield divided by seasonal water use) were calculated for each subplot using the soil water data, precipitation, applied irrigation and crop yield.

RESULTS AND DISCUSSION

Weather Conditions and Irrigation Requirements

In general, conventional tillage treatments were observed to emerge earlier and have improved growth during May and June as compared to the strip and no-tillage treatments, probably because of warmer soil temperatures. However, by about mid-summer in most of the years the conventional tillage treatments began to show greater water stress, particularly for the reduced irrigation capacities, as evidenced by some observed mid-day wilting. The conventional tillage plots also tended to senesce earlier in most years with the exception of 2004. Summer seasonal precipitation was approximately 2 inches below normal in 2004, near normal in 2005, nearly 3 inches below normal in 2006, and approximately 2.5 inches below normal in 2007. Calculated well-watered corn evapotranspiration was near normal in 2004, 2005, and 2006, but was approximately 3 inches below normal in 2007. Full irrigation needs varied between years with greatest needs in 2005 and 2006 at approximately 15 inches and was lower in 2004 and 2007 at approximately 12 inches.

Corn Yields, Yield Components, Water Use, and Water Productivity

Average (2004-2007) study wide corn yield, yield components, water use and water productivity are summarized in Table 1 and Figure 2 and 3.

Greatest corn yield was obtained by the fully irrigated treatment (Table 1 and Figure 2 top panel) where irrigation was supplied as needed at a capacity limited to 1 inch/4 days. Average yields decreased approximately 20 bushels/acre for the deficit irrigated treatments (1 inch/6 days and 1 inch/8 days). The greater irrigation capacity was positively reflected in both greater number of kernels/ear and kernel mass (Table 1 and Figure 2 middle and bottom panel), but the number of kernels/ear had the greatest effect (Figure 4 top panel).

Table 1. Summary of average corn yield and water use parameters from a sprinkler-irrigated research study, KSU Northwest Research-Extension Center, 2004-2007.

Treatment	Irrigation (inches)	Yield (bu/a)	Plant Density (p/a)	Ears /Plant	Kernels /Ear	Kernel Mass (mg)	Water Use (inches)	Water Productivity (lbs/acre-in)
1 in/4 day	13.8	243	30129	1.00	575	361	25.99	528
1 in/ 6 day	12.3	224	30137	1.00	546	350	25.05	503
1 in/ 8 day	10.3	221	30016	1.01	545	347	23.56	526
Conventional	12.1	221	30016	1.00	534	35.4	24.56	505
Strip Tillage	12.1	237	30226	1.01	567	35.3	25.15	530
No-Tillage	12.1	231	30040	1.00	565	35.0	24.88	522
PD 26,000 p/a	12.1	221	26822	1.01	577	36.2	24.85	501
PD 30,000 p/a	12.1	232	30145	1.00	556	35.3	24.87	524
PD 34,000 p/a	12.1	235	33315	1.00	532	34.2	24.88	531

The strip tillage and no-tillage treatment had greater yields (≈ 10 bushels/acre) than the conventional tillage treatment (Table 1 and Figure 2 top panel). The improved tillage schemes were positively reflected in a greater number of kernels/ear (≈ 32, Table 1 and Figure 2 middle panel). This nearly 6% greater number of kernels/ear for the two treatments resulted in an approximately 4.5 to 7% greater yield (Figure 4 middle panel).

Increasing plant density from 26,000 to 30,000 or 34,000 plants/acres increased yield approximately 12 bushels/acre (Table 1 and Figure 2 top panel). Both kernels/ear and kernel mass were reduced for the greater plant densities (Table 1 and Figure 2 middle and bottom panel), but the greater plant densities were able to fully compensate for these lower values by the increased number of plants (Table 1, Figure 4 bottom panel).

Water use was greatest for the fully-irrigated irrigation treatment (1 inch/4 days) as might be anticipated due to greater irrigation amounts (Table 1 and Figure 3 top panel). However it had the numerically greatest water productivity, although all three treatments had relatively similar values (Table 1 and Figure 3 bottom panel).

There were very little differences in overall crop water use as affected by tillage treatment (Table 1 and Figure 3 top panel). This is to be anticipated as with good irrigation management all treatments either used the provided irrigation or added it to soil water storage. Due to greater yields, the strip and no-tillage treatments had greater water productivity (Table 1 and Figure 3, bottom panel).

The range of plant densities from 26,000 to 34,000 plants/acre had no effect on crop water use (Table 1 and Figure 3, top panel) with the range of average values differing by less than 0.03 inches. Much greater water productivity was obtained by the greater plant densities (Table 1 and Figure 3, bottom panel).

CONCLUSIONS

The greatest irrigation capacity (1 inch/4days) had approximately 9% greater yield than the deficit-irrigated treatments (1 inch/6 days or 1 inch/8 days) due to a greater number of kernels/ear and to a lesser extent greater kernel mass. All irrigation treatments had relatively similar and high water productivity.

Strip tillage and no-tillage were superior to conventional tillage in terms of grain yield and water productivity. The number of kernels/ear was greater for the two reduced tillage schemes.

Increasing plant density from 26,000 to 30,000 or 34,000 plants/acre increased grain yield and water productivity although the number of kernels/ear and kernel mass were decreased by the increase in plant density. Crop water use was not affected over the entire range of plant density.

ACKNOWLEDGEMENTS

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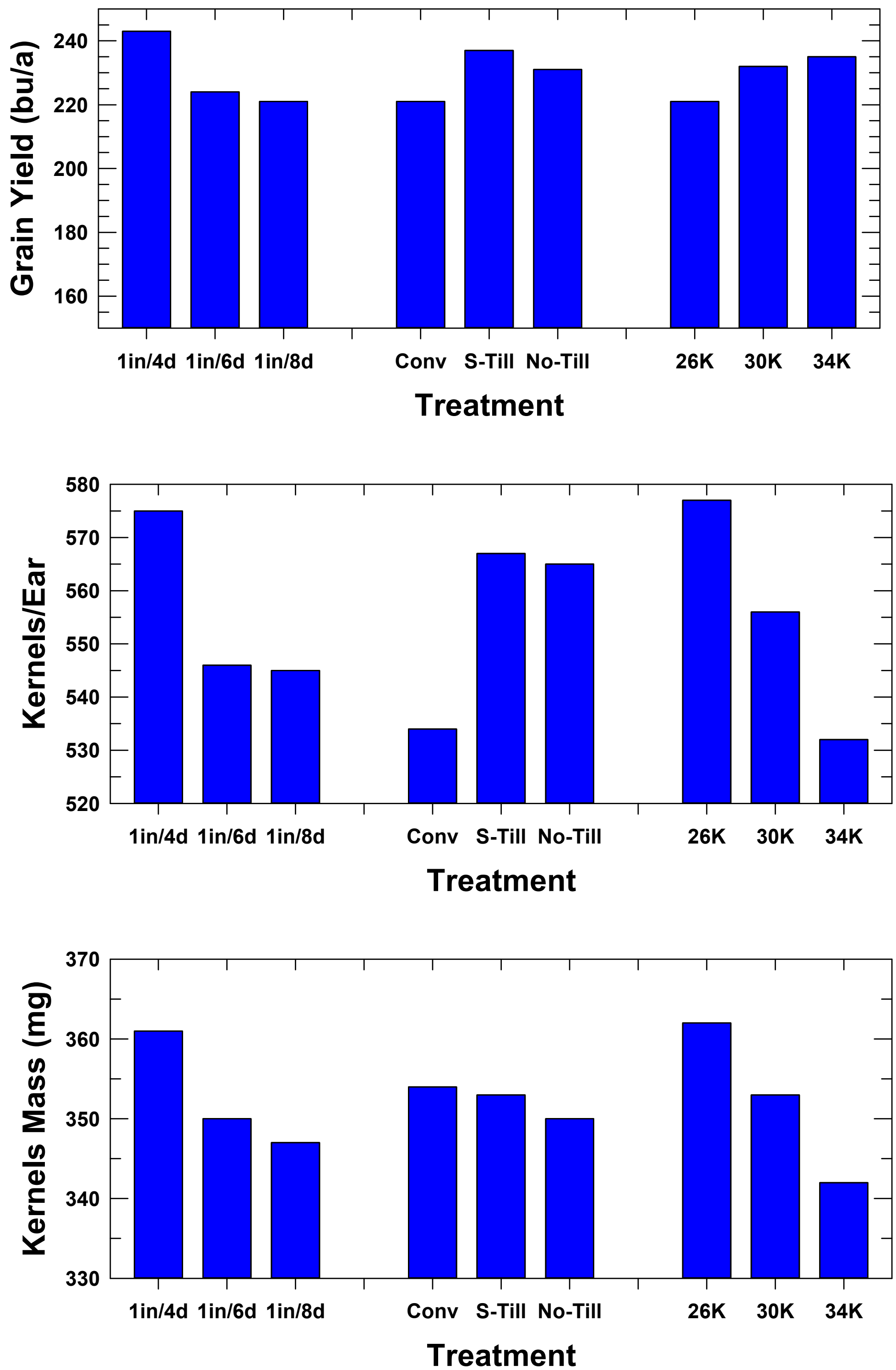
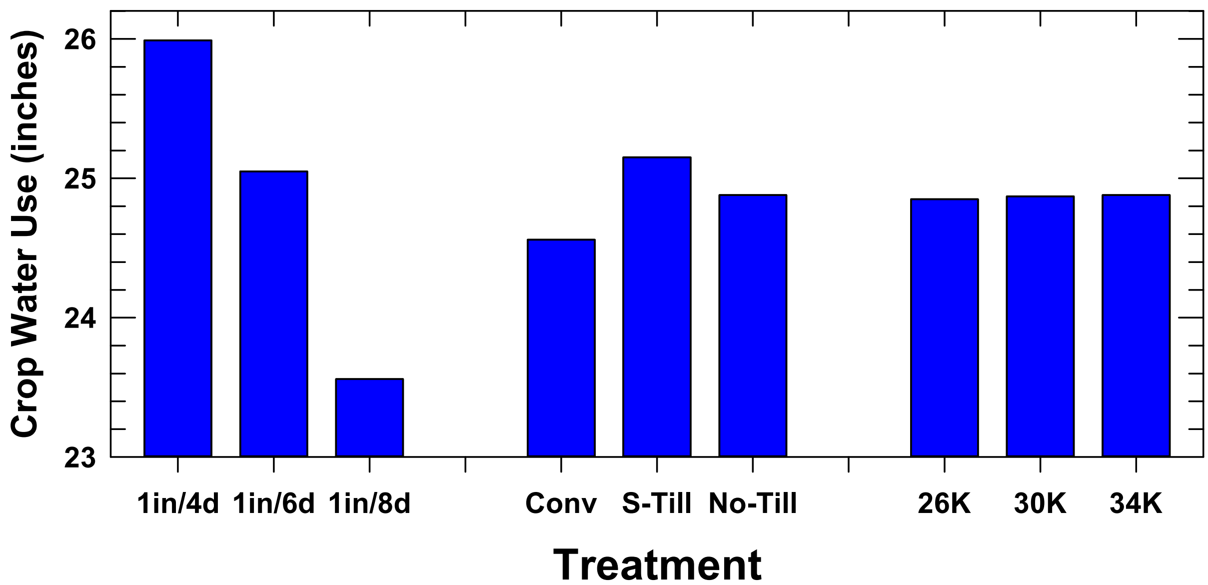


Figure 2. Corn grain yield, kernels/ear, and kernel mass as affect by irrigation capacity, tillage treatment and target plant density in a sprinkler-irrigated research study, KSU Northwest Research-Extension Center, Colby, Kansas, 2004-2007.



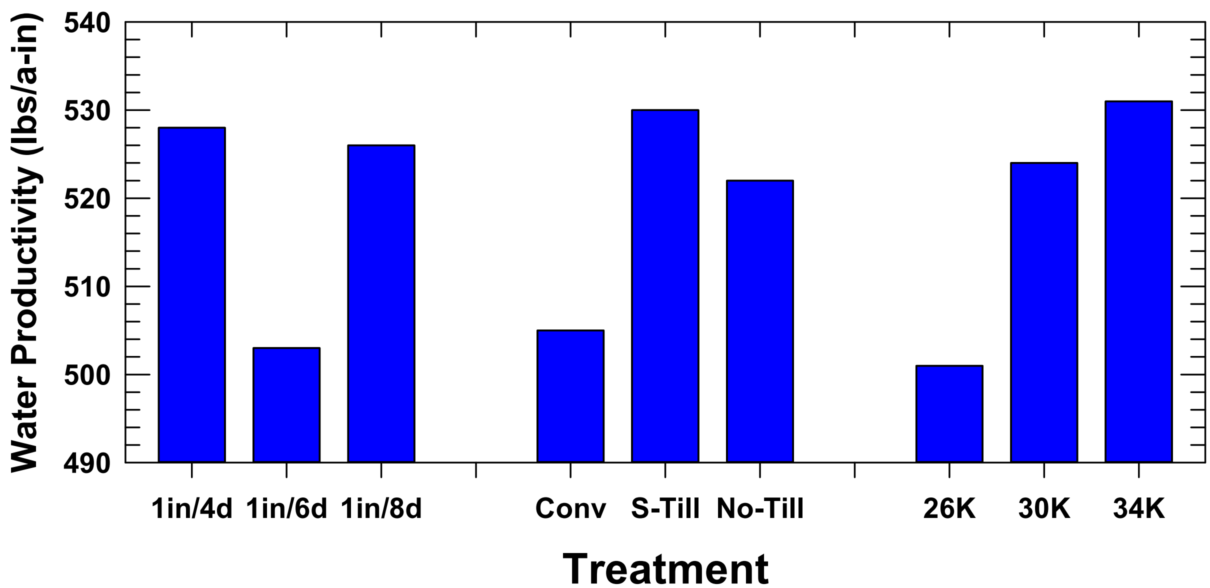


Figure 3. Corn water use and water productivity as affected by irrigation capacity, tillage treatment and target plant density in a sprinkler-irrigated research study, KSU Northwest Research-Extension Center, Colby, Kansas, 2004-2007.

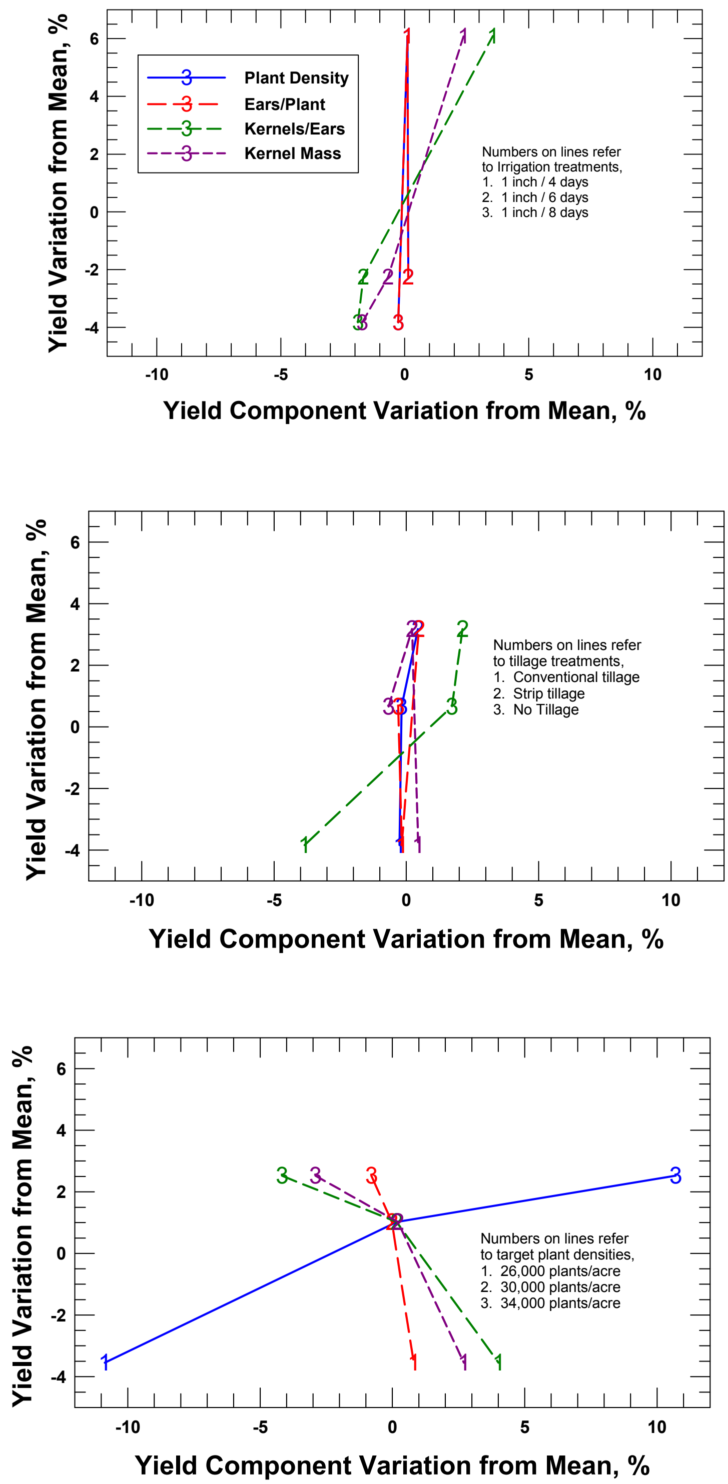


Figure 4. Contribution of various yield components to the yield variation for the three irrigation capacities (top panel), the three tillage systems (middle panel) and the three target plant densities (bottom panel). *Note: Upward sloping lines to the right, such as Kernel/Ear, indicate that treatment heavily affected the yield component and subsequently affected the grain yield, while vertical lines with little or no yield component variation from zero indicate little effect.*