An ASABE Meeting Presentation

Paper Number: 072283

Tillage and Irrigation Capacity Effects on Corn Production

Freddie R. Lamm, Professor and Research Irrigation Engineer

KSU Northwest Research-Extension Center
105 Experiment Farm Road, Colby, Kansas, USA 67701,
flamm@ksu.edu

Robert M. Aiken, Associate Professor and Crop Scientist

KSU Northwest Research-Extension Center,
105 Experiment Farm Road, Colby, Kansas, USA 67701
raiken@ksu.edu

Written for presentation at the
2007 ASABE Annual International Meeting
Sponsored by ASABE
Minneapolis Convention Center
Minneapolis, Minnesota
17 - 20 June 2007

Abstract. *Corn production was compared from 2004 to 2006 for three plant populations (62,800, 70,700 or 79,100 plants /acre) under conventional, strip and no tillage systems for irrigation capacities limited to 25 mm every 4, 6 or 8 days. Corn yield increased approximately 12% from the lowest to highest irrigation capacity in these three years of varying precipitation and near normal crop evapotranspiration. Strip tillage and no tillage had 8.8% and 7% higher grain yields than conventional tillage, respectively. Results suggest that strip tillage obtains the residue benefits of no tillage in reducing evaporation losses without the yield penalty sometimes occurring with high residue. The small increases in total seasonal water use (< 20 mm) for strip tillage and no-tillage compared to conventional tillage can probably be explained by the higher grain yields for these tillage systems.*

Keywords. Tillage management, conservation tillage, irrigation management, water use efficiency, corn production

Introduction

Declining water supplies and reduced well capacities are forcing irrigators to look for ways to conserve and get the best utilization from their water. Residue management techniques such as no tillage or conservation tillage have been proven to be very effective tools for dryland water conservation in the Great Plains. However, adoption of these techniques is lagging for continuous irrigated corn. There are many reasons given for this lack of adoption, but some of the major reasons expressed are difficulty handling the increased level of residue from irrigated production, cooler and wetter seedbeds in the early spring which may lead to poor or slower development of the crop, and ultimately a corn grain yield penalty as compared to conventional tillage systems. Under very high production systems, even a reduction of a few percentage points in corn yield can have a significant economic impact. Strip tillage might be a good compromise between conventional tillage and no tillage, possibly achieving most of the benefits in water conservation and soil quality management of no tillage, while providing a method of handling the increased residue and increased early growth similar to conventional tillage. Strip tillage can retain surface residues and thus suppress soil evaporation and also provide subsurface tillage to help alleviate effects of restrictive soil layers on root growth and function. A study was initiated in 2004 to examine the effect of three tillage systems for corn production under three different irrigation capacities. Plant population was also factor examined because corn yield increases in recent years have been closely related to increased plant populations.

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 2006. Corn was also grown on the field site in 2003 to establish residue levels for the three tillage treatments. The deep Keith silt loam soil can supply about 445 mm of available soil water for a 2.4 m soil profile. The semi-arid, summer pattern climate has an annual rainfall of approximately 485 mm. Average precipitation is approximately 310 mm during the 120-day corn growing season.

A corn hybrid of approximately 110 day relative maturity (Dekalb DCK60-19 in 2004 and DCK60-18 in 2005 and 2006) was planted in circular rows on May 8, 2004, April 27, 2005 and April 20, 2006, respectively. Three seeding rates (64,200, 74,100 and 84,000 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 25 mm every 4, 6, or 8 days. This translates into typical seasonal irrigation amounts of 375-500, 275-375, 200-300 mm, respectively. Each of the irrigation capacities (whole plot) were replicated three times in pie-shaped sectors (25 degree) of the center pivot sprinkler (Figure 1). Plot length varied from to 27 to 53 m, depending on the radius of the subplot from the center pivot point. Irrigation application rates (i.e. mm/h) at the outside edge of this research center pivot were similar to application rates near the end of full size systems. A small amount of preseason irrigation was conducted to bring the soil water profile (2.4 m) to approximately 50% of field capacity in the fall and as necessary in the spring to bring the soil water profile to approximately 75% in the top 1 m prior to planting. It should be recognized that preseason irrigation is not a recommended practice for fully irrigated corn production, but did allow the three irrigation capacities to start the season with somewhat similar amounts of water in the profile.

The three tillage treatments (Conventional tillage, Strip Tillage and No Tillage) were replicated in a Latin-Square type arrangement in 18.3 m ft widths at three different radii (Centered at 73, 91 and 110 m.) from the center pivot point (Figure 1). The various operations and their time period for the three tillage treatments are summarized in Table 1. Planting was in the 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.

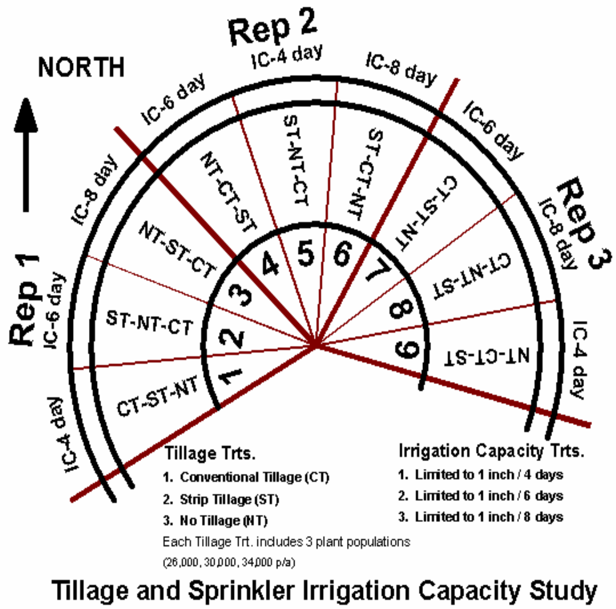

Figure 1. Physical arrangement of the irrigation capacity and tillage treatments.

Fertilizer N for all 3 treatments was applied at a rate of 224 kg/ha in split applications with approximately 95 kg/ha applied in the fall or spring application, approximately 34 kg/ha in the starter application at planting and approximately 95 kg/ha in a fertigation event near corn lay-by. Phosphorus was applied with the starter fertilizer at planting at the rate of 51 kg/ha P_2O_5. Urea-Ammonium-Nitrate (UAN 32-0-0) and Ammonium Superphosphate (10-34-0) were utilized as the fertilizer sources in the study. Fertilizer was incorporated in the fall concurrently with the Conventional Tillage operation and applied with a mole knife during the Strip Tillage treatment. Conversely, N application was broadcast with the No Tillage treatment prior to planting.

A post-plant, pre-emergent herbicide program of Bicep II Magnum and Roundup Ultra was applied. Roundup was also applied post-emergence prior to lay-by for all treatments, but was particularly beneficial for the strip and no tillage treatments. Insecticides were applied as required during the growing season.

Weekly to bi-weekly soil water measurements were made in 0.3 m increments to 2.4 m depth with a neutron probe. All measured data was taken near the center of each plot. These data were utilized to examine treatment differences in soil water conditions both spatially (e.g. vertical differences) and temporally (e.g. differences caused by timing of irrigation in relation to evaporative conditions as affected by residue and crop growth stage).

Table 1. Tillage treatments, herbicide and nutrient application by period.

Period	Conventional tillage	Strip Tillage	No Tillage
Fall 2003	1) One-pass chisel/disk plow at 20-25 mm with broadcast N, November 13, 2003.	1) Strip Till + Fertilizer (N) at 20-25 mm depth, November 13, 2003.	
Spring 2004	2) Plant + Banded starter N & P, May 8, 2004. 3) Pre-emergent herbicide application, May 9, 2004.	2) Plant + Banded starter N & P, May 8, 2004 3) Pre-emergent herbicide application, May 9, 2004.	1) Broadcast N + Plant + Banded starter N & P, May 8, 2004 2) Pre-emergent herbicide application, May 9, 2004.
Summer 2004	4) Roundup herbicide application near lay-by, June 9, 2004 5) Fertigate (N), June 10, 2004	4) Roundup herbicide application near lay-by, June 9, 2004 5) Fertigate (N), June10, 2004	3) Roundup herbicide application near lay-by, June 9, 2004 4) Fertigate (N), June 10, 2004
Fall 2004	1) One-pass chisel/disk plow at 20-25 mm with broadcast N, November 05, 2004.	*Too wet, no tillage operations*	
Spring 2005	2) Plant + Banded starter N & P, April 27, 2005. 3) Pre-emergent herbicide application, May 8, 2005.	1) Strip Till + Fertilizer (N) at 20-25 mm depth, March 15, 2005. 2) Plant + Banded starter N & P, April 27, 2005 3) Pre-emergent herbicide application, May 8, 2005.	1) Broadcast N + Plant + Banded starter N & P, April 27, 2005 2) Pre-emergent herbicide application, May 8, 2005.
Summer 2005	4) Roundup herbicide application near lay-by, June 9, 2005 5) Fertigate (N), June 17, 2005	4) Roundup herbicide application near lay-by, June 9, 2005 5) Fertigate (N), June 17, 2005	3) Roundup herbicide application near lay-by, June 9, 2005 4) Fertigate (N), June 17, 2005
Fall 2005	1) One-pass chisel/disk plow at 20-25 mm with broadcast N, November 10, 2005.	1) Strip Till + Fertilizer (N) at 20-25 mm depth, November 10, 2005.	
Spring 2006	2) Plant + Banded starter N & P, April 20, 2006. 3) Pre-emergent herbicide application, April 22, 2006.	2) Plant + Banded starter N & P, April 20, 2006 3) Pre-emergent herbicide application, April 22, 2006.	1) Broadcast N + Plant + Banded starter N & P, April 20, 2006 2) Pre-emergent herbicide application, April 22, 2006.
Summer 2006	4) Roundup herbicide application near lay-by, June 6, 2006 5) Fertigate (N), June 13, 2006	4) Roundup herbicide application near lay-by, June 6, 2006 5) Fertigate (N), June 13, 2006	3) Roundup herbicide application near lay-by, June6, 2006 4) Fertigate (N), June 13, 2006

Similarly, corn yield was measured in each of the 81 subplots at the end of the season. In addition, yield components (above ground biomass, plants/acre ears/plant, kernels/ear and kernel weight) were determined to help explain the treatment differences. Water use and water use efficiency were calculated for each subplot using the soil water data, precipitation, applied irrigation and crop yield.

Results and Discussion

Weather Conditions

Summer seasonal precipitation was approximately 50 mm below normal in 2004, near normal in 2005, and nearly 75 mm below normal in 2006 at 254, 304, and 228 mm, respectively for the 120 day period from May 15 through September 11 (long term average, 301 mm). In 2004, the last month of the season was very dry but the remainder of the season had reasonably timely rainfall and about normal crop evapotranspiration (Figure 2). In 2005, precipitation was above normal until about the middle of July and then there was a period with very little precipitation until the middle of August. This dry period in 2005 also coincided with a week of higher temperatures and high crop evapotranspiration near the reproductive period of the corn (July 17-25). In 2006, precipitation lagged behind the long term average for the entire season. Fortunately, seasonal evapotranspiration was near normal as it also was for the other two years (long term average of 586 mm).

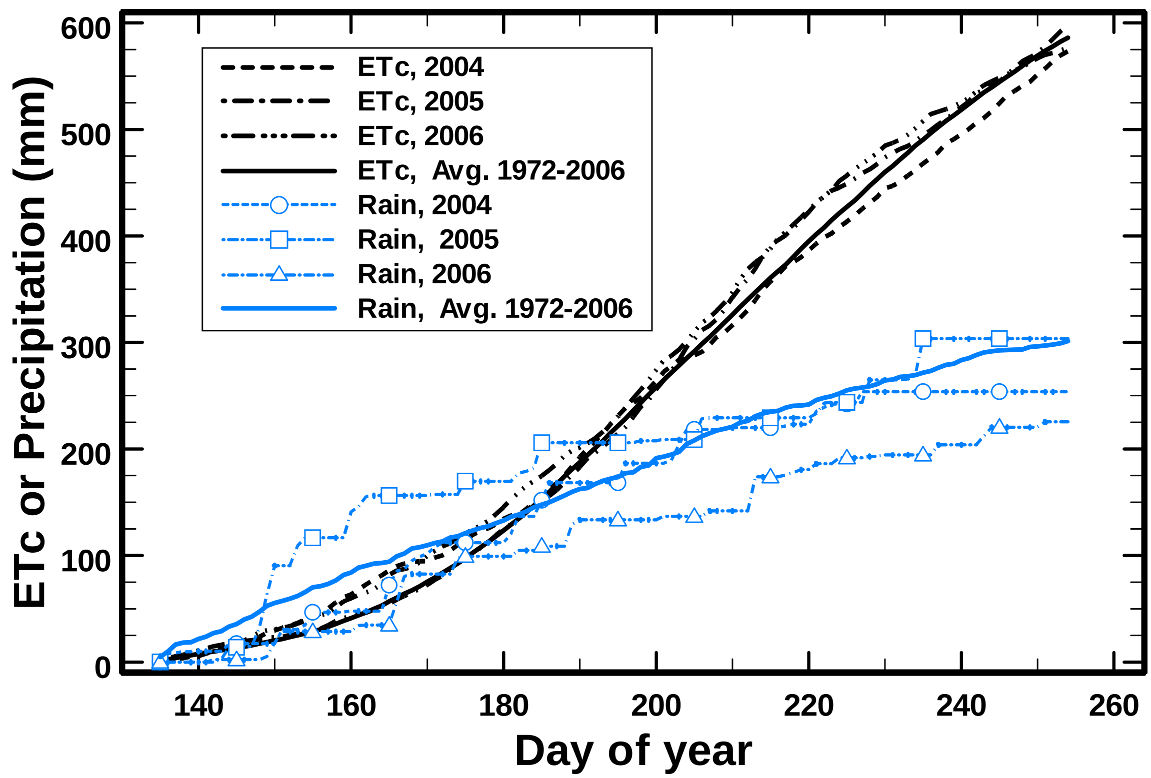

Figure 2. Calculated corn evapotranspiration and summer seasonal rainfall for the 120 day period, May 15 through September 11, KSU Northwest Research-Extension Center, Colby Kansas.

Irrigation requirements were lowest in 2004 with the 25 mm/4 day treatment receiving 305 mm, the 25 mm/ 6 day treatment receiving 279 mm and the 25 mm/8 day treatment receiving 229 mm (Figure 3). The irrigation amounts in 2005 were 381, 330, and 254 mm for the three respective treatments. The irrigation amounts were highest in 2006 at 394, 343, and 292 mm for the three respective treatments.

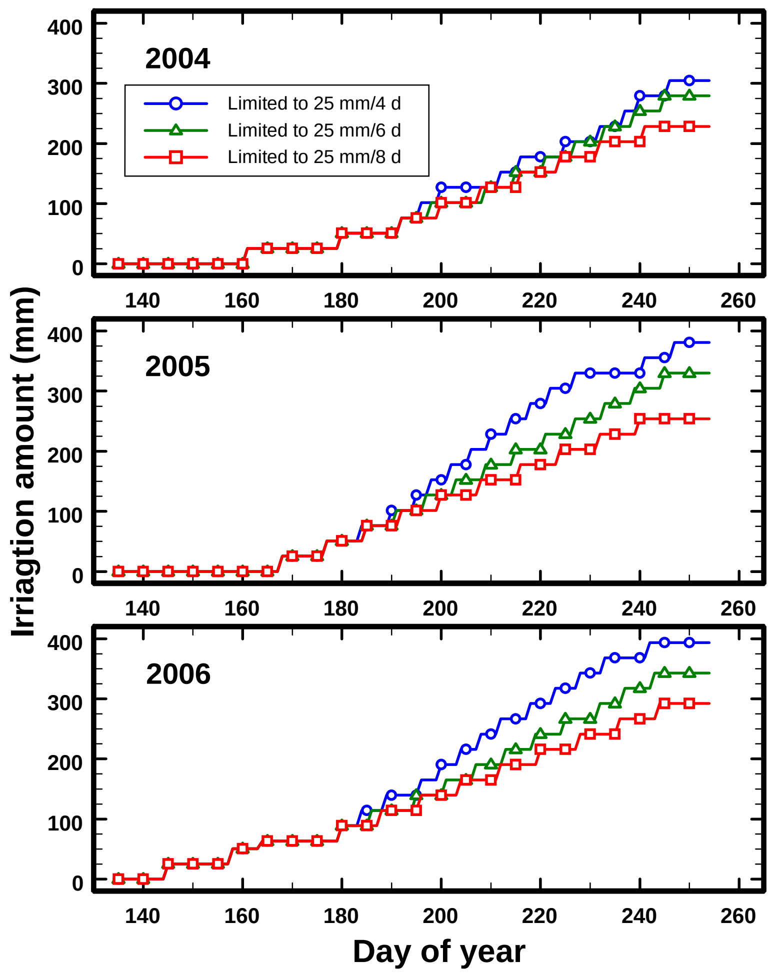

Figure 3. Seasonal irrigation for the 120 day period, May 15 through September 11 for the three irrigation treatments in an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby Kansas, 2004-2006.

Crop Yield and Selected Yield Components

Corn yield was relatively high for all three years ranging from 10.1 to 16.4 Mg/ha Table 2 through 4, and Figure 4). Higher irrigation capacity generally increased grain yield, particularly in 2005 and 2006. Strip tillage and no tillage had higher grain yields at the lowest irrigation capacity in 2004 and at all irrigation capacities in 2005 and 2006. Strip tillage tended to have the highest grain yields for all tillage systems and the effect of tillage treatment was greatest at the lowest irrigation capacity. These results suggest that strip tillage obtains the residue benefits of no tillage in reducing evaporation losses without the yield penalty sometimes associated with the higher residue levels in irrigated no tillage management.

Higher plant population had a significant effect in increasing corn grain yields (Tables 2 through 4, Figure 5) on the average about 0.6 to 1.2 Mg/ha for the lowest and highest irrigation capacities, respectively. Higher plant population gives greater profitability in good production years. Assuming a seed cost of $1.49/1,000 seeds and corn harvest price of $0.075/kg, this 0.6 to 1.2 Mg/ha yield advantage would increase net returns approximately $45 to $90/ha for the increase in plant population of approximately 15,100 seeds/ha. Increasing the plant population by 15,100 plants/ha on the average reduced kernels/ear by 48 and reduced kernel weight by 1.5 g/100 kernels (Tables 2 through 4). However, this was fully compensated by the increase in population increasing the overall number of kernels/ha by 12.8% (data not shown).

Table 2. Selected corn yield component data for 2004 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Target Plant Population (1000 p/ha)	Grain Yield Mg/ha	Plant Population (p/ha)	Kernels /Ear	Kernels 10^6/ha	Kernel Weight g/100)
25 mm/4 d	Conventional	64	14.4	68888	550	39.0	37.1
(301 mm)		74	14.8	72475	557	40.8	36.2
		84	14.7	79651	529	42.5	34.6
	Strip Tillage	64	15.4	68170	537	39.8	38.9
		74	14.6	75346	519	39.5	37.0
		84	14.9	81804	514	42.1	35.5
	No Tillage	64	13.7	63864	548	36.6	37.7
		74	14.2	72475	539	38.8	36.8
		84	15.7	83239	553	46.4	33.8
25 mm/6 d	Conventional	64	14.2	62429	557	36.4	39.0
(279 mm)		74	13.9	73193	522	39.7	34.9
		84	15.3	80369	522	42.4	36.0
	Strip Tillage	64	14.7	67452	558	40.1	36.9
		74	14.1	71040	556	40.3	35.0
		84	14.9	82522	487	42.0	35.6
	No Tillage	64	14.1	65300	537	37.4	37.8
		74	13.9	71758	556	40.3	34.6
		84	14.3	79651	545	43.8	32.8
25 mm/8 d	Conventional	64	12.4	60994	509	33.2	37.5
(229mm)		74	13.3	72475	531	38.5	34.5
		84	13.6	78216	494	39.7	34.9
	Strip Tillage	64	14.3	63864	644	42.1	34.2
		74	14.4	73911	518	40.5	35.6
		84	14.7	81086	507	41.8	35.1
	No Tillage	64	13.8	66735	541	37.6	36.6
		74	14.1	73193	528	40.9	34.5
		84	13.8	81086	506	42.9	32.2

Table 3. Selected corn yield component data for 2005 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Target Plant Population (1000 p/ha)	Grain Yield Mg/ha	Plant Population (p/ha)	Kernels /Ear	Kernels 10^6/ha	Kernel Weight g/100
25 mm/4 d	Conventional	64	13.7	58841	644	36.0	37.9
(381 mm)		74	14.9	68170	594	40.1	37.3
		84	16.3	74628	579	44.0	37.1
	Strip Tillage	64	14.9	60277	620	37.8	39.6
		74	15.7	68888	590	41.1	38.3
		84	15.9	76781	567	43.1	36.8
	No Tillage	64	14.3	61712	628	37.4	38.3
		74	15.9	66017	660	42.6	37.4
		84	16.5	77498	606	46.1	35.8
25 mm/6 d	Conventional	64	12.7	60994	546	33.7	37.7
(330 mm)		74	13.8	68170	544	36.7	37.5
		84	13.1	76781	472	35.9	36.2
	Strip Tillage	64	14.2	60277	604	36.4	38.9
		74	13.0	69605	487	33.5	38.4
		84	15.6	78934	560	43.4	36.0
	No Tillage	64	12.9	60994	565	33.6	38.2
		74	14.1	71758	547	38.5	36.6
		84	14.7	78216	512	39.7	37.1
25 mm/8 d	Conventional	64	11.7	60277	523	31.1	37.5
(254 mm)		74	13.7	67452	536	36.6	37.5
		84	13.1	78216	452	35.0	37.3
	Strip Tillage	64	13.3	58841	648	38.6	34.9
		74	13.5	68170	579	37.8	35.8
		84	15.0	77498	537	41.6	36.1
	No Tillage	64	13.1	59559	608	34.9	37.4
		74	13.2	68170	537	36.6	36.2
		84	13.6	76781	502	37.4	36.4

The number of kernels/ear was lower in 2004 and 2006 compared to 2005 (Table 2 through 4, Figure 6). The potential number of kernels/ear is set at about the ninth leaf stage (approximately 0.75 to 1 m tall) and the actual number of kernels/ear is finalized by approximately 2 weeks after pollination. Greater early season precipitation in 2005 (Figure 2) than 2004 and 2006 may have established a higher potential for kernels/ear and then later in the 2005 season greater irrigation capacity or better residue management may have allowed for more kernels to escape abortion. The time the actual kernels/ear was being set in 2005 was a period of high evapotranspiration (Figure 2) and also coincided with multiple irrigation events for the 25 mm /4 days irrigation capacity.

An intermediate yield component (kernels/ha)combines plant population, ears/plant and kernels/ear (Tables 4 through 6). There is less variation in kernels/ha for the various plant population treatments than for kernels/ear. This is further evidence that a key to increased yields and profitability is through appropriate plant population increases. The kernels/ha still tends to be lower for the conventional tillage treatments.

Table 4. Selected corn yield component data for 2006 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Target Plant Population (1000 p/ha)	Grain Yield Mg/ha	Plant Population (p/ha)	Kernels /Ear	Kernels 10^6/ha	Kernel Weight g/100
25 mm/4 d	Conventional	64	15.0	72475	542	39.3	38.1
(394 mm)		74	13.3	76781	476	36.6	36.4
		84	13.3	86827	434	37.1	36.1
	Strip Tillage	64	14.6	72475	514	37.2	39.1
		74	14.8	77498	483	38.8	38.2
		84	16.3	81804	522	42.3	38.6
	No Tillage	64	13.2	70323	497	35.0	37.9
		74	16.5	77498	535	41.1	40.3
		84	15.6	85392	516	43.7	35.7
25 mm/6 d	Conventional	64	10.1	71758	422	29.4	34.1
(343 mm)		74	13.0	78934	446	35.2	37.1
		84	10.6	83957	374	30.1	35.0
	Strip Tillage	64	13.0	71758	492	35.7	36.6
		74	13.5	77498	484	36.8	36.7
		84	13.6	84674	476	39.2	34.7
	No Tillage	64	14.4	72475	541	39.2	36.8
		74	13.7	74628	516	38.2	35.9
		84	14.0	81086	484	38.2	36.7
25 mm/8 d	Conventional	64	10.8	69605	417	28.7	37.8
(292 mm)		74	12.0	78216	411	31.8	37.7
		84	12.0	83957	385	32.3	37.2
	Strip Tillage	64	13.4	72475	565	40.9	32.7
		74	13.8	78934	510	40.2	34.4
		84	14.5	85392	479	40.5	35.7
	No Tillage	64	12.8	71040	501	34.9	36.9
		74	13.8	77498	497	38.5	35.8
		84	13.5	83957	458	38.1	35.6

Final kernel weight is affected by plant growing conditions during the grain filling stage (last 60 days prior to physiological maturity) and by plant population and kernels/ear. Deficit irrigation capacities often will begin to mine soil water reserves during the latter portion of the cropping season, so it is not surprising that kernel weight was increased with increased irrigation capacity (Tables 2 through 4, Figure 9).

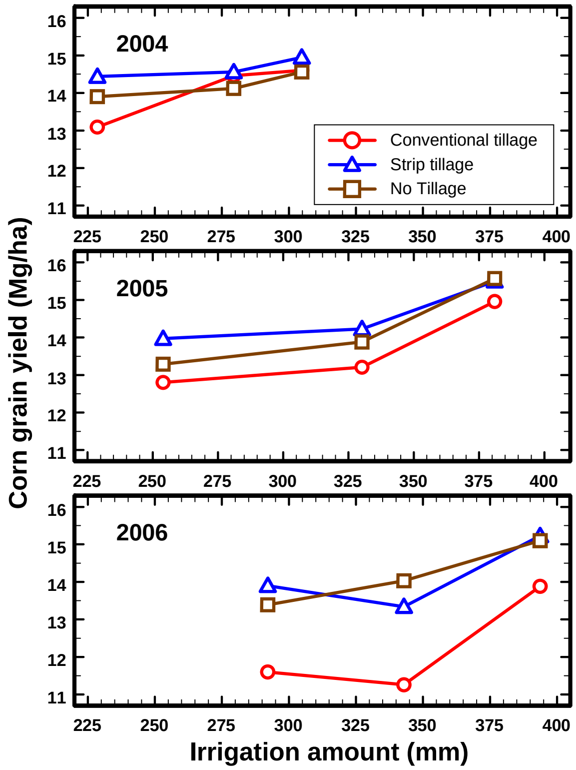

Figure 4. Corn grain yield as affected by irrigation capacity and tillage, 2004 to 2006, KSU Northwest Research-Extension Center, Colby Kansas.

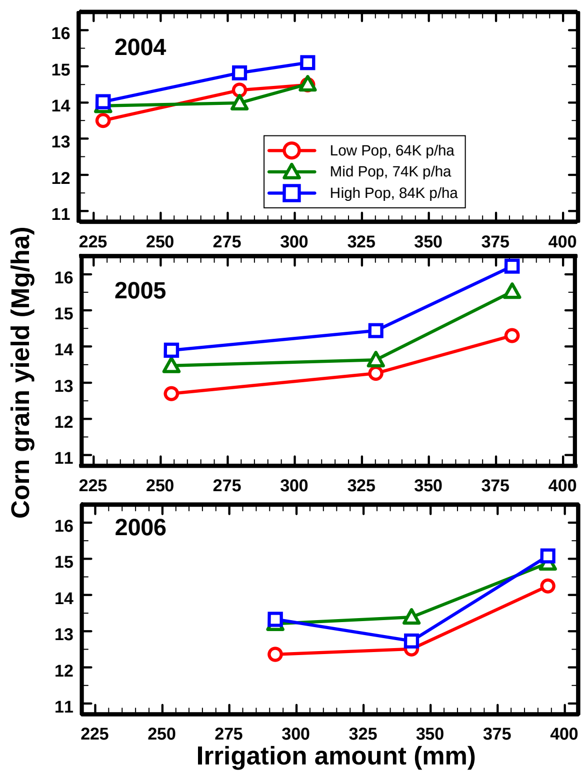

Figure 5. Corn grain yield as affected by irrigation capacity and plant population, 2004-2006, KSU Northwest Research-Extension Center, Colby Kansas.

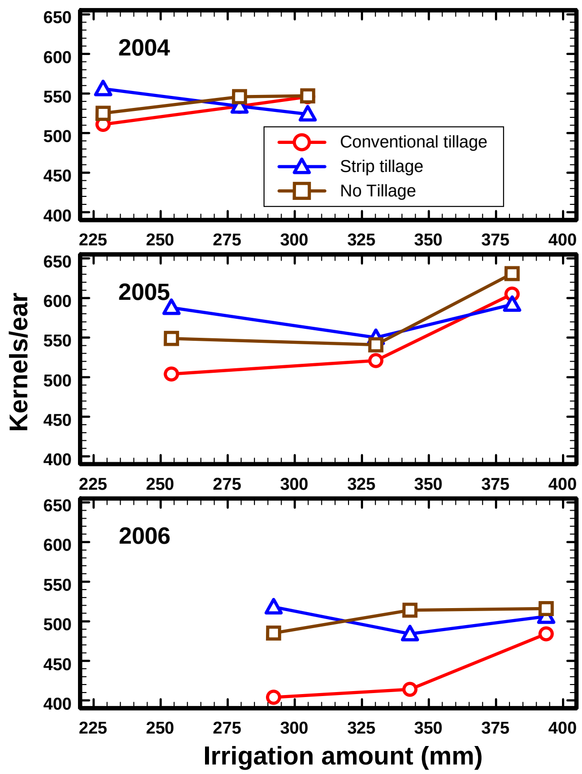

Figure 6. Kernels/ear as affected by irrigation capacity and plant population, 2004-2006, KSU Northwest Research-Extension Center, Colby Kansas.

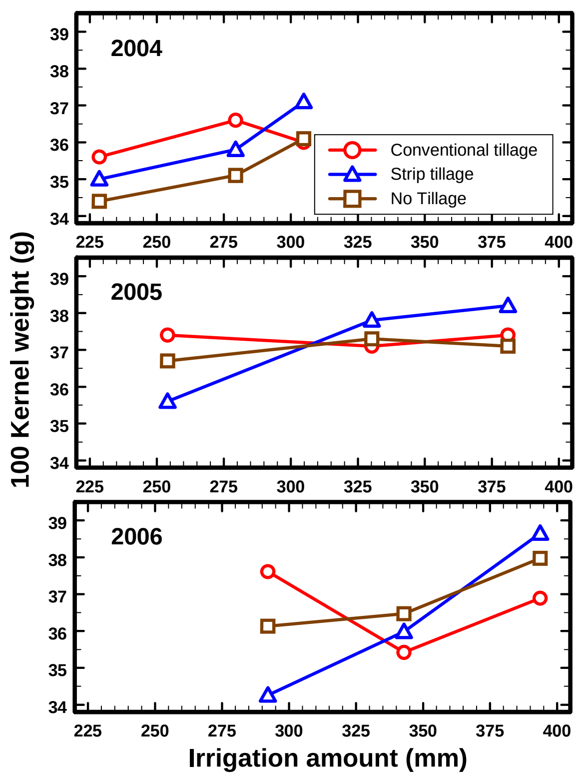

Figure 7. Kernel weight as affected by irrigation capacity and plant population, 2004-2006, KSU Northwest Research-Extension Center, Colby Kansas.

Tillage system also affected kernel weight, but it is thought by the authors that the effect was caused by different factors at the different irrigation capacities. At the lowest irrigation capacity, final kernel weight was highest for conventional tillage because of the lower number of kernels/ear. However, this higher kernel weight did not compensate for the decreased kernels/ear, and thus, grain yields were lower for conventional tillage. Strip tillage generally had higher kernel weights at higher irrigation capacity than the conventional and no tillage treatments for some unknown reason.

The changing patterns in grain yield, kernels/ear, and kernel weight that occurs between years and as affected by irrigation capacity and tillage system may be suggesting that additional factors besides differences in plant water status or evaporative losses is affecting the corn production. There might be differences in rooting, aerial or soil microclimate, nutrient status or uptake to name a few possible physical and biological reasons.

Total seasonal water use in this study was calculated as the sum of irrigation, precipitation and the change in available soil water over the course of the season. As a result, seasonal water use can include non-beneficial water losses such as soil evaporation, deep percolation, and runoff. Intuitively, one might anticipate that good residue management with strip tillage and no-tillage would result in lower water use than conventional tillage because of lower non-beneficial water losses. However, in this study, strip tillage and no-tillage generally had higher water use (Tables 5 through 7, Figure 8). The small increases in total seasonal water use (< 38 mm) for strip tillage and no-tillage compared to conventional tillage can probably be explained by the higher grain yields for these tillage systems (approximately 0.6 Mg/ha). Another possibility is that there were increased deep percolation losses in 2005 because of the higher early season precipitation.

Water use in 2004 was similar for the 25 mm/4 days and 25 mm/6 days irrigation treatment and only slightly higher for the 25 mm/8 days treatment, probably reflecting the timely and near normal rainfall pattern throughout the summer. There was only 72 mm difference in irrigation from highest to lowest amounts.

Water use efficiency was not affected by tillage in 2004 but was higher for strip and no tillage treatments in 2005 and 2006, probably reflecting the greater yields for these two tillage treatments (Tables 5-7). Water use efficiency was only slightly increased when irrigation was decreased indicating that non-beneficial water use and losses were relatively low. Higher water use efficiency was obtained by the higher plant populations because of increased yields. These increased yields at the higher plant populations occurred with little or no increase in total water use. Producers often ask about decreasing irrigation requirements with lower plant population. The data from this study indicate that much sharper reductions in plant population would be required than those examined here and with those reductions there likely would be additional yield reductions.

Although not a part of the study, the efficiency of nutrient use was high in this study. Total applied nitrogen would be 225 kg/ha of commercial fertilizer and 8 to 12 additional kg/ha in the in irrigation water. Approximately 61 kg of grain was produced for each kg of N. An older guideline for corn production in the region is approximately 45 kg grain for each kg of N.

Table 5. Total seasonal water use and available soil water on selected dates for 2004 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Water Use (mm)	Water use efficiency mg/ha-mm	ASW to 0.6 m on 5-21-04	ASW to 0.6 m on 6-25-04	ASW to 2.4 m on 7-15-04	ASW to 2.4 m on 9-25-04
25 mm/4 d	Conventional	584	0.02459	100	106	307	259
(301 mm)		575	0.02565	91	103	299	245
		559	0.02626	97	106	297	243
	Strip Tillage	598	0.02574	98	106	302	229
		620	0.02349	102	107	303	231
		618	0.02411	100	106	301	223
	No Tillage	559	0.02455	102	109	335	287
		599	0.02373	95	102	289	249
		589	0.02669	96	104	341	281
25 mm/6 d	Conventional	585	0.02425	98	107	261	206
(279 mm)		599	0.02328	95	103	267	208
		606	0.02515	95	100	250	182
	Strip Tillage	592	0.02489	87	101	306	242
		619	0.02275	96	102	289	126
		619	0.02402	89	97	302	214
	No Tillage	622	0.02268	93	101	254	177
		635	0.02193	92	98	238	147
		595	0.02413	96	102	244	194
25 mm/8 d	Conventional	563	0.02209	98	107	269	172
(229mm)		570	0.02328	102	111	270	177
		559	0.02427	102	105	238	164
	Strip Tillage	604	0.02364	104	111	320	209
		554	0.02594	93	110	316	215
		589	0.02492	100	105	303	209
	No Tillage	571	0.02414	108	114	306	210
		589	0.02395	104	111	303	183
		574	0.02402	103	110	307	212

Plant available soil water (ASW) in the top 0.6 m was similar across tillage treatments in all years except 2006 which had slightly lower amounts for the conventional tillage treatments (Tables 5 through 7). These slight differences in 2006 continued during the next month and possibly may have reduced the potential kernels/ear for the conventional tillage. However, the differences are not very large.

Table 6. Total seasonal water use and available soil water on selected dates for 2005 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Water Use (mm)	Water use efficiency mg/ha-mm	ASW to 0.6 m on 5-24-05	ASW to 0.6 m on 6-22-05	ASW to 2.4 m on 7-14-05	ASW to 2.4 m on 9-19-05
25 mm/4 d	Conventional	718	0.01903	96	105	346	285
(381 mm)		727	0.02051	104	109	322	266
		693	0.02356	96	98	338	294
	Strip Tillage	718	0.02078	100	106	339	265
		675	0.02329	101	107	381	354
		740	0.02143	95	103	342	265
	No Tillage	713	0.02011	102	111	387	329
		703	0.02264	97	103	383	348
		724	0.02275	103	106	387	334
25 mm/6 d	Conventional	671	0.01899	98	102	284	222
(330 mm)		656	0.02111	98	101	302	265
		643	0.02030	99	101	299	264
	Strip Tillage	679	0.02084	89	99	354	293
		689	0.01881	98	96	330	257
		666	0.02337	84	88	328	278
	No Tillage	679	0.01896	93	101	322	236
		691	0.02037	95	99	321	235
		653	0.02249	95	103	348	276
25 mm/8 d	Conventional	579	0.02022	98	101	265	206
(254 mm)		572	0.02387	99	107	309	246
		629	0.02075	100	103	282	189
	Strip Tillage	605	0.02202	105	106	353	255
		611	0.02214	104	113	366	260
		621	0.02422	101	110	348	246
	No Tillage	625	0.02092	108	109	374	254
		582	0.02270	102	109	381	281
		627	0.02165	105	112	359	264

Plant available water at anthesis in the total 2.4 m soil profile was more consistently higher for strip and no tillage treatments averaging 51 mm over the three years of the study with greatest differences in 2006 (Tables 5 through 7). These continuing differences may have resulted in the decreased kernels/ear for the conventional tillage treatments.

Table 7. Total seasonal water use and available soil water on selected dates for 2006 from an irrigation capacity and tillage study, KSU Northwest Research-Extension Center, Colby, Kansas.

Irrigation Capacity	Tillage System	Water Use (mm)	Water use efficiency mg/ha-mm	ASW to 0.6 m on 5-19-06	ASW to 0.6 m on 6-21-06	ASW to 2.4 m on 7-14-06	ASW to 2.4 m on 9-19-06
25 mm/4 d	Conventional	687	0.02178	94	97	275	213
(394 mm)		676	0.01973	91	91	303	244
		684	0.01949	95	96	286	218
	Strip Tillage	703	0.02072	100	108	327	229
		696	0.02125	100	106	326	246
		698	0.02341	99	103	289	211
	No Tillage	667	0.01981	105	112	382	310
		697	0.02365	102	109	368	291
		686	0.02273	102	109	388	305
25 mm/6 d	Conventional	631	0.01601	91	97	233	177
(343 mm)		624	0.02089	83	80	247	213
		636	0.01672	95	97	237	186
	Strip Tillage	662	0.01965	98	102	324	248
		657	0.02049	94	99	329	255
		673	0.02014	88	99	310	230
	No Tillage	657	0.02195	104	110	339	240
		651	0.02099	97	109	349	251
		649	0.02159	101	110	342	244
25 mm/8 d	Conventional	597	0.01811	92	92	222	158
(292 mm)		559	0.02141	100	110	268	225
		574	0.02091	97	105	238	185
	Strip Tillage	624	0.02153	105	109	296	192
		626	0.02208	105	112	316	210
		616	0.02346	101	105	299	208
	No Tillage	619	0.02070	109	115	357	243
		625	0.02212	108	113	337	222
		632	0.02139	104	111	349	221

Plant available water at physiological maturity in the total 2.4 m soil profile was more consistently higher for strip and no tillage treatments averaging 26 mm over the three years of the study with greatest differences in 2006 (Tables 5 through 7). These continuing differences may have resulted in the decreased yields for the conventional tillage treatments.

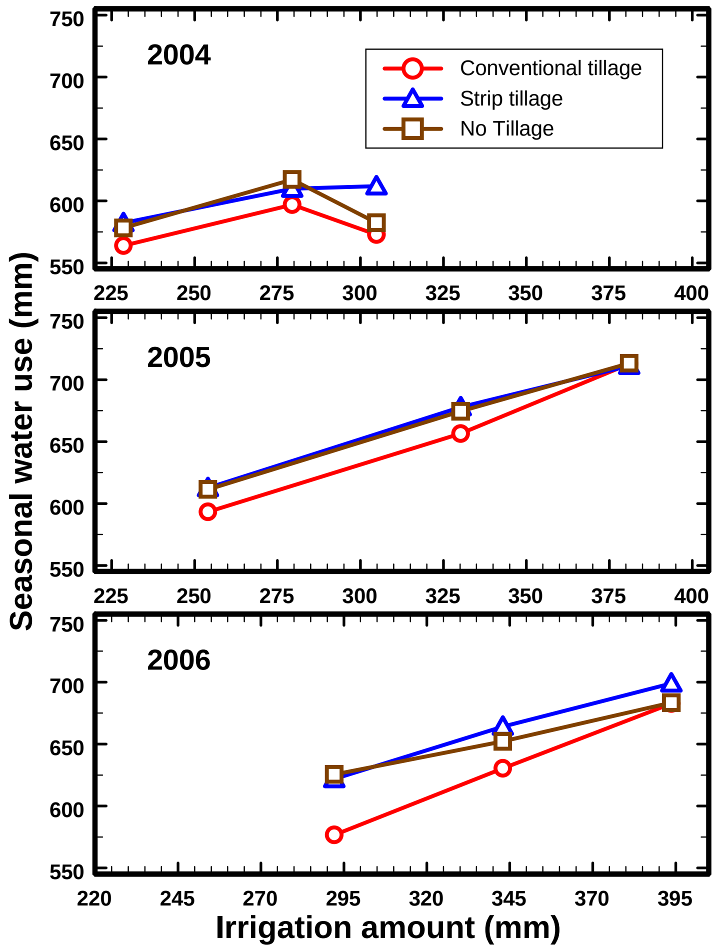

Figure 10. Total seasonal water use (sum of irrigation, precipitation, and seasonal changes in available soil water) as affected by irrigation capacity and plant population, 2004-2006, KSU Northwest Research-Extension Center, Colby Kansas.

CONCLUDING STATEMENTS

Corn grain yields were high all three years (2004 to 2006) with varying seasonal precipitation and near normal crop evapotranspiration. Strip tillage and no tillage generally performed better than conventional tillage. Yield components of kernels/ear and kernel weight were affected by both tillage and irrigation levels. Increasing the plant population from 64000 to 84000 plants/ha was beneficial at all three irrigation capacities. The study is being continued in 2007 to determine if the production trends will remain as residue levels continue to increase.

ACKNOWLEGEMENTS

This is Contribution No. 07-233-A from the Kansas Agricultural Experiment Station, Manhattan, Kansas.

The authors would like to acknowledge the financial support for this project from the Kansas Corn Commission and Monsanto.