MU DRAINAGE AND SUBIRRIGATION (MUDS) RESEARCH UPDATE

Kelly A. Nelson, Clinton G. Meinhardt, and Randall L. Smoot
University of Missouri Greenley Research Center, 660-739-4410, nelsonke@missouri.edu

Background:
Economic situations have caused several Missouri farmers to re-evaluate production systems that maximize yield and maintain environmental sustainability. Agricultural drainage is not a new concept; however, utilizing drainage as part of an integrated water management system (IWMS) is a relatively new concept that has been shown to improve water quality and sustain agricultural viability. Subsurface drainage water from agricultural lands contributes to the quantity and quality of water in receiving streams when properly implemented water management systems are adopted.

Upland, flat claypan soils commonly have a seasonal perched water table from November to May, which is caused by an impermeable underlying clay layer that restricts internal drainage. Research in other states has reported increased crop production using IWMS's that incorporate subsurface drainage and subirrigation. The MUDS research program was initiated to determine the suitability of claypan soils for drainage and a drainage/subirrigation (DSI) water-table management system, and to evaluate the effect of the systems on corn and soybean grain yield at different drain tile spacings compared to non-drained claypan soil.

Methods:
Subsurface drainage and DSI water-table management systems were installed in July, 2001. This research was arranged as a split-plot design with two main plots (drainage and drainage/subirrigation systems) and a factorial arrangement of sub-plots including a non-drained control and three drain tile spacings (20, 30, and 40 ft) and two crops (corn and soybean) with four replications. The corn and soybean plot size was 60 to 80 by 150 ft depending on the drain tile spacing. Soil was a Putnam silt loam with 10%, 75%, and 15% sand, silt, and clay, respectively. Field information and rainfall data are summarized in Tables 1 and 2, respectively. A delayed planting control was included in the design. Non-drained checks usually delay planting of drained treatments in research projects; therefore, two non-drained controls were included in the design to reduce the confounding effect of planting date on results. One is planted at the time the drained treatments are planted regardless of the soil conditions. The other is delayed based on typical soil conditions that are suitable for planting.

The DSI system was shifted into controlled drainage mode in June, 2002 and a temporary water supply system was implemented for subirrigation during the growing season. The water supply did not provide enough volume to substantially raise the water table; however, baseline data were established on the impact of subirrigation on production in 2002. These results have been similar to subsequent years and were included in the results. Soybean plots equipped with a water-table management system were not subirrigated in 2002. Subirrigation of soybean was initiated in 2003 and corn was subirrigated from 2004 to the present. Table 1 summarizes the subirrigation timing schedule while Table 2 summarizes the amount of water supplied through the subirrigation system on the 20 ft lateral spacing from 2004 to 2007. Water meters recorded the quantity of water supplied through the subirrigation system. This was converted to inch equivalents of rainfall.

Additional research was initiated in 2004 and 2005 to evaluate the use of slow-release nitrogen fertilizer (ESN, Agrium, Alberta, Canada) applied to corn to control nitrogen loss when there were differences in soil moisture conditions and drainage. Since there was no delay in early planted corn in 2002 and 2003, an overhead irrigation system was installed to replace this treatment. Corn was irrigated according to the Woodruff irrigation scheduling chart. The amount of water applied with the overhead irrigation system was reported in Table 2. Sub-plots included coated (ESN) and non-coated urea at 0, 125, and 250 lb N/a. Crop performance has been evaluated above and between drain tiles over the past seven years; however, data was not presented in this report.

Corn research in 2006 and 2007 compared the relative corn growth response and environmental N losses after application of different N fertilizer sources under a range of soil moisture conditions imposed by drainage and irrigation, and examined the spatial differences in soil N transformations and N losses during the growing season between drainage and subirrigation tile lines. Preplant injected anhydrous ammonia, urea ammonium nitrate, urea, or polymer coated urea applied at 150 lbs N/acre were incorporated following application.

The number of soybean cultivars evaluated were expanded to five in 2007 and 2008, while corn hybrid response was the primary focus in 2008 and will be repeated in 2009.

Results:
2002. Rainfall during the growing season was sufficient in some areas in Northeast Missouri and insufficient in others. Corn planting date was not delayed by wet conditions; however, the crop experienced excessive rainfall from Apr. 16 to May 13 (Table 2) and cool temperatures (data not presented). Rainfall was scattered and a total of 3.4 inches of rain was recorded from June 24 to August 24.

Corn grain yield for the non-treated control was 62 to 63 bu/acre (Table 3). Drainage only (DO) treatments increased corn grain yield 10 to 20 bu/acre depending on the drain tile spacing. The drainage/subirrigation treatment (DSI) with a 20 ft lateral spacing increased grain yield two fold compared to the non-drained control and was 10 bu/a greater than the DSI treatment with a 30 ft lateral spacing. Even though grain yield was doubled with the DSI system, the potential for the system was probably underestimated due to an inadequate water supply. Corn grain yield above the drain tile with subirrigation ranged from 150 to 165 bu/a depending on the treatment (data not presented).

Soybean was planted three days earlier in the subsurface drained compared to the non-drained, delayed planting control (Table 1). Soybean grain yield was 8 to 10 bu/a greater with subsurface drainage when compared to the non-drained and non-drained delayed planting treatments (Table 4).

2003. Rainfall was adequate until mid-August. Early planted corn was not delayed by wet conditions; however, the corn crop experienced excessive rainfall from mid-Apr. to mid-May (Table 2) and cool temperatures (data not presented). Rainfall was scattered and a total of 0.1 in. of rain was recorded from August 3 to August 25 with above average temperatures (data not presented).

Corn grain yield for the non-drained controls was 99 to 109 bu/acre in 2003 (Table 3) while drainage only increased corn grain yield 22 to 37 bu/acre depending on the drain tile spacing.

Soybean was planted two days earlier in subsurface drained treatments when compared with the non-drained control (Table 1). Soybean grain yield was 6 to 8 bu/a greater with subsurface drainage than the non-drained and non-drained delayed planting treatments (Table 4). Soybean grain yield was similar in the drained and subirrigated treatments. Late rains probably helped increase seed fill and test weight. An earlier subirrigation timing may be necessary to maximize soybean grain yields.

2004. In general, dryland corn and soybean grain yields were above average in Northeast Missouri. Rainfall was consistent throughout the spring and summer; however, excessive rainfall in the fall hindered harvest (Table 2). Harvesting during these conditions probably contributed to increased compaction. An additional 5.6 inches of water was recommended and applied according to the Woodruff chart during the season. However, only 0.33 inches of water were applied through the subirrigation system on the 20 ft drain tile spacing.

Drainage only increased corn grain yield up from 20 to 49 bu/acre depending on the N treatment, N rate, and drain tile spacing. All 20 ft drain tile spacings increased grain yield regardless of N rate or source when compared with the non-treated control. Corn grain yield was increased up to 36 bu/acre with DSI depending on the N source, N rate, and drain tile spacing. Drainage only or DSI increased grain yield up from 19 to 49 bu/acre when compared to overhead irrigation alone. Differences in corn grain yield response were probably related to denitrification differences due to N source and soil moisture differences among treatments.

Soybean planting date was delayed 17 days in the non-drained control compared to drained treatments due to wet soil conditions (Table 1). Soybean planted in the non-drained control at the same time drained treatments were planted had grain yields 12 bu/a greater than the delayed planting control (Table 3). Soybean grain yield was 12 to 27 bu/a greater with DO and DSI regardless of drain tile spacing when compared to the non-drained controls.

2005. Rainfall was below normal with a total of 11.6 inches throughout the growing season (Table 2). Less than 4 inches of rainfall was recorded from mid-June to early September. Variability between drainage tiles for the DSI treatment was evident in corn and soybean (visual observation). Twospotted spider mites (*Tetranychus urticae*) were widespread in non-irrigated treatments during the first week of August (Figure 3). The entire plot area was sprayed to minimize a possible confounding effect of insect feeding on soybean grain yield. A dry fall allowed for an efficient harvest and optimal weather for fall tillage.

The non-treated control corn grain yield was 28 to 40 bu/a (Table 3). Low rainfall, high air temperature, and wind during pollination of corn helped reduced grain yields (data not presented). Drainage only increased corn grain yield 1.7 to 2.8 fold when compared with the non-drained control. DSI increased grain yield from 3 to 5 times greater than the non-drained control. Finally, grain yield with overhead irrigation was 6 to 9 times greater than the non-drained control. The degree of impact of water management systems on corn grain yield was affected by N rate and source. Drought stress differences above and between the drainage tiles for the DSI system were evident and grain yields were quantified above and between the drainage tiles. Corn grain yield above the drain tile with subirrigation ranged from 160 to 190 bu/a depending on the drain tile spacing (data not presented).

There was no delay in soybean planting date due to wet soil conditions. Soybean yield increased 7 bu/a with drainage only on a 20 ft spacing compared with the non-drained control (Table 4). DSI increased grain yield 9 to 16 bu/a depending on the drain tile spacing. Soybean above the drain tiles in the drainage/subirrigation water management treatment matured earlier and had complete leaf senescence before soybean between the drain tiles and non-drained soybean.

2006. Precipitation following planting was limited, but sufficient for adequate germination and early growth (Table 2). Irrigation was needed in late June until the first week of August and again in late August. Overhead irrigation required over six times more water than subirrigation throughout the season. Another dry fall allowed timely harvest and tillage operations.

The corn hybrid was switched to 'DK C61-68' (Table 1). Dry conditions following pollination reduced grain yields of non-irrigated treatments. All of the water table management treatments responded to N applications regardless of N source in 2006 (Table 3). The non-drained control and drainage only treatments had similar grain yields which was probably due to a relatively dry spring. DSI on 20 ft lateral spacings increased yield 41 to 72 bu/acre when compared to the non-drained control with similar N sources. Subirrigated corn with ESN had grain yields similar to overhead irrigation. Crop response to the water-table management system was ranked overhead irrigation $\geq$ DSI $\geq$ drainage only = non-drained.

Soybean planting date was delayed 4 days for the non-drained control when compared with drained treatments (Table 1). Drainage only or DSI increased soybean yield 3 to 5 bu/acre when compared to the non-drained delayed planting control (Table 4). No differences in yield among drain tiles spacings were observed.

2007. Widespread spring rainfall delayed corn planting 5 days in the non-drained delayed planting control. Visual differences in soil surface drying were obvious (Figure 2). Irrigation was required in late June to mid-September. Supplemental water totaled 7.74 and 4.96 inches in the overhead and subirrigation systems, respectively (Table 2). Wet conditions early in the season caused poor rooting depth and drainage only treatments had grain yields that were 19 to 48 bu/acre greater than non-drained soil (Table 3). DSI increased grain yield 42 to 64 bu/acre when compared to the non-drained or non-drained delayed planting control. Overhead irrigation increased yield 24 to 55 bu/a greater than DSI. Differences in drain tile spacing were undetectable in 2007. Corn response to water management was overhead irrigation > DSI > drainage only > non-drained.

High yielding soybean cultivars were included in the experimental design in 2007. Soybean planting date was late and soil was moist in all treatments. Soybean response to drainage was ranked DSI > DO > non-drained (Table 4). Drainage only increased yield 7 to 10 bu/acre greater than the non-drained soil, while DSI increased yield 20 bu/a over the non-drained control. Soybean cultivar yield response differences were detected for DSI (Figure 1), but limited differences were observed among cultivars for the non-drained control, drainage only on a 20 ft spacing, and drainage only on a 40 ft spacing. There was a 13 to 20 bu/acre increase in average yield of Kruger 382, Asgrow 3602, and Morsoy 3636 on a 20 and 40 ft drain tile spacing, while average yield increased 8 to 13 bu/acre with Pioneer 93-M96 or NK S37-N4 on either drain tile spacing. Grain yield response differences to DSI were primarily related to the impact on yield above and 10 to 20 ft from the drain tile.

2008. Rainfall was extensive and intensive in 2008 (Table 2). Supplemental irrigation was required according to the Woodruff scheduling chart. However, rainfall generally followed irrigation events; therefore, supplemental irrigation was not beneficial in 2008. Corn hybrids were expanded to include Kruger 2114, LG 2642, Asgrow 785, DeKalb C61-73, and DeKalb C63-42. There was no interaction between water management system and hybrid; therefore, results were combined over hybrid (Table 3). Drainage at 20 or 40 ft spacings increased yield 21 and 25 bu/acre, respectively, when compared to the non-drained control. Corn response to water management systems was ranked drainage only $\geq$ overhead irrigation = DSI $\geq$ non-drained.

High yield soybean cultivars were included in the experimental design similar to 2007 (Table 1). Soybean planting date was extremely late due to wet conditions throughout the spring (Table 2). Data were averaged over cultivar since there was no interaction between cultivar and water management system (Table 4). Soybean response to water management systems was ranked DO = DSI $\geq$ the non-drained control. Drainage only increased grain yield 8 to 11 bu/acre when compared to non-drained soil. No difference between drain tile spacing was observed in 2008.

Summary:

- Drainage only increased average corn grain yields up to 15% while DSI has increased average yields up to 45% when compared with non-drained, non-irrigated soil (Table 3).

- Overhead irrigation increased grain yield 25% compared to subirrigated corn with 20 ft laterals when averaged over all N treatments from 2004 to 2008 (Table 3). However, applied water was on average 4 times greater for overhead irrigated corn compared with subirrigated corn on a 20 ft drain tile spacing from 2004 to 2007 (Table 2).

- Soybean planting date was delayed an average of 3 days for the non-drained control when compared with drained soils from 2002 to 2008 (Table 1).

- Soybean grain yield with DO has averaged up to 23% greater than the non-drained delayed planting controls (Table 4). Similarly, DSI had soybean grain yields up to 27% greater than the non-drained delayed planting controls.

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Table 1. Field information and selected management practices for corn and soybean from 2002 to 2008.

	2002	2003	2004	2005	2006	2007	2008
Corn							
Tillage	Nov. 12, 2001 chisel plowed; Apr. 5, 2002 field cultivated	No-till	Nov. 17, 2003 chisel plowed; Mar. 24, 2004 and Apr. 15, 2004 field cultivated	Mar. 13, 2005 disk-harrowed; Apr. 8, 2005 field cultivated	Nov. 10, 2005 chisel plowed; Mar. 2, 2006 disk-harrowed and Apr. 11, 2006 field cultivated	Nov. 22, 2006 chisel plowed, May 1 and May 2, 2007 field cultivated	May 2, 2008 Tilloll,
Row spacing (in.)	30	30	30	30	30	30	30
Planting date	Apr. 17	Apr. 12	Apr. 15	Apr. 8	Apr. 11	May 13	May 5
Delayed planting date	None	None	None	None	None	May 18	None
Hybrid(s)	'Pioneer 33P67'	'Pioneer 33P67'	'Pioneer 33P67'	'Pioneer 33P67'	'DeKalb C61-68'	'DeKalb C61-68'	'Kruger 2114, LG 2642, Asgrow 785, DeKalb C61-73, DeKalb C63-42'
Seeding rate (seeds/a)	30,000	31,000	32,000	34,000	33,000	33,000	32,000
Controlled drainage date(s)	June 15	June 10	July 1	June 1	June 15	June 15	July 17
Subirrigation date	July 19-Aug. 30[a]	——[b]	July 20-Aug. 25	June 1-Sep. 6	June 23-Aug. 30	June 28-Sep. 14	July 17-Sep. 10
Drainage mode	Sep. 1	Sep. 15	Sep. 25	Sep. 6	Aug. 30	Sep. 14	July 25-Aug. 4, Sep. 10
Harvest date	Sep. 15	Sep. 30	Nov. 12	Sep. 20	Sep. 8	Oct. 6	Nov. 4
Fertility	Fall, 2001 17-80-100 Apr. 17, 2002 200-0-0 Ammonium nitrate	Fall, 2002 17-80-100 Apr. 3, 2003 250-0-0 Anhydrous ammonia	Mar. 24, 2004 17-80-140-3 + 5 lb/a Zn Apr. 15, 2004 125-0-0 urea or ESN 250-0-0 urea or ESN	Mar. 17, 2005 12-60-120 Apr. 8, 2005 125-0-0 urea or ESN 250-0-0 urea or ESN	Apr. 11, 2006 150-0-0 urea, ESN, urea ammonium nitrate, or anhydrous ammonia	May 1, 2007 22-104-300 150-0-0 urea, ESN, urea ammonium nitrate, or anhydrous ammonia	May 1, 2007 180-0-0 anhydrous ammonia, Nov. 26, 2008 30-80-160
Weed management							
Timing, date	Preemergence, Apr. 19	Preemergence, Apr. 12	Early postemergence, Apr. 27	Early postemergence, May 6	Early postemergence, May 15	Early POST, May 19	Early POST, May 29
Herbicide	Bicep II Magnum + Princep + 2,4-D ester	Guardsman MAX + Princep + Touchdown + Quest	Lumax	Lumax + NIS	Lumax + NIS	Roundup WeatherMAX + AMS	Roundup PowerMAX + Lumax + AMS
Rates	2.6 qt/a + 1 qt/a + ½ pt/a	2 qt/a + 1 qt/a + 1 pt/a + ½ pt/a	3 qt/a	3 qt/a + 0.25% v/v	3 qt/a + 0.25% v/v	22 oz/a + 17 lb/100 gal	22 oz/a + 3 qt/a + 17 lb/100 gal
Timing, date		POST, June 5				POST, June 11	
Herbicide		Callisto + atrazine + COC + AMS				Bicep II Magnum + Roundup OriginalMAX + AMS	
Rates		3 oz/a + 8 oz + 1% v/v + 2 lb/a				2.5 qt/a + 22 oz/a + 17 lb/100 gal	
Insect management	Kernel guard	Gaucho seed treatment	Poncho 250 seed treatment	Poncho 250 seed treatment; Warrior 3.8 oz/a, May 6	Poncho 250 seed treatment; Warrior 3.8 oz/a, May 15	Poncho 250 seed treatment, Warrior 2.2 oz/a, May 11; Perm up 6	Poncho 250 seed treatment
Disease management						Headline 6 oz/a, July 17	
pHs	6.5 ± 0.5	6.8 ± 0.3	6.7 ± 0.1	6.9 ± 0.2	6.6 ± 0.1	6.9 ± 0.1	
SOM (%)	2.6 ± 0.2	1.9 ± 0.1	2.1 ± 0.1	2.7 ± 0.1	1.8 ± 0.1	1.9 ± 0.1	

Table 1 con't.

Soybean							
Tillage	November 12, 2001 chisel plowed Apr. 5, 2002 field cultivated	No-till	No-till	No-till	No-till	No-till	No-till
Row spacing (in.)	7.5	7.5	7.5	7.5	7.5	15	15
Planting date	May 30	May 27	May 21	May 2	May 11	May 23	June 16
Delayed planting date	June 2	May 29	June 4	May 2	May 15	May 23	June 16
Cultivar	Pioneer 93B85	Kruger 401RR/SCN	Kruger 380RR/SCN	Kruger 380RR/SCN	Kruger 380RR/SCN	Asgrow 3602, Kruger 382, Pioneer 93M96, NK S37-N4, Morsoy3636	Asgrow 3602, Kruger 382, Pioneer 93M96, NK S37-N4, Morsoy3636
Seeding rate (seeds/a)	180,000	200,000	200,000	200,000	200,000	200,000	200,000
Controlled drainage date(s)	June 20	June 25	July 1	June 1	June 15	June 15	July 17
Subirrigation date	——[b]	Aug. 21	July 20-Aug. 25	June 1-Sep. 6	June 23-Sep. 30	June 28-Oct. 1	July17-Sep. 15
Drainage mode	Oct. 4	Sep. 15	Sep. 25	Sep. 15	Sep. 19	Oct. 1	July 25-Aug. 4, Sep. 15
Harvest date	Oct. 9	Oct. 8	Oct. 17	Oct. 10	Oct. 3	Oct. 30	Oct. 30
Fertility	Fall, 2001 17-80-100	Fall, 2002 17-80-100	Mar. 24, 2004 17-80-140-3 & 5 lb/a Zn	Mar. 17, 2005 12-60-120	NA	May 1, 2007 22-104-300	Nov. 26, 2008 30-80-160
Weed management							
Timing, date	Burndown, June 7	Burndown, June 20	Burndown, May 3	Early Postemergence, June 1	Burndown, May 15	Burndown, May 18	Burndown, May 28
Herbicide	Roundup UltraMAX + AMS	Roundup WeatherMAX + AMS	Roundup WeatherMAX + AMS	Roundup WeatherMAX + AMS	Roundup WeatherMAX + AMS	Roundup WeatherMAX + AMS	Roundup PowerMAX + Dual II Magnum
Rates	26 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100gal	32 oz/a + 1.66 pt/a
Timing, date	Postemergence, July 5	Postemergence, July 9	Postemergence, July 26	Postemergnce, July 11	POST, June 27	EPOST, June 11 LPOST, July 17	POST, July 17 LPOST, Aug. 26
Herbicide	Roundup UltraMAX + AMS	Roundup WeatherMAX + AMS + DriftGuard	Roundup WeatherMAX + AMS + DriftGuard + Headline	Roundup WeatherMAX + AMS + DriftGuard + Quadris	Roundup WeatherMAX + AMS	Roundup OriginalMAX	POST: Roundup PowerMAX + AMS + FirstRate + NIS, LPOST: Roundup PowerMAX
Rates	26 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal + 2 oz/100 gal	22 oz/a + 17 lb/100 gal + 2 oz/100 gal + 6 oz/a	22 oz/a + 17 lb/100 gal + 2 oz/100 gal + 6 oz/a	22 oz/a + 17 lb/100 gal	22 oz/a + 17 lb/100 gal AMS	32 oz/a + 17 lb/100 gal + 0.3 oz/a, 22 oz/a
Insect management	None	None	None	Warrior at 2.5 oz/a, July 11 Lorsban at 1 pt/a, Aug. 9	Warrior at 2.6 oz/a, June 27	Warrior at 2.2 oz/a, June 11; Permup 6 oz/a, July 17	Warrior at 2 oz/a, Aug. 26
Disease management					Headline 6 oz/a, June 27	Headline 7 oz/a, July 17	Quadris 6 oz/a Aug 26
pHs	6.5 ± 0.5	6.7 ± 0.2	6.7 ± 0.2	6.8 ± 0.1	6.5 ± 0.1	7.0 ± 0.1	
SOM (%)	2.6 ± 0.2	2.0 ± 0.1	2.2 ± 0.2	2.7 ± 0.2	2.0 ± 0.1	1.8 ± 0.1	

[a]The water supply provided approximately 1500 gallon/replication/day. This did not provide enough volume to substantially raise the water table; however, preliminary data was established on the impact of subirrigation on corn production in 2002.

[b]Treatments were not included.

Table 2. MUDS annual rainfall, overhead irrigation, and subirrigation totals for 2002 to 2008.

	2002	2003	2004			2005			2006			2007			2008	
Time period	Precip.[a]	Precip.	Precip.	OhIrr.	SubIrr.[b]	Precip.	OhIrr.	SubIrr.	Precip.	OhIrr.	SubIrr.	Precip.	OhIrr.	SubIrr.	Precip.	OhIrr.
								Inches								
January	0.65	0.29	1.14	0	0	2.74	0	0	2.11	0	0	0.83	0	0	0.78	
February	2.08	0.88	0.38	0	0	2.15	0	0	0.09	0	0	2.68	0	0	3.90	
Mar.	0.96	1.27	1.94	0	0	1.21	0	0	2.83	0	0	4.87	0	0	3.08	
Apr 1 to Apr 15	1.25	1.73	0.48	0	0	1.17	0	0	0.69	0	0	2.19	0	0	2.47	
Apr 16 to Apr 29	5.01	3.65	1.81	0	0	0.71	0	0	0.06	0	0	1.98	0	0	2.11	
Apr 30 to May 13	7.93	3.67	0.85	0	0	1.45	0	0	2.20	0	0	2.68	0	0	2.43	
May 14 to May 27	2.01	0.72	1.81	0	0	0.36	0	0	0	0	0	0.20	0	0	1.19	
May 28 to June 10	1.07	2.38	2.92	0	0	2.85	0.6	0	2.22	0	0	1.90	0	0	3.31	
June 11 to June 24	3.59	0.06	0.91	0	0	0.70	1.1	0.23	1.64	0	0	0.60	0	0	1.94	
June 25 to July 8	0.27	1.63	1.42	0	0	0.12	2.4	0.17	0.97	3	0.12	0.83	1.20	0.97	6.35	
July 9 to July 22	0.79	2.00	0.59	0.6	0.25	0.12	2.3	0.15	1.23	1	0.01	0.60	0.60	1.26	1.32	0.51
July 23 to Aug 5	1.17	1.76	2.88	3.9	0.06	1.80	3.3	0.65	0.56	2.27	0.25	0.72	2.47	0.69	7.23	
Aug 6 to Aug 19	1.16	0.13	0.48	1.1	0.01	0.83	2.2	0.18	3.85	0	0.66	1.72	1.77	0.61	0.87	2.94
Aug 20 to Sep. 2	2.11	5.04	7.56	0	0.01	0.00	0	0.03	1.42	1.30	0.16	2.05	0.84	1.20	3.13	0.80
Sep. 3 to Sep. 16	0.11	3.04	0.42	0	0.01	1.03	0	0	0.38	0	0	0	0.86	0.23	8.77	
Sep. 17 to Sep. 30	0.81	3.08	0.23	0	0	0.47	0	0	0.28	0	0	0	0	0	0.5	
Total irrigation				5.6	0.33		11.9	1.41		7.57	1.20		7.74	4.96		4.25

[a]Abbreviations: OhIrr., Overhead Irrigation; Precip. Precipitation; and SubIrr., Subirrigation.
[b]Subirrigation water use was reported for the 20 ft drainage/subirrigated drain tile spacing for corn.

Table 3. Corn grain yield for the non-drained, drainage only, and drainage/subirrigation water-table management treatments at 20, 30, and 40 ft lateral spacings from 2002 to 2008.[a]

Year	N source	N rate	Non-drained	Non-drained delayed planting	Non-drained overhead irrigated	Drainage only 20 ft	Drainage only 40 ft	Drainage/subirrigation 20 ft	Drainage/subirrigation 40 ft	LSD ($p \leq 0.05$)
		lbs/acre	bu/a							
2002	AN[b]	200	63	62	——[c]	81	79	120[d]	104[d]	12
2003	AA	250	99	109	——	131	136	——	——	20
2004	Non-treated	0	97	——	83	129	115	115	63	26
	Urea	125	168	——	197	208	207	198	194	27
		250	182	——	197	215	197	216	200	13
	ESN[e]	125	181	——	197	211	214	217	205	19
		250	201	——	189	221	209	218	212	19
2005	Non-treated	0	39	——	98	66	74	72	59	23
	Urea	125	38	——	240	74	66	113	115	25
		250	28	——	263	77	61	147	126	32
	ESN	125	40	——	236	66	71	125	117	30
		250	31	——	263	52	59	139	132	26
2006	Non-treated	0	85	——	114	93	88	102	91	25
	AA	150	138	——	240	136	137	179	168	37
	ESN	150	131	——	241	139	143	203	182	40
	Urea	150	129	——	237	142	135	198	184	39
	UAN	150	123	——	227	142	137	175	171	35
2007	Non-treated	0	69	73	107	110	105	112	93	25
	AA	150	112	113	216	144	151	164	163	21
	ESN	150	116	110	220	136	152	172	167	28
	Urea	150	107	104	201	143	141	168	160	20
	UAN	150	102	98	176	136	143	152	144	18
2008[f]	AA	180	166		174	187	191	172	186	19
Average[g]			118		217	136	139	171	164	

[a]Comparisons within rows are valid.
[b]Abbreviations: AA, anhydrous ammonia; AN, ammonium nitrate; and UAN, 32% urea ammonium nitrate.
[c]Treatments were not included.
[d]The water supply provided approximately 1500 gallon/replication/day. This did not provide enough volume to substantially raise the water table; however, baseline data was established on the impact of subirrigation on corn production in 2002.
[e]Polymer coated urea (Agrium, Calgary, Alberta, Canada).
[f]Grain yield was averaged over hybrid (Kruger 2114 RR/YGCB, LG 2642BtRR, Asgrow 785 VT3, DKC 61-73, and DKC 63-42.
[g]Calculated as the average yield for ESN at 250 lb/a in 2004 and 2005, and ESN at 150 lb/a in 2006 and 2007.

Table 4. Soybean grain yield for non-drained, drainage only, and drainage/subirrigation water-table management treatments at 20, 30, and 40 ft lateral spacings from 2002 to 2008.

Water-table management	2002	2003	2004	2005	2006	2007[a]	2008[b]	Average[c]
Non-drained	36	40	57	38	63	41	37	46
Non-drained delayed planting[d]	36	42	45	38	61	40	35	44
Drainage only								
20 ft lateral spacing	45	48	71	45	66	50	45	54
30 ft lateral spacing	43	47	70	39	65	——	——	
40 ft lateral spacing	46	48	72	41	66	48	46	54
Drainage/subirrigation								
20 ft lateral spacing	——[e]	46	72	54	65	61	39	56
30 ft lateral spacing	——	48	69	47	64	——	——	
40 ft lateral spacing	——	47	69	51	66	60	40	56
LSD ($p \leq 0.05$)	— 3 —	— 3 —	— 3 —	— 5 —	— 3 —	— 6 —	— 7 —	

[a]Soybean cultivar was Kruger 382.
[b]Soybean yield was averaged over Kruger 382, Pioneer 93M96, NK S37-N4, Asgrow 3602, and Morsoy 3636N.
[c]Calculated as the average yield for 2003-2008.
[d]The planting date was delayed 3, 2, 14, 0, 4, 0, and 0 days after the drainage only and drainage/subirrigation treatments in 2002, 2003, 2004, 2005, 2006, 2007 and 2008, respectively.
[e]Treatments were not included.

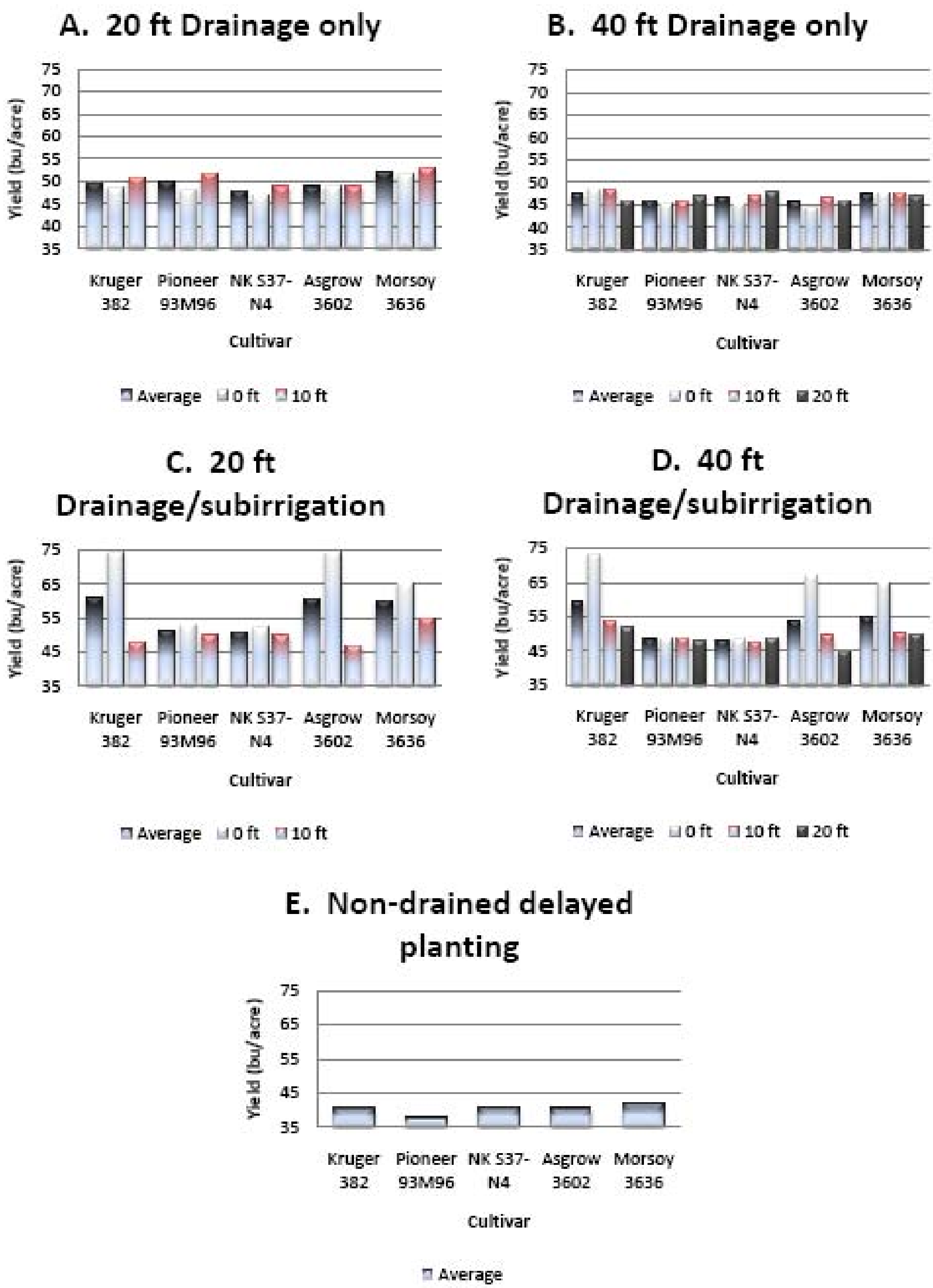

Figure 1. Soybean cultivar response to drainage (A, B), subirrigation (C, D), and no drainage (E) in 2007. Drain tile spacing was represented as feet from the drain tile. The average yield for drain tile spacings was reported. The least significant difference (LSD at P=0.05) was 6.