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Mobile Drip Irrigation for Water Limited Crop Production: Initial Results

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Mobile Drip Irrigation for Water Limited Crop Production: Initial Results

Abstract

The farmers within the Ogallala aquifer desire to extend the usable life of this aquifer despite experiencing diminishing well capacities, thus the quest for more efficient irrigation application technologies. Mobile drip irrigation (MDI), which integrates drip lines onto a mechanical irrigation system such as a center pivot, has attracted their attention lately. The concept is that by applying water along crop rows, it was hypothesized that MDI could eliminate water losses due to spray droplet evaporation, wind drift, and reduce soil evaporation due to limited surface wetting especially before canopy closure. A study was conducted with the following objectives: 1) compare soil water evaporation under MDI and in-canopy spray nozzles (low elevation spray application (LESA)); 2) evaluate soil water redistribution under MDI at 60-inch drip line lateral spacing; and 3) compare corn grain yield, and water productivity under MDI and LESA at two well capacities (300 and 600 gpm). The experimental design was randomized complete block with four replications and two treatments (MDI and LESA). Nozzle performance was evaluated using the Spot-on flow measurement device. Soil water evaporation was measured using 4-inch mini-lysimeters placed between corn rows. The effect of a 60-inch lateral spacing on soil water redistribution was measured using neutron attenuation to a depth of 8 feet. Corn yield was determined from harvesting two 40-foot corn rows in the center of each plot. Measured and design nozzle flow rates were similar indicating the irrigation system was performing as designed. Results indicate that soil water evaporation was lower under MDI compared to LESA by an average of 35%. Soil water was greatest at the mid-point between two drip line laterals spaced 60 inches apart at a depth of approximately 20–24 inches. These results indicate drip line spacing of 60 inches is adequate for silt loam soils of southwest Kansas. The effect of irrigation application method (MDI versus spray nozzles [LESA]) on yield at high (600 gpm) and low (300 gpm) well capacities was not statistically significant at the 5% level ($P > 0.05$). The effect of application method on water productivity and irrigation water use efficiency was also not significant. The lack of significant differences in yield could be attributed to the above normal rainfall received during the 2015 growing season (18 inches from May to September). However, it is worth noting that the effect of application method on end-of-season soil water was statistically significant under low well capacity (300 gpm) with mobile drip irrigation having more soil water compared to spray nozzles.

Keywords

mobile drip irrigation, MDI, center pivot, crop, irrigation

Mobile Drip Irrigation for Water Limited Crop Production: Initial Results

J. Aguilar, T. Oker, and I. Kisekka

Summary

The farmers within the Ogallala aquifer desire to extend the usable life of this aquifer despite experiencing diminishing well capacities, thus the quest for more efficient irrigation application technologies. Mobile drip irrigation (MDI), which integrates drip lines onto a mechanical irrigation system such as a center pivot, has attracted their attention lately. The concept is that by applying water along crop rows, it was hypothesized that MDI could eliminate water losses due to spray droplet evaporation, wind drift, and reduce soil evaporation due to limited surface wetting especially before canopy closure. A study was conducted with the following objectives: 1) compare soil water evaporation under MDI and in-canopy spray nozzles (low elevation spray application (LESA)); 2) evaluate soil water redistribution under MDI at 60-inch drip line lateral spacing; and 3) compare corn grain yield, and water productivity under MDI and LESA at two well capacities (300 and 600 gpm). The experimental design was randomized complete block with four replications and two treatments (MDI and LESA). Nozzle performance was evaluated using the Spot-on flow measurement device. Soil water evaporation was measured using 4-inch mini-lysimeters placed between corn rows. The effect of a 60-inch lateral spacing on soil water redistribution was measured using neutron attenuation to a depth of 8 feet. Corn yield was determined from harvesting two 40-foot corn rows in the center of each plot. Measured and design nozzle flow rates were similar indicating the irrigation system was performing as designed. Results indicate that soil water evaporation was lower under MDI compared to LESA by an average of 35%. Soil water was greatest at the mid-point between two drip line laterals spaced 60 inches apart at a depth of approximately 20–24 inches. These results indicate drip line spacing of 60 inches is adequate for silt loam soils of southwest Kansas. The effect of irrigation application method (MDI versus spray nozzles [LESA]) on yield at high (600 gpm) and low (300 gpm) well capacities was not statistically significant at the 5% level ($P > 0.05$). The effect of application method on water productivity and irrigation water use efficiency was also not significant. The lack of significant differences in yield could be attributed to the above normal rainfall received during the 2015 growing season (18 inches from May to September). However, it is worth noting that the effect of application method on end-of-season soil water was statistically significant under low well capacity (300 gpm) with mobile drip irrigation having more soil water compared to spray nozzles.

Introduction

Economies of many rural communities in the Central Plains rely heavily on irrigated agriculture. Diminishing well capacities coupled with the desire to extend the usable life of the Ogallala aquifer have stimulated the quest for efficient irrigation application technologies. Mobile drip irrigation (MDI) which integrates drip line onto a mechanical irrigation system such as a center pivot has attracted attention lately. The concept is not new but with some tweaks from the previous design and the affordability of new materials (e.g. pressure compensating emitters on the drip line), MDI is back in the market. By applying water along crop rows, it hypothesized that MDI could eliminate water losses due to spray droplet evaporation, wind drift, and reduce soil evaporation due to limited surface wetting especially before canopy closure. However, there were questions raised, particularly during the 2015 Southwest Research-Extension Center Advisory Committee meeting in Garden City, KS, about the use of MDI as it relates to ease of conversion, effect of friction on longevity of the dripline, emitter clogging, rodent damage, and agrochemical application. The SWREC Advisory Committee is composed of crop consultants, one farmer from every county in southwest Kansas, and agriculture and natural resource county extension agents in southwest Kansas. This group was very supportive of testing this technology side by side with existing older technology.

Experimental Procedures

The experimental design was randomized complete block with four replications (each center pivot span was a replication having MDI and LESA [spray nozzles]). Mobile drip irrigation and in-canopy spray nozzles were compared at high (600 gpm) and low (300 gpm) well capacities to mimic a range of pumping capacities experienced by producers (Figure 1). Nozzle performance was evaluated using the Spot-on device (Figure 2). By applying water along crop rows, it was hypothesized that MDI could reduce soil water evaporation due to reduced surface wetting. Soil water evaporation was measured using 4-inch mini-lysimeters placed between corn rows (Figure 3) in the MDI and LESA research plots. The effect of a 60-inch lateral spacing on soil water redistribution was measured using neutron attenuation to a depth of 8 feet in a transect of five neutron probe access tubes (Figure 4). Corn yield was determined from harvesting two 40-foot corn rows in the center of each plot. Seasonal crop water use was determined from a soil water balance and used in calculating water use efficiency (WUE, also known as water productivity).

Results and Discussion

Measured mean flow rate, $\bar{q}$, for MDI was 1.03±0.08 m^3/s, which is equivalent to the manufacturer's value (3.7 L/h), indicating that the driplines were functioning as designed. The uniformity coefficient, *UC*, of MDI was 93.8%. The uniformity coefficient, CU_H, for LESA was 83.8%, which was less than that of MDI by 8.9%. Measured and design nozzle flow rates for each span are shown in Table 2, which generally implies the system was uniformly applying water and was performing according to design.

Results indicate that soil water evaporation was lower under MDI compared to LESA on average by 35% (Figure 5). Soil water was greatest at the mid-point between two drip line laterals spaced 60 inches apart at a depth of approximately 20–24 inches (Figure 6).

These results indicate that drip line spacing of 60 inches is adequate for silt loam soils of southwest Kansas. The effect of irrigation application method (MDI versus spray nozzles [LESA]) on yield at a high (600 gpm) and low (300 gpm) well capacities was not statistically significant at the 5% level (Figures 8 and 10). For the 600 and 300 gpm studies, the *P*-values were P = 0.37 and 0.67, respectively. The effect of application method on water productivity and irrigation water use efficiency was also not significant at high and low well capacities (Figures 9 and 11). The lack of significant differences in yield could be attributed to the high rainfall received during the 2015 growing season (18 inches from May to September). Figure 7 shows the 2015 growing season rainfall in comparison to long-term averages. However, it is worth noting that the effect of application method on end-of-season soil water was statistically significant under low well capacity (300 gpm). Plots with mobile drip irrigation have more end-season soil water compared to spray nozzles (Figure 13).

Based on the initial two years of data, it appears that there is lower soil water evaporation under MDI compared to LESA (in-canopy spray nozzles). The spacing of 60 inches also appears adequate for MDI on silt loam soils. Results have shown that there is no significant difference in yield during the two years of corn growing seasons. Accordingly, there was no significant difference in water productivity and irrigation water use efficiency at the same well capacity between the application technologies, but water use efficiency (WUE) was higher at low well capacity (300 gpm) compared to WUE at 600 gpm. It was interesting to note that the end-of-season soil water was significantly higher under MDI for low well capacity (300 gpm) for 2015, but this was not evident in 2016.

Table 1. Measured and design spray nozzle flow rates for selected nozzles in span 1 at the Kansas State University Southwest Research-Extension Center, near Garden City, KS

No.	Span	Sprinkler	Design value	Measured value 07/09/2015	Measured value 06/30/2015	Mean
			gpm	gpm	gpm	gpm
1	1	3	0.57	0.56	0.53	0.55
2	1	5	0.68	0.66	0.64	0.65
3	1	6	0.68	0.65	0.64	0.65
4	1	8	0.68	0.77	0.72	0.75

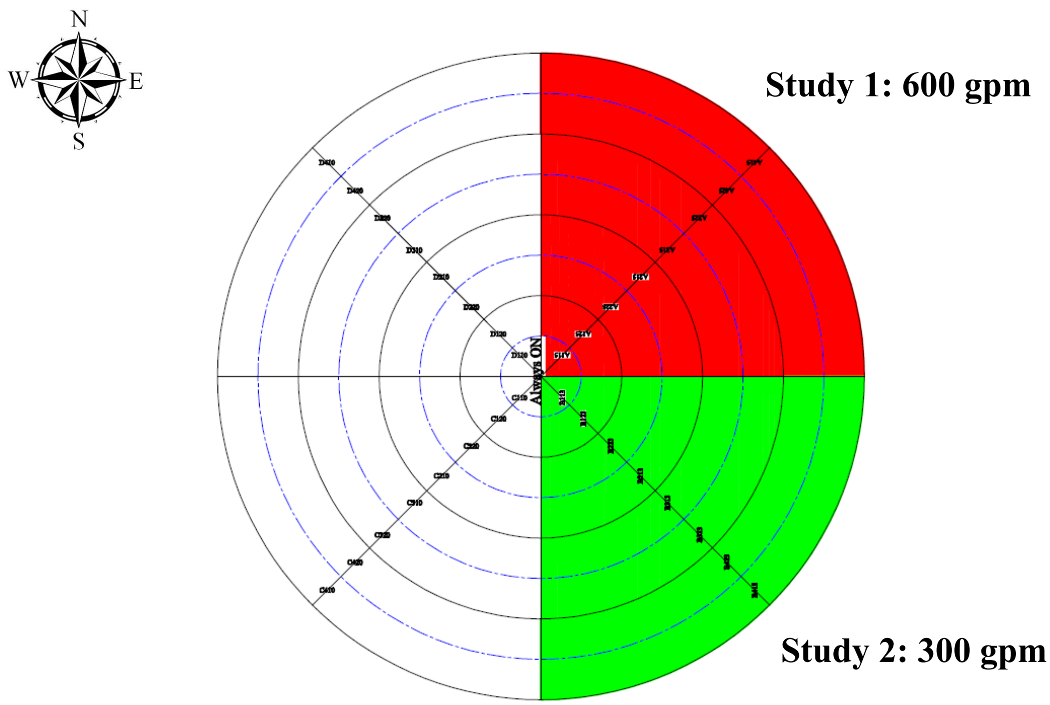

Figure 1. Experimental layout of two studies comparing mobile drip irrigation (MDI) and in-canopy spray nozzles at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

Figure 2. Measuring spray nozzle flow rate using a Spot-on device to compare with design flow rates at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

Figure 3. Measuring soil water evaporation using mini-lysimeter under spray nozzles and mobile drip irrigation at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

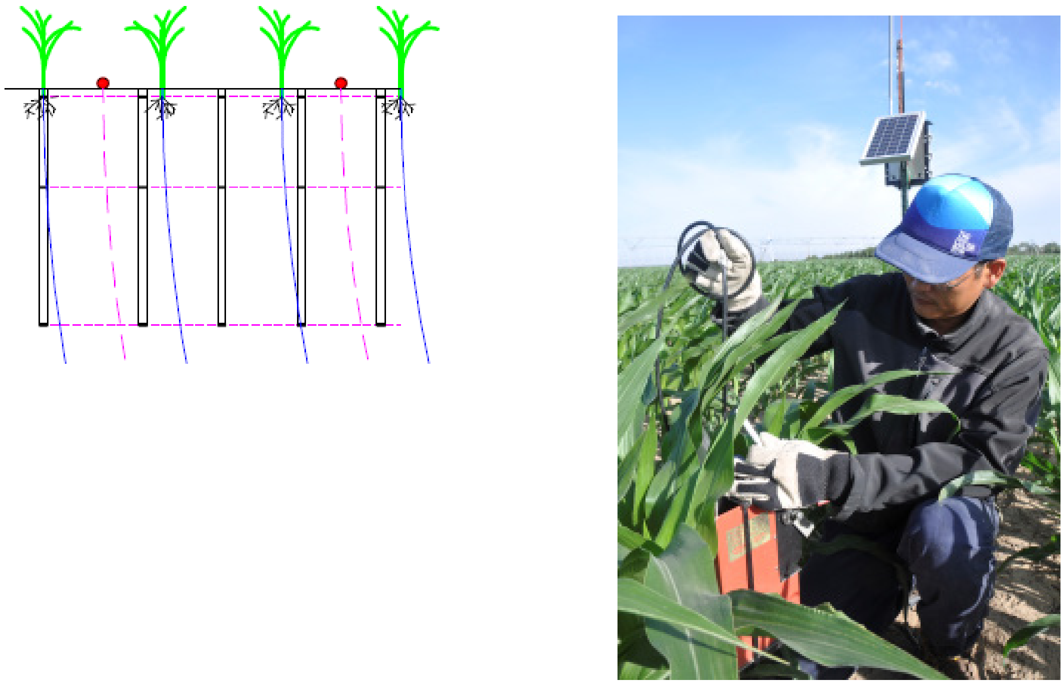

Figure 4. Soil water measurement using a neutron probe to determine soil water redistribution and crop water use at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

Figure 5. Shelling corn to determine yield at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

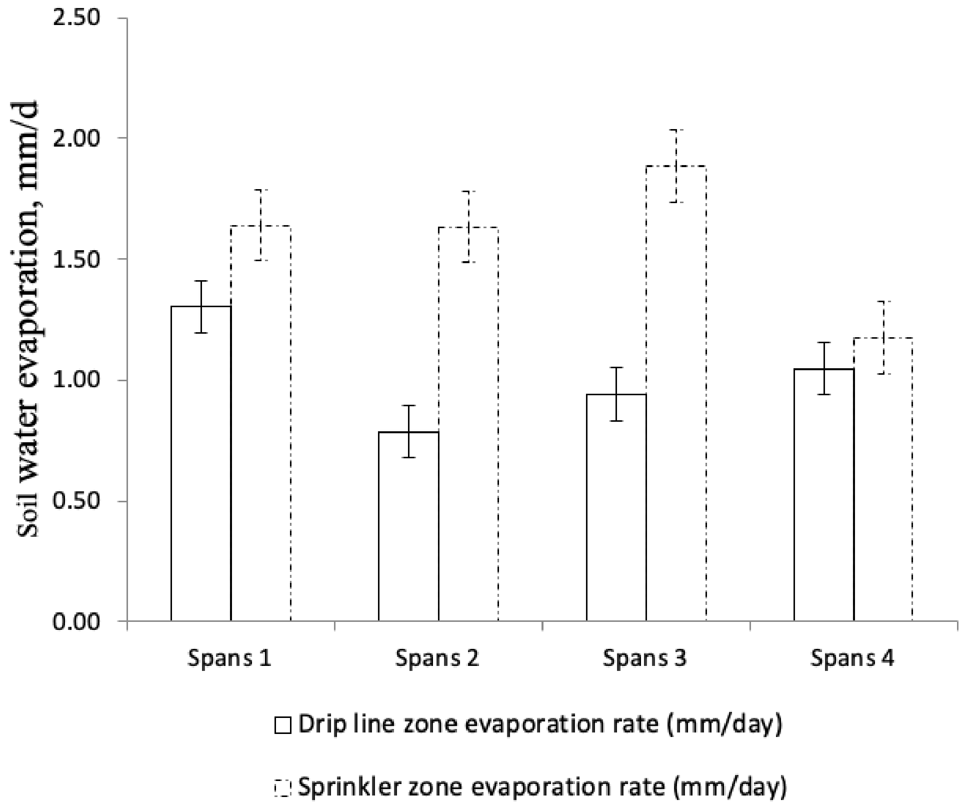

Figure 6. Comparing soil water evaporation under MDI and spray nozzles during the 2015 corn growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

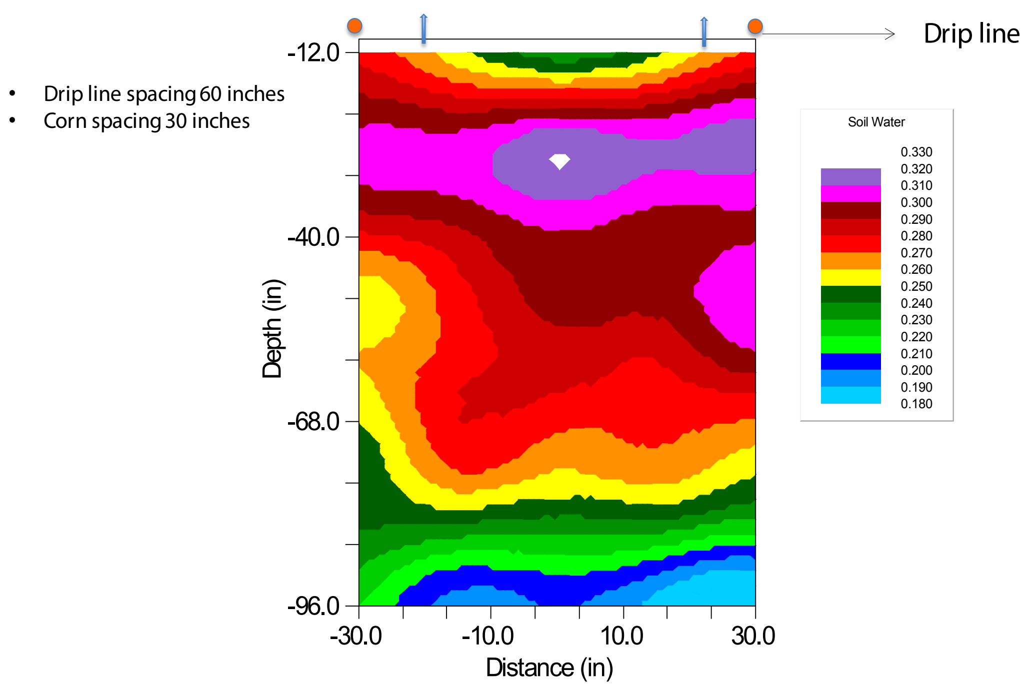

Figure 7. Soil water at different points within the root zone under mobile drip irrigation, drip line lateral spacing is 60 inches, data are from transect of five neutron probes access tubes and surface created using Kriging.

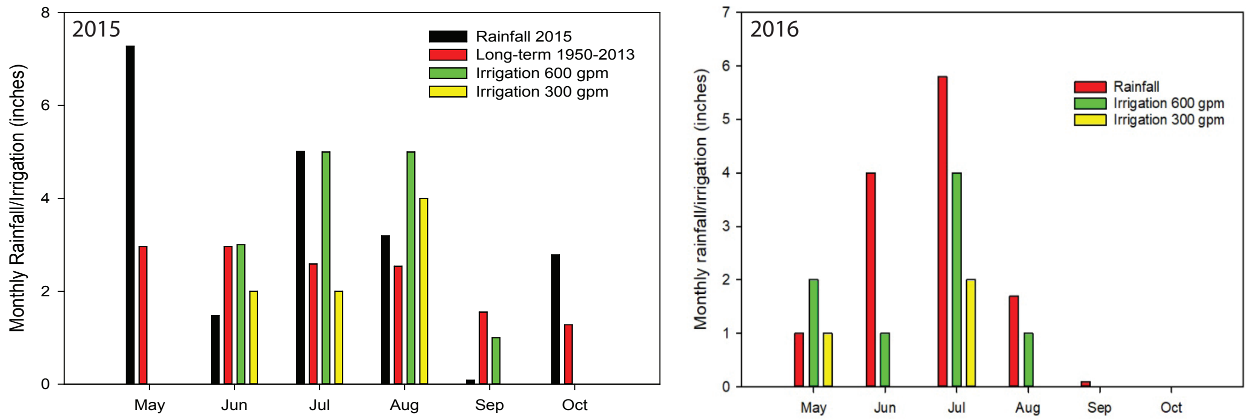

Figure 8. Growing season (May to September) rainfall, long term average, monthly irrigation applications for the 300 and 600 gpm studies at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

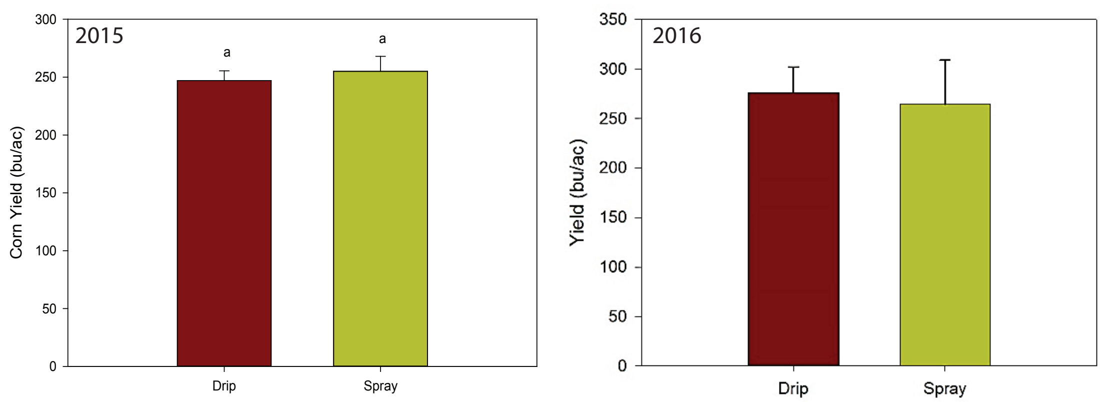

Figure 9. Corn grain yield under mobile drip irrigation and spray nozzles for well capacity of 600 gpm during the 2015 and 2016 growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

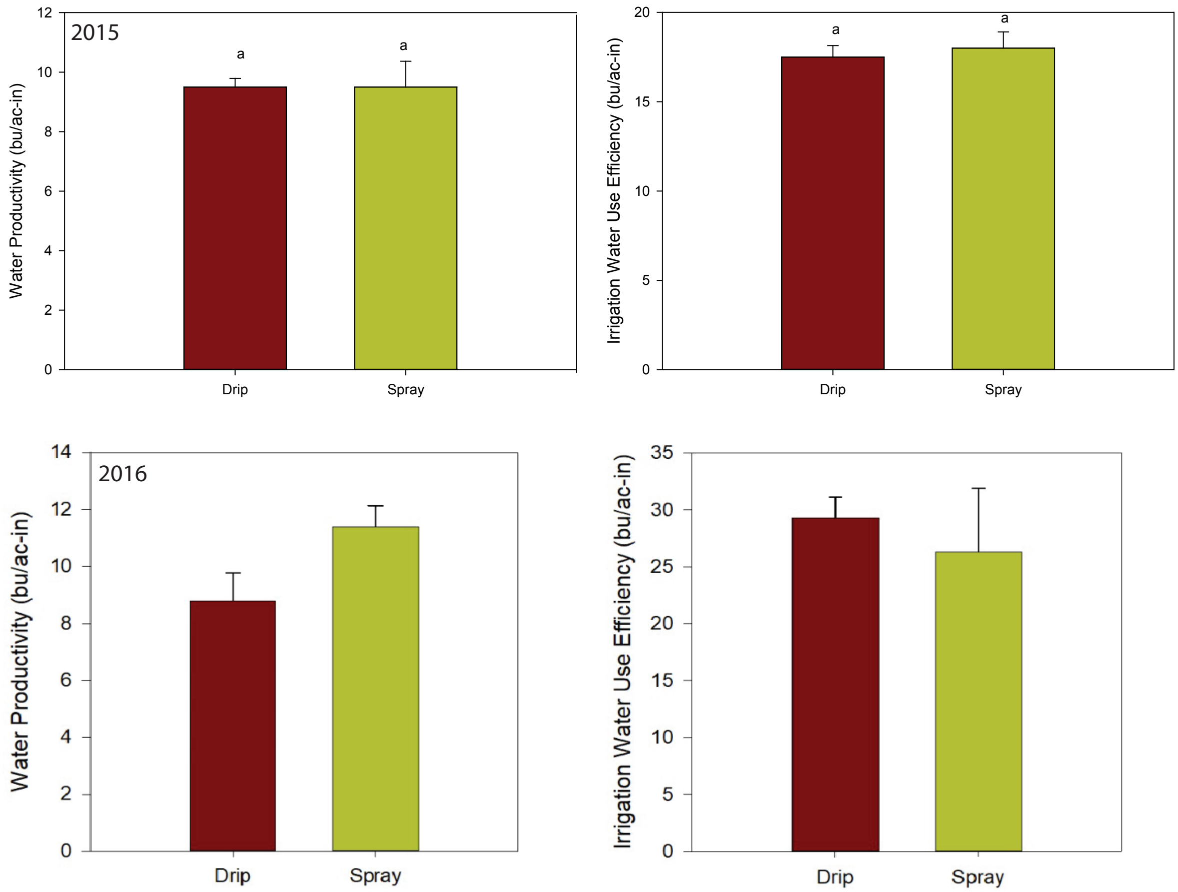

Figure 10. Water productivity and irrigation water use efficiency of mobile drip irrigation and spray nozzles for well capacity of 600 gpm during the 2015 and 2016 growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

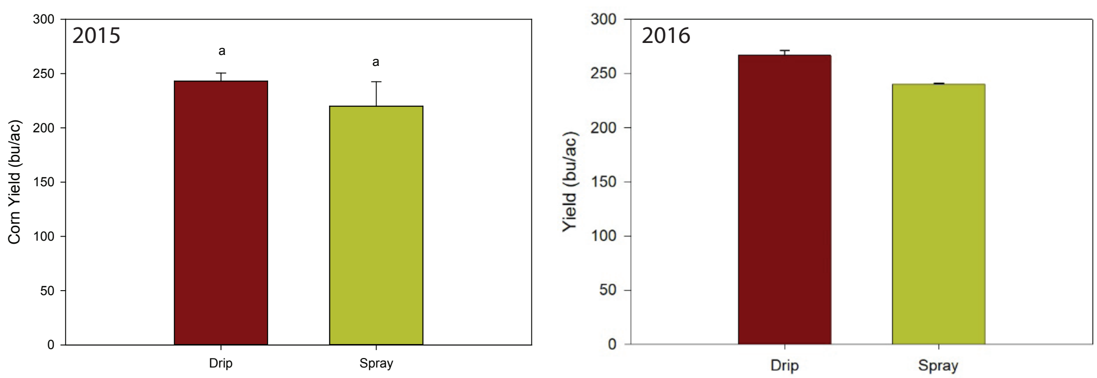

Figure 11. Corn grain yield under mobile drip irrigation and spray nozzles for well capacity of 300 gpm during the 2015 and 2016 growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

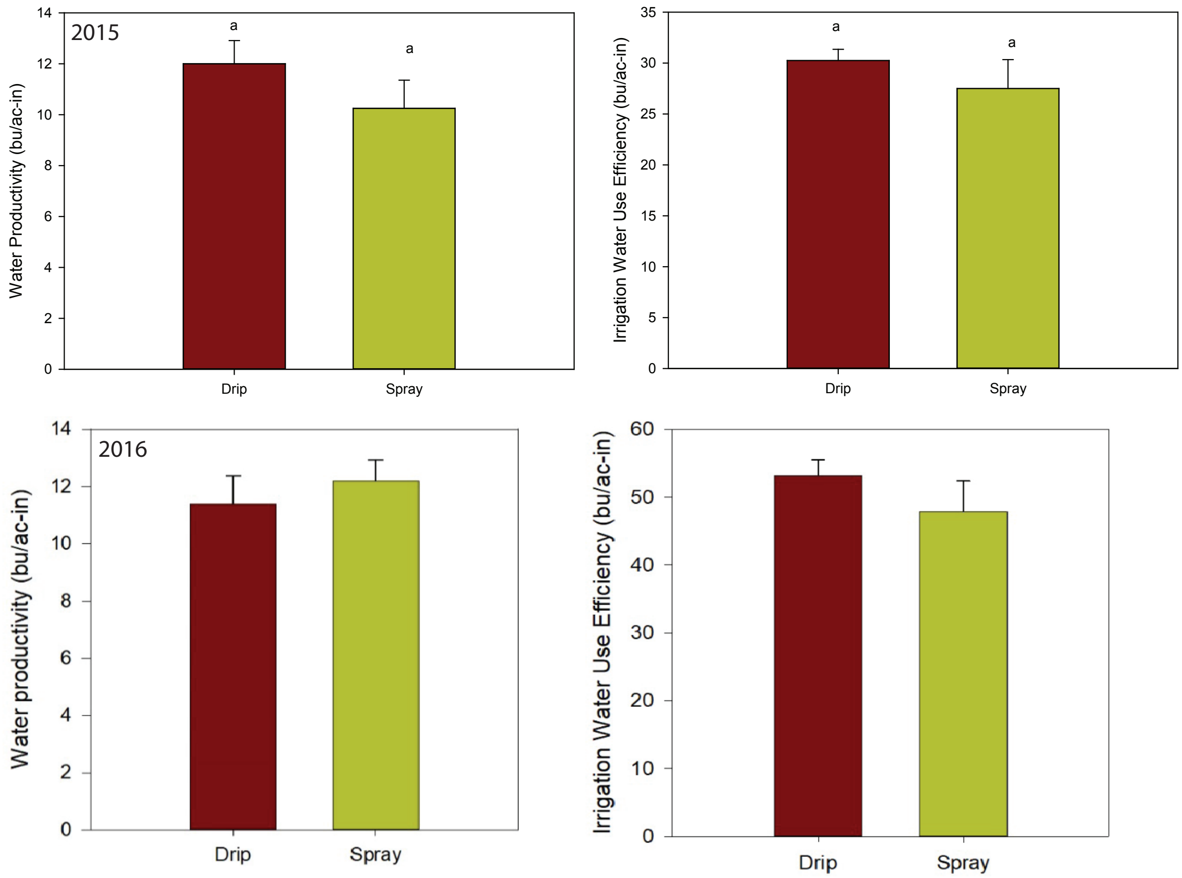

Figure 12. Water productivity and irrigation water use efficiency of mobile drip irrigation and spray nozzles for well capacity of 600 gpm during the 2015 and 2016 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

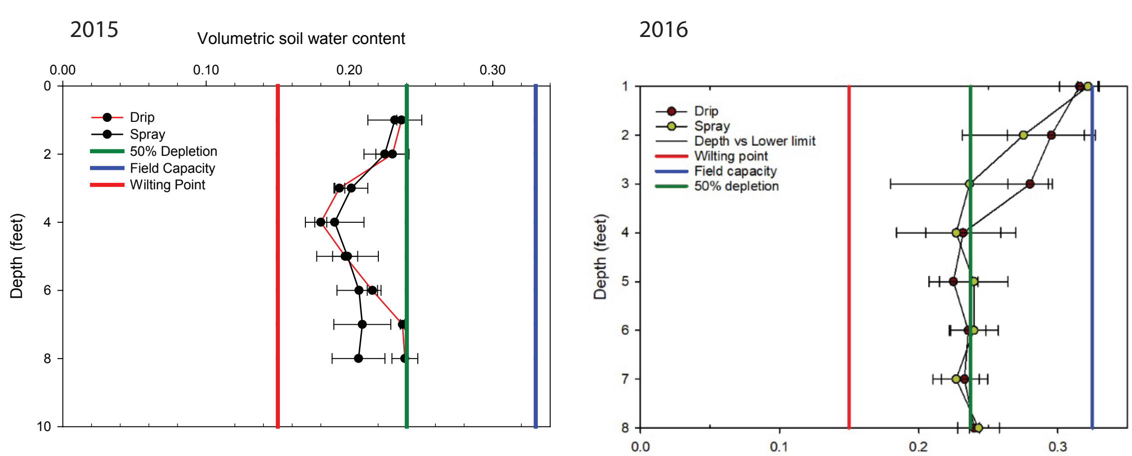

Figure 13. End-of-season soil water measurements under mobile drip irrigation and spray nozzles for well capacity of 600 gpm during the 2015 and 2016 growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.

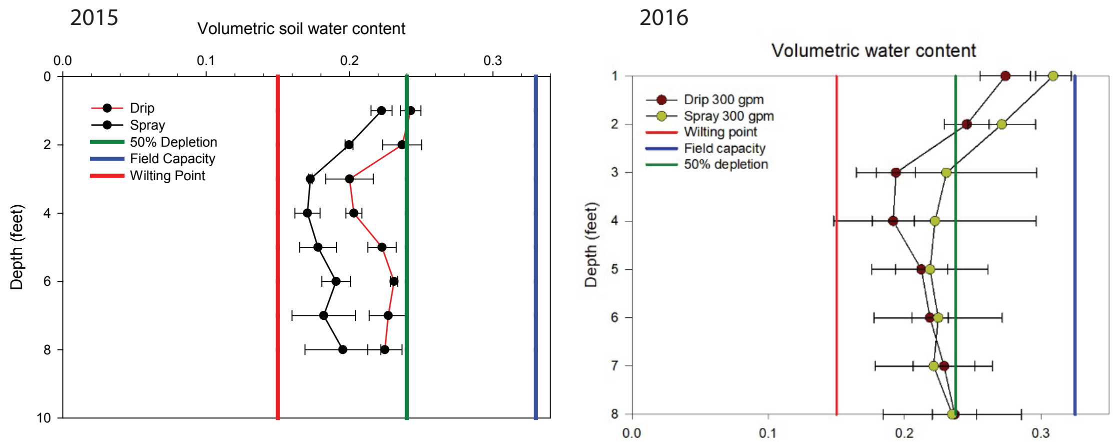

Figure 14. End-of-season soil water measurements under mobile drip irrigation and spray nozzles for well capacity of 300 gpm during the 2015 and 2016 growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, KS.