Kansas Agricultural Experiment Station Research Reports

Volume 2
Issue 7 *Southwest Research-Extension Center Reports*

Article 8

January 2016

Mobile Drip Irrigation Evaluation in Corn

I. Kisekka
Kansas State University, ikiskka@ksu.edu

T. Oker
Kansas State University, oker@ksu.edu

G. Nguyen
Kansas State University, gianguyen@ksu.edu

See next page for additional authors

Recommended Citation

Kisekka, I.; Oker, T.; Nguyen, G.; Aguilar, J.; and Rogers, D. (2016) "Mobile Drip Irrigation Evaluation in Corn," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 7. https://doi.org/10.4148/2378-5977.1253

Mobile Drip Irrigation Evaluation in Corn

Abstract

Mobile Drip Irrigation (MDI) involves attaching driplines to center pivot drops. MDI has potential to eliminate water losses due to spray droplet evaporation, water evaporation from the canopy, and wind drift. MDI also may reduce soil water evaporation due to limited surface wetting. A study was conducted with the following objectives: 1) compare soil water evaporation under MDI and in-canopy spray nozzles; 2) evaluate soil water redistribution under MDI at 60 inch dripline lateral spacing; 3) compare corn grain yield, water productivity, and irrigation water use efficiency; and 4) compare end-of-season profile soil water under MDI and in-canopy spray at two well capacities 300 and 600 gpm. The experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, Kansas. The experimental design was randomized complete block with four replications, and two treatments MDI and in-canopy spray nozzles. Soil water evaporation was measured using four-inch mini-lysimeters placed between corn rows. The effect of a 60-inch lateral spacing on soil water redistribution was evaluated using soil water measurements made using neutron attenuation to a depth of 8 feet. Preliminary results indicate soil water evaporation was lower under MDI compared to in-canopy spray nozzles, by 35% on average. Soil water redistribution was adequate for dripline spacing of 60 inches in silt loam soils of southwest Kansas. At 600 gpm well capacity, corn yields were 247 and 255 bu/a for MDI and in-canopy spray nozzles, respectively. At 300 gpm well capacity, yields were 243 and 220 bu/a for MDI and in-canopy spray nozzles, respectively. However, the differences were not significant ($p > 0.05$) between the irrigation application technologies in 2015. The effect of application method on water productivity and irrigation water use efficiency was also not significant. The lack of significant differences could be attributed to the above normal rainfall received during the 2015 growing season (18.3 inches from May to October). Normal mean annual rainfall for the study area is 18 inches. 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 in-canopy spray nozzles in the 8 foot profile at harvest. It is worth noting that plots under MDI did not have deep wheel tracks associated with sprinkler nozzles.

Keywords

mobile drip irrigation, soil water evaporation, in-canopy, corn, spray droplet evaporation, irrigation management, soil water redistribution, crop water use, end of season soil water

Cover Page Footnote

The authors would like to thank Teeter Irrigation, Servi-Tech Inc., K-State Global Food Systems, U.S. Department of Agriculture Ogallala Aquifer Program, and Kansas Water Office for providing funding or material support for this project. The authors would also like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for their help in implementing this project and data collection and processing.

Authors

I. Kisekka, T. Oker, G. Nguyen, J. Aguilar, and D. Rogers

Mobile Drip Irrigation Evaluation in Corn

I. Kisekka, T. Oker, G. Nguyen, J. Aguilar, and D. Rogers

Summary

Mobile Drip Irrigation (MDI) involves attaching driplines to center pivot drops. MDI has potential to eliminate water losses due to spray droplet evaporation, water evaporation from the canopy, and wind drift. MDI also may reduce soil water evaporation due to limited surface wetting. A study was conducted with the following objectives: 1) compare soil water evaporation under MDI and in-canopy spray nozzles; 2) evaluate soil water redistribution under MDI at 60 inch dripline lateral spacing; 3) compare corn grain yield, water productivity, and irrigation water use efficiency; and 4) compare end-of-season profile soil water under MDI and in-canopy spray at two well capacities 300 and 600 gpm. The experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, Kansas. The experimental design was randomized complete block with four replications, and two treatments MDI and in-canopy spray nozzles. Soil water evaporation was measured using four-inch mini-lysimeters placed between corn rows. The effect of a 60-inch lateral spacing on soil water redistribution was evaluated using soil water measurements made using neutron attenuation to a depth of 8 feet. Preliminary results indicate soil water evaporation was lower under MDI compared to in-canopy spray nozzles, by 35% on average. Soil water redistribution was adequate for dripline spacing of 60 inches in silt loam soils of southwest Kansas. At 600 gpm well capacity, corn yields were 247 and 255 bu/a for MDI and in-canopy spray nozzles, respectively. At 300 gpm well capacity, yields were 243 and 220 bu/a for MDI and in-canopy spray nozzles, respectively. However, the differences were not significant ($p > 0.05$) between the irrigation application technologies in 2015. The effect of application method on water productivity and irrigation water use efficiency was also not significant. The lack of significant differences could be attributed to the above normal rainfall received during the 2015 growing season (18.3 inches from May to October). Normal mean annual rainfall for the study area is 18 inches. 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 in-canopy spray nozzles in the 8 foot profile at harvest. It is worth noting that plots under MDI did not have deep wheel tracks associated with sprinkler nozzles.

Introduction

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 driplines onto a mechanical irrigation system such as a center pivot, has attracted attention lately. By applying water along crop rows, it is hypothesized that MDI could eliminate water losses due to spray droplet evaporation, water evaporation from wetted canopy, and wind drift. MDI also may reduce soil evaporation due to limited surface wetting especially before canopy closure.

The idea of replacing center pivot sprinkler nozzles with driplines is not new (Olson and Rogers, 2007; Rawlins et al., 1974 and Phene et al., 1981). However, what is new is the advancement in the way the dripline is connected to the center pivots and drip-line emitter technology, e.g., pressure compensated emitters. Such emitters eliminate the need for pressure regulators, which reduces the weight being dragged by the center pivot. Another advantage of MDI is that in areas where this technology could prove very useful, such as western Kansas, many producers already own center pivots; therefore the transition from sprinklers to MDI would be relatively easy.

To quantify the benefits of MDI, a study was conducted with the following objectives: 1) compare soil water evaporation under MDI and in-canopy spray nozzles; 2) evaluate soil water redistribution under MDI at 60 inch dripline lateral spacing; and 3) compare corn grain yield, water productivity, irrigation water use efficiency, and end of season profile soil water under MDI and in-canopy spray nozzles at two well capacities, 300 and 600 gpm.

Procedures

Experimental Site

The study was conducted at the Kansas State University Southwest Research-Extension Center (38°01'20.87" N, 100°49'26.95" W, elevation of 2,910 feet above mean sea level) near Garden City, Kansas. The soil at the study site is a deep, well-drained Ulysses silt loam. The climate of the study area is semi-arid, and average annual rainfall is 18 inches. Two independent studies were conducted to compare MDI and in-canopy spray nozzles. Study 1 compared the two application technologies at high well capacity (600 gpm) and Study 2 compared the technologies at low well capacity (300 gpm). The two well capacities were intended to mimic a range of pumping capacities experienced by producers in southwest Kansas. The experimental design in each study was a randomized complete block with four replications (each span 135 feet long was a replication having MDI and in-canopy spray nozzles) as shown in Figure 1.

Agronomic Management

The experiment was conducted in a field that was previously under fallow. The corn hybrid planted in 2015 was DKC 61-89 GENVT2P, with a relative maturity of 111 days. Planting was done on May 18, 2015, at a seeding rate of 32,000 seeds per acre using a no-till planter, planting depth was 2 inches. Nitrogen fertilizer was applied preplant at a rate of 300 pounds of N per acre as urea 46-0-0. Weed control involved application of 3 qt/a of Lumax EZ (S-metolachlor, Atrazine, Mesotrione) and 2 oz/a of Sharpen (Saflufenacial) as pre-emergence herbicide and 32 oz/a of Mad Dog Plus (Glyphosate) and Prowl H2O (Pendimethalin) as post emergence herbicides. Harvesting was done by hand by taking two 40 feet corn rows in the center of each plot at physiological maturity.

Irrigation Management

Irrigation was applied using a center pivot sprinkler system (Model: Valley 8000 Polyline, 4 Tower 560 feet, Valmont Industries, Inc., Valley, Nebraska). A 130 micron disc filter with a flow rating of 200 gpm was installed at the pump station also equipped with a Variable Frequency Drive (VFD) to prevent emitter clogging. Irrigation treatments for the two studies are listed below:

Study 1: 600 gpm well capacity
MDI 4.6 gal/a irrigation capacity (1 inch every 4 days)
In-canopy spray nozzles and 4.6 gal/a irrigation capacity (1 inch every 4 days)

Study 2: 300 gpm well capacity
MDI and 2.3 gal/a irrigation capacity (1 inch every 8 days)
In-canopy spray nozzles and 2.3 gal/acre irrigation capacity (1 inch every 8 days)

Irrigation was triggered whenever available soil water reached 60% in the top 4.0 feet of the soil profile, but irrigation frequency was limited by irrigation capacity. Soil water measurements were taken weekly using a neutron probe (CPN 503DR, CPN International, Concord, California) at 1-foot depth increments from 1 to 8 feet depth. Each irrigation event applied 1.0 inch for all treatments scheduled to be irrigated on a given day. Nozzle flow rate was confirmed using the Spot-on flow device.

Soil water evaporation was measured using four-inch mini-lysimeters placed within the variably wetted surface by the dripline in the MDI plots, and under in-canopy spray nozzle plots. Lysimeters were installed approximately 24 hours after an irrigation event or after the soil had drained. Changes in lysimeter weight were recorded every 24 hours and converted to evaporation rates. The effect of 60 inches lateral spacing on soil water redistribution was evaluated by Kriging (interpolating) soil water measurements made using neutron attenuation to a depth of 8 feet in a transect of five neutron probe access tubes placed 15 inches apart. The GS+ software (Gamma Design Software, LLC, Plainwell, Michigan) was used to implement kriging of soil water measurements.

Results and Discussion

Rainfall

Rainfall during the 2015 growing season from May 1 to October 31 exceeded the long-term average in the same period from 1950 to 2013 as shown in Figure 2. The 2015 summer growing season rainfall exceeded the long-term average by 4.2 inches. Above normal rainfall in May of 2015 ensured sufficient soil water at corn planting. Also, above normal rainfall at tasselling in July and during grain fill in August contributed substantially to crop water needs.

Soil Water Evaporation and Redistribution

Preliminary results indicate soil water evaporation was significantly lower ($p < 0.05$) under MDI, compared to in-canopy spray, on average by 35% (Figure 3). The differences could be attributed to the reduced surface area wetted by the dripline compared to the sprinklers. Regarding soil water redistribution beneath the soil surface, soil water was well distributed between corn rows and was greatest mid-point between the two driplines laterals spaced 60 inches apart at a depth of approximately 20-24 inches (data not shown). These results indicate dripline spacing of 60 inches is adequate for silt loam soils of southwest Kansas to ensure all plants have equal access to the water. This spacing could also enhance precipitation capture and storage.

Yield

The effect of irrigation application method (MDI versus in-canopy spray nozzles) on yield at high (or 4.6 gpm/a) and low (2.3 gpm/a) well capacities was not statistically significant at the 5% level (Figures 4 and 5). The p-values were p = 0.37 and p = 0.67 for Study 1 and 2, respectively. In Study 1 (4.6 gpm/a), MDI and in-canopy spray nozzles produced yields of 247 and 255 bu/a, respectively. Under Study 2 (2.3 gpm/a) MDI and in-canopy spray nozzles produced yields of 243 and 220 bu/a, respectively. 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 October).

Crop Water Use

Crop water use under Study 1 was 29.8 and 29.0 inches for MDI and in-canopy spray nozzles respectively. Study 2 crop water use was 22.6 inches and 23.3 inches for MDI and in-canopy spray nozzles, respectively. The differences in seasonal crop water use (ETc) could be attributed to differences in irrigation application amounts between the two studies. Fourteen inches were applied in Study 1 while 8 inches were applied in Study 2. High irrigation amounts under Study 1 probably increased water losses in form of soil water evaporation and deep drainage. The effect of application method on water productivity and irrigation water use efficiency was also not significant at high and low well capacities (Figures 6 and 7). In Study 1, average water productivity of MDI and in-canopy spray nozzles was 8.3 and 8.9 bu/a/in, respectively. In Study 2, average water productivity of MDI and in-canopy spray nozzles was 10.7 and 9.5 bu/a/in, respectively. Irrigation water use efficiency was not significantly different in Studies 1 and 2 (Figure 7). However, it can be seen from Figures 6 and 7 that water productivity and IWUE were higher under the low well capacity, implying irrigation water was used more efficiently as the number of irrigation applications was reduced.

End of Season Soil Water

End of season soil water measured on October 6, 2015 showed that total soil water in the 8 foot profile was significantly higher in MDI compared to in-canopy spray in Study 2 (Figure 9). However, in Study 1, end-of-season soil water was not significantly different between MDI and in-canopy spray (Figure 8). Figures 8 and 9 also show that MDI was able to store more water at deeper depth compared to in-canopy spray nozzles. In Study 2, plant available water at harvest under MDI was twice that under in-canopy spray (Figure 9). We can conclude that storage efficiency was higher under MDI particularly under low well capacity. It was also observed that plots under MDI did not have deep wheel tracks associated with sprinkler nozzles as shown in Figure 10.

Conclusion

Mobile Drip Irrigation was evaluated under high and low well capacities in corn. Soil water evaporation was significantly lower under MDI compared to in-canopy spray nozzles. Soil water beneath the surface was well redistributed under lateral spacing of 60 inches on silt loam soils. The effect of irrigation application method (MDI versus spray nozzles) on yield at high (600 gpm) and low (300 gpm) well capacities was not significant ($p > 0.05$) in 2015. The effect of application method on water productivity and irrigation water use efficiency was also not significant. The lack of significant differences could be attributed to the above normal rainfall received during the 2015 growing season (18.3 inches received between May to October). Normal annual mean rainfall for the study area is 18 inches. Water productivity and irrigation water use efficiency were higher under the 300 gpm study compared to the 600 gpm, implying that water was used more efficiently as the number of irrigation applications decreased. End-of-season soil water measured at harvest showed that total soil water in the 8 foot profile was significantly higher in MDI compared to in-canopy spray nozzles under low well capacity. However, at the high well capacity, end of season soil water was not significantly different between MDI and in-canopy spray. It is worth noting that plots under MDI did not have deep wheel tracks associated with sprinkler nozzles. More research is needed to confirm benefits of MDI.

Acknowledgments

The authors would like to thank Teeter Irrigation, Servi-Tech Inc., K-State Global Food Systems, U.S. Department of Agriculture Ogallala Aquifer Program, and Kansas Water Office for providing funding or material support for this project. The authors would also like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for their help in implementing this project and data collection and processing.

References

Olson, B. and D. Rogers. 2007. Center Pivot Precision Mobile Drip Irrigation. In Proceedings: Central Plains Irrigation Conference. Kearny, NE.

Phene C. J., T. A. Howell, R. D. Beck, and D. C. Sanders. 1981. A traveling trickle irrigation system for row crops. "Irrigation, the hope and the promise." Annu Techn Conf Proc Irrigation Association, Arlington, Virginia, pp 66-81.

Rawlins, S. L., G. J. Hoffman and S. D. Merrill. 1974. Traveling trickle system. In: Proc. Second Drip Irrigation Cong. pp. 184-187.

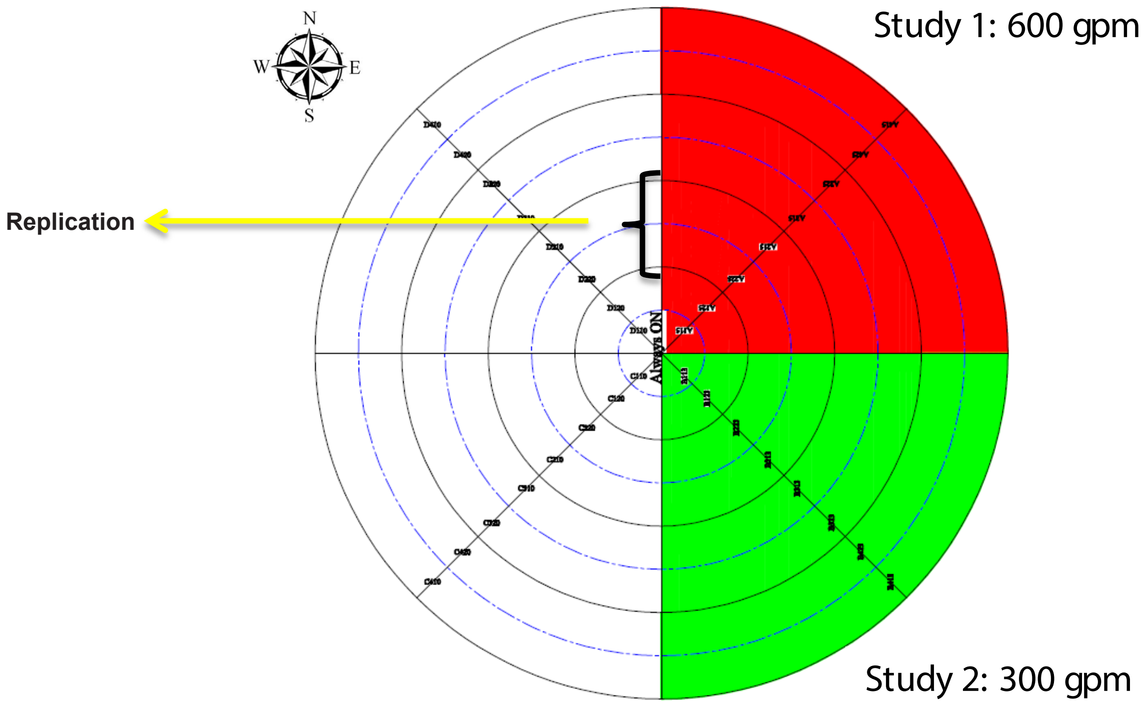

Figure 1. Experimental layout of study comparing Mobile Drip Irrigation (MDI) and in-canopy spray nozzles at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

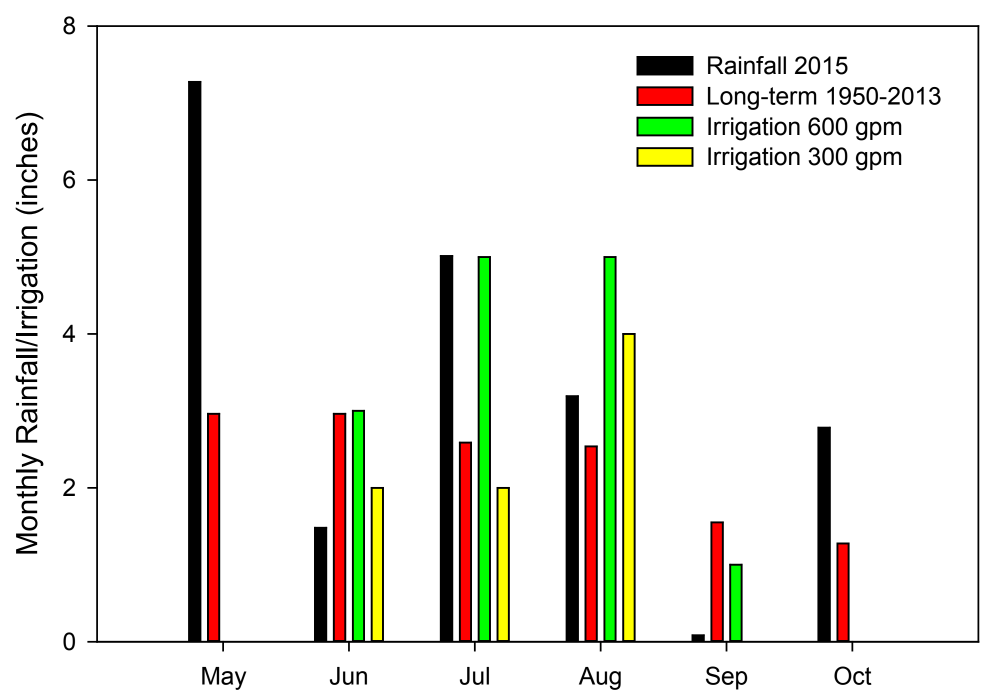

Figure 2. Growing season (May to October) rainfall for 2015 and long-term average, monthly irrigation applications for the 300 and 600 gpm studies at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

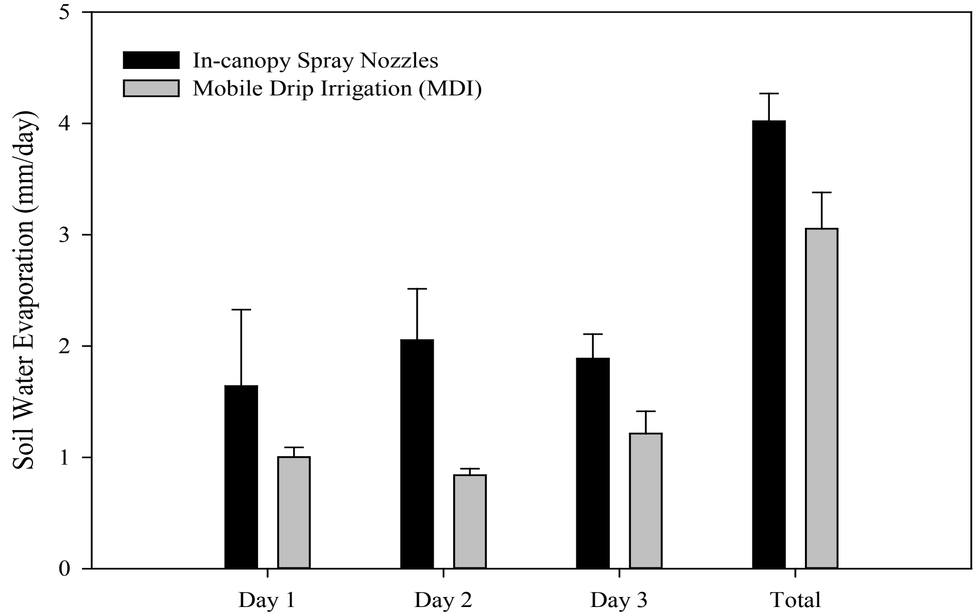

Figure 3. Comparing soil water evaporation under MDI and spray nozzles for three days during the 2015 corn growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

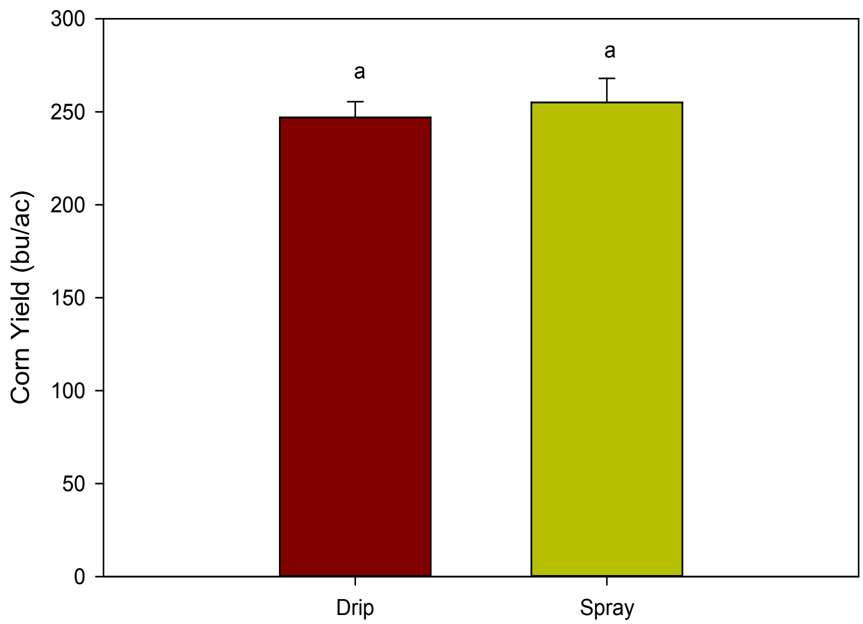

Figure 4. Corn grain yield under Mobile Drip Irrigation and in-canopy spray nozzles for well capacity of 600 gpm during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

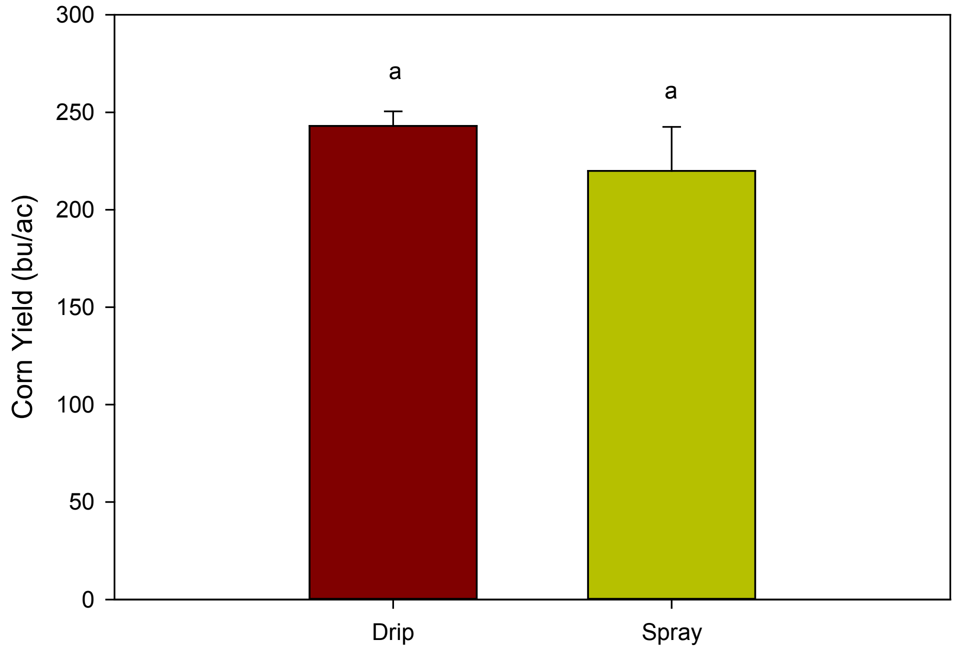

Figure 5. Corn grain yield under Mobile Drip Irrigation and spray nozzles for well capacity of 300 gpm during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

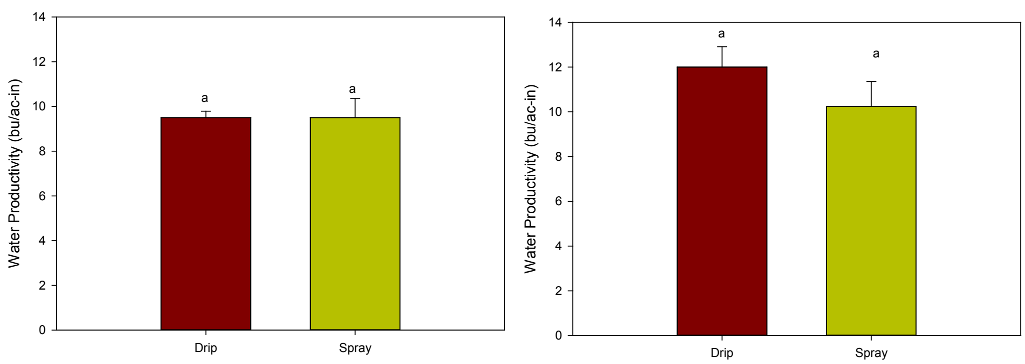

Figure 6. Water productivity of Mobile Drip Irrigation and in-canopy spray nozzles for well capacity of 600 gpm during the 2015 growing season at the Kansas State University SWREC, near Garden City, Kansas.

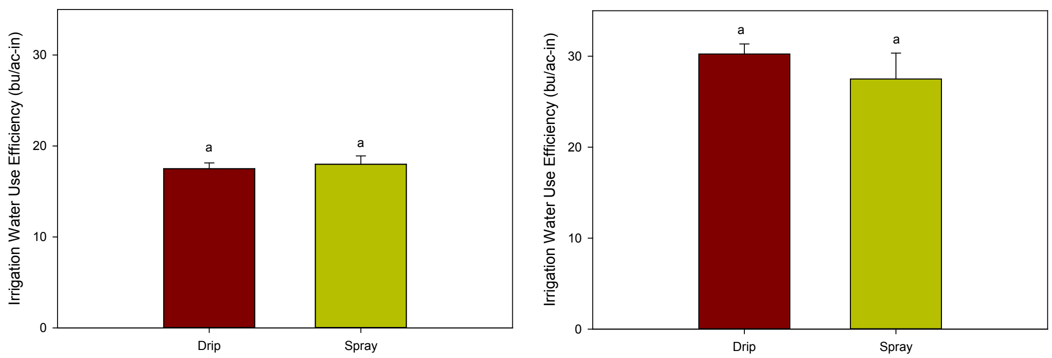

Figure 7. Irrigation water use efficiency of Mobile Drip Irrigation and spray nozzles for well capacity of 300 gpm during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

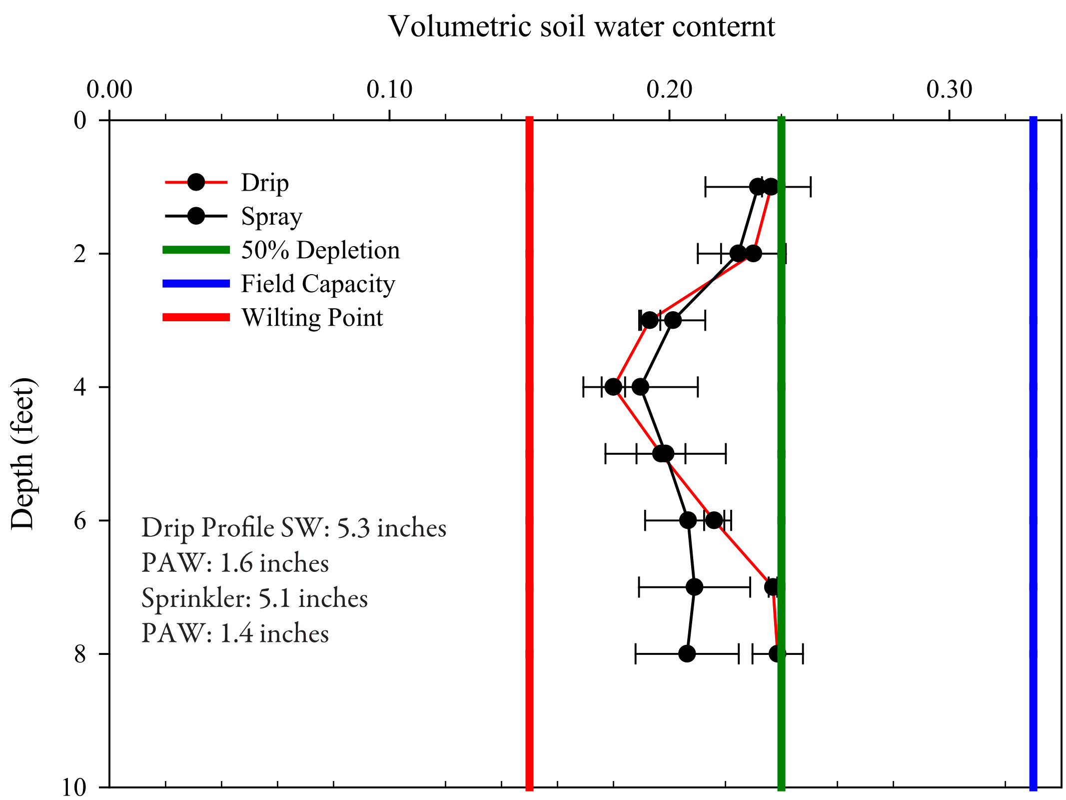

Figure 8. End of season soil water under Mobile Drip Irrigation and in-canopy spray nozzles for well capacity of 600 gpm during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

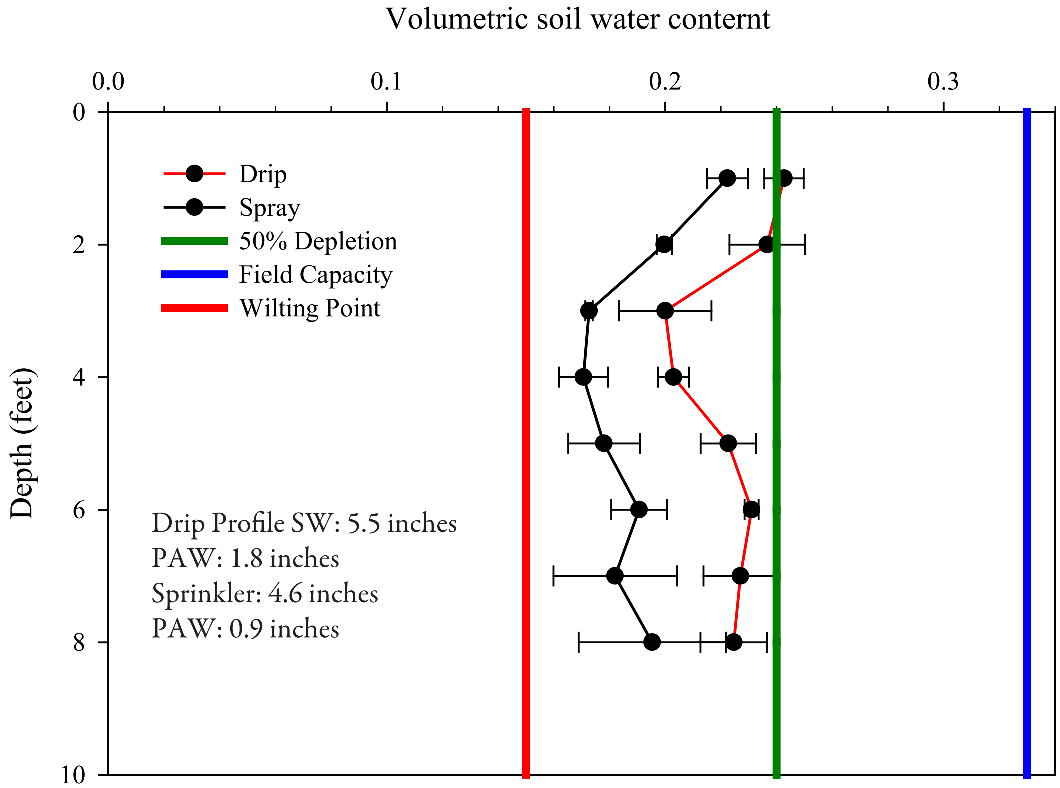

Figure 9. End of season soil water under Mobile Drip Irrigation and in-canopy spray nozzles for well capacity of 300 gpm during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

Figure 10. Wheel tracks under Mobile Drip and in-canopy spray nozzles at the Kansas State University Southwest Research-Extension Center near Garden City.