Proceedings of the 29th Annual Central Plains Irrigation Conference, Burlington, Colorado, Feb. 21-22, 2017
Available from CPIA, 760 N. Thompson, Colby, Kansas

MOBILE DRIP IRRIGATION EVALUATION IN CORN

Isaya Kisekka
Research Agricultural Engineer
Southwest Research-Extension Center
Garden City, Kansas
Voice: 620-275-9164
Email: ikisekka@ksu.edu

Tobias E. Oker
Graduate Student
Biological and Agricultural Engineering
Manhattan, Kansas
Voice: 620-275-9164
Email: oker@ksu.edu

Jonathan P. Aguilar
Extension Agricultural Engineer
Southwest Research-Extension Center
Garden City, Kansas
Voice: 620-275-9164
Email: jaguilar@ksu.edu

Danny Rogers
Extension Agricultural Engineer
Biological and Agricultural Engineering
Manhattan, Kansas
Voice: 785-532-2933
Email: drogers@ksu.edu

Kansas State Research and Extension

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 in the central High Plains. Mobile Drip Irrigation (MDI), which integrates driplines onto a mechanical irrigation system such as a center pivot, has attracted interest from farmers and other stakeholders as water supplies have become more constrained. 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 drip lines 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 precisely connected to the center pivots and dripline emitter technology, e.g., pressure compensated emitters. Such emitters ensure uniform water application over a wide range of pressure variation. Another advantage of MDI is that in areas where this technology could prove very useful, such as central High Plains, many producers already own center pivots; therefore the transition from sprinklers to MDI would be relatively easy. However, there are still many issues that need to be understood and resolved before this technology can become widely accepted e.g., precision positioning of the drip under circular planting, effect of on yield and water productivity as well as onfarm operation and maintenance requirements.

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 in 2015; and 2) compare corn grain yield, water productivity, irrigation water use efficiency, and end of season profile soil water under MDI and LESA (Low Elevation Spray Application) at various irrigation capacities.

METHODS AND MATERIALS

Experimental Site

The study was conducted at the Kansas State University Southwest Research-Extension Center (38o01’20.87” N, 100o49’26.95’’ 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 LESA in 2015. Study 1 compared the two application technologies at a high irrigation capacity (4.6 gpm/ac) and Study 2 compared the technologies at low irrigation capacity (2.3 gpm/ac). The two irrigation 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. The study was repeated during the 2016 corn growing season but the experimental design was modified to add more treatments and to compare the technologies and irrigation capacities under one study instead of two independent studies. In 2016, the irrigation application technologies compared included drip line of 1 gph, drip line 2 gph, LESA, and bubblers. Three irrigation capacities were compared 1.2, 2.3, and 4.6 gpm/ac.

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 and in 2016 it was DKC64-89, with relative maturities of 111 and 114 days respectively. Planting was done on May 18, 2015 and on May 06, 2016 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 2015 are listed below:

Study 1: 2015
1. MDI 1 gph 4.6 gpm/ac
2. LESA 4.6 gpm/ac

Study 2: 2015
1. MDI 1 gph 2.3 gpm/ac
2. LESA and 2.3 gpm/ac i

Irrigation treatments arranged in a split-plot RCBD for 2016 are listed below:
1. MDI 1 gph 4.6 gpm/ac
2. MDI 2 gph 4.6 gpm/ac
3. LESA 4.6 gpm/ac
4. Bubbler 4.6 gpm/ac
5. MDI 1 gph 2.3 gpm/ac
6. MDI 2 gph 2.3 gpm/ac

7. LESA 2.3 gpm/ac
8. Bubbler 2.3 gpm/ac
9. MDI 1 gph 1.2 gpm/ac
10. MDI 2 gph 1.2 gpm/ac
11. LESA 1.2 gpm/ac
12. Bubbler 1.2 gpm/ac

Irrigation was triggered based on an ET soil water balance but 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 deep to assess adequacy of the irrigation schedule. Each irrigation event applied 1.0 inch for all treatments scheduled to be irrigated on a given day.

Soil Water Evaporation

Soil water evaporation was measured using four-inch mini-lysimeter placed within the variably wetted surface by the dripline in the MDI plots, and under LESA plots in 2015. 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 soil water evaporation rates.

RESULTS AND DISCUSSIONS

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. 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. In 2016, growing season rainfall exceeded long-term average (1950-2013) by 2.8 inches and was equally well distributed during the growing season.

Soil Water Evaporation

Preliminary results indicate soil water evaporation was significantly lower ($p < 0.05$) under MDI, compared to LESA, on average by 35% (Figure 1). The differences could be attributed to the reduced surface area wetted by the dripline compared to the sprinklers. These results indicate there is potential to increase water productivity using MDI by partitioning more water to transpiration and less to soil water evaporation.

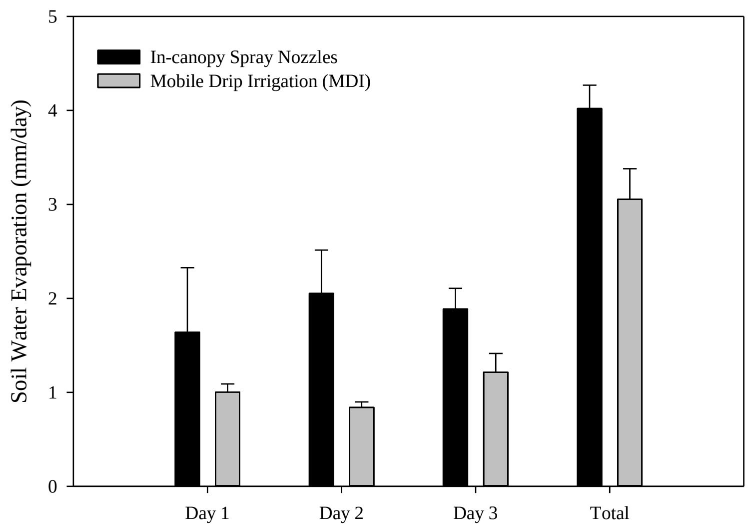

Figure 1. Comparing soil water evaporation under MDI and spray nozzles for three days during the 2015 corn growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

Yield

During the 2015 growing season, the effect of irrigation application method on yield at high (4.6 gpm/a) and low (2.3 gpm/a) well capacities was not statistically significant at the 5% level Table 1. 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 LESA produced yields of 247 and 255 bu/ac, respectively. Under Study 2 (2.3 gpm/a) MDI and LESA produced yields of 243 and 220 bu/ac, respectively. The lack of significant differences in yield could be attributed to the above normal rainfall received during the 2015 growing season.

During the 2016 growing season the effect of irrigation application method on yield was not significant at 5% level (p-value=0.1) but the effect of irrigation capacity on yield was significant (p-value=0.0365). At all irrigation capacities MDI produced the highest mean yield of 235 bu/ac, 211 bu/ac and 205 bu/ac for 4.6 gpm/ac, 2.3 gpm/ac, and 1.2 gpm/ac irrigation capacities respectively. Results for all other irrigation application methods and irrigation capacities are shown in Table 1. These results suggest that farmers might be able to harness the advantages of drip irrigation such reduction in water evaporation losses using MDI.

Table 1. Corn grain yield for different irrigation application methods and irrigation capacities at the Kansas State University, Southwest Research-Extension Center near Garden City Kansas.

Irrigation Type	Well Capacity (gpm)	Yield (bu/ac)	Means with the same letter are not significantly different		
[1]MDI 1gph	4.6	234		A	
Bubbler	4.6	219	B	A	
MDI 2 gph	2.3	215	B	A	
[2]LESA	4.6	211	B	A	
MDI 1gph	2.3	210	B	A	
MDI 1gph	1.2	204	B	A	
Bubbler	2.3	204	B	A	C
MDI 2 gph	1.2	203	B	A	C
MDI 2 gph	4.6	195	B		C
LESA	2.3	192	B		C
Bubbler	1.2	190	B		C
LESA	1.2	169			C

[1]Mobile Drip Irrigation
[2]Low Elevation Spray Application

Crop Water Use

Crop water use during the 2015 corn growing season under Study 1 was 29.8 and 29.0 inches for MDI and LESA respectively. Study 2 crop water use was 22.6 inches and 23.3 inches for MDI and LESA, 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 irrigation capacities (Figures 2 and 3). In Study 1, average water productivity of MDI and LESA was 8.3 and 8.9 bu/a/in, respectively. In Study 2, average water productivity of MDI and LESA was 10.7 and 9.5 bu/a/in, respectively. Irrigation water use efficiency was not significantly different in studies 1 and 2 (Figure 3). However, it can be seen from Figures 2 and 3 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.

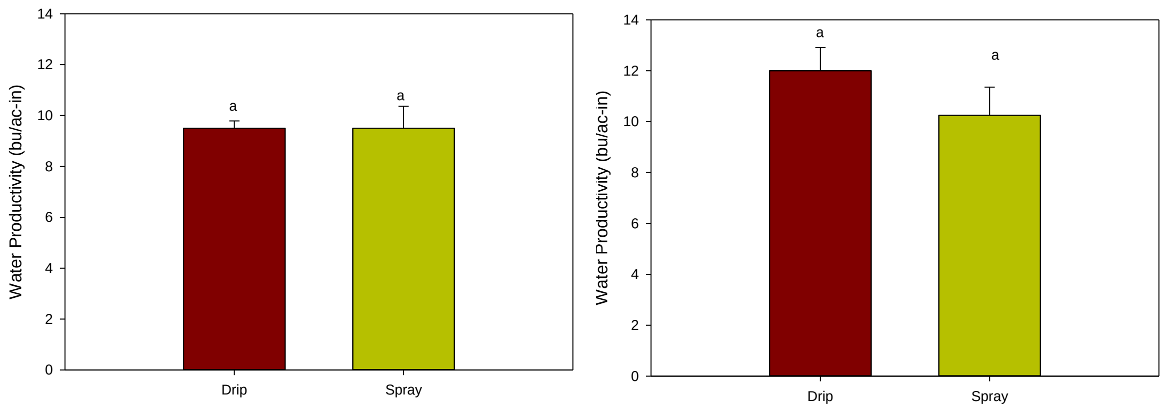

Figure 2. Water productivity of Mobile Drip Irrigation (Drip) and Low Elevation Spray Application (Spray) for irrigation capacity of 4.6 gpm/ac during the 2015 growing season at the Kansas State University SWREC, near Garden City, Kansas.

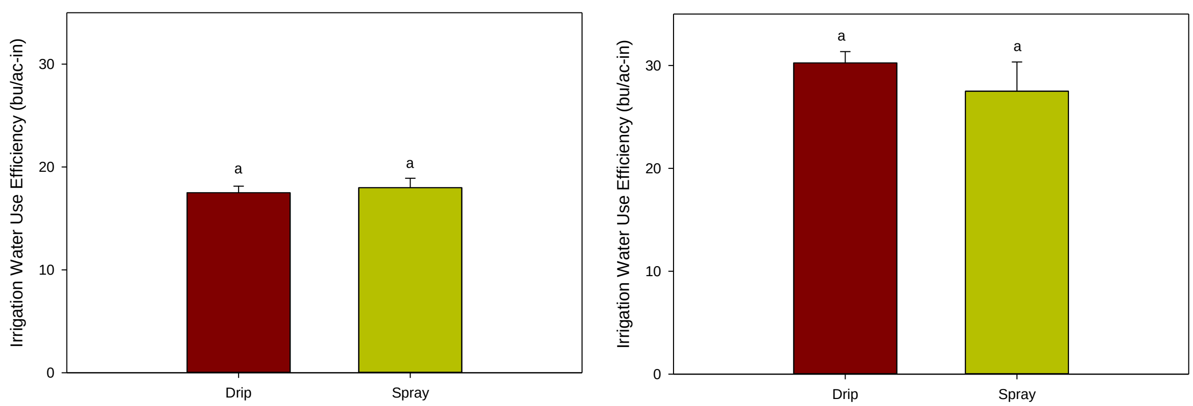

Figure 3. Irrigation water use efficiency of Mobile Drip Irrigation (Drip) and Low Elevation Spray Application (Spray) for irrigation capacity of 2.3 gpm/ac during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

In 2016, a total of 7, 4 and 3 inches of irrigation were applied corresponding to 1.2, 2.3 and 4.6 gpm/ac irrigation capacity respectively. Crop water use for the different treatments are summarized in Table 2. Irrigation capacity and irrigation application method both had a significant effect on water productivity at 5% significant level with p-value< 0.0001, and p-value= 0.0163 respectively. The lowest irrigation capacity produced the highest water productivity and irrigation water use efficiency as shown in Tables 3 and 4. Irrigation water use efficiency increased with decrease in irrigation capacity and was higher for MDI compared to LESA and bubbler as shown in Table 4. This is due to the fact that as the number of irrigation applications reduced nonproductive water losses due to evaporation or deep drainage were minimized.

Table 2. Crop water use for the different irrigation application methods and irrigation capacities during the 2016 corn growing season at Kansas State University, Southwest Research-Extension Center near Garden City Kansas

Irrigation Capacity (gpm/ac)	Irrigation application methods			
	[1]MDI 2 (gph)	MDI 1 (gph)	[2]LESA	Bubbler
4.6	15.7	17.8	17.6	17.3
2.3	19.7	18.1	20.6	18.4
1.2	24.0	24.6	24.6	24.1

[1]Mobile Drip Irrigation
[2]Low Elevation Spray Application

Table 3. Water productivity for the different irrigation application methods and irrigation capacities during the 2016 corn growing season at Kansas State University, Southwest Research-Extension Center near Garden City Kansas

Irrigation Capacity (gpm/ac)	Irrigation application methods			
	[1]MDI 2 (gph)	MDI 1 (gph)	[2]LESA	Bubbler
4.6	8.2	9.6	8.7	9.2
2.3	11.1	11.8	9.3	11.1
1.2	13.0	11.6	9.8	11.0

[1]Mobile Drip Irrigation
[2]Low Elevation Spray Application

Table 4. Irrigation water use efficiency for the different irrigation application methods and irrigation capacities during the 2016 corn growing season at Kansas State University, Southwest Research-Extension Center near Garden City Kansas

Irrigation Capacity (gpm/ac)	Irrigation application methods			
	[1]MDI 2 (gph)	MDI 1 (gph)	[2]LESA	Bubbler
4.6	68	68	57	63
2.3	54	53	48	51
1.2	28	34	31	31

[1]Mobile Drip Irrigation
[2]Low Elevation Spray Application

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 LESA in Study 2 (Figure 4). However, in Study 1, end-of-season soil water was not significantly different between MDI and LESA (Figure 5). Figures 4 and 5 also show that MDI was able to store more water at deeper depth compared to LESA. In Study 2, plant available water at harvest under MDI was twice that under LESA (Figure 4). We can conclude that storage efficiency was higher under MDI particularly under low irrigation capacity during the 2015 growing season. It was also observed that plots under MDI did not have deep wheel tracks associated with sprinkler nozzles as shown in Figure 6.

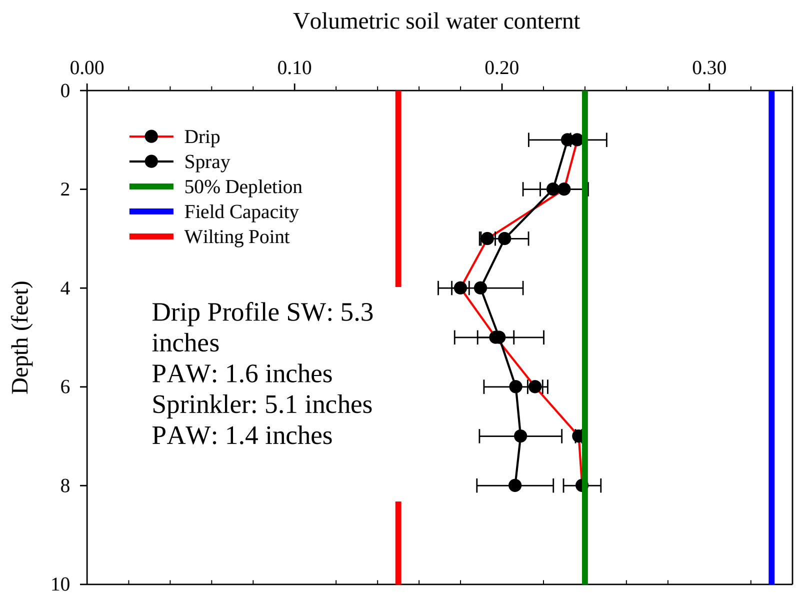

Figure 4. End of season soil water under Mobile Drip Irrigation (Drip) and Low Elevation Spray Application (Spray) for irrigation capacity 2.3 gpm/ac during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas (Kisekka et al. 2017).

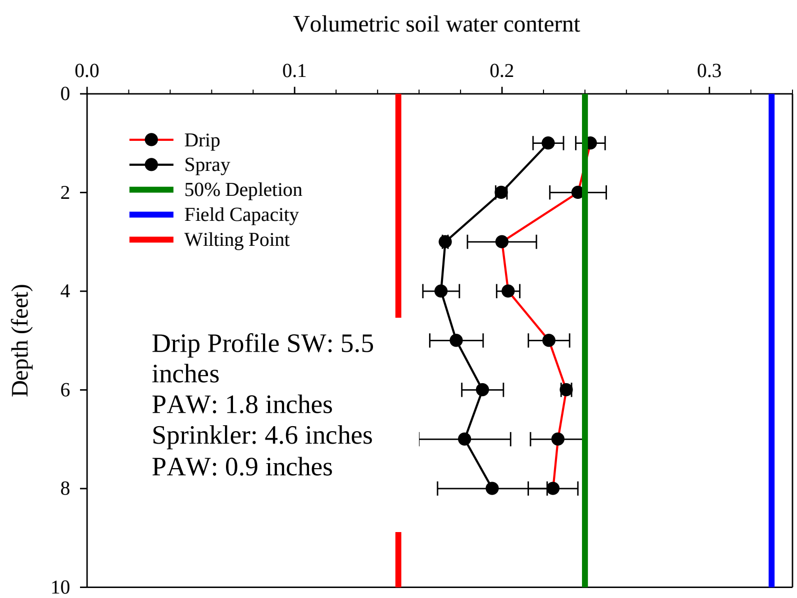

Figure 5. End of season soil water under Mobile Drip Irrigation (Drip) and Low Elevation Spray Application (Spray) for at high irrigation capacity of 4.6 gpm/ac during the 2015 growing season at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas (Kisekka et al. 2017).

Figure 6. Difference between wheel tracks in Mobile Drip Irrigation (left) and Low Elevation Spray Application (Right) at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas.

CONCLUSIONS

Mobile Drip Irrigation was evaluated under 1.2, 2.3 and 4.6 gpm/ac irrigation capacities during the 2015 and 2016 corn growing seasons at the Kansas State University Southwest Research-Extension Center, near Garden City, Kansas. Soil water evaporation was significantly lower under MDI compared to LESA. The effect of irrigation application method on yield at high irrigation capacity was not significant ($p > 0.05$) during the 2015 and 2016 corn growing seasons. However, the effect of irrigation capacity on yield was significant. Also irrigation application method had a significant effect on water productivity with MDI 1gph producing the highest average water productivity. Irrigation water use efficiency increased with decrease in irrigation capacity and was higher for MDI compared to LESA and bubbler. 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 LESA under low irrigation capacity during the 2015 growing season. However, at the high well capacity, end of season soil water was not significantly different between MDI and LESA. 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 Project, 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

Kisekka, I., T. Oker, G. Nguyen, J. Aguilar and Danny Rogers. 2016. Mobile Drip Irrigation Evaluation in Corn. Irrigation Science. Submitted

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.