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EVALUATION OF MOBILE DRIP IRRIGATION (MDI) AND OTHER SPRINKLER PACKAGES

Jonathan Aguilar
Water Resource Engineer
Kansas State University
Southwest Research-Extension Center
Garden City, Kansas
Voice: 620-275-9164
Email: jaguilar@ksu.edu

Danny H. Rogers
Extension Agricultural Engineer (Retired)
Kansas State University
Biological and Agricultural Engineering
Manhattan, Kansas
Voice: 785-532-2933
Email: drogers@ksu.edu

INTRODUCTION

Agricultural irrigation is by far the largest user of freshwater in the world and provides the most important role in bolstering crop production. The Ogallala aquifer has been a major driver of agriculture in the U.S. High Plains for the past six decades. However, this agricultural productivity led to the decline of the aquifer. As a result of drastic aquifer drawdown, well capacities in some regions of the High Plains are no longer sufficient to sustainably irrigate crops. Irrigators have been converting their flood irrigation systems to a relatively more efficient and easier to manage center pivot systems (Figure 1) which has now become the most widely used system in Kansas. However, there are still efforts to further improve irrigation efficiency by focusing on the different water application packages. The producers are looking for visible proof as to which application packages are going to work for their particular location and cropping management. These water application packages include new mobile drip irrigation (MDI), bubbler nozzle package and sprinkler nozzle package. Evaluation of these application packages were based on the studies done on the research plots at K-State Southwest Research-Extension Center and at select Water Technology Farms (WTFs) in western Kansas. WTFs are demonstration farms that allow the installation and testing of the latest irrigation technologies on a commercial or farmer field scale. K-State Research Extension (KSRE) and Kansas Water Office (KWO), along with private and non-governmental entities, monitor and provide support to these WTFs. This paper will focus on the evaluation of the MDI, bubbler or low elevation precision application (LEPA), fixed spray and moving-plate spray application devices attached on center pivot irrigation systems.

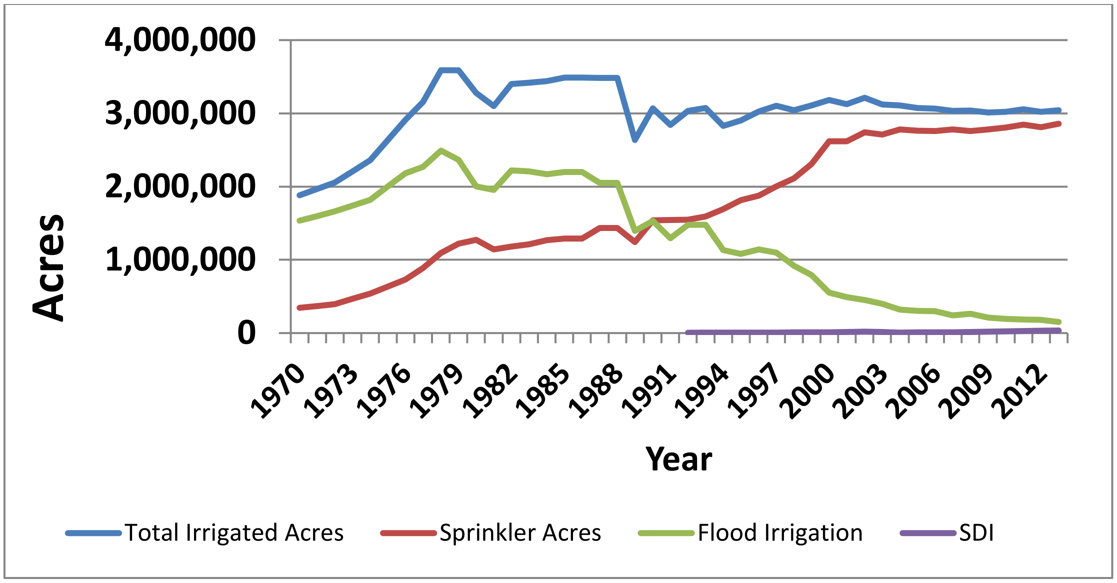


Figure 1. Historical irrigated acres in Kansas by three major types of irrigation systems.

Mobile Drip Irrigation

The concept of using driplines on center pivot (CP) system is not new. T-L Irrigation, Inc. experimented with this idea in the early 2000s, calling it precision mobile drip irrigation (PMDI). However, based on the studies of Olson and Rogers (2007), no yield differences between the PMDI and CP were found. They associated the lack of discernible impact to the relatively wet years of the study and inherent high variability in the field caused by factors beyond the control of the investigators. The MDI was developed with the concept of combining the high efficiency but expensive subsurface drip irrigation (SDI) technologies and the relatively low-cost simple operation and maintenance of center pivot irrigation technologies. Although, MDI should increase irrigation efficiency, a previous study on a similar product found more negative management issues than positive efficiency advantages (Olson and Rogers, 2007). However, a recent study using new MDI product lines in corn reported no significant differences in yield between MDI and in-canopy spray nozzles but better soil water storage under MDI (Kisekka et al., 2016). In addition to potential irrigation efficiency improvement with MDI, there is producer interest in MDI as a potential water application system to help alleviate wheel track rutting issues, (Rogers, personal communication, 2016) which in turn would reduce erosion and improve field conditions. Currently, there are two dealers of MDI in the market, Dragon-Line by Teeter Irrigation and PMDI by Netafim and T-L Irrigation. Both dealers uses pressure compensating (pc) emitters on the hoses dragged behind the center pivot. The major difference in their design is how the hoses are attached to the manifold or the center pivot structure.

The Water Technology Farms

T&O Farms, LLC in Finney County (Figure 2) consists of 10 sprinkler systems, four equipped with MDI, one with multiple applicators (spray and MDI), and four equipped with low pressure spray nozzles. There are four circles planted to sorghum and alfalfa that are set-up as paired field comparison of MDI and spray nozzles. Each field has a soil water sensor. The systems are fully automated with water use, groundwater levels, moisture sensor data and weather station data tied to a real-time website.

The Garden City Company/Dwane Roth Farm in Finney County (Figure 2) north of Holcomb consists of a circle with multiple modes and spacing of water application packages on its four outer spans. These application packages include MDI on 30- and 60-in spacing, i-Wob spray nozzle, and bubbler on 30- and 60-in spacing (MDI was removed by the farmer in 2019). The farm is unique as the water source is both ground and surface water. The circle is planted circle to corn managed with a precision soil zoning package, uses soil water sensors and has aerial imageries for thermal and plant health assessment.

The WaterPACK/ ILS Farm in Pawnee County (Figure 1) is comparing MDI with regular spray nozzles during its first three years (2016-2018) on a higher utilizing volume irrigation wells than those wells being studied in Finney County. Two corn circles are involved with the spray nozzles planted in typical straight rows with the other field is planted in circle. Irrigation scheduling using weather-based and soil water sensors was utilized at this farm. In 2019, the field was replaced and focused more on different spray nozzle packages and other system integration.

The Hatcher Farm in Seward County (Figure 2) is made up of two fields that have had field mapping completed to identify management zones and locate where soil moisture probes were to be installed. The farm utilizes soil moisture probes, aerial imagery, center pivot controllers, iWob nozzles, Bubbler nozzles, MZB soils map. Both fields have water application comparisons with different nozzle packages.

The Circle C Farm that straddles in the boundaries of Scott and Lane Counties (Figure 2) is comparing several technologies including EC soils mapping of all fields, soil moisture probes, variable rate irrigation, iWob and Bubbler nozzles, and aerial imagery. The goal of the farm is to maintain production while increasing water use efficiency with the use of the technology together with cover crops.

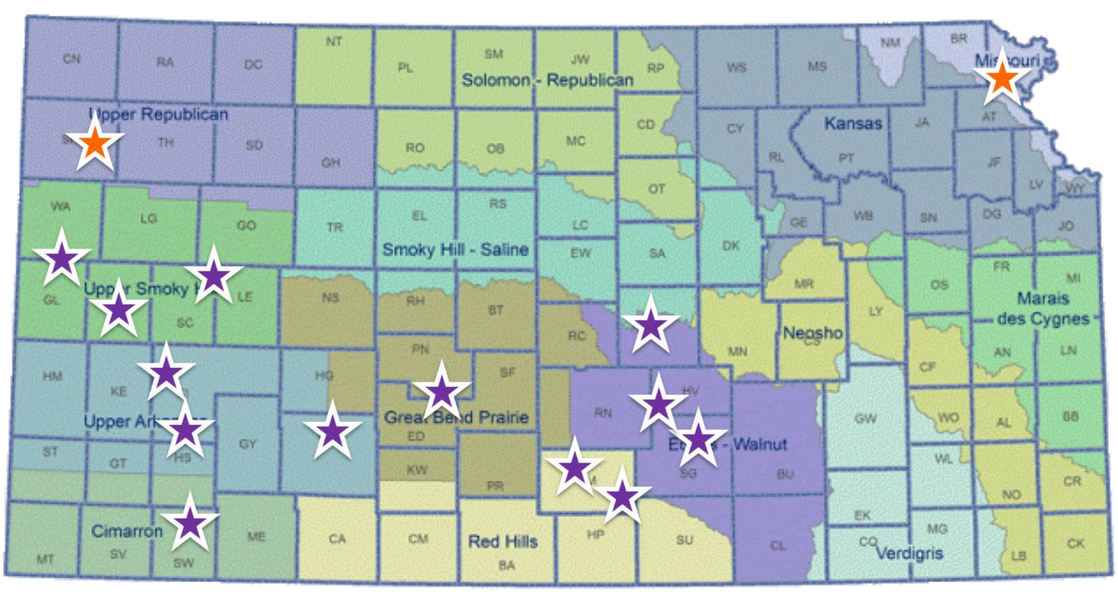


Figure 2. The location of the 15 water technology farms in 2019. Most of the farms (purple stars) are testing different sprinkler application packages while two farms (orange stars) are focused on workforce development and soil health.

PRELIMINARY EVALUATION RESULTS

MDI, Bubbler and Spray Packages at SWREC Research Plots

The yield data in 2016 at the SWREC plots showed that there was barely any difference between the MDI treatments, bubbler and sprays at the higher well capacities (600 and 300 gpm). Interestingly, at the 600 gpm, spray seem to have a significant advantage with the MDI with 2gpm hose. However, at the 150 gpm well capacity, the spray did show a significant disadvantage or yield penalty compared with most of the other treatments.

Table 1. Yield data for 2016 from the different application packages at the SWREC research plots.

Simulated well gpm on 125 ac	600	300	150
Drip 2 gpm	245 b	271 a	243 ab
Drip 1 gpm	294 ab	263 a	268 a
Bubbler	275 ab	256 a	239 ab
Spray	265 a	240 a	212 b
Irrigation (in)	11	6	4

MDI vs Spray at T&O Farms, LLC

In 2016, the center pivots in the fields incurred substantial repair costs particularly related to wheels and wheel drive train. The costs of these repairs were included in a partial budget analysis (Table 2) for that year on four of the ten fields. If the producer considers the profit above variable expenses, there is slight advantage in using the MDI ($366 and $478) compared with spray nozzles ($351 and $475). However, if the farmer consider the water use in the computation, then the profit per acre-inch per acre now becomes favorable for spray. A couple of caveats on this data that this this the first year of the alfalfa and that this is only based on one year of data.

Table 2. Partial budget analysis of fields with comparable systems at T&O Farm for the cropping year 2016.

Pivot Designation	NE20	SW20	SE20	NW20
Technology	MDI	Spray	MDI	Spray
Crop	Alfalfa	Alfalfa	Sorghum	Sorghum
Income				
Acres	123	123	123	122
Yield per Acre	2.97	3.13	140.04	145.25
Price	$161.48	$161.48	$4.46	$4.46
Gross Profit ($/ac)	$479.19	$505.45	$624.58	$647.80
Expenses				
Seed	$74.63	$96.59	$8.45	$9.00
Herbicide	$13.18	$13.18	$60.68	$59.37
Fertilizer	$25.06	$40.88	$77.69	$91.69
Drive Train Repairs	$0.00	$3.86	$0.00	$12.88
Variable Expenses	$112.87	$154.51	$146.82	$172.94
Profit Above Variable Expenses	**$366.31**	**$350.94**	**$477.76**	**$474.86**
Water Use (ac-in/ac)	4.46	3.77	9.65	9.36
Profit per ac-in/ac	**$82.14**	**$93.10**	**$49.53**	**$50.71**
Yield per ac-in/ac	0.67	0.83	14.52	15.51

Several Sprinkler Packages at The Garden City Company/Dwane Roth Farm

The yield comparisons for the different sprinkler packages on this farm are presented in Figure 3. It shows the hose has consistently had the lowest yield while the bubbler had consistently higher yields. For some reason in 2018 the hose had a slightly higher population rate than over the other treatments. The differences in each package did not show in the yield monitor of the combine harvester. The producer claims that given no major differences in the packages, his preference may now be based on ease of use and management of these sprinkler packages. So in 2019 he removed the MDI but this time the yield under the I-Wob was higher than the bubbler.

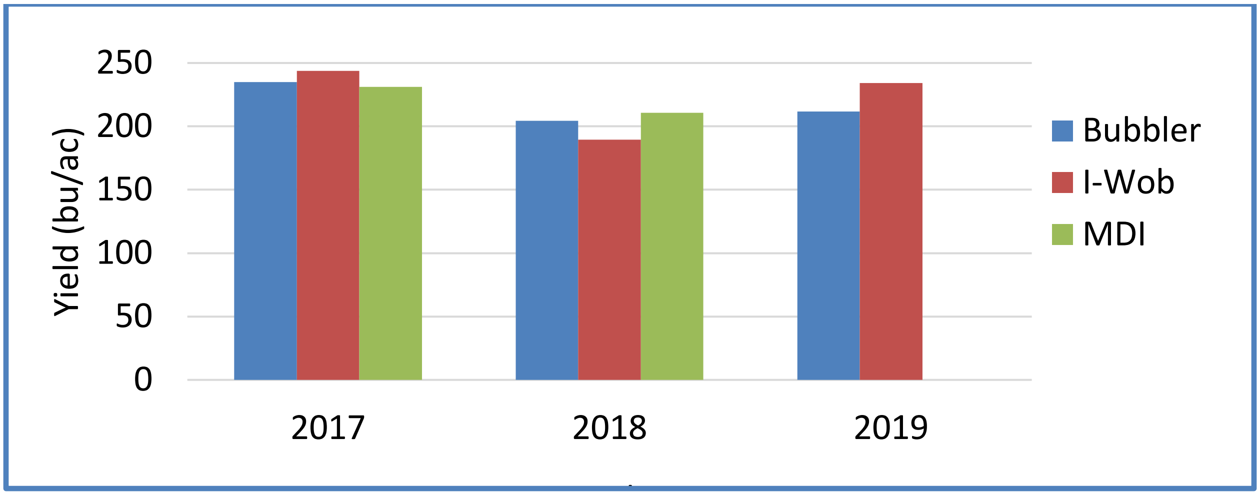


Figure 3. Three years of yield data under each sprinkler packages at The Garden City Company/Roth Farm.

MDI vs Spray at the WaterPACK/ ILS Farm

The farm received a total of 17 inches of rainfall during the 2016 cropping season. The total depth of irrigation they applied was 13.5 inches to the South field and 14.1 inches to the North field. The yields from both fields and treatments were not significantly different (Figure 4) whose values ranged from 222 bu/ac in the South field and 235 bu/ac for the MDI in the North field. The average yield from the tractor combine was 200 bu/ac for both fields. In 2017 cropping season, a very similar yield results were observed, no significant differences.

The farm cooperators decided that on its last year (2018) of the project they would like to test the limits of the MDI. They decided to reduce the application rates in the MDI by 20 and 30 percent while maintaining a full rate at the nozzle spray packages. Table 2 summarizes the yield data and the water use efficiencies of each treatments in the farm. With the reduction in the application rate, the MDI did suffer yield losses of about 20 bu/ac. However, the water use efficiency was greater in the MDI compared with the spray considering that the MDI had as much as four inches difference compared with what the spray treatments applied.

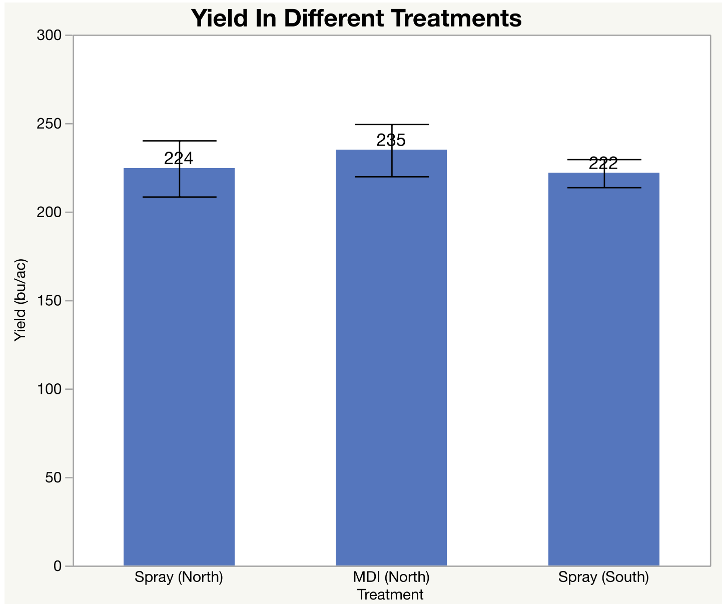


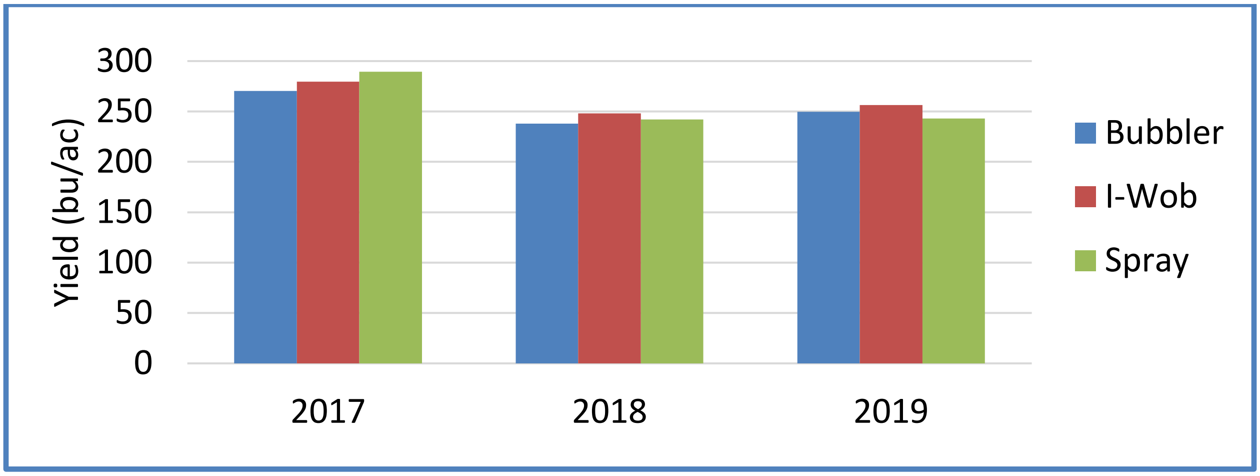
Figure 4. Corn yields at the different treatments at the ILS farm.

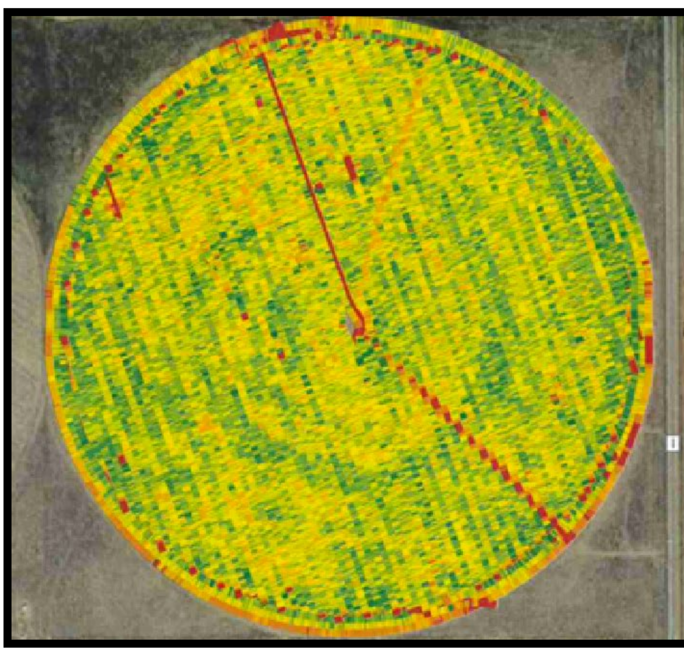
Table 3. Yield and water use data for 2018 cropping season at the ILS Farm.

FIELD	TREATMENT	YIELD (Combine) (BU/AC)	YIELD (Hand) (BU/Ac)	IRRGN APPLIED (IN)	WATER USE EFFICIENCY (BU/Ac-IN)
NORTH 16	ALL	234	244	13.1	18.62
	MDI (70%)	231	243	9.8	24.8
	MDI (80%)		237	11.2	21.2
	SPRAY (100%)	249	259	14.0	18.5
SOUTH 15	SPRAY	232	237	15.3	15.5

Moving Plates, Fixed Plates and LEPA/Bubbler Packages at Hatcher Farm

Hatcher farm was not interested in MDI but rather was interested at evaluating other different types of nozzle packages, namely I-Wob, Bubbler and Spray. For the two years and two fields, the bubbler package did have the lowest yield and the fixed spray had the highest yield in most instances. However, when the producer got the combine yield spatial data, there was a noticeable ring of higher yielding section in the field (Fig. 6). Upon further investigation, the ring was around the fourth span which a moving plate package and that the ring was very apparent around the southeast section of the field. This section of the field has about 10% slope towards the southeast. Based on field observation and this information, there is concern that the water applied from the third span with bubbler is running-off toward the fourth span, thus the yield increase on the fourth span and the relatively low yield on bubblers. The KSRE data did not reflect this difference because the area being monitored (NNE of the field) was relatively flat and was chosen precisely to minimize this type of interaction or data complication.





MC	Spans	Treatment
0.29	7	Moving Plate
0.28	6	Fixed Pads
0.29	5	Bubbler/LEPA
0.26	4	Moving Plate
0.25	3	Bubbler/LEPA
0.26	2	Fixed Pads
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Figure 5. Yield of corn in the different application packages at Hatcher's farm for three years.

Figure 6. Combine yield map at the eastern part of Hatcher's farm and the designated treatments on each span. MC is the average volumetric soil moisture content at the NNE area of the field.

Moving Plates, Fixed Plates and LEPA/Bubbler Packages at Circle C Farm

The spray nozzle treatments in the Circle Farm have consistently been low in the last three years. In 2017, the difference was not significant. However, in 2018 both the spray and I-Wob nozzle packages was significantly different from the bubbler. Upon talking with the farmer, the yield map from the combine did not pick-up this difference. In 2019, bubbler and spray were almost similar in yield, but the yield on the I-Wob varied depending on the farm. Unlike the Hatcher's farm, the fields in Circle farm are very flat and we did not notice any movement of the water in all of the nozzle packages.

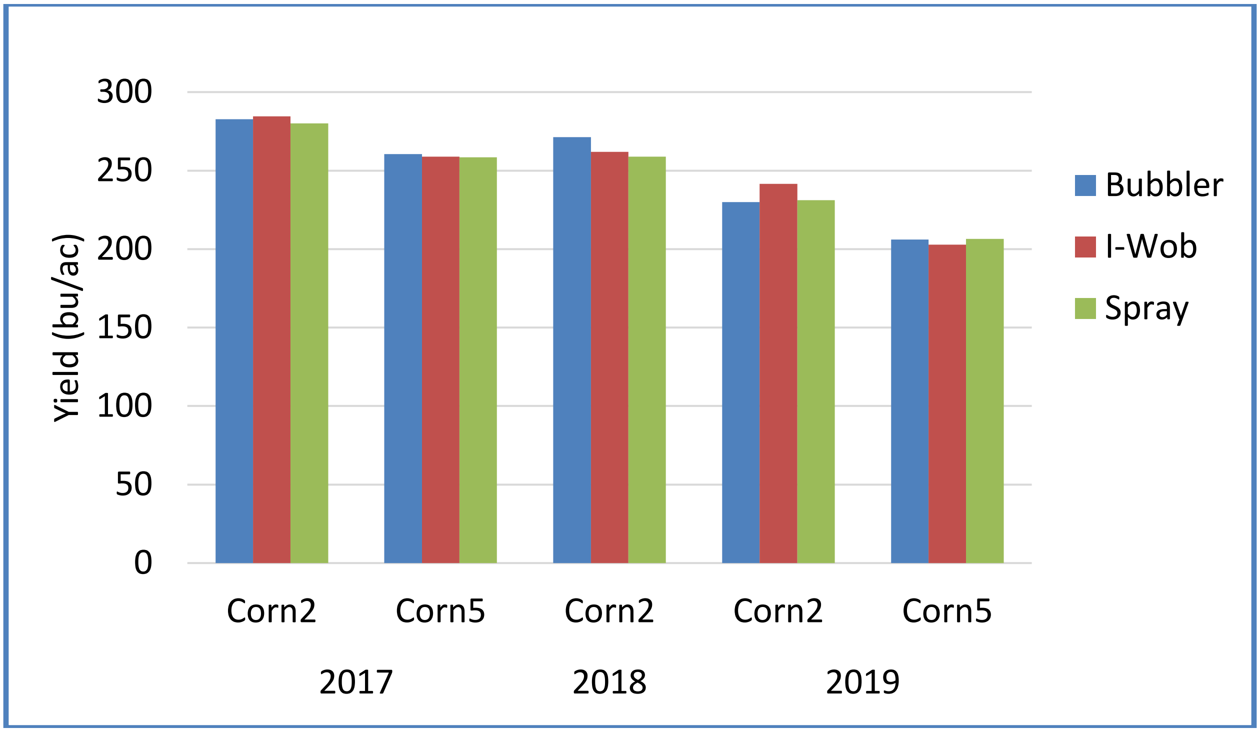

Figure 7. Yield data for the different nozzle packages installed in Circle C farms. Corn2 is from the Lane county farm and Corn5 is from Scott County farm.

PRELIMINARY CONCLUSION

There are many ways of improving the water use efficiency in irrigated fields. This paper looked at the performance of some water application packages. These are just preliminary data and analysis since we plan to look at the other parameters that may be affecting these yield differences and similarities. In general, performance of the different application devices depends on several factors, one of which is the topography or slope, then the wetted area of the application. Where there is in-field movement of water away from the target area, yields are usually suppressed (e.g. Hatcher farm). But if the runoff is minimal, then the wetted area of application become more critical. The less water lost through drift and canopy evaporation, the better is the performance of the nozzle package as reflected in the yields.

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