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Comparison of Drip Irrigation to Flood and Center Pivot Irrigation Systems in Hudspeth County

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Texas Water Development Board

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1 Executive Summary

El Paso Water owns farmland and water rights in Dell City, Hudspeth County, Texas as part of its long-term strategic plan for water supply. Dell City is a small farming community in the high desert of the Trans Pecos area of Texas with an elevation of approximately 3,700 feet and an average annual rainfall of nine inches. The land has historically been irrigated using flood and center pivots systems, and it has a history of producing alfalfa, red chilies, cotton, and small grains. The area will continue to be farmed for many years to come. As part of an ongoing effort to improve water conservation and land stewardship the utility began to explore alternative irrigation methods that might result in water savings without detriment to crop yields. It was determined that sub-surface drip irrigation was a likely candidate so a project to evaluate drip irrigation was designed. The project was funded by El Paso Water with a grant from the Texas Water Development Board.

Figure 1-1 Location of Dell City, Texas

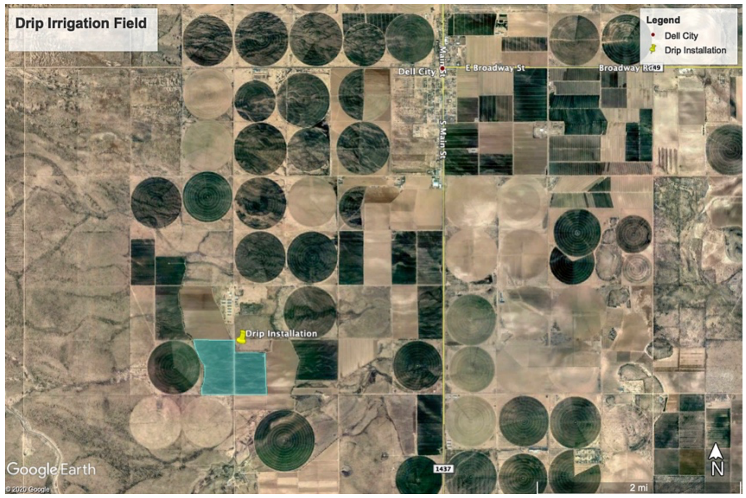

Figure 1-2 Location of drip irrigation field

A sub-surface drip irrigation system for approximately 150 acres was designed and installed to demonstrate water savings relative to conventional flood and center pivot irrigation methods. It was anticipated that the introduction of drip irrigation would reduce water use by twenty to thirty percent with fewer inputs and less energy relative to conventional flood and center pivot irrigation, and that crop yields would be similar, or greater, due to the ability to better manage water and nutrient delivery within the rootzone. Fertilizer volume and tractor activities were measured for each irrigation type with the anticipation that these inputs would also be reduced.

The drip irrigation system was completed in January of 2019 and the field was planted in upland cotton in 2019, red chili in 2020 and upland cotton again in 2021. Control fields with similar soils were planted with the same crops using flood and center pivot irrigation. The 2021cotton crops in the drip and flood irrigated fields were destroyed by wind and hail in May and again in June, so no comparison between 2021 and other years is available.

The difference in water consumption between flood, pivot and drip irrigation is depicted below in Table 1-1. If the control fields had been irrigated with drip irrigation rather than conventional flood and center pivot, the resulting savings would have totaled 121,907,970 gallons for flood irrigation and 108,765,701 gallons for the center pivot irrigation, or water savings of forty-one and thirty-eight percent, respectively.

Table 1-1 Total gallons of irrigation water saved.

Gallons H2O Saved by Using Drip Irrigation 2019-2020				
Irrigation method	Total gal/ac used	Total gal/ac saved by using drip irrigation	Total gal/150 ac saved by using drip irrigation	% Savings with drip irrigation
Flood	1,979,033	812,720	121,907,970	41%
Pivot	1,891,418	725,105	108,765,701	38%
Drip	1,166,313	-	-	-

The amount of water per unit of crop yield was less for the drip irrigated fields than conventional methods. The gallons of water per unit of yield was forty-seven percent less for drip irrigation over flood irrigation, and fifty-one percent less for drip irrigation over center pivot irrigation.

The number of tractor passes and the amount of fertilizer applied were also measured. Fewer tractor passes on the drip field resulted in savings in labor and fuel while reducing soil compaction. Less fertilizer was required by the drip system to produce yields similar to conventional methods, and in some instance greater yields were achieved.

2 Scope of work

In 2019 sub-surface drip irrigation was installed on 150 acres of farmland in Dell City to compare it to customary flood and center pivot irrigation methods. Irrigation water, tractor activity and fertilizer were measured throughout three seasons between 2019 and 2021 on the drip irrigated field and comparable fields irrigated by flood and center pivot systems. A catastrophic crop loss due to weather prevented final comparisons between 2021 and the previous two years, so results are based on 2019 and 2020 data.

Information about the project was distributed to local farmers on an annual basis and informal tours were provided as requested throughout the duration of the project. In March of 2019 the farm hosted thirty-eight members of the Illinois Young Leaders group, which consists of farmers, marketers, and agriculture support personnel under the age of thirty-five. This group traveled to Dell City for a day to see how the farm was using new technology to save water and increase yields in the desert, and to explore how these management practices could be applied at home. AgriLife and NRCS officials were given tours in 2020 and 2021, however access to the public was limited beginning in 2020 due to COVID 19. In 2021the utility made a series of videos about conservation on the farm for distribution to major media outlets (https://www.youtube.com/watch?v=VBbSUYtTya8&list=PLq91nL04dH2QMn4bceAcIL04Ts43PFlRs&index=4). Beginning in 2021, AgriLife was engaged in a long-term project to collect baseline conservation data and to explore management practices that might enhance water and soil conservation. The demonstration drip irrigation field is included in that study, and AgriLife staff have access to all the data collected over the life of the project. The drip irrigation system will continue to be monitored by AgriLife researchers over the next three years to evaluate how sub-surface drip irrigation can be successfully implemented in the dessert.

3 Description of research performed

Drip irrigation was compared to flood and center pivot irrigation by measuring water, fertilizer, tillage activities and crop yields throughout 2019, 2020 and 2021. Cotton was harvested in 2019 and red chilies were harvested in 2020. Cotton was planted in 2021 but suffered catastrophic damage from wind and hail, thereby providing no valid comparative data for year three.

3.1 2019 Season

The field was prepared and planted in a wheat cover crop in January of 2019. It was then strip tilled in upland cotton in April for harvest in the fall.

3.2 2020 Season

A cover crop of wheat was planted in 2020 prior to strip tilling with red chilies in late March. Chilies were harvested in October. The test field suffered hail damage late in the season, so actual yields were reduced. Insurance adjusted yields were measured and recorded in addition to actual yields.

3.3 2021 Season

The drip field was planted in a wheat cover crop in January of 2021 and then strip tilled in upland cotton in April. The crop suffered hail damage in May and was replanted, only to be destroyed again by high winds and hail. The field was again planted in wheat as a cover crop for the following year. Due to crop loss, 2021 water and yield data are not included in this analysis.

4 Methodology and materials used

A subsurface drip irrigation system for 150 acres was designed, engineered, and installed between October 2018 and January 2019. Installation included five, forty-eight-inch tank sand media filters capable of 1,200 to 1,800 gallons per minute. Jain Cascade drip tape between one and one and one-eighth inch diameter and thirteen millimeters thick was installed. Emitters were calibrated to thirteen hundredths of a gallon per hour output with twelve inch spacing and they were buried eight-to-twelve-inch sub-surface. The length of the lateral field lines determined the size of the tape so two tape sizes were used. The system was designed for a total of twenty-eight zones with seven concurrent watering zones in one cycle at 260 gallons per zone. One, three-inch plastic solenoid control valve was installed per zone. Each zone is controlled by a GreenPlanet thirty station controller in the filter house and fitted with an AgSense Field Commander for remote monitoring. A thirty gallon per hour acid resistant chemigation pump with single phase meter and EZ grab base was installed. The system is fully automated and corrosion and rust resistant. The filtration system uses a corrosion-proof integral polyethylene liner, plastic underdrain, and polypropylene manifolds resistant to common agricultural chemicals. The system was tested and visually inspected for leaks by walking each zone. The farm staff was trained in how to use and monitor the system.

System specifications:

- Good Quality Water – twenty-five gallons per minute per square foot
- Dirty Water - twenty gallons per minute per square foot

- Minimum Filtration Pressure: fifteen pounds per square inch
- Minimum Backflush Pressure: thirty pounds per square inch
- Maximum Operating Pressure: eighty-five pounds per square inch
- Sand Requirement: thirteen hundred pounds per forty-eight-inch tank
- Manifolds: Polypropylene
- Leg Height: Adjustable
- Backflush Valve: four-inch plastic grooved valve

Water applied to each field was monitored and recorded using flow meter and AgSense Field Commander data. Manual inspection for leaks was performed with each irrigation cycle. Fertilizer applications and tactor activities were monitored and recorded throughout each season. Crop yields from each field were recorded at harvest. The amount of water per unit of yield was compared for each method of irrigation for each field.

5 Analysis of results

5.1 Comparisons of irrigation water, fertilizer, and tractor use

For each field the gallons of irrigation water, fertilizer and tractor passes were recorded each year. The cumulative data for 2019 and 2020 are shown in Table 5-1 below. Data for 2021 is not included due to the destruction of the drip irrigated cotton crop by weather. The drip field was replanted and was again destroyed by weather. The drip field remained fallow for the remainder of 2021.

Table 5-1 Total gallons water per acre, gallons fertilizer per acre and tractor passes for 2019-2020

Field type	Gal H2O/ac	Gal fertilizer/ac	Tractor passes
Flood	1,979,033	110	27
Pivot	1,891,418	104	20
Drip	1,166,313	57	10

5.1.1 Irrigation water

As depicted in Table 5-2 the amount of water saved by using drip irrigation rather than flood irrigation was forty-one percent equating to 121,907,970 gallons of water that would have been saved if the flood field was drip irrigated. Similarly, the reduction in water by using drip rather than center pivot irrigation was thirty-eight percent, or 108,765,701 gallons. The total gallons of water that would have been saved if both the flood and center pivot irrigated fields were drip irrigated would have been 230,673,670.

Table 5-2 Gallons of water used and projected savings – 150 acres per field

Irrigation Method	2019	2020	2021	Total gal used	Change in % used	Projected savings
Flood	76,905,495	219,949,425	-	296,854,920	-41%	121,907,970
Pivot	83,314,286	200,398,365	-	283,712,651	-38%	108,765,701
Drip	28,314,000	146,632,950	-	174,946,950	0%	
					Total Savings	230,673,670

Figure 5-1 depicts the comparison of water used per acre for each irrigation method in 2019 and 2020, while Figure 5-2 depicts the comparison of total water used by irrigation type.

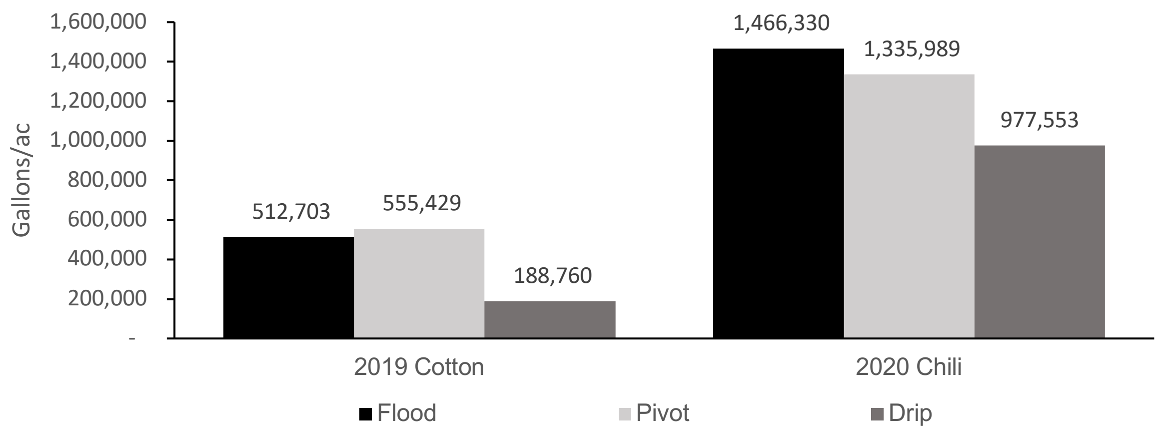

Figure 5-1 Comparison of irrigation water per acre by irrigation type per year

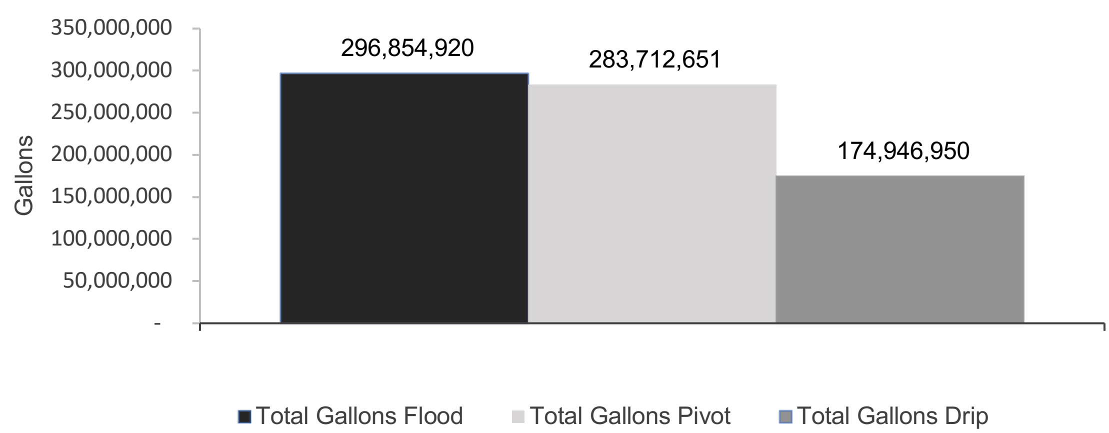

Figure 5-2 Total gallons of irrigation water by irrigation type – all years

5.1.2 Tractor Use and Fertilizer

The number of times a tractor was required to pass over each field was recorded, as was the amount of fertilizer applied to each field.

Table 5-3 Tractor passes and gallons fertilizer used

Tractor Passes/field and Gallons Fertilizer/acre						
	2019		2020		2019/2020 combined	
Irrigation method	Tractor passes	Gallons fertilizer	Tractor passes	Gallons fertilizer	Tractor passes	Gallons fertilizer
Flood	15	45	12	65	27	110
Pivot	13	41	7	62	20	103
Drip	6	17	4	40	10	57

As shown in Figure 5-3 below, tractor use was significantly less on the drip irrigated field than both flood and center pivot irrigated fields, thereby reducing fuel and labor inputs without sacrificing yields.

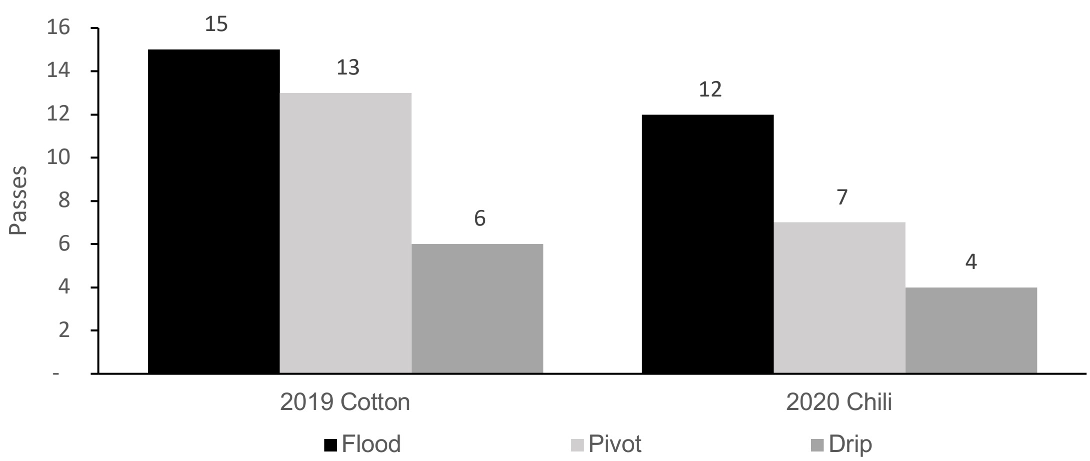

Figure 5-3 Number of tractor passes by irrigation type and year

The amount of fertilizer was also significantly less on the drip irrigated field compared to the flood and center pivot fields, as shown in Figures 5-4 and 5-5 below. The ability to apply fertilizer directly into the root zone improved the fertilizer efficiency thereby reducing the amount of fertilizer required relative to the other irrigation methods.

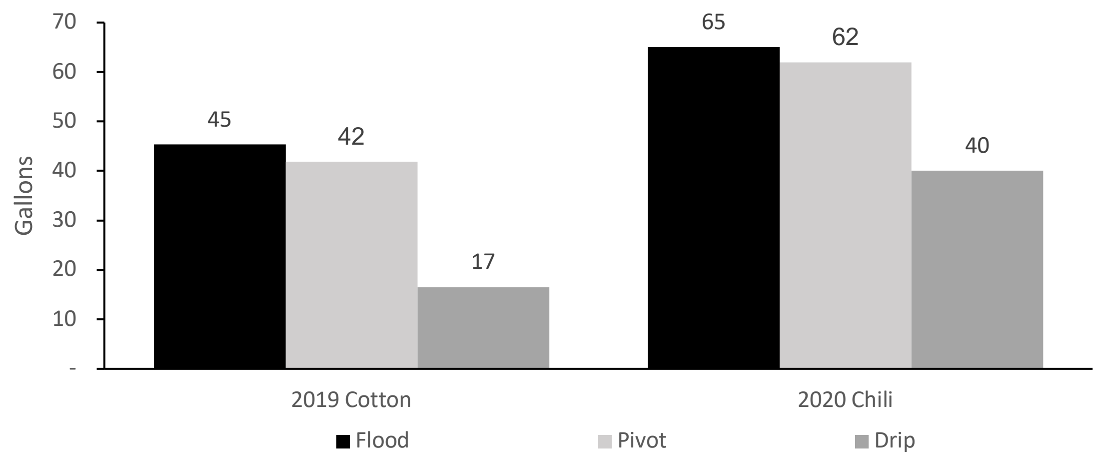

Figure 5-4 Gallons fertilizer/ac by irrigation type and year

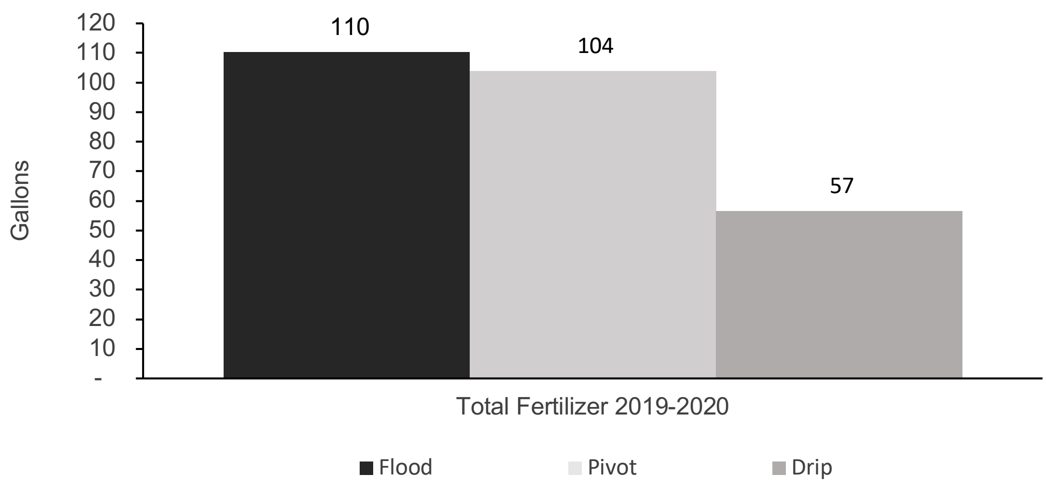

Figure 5-5 Total fertilizer 2019-2020

5.2 Crop yields

Each year the yields from each field were recorded and compared. Table 5-4 compares yields between the various irrigation methods. The flood irrigated field produced the highest yield of cotton at 4.10 bales per acre, followed by the drip irrigated field at 3.83 bales per acre. The center pivot irrigated field had the lowest cotton yield at 3.10 bales per acre. The drip irrigated chili crop suffered weather damage in 2020 resulting in an insurance claim. Both actual and insurance adjusted yields were recorded. Actual chili yields were equal between drip and flood irrigation at 2,200 pounds per acre, while the center pivot field produced slightly less at 2,100 pounds per acre. Insurance adjusted yield on the drip irrigated field was superior at 3,600 pounds per acre.

Table 5-4 Comparison of crop yields on flood, center pivot and drip irrigated fields

Comparison of Crops Yields			
Irrigation method	2019 cotton bales/ac	2020 chili lbs./ac	2021
Flood	4.10	2,200	na
Pivot	3.10	2,100	na
Drip	3.83	2,200 (3,600 ins. Adj.)	na

5.3 Water and crop yields

The amount of water used to produce one unit of crop yield was calculated to determine if the drip irrigation was more, or less, water efficient and is shown in Table 5-5.

Table 5-5 Gallons of water per unit crop yield

Gallons Water/unit Crop Yield			
	2019	2020	2021
Irrigation method	Gallons water/bale cotton	Gallons water/lb. chili	Gallons water/bale cotton
Flood	125,049.58	666.51	na
Pivot	179,170.51	636.19	na
Drip	49,349.02	444.34	na

Figure 5-6 compares the bales of cotton produced and the amount of water used to produce them for each irrigation method. The amount of water per bale of cotton produced was greatest with center pivot at 179,170 gallons per bale. Flood irrigation used 125,049 gallons per bale, while drip irrigation used the least water per bale at only 49,349 gallons per bale.

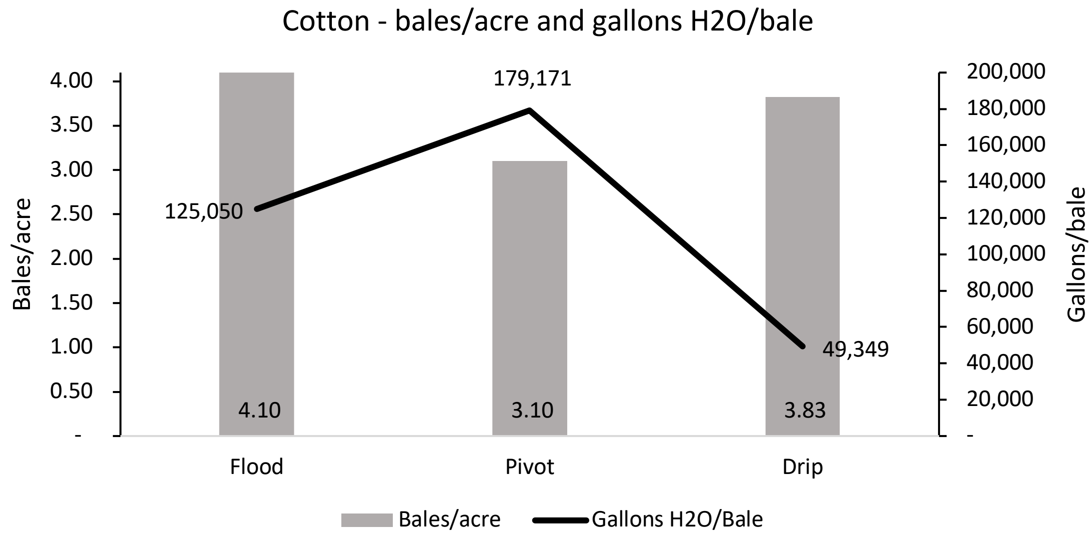

Figure 5-6 Bales cotton per acre and gallons water per bale

Figure 5-7 below shows that flood irrigation on chili used the most water per pound at 666.51 gallons per pound. Center pivot irrigation was second highest for chili at 636.19 gallons per pound, and drip irrigation used the least at 444.34 gallons per pound. The amount of water per pound of adjusted yield for the drip irrigated crop was the most efficient at only 271.54 gallons per pound.

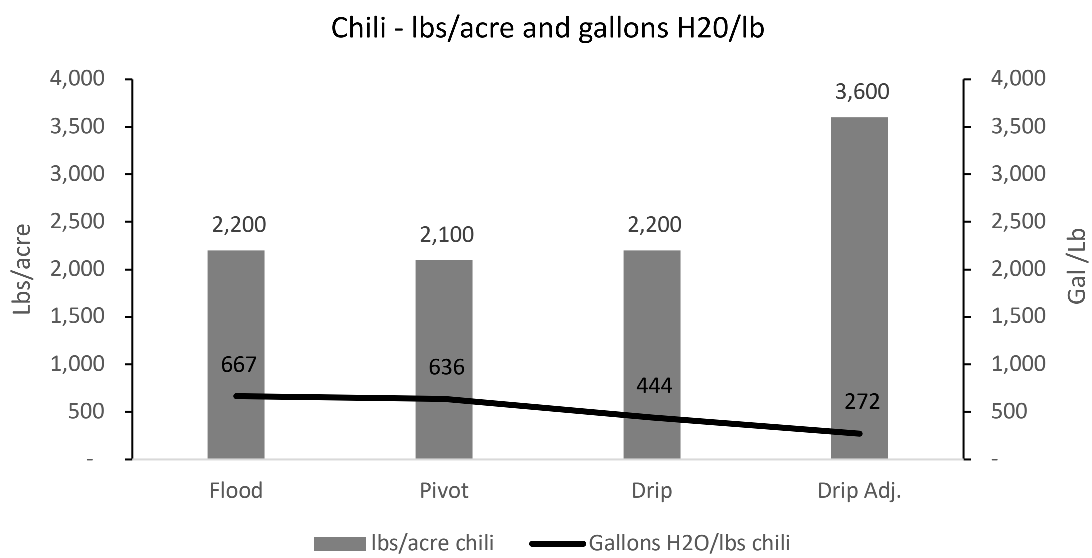

Figure 5-7 Lbs. chili per acre and gallons water per lb.

6 Conclusions and recommendations

The comparison of sub-surface drip irrigation to flood and center pivot irrigation on land in Dell City, Texas demonstrated that drip irrigation can improve efficiencies in water use, crop yields, fertilizer use and tractor activities compared to conventional flood and center pivot irrigation systems.

The results of these comparisons suggest that had both the flood and center pivot irrigated fields used drip irrigation a total savings of 230,673,670 gallons of water would have been realized. There was a forty-one percent reduction over flood irrigation, and a thirty-eight percent reduction over center pivot irrigation. The use of sub-surface drip irrigation also resulted in savings in fertilizer and tractor activities without sacrificing yields, and in some instances yields were greater.

These results can reasonably project significant water conservation with the potential for improved operating income relative to conventional irrigation methods. A careful analysis of the capital costs and operating savings should be performed to evaluate potential financial savings and returns.