Determining the Ideal Irrigation Strategy for High Intensity Corn Production

MGPUB Grant Proposal Number 2017305 – 5th Year Project Report

Principal Investigators: James Adkins, Cory Whaley, Phillip Sylvester & Amy Shober

***Project Overview*:**

This 5-year project will determine the ideal irrigation management strategy for intensively managed corn through randomized research plots under the University of Delaware's variable rate center pivot. Each of the 11 irrigation treatments will have their soil moisture levels continuously monitored and the irrigation will be applied accordingly. The final result will be a determination of the most profitable method to manage irrigation for the coastal plains of the Mid-Atlantic.

Project Activities & Methods:

An intensive study was conducted in the 2013 through 2017 crop seasons to determine the response of intensively managed, high population corn to various soil moisture levels. All of the work for these studies was conducted under a variable rate four tower center pivot irrigation (VRI) system located on the University of Delaware's Warrington Irrigation Research Farm in Harbeson, DE. The entire study area was treated identically for all production inputs except irrigation. Fertilizer was applied based on the University of Delaware recommendations for irrigated corn production and included applications of poultry manure, potash, starter, and sidedress (*Table 1*).

Table 1. Field Operations, nutrient and pesticide applications.

Date	Corn	Material	Rate
18-Apr	Poultry Manure		3 tons/A
19-Apr	Chisel Plow		
25-Apr	Field Cultivate		
1-May	Potash	0-0-60	200 lbs/A
2-May	Field Cultivate		
3-May	Planted		
	Hybrid	Axis 66A22 and Axis 66P25	
	Seeding Rate		34,000 sd/A
	Starter	20-12-0-3S	15 gal/A
4-May	Bicep II Magnum		1.75 qts/A
8-June	Generic Glyphosate		32 oz/A
	Callisto		3 oz/A
	Aatrex		1 pt/A
9-Jun	Sidedress	28-0-0-2S	55 gal/A
30-Jul	Headline Amp		12.3 oz/A
2-Oct	Harvest		

Using a combination of soil electro-conductivity mapping, aerial imagery and historical yield maps, the field was divided into 5 tiers (replications) of varying soil type (Tier 1 = 20% wettest/heaviest soil – Tier 5 = 20% driest/lightest soil). Within each soil type tier, the 24 acre research field was divided into 6 randomized irrigation treatments (*Table 2*) for a total of 30 individual plots. The VRI pivot enables each of the 30 plots to be irrigated separately through a complex control system that uses GPS to monitor the pivot's location and individually control each of the 85 nozzle control solenoids. Plot size measured 120 ft x 120 ft. Each plot was split with 2 corn hybrids, Axis 66A22 and Axis 66P25.

Table 2. Irrigation Treatments
Higher centibar (cb) triggers indicate drier plots while lower cb triggers are wetter. The 100% ET treatment should be similar to the 30 cb treatments (moderately wet).

1. Evapotranspiration (ET) based irrigation management using the Delaware Environmental Observing System's weather station located on the research farm and the commonly accepted corn crop coefficients. Irrigation will be triggered when the predicted soil moisture level reaches a 50% Managed Allowable Depletion (MAD).
2. ET based schedule using the same trigger as treatment #1 but only applying 80% of the irrigation depth applied at each event.
3. ET based schedule using the same trigger as treatment #1 but only applying 50% of the irrigation depth applied at each event.
4. 30 cb Soil Moisture based irrigation trigger.
5. High population dryland (34,000 seeds/acre).
6. Low population dryland (22,000 seeds/acre).

Soil moisture was monitored in each plot using Watermark soil moisture sensors placed at 6", 12" and 18" below the soil surface. The corresponding soil moisture data was transmitted wirelessly approximately 10 - 20 times daily from the field to a data logging receiver. Moisture data was viewed, analyzed and interpreted daily to determine if any treatments required irrigation. Plot irrigation was triggered whenever soil moisture reached the specific treatment requirements at the 6" or 12" depth. Given the number of irrigation treatments and variability in soils, the irrigation system was run daily, except during major rain events, irrigating anywhere from 1 to 30 plots depending on moisture levels. Weather data was collected by a Delaware Environmental Observing System weather station located on the irrigation research farm.

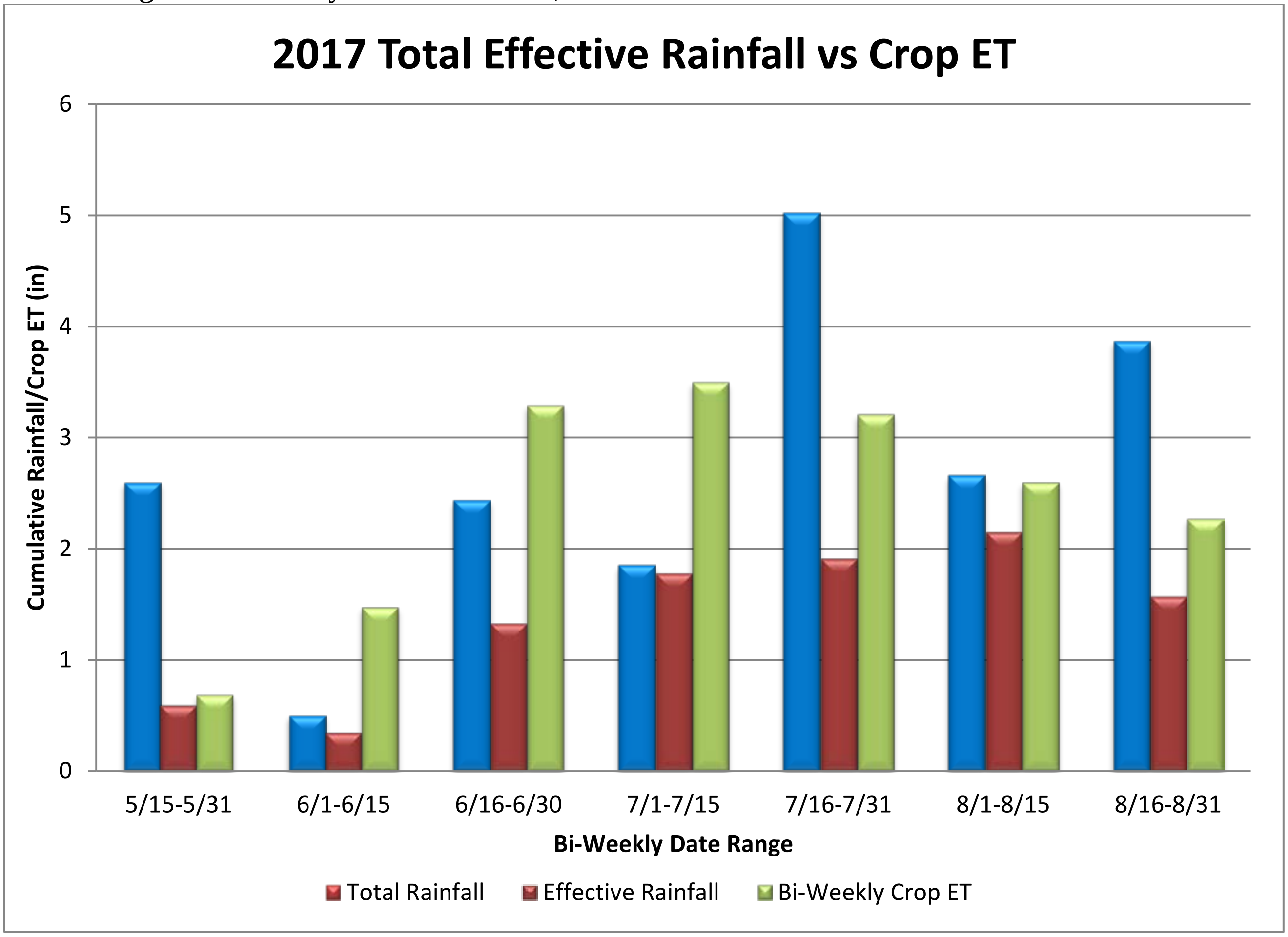
Plots were harvested with a Massey Ferguson plot combine to determine yield, moisture and test weight of each corn hybrid and the measured grain yield was adjusted to 15.5% moisture.

Results and Discussion:

Rainfall

In our area, 2017 was a below average year for irrigated corn production. Planting occurred in the normal first week of May target date, however pollination occurred when nighttime temperatures were oppressive. Heavy rainfall in early May hurt stands and adequate of rain fell in late July and August. The first half of July was the only time the crop was stressed for water all season. *Figure 1* illustrates the rainfall totals received (blue bars) at the research site in comparison to effective rainfall (red bars) and the calculated crop ET (green bars). Effective rainfall is a measure of the volume of rain that is stored in the soil and not lost to deep infiltration or runoff. Overall the center pivot managed corn crop received a seasonal total of 19" of rain with 9.7" of that rain being effective or stored. As a result, a total of 2.2" of rain either ran off the field or infiltrated beyond the root zone. In comparison, this same research site received a total of 25" of rain in 2013 with 9" being effective, 17" in 2014 with 9" being effective, 11.4" in 2015 with 7.4" being effective, and 10.2" in 2016 with 8" being effective.

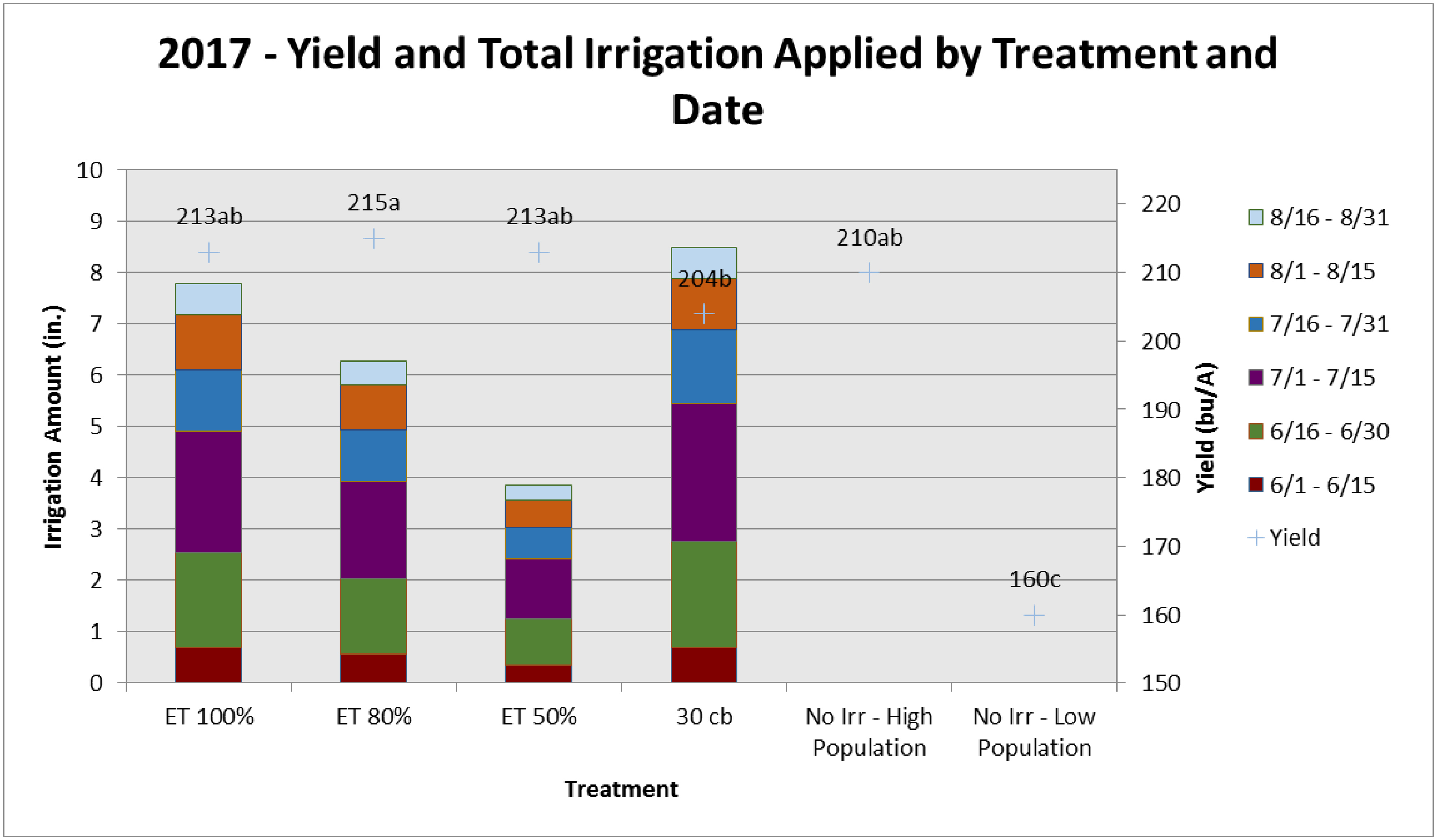
Figure 1. Bi-weekly rainfall totals (blue), Effective Rainfall (red) and Cumulative Crop ET (green) at the Warrington Farm study site in Harbeson, DE in 2017.



Applied Irrigation:

The total amount of applied irrigation staged as one would expect based on the treatments shown in *Figure 2*. The 100% ET and 30 cb treatments had similar applied irrigation totals at 8" +/- 0.1". The remaining treatments, received declining irrigation totals as defined by the treatment. The amount of irrigation varied by 2.5 in. across the 5 replications of the 30cb treatment (data not shown). This variance points towards soil type and condition as being the primary driver of irrigation needs.

Figure 2. Corn yield (black squares) and total irrigation applied bi-weekly by treatment in 2017. Each color represents the total amount of irrigation applied to the specified date range. The top of the bar represents the cumulative total irrigation applied for the season. Yields with the same letter designation have no statistical difference.



Summary of Results:

The 2017 yields at the University of Delaware Warrington Irrigation Research Farm were off by about 20-30 bushels per acre compared to yields achieved in 2014 and 2015, and were similar to 2016. The low population dryland yield in 2017 was typical for the area and soil type. The 50 bu/acre disparity between the low and high population dryland treatments demonstrates the benefits of increased population during years with moderate to high rain.

In 2017, there was very little separation in yield between any irrigated treatment where yields ranged from 204 to 215 bu/A. Statistically, the only irrigated treatment with a yield drag was the sensor trigger 30cb; which also received the most irrigation. There was no statistical difference between the ET triggered plots that received half the water and the full rate, again indicating that yields were not limited by water. The quadrupling of the plot size to 120' x 120' greatly improved our confidence in the research methods. Going forward, this type of project may require a rainfall protection structure to remove rain from the uncontrolled variables. Additional work on population, maturity range and planting date also play a major part irrigated yield differences.

Year 4 Project Expenditures:

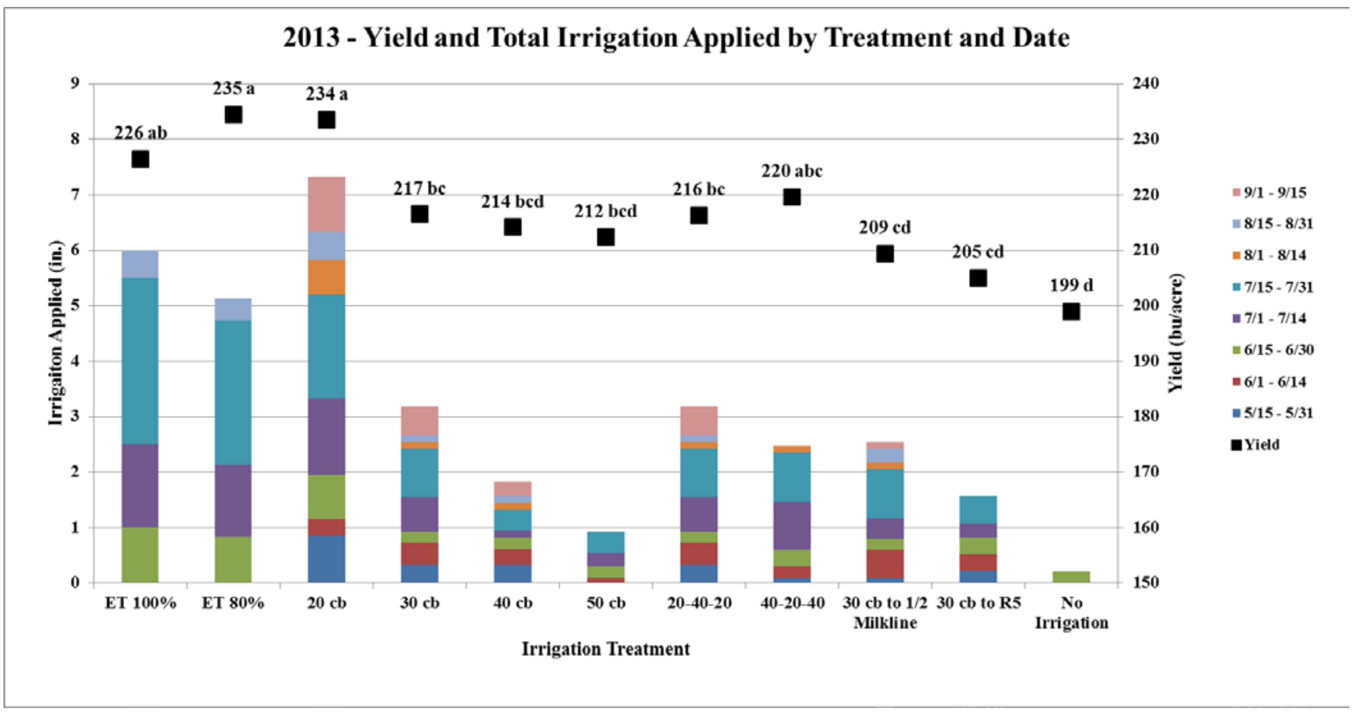
Purpose	Amount
Professional Salary	$ 15,021.07
Fringe benefits	$ 4,159.50
Student Wages	$ 0.00
Fringe benefits	$ 0.00
Travel - PI Travel to Research Site	$ 0.00
Supplies - Sensor Repair & Installation	$ 0.00
2017 Total Project Expenditures	**$ 19,180.57**
2017 MGPUB Project Award	**$ 22,720.00**

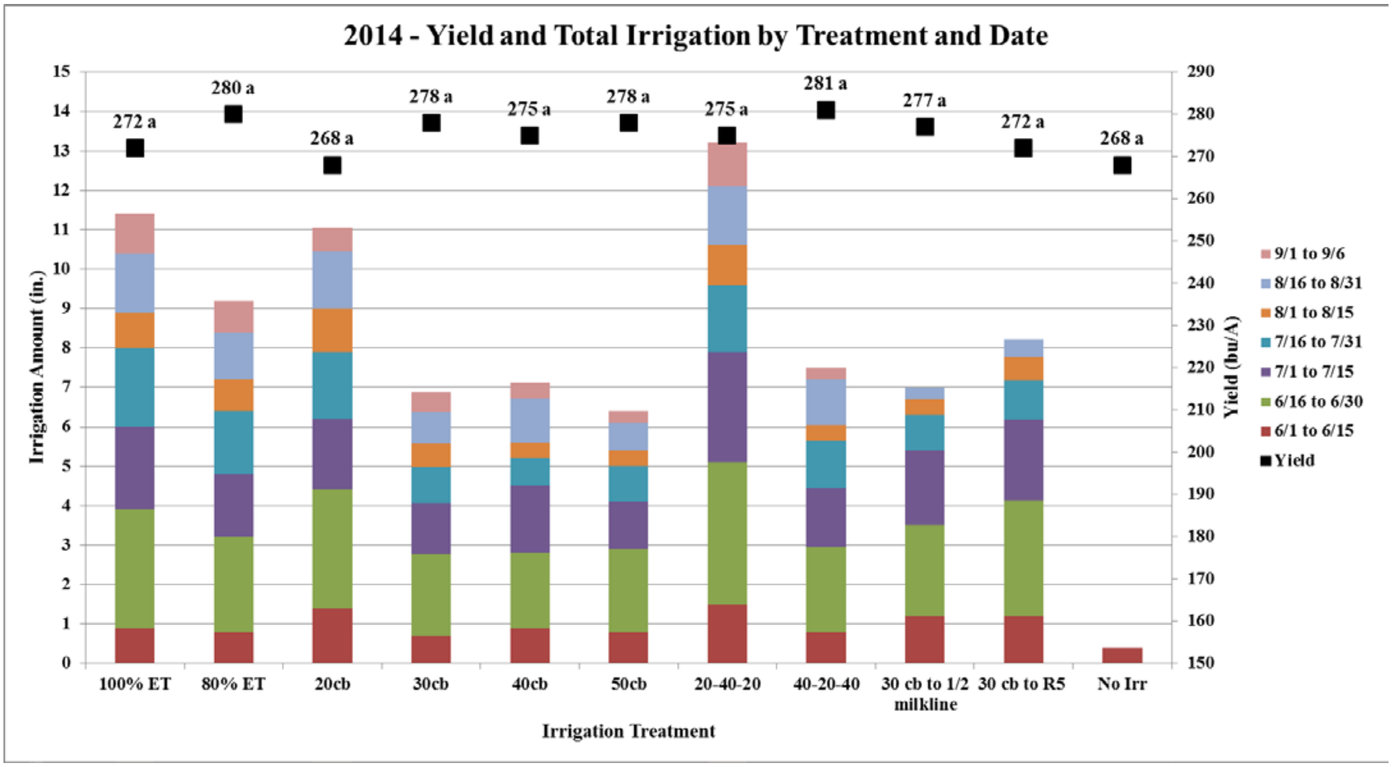
Please contact the project PI (James Adkins adkins@udel.edu) if further clarification is needed.

Summary 2013, 2014, 2015, 201, and 2017Research Results

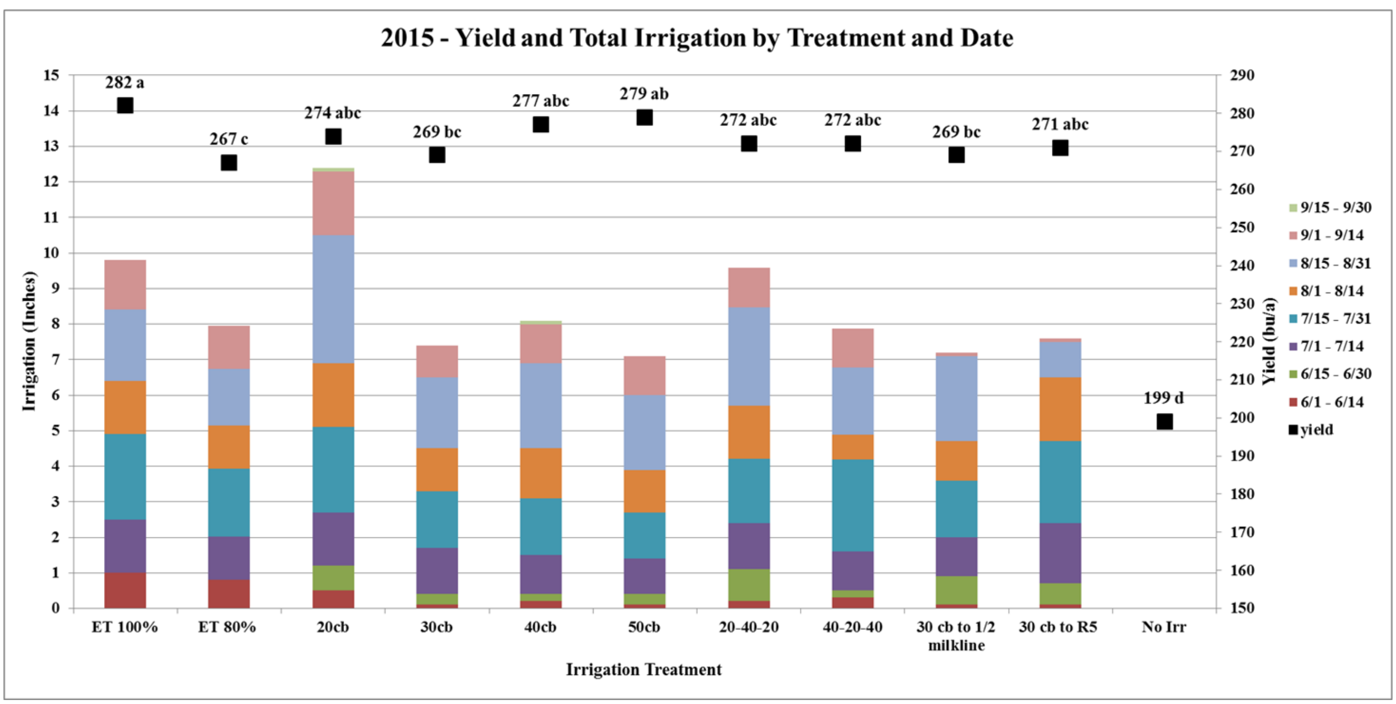
Each of the 5 years of this study demonstrated different trends regarding the best method to schedule pivot irrigation. 2013 tended to show that the wetter treatments performed best; in 2014 there was no need to irrigate as the dryland yields were not significantly lower than irrigated; in 2015 the yields were good as long as some irrigation was provided; and in 2016 irrigated treatments were similar and only slightly higher than the dryland treatment; 2017 showed no difference between identically timed irrigations at 100 and 50 percent of the applied irrigation.

The main conclusion that can be drawn is that '13-'15 season were ideal corn production years with little natural moisture stress. In our area, 2016 was not a great year for high-yield corn production. Yield levels achieved in this research in 2016 were off by about 40 bushels per acre compared to yields achieved in 2014 and 2015. In addition, the dryland treatment yield in 2016 was higher than expected despite the less than adequate rainfall received in July and August. 2017 yield were limited by something other than water, likely heat during pollination.

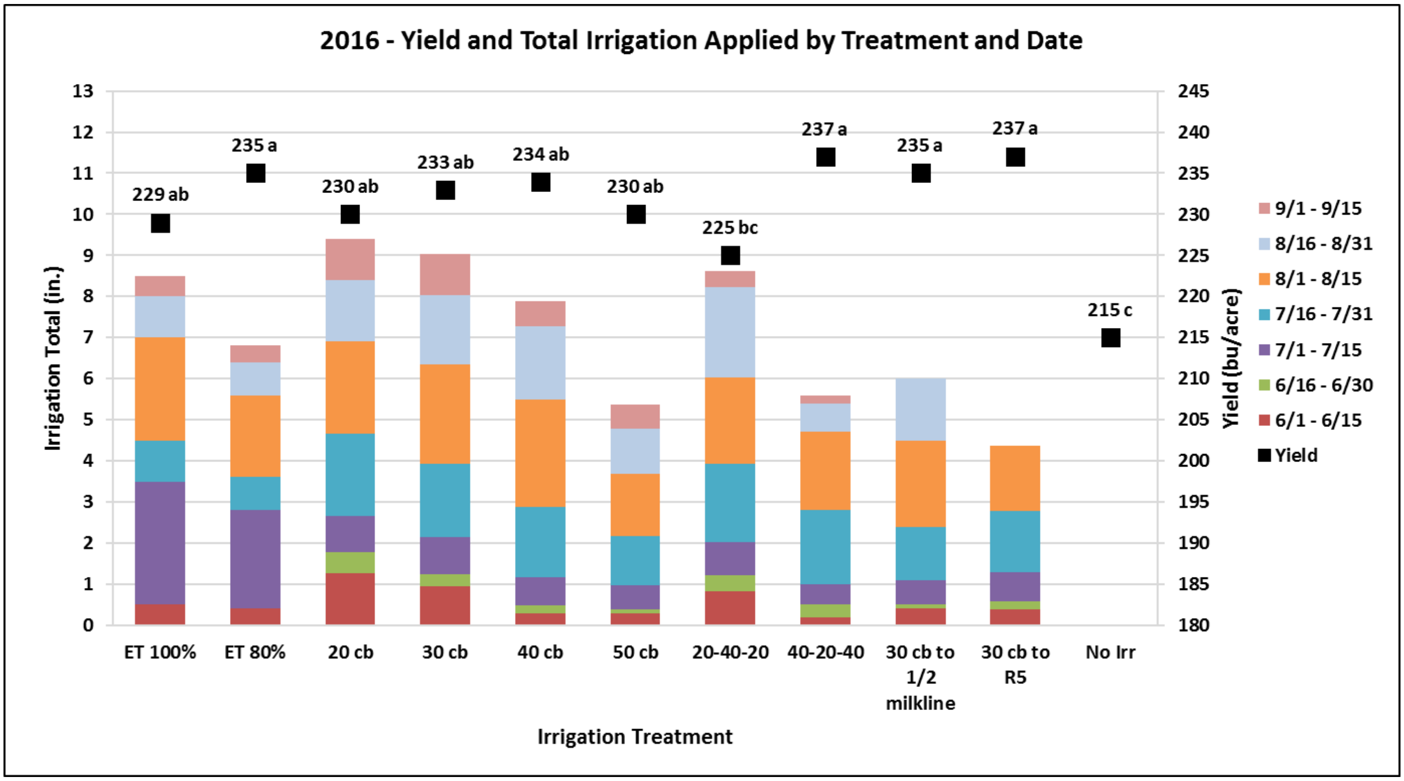


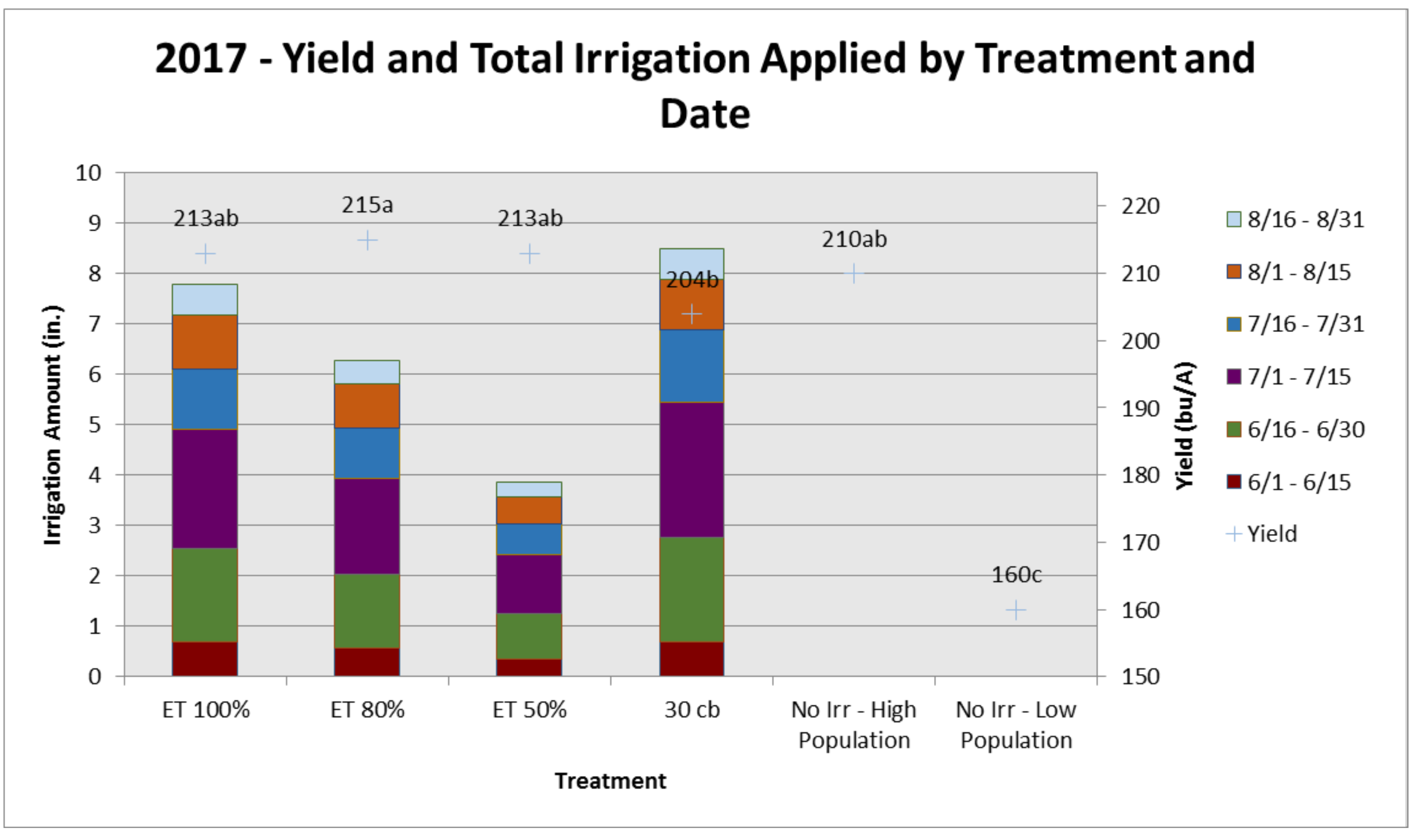


2014 - Yield and Total Irrigation by Treatment and Date
Irrigation Amount (in.)
Yield (bu/A)
Irrigation Treatment
100% ET
80% ET
20cb
30cb
40cb
50cb
20-40-20
40-20-40
30 cb to 1/2 milkline
30 cb to R5
No Irr
272 a
280 a
268 a
278 a
275 a
278 a
275 a
281 a
277 a
272 a
268 a
9/1 to 9/6
8/16 to 8/31
8/1 to 8/15
7/16 to 7/31
7/1 to 7/15
6/16 to 6/30
6/1 to 6/15
Yield



2015 - Yield and Total Irrigation by Treatment and Date
Irrigation (Inches)
Yield (bu/a)
Irrigation Treatment
ET 100%
ET 80%
20cb
30cb
40cb
50cb
20-40-20
40-20-40
30 cb to 1/2 milkline
30 cb to R5
No Irr
282 a
267 c
274 abc
269 bc
277 abc
279 ab
272 abc
272 abc
269 bc
271 abc
199 d
9/15 - 9/30
9/1 - 9/14
8/15 - 8/31
8/1 - 8/14
7/15 - 7/31
7/1 - 7/14
6/15 - 6/30
6/1 - 6/14
yield


2016 - Yield and Total Irrigation Applied by Treatment and Date
Irrigation Total (in.)
Yield (bu/acre)
229 ab
235 a
230 ab
233 ab
234 ab
230 ab
225 bc
237 a
235 a
237 a
215 c
9/1 - 9/15
8/16 - 8/31
8/1 - 8/15
7/16 - 7/31
7/1 - 7/15
6/16 - 6/30
6/1 - 6/15
Yield
ET 100%
ET 80%
20 cb
30 cb
40 cb
50 cb
20-40-20
40-20-40
30 cb to 1/2 milkline
30 cb to R5
No Irr
Irrigation Treatment


2017 - Yield and Total Irrigation Applied by Treatment and Date
Irrigation Amount (in.)
Yield (bu/A)
213ab
215a
213ab
204b
210ab
160c
8/16 - 8/31
8/1 - 8/15
7/16 - 7/31
7/1 - 7/15
6/16 - 6/30
6/1 - 6/15
Yield
ET 100%
ET 80%
ET 50%
30 cb
No Irr - High Population
No Irr - Low Population
Treatment