Determining the Ideal Irrigation Strategy for High Intensity Corn Production

MGPUB Grant Proposal Number 2015305 – 3rd Year Project Report
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***Project Overview*:**

This 3 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 2013, 2014, and 2015 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, starter, side dress, and fertigation (*Table 1*).

Table 1. Field Operations, nutrient and pesticide applications.

Date	Corn	Material	Rate
22-Apr	Poultry Manure		3 tons/A
24-Apr	Chisel Plow		
4 & 12 May	Field Cultivate		
14-May	Planted		
	Hybrid	Dekalb 62-08 with Poncho 500/Votivo	
	Seeding Rate		34,000 sd/A
	Starter	20-12-0-2S	15 gal/A
21-May	Bicep II Magnum		1.4 qts/A
	Generic Glyphosate		32 oz/A
17-June	Generic Glyphosate		32 oz/A
	Callisto		3 oz/A
	Aatrex		1 pt/A
11-Jun	Sidedress	26-0-0-4S	23 gal/A
10-Jun	Fertigate	26-0-0-4S	14.1 gal/A
30-Jun	Fertigate	26-0-0-4S	14.1 gal/A
13-Jul	Fertigate	26-0-0-4S	14.1 gal/A
15-Jul	Headline Amp		12.3 oz/A
	Warrior		3.84 oz/A
30-Sept	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 11 randomized irrigation treatments (*Table 2*) for a total of 55 individual plots. The VRI pivot enables each of the 55 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.

Table 2. Irrigation Treatments Higher cb triggers indicate drier plots while lower cb triggers are wetter. The ET treatment should be similar to the 30cb 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. 80% of ET applications
3. Full season irrigation using 20 centibar soil moisture trigger
4. Full season irrigation using 30 centibar soil moisture trigger
5. Full season irrigation using 40 centibar soil moisture trigger
6. Full season irrigation using 50 centibar soil moisture trigger
7. Emergence to V16 – 20 centibar soil moisture trigger; V16 to R3 – 40 centibar soil moisture trigger; R3 to Maturity – 20 centibar soil moisture trigger (20-40-20)
8. Emergence to V16 – 40 centibar soil moisture trigger; V16 to R3 – 20 centibar soil moisture trigger; R3 to Maturity – 40 centibar soil moisture trigger (40-20-40)
9. Emergence to R5 – 30 centibar soil moisture trigger; R5 to Maturity – No irrigation (30cb – R5)
10. Emergence to Half Milkline – 30 centibar soil moisture trigger; Half Milkline to Maturity – No irrigation (30cb to half milkline)
11. No Irrigation

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 50 plots depending on moisture levels. Weather data was collected by a Delaware Environmental Observing System weather station located on the irrigation research farm.

Stalk nitrate samples were collected prior to harvest. Plots were harvested with a Gleaner K2 plot combine to determine yield, moisture and test weight differences and the measured grain yield was adjusted to 15.5% moisture.

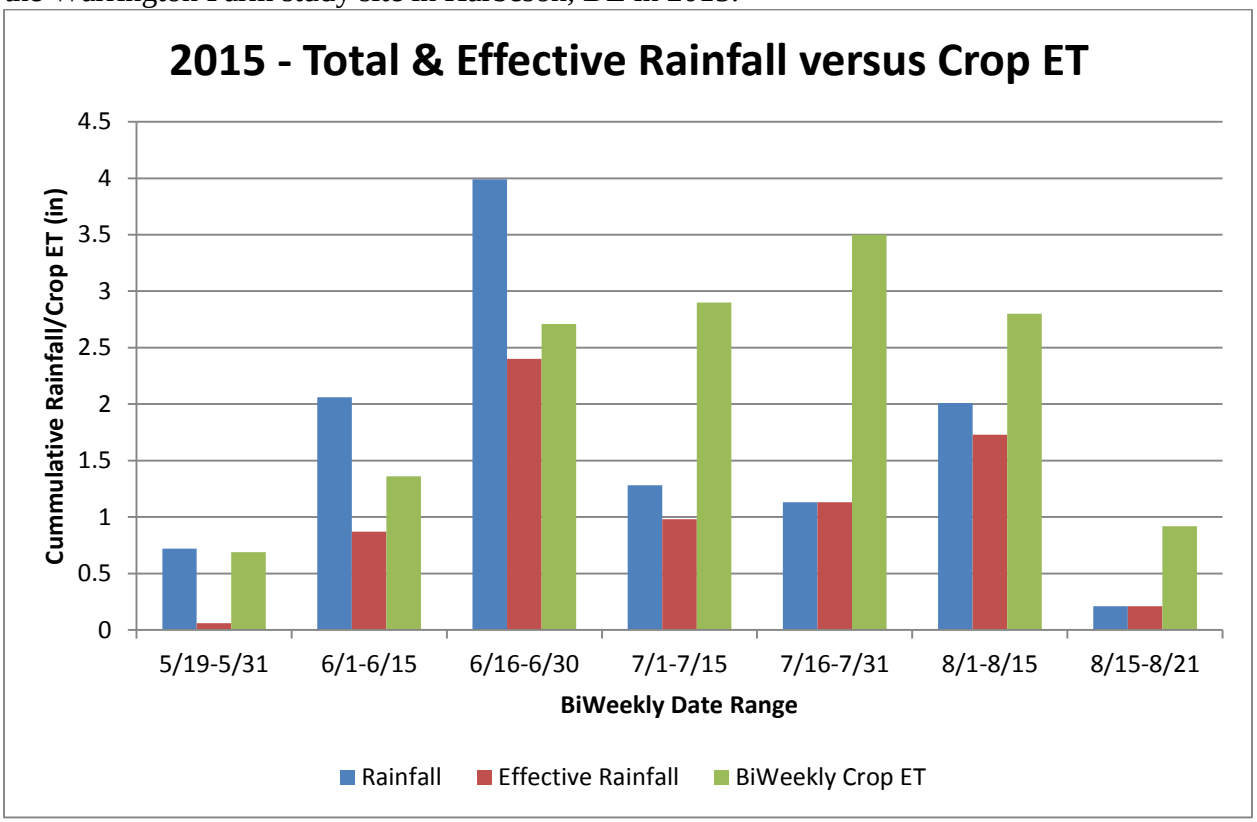
Results and Discussion:

Rainfall

2015 was a good year for corn production statewide. Early season rainfall was timely and able to provide more than adequate water for the crop. Rainfall in July was sparse and inadequate for the crop however relatively mild temperatures limited yield losses from heat stress. *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 11.4" of rain with 7.4" (irrigated) of that rain being effective or stored. As a result, a total of 4" of rain either ran off the field or infiltrated beyond the root zone carrying with it at least some of the applied nitrogen. In comparison, this same research site received a total of 25" of rain in 2013 with 9" being effective and 17" in 2014 with 9" being effective.

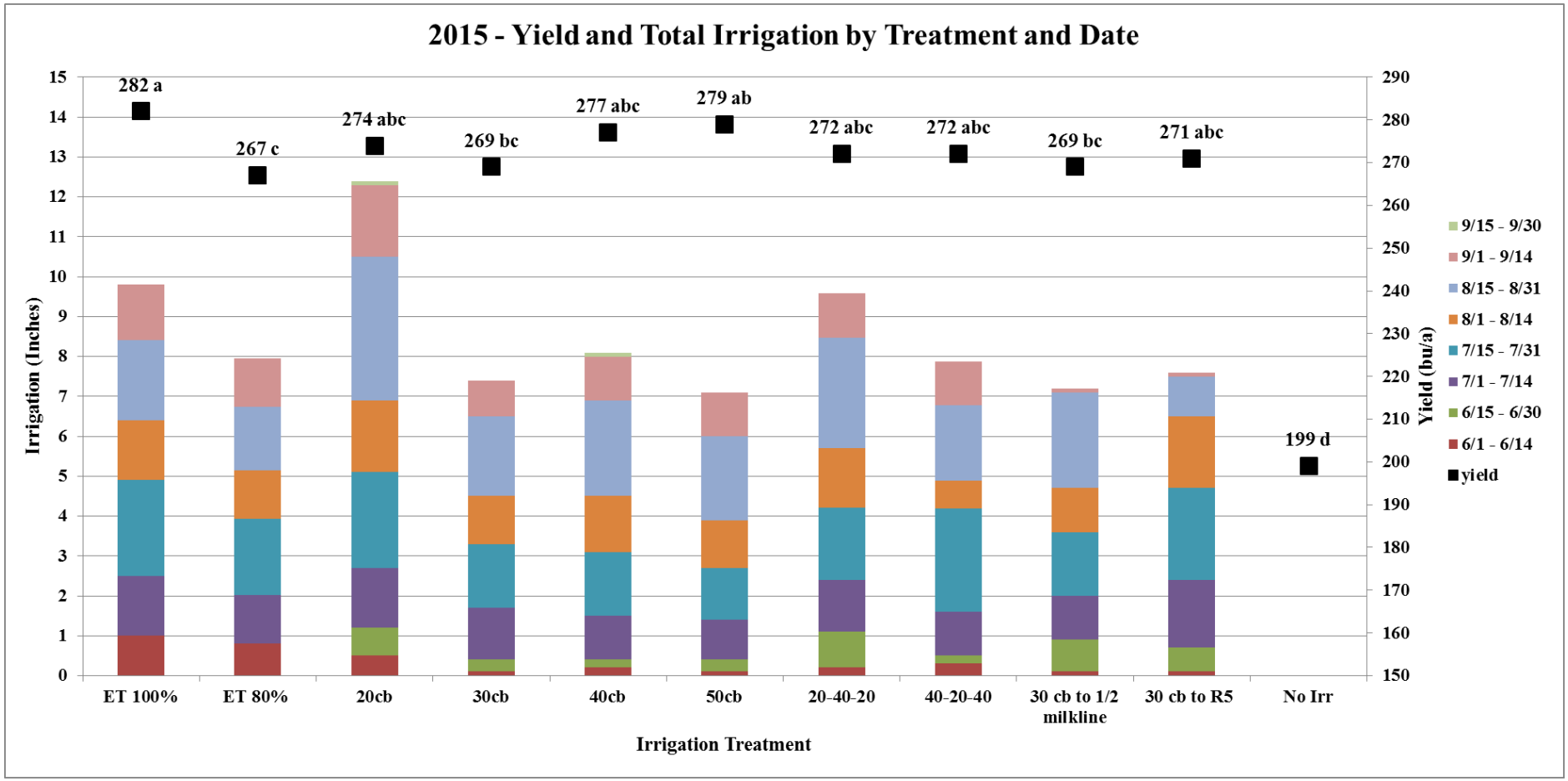
Figure 1. Bi-weekly rainfall totals (blue), Effective Rainfall (red) and Cumulative Crop ET (green) at the Warrington Farm study site in Harbeson, DE in 2015.



Applied Irrigation:

The total amount of applied irrigation staged as one would expect based on the treatments shown in *Figure 2*. The 20cb, 100% ET, 20-40-20cb and 80% ET treatments received the most irrigation with a total of 12", 10", 9.5", and 8" applied. The remaining treatments received nearly equal amount of irrigation (around 7") although the timing of the applications varied slightly. The amount of irrigation varied greatly across the 5 replications of any given treatment. 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 2015. 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 yields at the University of Delaware Warrington Irrigation Research Farm were good in 2015 (*Figure 2*). The dryland yield was consistent across all replications; it is not representative of true dryland yields at this site due to the application of 260 pounds of nitrogen and planted population of 34,000 seeds per acre. These non-typical dryland planting and fertilizer rates are a function of the limited ability of the equipment to apply randomized treatments. Furthermore, the purpose of this project is to compare irrigation methods and timings and multiple populations/fertility would create a biased experiment.

2015 irrigation amounts were very similar across all treatments as were the respective yields. The lack of any trend is likely the function of favorable weather for corn production and adequate subsoil moisture. The subsoil moisture may be mitigating the negative effects of the dry irrigation treatments and providing enough water to carry the plant through to the next rain event.

The common irrigation amounts across all treatments are a reflection that the evapotranspiration based model is closely predicting the actual soil moisture values. If this correlation continues to hold true, ET could be a more accurate predictor of crop water use than has been previously assumed.

Year 3 Project Expenditures:

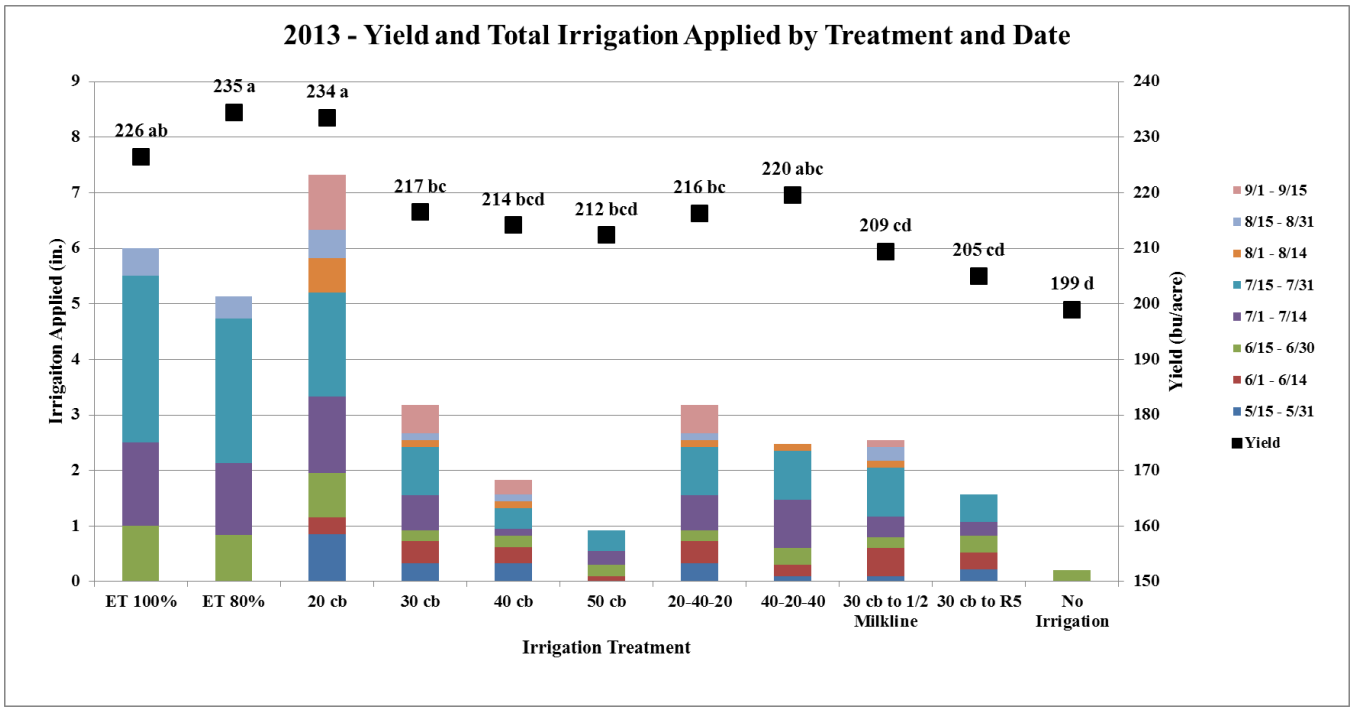
Purpose		Amount
Professional Salary	Willey	$ 16,228.11
Fringe benefits	Willey	$ 5,684.59
Student Wages	Pedigo	$ 514.25
Fringe benefits	Pedigo	$ 40.63
Travel - PI Travel to Research Site		$ 313.38
Supplies - Sensor Repair & Installation		$ 192.53
2015 Total Project Expenitures		**$ 22,973.49**
2015 MGPUB Project Award		**$ 27,394.65**

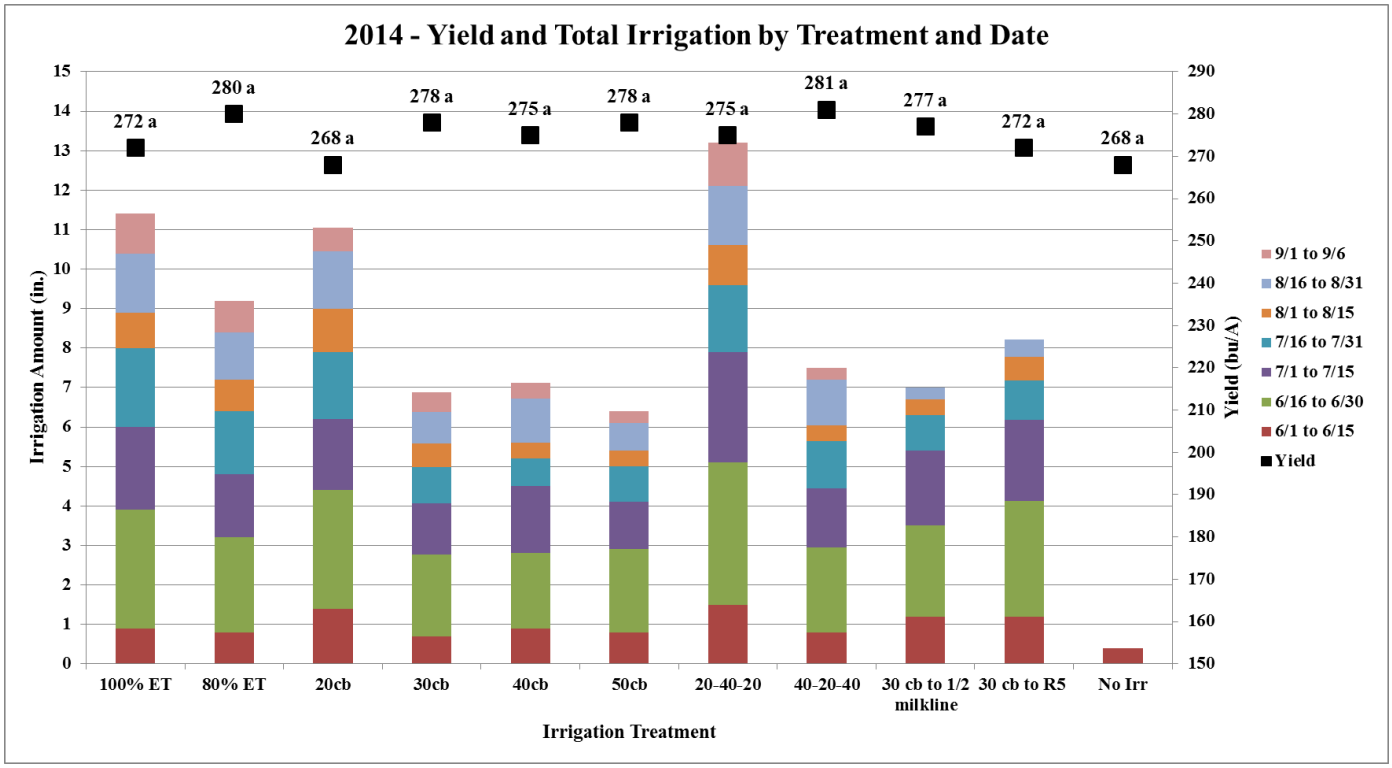
Please contact the project PI (James Adkins adkins@udel.edu) if further clarification is needed.

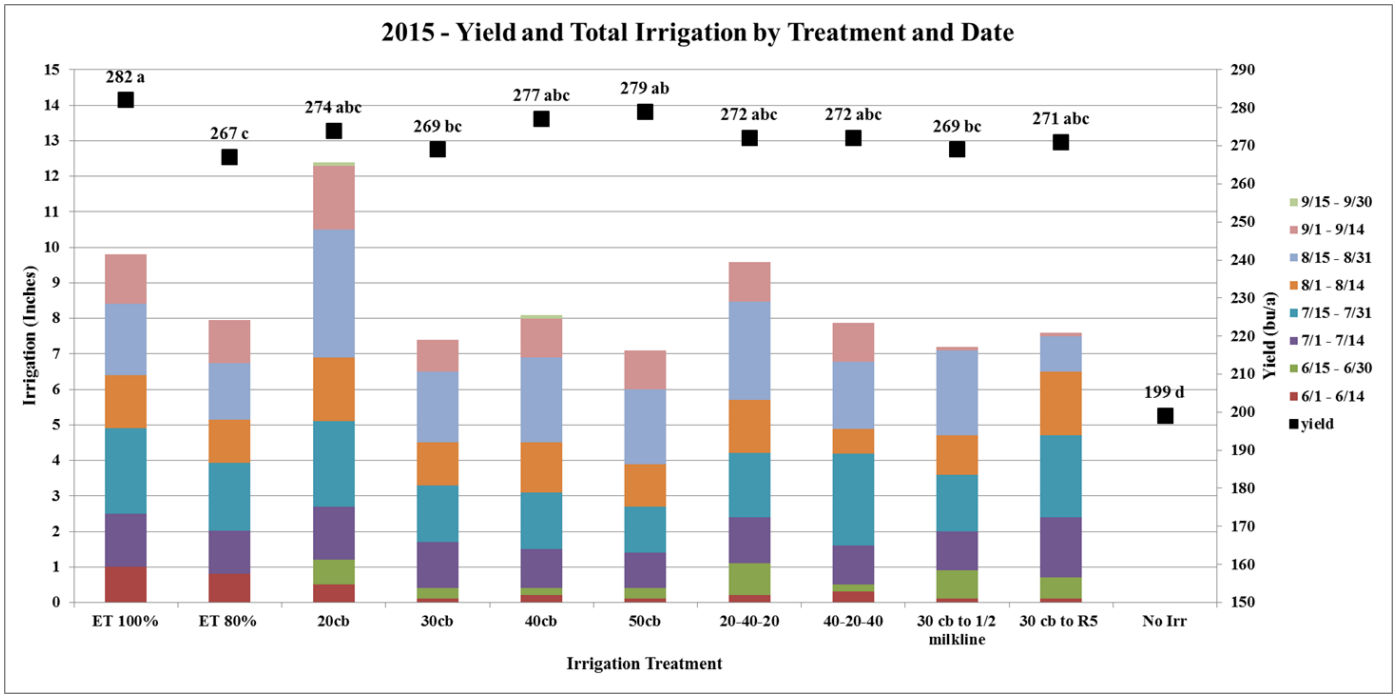
Summary 2013, 2014, 2015 Research Results

Each of the 3 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; and in 2015 the yields were good as long as some irrigation was provided; relative timing and degree of dryness seemed to be irrelevant.

Perhaps the main conclusion that can be drawn is that '13-'15 season were ideal corn production years with little natural moisture stress. **In order to draw a relevant conclusion from this project continued research in a year with inadequate rainfall for corn production is necessary.**




2014 - Yield and Total Irrigation by Treatment and Date
Irrigation Amount (in.)
Yield (bu/A)
272 a
280 a
268 a
278 a
275 a
278 a
275 a
281 a
277 a
272 a
268 a
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
Irrigation Treatment
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)
282 a
267 c
274 abc
269 bc
277 abc
279 ab
272 abc
272 abc
269 bc
271 abc
199 d
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
Irrigation Treatment
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