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# Sprinkler Irrigation Management of Modern Corn Hybrids under Institutional Constraints


**Freddie Lamm**

Kansas State University

Northwest Research-Extension Center

Colby, Kansas

flamm@ksu.edu


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# Conclusions

- **Full irrigation was still relatively efficient but used 30 to 36% more water.**

When irrigation is not severely restricted, corn prices are greater, and/or irrigation costs are lower, managing irrigation at this level and reducing irrigated land area may be more profitable.

# Conclusions

- **Pre-anthesis water stress was more detrimental to grain yield than similar levels of post-anthesis water stress because of reductions in kernels/ear. This reduction occurred for all 4 hybrids when subjected to pre-anthesis irrigation reductions.**

This is somewhat counter to typical older guidelines which indicated that moderate stress during the corn vegetative stage may not be detrimental. This may be indicating that kernel set on modern hybrids is a greater factor in determining final yields.

# Conclusions

- **When water is greatly restricted, a 50% reduction post-anthesis might fare reasonably well by relying on stored soil water and precipitation for grain filling.**

The rationale is that it is important to establish a sufficient number of kernels/ear (i.e., sinks) that potentially can be filled if soil water and weather conditions permit.

# Conclusions

- **Hybrid selection remains important and modern corn hybrids exhibited different schemes of attaining yields (i.e., changes in yield components).**

As an example, the highest yielding hybrid attained greater kernel mass which was relatively stable across irrigation regimes while the lowest yielding hybrid attained the largest number of kernels/ear and had a relatively stable but much smaller kernel mass.

# Conclusions

- **These results might not repeat on less productive soils or under harsher environmental conditions.**

On coarser soils (e.g. sandy soils), stored soil water and sporadic precipitation might not be sufficient to "carry" the crop through the post-anthesis period as well as in this study.

# Introduction

In 2012, the Kansas legislature passed new water laws that allowed creation of a new water management structure known as a Locally Enhanced Management Area (LEMA).

It allows stakeholder groups of various sizes to locally come together and design a management strategy to reduce overdraft of the Ogallala Aquifer in their area subject to approval by the Kansas Division of Water Resources.



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# Introduction

The first LEMA to be approved known as Sheridan High Priority Area 6 became a reality within Sheridan and Thomas Counties in northwest Kansas in 2013.

The stakeholders in a 100 square mile area voluntarily agreed to reduce their average water right to 11 inches/year for the next 5 year period. This represents ≈ 27% reduction from the Net Irrigation Requirement.

# Introduction

ET-based irrigation scheduling has been promoted in the Central Great Plains for many years.

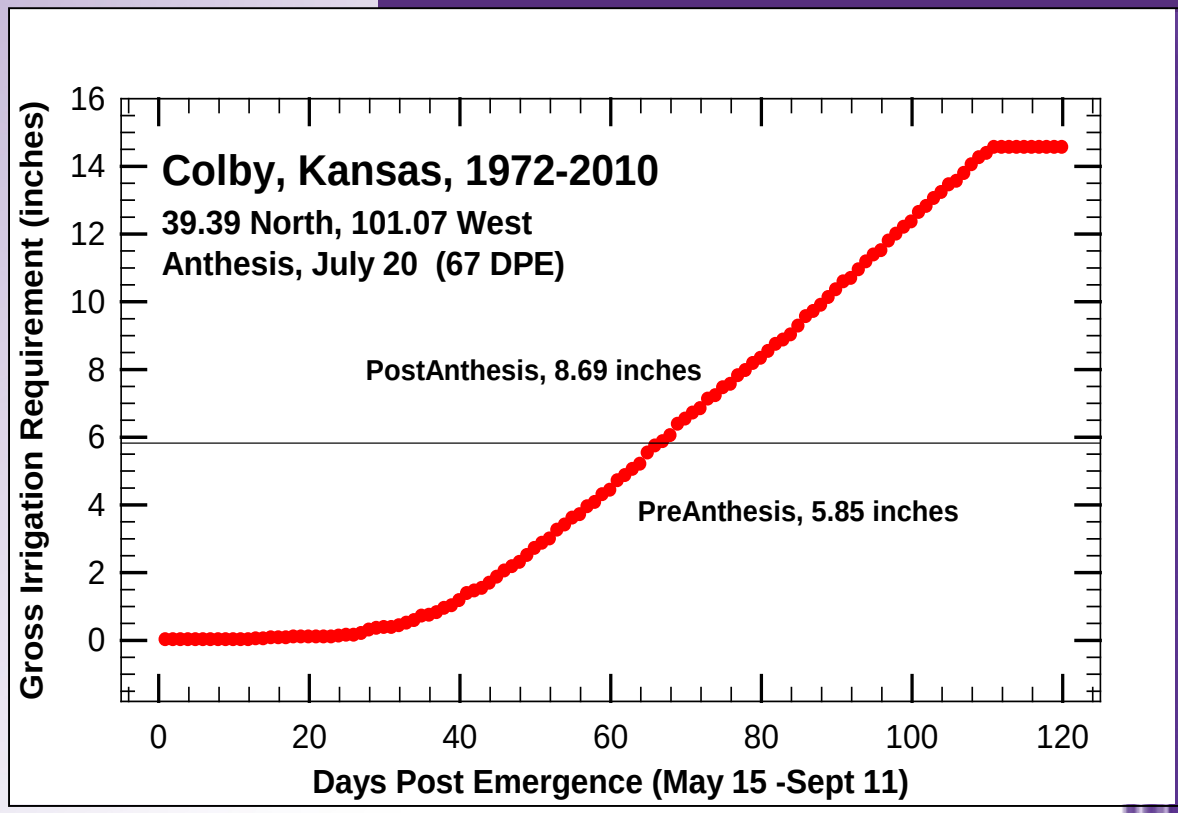
As producers move to deficit irrigation strategies this method of scheduling can still be useful in alerting the producer to soil water conditions and can help the producer decide when to allocate their limited supply.

# Introduction

Sprinkler irrigation does not allow for large amounts of water to be timed to a specific growth stage without incurring runoff, so strategies must be employed that can either slowly restrict or slowly increase water available to the crop and to soil water storage for later usage.

# Initial Hypothesis

Computer simulation has indicated that on average, ≈ 40% of the seasonal irrigation amount is required prior to anthesis, so an imposed 50% reduction during this period might be acceptable most years, yet not be excessive in the drier years.



# Adding a Counter Hypothesis

Since grain filling (post anthesis) is important, intuitively, one might surmise that those strategies restricting water during the pre-anthesis stages would always be preferable, but the pre-anthesis period is also when the number of kernels/acre is being potentially set and also the soil water storage allows for "banked" water to be used later by a deep rooted crop such as corn.

# and so, a Field study:

A 3-year field irrigated corn study was conducted on a deep silt loam soil in NW Kansas to examine restriction of irrigation to approximately to 50 or 75% of the ET-Rain value for either the pre-anthesis period or during the post-anthesis period.

These 4 deficit strategies were compared to a fully-irrigated control treatment.

# Irrigation Treatments:

1. Full irrigation (100% ET) with no restriction on total irrigation.
2. Irrigation restricted pre-anthesis to 50% of ET, 100% of ET thereafter with 11.5 inches total restriction.
3. Irrigation restricted pre-anthesis to 75% of ET, 100% of ET thereafter with 11.5 inches total restriction.
4. Irrigation restricted post-anthesis to 50% of ET with 11.5 inches total restriction.
5. Irrigation restricted post-anthesis to 75% of ET with 11.5 inches total restriction.

# Procedures

Irrigation amounts of 1 inch/event were scheduled according to water budget weather-based irrigation scheduling procedures only as needed subject to the specific treatment limitations.

As an example, during the pre-anthesis stage, Irrigation Trt 3 would only receive 75% ET, but after anthesis would receive irrigation at 100% until such time that the total irrigation is 11.5 inches.

# Procedures

The four corn hybrids were Pioneer brand

- 35F48
- P0876CHR
- P1151YXR
- P1498AM1

with the latter two hybrids being marketed as drought tolerant Aquamax hybrids.

# Procedures

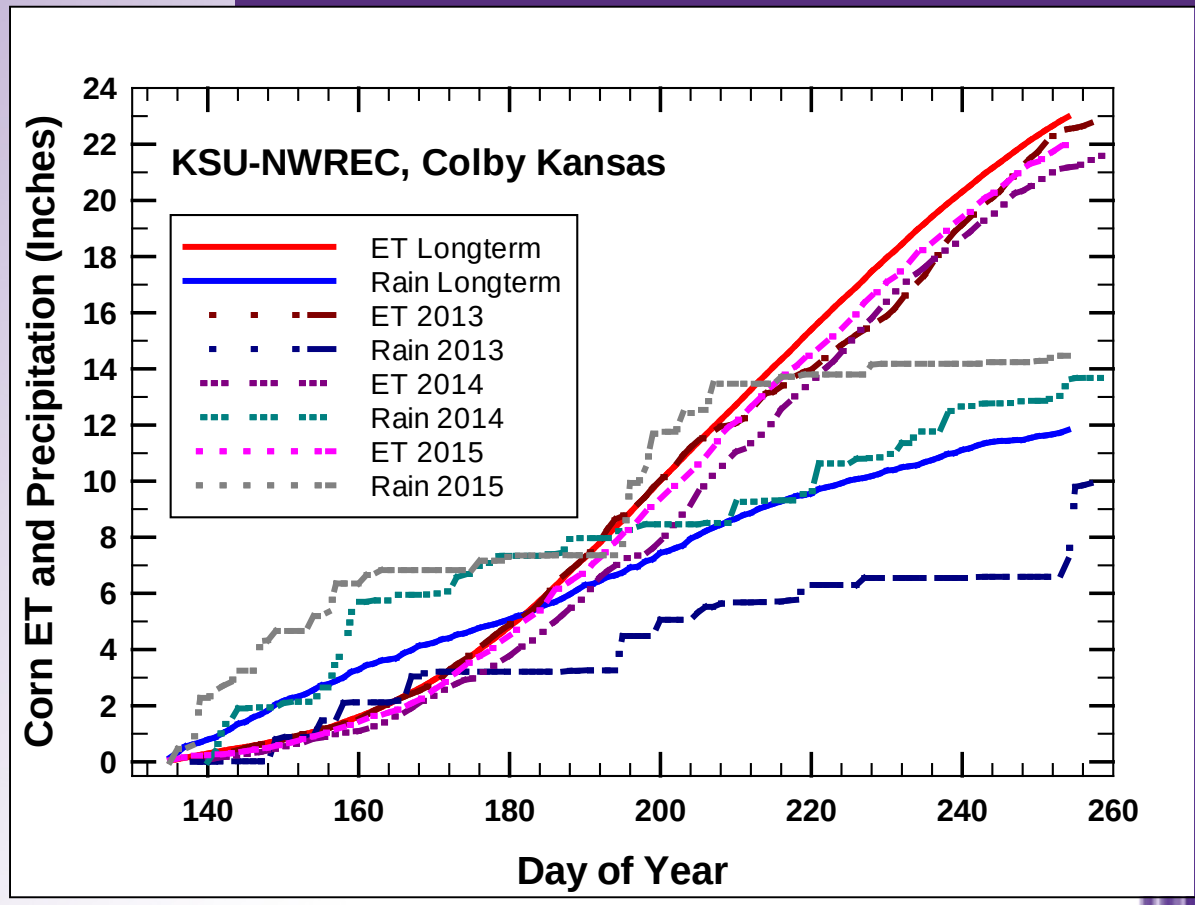
Volumetric soil water was monitored periodically (≈ 2 to 3 times/month) to a depth of 8 ft. in 1 ft. increments with neutron moderation techniques.

Corn yield and yield components were determined through hand harvesting a representative sample at physiological maturity.

Crop water productivity was calculated as grain yield/crop water use.

# Results and Discussion

Calculated crop ET for 2013 through 2015 was slightly lower than long term values and seasonal precipitation was 2 to 3 inches greater than normal in 2014 and 2015 and 2 inches less than normal in 2013.



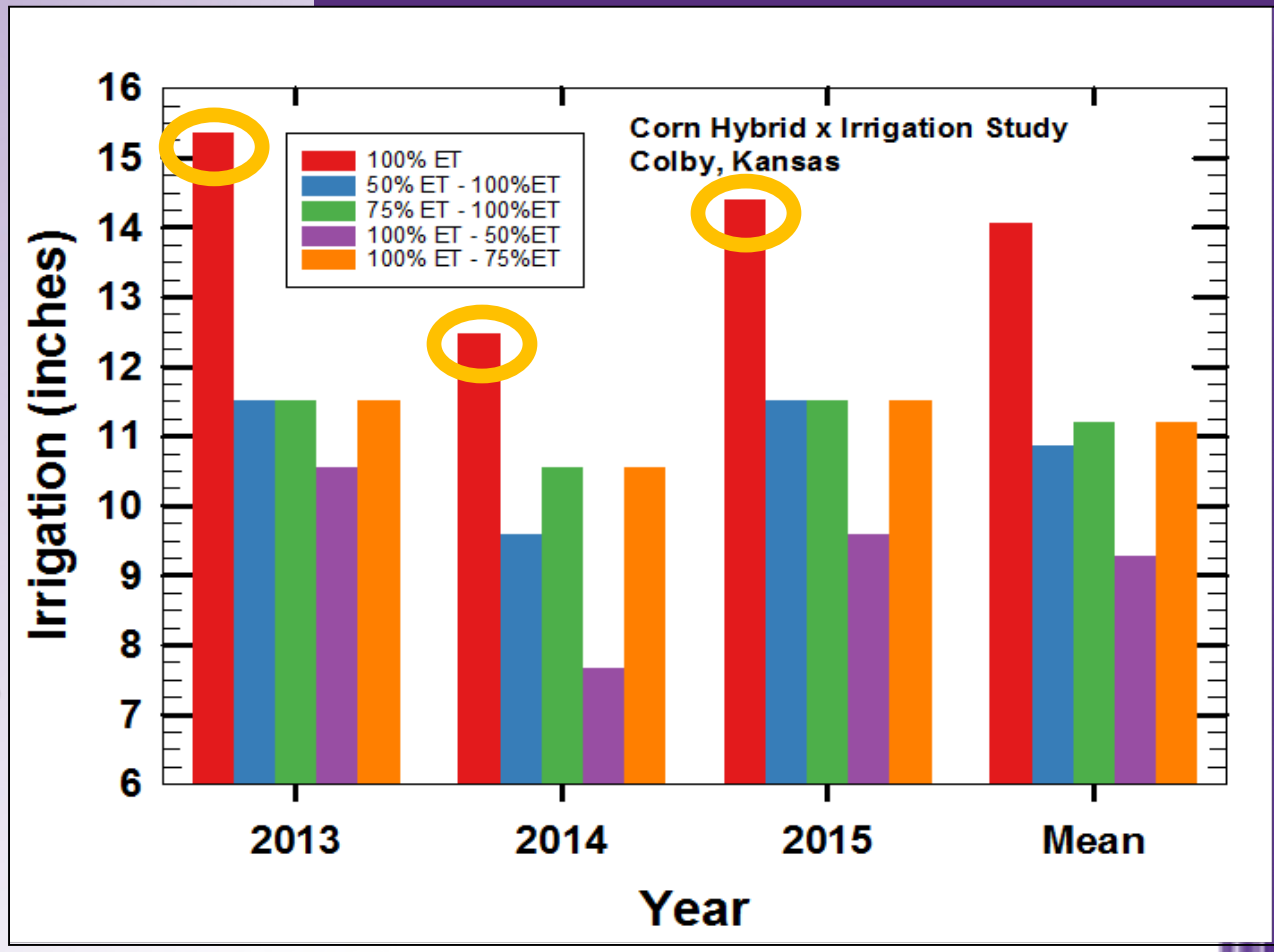
# Results and Discussion

Full irrigation amounts were:

15.4 inches in 2013

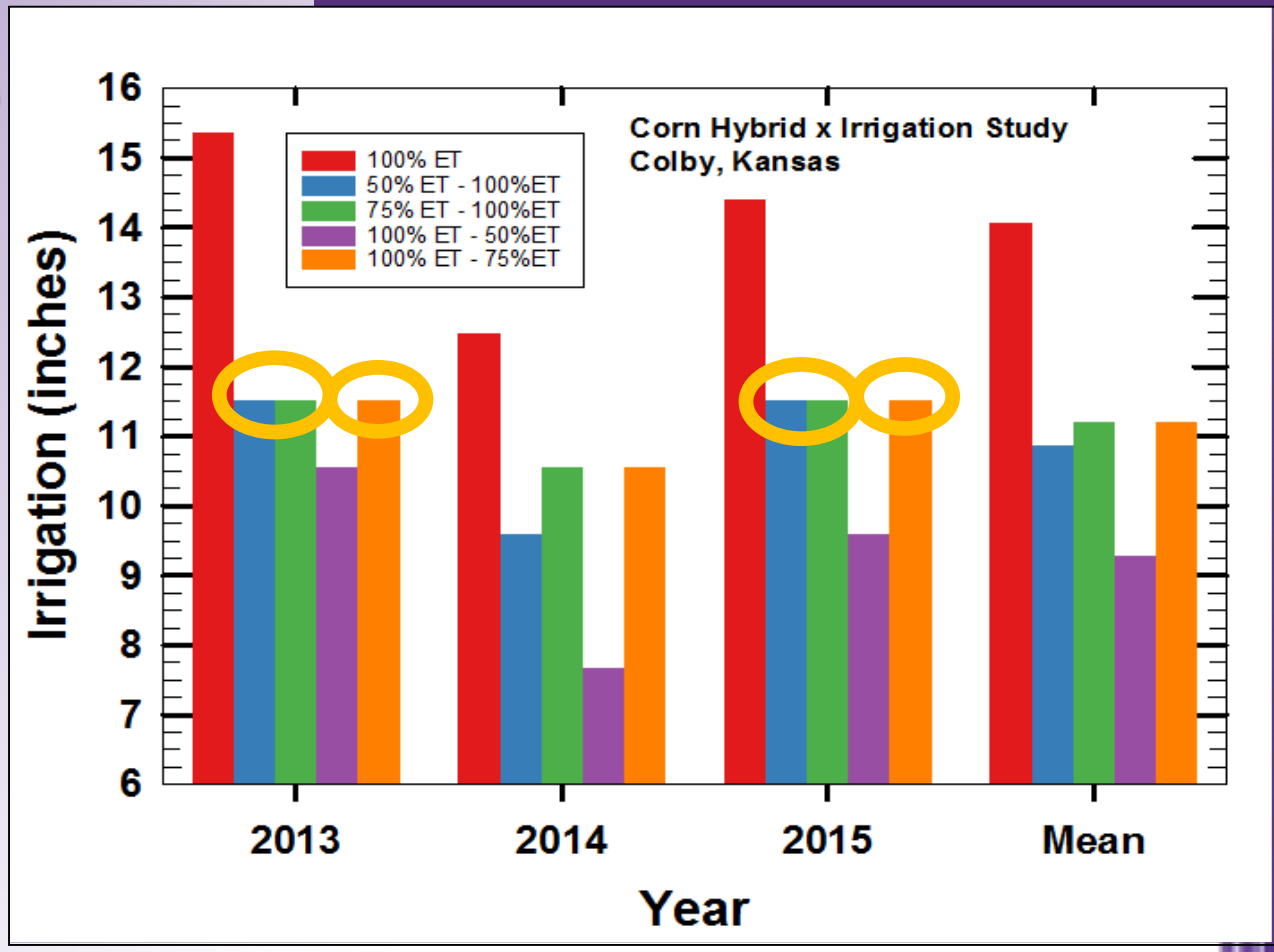
12.5 inches in 2014

14.4 inches in 2015.



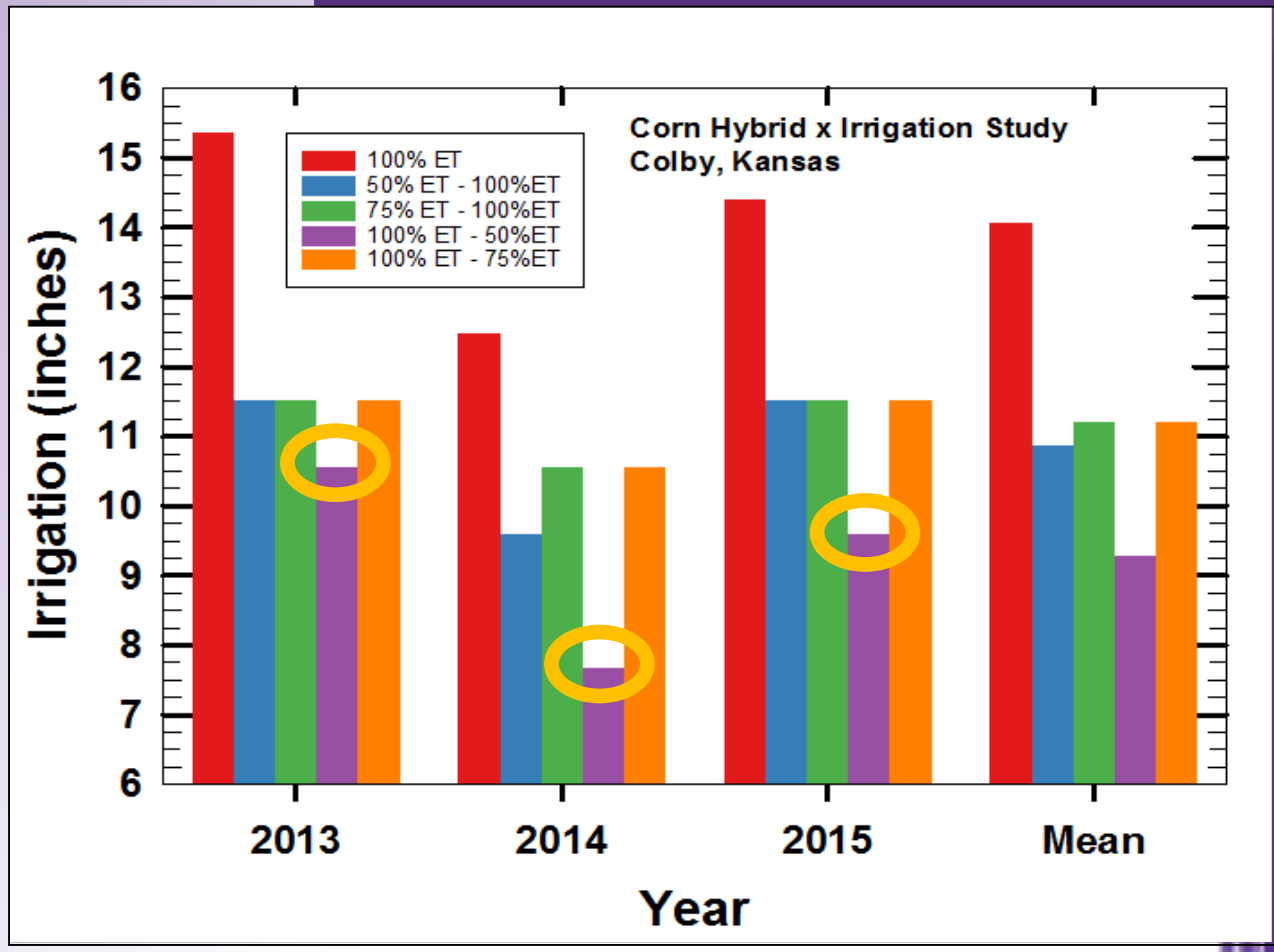
# Results and Discussion

Treatments 2 and 3 with pre-anthesis water restrictions of 50% and 75 % ET respectively, reached their water limitation (11.5 inches) in 2 of 3 years (2013 and 2015).



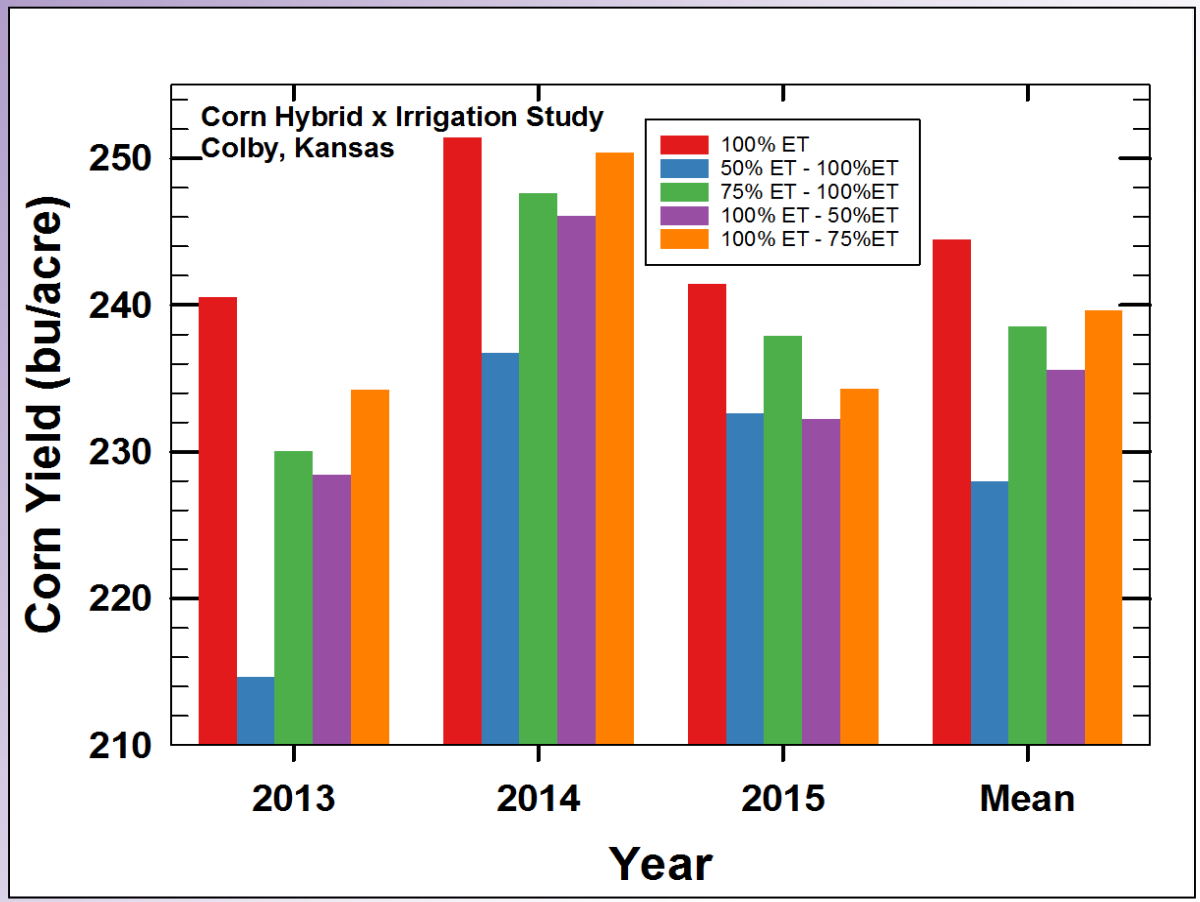

This was also the case for the 75% ET treatment imposed during the post anthesis period.

# Results and Discussion



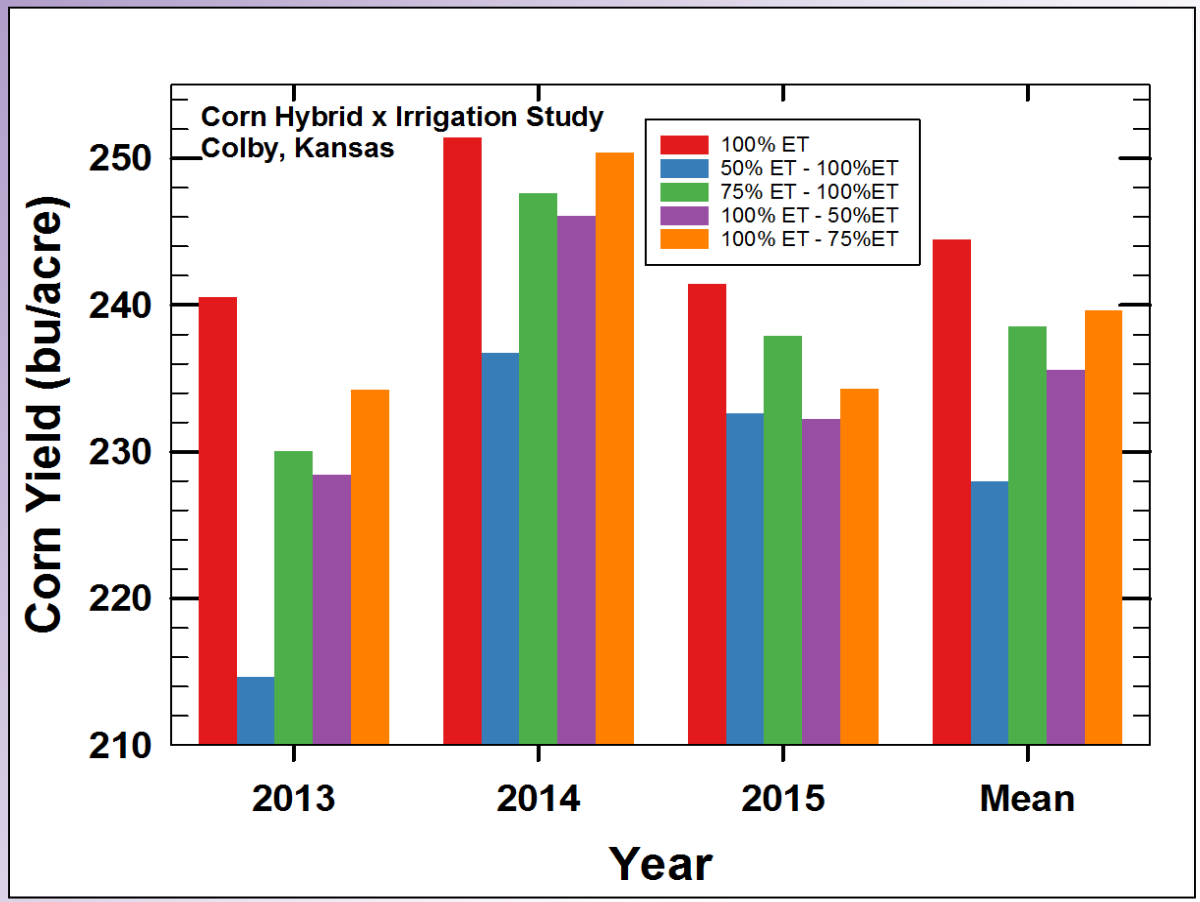

The irrigation treatment using the least amount of water during the three years of the study was the treatment where irrigation was restricted to 50% of ET during post-anthesis period.

# Results and Discussion




**Fully irrigated corn grain yields ranged annually from 241 to 251 bu/acre with the deficit-irrigated lowest yields ranging from 215 to 237 bu/acre.**

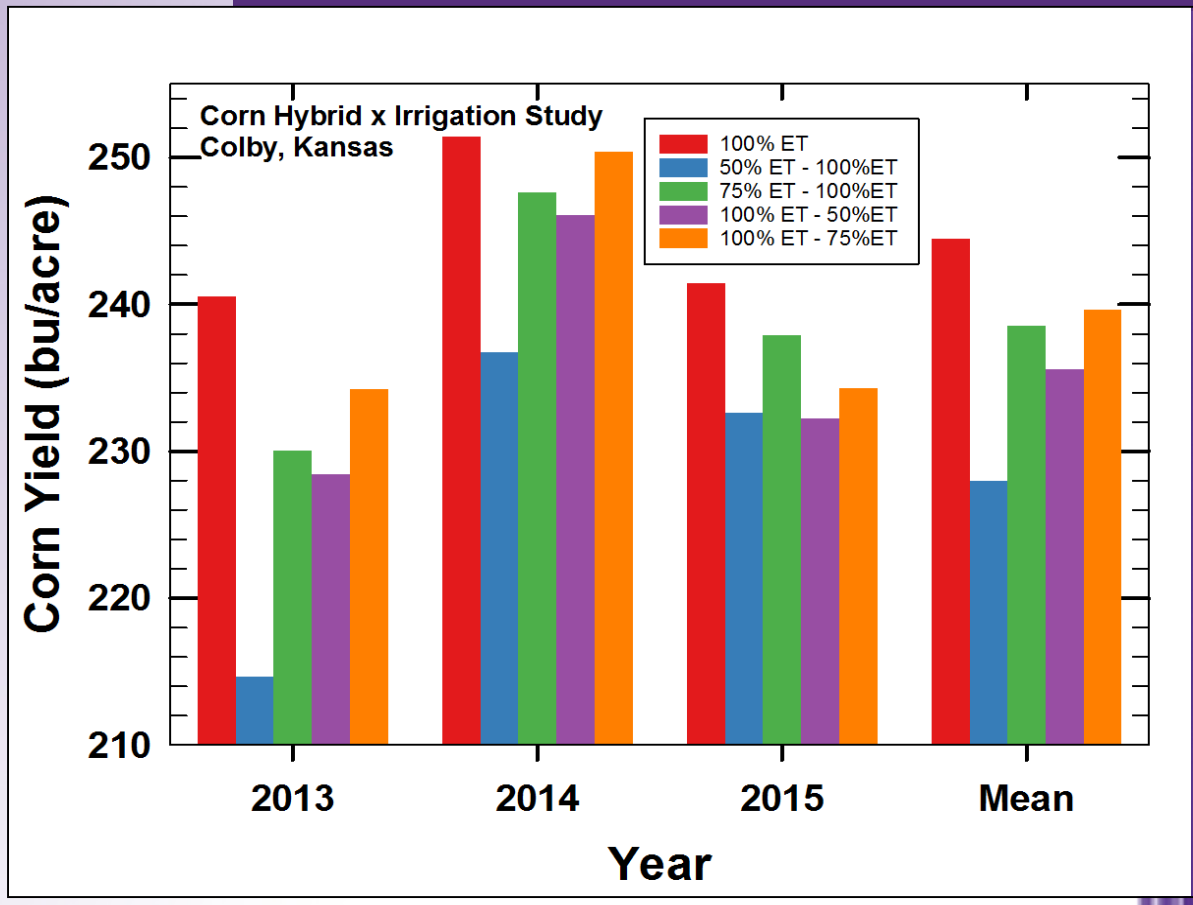
# Results and Discussion




**Corn yield was greatest for unrestricted irrigation (Trt 1) but required 30 to 36% more irrigation, but was still very efficient with only a 2 to 4% reduction in water productivity.**

# Results and Discussion

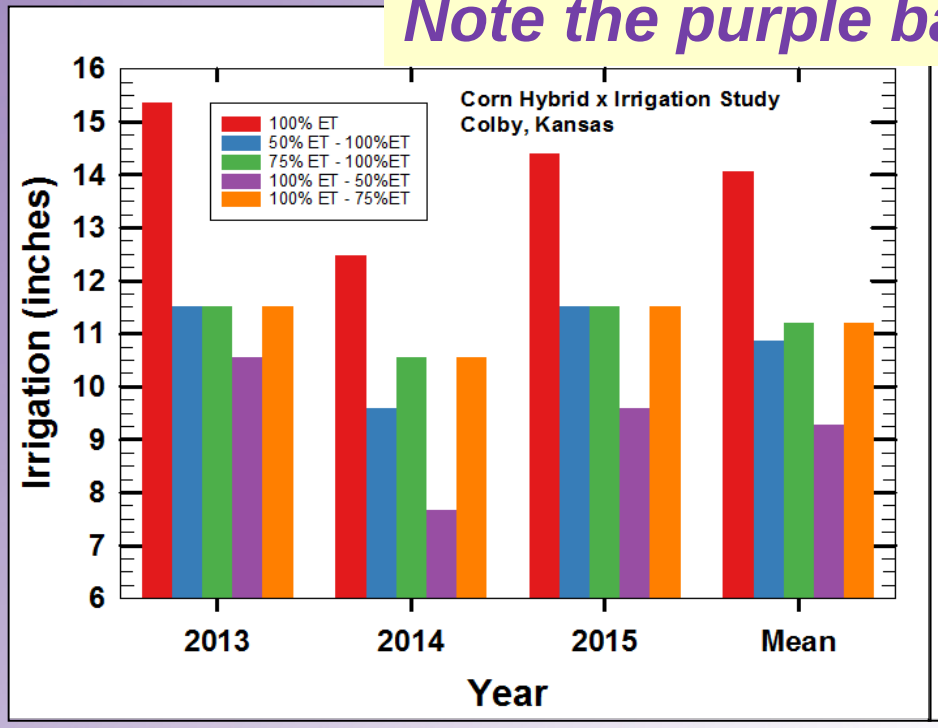
Lower yields occurred for pre-anthesis water restrictions (Trt 2 and Trt 3) than for similar post-anthesis restrictions (Trt 4 and Trt 5).

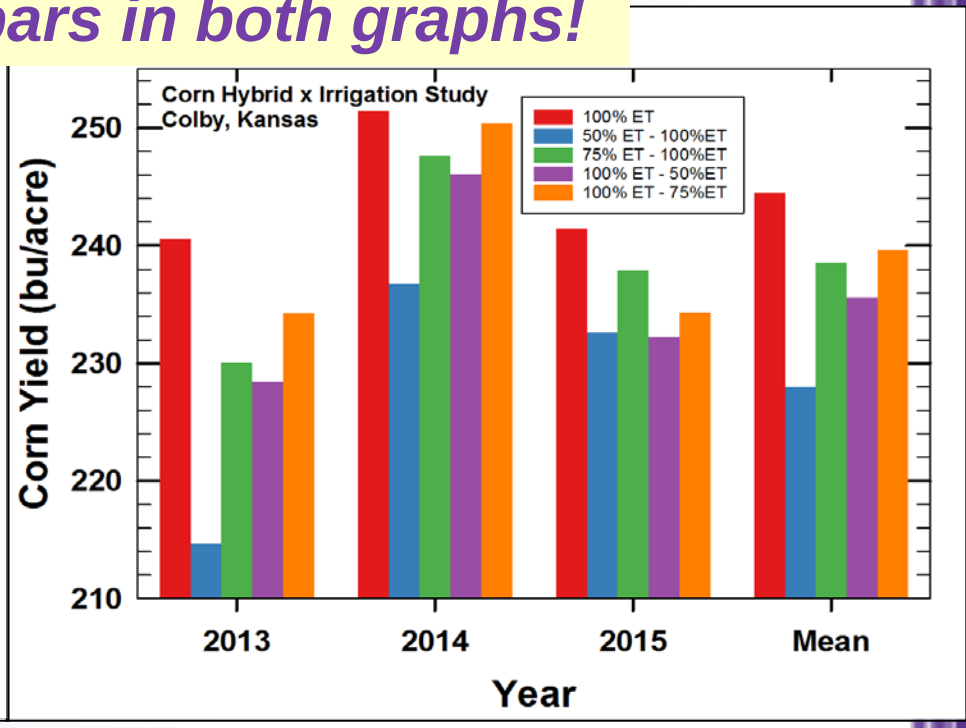



These results suggests that obtaining sufficient kernel set was more important than saving irrigation for grain filling in this study.

# Results and Discussion

*Note the purple bars in both graphs!*




**When irrigation is greatly restricted, a 50% reduction post-anthesis appears as a promising alternative, relying more heavily on stored soil water and precipitation for grain filling.** ***This contradicts previous guidelines!***

# Examination of Yield Components

## Yield can be calculated as:

$$Yield = \frac{Plants}{Area} \times \frac{Ears}{Plant} \times \frac{Kernels}{Ear} \times \frac{Mass}{Kernel}$$

The first two terms are typically determined by the cropping practices and generally are not affected by irrigation practices later in the season.

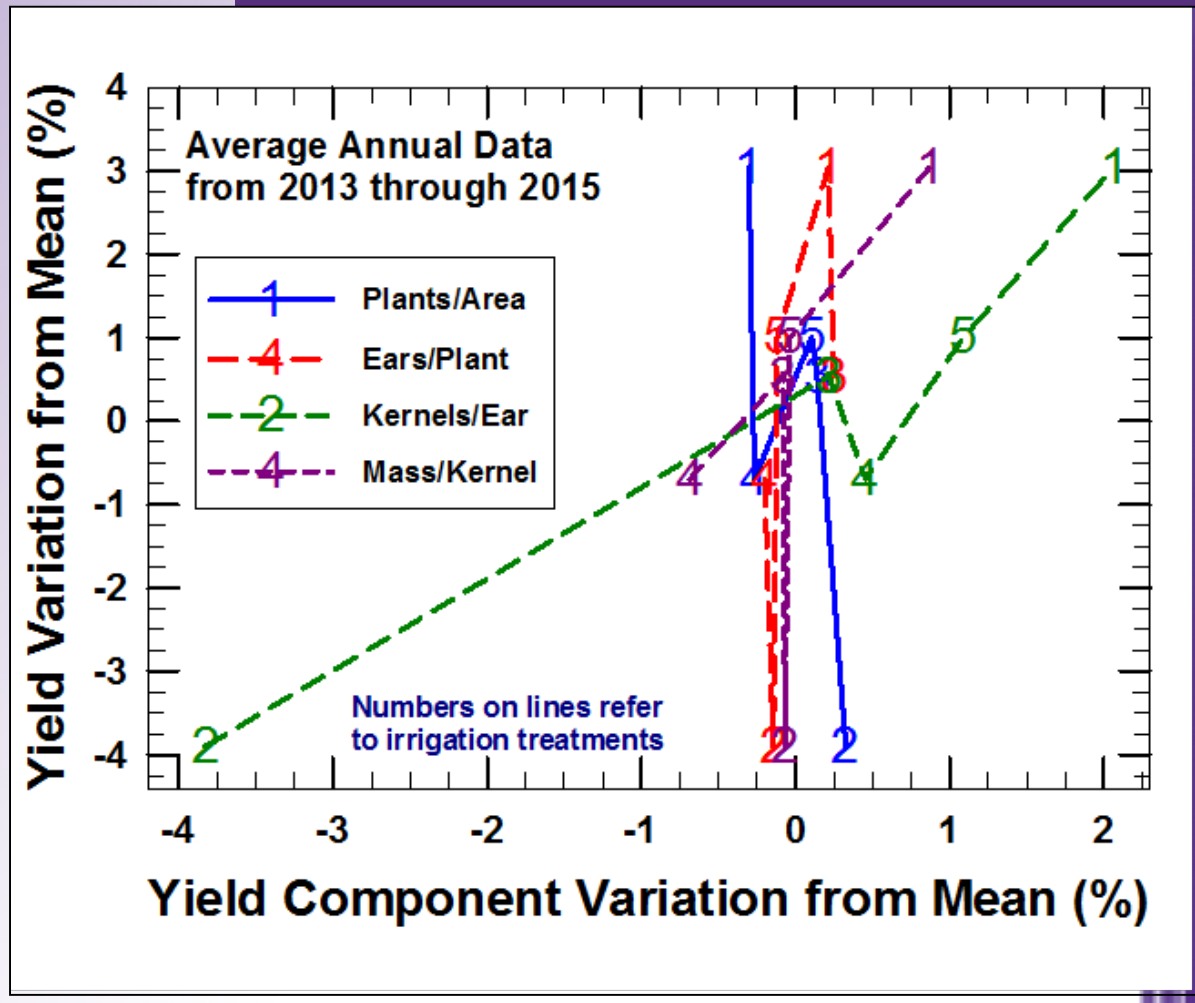
Water stresses during the mid-vegetative period through about 2 weeks after anthesis can greatly reduce kernels/ear.

Kernel mass, through greater grain filling, can partially compensate when insufficient kernels/ear are set, but may be limited by late season water stress or hastened senescence caused by weather conditions.

# Results and Discussion

Because all the yields components combine directly through multiplication to calculate yield, their effect on yield can be easily compared in this figure.

*The numbers on the lines refer to the 5 irrigation trts and the lines just connect similar data.*




**Holding other yield components static, a variation of 1% in any yield component would affect yield by the same 1%.**





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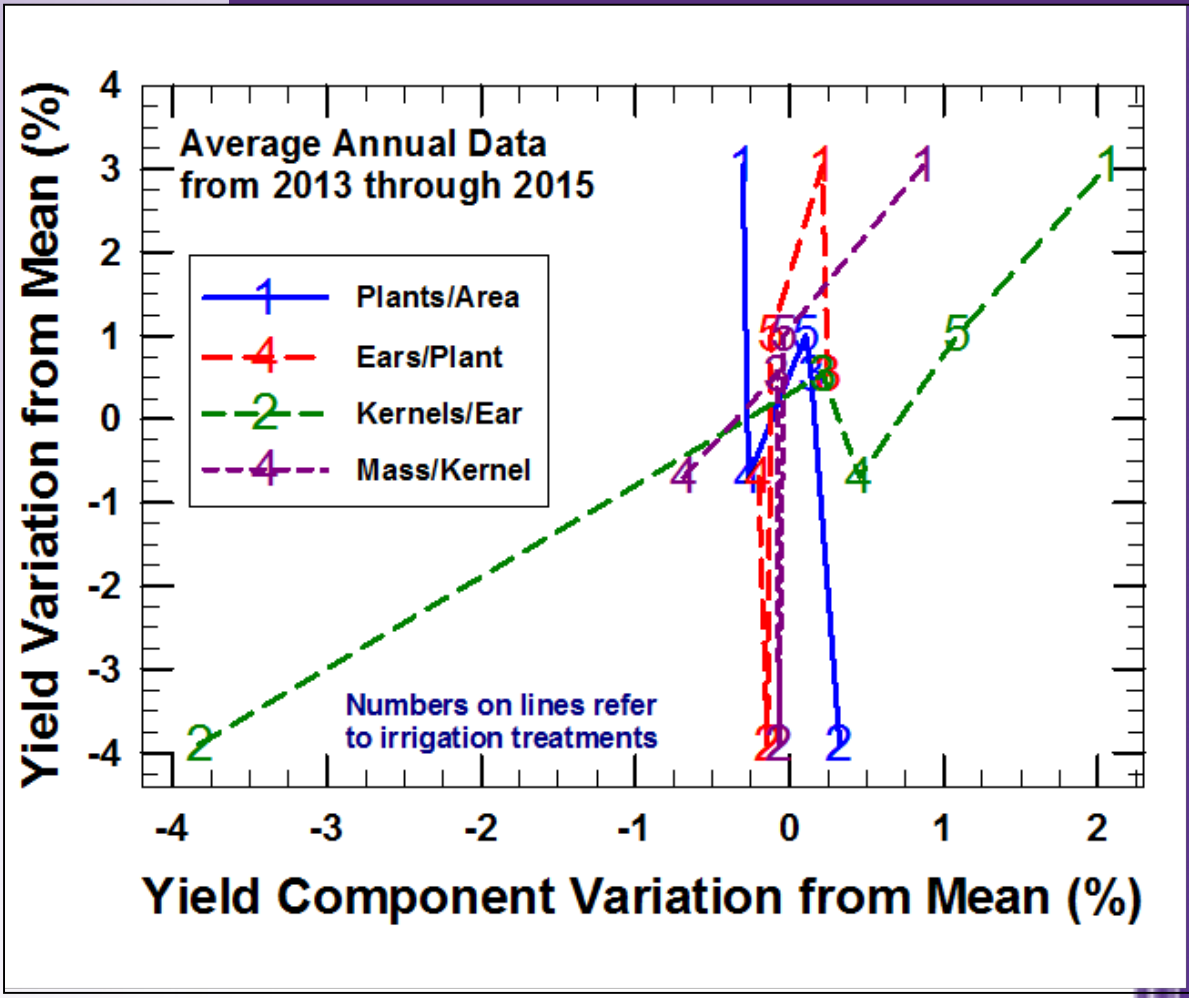
# Results and Discussion

It can be observed that there is much greater horizontal dispersion for kernels/ear than for all the other yield components which vary less than approximately 1%.




**Thus, irrigation treatment had a much greater effect on kernels/ear and the fully irrigated 100%ET, Trt 1 and the pre-anthesis 50% ET, Trt 2 were affected the greatest.**

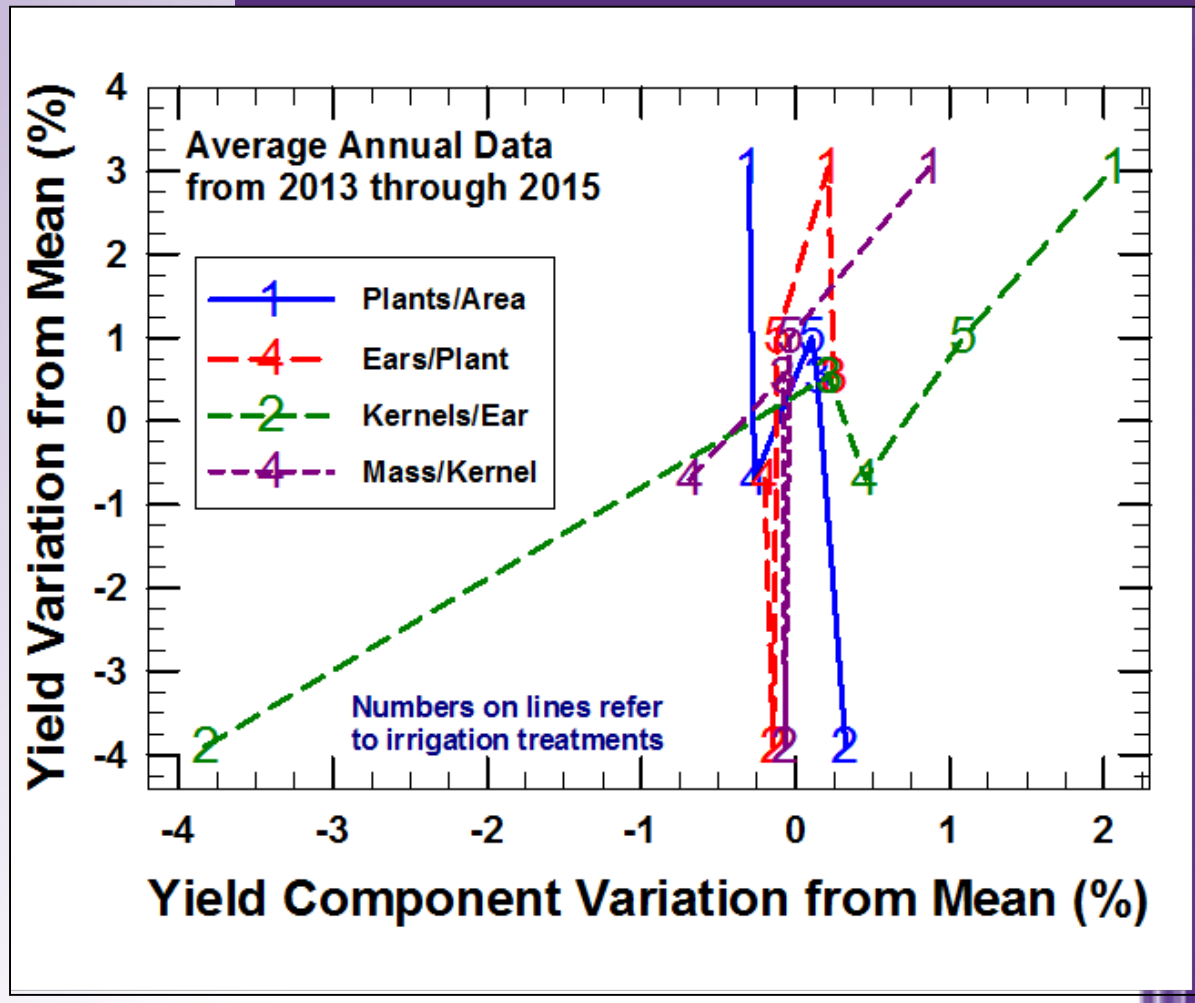
# Results and Discussion

The major difference between

Trt 4 (post-anthesis 50%) and

Trt 2 (pre-anthesis 50%)

was that Trt 4 was able to set a kernels/ear value much closer to the mean value than Trt 2.




**Trt 4 vs Trt 2, 15% less irrigation and 3% greater yield.**





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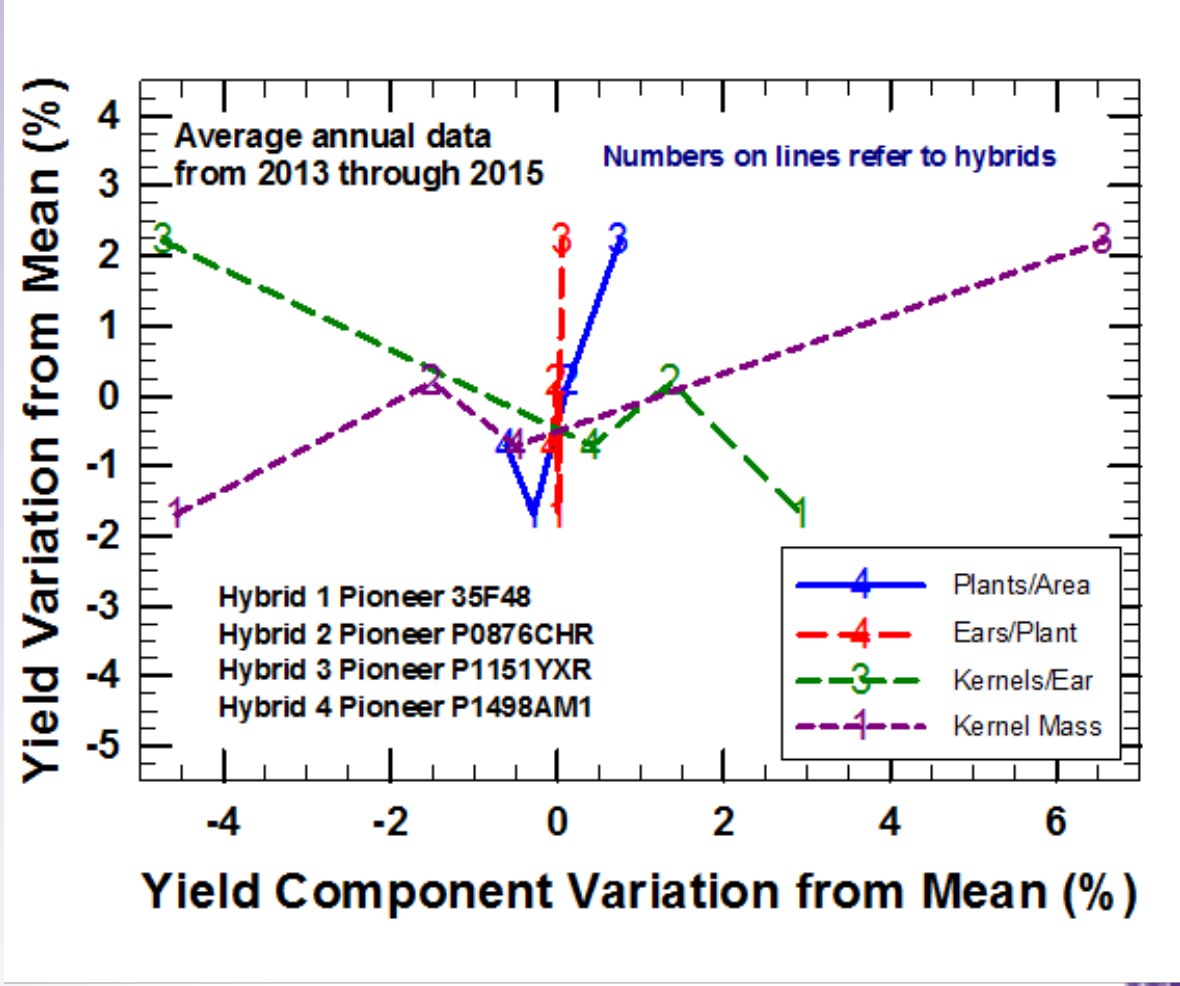
# Results and Discussion

There were also differences between corn hybrids.

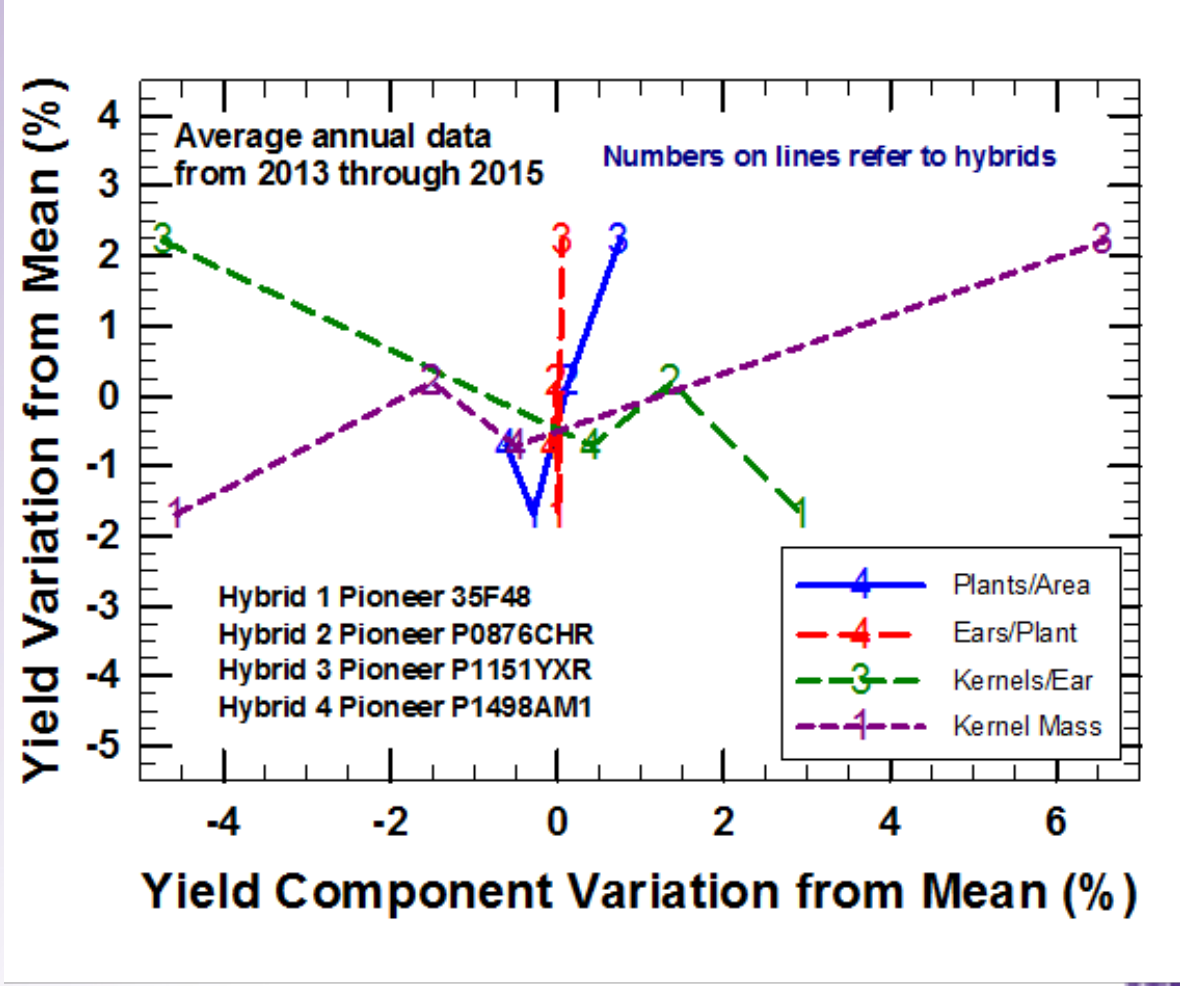
The highest yielding hybrid, P1151YXR, had the least number of kernels/ear while the lowest yielding hybrid, 35F48, had the greatest kernels/ear.




This ranking reversed for kernel mass with P1151YXR having the greatest kernel mass and 35F48 having the least.

# Results and Discussion

The other two hybrids (P0876CHR and P1498AM1) had near average values of kernels/ear and kernel mass.




It can be noted that hybrid P1151YXR and P1498AM1 are both marketed as drought tolerant (Aquamax hybrids).

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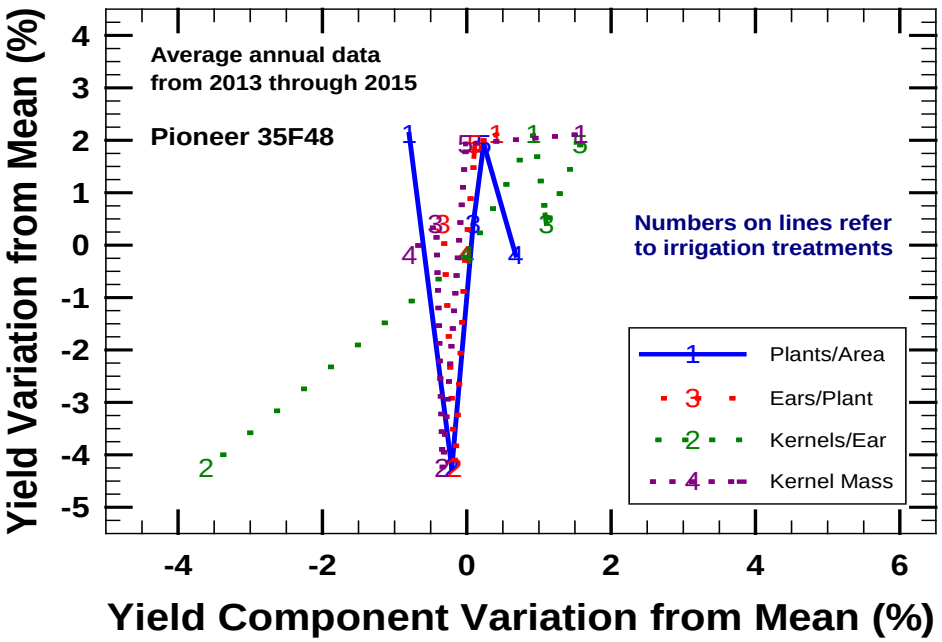
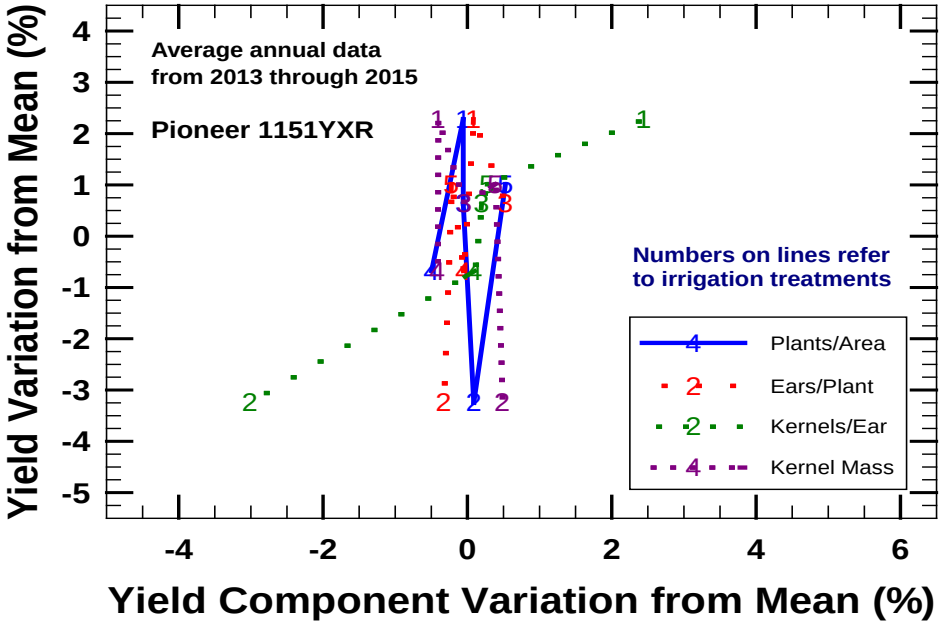
Although kernel mass was very different for hybrids, with 35F48 having 12% less than P1151YXR, both hybrids individually had stable values that were relatively unaffected by irrigation treatment.

For these two hybrids, kernels/ear was the most responsive yield component to irrigation treatment.



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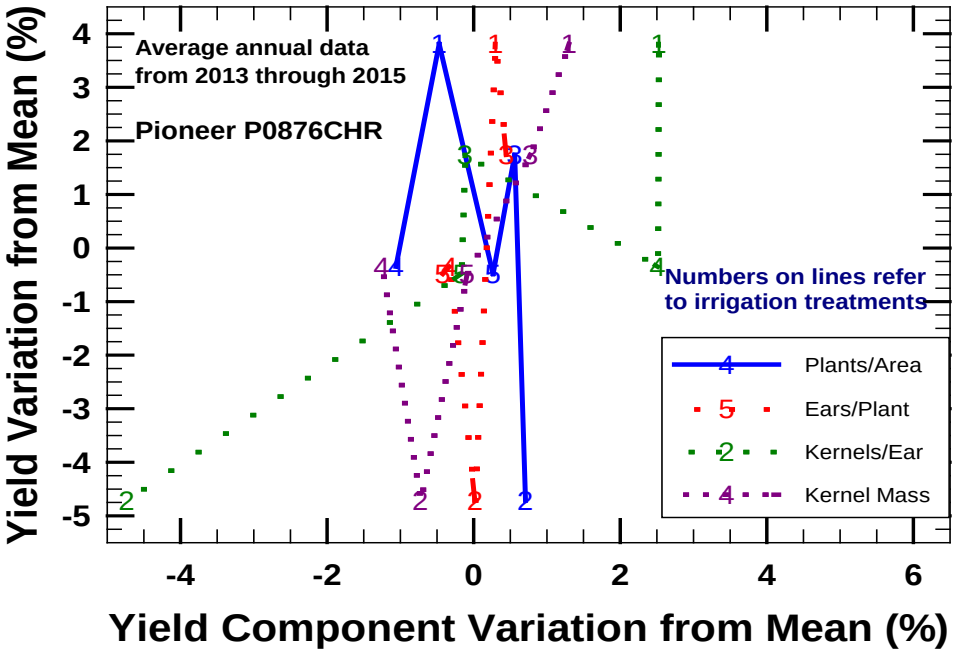
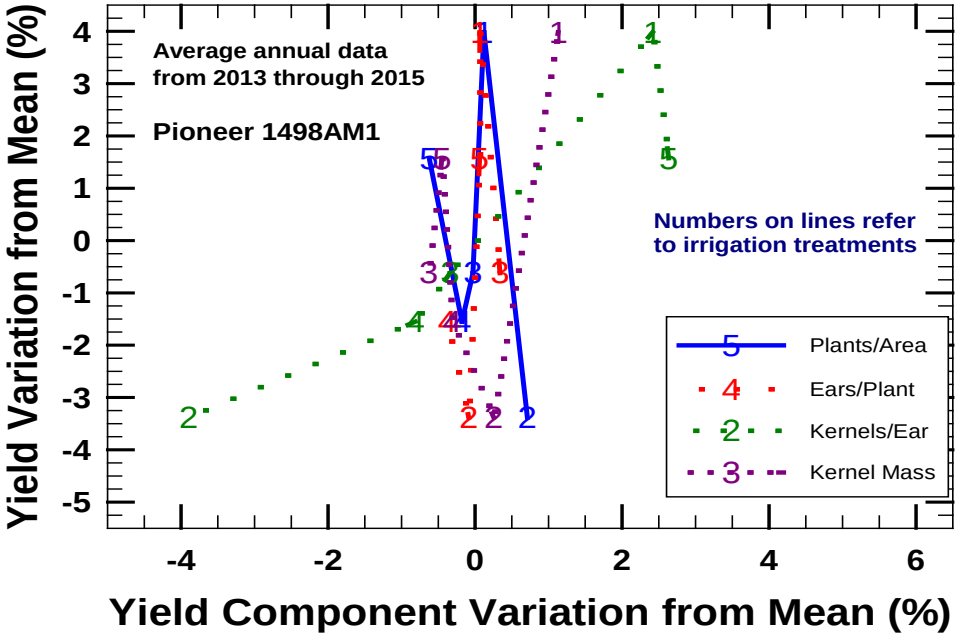
The other two hybrids P0876CHR and P1498AM1 had slightly greater ability to flex kernel mass with differences between Irr 1 and 4 having the greatest effect on kernel mass and subsequently yield.

That is, greater irrigation increased kernel mass and subsequently increased yield.



# Results and Discussion

## When comparing Irr 2 and 4 for all 4 hybrids:

Irr 4 (50% ET Post-anthesis, least amount of total irrigation, 9.28 inches) had relatively minor effect on the yield components and thus had a smaller effect on grain yield.

Irr 2 (50% ET Pre-anthesis, 10.88 inches) negatively affected kernels/ear and severely reduced grain yield.

# Closing Thoughts and Conclusions

- Full irrigation was still relatively efficient but used 30 to 36% more water.
- Pre-anthesis water stress was more detrimental to grain yield than similar levels of post-anthesis water stress because of reductions in kernels/ear.
- Hybrid selection remains important and modern corn hybrids exhibited different schemes of attaining yields (i.e., changes in yield components).
- When water is greatly restricted, a 50% reduction post-anthesis might fare reasonably well by relying on stored soil water and precipitation for grain filling.
- These results might not repeat on less productive soils or under harsher environmental conditions.

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# Comments or Questions?

## Google Irrigation at K-State

http://www.ksre.ksu.edu/irrigate

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