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Differential Corn Hybrid Response to Irrigation Management

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ABSTRACT. *Separate field studies using sprinkler and subsurface drip irrigation for corn production were conducted at Colby, Kansas from 2014 to 2016 examining five different irrigation capacities ranging from 25 mm/4 days to 25 mm/12 days. The irrigation treatments were scheduled only according to need with calculated ET-based water budgets but were limited to specific capacities. The conventional and drought tolerant hybrids performed differently with the drought tolerant hybrid generally establishing greater kernels/ear when conditions were drier and the conventional hybrid tended to compensate under wetter conditions with greater kernel mass (i.e., grain filling.) There appeared to be greater stability in grain yield for the subsurface drip irrigation system due to differences in yield component formation between the two irrigation systems.*

Keywords. Corn, crop yield, deficit irrigation, irrigation management, maize, sprinkler irrigation, subsurface drip irrigation.

Introduction

In the semi-arid U.S. Central Great Plains and particularly northwest Kansas, soils are generally productive deep silt loam soils but precipitation is limited and sporadic with mean annual precipitation ranging from 16 to 20 inches across the region, which is only 60-80% of the seasonal water use for corn. Irrigation is often used to mitigate these water stress effects but at the expense of the continued decline of the Ogallala Aquifer.

The major corn seed companies have extensive hybrid development work underway in the western Corn Belt to develop hybrids that are drought tolerant. The overall goal is to develop hybrids that will not incur a yield reduction under ideal conditions, yet stabilize yield under water-stressed conditions.

Center pivot sprinkler irrigation (CP) is by far the predominant method of irrigation in the U.S. Central Great Plains, but some producers are beginning to use subsurface drip irrigation (SDI) to perhaps make more effective use of the limited water resource by a further limiting of the water losses (e.g., air and canopy evaporative losses, soil water evaporation, irrigation runoff and deep percolation).

As corn is the major irrigated crop in the U.S. Central Great Plains, efforts are justified to develop irrigation management strategies that optimize corn grain yield and appropriate use of CP and SDI irrigation methods. Separate field studies were conducted from 2014 through 2016 at the KSU Northwest Research-Extension Center in Colby, Kansas to examine the differential corn response of two commercially available corn hybrids as affected by irrigation system (CP or SDI) under different irrigation capacities (i.e., applied volume per time or applied depth per unit area over time). In the sprinkler-irrigated study, a lateral move sprinkler irrigation system was used as a substitute for the CP system and will be referred to as the LMS system in the remaining document. The usage of the LMS system improved research plot management (i.e., avoiding the plot management in pie-shaped sectors that would occur for CP systems).

Procedures

Two different commercial corn hybrids (DK 6298, a conventional hybrid and DK 6227, a hybrid specifically marketed as drought tolerant) were compared under five different irrigation regimes for both LMS and SDI systems in separate field studies at the KSU Northwest Research-Extension Center at Colby, Kansas. The study was conducted under the LMS system in the years 2014 through 2016 and the study under the SDI system was conducted in 2014 and 2016. . Under LMS irrigation, irrigation were managed to nominally apply 25 mm on frequencies governed by the irrigation capacity (i.e., limited to 25 mm every 4, 6, 8, 10 or 12 days). Under the SDI system, irrigation was managed to apply on a two-day frequency with fixed amounts governed by the irrigation capacity (i.e., 12.7, 8.5, 6.4, 5.1, or 4.2 mm/ 2 days). It can be noted that the 5 individual LMS and SDI irrigation regimes are equivalent in terms of capacity. Irrigation events were only scheduled according to water budget weather-based irrigation scheduling procedures only as needed subject to the specific treatment limitations. As needed irrigation was confined to having sufficient storage within the soil profile and crop rootzone for the irrigation amount plus an additional amount of storage of approximately 25 mm for occasional precipitation events. Soil water was monitored periodically (approximately 2 to 4 times/month) to a depth of 2.4 m in 0.3 m increments with neutron moderation techniques. This data was used to assess crop water stress as well as to determine total water use throughout the season. Corn yield and yield components were determined through hand harvesting a representative sample at physiological maturity. The 5 irrigation treatments (whole plot, 6 reps for the LMS system and 4 reps for the SDI system) were in a RCB design and the 2 corn hybrid treatments superimposed as split plots. The data were analyzed using standard PC-SAS procedures.

Results and Discussion

Weather Conditions and Irrigation Requirements

Overall weather conditions for the three years were favorable for excellent corn production during the study. Calculated well-watered corn ET for 2014 through 2016 was slightly lower than long term values (24 to 38 mm less) and seasonal precipitation was 49 and 69 mm greater than normal in 2014 and 2015, respectively, and 107 mm less than normal in 2016 (Fig. 1).

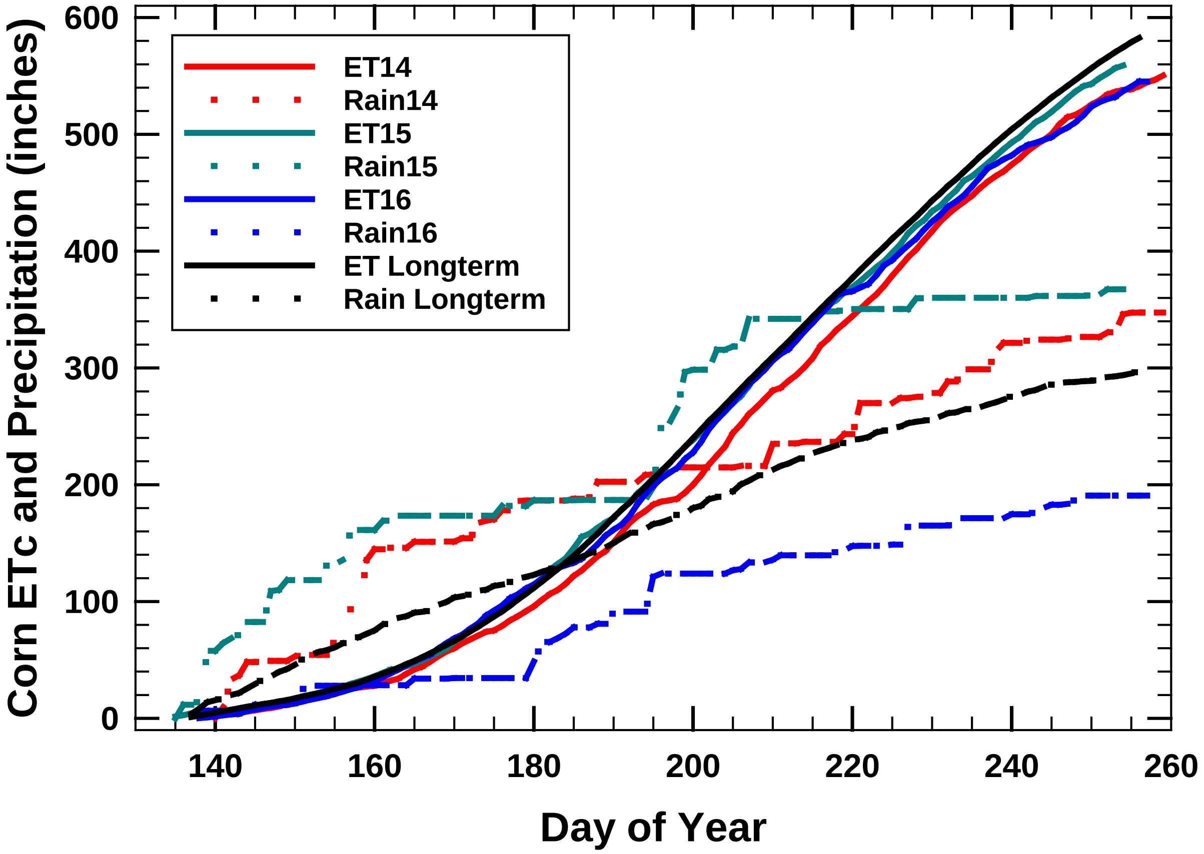

Figure 1. Seasonal calculated evapotranspiration for a well-watered corn crop and precipitation at Colby, Kansas for 2014 through 2016.

Seasonal irrigation amounts for the LMS system greatest irrigation capacity (25 mm/4 days) were 341, 390, and 366 mm in 2014, 2015 and 2016, respectively. Seasonal irrigation amounts for the SDI system greatest irrigation capacity (12.5 mm/2 days) were 312 and 358 mm in 2014 and 2016, respectively (Fig. 2).

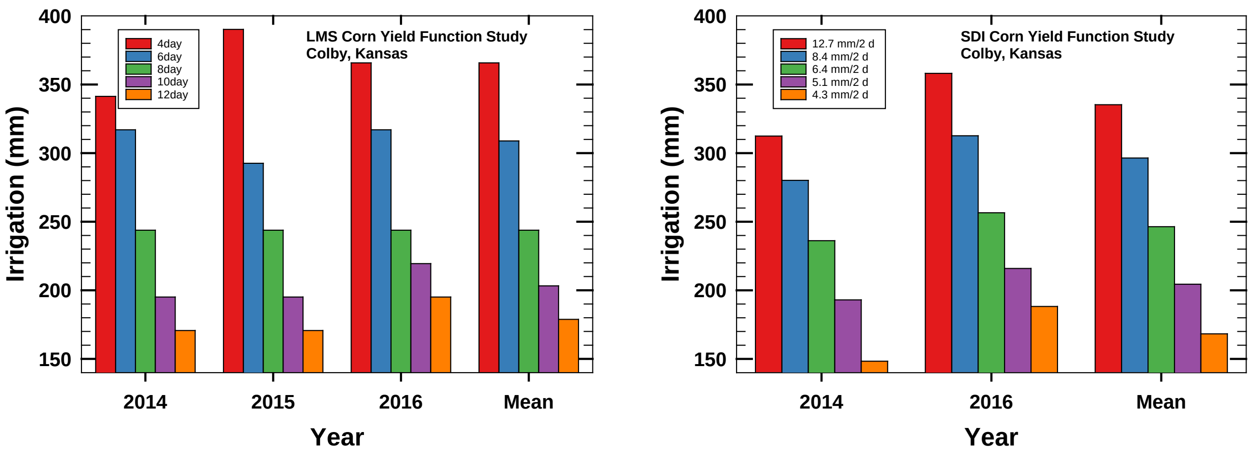

Figure 2. Seasonal irrigation amounts for the LMS and SDI studies, KSU Northwest Research-Extension Center at Colby, Kansas for 2014 through 2016.

Overall Grain Yield Response to Irrigation Capacity and System

Overall grain yields were excellent, ranging from 14.1 to 15.9 Mg/ha for the LMS system and ranging from 15.4 to 16.5 Mg/ha for the SDI system (Fig. 3). Since the studies were separately conducted, it is not appropriate to ascribe statistical differences to the two irrigation methods. However, the studies were conducted on similar soil types within 100 m of each other.

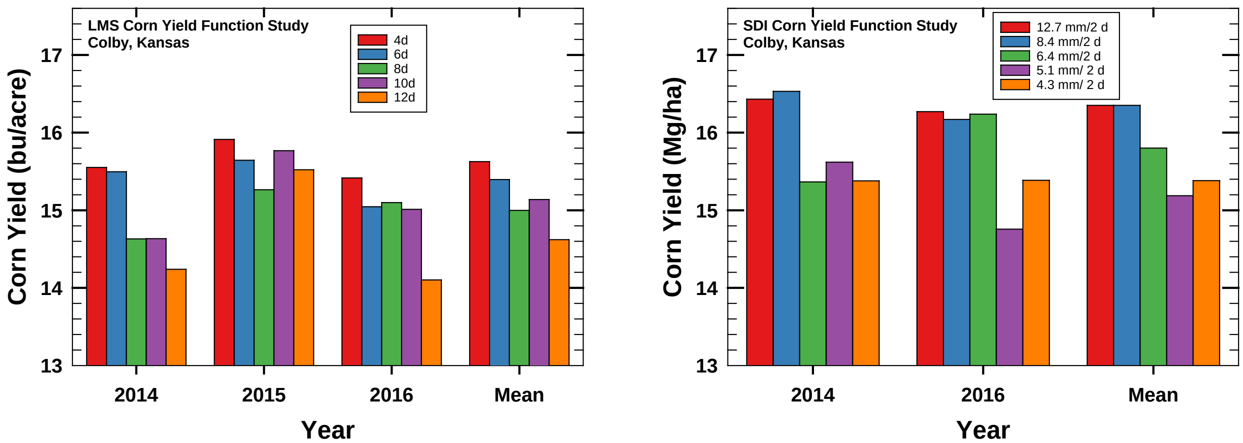

Figure 3. Corn grain yields for the LMS and SDI studies, KSU Northwest Research-Extension Center at Colby, Kansas for 2014 through 2016.

Examination of the Yield Components

Corn grain yield can be calculated as the product of the yield components:

$$Yield = \frac{Plants}{Area} \times \frac{Ears}{Plant} \times \frac{Kernels}{Ear} \times \frac{Mass}{Kernel} \qquad \text{Eq. 1}$$

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. Because all the yield components combine directly through multiplication to calculate yield, their effect on yield can be easily compared as shown in the examples in Fig. 4. Vertical or near vertical lines near zero on the x-axis indicate that yield component had no effect on variation. Holding other yield components static, a variation of 1% in any yield component would affect yield by the same 1%. For explanation the numbers on the lines refer to the 5 irrigation treatments and the lines are just used to connect data from each yield component. No functional or extrapolated relationships are intended for the connecting lines.

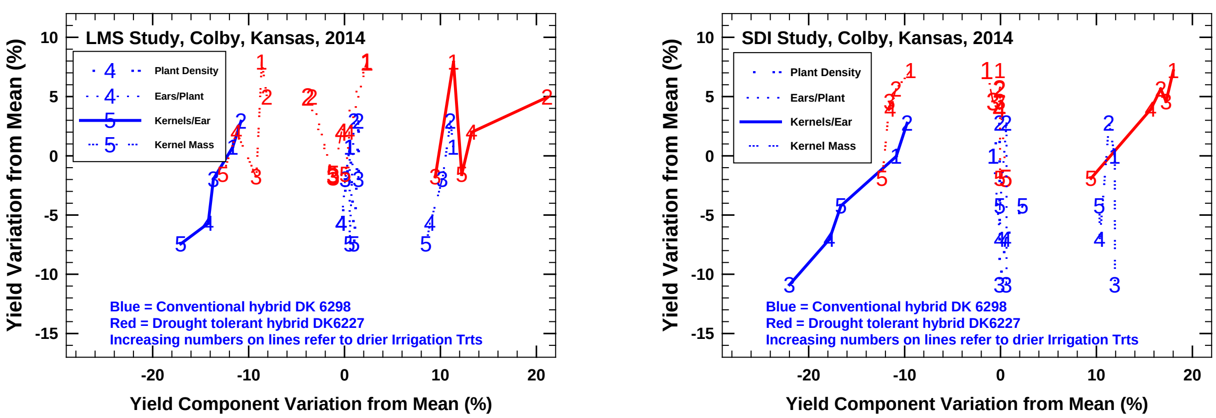

Figure 4. Variation in yield as related to yield component variation for the LMS and SDI systems in 2014.

In 2014, kernels/ear had much greater upward sloping horizontal dispersion as compared to other yield components. The drought tolerant hybrid generally used this aspect more positively. Generally less kernel mass was achieved by the drought tolerant hybrid but was compensated for by the greater kernel number. There "tended" to be more stability in both kernels/ear and kernel mass for the upper 4 irrigation capacities with SDI as compared to the LMS study, but once again a statistical comparison should not be inferred.

There was no SDI study in 2015. Kernels/ear was set at relatively high level for both hybrids (≈ 616 kernels/ear) and thus there was less distinction in how yield components affected the relatively high corn yields (15.3 to 15.9 Mg/ha) in 2015 (Fig. 5)

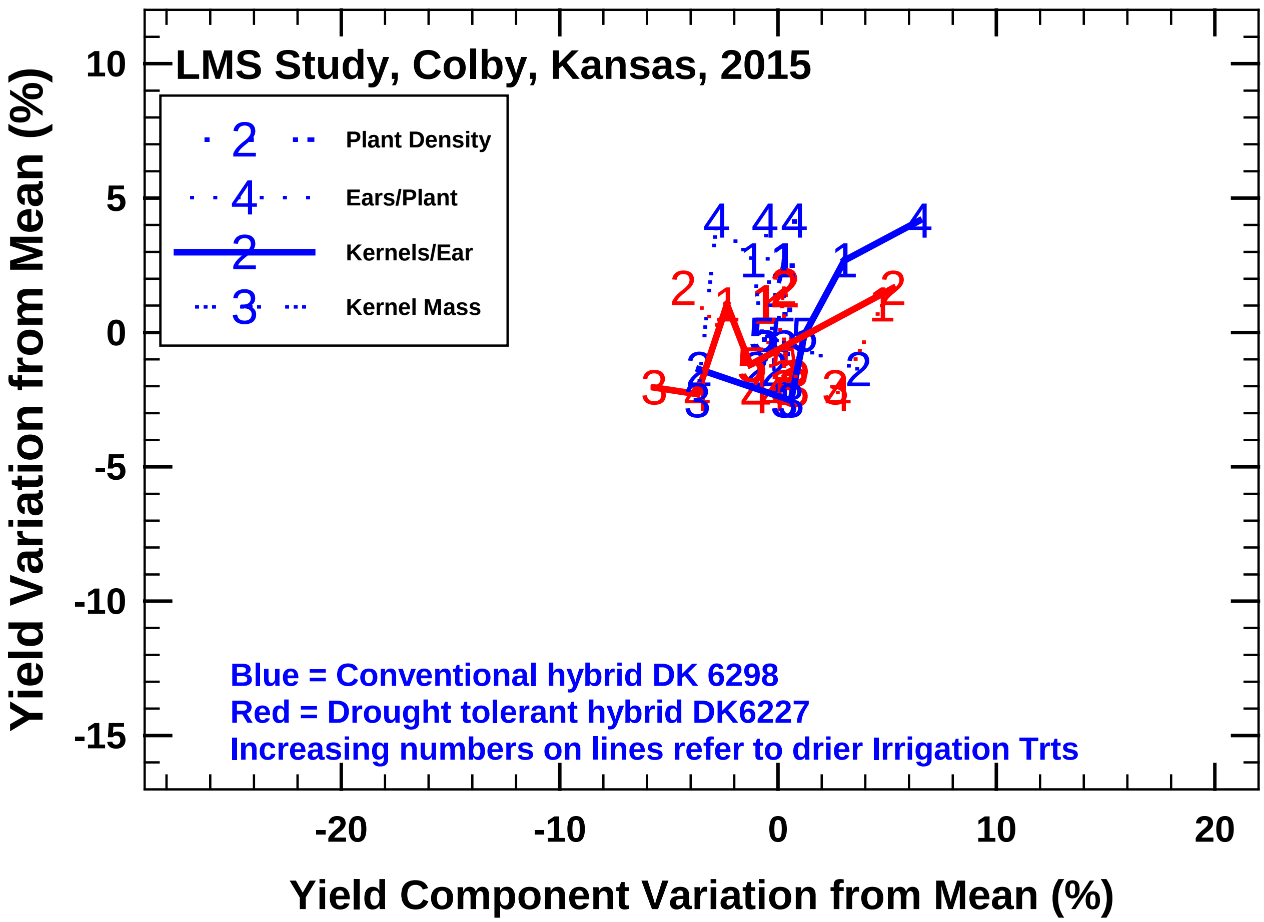

Figure 5. Variation in yield as related to yield component variation for the LMS system in 2015.

In 2016, kernels/ear had much greater upward sloping horizontal dispersion as compared to other yield components. The drought tolerant hybrid generally used this aspect more positively. Generally less kernel mass was achieved by the drought tolerant hybrid but was compensated for by the greater kernel number.

Closing Thoughts and Conclusions

The conventional and drought tolerant hybrids performed differently with the drought tolerant hybrid generally establishing greater kernels/ear when conditions were drier and the conventional hybrid tended to compensate under wetter conditions with greater kernel mass (i.e., grain filling). There “appeared” to be greater stability in grain yield across upper irrigation levels for the SDI system due to differences in yield component formation between the two irrigation systems (LMS and SDI).

Based on this and another recent study at this location, modern corn hybrids use differing strategies to achieve their optimum yield. There appears to be an opportunity to optimize corn yields with irrigation management and systems if producers could be apprised of these hybrid differences upfront.

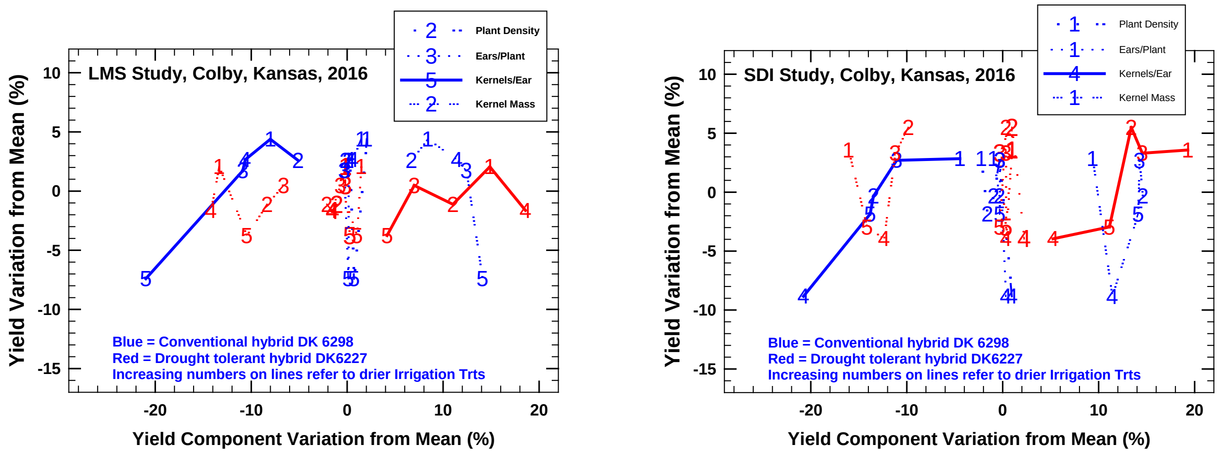

Figure 6. Variation in yield as related to yield component variation for the LMS and SDI systems in 2016.