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Abstract
Due to increasing non-irrigated corn acres, decreasing availability of irrigation water in some areas of western Kansas, and increasing water restrictions, producers are looking for more efficient ways to use available water. Drought-tolerant (DT) hybrid technologies are marketed for their ability to produce more stable yields in stress-prone environments. The objective of this research was to understand how DT and non-DT corn hybrids respond to a wide range of environmental conditions in terms of soil water status change, canopy indicators of stress, dry matter partitioning, and grain yield. Two DT hybrids, and one non-DT hybrid were compared in 2014 and 2015 at five locations in rain-fed, limited-irrigation, or fully irrigated regimes making a total of 18 environments. Grain yield was measured at all 18 environments, and biomass production was estimated at 14 of the environments. Yields of all hybrids were comparable in most environments, but as environment yields increased beyond 200 bu/a, one of the DT hybrids lagged behind the other two hybrids. Although one of the DT hybrids had slightly greater harvest index values than the other two hybrids in environments that resulted in a greater portion of dry matter allocated to grain, the differences were not consistent enough to be conclusive.

Keywords
DT corn hybrids, soil water, yield

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Response of Drought-Tolerant Hybrids to Environmental Yield Potential

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Summary

Due to increasing non-irrigated corn acres, decreasing availability of irrigation water in some areas of western Kansas, and increasing water restrictions, producers are looking for more efficient ways to use available water. Drought-tolerant (DT) hybrid technologies are marketed for their ability to produce more stable yields in stress-prone environments. The objective of this research was to understand how DT and non-DT corn hybrids respond to a wide range of environmental conditions in terms of soil water status change, canopy indicators of stress, dry matter partitioning, and grain yield. Two DT hybrids, and one non-DT hybrid were compared in 2014 and 2015 at five locations in rain-fed, limited-irrigation, or fully irrigated regimes making a total of 18 environments. Grain yield was measured at all 18 environments, and biomass production was estimated at 14 of the environments. Yields of all hybrids were comparable in most environments, but as environment yields increased beyond 200 bu/a, one of the DT hybrids lagged behind the other two hybrids. Although one of the DT hybrids had slightly greater harvest index values than the other two hybrids in environments that resulted in a greater portion of dry matter allocated to grain, the differences were not consistent enough to be conclusive.

Introduction

Since the mid 1990s, Kansas's corn acres have doubled, although irrigated corn acres have remained relatively unchanged. The mean annual precipitation of 14-22 inches across the High Plains region supplies only 60-90% of the seasonal water requirement of full-production corn. With most of the new corn acres in Kansas going to rain-fed production systems, producers have shifted production practices to compensate for the lack of rainfall. This has included the adoption of no-till and conservation-tillage practices as well as reduced irrigation inputs. Well-adapted corn hybrids have always been an essential component of non-irrigated production systems. In recent years, specific drought-tolerant technologies have been coming into the corn seed market.

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Drought tolerant corn hybrids are being marketed as part of the solution to maintaining yield stability with below-optimal water availability during the growing season. Drought tolerant corn hybrids are a relatively new technology but could be valuable for producers in semi-arid cropping regions when combined with other water conserving practices. The objective of this study was to understand the yield, change in soil water status, and response to environment of drought-tolerant corn hybrids across a wide range of water-input environments.

Procedures

Experiments were conducted at five locations throughout Kansas during two years: Topeka, Hutchinson, Scandia, Garden City, and Tribune in 2014 and 2015. Each location contained 1-3 different irrigation regimes for a total of 18 distinct environments. Hutchinson was the only site to contain dryland, limited-irrigation, and fully irrigated environments. Topeka and Scandia both contained rain-fed and fully irrigated environments. Tribune and Garden City each contained only a rain-fed environment. Seeding and fertilizer rates were adjusted for yield goals appropriate to the location and irrigation inputs. All plots were planted into 30-inch rows with four rows per plot and a length of 30 to 45 ft. Experiments were conducted in a randomized complete block design with each hybrid replicated four or five times within each environment.

Three corn hybrids were used in all experiments. Hybrids were chosen based on their drought-tolerant (DT) characteristics. The non-DT hybrid was a 111-day relative maturity (RM) hybrid with no documented specific drought tolerance characteristics, but was selected for proven production in well-watered environments as an intentional contrast with the two DT hybrids. DT-1 was a 111-day RM hybrid selected for non-transgenic drought tolerance. DT-2 was a well-adapted 111-day RM selected for conventional drought tolerance plus transgenic drought tolerance.

Corn hybrid response was characterized by canopy characteristics that are sensitive to drought stress (canopy temperature, ear leaf temperature, and leaf color), productivity (biomass yield, grain yield, and harvest index, HI = grain mass/total biomass), and soil moisture status (changes over time and depth). All results were subjected to analysis of variance within each environment and means were separated at alpha = 0.10. Measures of productivity were subjected to plasticity analysis by regressing hybrid performance within each of the 18 environments against the average performance of that environment. If the slopes of the regressions for each hybrid differed (alpha = 0.10), the hybrids were considered to be responding to the environments differently.

Results

Canopy and leaf characteristics occasionally showed differential hybrid responses in specific environments, but no consistent patterns emerged across the 18 environments (not shown). The soil profile under the non-DT hybrid showed greater water loss than for one or the other of the DT hybrids in five of the 18 environments, with three of those being non-irrigated. Even then the differences were relatively minor. The two DT hybrids responded similarly to the non-DT hybrid for these parameters in most instances.

Productivity of the hybrids changed in response to the environment, but all three hybrids responded to environmental changes in a similar manner. Yields generally increased with greater water supply, although timing of precipitation and temperature stress likely reduced yields in some instances, even when water was not limited on a seasonal basis (not shown).

Plasticity analysis of grain yield provided evidence that DT-2 had a different response than the other two hybrids as mean environmental grain yield increased (Figure 1). The slope for DT-2 was less than for DT-1, but was not different from the slope of the non-DT hybrid. Similar intercepts for all three hybrids implied that hybrid yields were similar in yield-limited environments, but DT-2 did not keep pace with the other two hybrids as yields exceeded 200 bu/a. In an environment supporting yields of 210 bu/a, the predicted difference in yield between DT-2 and DT-1 was less than 12 bu/a. The lack of hybrid separation when yields were less than 100 bu/a may indicate that all three of these hybrids were well suited to drought-stressed environments, whether or not they possessed specifically selected drought tolerance characteristics or transgenes.

The harvest index provided an estimate for the fraction of total production that was allocated to grain, a measure of how the hybrid allocated resources between vegetative tissues and grain. Plasticity analysis for this parameter revealed that DT-2 may have maintained a greater HI as yield increased; however, variability in the data prevented conclusive separation between the hybrid responses (Figure 2). The slopes for the lines associated with each hybrid were not different. Regression of yield on HI revealed no significant slope, indicating that HI did not increase as yield increased in this data set (not shown).

The two DT hybrids and one non-DT hybrid evaluated in this study differed little in their response to environments, producing yields from 60 to 220 bu/a. Although there was some indication that one of the DT hybrids did not keep up with the other hybrids in very productive environments, yield differences between the hybrids were minor in less productive environments. Although not true in all cases, these less productive environments were those most likely to have been subjected to yield-limiting moisture availability.

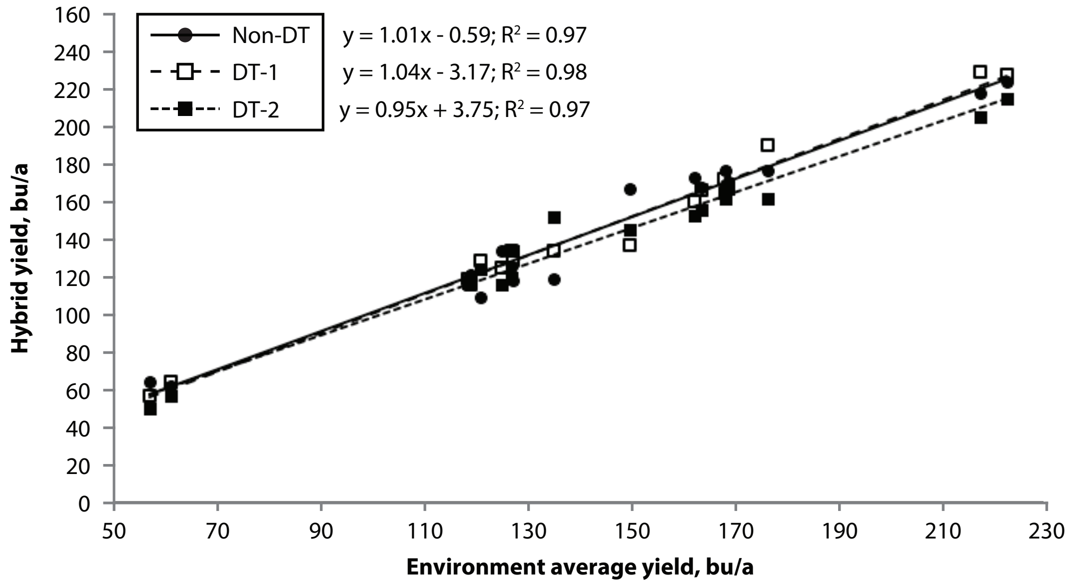

Figure 1. Regression of individual hybrid yield on mean yield for three hybrids in 18 environments in Kansas during 2014 and 2015.

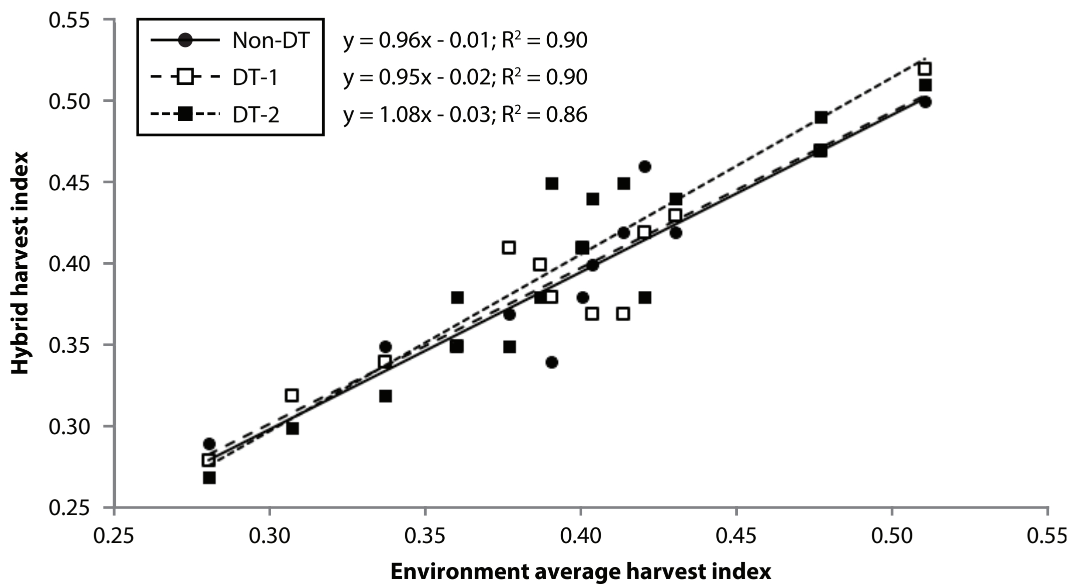

Figure 2. Regression of individual hybrid harvest index on mean harvest index for three hybrids in 18 environments in Kansas during 2014 and 2015.