Drought Tolerant Corn Yield Response to Water Availability

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Introduction

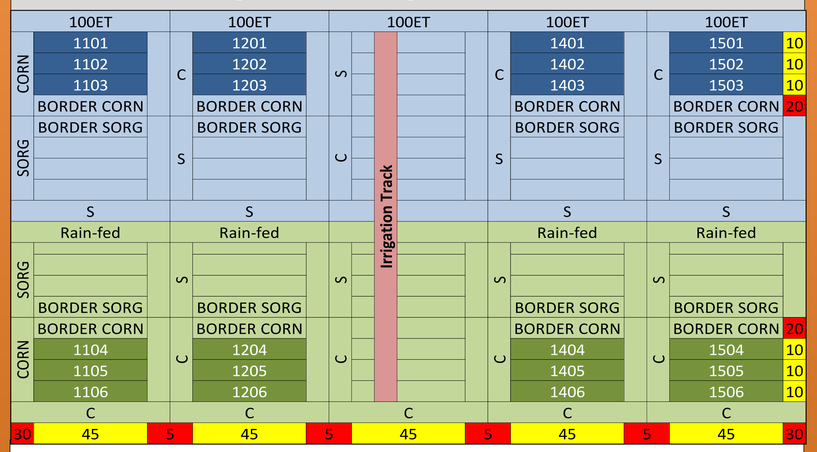
With decreased availability of irrigation water in central and western Kansas, producers are looking for more efficient ways to use available irrigation water. New drought-tolerant (DT) technologies have become popular in hybrids for low-yielding environments across central and western Kansas as a way to produce more grain with less water.

Objective

The objective of this study was to compare water use, yield, and water use efficiency of two types of drought tolerant (DT) corn hybrids and a high-yielding non-DT hybrid across two water environments of rain-fed and fully irrigated.

Materials and Methods

- Experiment at Scandia, KS with four replications
- Two DT corn hybrids, one conventional corn hybrid:
  - Pioneer 1151 AQUAmax™ (AM): Bred drought tolerance, 111 day relative maturity
  - Croplan 6000 DroughtGard™ (DG): Bred drought tolerance + transgenic drought tolerance, 111 day relative maturity
  - Croplan 6274: No drought tolerance traits, adapted to well-watered conditions, 111 day relative maturity
- Two water environments
  - Fully irrigated
  - Rain-fed
- Environment Management:
  - Fully irrigated yield goal 16,320 kg ha^{-1}, 86,360 seeds ha, 109 kg. N
  - Rain-fed yield goal 10,043 kg ac^{-1}, 66,040 seeds ac, 45 kg. N
  - Planted May 2, 2014 using a Monosem Precision Planter (Monosem Inc., Edwardsville, KS)
  - Harvested 9/22/14 (rain-fed), 10/15/14 (irrigated)
- Measurements taken include
  - Soil moisture status using a Campbell Scientific neutron moisture meter, using a factory calibration.
  - Chlorophyll content using a Konica Minolta SPAD-502Plus, as a measure of crop health
  - Canopy temperature using an Omega OS499L-12 infrared thermometer. Hybrids that maintain a higher canopy temperature may be more drought tolerant.
  - Yield, adjusted to 15.5% moisture
  - Harvest index
  - Moisture readings taken at emergence, V9, VT, R3, R6



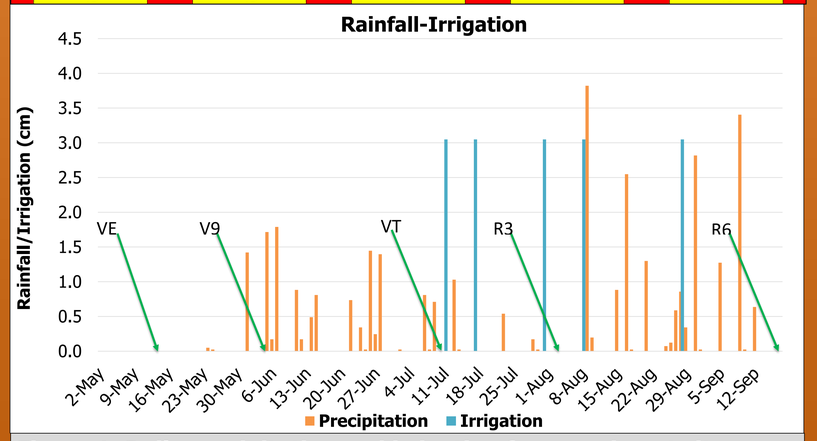


Figure 1. Daily precipitation and irrigation for experiment site
- Precipitation totaled total 35.26 cm during the season, and irrigation total was 15.24 cm. Water loss from drainage and runoff was negligible.

Results and Discussion

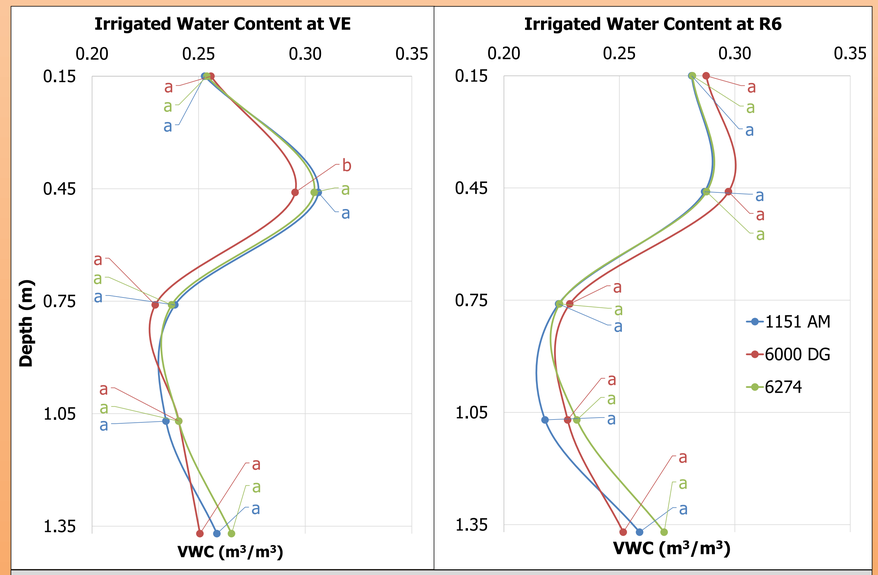


Figure 2. Volumetric water content for the irrigated environment
- Soil profile water content did not differ between hybrids at the end of the season.

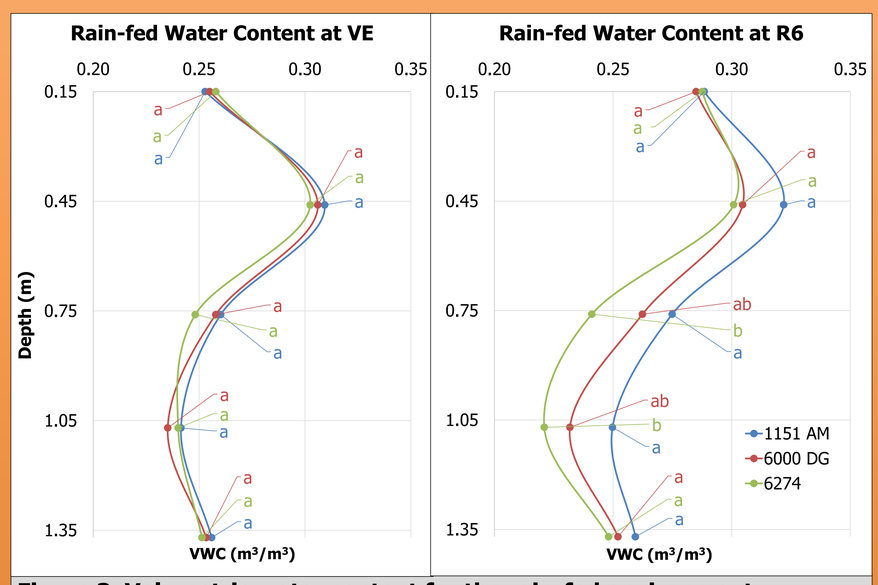


Figure 3. Volumetric water content for the rain-fed environment
- Total soil profile water content did not differ between hybrids at the end of the season, but hybrid 6274 does appear to have extracted more water between the .45 and 1.05 m. depths.

Table 1. Canopy Temperature

Irrigated	6/11/2014 °C	7/15/2014 °C	8/4/2014 °C
Pioneer 1151AM	31a†	24a	32a
Croplan 6274	30a	25a	33a
Croplan 6000DG	30a	24a	32a
Rain-fed			
Pioneer 1151AM	30a	23a	37a
Croplan 6274	30a	24a	36a
Croplan 6000DG	31a	23a	37a
Sampling Date Air Temperatures			
T max	29	23	36
T min	15	9	17

†Values in a column within a water environment followed by the same letter are not different (α=0.10)

- Hybrids did not differ in canopy temperature at any of the three sampling dates.

Table 2. Chlorophyll Content

Irrigated	6/11/2015	7/15/2014	8/4/2014
Pioneer 1151AM	53a†	50a	53b
Croplan 6000DG	54a	52a	56a
Croplan 6274	54a	49b	54b
Rain-fed			
Pioneer 1151AM	58a	58a	54a
Croplan 6000DG	56a	58a	53a
Croplan 6274	53b	50b	46b

†Values in a column within a water environment followed by the same letter are not different (α=0.10)

- In the irrigated environment 6274 had a lower chlorophyll content in mid-July, and both 6000DG and 1151AM had lower chlorophyll content in early August.
- In the rain-fed environment, 6274 had a lower mean chlorophyll content than 1151AM and 6000DG throughout the season.

Results and Discussion

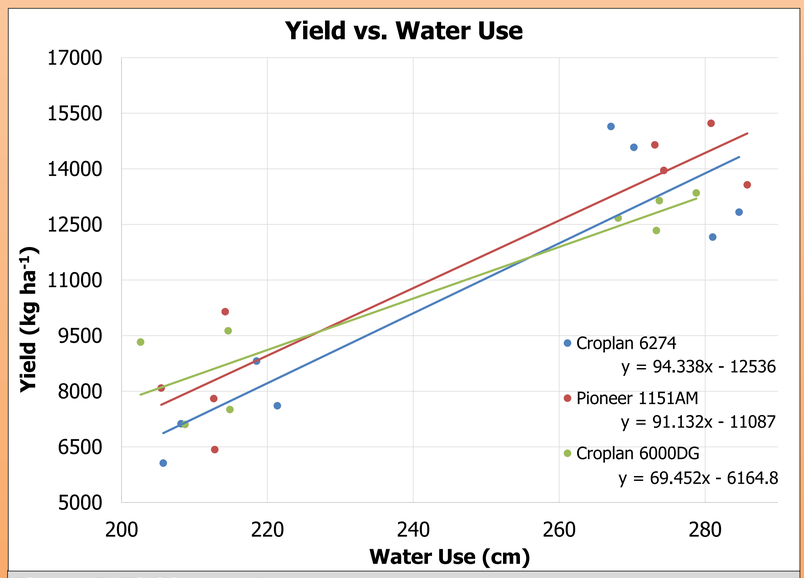


Figure 4. Yield vs. water use
- 1151AM and 6274 had similar yield response to water availability.

Table 3. Dry Matter Production

Hybrid	Irrigated (kg ha^{-1})	Irrigated Range (kg ha^{-1})	Rain-fed (kg ha^{-1})	Rain-fed Range (kg ha^{-1})
Pioneer 1151AM	6181.87a	5714-6591	4138.83c	2530-6802
Croplan 6000DG	4334.90b	3963-6473	4934.67b	3284-5042
Croplan 6274	4442.20b	5543-6194	5631.82a	2473-4338

†Values in a column within a water environment followed by the same letter are not different (α=0.10)

- Pioneer 1151AM had the highest mean DM production in the irrigated environment
- Croplan 6274 had the highest mean DM production in the rain-fed environment

Table 4. Harvest Index

	Irrigated	Irrigated Range	Rain-fed	Rain-fed Range
Pioneer 1151AM	.48b†	.46-.51	.45b	.28-.56
Croplan 6000DG	.51a	.48-.58	.45b	.36-.49
Croplan 6274	.49b	.45-.52	.49a	.42-.59

†Values in a column within a water environment followed by the same letter are not different (α=0.10)

- Croplan 6000DG had the highest mean harvest index in the irrigated environment, as well as the widest range of harvest index values
- Croplan 6274 had the highest harvest index in the rain-fed environment
- Pioneer 1151AM had the widest range of harvest index values in the rain-fed environment

Table 5. Hybrid Means

Irrigated	Water Use (cm)	Grain Moisture (%)	Test Weight (kg m^{-3})	Yield (kg ha^{-1})	WUE (kg ha^{-1} cm^{-1})
Pioneer 1151AM	54.97a†	14.4b	808.2a	14,374a	261.5a
Croplan 6000DG	53.98a	14.0c	799.2a	12,868b	238.4a
Croplan 6274	54.43a	14.9a	803.1a	16,634ab	305.6a
Rain-fed					
Pioneer 1151AM	41.71a	14.6b	761.9a	8,097a	194.1a
Croplan 6000DG	41.48a	14.3b	731.1b	8,411a	202.8a
Croplan 6274	42.11a	19.5a	734.8b	7,407a	175.9a

†Values in a column within a water environment followed by the same letter are not different (α=0.10)

- 6274 had higher moisture content than both DT hybrids.
- 1151AM had a higher test weight than other hybrids in the rain-fed environment only.
- Yields for all three hybrids were similar in the rain-fed environment, but in the irrigated environment 6000DG was significant less than 1151AM.

Conclusions

- Pioneer 1151AM and Croplan 6274 had similar responses in yield to water use.
- No significant differences in water use among hybrids were observed
- All three hybrids had similar yields in the rain-fed environment, but yields in this environment were on the upper end of the range where drought tolerant traits are likely to produce a response.
- No significant differences in WUE were observed among hybrids
- Croplan 6000DG had a significantly higher HI in the irrigated environment among hybrids, but not in the rain-fed environment