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Response of Drought Tolerant and Conventional Corn to Limited Irrigation

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Response of Drought Tolerant and Conventional Corn to Limited Irrigation

Abstract

The purpose of this study was to evaluate the response of two commercial hybrids (DKC 62-27 DGVT2PRO [drought tolerant trait (DT)] and DKC 62-98 VT2PRO [conventional]) to limited irrigation. Preliminary results from the 2014 and 2015 growing seasons at Southwest Research-Extension Center near Garden City, Kansas, indicate the effect of irrigation capacity on corn yield was significant ($P < 0.001$) for both hybrids. The effect of the drought tolerance trait on yield was not significant ($P > 0.05$) in both years. The effect of the interaction between irrigation capacity and corn hybrid on yield was also not significant ($P > 0.05$). Hybrid type had a significant effect on crop water use ($P < 0.05$). Crop water use ranged between 25.1 to 15.2 and 26.0 to 15.1 inches for the conventional and DT corn hybrids respectively. Averaged across treatments, the DT hybrid used approximately 3% more water compared to the locally adapted hybrid. It is worth noting that since the two hybrids were not isolines, any differences in crop water use could be attributed to differences in genetics and not the drought tolerant trait. The effects of the drought tolerant trait on water productivity were not significant in both years ($P > 0.05$). Water productivity ranged between 10.9 to 3.6 and 11.2 to 5.6 bu/a/in for conventional and DT corn hybrids, respectively. As expected, DT and conventional corn hybrids had curvilinear yield response to irrigation and linear response to seasonal crop water use/evapotranspiration (ETc). The marginal water productivity for conventional and DT hybrids ranged from 18.4 to 14.5 bu/a/in and from 15.2 to 14.6 bu/a/in respectively. These preliminary results indicate no significant differences in yields and water productivity between DT and conventional hybrids under full and limited irrigation. More research is needed to confirm these findings.

Keywords

corn, drought tolerant corn, limited irrigation, crop water use, water productivity response, irrigation management

Cover Page Footnote

The authors would like to thank Ogallala Aquifer Program for providing funding for the study. Sincere appreciation is expressed to all participating researchers and seed suppliers who have supported corn production in Kansas. We would like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for implementing the research protocols and for collecting and processing field data.

Response of Drought Tolerant and Conventional Corn to Limited Irrigation

I. Kisekka and F. Lamm

Summary

The purpose of this study was to evaluate the response of two commercial hybrids (DKC 62-27 DGVT2PRO [drought tolerant trait (DT)] and DKC 62-98 VT2PRO [conventional]) to limited irrigation. Preliminary results from the 2014 and 2015 growing seasons at Southwest Research-Extension Center near Garden City, Kansas, indicate the effect of irrigation capacity on corn yield was significant ($P < 0.001$) for both hybrids. The effect of the drought tolerance trait on yield was not significant ($P > 0.05$) in both years. The effect of the interaction between irrigation capacity and corn hybrid on yield was also not significant ($P > 0.05$). Hybrid type had a significant effect on crop water use ($P < 0.05$). Crop water use ranged between 25.1 to 15.2 and 26.0 to 15.1 inches for the conventional and DT corn hybrids respectively. Averaged across treatments, the DT hybrid used approximately 3% more water compared to the locally adapted hybrid. It is worth noting that since the two hybrids were not isolines, any differences in crop water use could be attributed to differences in genetics and not the drought tolerant trait. The effects of the drought tolerant trait on water productivity were not significant in both years ($P > 0.05$). Water productivity ranged between 10.9 to 3.6 and 11.2 to 5.6 bu/a/in for conventional and DT corn hybrids, respectively. As expected, DT and conventional corn hybrids had curvilinear yield response to irrigation and linear response to seasonal crop water use/evapotranspiration (ETc). The marginal water productivity for conventional and DT hybrids ranged from 18.4 to 14.5 bu/a/in and from 15.2 to 14.6 bu/a/in respectively. These preliminary results indicate no significant differences in yields and water productivity between DT and conventional hybrids under full and limited irrigation. More research is needed to confirm these findings.

Introduction

The purpose of this study was to determine grain yield, crop water use (ET), and water productivity response to 5 different irrigation capacities limited to 1 inch every 4, 6, 8, 10, or 12 days and dryland for two corn hybrids (DKC 62-27 DGVT2PRO [drought tolerant trait] and DKC 62-98 VT2PRO [conventional]) planted at a plant density of 32,000 plants/acre.

Procedures

Experimental Design

The study was conducted at the Kansas State University Southwest Research-Extension Center's Finnup Farm (38°01'20.87" N, 100°49'26.95" W, elevation of 2,910 feet above mean sea level) near Garden City, Kansas. The soil at the study site is a deep, well-drained Ulysses silt loam with water holding capacity of 2 in./ft. The experimental design was split-plot with whole plots (irrigation capacity; 5 levels plus dryland) arranged in a randomized complete block and subplot factor being corn hybrid with two levels (DT and conventional corn hybrids) arranged as split-plots within the whole plots. The experiment was replicated four times. Rainfall recorded from May to October in 2014 and 2015 was above normal (Figure 1). Normal annual rainfall for Garden City is 18 inches, but growing season rainfall alone in 2014 and 2015 was 18 and 20 inches, respectively.

Irrigation Management

Irrigation was applied using a linear move sprinkler system (Model: Valley 8000 series, Valmont Industries, Inc., Valley, Nebraska) with four spans and each span serving as a replicate. Irrigation treatments were designed to mimic the following irrigation capacities.

1. T1: Irrigate every 4 days
2. T2: Irrigate every 6 days
3. T3: Irrigate every 8 days
4. T4: Irrigate every 10 days
5. T5: Irrigate every 12 days
6. T6: Dryland treatment

Irrigation was triggered based on frequency and limited by ET water budget. Soil water measurements taken weekly using a neutron probe (CPN 503DR, CPN International, Concord, California) at 12-in. increments up to 8 ft. deep in both the DT and conventional corn subplots were used to monitor adequacy of irrigation. Each irrigation event applied 1 in. for all treatments irrigated on a given day.

Agronomic Management

The rotation was corn-corn-forage sorghum-corn under no-till. Two Monsanto corn cultivars planted were: 1) DT corn containing the cspB transgenic trait [Genuity® DroughtGard, 62-27 DGVT2PRO], and 2) non-isoline, locally adapted conventional corn hybrid [DeKalb DKC 62-98 VT2PRO]. Both hybrids had a relative maturity of 112 days. Planting occurred on May 7, 2014 and May 18, 2015. The planting was done using a no-till planter. Planting depth was 2 in. and seeding rate was 32,000 seeds per acre applied uniformly across all treatments. The no-till planter was equipped with a single coulter preceding a double disc furrow opener, and two rubber-tire closing wheels. The crop row direction was north-south. Nitrogen fertilizer was applied preplant at a rate of 300 pounds of N per acre as urea 46-0-0. Weed control involved application of 3 qt/a of Lumax EZ (S-metolachlor, Atrazine, Mesotrione) and 2 oz/a of Sharpen (Saflufenacial) as pre-emergence herbicide and 32 oz/a of Mad Dog Plus (glyphosate) and Prowl H2O (Pendimethalin) as post emergence herbicides. Harvesting was done by hand by taking two 10-foot corn rows in the center of each plot at physiological maturity.

Statistical Analysis

Statistical analysis was implemented using the PROC GLIMMIX procedure in SAS studio (*http://www.sas.com/en_us/software/foundation/studio.html*). Statistical tests were conducted at a 5% level of significance.

Results and Discussion

Corn Yield and Yield Components

Corn yields adjusted to 15.5% moisture (bu/a), for 2014 and 2015 are summarized in Table 1. The effect of irrigation capacity on corn yield was significant ($P < 0.001$). The effect of the drought tolerance trait in the DT hybrid did not significantly affect yield ($P > 0.05$) in 2014 and 2015, and the effect of the interaction between irrigation capacity and corn hybrid on yield ($P > 0.05$) was also not significant. The dryland treatment produced significantly lower yield compared to all other irrigated treatments in both years, implying even a little irrigation can improve corn yields.

Crop Water Use

As would be expected, irrigation level had a significant effect on crop water use ($P < 0.001$) in both years. Corn hybrid also had a significant effect on crop water use ($P = 0.0005$) and ($P = 0.04$) in 2014 and 2015, respectively, as shown in Tables 2 and 3. Crop water use ranged between 25.1 to 15.2 and 26.0 to 15.1 inches for the conventional and DT corn hybrids respectively. Averaged across treatments, the DT hybrid used approximately 3% more water compared to the locally adapted conventional hybrid. It is worth noting that since the two hybrids were not isolines, any differences in crop water use could be attributed to differences in genetics and not the drought tolerant trait. The effect of the drought tolerant trait on water productivity was not significant in both years ($P > 0.05$). Water productivity ranged between 10.9 to 3.6 and 11.2 to 5.6 bu/a/in for conventional and DT corn hybrids respectively. DT and conventional corn hybrids had curvilinear yield responses to irrigation (Figure 2) and linear responses to seasonal crop water evapotranspiration (ETc) (Figure 3). Due to differences in total growing season rainfall in 2014 and 2015 (18 inches in 2014 and 20 inches in 2015 [May to October]), maximum yield was reached with 6 inches of irrigation in 2015 compared to 8 inches in 2014; this indicates that the yield versus irrigation production functions are not unique and exhibit inter-seasonal variations. The marginal water productivity for conventional and DT hybrids ranged from 18.4 to 14.5 bu/a/in and from 15.16 to 14.59 bu/a/in, respectively.

Conclusion

Preliminary results from the 2014 and 2015 growing seasons indicate that the effect of irrigation capacity on yield was significant. The drought tolerant trait did not have a significant effect on yield. Corn hybrid type had a significant effect on crop water use. Averaged across treatments, the DT hybrid used approximately 3% more water compared to the locally adapted hybrid although this could be attributed to underlying differences in genetics and not the drought tolerant trait. DT and conventional corn hybrids had curvilinear yield responses to irrigation and linear responses to seasonal crop water use. The drought tolerant trait did not have a significant effect on water productivity. These preliminary results indicate no significant differences in yields between DT and conventional hybrids at Garden City, Kansas. More research is needed to confirm the effect of the drought tolerant trait on corn yield and water productivity.

Acknowledgements

The authors would like to thank Ogallala Aquifer Program for providing funding for the study. Sincere appreciation is expressed to all participating researchers and seed suppliers who have supported corn production in Kansas. We would like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for implementing the research protocols and for collecting and processing field data.

Table 1. Conventional and drought tolerant corn yield for the 2014 and 2015 growing seasons at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.

	Yield (bu/a)			
	2014		2015	
[*]Irrigation frequency (days)	Con.[1] Corn	DT[2] Corn	Con. Corn	DT Corn
4	242 ± 24 a[3]	214 ± 9 a	211 ± 11 a	224 ± 30 a
6	219 ± 15 a	218 ± 27 a	208 ± 39 a	222 ± 21 a
8	211 ± 37 ab	194 ± 8 ab	200 ± 16 a	213 ± 31 ab
10	176 ± 30 bc	183 ± 37 ab	190 ± 41 a	165 ± 28 c
12	162 ± 51 c	157 ± 33 b	200 ± 43 a	180 ± 33 bc
Dryland	62 ± 13 d	60 ± 23 c	112 ± 26 b	107 ± 27 d
	NS[3]		NS[3]	

[*]Irrigation frequency is used to mimic irrigation capacity.
[1]Conventional corn hybrid (DKC 62-98 VT2PRO).
[2]Drought tolerant corn hybrid (DKC 62-67 DGVT2PRO).
[3]NS LS-means in the two columns are not statistically significant at 5% level.

Table 2. Conventional and drought tolerant corn seasonal crop water use and water productivity for the 2014 growing season at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.

Irrigation frequency (days)	Seasonal irrigation (in)	Crop water use (in)		Water productivity (bu/a/in)	
		Con.[1] Corn	DT[2] Corn	Con. Corn	DT Corn
4	12	25.1a[3]	26.0 a	9.5 a	8.4 a
6	8	23.2 b	25.0 b	9.5 a	8.2 a
8	7	21.5 c	23.0 c	9.3 a	7.8 a
10	6	21.3 c	20.4 d	7.9 a	7.6 a
12	5	19.7 d	21.1 d	7.2 a	7.9 a
Dryland	.	15.9 e	15.7 e	3.6 b	7.5 a
		**[3]		NS[5]	

[1]Conventional corn hybrid (DKC 62-98 VT2PRO).
[2]Drought tolerant corn hybrid (DKC 6267 DGVT2PRO).
[3]LS-means with the same letters are not significantly different at 5% level.
[4]L-means in the two columns are statistically significant at 5% level.
[5]L-means in the two columns are not statistically significant at 5% level.

Table 3. Conventional and drought tolerant corn seasonal crop water use and water productivity for the 2015 growing season at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.

Irrigation frequency (days)	Seasonal irrigation (in)	Crop water use (in)		Water productivity (bu/a/in)	
		Con.[1] Corn	DT[2] Corn	Con. Corn	DT Corn
4	8	21.2 a[3]	23.1 a	10.9 a	11.2 a
6	8	21.5 a	22.7 ab	9.6 ab	10.3 a
8	6	21.5 a	21.5 bc	9.3 b	10.5 a
10	4	17.6 c	18.0 d	8.5 b	9.0 b
12	4	19.6 b	20.1 c	8.4 b	8.8 b
Dryland	.	15.2 d	15.1 e	5.7 c	5.6 c
		**4		NS[5]	

[1]Conventional corn hybrid (DKC 62-98 VT2PRO).
[2]Drought tolerant corn hybrid (DKC 6267 DGVT2PRO).
[3]LS-means with the same letters are not significantly different at 5% level.
[4]L-means in the two columns are statistically significant at 5% level.
[5]L-means in the two columns are not statistically significant at 5% level.

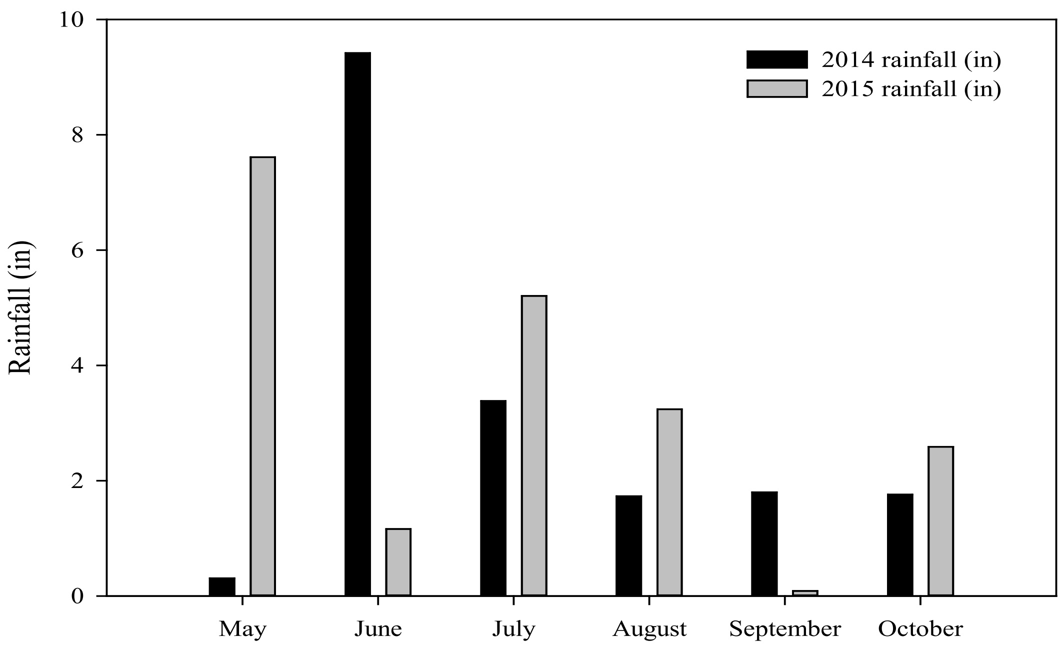

Figure 1. May to October rainfall for 2014 and 2015 at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.

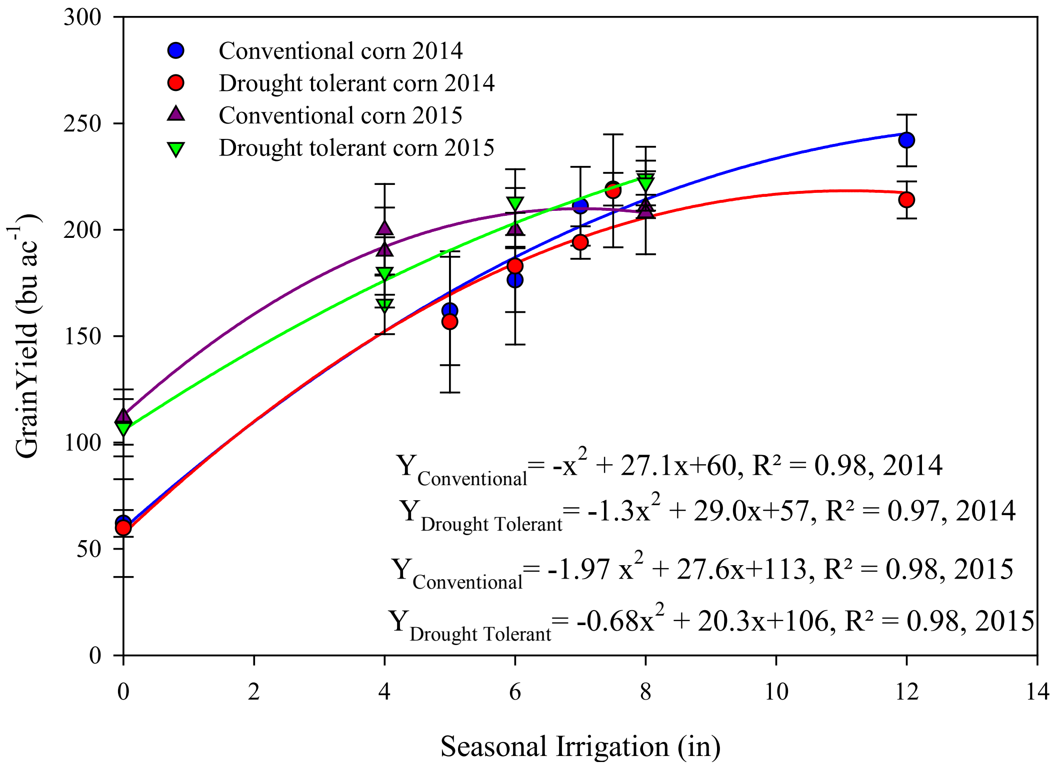

Figure 2. Response of conventional and drought tolerant corn to limited irrigation during the 2014 and 2015 corn growing seasons at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.

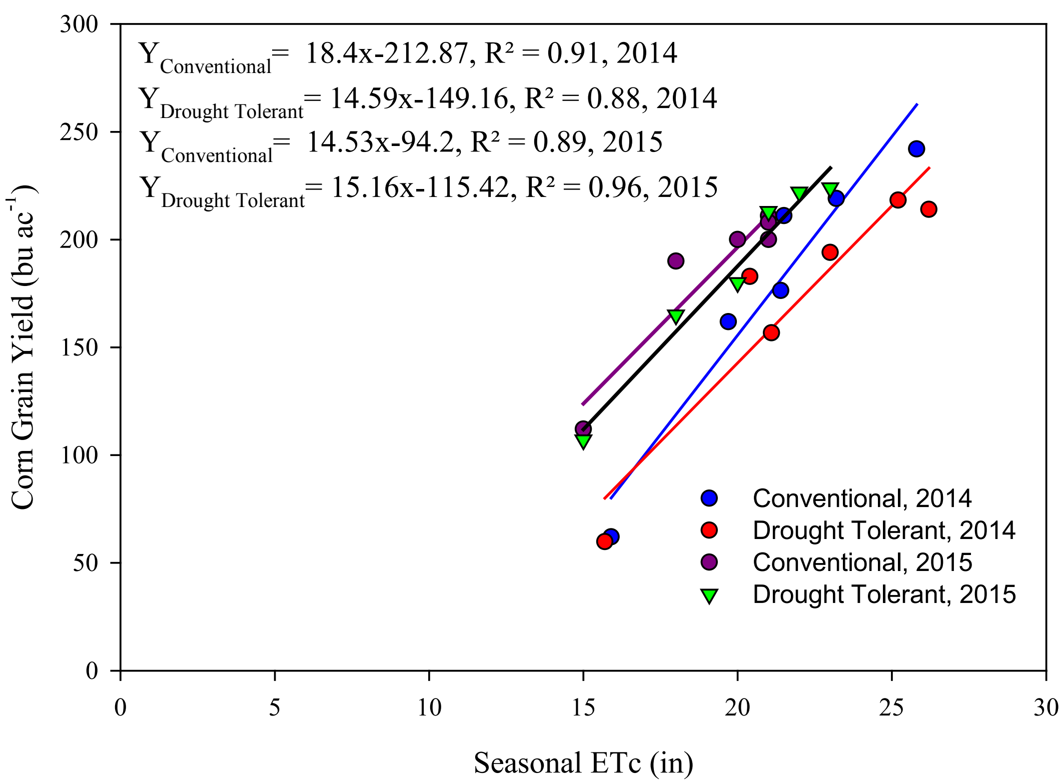

Figure 3. Yield versus seasonal evapotranspiration for conventional and drought tolerant corn during the 2014 and 2015 corn growing seasons at the Kansas State University Southwest Research-Extension Center Finnup Farm near Garden City, Kansas.