Comparison of Yield Components and Physiological Parameters of Drought Tolerant and Conventional Corn Hybrids

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ABSTRACT

Corn (*Zea mays* L.) consumes large quantities of water to produce yield. When sufficient hectares within an area are irrigated using deep wells, corn production can contribute to depleting underground aquafers. Hybrids genetically engineered for drought tolerance have recently become available to producers. Six hybrids, three sold as drought tolerant, were evaluated for yield, yield components, and physiological parameters of net assimilation rate (*A*), stomatal conductance (g_s), transpiration rate (*Em*), intercellular CO_2 (C*i*), and intrinsic water use efficiency (IWUE) during early reproductive growth in 2014 through 2016 with irrigated and nonirrigated treatments applied after anthesis. Irrigation did not improve yields among hybrids in any year. Hybrid differences in yield occurred each year but with no consistency across years, and genetically drought-tolerant hybrids were not always superior. Mean yields by year were 2016 (12,590 kg ha^{-1}) > 2015 (10,214 kg ha^{-1}) > 2014 (7843 kg ha^{-1}). Low yields in 2014 are attributed to fewer kernels per plant due to possible Formesafen herbicide carryover applied to soybean (*Glycine max* L. Merr.) the previous year. Of the physiological parameters measured (*A*, g_s, *Em*, C*i*, and IWUE), no hybrid differences were observed, only *Em* was found to be greater at anthesis (R1) than at kernel filling (R2), and irrigated treatments had greater *Em* than nonirrigated treatments. Data from this experiment and its environmental conditions showed no yield or physiological differences between drought-tolerant and conventional corn hybrids. Only on nonirrigated fields during limited soil moisture would drought-tolerant hybrids possibly be beneficial. Any reduction in irrigation by growing drought-resistant hybrids could not be determined in this experiment.

Core Ideas

- Drought-tolerant corn hybrids did not out-yield conventional corn hybrids.
- No yield components differed among hybrids.

Corn consumes large quantities of water to produce a profitable grain yield. It is estimated that grain yields of 12.5 Mg ha^{-1} require about 1.1 ML of water for every 0.6 Mg of grain produced (eXtension.org, 2008). Campos et al. (2006) stated that drought is one of the most yield-limiting factors that corn encounters. In the lower Mississippi River Valley, corn has become a major crop enterprise, especially in rotation with cotton (*Gossypium hirsutum* L.). Irrigation is readily available on much of the land used for corn production in the mid-southern states: ~90% or 405,000 ha in Arkansas (University of Arkansas, 2018), ~55% or 118,000 ha in Louisiana (USDA–NASS, 2017), and ~65% or 81,000 ha in Mississippi (MSUES, 2018). A number of economic and environmental factors pertaining to irrigated crop production have resulted in water conservation being brought to the forefront with respect to sustainability of the Alluvial Aquafer and other major groundwater and surface watersheds around the world.

There has been interest in reducing water consumption of crops for many decades, even prior to extensive irrigation. Recently, emphasis has been directed toward genetic manipulation of the water consumption by crops, especially corn. Predictions of increases in frequency and longevity of droughts brought on by climate change (Cook et al., 2015; Cooper et al., 2014; Kunkel et al., 1999; Lobell et al., 2008) have spurred interest in developing genetically drought-tolerant corn hybrids. Corn is the most abundantly produced and used feed, food, and industrial cereal in the world (FAOSTAT, 2014). Historically, corn geneticists and other crop breeders have considered stability in yield across both stressed and favorable environments as the key selection criteria for drought tolerance/avoidance in several species (Finlay and Wilkenson, 1963). In some of the earlier research on drought-tolerant corn hybrids, Bolaños and Edmeades (1993) and Edmeades et al. (1999) stated that increased grain yields in such corn hybrids are due less to an increase in phytomass and are more related to a reduction in barrenness through greater partitioning of photosynthate to reproductive growth. Bruce et al. (2002) stated that for corn the period during anthesis (growth stage R1; Ritchie et al., 1992) and early grain filling (growth stage R2) is the most water-stress

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Abbreviations: crm, comparative relative maturity; IPAR, indicated photosynthetically active radiation; IWUE, intrinsic water use efficiency.

sensitive part of the growing season for the crop when compared with the preflowering vegetative stages and late kernel filling.

There are presently three drought-tolerant technologies available in hybrid corn. DroughtGard is part of Monsanto's Dekalb Genuity (Monsanto Co., St. Louis, MO) hybrids and is marketed as achieving drought tolerance through a combination of traditional breeding and transgenics. Two others are Pioneer Optimum AQUAmax (DuPont Pioneer, Johnston, IA) and Syngenta Artesian (Syngenta Seeds, Minnetonka, MN), both of which are marketed as having been developed through traditional breeding methods. There are also hybrids being marketed as having "excellent" drought tolerance without further designation. The suitability of such corn hybrids for production in the lower Mississippi River Valley are not well documented, especially given the fact that over half of this region's corn production occurs with some form of irrigation. A study was initiated in 2014 to evaluate the physiology and agronomic characteristics of some of the available drought-tolerant corn hybrids grown under irrigated and nonirrigated conditions in the Mississippi River Delta and to compare them with the same characteristics in commonly grown conventional hybrids. If differences are observed, can those characteristics be beneficially used to reduce irrigation water consumption for corn production?

MATERIALS AND METHODS

The experiment was conducted for three growing seasons (2014, 2015, and 2016) on a Dundee fine sandy loam site (Fine-silty, mixed, active, thermic Typic Endoaqualfs) 1.5 km north of Elizabeth, MS, leased by the USDA–ARS Delta States Research Facility, Crop Production Systems Research Unit in Stoneville, MS. Six commercially available corn hybrids were selected at the initiation of the experiment: Pioneer brand AQUAmax P0636 (comparative relative maturity [crm] 106 d) and P1498AM (crm 114 d) along with P1745BVT (crm 117 d), P1319HR, (crm 113 d) P1739HR (crm 117 d), and Dekalb brand DKC62–05 (non-DroughtGard drought-tolerant hybrid, crm 112 d). Sufficient seeds were purchased at the onset of the study to carry the experiment to conclusion. Seeds were stored at −3.0°C or colder between seasons. All hybrids were germination tested prior to planting in 2015 and 2016 and were found to have ≥95.0% viable kernels.

The design used was a split plot of a randomized complete block replicated twice, with whole plots being either a furrow-irrigated or nonirrigated treatment. Irrigated and nonirrigated whole plots were separated by a four-row nonirrigated buffer of corn planted the length of the field. Subplots were the six hybrids factorially arranged within each of three subreplications of the whole plot. Individual experimental units were four 12-m-long rows spaced 102 cm apart. Yield and yield component data were collected from the two center rows of each unit at harvest maturity (growth stage R6).

The previous crop prior to initiating the experiment at the site for Seasons 1 and 2 was soybean (*Glycine max* L. Merr). The site for Season 3 was ~50 m south of the first seedings and had previously been in soybean and cotton (*Gossypium hirsutum* L.). Site preparation for planting began by disking the land level each autumn followed in late winter by the forming of 40-cm-high ridges, spaced 102 cm apart. Prior to planting, the ridges were harrowed to form a 35-cm-wide seedbed. The experiment was conducted over three growing seasons with plantings occurring 11 Apr. 2014, 30 Mar. 2015, and 8 Apr. 2016. Individual experimental units were planted using a John Deere 7100 vacuum planter set at a seeding rate of 92,600 kernels ha^{-1} with a final population goal of 82,500 plants ha^{-1}. Weed control each season was accomplished with a pre-emergence application of Lexar (Syngenta, Basel, Switzerland) at 1.8 kg ai ha^{-1}. Irrigation treatments were furrow irrigations applied beginning at growth stage R1 and every 10 d thereafter or 10 d after a rain event of 25.4 mm or more until physiological maturity (R6) (Table 1).

Table 1. Rainfall and irrigation events during the growing seasons on a drought-tolerant vs. conventional hybrid corn experiment near Stoneville, MS (MSUES, 2018).

2014		2015		2016	
Date	Rainfall	Date	Rainfall	Date	Rainfall
	mm		mm		mm
14–15 Apr.	72.9	1–4 Apr.	25.7	11–12 Apr.	46.7
25 Apr.	44.7	10 Apr.	61.5	24 May	25.4
13–16 May	34.0	17–20 Apr.	24.1	2–6 June	87.4
28–31 May	102.4	23–25 Apr.	37.3	13–18 June	40.9
1–3 June	11.2	16–19 May	105.7	27 June†	25.4
10 June	47.5	25 May–1 June	77.0	5–6 July	28.4
19 June†	25.4	11 June†	25.4	9–16 July†	114.6
24–29 June	69.1	21 June†	25.4	18 July†	25.4
10 July†	25.4	25–28 June	29.7	25–31 July	101.3
15–19 July	90.2	4–6 July	61.0	16–23 Aug.	84.8
11–12 Aug.	30.7	24 July†	25.4	Total	580.4
Total	553.5	Total	498.1		

† Irrigation application.

Ear leaf net assimilation rate [µmol CO_2 m^{-2} (leaf area) s^{-1})] (A), stomatal conductance (mmol H_2O m^{-2} s^{-1}) (g_s), transpiration rate (mol H_2O m^{-2} s^{-1}) (Em), intrinsic water use efficiency [IWUE; $A/(Em \times 100)$], and intercellular CO_2 (µmol CO_2 mol air^{-1}) (Ci) were measured on three randomly selected plants of each hybrid from one subreplication at Growth Stages R1 (Silking) just prior to any irrigation. About 14 and 15 d later at R2 (Blister), the same measurements were taken on one subreplication of an irrigated and nonirrigated treatment. All measurements were made between 8:30 and 11:30 AM CST after the foliage had dried of dew and on days with £33.0% cloud cover. Measurements were taken using a Li-Cor LI-6400XT Portable Photosynthesis System (Li-Cor Biosciences, Lincoln, NE) with a 6400–02(B) LED light source. A 0.6-cm^2 leaf surface area was sampled with the cuvette. Leaf chamber CO_2 levels were controlled by using a CO_2 cartridge and a fixed flow rate of 500 µmol s^{-1}. Carbon dioxide concentration within the leaf chamber was fixed at 355 µmol mol^{-1}, which was determined to be the mean atmospheric CO_2 level for the region at the initiation of the experiment. Beginning light levels were set at 2200 µmol m^{-2} s^{-1} indicated photosynthetic active radiation (IPAR). Levels were allowed to stabilize, data were then recorded, and the indicated IPAR level was reduced by 200 µmol m^{-2} s^{-1}. This process was repeated until an IPAR level of 200 µmol m^{-2} s^{-1} was obtained. Values for A, g_s, Em, Ci, and IWUE were determined for each hybrid at R1 and again at R2 for both whole plot irrigation treatments. Analyses were done using the PROC MIXED procedure of Statistical Analysis System 9.4 (SAS Institute, Cary, NC) (Table 2). Regression analyses were performed on the data collected versus IPAR levels. Trend lines were determined for each regression analysis, and the corresponding model that best fit the observations along with R^2 was determined.

Table 2. Type 3 tests of fixed and covariance parameter estimates of ear leaf net assimilation rate (*A*), stomatal conductance (g_s), transpiration rate (*Em*), intercellular CO_2 (*Ci*), and intrinsic water use efficiency (IWUE) for the irrigated and nonirrigated drought-tolerant and conventional corn hybrids experiment conducted on Dundee fine sandy loam near Elizabeth, MS.

		$P > F$				
Sources	DF	*A*	g_s	*Em*	*Ci*	IWUE†
		μmol CO_2 m^{-2} (leaf area) s^{-1})	mmol H_2O m^{-2} s^{-1}	mol H_2O m^{-2} s^{-1}	μmol CO_2 mol air^{-1}	
Hybrid	5	0.25	0.0175	0.5788	0.0156	0.0167
Stage	2	0.0106	0.2758	<0.0001	0.0057	0.103
Hybrid × stage	10	0.5583	0.4884	0.8022	0.4031	0.3791
IPAR	10	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hybrid × IPAR	50	0.9937	0.6606	<0.0001	0.1921	0.3993
Stage × IPAR	20	<0.0001	<0.0001	<0.0001	0.3262	0.2459
Hybrid × irrigation × IPAR	100	0.9859	0.999	<0.0001	1	0.9973
Covariance parameter estimates						
Year		7.278	0.000353	1.1594	0	0
ear × hybrid × stage		3.0131	0.002956	1.6059	569.83	0.02527
Residual		3.1664	0.000464	0.1781	221.86	0.005948

† Calculated as *A*/(*Em* × 100).

At R6, the two center rows of each experimental unit were counted to determine plant stands and inspected for dropped ears and lodging. They were then harvested using a Kincaid 8X-P (Kincaid Equipment Mfg., Haven, KS) combine equipped with a HarvestMaster weighing system (Juniper Systems, Logan, UT). At harvest, weight and relative grain moisture were recorded. After a sample of shelled grain (~500 g) was collected and dried for 24 h at 70°C, a sample of 100 sound kernels were weighed to determine kernel weight. Yield data for each experimental unit were adjusted to standard moisture content of 155 g kg^{-1}. Kernels per plant were estimated by assuming one ear per plant, using the stand count of the harvested rows, the grain yield per experimental unit, and the 100-kernel weight in the calculation. These data were analyzed using PROC MIXED of Statistical Analysis System 9.2 using procedures for a split plot replicated twice with three subreplications (Table 3).

RESULTS AND DISCUSSION

Physiological Parameters

Measurements of physiological parameters found no hybrid differences for *A* [μmol CO_2 m^{-2} (leaf area) s^{-1}] at any level of IPAR (μmol m^{-2} s^{-1}) for measurements taken at either R1 or R2 or between irrigated and nonirrigated treatments (Fig. 1). Similar observations were made for g_s, which did not differ among the hybrids or growth stage at sampling and was not influenced by irrigation (Fig. 2). Rates of g_s with changes of IPAR were linear ($y = 0.0001x + 0.1869$; $R^2 = 0.967$) from 200 to 2200 μmol m^{-1} s^{-2}. Transpiration rate was the only parameter measured in which a significant ($P \leq 0.05$) interaction (Growth Stage × IPAR) was observed (Fig. 3). A greater change in *Em* occurred as IPAR levels were reduced in plants at R1 than during R2. Also, *Em* was lower across all IPAR levels for the nonirrigated treatment than for the irrigated treatment at R2.

Internal CO_2 levels were also unaffected by growth stage at sampling, hybrid, or the application or absence of irrigation (Fig. 4). No noticeable increases in *Ci* were observed until IPAR was reduced to £1000 μmol m^{-2} s^{-1}. Intrinsic water use efficiency as defined by Farquhar and Sharkey (1982) was not observed to differ among the hybrids as IPAR was reduced (Fig. 5). There were no significant differences in IWUE as a result of growth stage at sampling for the absence or application of irrigation by R2. The ratio of 1:1 between *A* and equivalent units of g_s was ~ 1200 μmol m^{-2} s^{-1} IPAR. A further reduction in IPAR resulted in a steep decline of IWUE. Such a decline indicates that *A* decreases more rapidly than stomatal closure as light levels are reduced. These results are similar to results from earlier research

Table 3. Type 3 tests of fixed and covariance parameter estimates of yield and yield component data for irrigated and nonirrigated drought-tolerant and conventional corn hybrids experiment conducted on Dundee fine sandy loam near Elizabeth, MS.

Sources	DF	Yield, $P > F$	Kernels/plant, $P > F$	100 kernel wt, $P > F$
		kg ha^{-1}		
Hybrid	5	0.0408	0.008	<0.0001
Irrigation	1	0.3586	0.2504	0.1983
Hybrid × irrigation	5	0.9773	0.8596	0.3383
Year	2	0.0027	0.006	<0.0001
Hybrid × year	10	0.0071	0.0061	0.0042
Irrigation × year	2	0.0583	0.0012	0.013
Hybrid × irrigation × year	10	0.4248	0.4686	0.6621
Covariance parameter estimates				
Whole replications (years)		92,047	19.9235	0
Whole replications × irrigation (years)		40,435	0	1.90×10^{-18}
Subreplications (whole replications × irrigation × years)		56,217	3.9003	0
Whole replications × hybrid (irrigation × years)		0	0	0.2494
Residual		962,047	225.56	2.3161

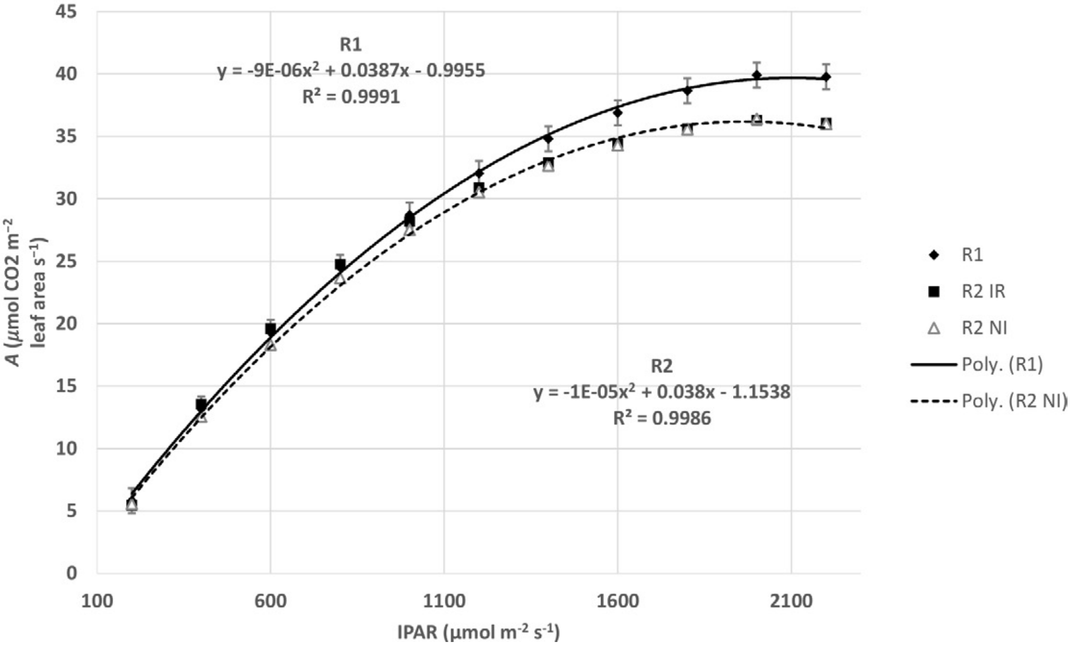

Fig. 1. Photosynthesis rates (*A*) at decreasing indicated photosynthetic active radiation (IPAR) measured at growth stages R1 and R2 of six corn hybrids (three genetically drought tolerant) grown with or without irrigation in 2014, 2015, and 2016 near Elizabeth, MS.

on grain sorghum (*Sorghum bicolor* L. Moench) (Bruns, 2016). These data do not indicate any measurable metabolic differences between corn hybrids developed for drought tolerance versus current conventional hybrids. These data were collected over a brief moment in a plant's life, whereas crop yield is the culmination of these physiological parameters throughout the growing season.

Agronomic Observations

At maturity there was essentially no lodging (root or stalk) and no dropped ears to report. Mean plant populations were 86,436, 86,292, and 90,712 plants ha^{-1} for seedings in 2014, 2015, and 2016, respectively, exceeding the final population goal each season. Heat stress was not a factor during the experiment's duration. Only 4 d (25 and 26 July 2015 and 7 and 9 Aug. 2015) had maximum ambient temperatures ^{3}37.0°C (MSUES, 2018). Such temperatures were not recorded in 2014 and 2016. Only two irrigations were applied in 2014, whereas three irrigations were necessary in 2015 and 2016 (Table 1). Total water received by the experiment during each season was 553.5, 498.1, and 580.4 mm for 2014, 2015, and 2016, respectively.

Mean grain yields across all hybrids were 7842.7, 10214.0, and 12590.0 kg ha^{-1} for 2014, 2015, and 2016, respectively ($P \leq 0.05$) (Table 4). No hybrid or set of hybrids was found to be significantly superior or inferior in grain yield during this

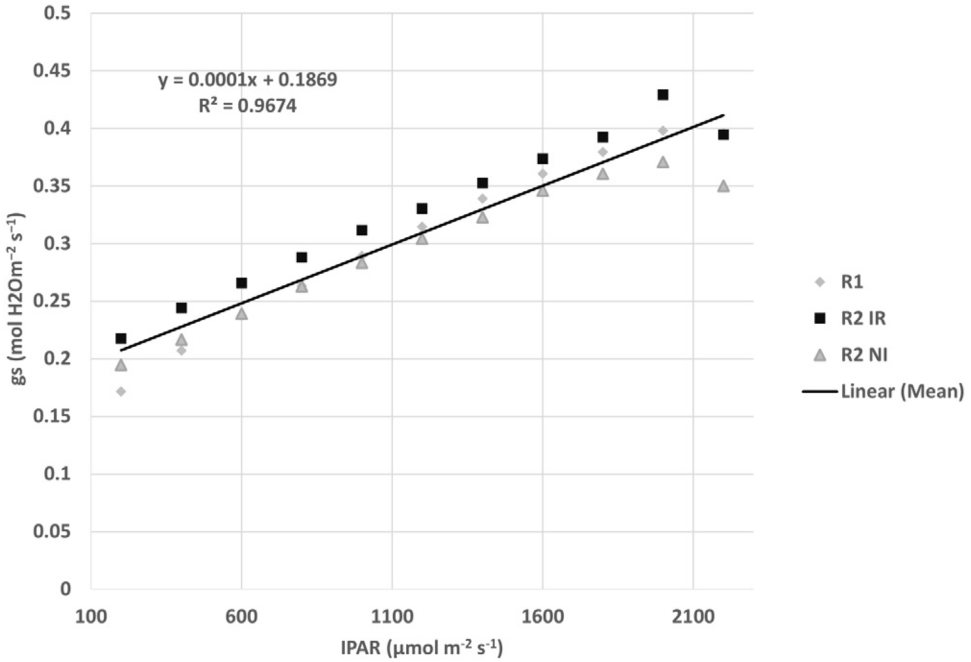

Fig. 2. Stomatal conductance (g_s) at decreasing indicated photosynthetic active radiation (IPAR) measured at growth stages R1 and R2 of six corn hybrids (three genetically drought tolerant) grown with or without irrigation in 2014, 2015, and 2016 near Elizabeth, MS.

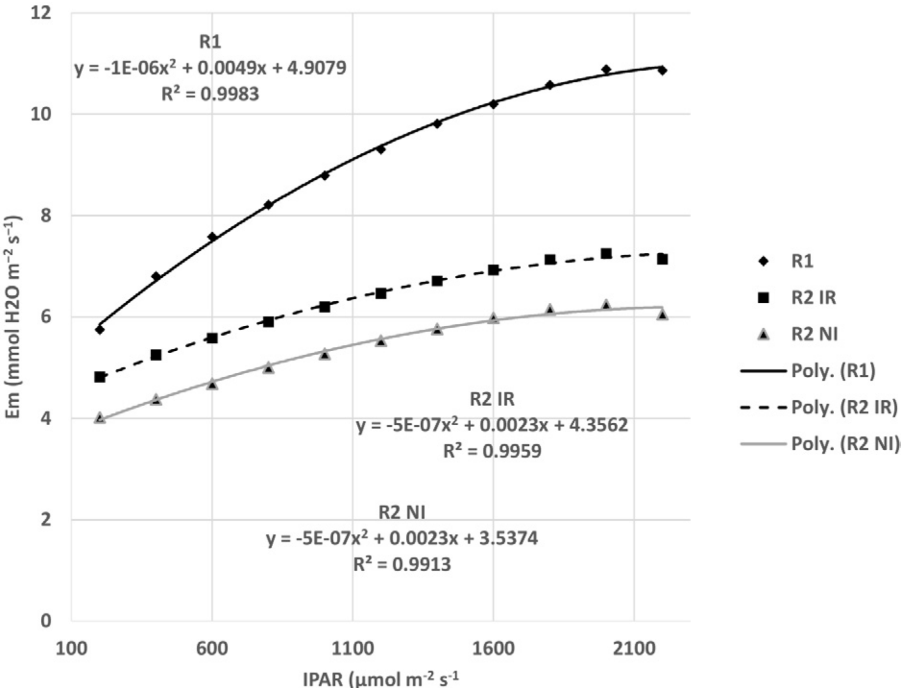

Fig. 3. Transpiration rates (*Em*) at decreasing indicated photosynthetic active radiation (IPAR) measured at growth stages R1 and R2 of six corn hybrids (three genetically drought tolerant) grown with or without irrigation in 2014, 2015, and 2016 near Elizabeth, MS.

experiment. At least one genetically drought-resistant hybrid would be among the higher-yielding hybrids in a particular year, but at least one such hybrid would be among the lower-yielding hybrids each season. Not one of these hybrids was continuously among the better yielding. Irrigation had no effect on the observed grain yields in this experiment. Neither the main effect of irrigation, hybrid × irrigation, nor year × irrigation was statistically significant.

Data on 100-kernel weights showed DKC 62–05 to consistently be highest in kernel weight among all hybrids across all seasons (Table 5). This corn hybrid is advertised as having "excellent drought tolerance" but not as a genetically engineered DroughtGard hybrid, similar to the two Pioneer AQUAmax hybrids in this experiment. No other hybrid exhibited a similar consistency regarding kernel weights. Kernel weights for all hybrids were significantly ($P \leq 0.05$) greater for the 2014 crop than the 2016 crop, which was, with the exception of P0636, greater than grain grown in 2015.

Estimates on the number of kernels produced per plant were determined from data on established stands, grain yields, and

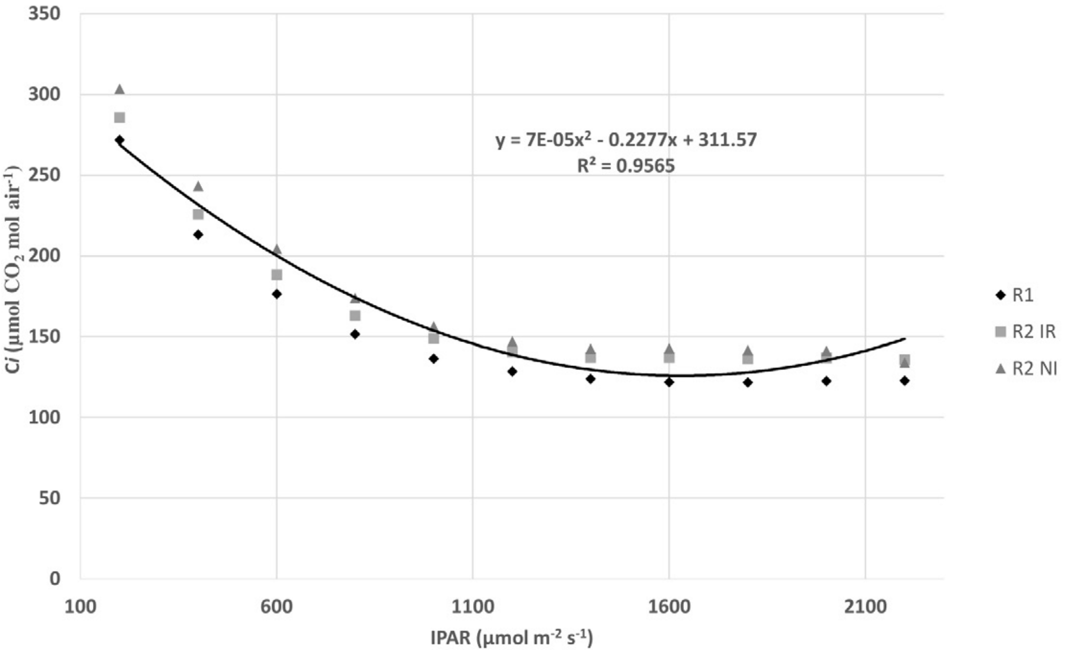

Fig. 4. Internal [CO_2] (*Ci*) at decreasing indicated photosynthetic active radiation (IPAR) measured at growth stages R1 and R2 of six corn hybrids (three genetically drought tolerant) grown with or without irrigation in 2014, 2015, and 2016 near Elizabeth, MS.

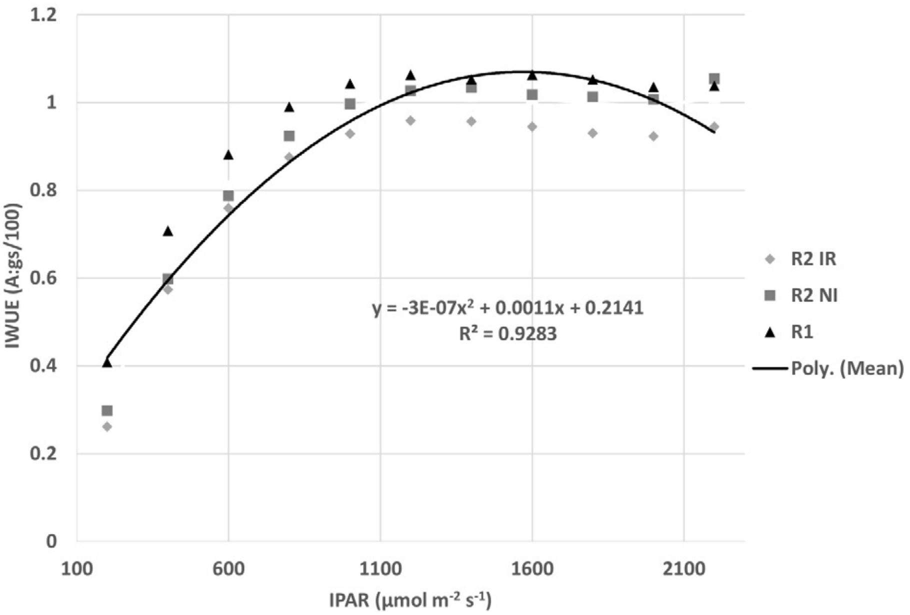

Fig. 5. Intrinsic water use efficiency (IWUE) at decreasing indicated photosynthetic active radiation (IPAR) measured at growth stages R1 and R2 of six corn hybrids (three genetically drought tolerant) grown with or without irrigation in 2014, 2015, and 2016 near Elizabeth, MS.

100-kernel weights (Table 6). No differences among hybrids in kernels per plant were observed in 2014. However, all hybrids that year had significantly ($P \leq 0.05$) fewer kernels per plant than seedings in the two successive years. The hybrids P0636 (a drought-resistant hybrid) and P1739HR produced more kernels per plant in the latter 2 yr of the experiment than most of the other hybrids. The hybrid DKC62–05 produced fewer kernels per plant during the same period than most of the other hybrids but had mean 100-kernel weights greater than most of the other hybrids in the study, which is a classic example of compensatory effects among yield components.

The exceptionally low grain yields in 2014 compared with the succeeding seasons is rather difficult to explain. The first two seasons were planted on the same site. The third season was planted on the same soil type ~50 m from the previous two. As stated in the Materials and Methods, seed was purchased in 2014, and the bags were stored in a freezer between seasons and used the two succeeding years. Fertilizer applications were virtually identical each season, and the same weed control methods were applied. Seeding dates did not differ much; in fact, only a 3-d difference existed between planting in 2014 (11 April) and 2016 (April 8). Rainfall after seeding appears sufficient for all three seasons to have avoided moisture stress on the young plants (Table 1). No extremes in temperature after seeding until late in 2015 were observed, and the observed extreme temperatures lasted only for only two 2-d periods (MSUES, 2018).

Table 4. Annual mean grain yields of drought-tolerant† and conventional corn hybrids grown with or without irrigation for 3 yr (2014–2016) near Elizabeth, MS.†

	Mean grain yield		
Hybrid	2014	2015	2016
		kg ha^{-1}	
DKC 62-05‡	7,509 b z	10,836 a y	12,943 a x
P0636§	7,302 b z	10,328 abc y	12,907 a x
P1319HR	8,051 ab z	9,988 b y	12,584 a x
P1498AM§	7,952 ab z	9,552 c y	11,827 b x
P1739HR	7,861 ab z	10,738 ab y	12,886 a x
P1745BVT	8,381 a z	9,844 c y	12,396 ab x

† Means of two replications, three subreplications, and irrigated and nonirrigated treatments. Means within a column followed by the same letter or letters (a, b, or c) or within a row (x, y, or z) are not significantly different at $LSD_{0.05}$ = 752.

‡ Non-DroughtGard drought-tolerant hybrid.

§ AQUAmax hybrid.

Palmer amaranth (*Amaranthus palmeri*) and other pigweed species have recently become serious pests to crops in the Mississippi River Delta and elsewhere due to their resistance to the herbicide glyphosate, which has been extensively used in corn and soybean production with the advent of glyphosate-resistant hybrids and cultivars. Growers have turned to the extensive use of Group 14 herbicides (protoporphyrinogen oxidase-inhibiting), some of which contain fomesafen, for late-season control of various amaranth species. These products have a 10-month post-application waiting period before corn can be safely grown, so a late June or July application of a fomesafen herbicide could be hazardous to an early seeding of corn the following season (Hartzler, 2014). It is possible that a fomesafen herbicide was applied to the field in 2013 for late-season *Amaranth* spp. control, although no record could be found

Table 5. Annual mean 100-kernel weights of drought-tolerant and conventional corn hybrids grown with or without irrigation over 3 yr (2014–2016) Near Elizabeth, MS.†

Hybrid	2014	2015	2016
		g	
DKC 62–05‡	41.4 a x	34.0 a z	37.3 a y
P0636§	37.5 d x	30.5 b y	31.5 c y
P1319HR	40.0 b x	29.3 b z	34.3 b y
P1498AM§	35.8 e x	25.9 d z	29.7 d y
P1739HR	38.0 c x	28.1 c z	31.0 c y
P1745BVT	39.4 b x	30.1 b z	34.2 b y

† Means of two replications, three subreplications, and irrigated and nonirrigated treatments. Means within a column followed by the same letter or letters (a, b, c, d, or e) or within a row (x, y, or z) are not significantly different at $LSD_{0.05}$ = 1.4.

‡ Non-DroughtGard drought-tolerant hybrid.

§ AQUAmax hybrid.

Table 6. Annual mean kernels per plant of drought-tolerant and conventional corn hybrids grown with or without irrigation over 3 yr (2014–2016) near Elizabeth, MS.†

Hybrid	2014	2015	2016
DKC 62–05‡	211 y	377 c x	382 c x
P0636§	232 z	421 ab y	470 ab x
P1319HR	240 y	387 c x	394 c x
P1498AM§	257 y	446 a x	438 b x
P1739HR	241 y	453 a x	478 a x
P1745BVT	240 z	354 c y	395 c x

† Means of two replications, three subreplications, and irrigated and nonirrigated treatments. Means within a column followed by the same letter or letters (a, b, or c) or within a row (x, y, or z) are not significantly different at $LSD_{0.05}$ = 33.

‡ Non-DroughtGard drought-tolerant hybrid.

§ AQUAmax hybrid.

confirming this. Also, most available literature on formesafen injury to corn states that the crop tends to “grow out” of the injury as the season progress. No information could be found that shows reduced yields may occur due to fewer kernels per plant as a result of formesafen carryover. Further research to confirm or disprove this possible effect on corn is warranted.

None of the three growing seasons in which this study occurred was droughty, which is unusual in this region during corn reproductive growth. This study did not demonstrate an advantage or disadvantage to growing these hybrids in an irrigated production system, and therefore a reduction in water application to an irrigated crop by planting drought-tolerant hybrids could not be determined from this experiment. On nonirrigated corn hectarage, genetically drought-tolerant corn hybrids could likely be of benefit during dry weather. Based on this study, they would not be adversely affected if optimum growing conditions prevailed throughout the year. Given the lack of a major price difference for the drought-tolerant traits (Richard Taylor, Farmers Feed & Supply, Leland, MS, personal communication), their selection for fields not equipped for irrigation could be a wise investment. The growing of such hybrids to reduce irrigation requirements and thus conserve water resources has yet to be determined.

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