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Title: Yield Performance Characteristics of Corn Hybrids under Limited Irrigation in the Northern Texas High Plains

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Project location: North Plains Research Field, Texas AgriLife Research, Etter, TX.

Summary: Since only 12 inches of irrigation was applied in the 2011 corn growing season, corn plants experienced moderate to severe water and heat stresses during grain filling. As a result, grain yield, seasonal evapotranspiration (ET) and water use efficiency (WUE) were generally low. Yield ranged from 26.3 to 62.1 bu/ac, ET was averaged 14.9 inches, and WUE was generally less than 4 bu/ac/in. The dry and hot conditions provided opportunity to distinguish the differences in drought tolerance among hybrids. Hybrids P31G96 and P33D49 significantly had higher average yields (53.9 for P31G96 and 46.3 bu/ac for P33D49) than hybrid DKC67-87 (30.1 bu/ac). The higher yields in P31G96 and P33D49 were contributed by both higher biomass and harvest index (HI). Among the yield components, more kernel numbers were highly associated with high yields. The results of this study indicated that selecting drought tolerant hybrids is important for higher yield under limited irrigation conditions.

Research background: Corn is a major irrigated crop in the northern Texas High Plains, with some of the highest average yields in the nation, particularly in the northwestern four-county area. Corn production in this area is achievable only with irrigation derived from the Ogallala aquifer. However, the declining water table and water conservation awareness of the aquifer has questioned these sustainable high yields with irrigated corn for the future. Recently, the Texas Region A 2011 Water Plan projects the continuing decline of the aquifer over the next 50 years, and the reduction of current irrigation levels is inevitable. Limited irrigation, the application of less irrigation water than the plants required for full evapotranspiration (ETc), will be the primary practice in the future. Managing corn under limited irrigation is risky because water stress cannot be avoided. Therefore, development of management strategies under limited irrigation is extremely important to reducing production risk and maintaining profitability.

In general, crop grain yield is determined by aboveground biomass and the fraction of biomass partitioning to grains (namely harvest index, HI). For corn plants, all of the biomass that is allocated to grain kernels is fixed through photosynthesis during grain filling period (GFP). Therefore, high yield requires high biomass at flowering and during GFP and longer GFP. The length of GFP is related to functional stay-green (i.e., leaves keep functioning in a

longer period). Under reduced irrigation regime, water stress will affect the rate of biomass accumulation as well as the GFP length. A better understanding of the biomass accumulation and stay-green characters in differing hybrids and planting densities under limited irrigation will lead to identification of a proper hybrid and planting density combination, while maintaining a profitable, high grain yield.

Objective: Investigate physiological attributes of corn yield determination under limited irrigation.

Methodology: Field experimentation was conducted at the North Plains Research Field, Texas AgriLife Research near Etter, TX under a center pivot irrigation system. Treatments consist of 3 commercially available hybrids (Pioneer P31G96, Pioneer P33D49 and Monsanto DKC67-87) and 4 planting densities (20,000, 24,000, 28,000 and 32,000 plants/ac). The experimental design was a completely randomized design with four replications. Each plot is 30 feet wide and 300 feet long with a row spacing of 30 inches.

The corn hybrids were planted on May 9, 2011. Field plots were irrigated before planting due to dry conditions this year. Soil water content at 4-ft profile was determined by gravimetric method before planting (April 26, 2011) and after harvest (October, 2011). Irrigation schedules were determined when plant available water (PAW) is at 50% within a four foot soil profile. The total irrigation level was 12 inches and last irrigation was July 11, 2011 when plants are in pre-silking to silking stages.

Silking and physiological maturity dates were recorded from visual observations. The physiological attributes of yield were assessed by destructive sampling of 10 plants in each plot before silking (Jul. 14, 2011) and at silking (Aug. 3, 2011). Leaf area was measured by an area meter. Biomass was determined after oven dry at 60^0C to constant weight. After maturity (end of September), biomass samples were collected from 20 randomly selected plants from each plot. Depending on planting density, these 20 plants represented 2.5-4.0 m^2 plot area. Biomass, grain yield, test weight, yield components (kernel numbers and kernel weight), and harvest index (HI) were determined by processing samples collected after maturity. Stay-green characters (leaf chlorophyll content) were assessed using a chlorophyll meter during grain filling.

Results: The stands count data are shown in Table 1. In general, the corn population is about 10% less than target planting density. However, these stands data are good given very dry, hot and windy early season weather.

The biomass and leaf area in single plant and unit area before silking and after silking are shown in Table 2. In general, biomass and leaf area per single plant decreased as planting density increased. However, biomass and leaf area per unit area increased as planting density increased. Among the three hybrids, P33D49 had the lowest leaf area. P31G96 produced more biomass and had higher leaf area than P33D49 and DKC67-87.

The chlorophyll content in three hybrids during grain filling is shown in Fig. 1. Consistently cross three measurement dates, P33D49 had the highest chlorophyll, P31G96 had the lowest, and

DKC67-87 was in the middle. The consistent lower chlorophyll readings in P31G96 may be due to the higher leaf area in this hybrid.

Since only 12 inches of irrigation was applied up to silking in this season, corn plants experienced moderate to severe water and heat stresses during grain filling. As a result, grain yield, seasonal evapotranspiration (ET) and water use efficiency (WUE) were generally low. Yield ranged from 26.3 to 62.1 bu/ac, ET was averaged 14.9 inches, and WUE was less than 4 bu/ac/in (Table 3).

The dry and hot conditions in this season provided opportunity to distinguish the differences in drought tolerance among hybrids. The two Pioneer hybrids (P31G96 and P33D49) clearly had higher average yields (53.9 for P31G96 and 46.3 bu/ac for P33D49) than Monsanto hybrid (DKC67-87, 30.1 bu/ac). The higher yields in P31G96 and P33D49 were contributed by both higher biomass and HI. On average, P31G96 and P33D49 had 20% more biomass at maturity than DKC67-87. The HI in DKC67-87 was generally less than 0.20. However, HI averaged 0.28 and 0.25 in P31G96 and P33D49, respectively. Among the yield components, higher yields were associated with more kernels per square meter and per plant. For example, the number of kernels per square meter in P31G96 was 227% higher than DKC67-87. Although DKC67-87 had higher kernel weight than other two hybrids, the difference was less than 30% (Table 3).

In general, planting density had less effect on biomass, yield, and yield components. However, hybrids seemed to respond differently to planting density. Yield in DKC67-87 tended to increase as planting density increased. However, the highest planting density (32,000 plants/ac) resulted in lower yield in P31G96 and P33D49 (Table 3).

Conclusion: There were significant differences in drought tolerance among the three hybrids under limited irrigation conditions. P31G96 and P33D49 were more drought tolerant, and had higher grain yields than DKC67-87. The higher yields were contributed by both higher biomass and harvest index. Among the yield components, more kernel numbers were highly associated with high yield. The results reported here were only from one growing season. The more robust conclusions for the differences in yield and drought tolerance among corn hybrids will depend on field experiment from multiple seasons.

Table 1. The actual corn stands count (plants/ac) in three hybrids at four planting densities during 2011 corn growing season at Etter, TX.

Hybrid	Target	Actual	% Target
	plants/ac	plants/ac	
DKC67-87	20,000	17,533	88
	24,000	22,216	93
	28,000	24,720	88
	32,000	28,859	90
P31G96	20,000	17,751	89
	24,000	21,998	92
	28,000	25,809	92
	32,000	28,314	88
P33D49	20,000	19,929	100
	24,000	23,849	99
	28,000	23,631	84
	32,000	29,730	93

Table 2. Biomass and leaf area before silking and at silking in three hybrids at four planting densities under limited irrigation during 2011 corn growing season at Etter, TX.

Hybrid	Planting density (PD)	Biomass		Leaf area		Biomass		Leaf area	
	plants/ac	kg/plant	Mg/ha	m^2/plant	m^2/m^2	kg/plant	Mg/ha	m^2/plant	m^2/m^2
		Before silking (Jul. 14, 2011)				Silking (Aug. 3, 2011)			
DKC67-87	20,000	0.110	4.74	1.01	4.35	0.169	7.34	0.84	3.62
	24,000	0.105	5.76	0.94	5.13	0.159	8.77	0.85	4.65
	28,000	0.095	5.90	0.73	4.55	0.145	8.92	0.81	4.94
	32,000	0.104	7.37	0.84	6.01	0.139	9.91	0.70	4.94
	Mean	**0.103**	**5.94**	**0.88**	**5.01**	**0.153**	**8.73**	**0.80**	**4.54**
P31G96	20,000	0.118	5.16	1.04	4.52	0.168	7.23	0.94	4.05
	24,000	0.117	6.33	1.04	5.67	0.177	9.55	1.05	5.66
	28,000	0.102	6.66	0.93	6.09	0.146	9.32	0.93	5.89
	32,000	0.105	7.35	0.89	6.26	0.139	9.69	0.78	5.49
	Mean	**0.111**	**6.37**	**0.98**	**5.63**	**0.157**	**8.95**	**0.92**	**5.27**
P33D49	20,000	0.102	5.04	0.69	3.42	0.167	8.24	0.76	3.74
	24,000	0.103	6.10	0.82	4.83	0.163	9.60	0.74	4.38
	28,000	0.100	5.86	0.72	4.18	0.149	8.70	0.70	4.12
	32,000	0.095	7.00	0.67	4.96	0.128	9.40	0.64	4.66
	Mean	**0.100**	**6.00**	**0.72**	**4.35**	**0.152**	**8.98**	**0.71**	**4.22**
LSD (0.05)	**Hybrid**	**0.01**	**NS**	**0.08**	**0.53**	**NS**	**NS**	**0.10**	**0.53**
	PD	**0.01**	**0.74**	**0.10**	**0.62**	**0.02**	**1.10**	**0.11**	**0.61**

NS: not significant, P>0.05.

Table 3. Grain yield, evapotranspiration (ET), water use efficiency (WUE), biomass, harvest index (HI), grain test weight, and yield components in three hybrids at four planting densities under limited irrigation during 2011 corn growing season at Etter, TX.

Hybrid	Planting density (PD)	Yield	ET	WUE	Biomass	HI	Test weight	Kernel numbers		Kernel weight
	plants/ac	bu/ac	in	bu/ac/in	Mg/ha		lb/bu	no./m^2	no./plant	mg
DKC67-87	20,000	26.3	15.5	1.75	6.4	0.20	62.1	804.6	187.4	183.15
	24,000	26.9	14.9	1.80	6.7	0.19	61.6	940.9	173.6	161.85
	28,000	31.3	14.2	2.21	7.6	0.19	61.5	1060.7	169.6	165.18
	32,000	36.0	14.1	2.52	8.6	0.19	61.0	1194.9	165.6	166.30
	Mean	**30.1**	**14.7**	**2.07**	**7.3**	**0.19**	**61.5**	**1000.3**	**174.0**	**169.12**
P31G96	20,000	57.1	15.5	3.78	8.7	0.31	59.7	2365.5	551.4	134.40
	24,000	58.1	14.5	4.05	9.1	0.30	58.7	2472.5	451.1	129.73
	28,000	62.1	15.0	4.09	9.5	0.30	59.5	2555.3	397.5	135.15
	32,000	38.3	15.6	2.43	7.9	0.22	59.8	1687.8	244.8	121.05
	Mean	**53.9**	**15.2**	**3.59**	**8.8**	**0.28**	**59.4**	**2270.3**	**411.2**	**130.08**
P33D49	20,000	53.3	14.8	3.58	8.6	0.29	59.0	2125.1	426.5	140.23
	24,000	51.1	14.8	3.89	9.0	0.26	59.5	2045.0	349.7	138.53
	28,000	43.1	14.5	2.97	8.4	0.24	57.8	1716.3	295.9	140.68
	32,000	37.8	14.9	2.33	9.4	0.19	58.3	1550.4	212.7	136.18
	Mean	**46.3**	**14.8**	**3.20**	**8.9**	**0.25**	**58.7**	**1859.2**	**321.2**	**138.90**
LSD (0.05)	**Hybrid**	**11.7**	**NS**	**0.84**	**1.1**	**0.04**	**0.9**	**429.5**	**74.2**	**9.69**
	PD	**NS**	**NS**	**NS**	**NS**	**0.05**	**NS**	**NS**	**85.7**	**NS**

NS: not significant, P>0.05.

Fig. 1. Chlorophyll readings in three days during grain filling in three hybrids in 2011 season at Etter, TX.