TCPB Research Final Report – December 28, 2012

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: The 2012 was another dry and hot year for corn production in the Northern Texas High Plains even though there was more rainfall than 2011. However, 12 inches of irrigation resulted in much higher yields in 2012 (100 bu/ac level) than 2011 (40 bu/ac level). Yield ranged from 74 to 132 bu/ac, ET was averaged 22 inches, and WUE was from 3.2 to 6.0 bu/ac/in, depending on hybrids and planting densities (PDs). For the hybrids, DKC67-87 had higher average yields (110 bu/ac) than P31G96 (86 bu/ac) and P33D49 (91 bu/ac). Although PD had less effect on yield, higher densities (>24,000 plants/ac) did not provide any yield benefit. The higher yields were contributed by both higher biomass and harvest index (HI). Regardless of hybrid and PD, yield was linearly related to biomass at maturity and biomass increase during grain filling. Among the yield components, both kernel numbers and kernel weight were highly associated with high yields. The results of this study indicated that maintaining higher biomass during grain filling 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 (PDs) (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 7, 2012. Field plots were irrigated before planting due to dry conditions this year. Irrigation schedules were determined when plant available water (PAW) was at 50% within a four foot soil profile. The irrigation level was limited to 12 inches.

Silking and physiological maturity dates were recorded from visual observations. The physiological attributes of yield were assessed by destructive sampling 10 plants per plot at silking (middle of July) and 20 plants per plot after physiological maturity (black layer, first week of September). 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 were assessed using a chlorophyll meter during grain filling. Soil water content at 4-ft profile was determined by gravimetric method at emergence and after harvest. The soil water content at emergence and maturity, and seasonal precipitation and irrigation were used to calculate evapotranspiration (ET). Water use efficiency (WUE) was calculated as the ratio of yield and ET.

Results: The stands count data are shown in Table 1. In general, the corn populations are close to or over the target planting densities. The good stands of this year were contributed by sufficient soil moisture at plating as well as strip-tillage for better retaining soil water.

The corn yield, seasonal ET, WUE, HI, test weight and yield components are shown in Table 2. There were significant yield differences among hybrids, with DKC67-87 having higher average yield (110 bu/ac) than P31G96 (86 bu/ac) and P33D49 (91 bu/ac). Although the planting density (PD) effect on yield was not significant (P>0.10), higher PD (>24,000 plants/ac) generally did not increase yield. There were no differences in ET (20.6-22.7 in) among hybrids and PD treatments. As such, WUE was largely determined by yield, and treatments with higher yields had higher WUE. For 3 hybrids, DKC67-87 had higher WUE (5.4 bu/ac/in) than P31G96 and P33D49 (4.1 bu/ac/in). Among the 4 PDs, the lower PDs (20,000 or 24,000) had higher WUE. The HI ranged from 0.35 to 0.43, depending on hybrids and PDs. There were no differences in

HI among hybrids but HI decreased as PD increased. The grain test weight was generally high for all treatments (>58 lb/bu) but plants at higher PDs had slightly lower test weight. For the hybrids, P31G96 had higher test weight (60 lb/bu) than DKC67-87 and P33D49 (58 lb/bu). There were significant differences in kernel numbers and thousand kernel weight (TKW) among hybrids and PDs. Comparing DKC67-87 and P33D49, DKC67-87 had less kernels/m^2 but higher TKW, and P33D49 had more kernels/m^2 but lower TKW. The PD did not affect kernels/m^2 and TKW but kernels/plant decreased as PD increased (Table 2).

The aboveground biomass (BM) at silking (R1) and maturity (MA) in single plant and unit area is shown in Table 3. Among the 3 hybrids, DKC67-87 consistently had higher BM and more BM increase during grain filling than P31G96 and P33D49, either on single plant or unit area basis. In particular, DKC67-87 had over 20% more biomass than P31G96 and P33D49 at maturity. Also, DKC67-87 had more biomass increase during grain filling than other two hybrids (Table 3).

Yield was highly correlated to HI, kernel numbers, BM at maturity, and BM increase during grain filling (Table 4). Regardless of hybrid, yield had linear relationships with BM at maturity and BM increase during grain filling (Figure 1). For the 3 hybrids, DKC67-87 was more responsive to kernels/m^2 than P33D49. Both higher TKW and more kernels/m^2 contributed to higher yield in DKC67-87 (Figure 2).

The chlorophyll readings in 3 hybrids during grain filling are shown in Fig. 3. Consistently cross 4 measurement dates, P31G96 had the lower readings than and DKC67-87 and P33D49. The chlorophyll readings in P33D49 reduced more rapidly than DKC67-87. The higher yield in DKC67-87 could be because the hybrid kept leaves green at longer time in this season.

Conclusion: There were significant differences in yield and WUE among the three hybrids under limited irrigation conditions. In contrast to 2011, DKC67-87 had higher yield and WUE than P31G96 and P33D49 in 2012 season. The higher yields were contributed by both higher biomass and harvest index (HI). Regardless of hybrid, yield was linearly related to biomass at maturity and biomass increase during grain filling. Among the yield components, both kernel numbers and kernel weight were highly associated with high yields. The results of this study indicated that maintaining higher biomass during grain filling is important for higher yield under limited irrigation conditions.

Table 1. The actual corn stands count (plants/ac) in three hybrids at four planting densities during 2012 corn growing season at Etter, TX.

Hybrid	target	Actual	% Target
	plants/ac	plants/ac	
DKC67-87	20,000	21562.2	108
	24,000	25047.0	104
	28,000	28749.6	103
	32,000	32778.9	102
P31G96	20,000	21090.3	105
	24,000	23740.2	99
	28,000	27987.3	100
	32,000	30709.8	96
P33D49	20,000	21235.5	106
	24,000	24502.5	102
	28,000	28858.5	103
	32,000	32887.8	103

Table 2. Yield, evapotranspiration (ET), water use efficiency (WUE), harvest index (HI), grain test weight, kernel numbers and thousand-kernel weight (TKW) in three hybrids at four planting densities under limited irrigation during 2012 corn growing season at Etter, TX.

Hybrid	Planting density (PD)	Yield	ET	WUE	HI	Test weight	Kernel numbers		TKW
	plants/ac	bu/ac	in	bu/ac/in		lb/bu	no./m^2	no./plant	g
DKC67-87	20,000	115.9	20.6	5.56	0.432	58.9	2839.1	533.5	213.3
	24,000	131.8	21.8	6.03	0.442	58.7	3329.4	538.5	212.2
	28,000	93.9	22.1	4.26	0.367	58.0	2375.9	335.1	210.2
	32,000	97.8	21.5	5.78	0.332	58.3	2135.7	395.9	183.7
	Mean	**109.8**	**21.5**	**5.41**	**0.393**	**58.5**	**2670.0**	**450.7**	**204.8**
P31G96	20,000	101.5	21.0	4.80	0.410	60.4	2755.2	524.9	193.5
	24,000	74.8	22.5	3.33	0.392	59.9	2361.4	403.5	168.2
	28,000	77.9	21.0	4.26	0.339	60.1	2352.8	340.0	170.2
	32,000	89.3	21.5	4.15	0.380	60.2	2778.6	366.8	170.0
	Mean	**85.9**	**21.5**	**4.13**	**0.380**	**60.1**	**2562.0**	**408.8**	**175.5**
P33D49	20,000	104.1	21.6	4.85	0.431	59.7	3348.7	639.3	164.8
	24,000	93.1	22.3	4.17	0.429	58.2	3227.3	536.1	151.1
	28,000	74.4	22.7	3.28	0.351	58.4	2821.2	394.7	139.5
	32,000	93.5	22.4	4.19	0.380	57.7	3498.3	432.8	141.8
	Mean	**91.3**	**22.3**	**4.12**	**0.398**	**58.5**	**3223.9**	**500.7**	**149.3**
LSD (0.05)	**Hybrid**	**17.2**	**NS**	**0.73**	**NS**	**0.8**	**427.2**	**75.3**	**20.5**
	PD	**NS**	**NS**	**0.84**	**0.032**	**0.9**	**NS**	**87.0**	**NS**

NS: not significant, P>0.05.

Table 3. Biomass (BM) at silking (R1) and maturity (MA), and BM increase during grain filling in three hybrids at four planting densities under limited irrigation during 2012 corn growing season at Etter, TX.

Hybrid	Planting density (PD)	Biomass (BM, Mg/ha)			Biomass (BM, g/plant)		
		R1	MA	BM increase	R1	MA	BM increase
	plants/ac						
DKC67-87	20,000	8.52	14.06	5.54	160.1	264.3	104.2
	24,000	8.96	15.79	6.84	144.7	255.6	110.8
	28,000	9.30	13.59	4.73	131.1	191.3	66.4
	32,000	9.75	14.39	4.65	120.4	177.3	56.9
	Mean	**9.13**	**14.46**	**5.44**	**139.1**	**222.1**	**84.6**
P31G96	20,000	8.36	13.14	4.78	161.8	249.7	87.9
	24,000	8.25	10.14	1.90	140.8	173.5	32.7
	28,000	8.73	11.78	3.05	126.2	170.2	44.0
	32,000	9.71	12.40	2.69	128.0	163.6	35.6
	Mean	**8.76**	**11.86**	**3.10**	**139.2**	**189.2**	**50.0**
P33D49	20,000	7.42	12.80	5.39	141.6	244.7	103.1
	24,000	8.00	11.38	3.59	133.9	188.9	60.7
	28,000	7.65	11.06	3.41	107.4	155.1	47.7
	32,000	8.44	12.93	4.49	103.9	159.7	55.8
	Mean	**7.88**	**12.04**	**4.22**	**121.7**	**187.1**	**66.8**
LSD (0.05)	**Hybrid**	**0.43**	**1.70**	**1.71**	**9.8**	**26.3**	**28.1**
	PD	**0.50**	**NS**	**NS**	**11.3**	**30.4**	**32.5**

NS: not significant, P>0.05.

Table 4. Pearson correlation coefficients among yield, yield components, biomass per unit area (BM) at silking (R1) and maturity (MA), BM per plant (BMpl) at R1 and MA, and BM and BMpl increases during grain filling.

	Yield	HI	TKW	Kernels	Kernels	BM _R1	BM_MA	BM increase	BMpl_R1	BMpl_MA
	bu/ac		g	/plant	/m2	Mg/ha	Mg/ha	Mg/ha	g/plant	g/plant
HI	0.80***	1.00								
TKW	0.56***	0.38**	1.00							
Kernels/plant	0.71***	0.73***	-0.01	1.00						
Kernels/m2	0.77***	0.75***	0.01	0.83***	1.00					
BM_R1	0.26	0.01	0.40**	-0.19	-0.07	1.00				
BM_MA	0.93***	0.55***	0.52***	0.59***	0.67***	0.36*	1.00			
BM increase	0.91***	0.58***	0.41**	0.72***	0.76***	0.03	0.94***	1.00		
BMpl_R1	0.35*	0.46**	0.55***	0.36*	0.06	0.24	0.19	0.11	1.00	
BMpl_MA	0.84***	0.69***	0.59***	0.76***	0.55***	0.00	0.77***	0.82***	0.62***	1.00
BMpl increase	0.87***	0.62***	0.47**	0.76***	0.68***	-0.12	0.85***	0.95***	0.28	0.92***

**: P<0.01; ***: P<0.001.

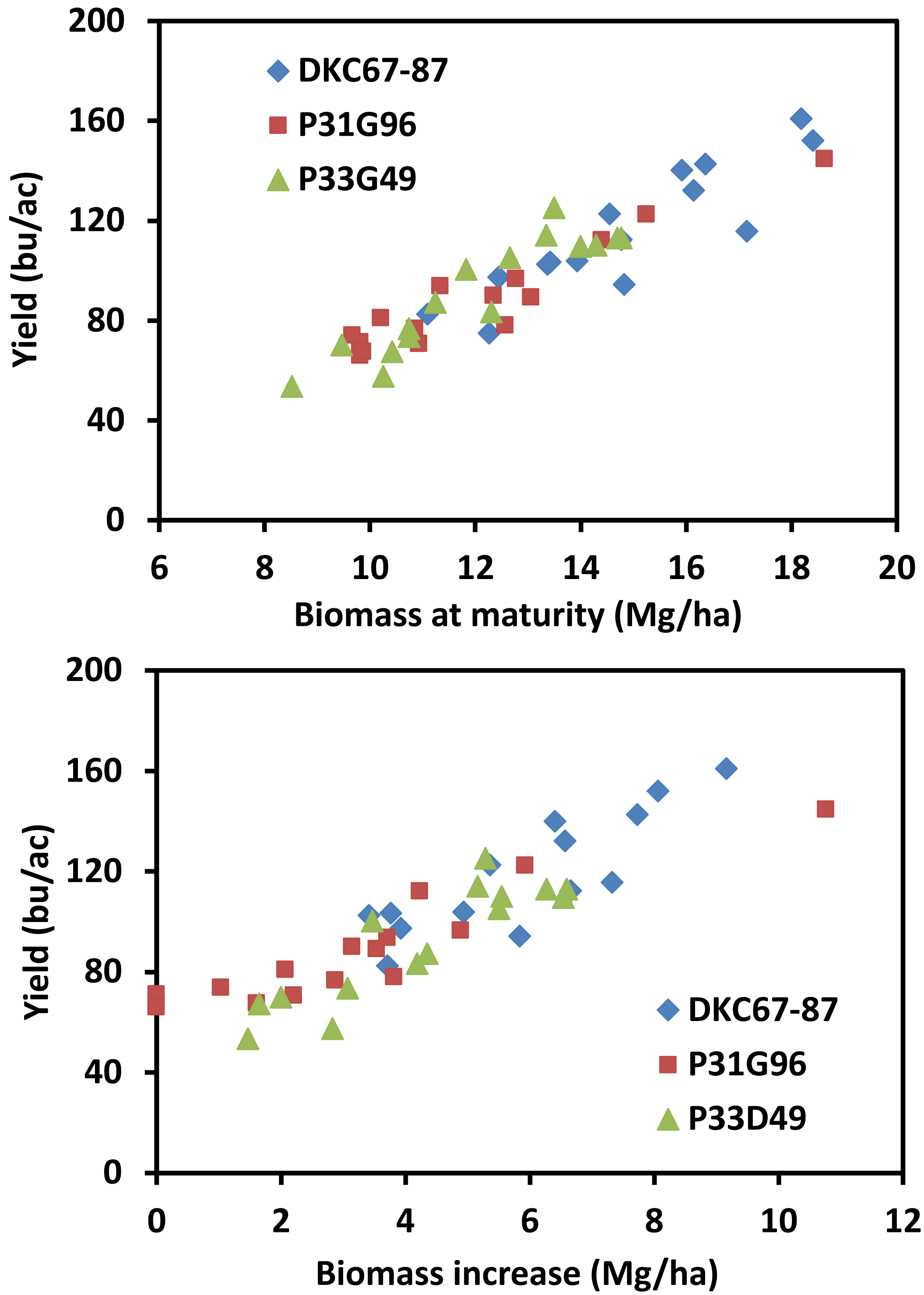

Figure 1. Linear relationships between yield and biomass at maturity, and between yield and biomass increase during grain filling.

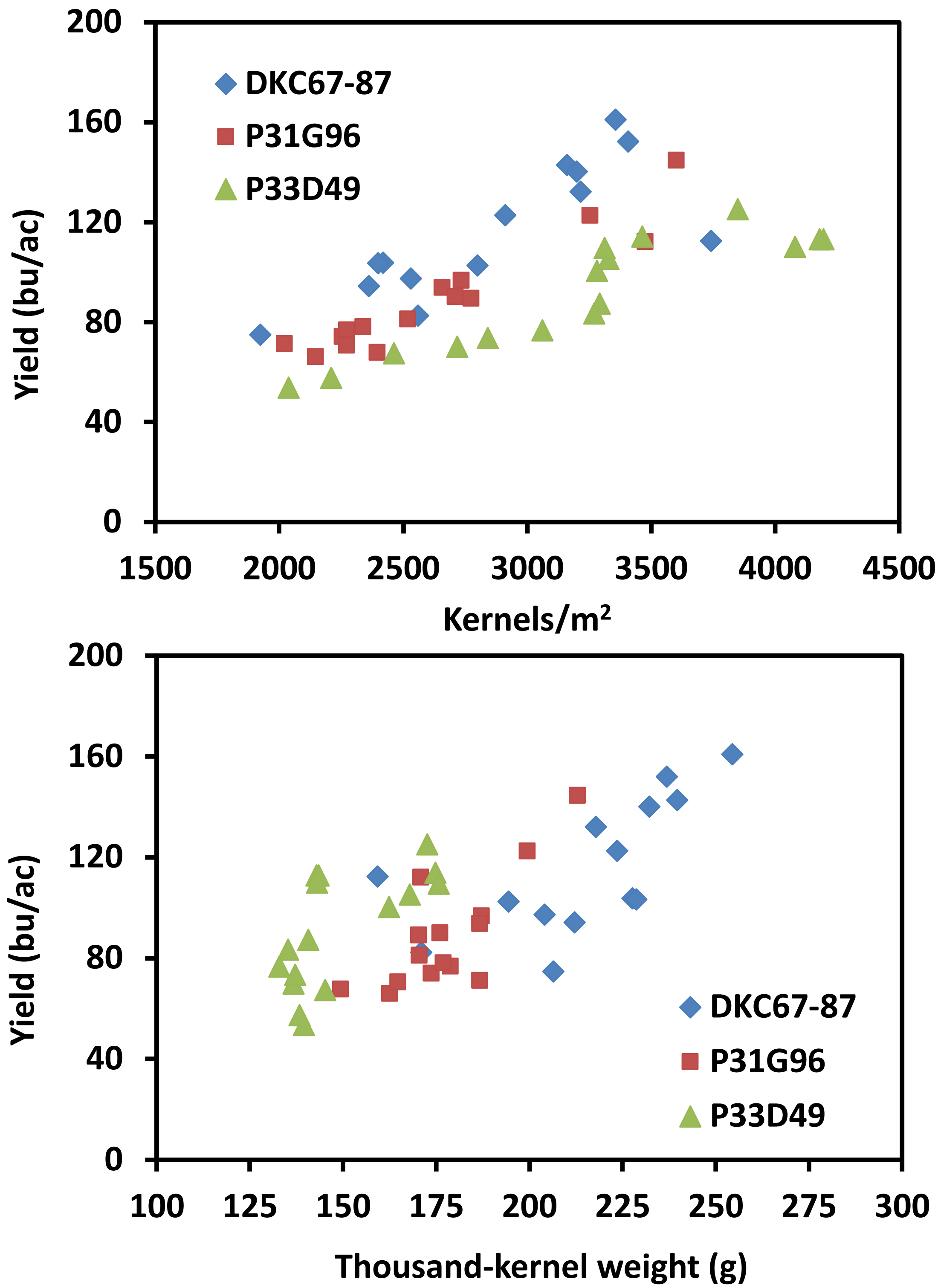

Figure 2. Linear relationships between yield and kernels/m^2, and between yield and thousand-kernel weight.

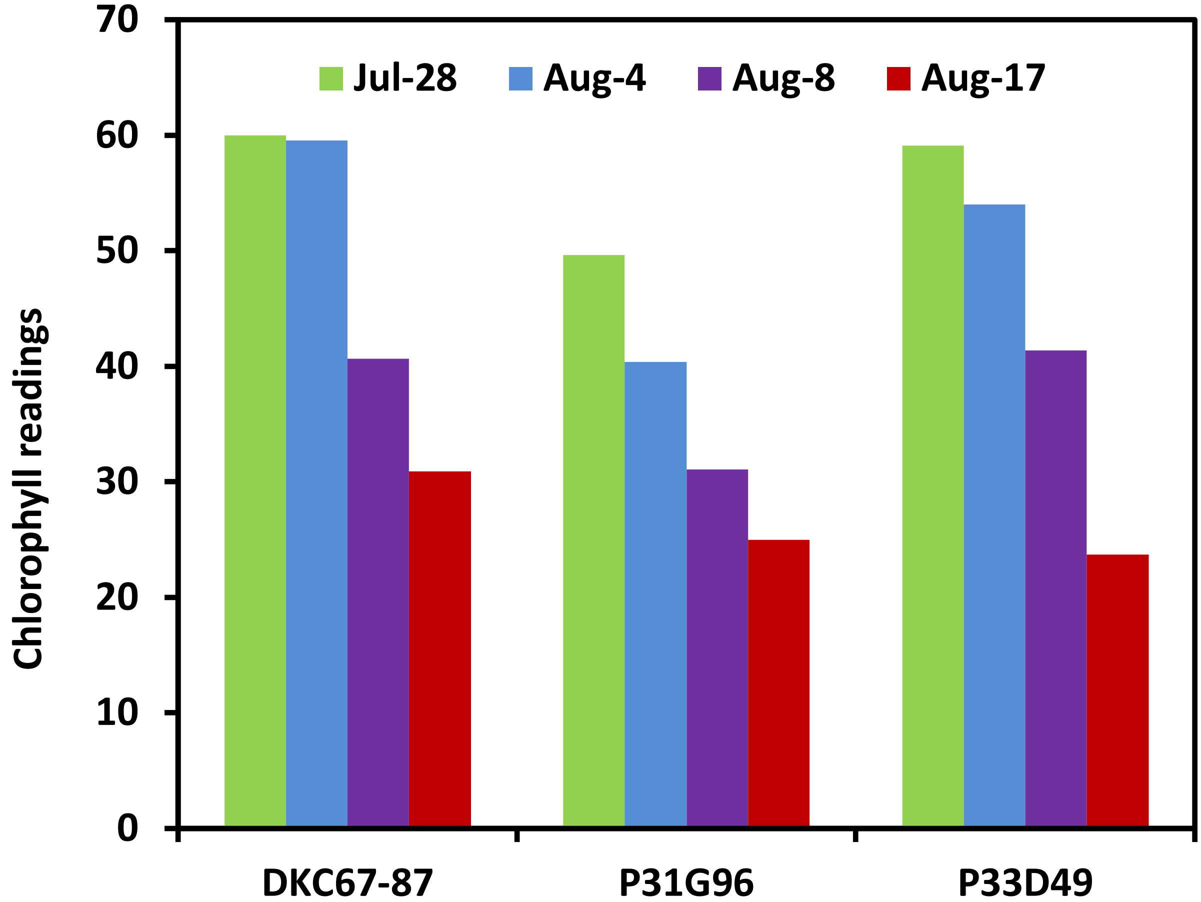

Figure 3. Chlorophyll readings in four days during grain filling in three hybrids in 2012 season at Etter, TX.