Plant Population and Planting Date Effects on Drought-Tolerant Corn Hybrid Physiology

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Introduction

- Recently introduced drought-tolerant corn (*Zea mays* L.) hybrids may be more tolerant of greater plant populations compared to hybrids more susceptible to moisture stress.
- May also produce greater yields in late-planted conditions when moisture stress at flowering is more likely to occur.
- Mechanisms for drought tolerance in these hybrids is not well documented (Roth et al. 2013).

Objectives

- Investigate the physiological response of a drought-tolerant and a susceptible hybrid to plant population
- Observe the effect of planting date on hybrid physiology

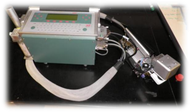
Materials and Methods

- Field study conducted in 2013
  - Hoytville, South Charleston, and Wooster, OH
- 8 m x 3.1 m plots, 4 rows at 0.76 m spacing
- Two planting dates (PD)
  - PD1: Mid-May (6, 20, or 16 by site, respectively)
  - PD2: Mid-June (7, 12, or 15 by site, respectively)
- Planted at five target populations
  - 59,000, 74,000, 89,000, 104,000, and 124,000 plants ha^{-1}
  - Focus on 59,000 and 104,000 plants ha^{-1}
- Four Pioneer brand hybrids examined

Hybrid	Drought Tolerance	GDUs to Silk (°C)	GDUs to Maturity (°C)	Comparative Relative Maturity (days)
P0210YXR	9 (Tolerant)	730	1405	102
P0448YXR	7 (Susceptible)	705	1390	104
P1184XR	7 (Susceptible)	770	1470	111
P1352YXR	9 (Tolerant)	740	1430	113

  - Focus on P1184XR and P1352YXR
- Measured plant growth parameters at V10, R2, and R5
  - Chlorophyll content: SPAD 502 Plus Meter, Konica Minolta

  - Transpiration, stomatal conductance, net photosynthesis, light-adapted quantum yield, and efficiency of PSII: LI-COR 6400XTF, LI-COR Biosciences



  - Leaf water potential: 610 Pressure Chamber, PMS Instruments

  - Dry plant biomass (V10, R2 only)

Statistics

- Split-plot randomized complete block design
  - Whole plot: Population; Sub-plot: Hybrid
  - Four replications per planting date
- Data analyzed using PROC MIXED in SAS 9.2
  - Combined across sites
  - Means separated using LSMEANS
- PROC REG used for SPAD regressions by hybrid

Results and Discussion

Table 1. Water usage of the susceptible and drought-tolerant hybrid across populations at V10, R2, and R5. Cells in bold are greater within a growth stage (P<0.1).

PD and Hybrid	Transpiration (mmol H_2O m^{-2} s^{-1})			Stomatal Conductance (mmol H_2O m^{-2} s^{-1})			Leaf Water Potential (MPa)		
PD1	V10	R2	R5	V10	R2	R5	V10	R2	R5
Susceptible	2.2999	1.5189	**1.9613**	231.6	183.1	**173.0**	-0.8055	-0.9754	**-1.1997**
Tolerant	2.3960	1.3553	1.5059	233.5	148.0	124.8	-0.8037	-0.9348	-1.0815
P-value	0.4804	0.2576	0.0774	0.9138	0.2309	0.0029	0.9446	0.2684	0.0053
PD2									
Susceptible	2.6803	**1.1506**	**0.8717**	226.2	**152.7**	**88.16**	-1.0091	-0.8285	-0.8158
Tolerant	2.8289	0.9652	0.6903	247.3	109.0	65.53	-0.9814	-0.7766	-0.7619
P-value	0.4056	0.0602	0.0175	0.3249	0.0835	0.0002	0.2757	0.3095	0.1395

Table 2. Net photosynthesis and photosynthetic efficiency for the susceptible and drought-tolerant hybrid across populations at V10, R2, and R5. Cells in bold are greater within a growth stage (P<0.1).

PD and Hybrid	Net Photosynthesis (µmol CO_2 m^{-2} s^{-1})			Light-Adapted Quantum Yield ($\Delta F/Fm' = \Phi_{PSII}$)			Efficiency of Photosystem II (Fv'/Fm')		
PD1	V10	R2	R5	V10	R2	R5	V10	R2	R5
Susceptible	4.5638	4.5662	4.4447	0.6636	0.6540	0.6495	0.6755	0.7187	0.7235
Tolerant	4.5297	**4.9603**	4.6112	**0.6795**	0.6496	0.6520	**0.7028**	**0.7259**	0.7210
P-value	0.9109	0.0330	0.3760	0.0128	0.6291	0.8140	<.0001	0.0054	0.3609
PD2									
Susceptible	3.2908	4.5157	4.7181	0.6949	0.6510	**0.6313**	0.7150	0.7050	0.6926
Tolerant	3.5532	4.7332	4.4814	**0.7024**	0.6453	0.6127	**0.7300**	**0.7143**	0.6963
P-value	0.1947	0.3286	0.1292	0.0278	0.2373	0.0056	<.0001	0.1062	0.3721

Each hybrid responded similarly to population, so only hybrid differences are presented in Tables 1-3.

Water Usage (Table 1):

- The susceptible hybrid exhibited a greater transpiration rate and stomatal conductance at R5 in PD1, and at R2 and R5 in PD2 when compared to the drought-tolerant hybrid.
- Leaf water potential was more negative at R5 in the susceptible hybrid in PD1.

Photosynthetic Properties (Tables 2 and 3, Figures 1 and 2):

- Net photosynthesis was only greater in the drought-tolerant hybrid at R2 in PD1 .
- Light-adapted quantum yield was greater in the tolerant hybrid at V10 and Fv'/Fm' was greater at V10 and R2 in both planting dates when compared to the susceptible hybrid.
- The drought-tolerant hybrid produced more dry biomass at all sampled growth stages.
- SPAD in all hybrids decreased with population.
- Drought-tolerant hybrids exhibited lower SPAD values than susceptible hybrids.

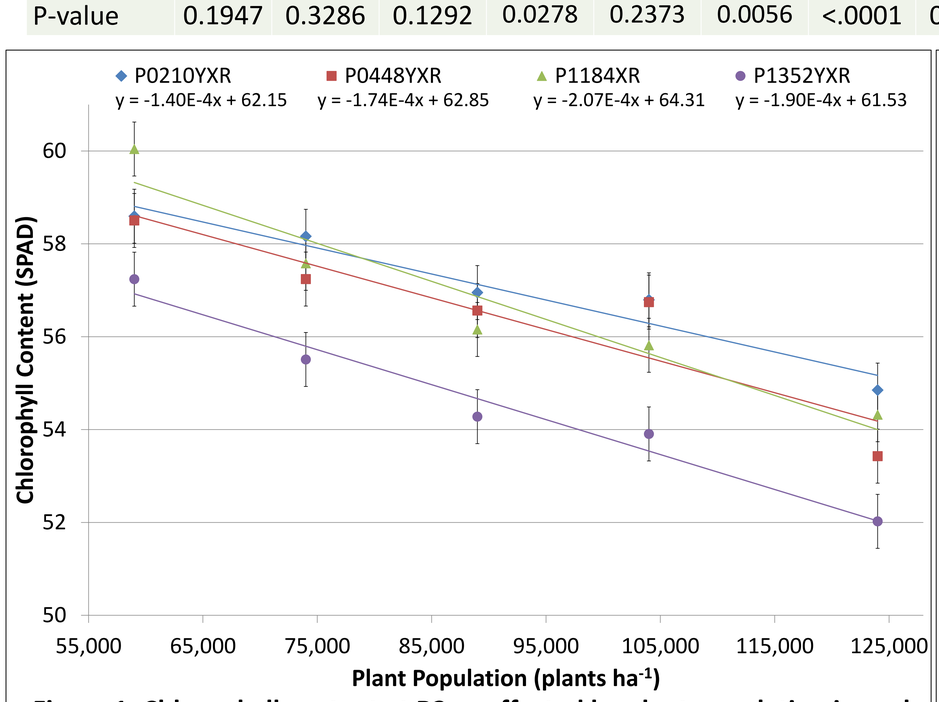


Figure 1. Chlorophyll content at R2 as affected by plant population in each hybrid for PD1. The regression for each hybrid was significant (P<0.001).

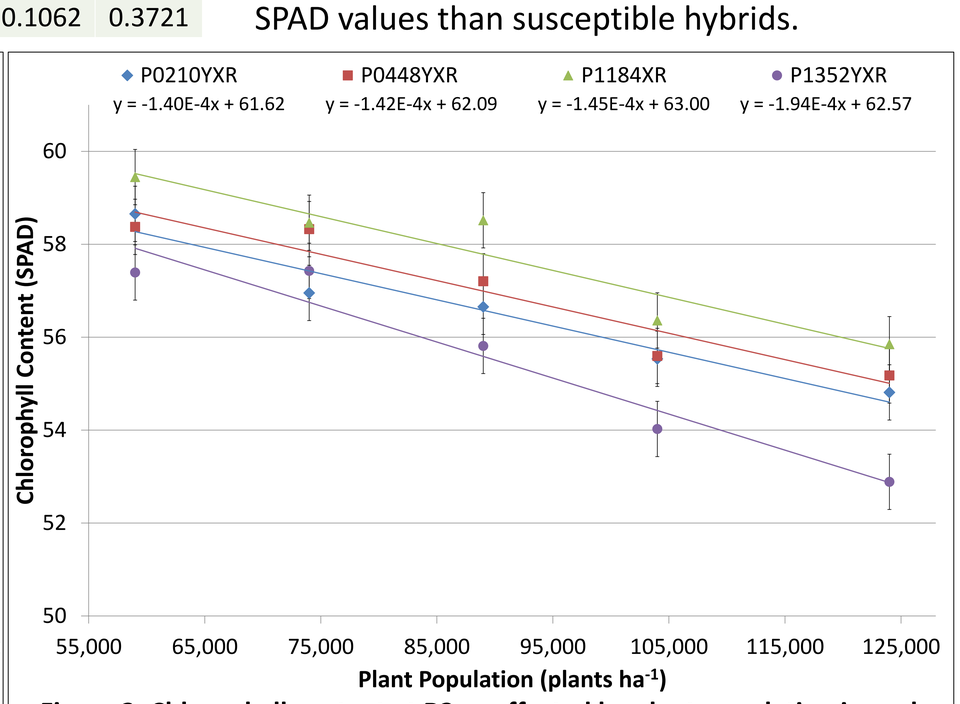


Figure 2. Chlorophyll content at R2 as affected by plant population in each hybrid for PD2. The regression for each hybrid was significant (P<0.001).

Table 3. Dry biomass of the susceptible and drought-tolerant hybrid across populations at V10 and R2. Bolded cells indicate significance (P<0.06).

PD and Hybrid	Dry Biomass (g)	
PD1	V10	R2
Susceptible	38.85335	77.7067
Tolerant	**42.5871**	**85.1742**
P-value	0.0519	<.0001
PD2		
Susceptible	28.47315	129.40
Tolerant	**37.6046**	**149.96**
P-value	<.0001	<.0001

Conclusions

- The drought-tolerant hybrid maintained net photosynthesis rates similar to the susceptible hybrid while having lower rates of transpiration.
- The drought-tolerant hybrid exhibited greater efficiency at using photons than the susceptible hybrid (greater Φ_{PSII} and Fv'/Fm' values).
- Biomass production was greater for the drought-tolerant hybrid at each stage.
- Chlorophyll content was consistently less for drought-tolerant hybrids.
- These results suggest an increased ability in this drought-tolerant hybrid to more efficiently utilize light energy with less water to maintain photosynthetic rates.

Reference:
Roth, J.A., I.A. Ciampitti, and T.J. Vyn. 2013. Physiological evaluations of recent drought-tolerant maize hybrids at varying stress levels. Agron. J. 105:1129-1141.

Acknowledgements

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