Plant Factors Related to Ear Size in Maize Grown at Different Densities

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Introduction

The creation and maintenance of growth and developmental homogeneity among plants within a maize stand may contribute to higher average per-plant grain yield. A number of studies have shown that plant-to-plant growth and developmental uniformity is strongly associated with greater yield in maize, though cause-and-effect have not been clearly established.

Corn ears are not uniform in size even in uniform stands, and it is not known how and when such differences in ear size develop. Not only do we not know what factors might lead to non-uniformity; we also have not discovered how to render ear size more uniform. Plants at lower density are posted as having more uniform ears, but this has not been shown clearly. It is also not known if different hybrids might differ in ear size uniformity.

Study Design and Sites

- A split plot design, with plant density assigned to main plots, and hybrid to sub-plots
- RRBD arrangement of treatments with two replications
- The study was conducted in 2014 at Urbana and St. Peter in east and south central Illinois, respectively. Only the Urbana results will be discussed here.
- Plots consisted of four 76-cm rows, 7 m long

Materials and Methods

- Main plots consisted of 5 plant densities: 4.4, 6.4, 8.4, 10.4, and 12.4 plants m^{-2}. Plots were planted to stand with an Almaco plot planter.
- To subplots were assigned 5 DuPont Pioneer® hybrids: P0157AMX, P0419AMX, P0909CHR, P1221AMXT, P1257AMX.
- Ten consecutive and representative plants from each border row of plots were selected at V1 and tagged for evaluation. The ten plants (all aerial part) were harvested by hand individually at R6.
- Individual plant measurements included: leaf orientation with regard to row direction by compass; stem cross-sectional area (long axis × short axis × 0.7854) at V9 and R2; mid-ear diameter at R2; shank cross-sectional area at R2; ear angle from horizontal at R3; ear height at R3; plant height at R3; ear leaf area (length × width × 0.75) at R3; grain dry weight per ear at R6; and plant dry weight at R6.
- Analysis of variance was conducted for each hybrid using SAS PROC MIXED and correlations among parameters for the 20 plants/ears conducted in Microsoft Excel

Results

Table 1. ANOVA of parameters for main effects and interactions. Table contains F values; *Pr>F ≤ 0.05; **Pr>F ≤ 0.01.

Parameter	Density df=4	Hybrid df=4	Dens x hyb df=16
Stem x-sec area at V9	169**	4ns	2ns
Stem x-sec area at R2	157**	11ns	1ns
Shank x-sec area at R2	110**	5ns	1ns
Mid-ear diameter at R2	35**	6ns	2ns
Ear angle from horizontal	9**	69**	1ns
Ear height at R3	4*	51*	1ns
Plant height at R3	46**	4ns	2ns
Ear leaf area at R3	35**	450**	2ns
Available ear length at R6	94**	5ns	2ns
Kernel number per ear at R6	65**	6ns	1ns
Weight per kernel	50**	4ns	1ns
Harvest index	7*	2ns	1ns
Grain dry weight per ear	99**	4ns	1ns

Correlations in Figures 1-3: *P<0.05; **P<0.01; ***P<0.001

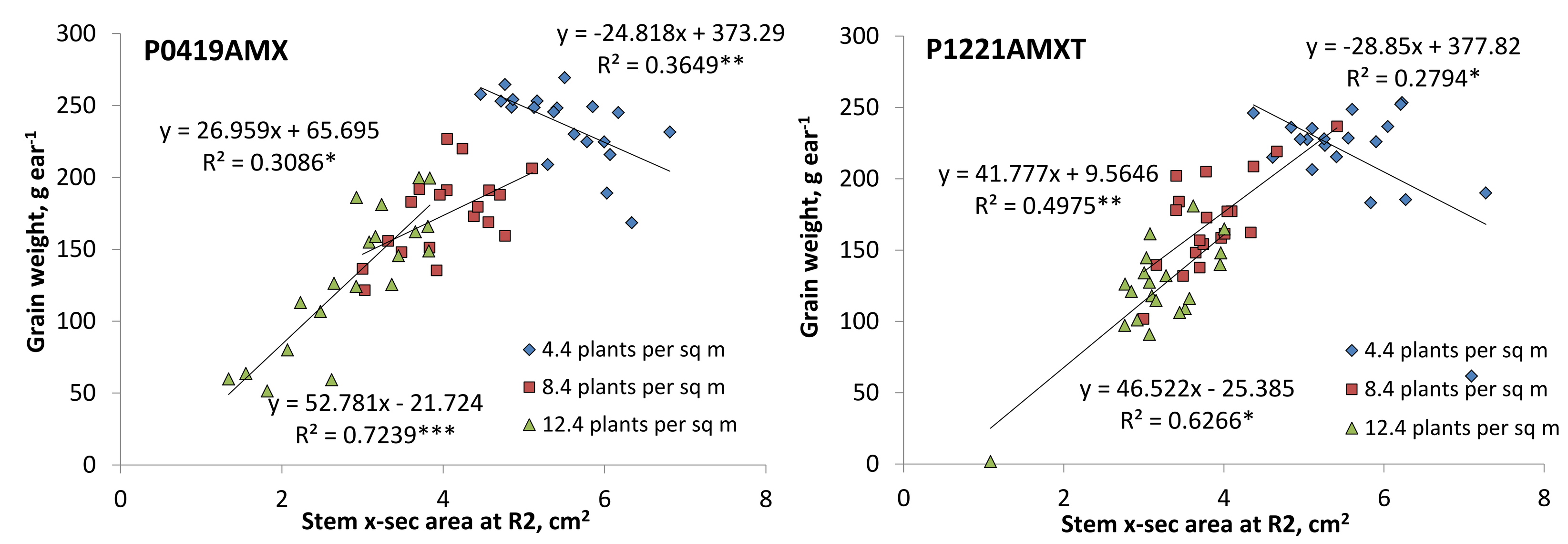

Figure 1. Correlation of stem cross-sectional area at R2 and grain dry weight for two hybrids and at three densities.

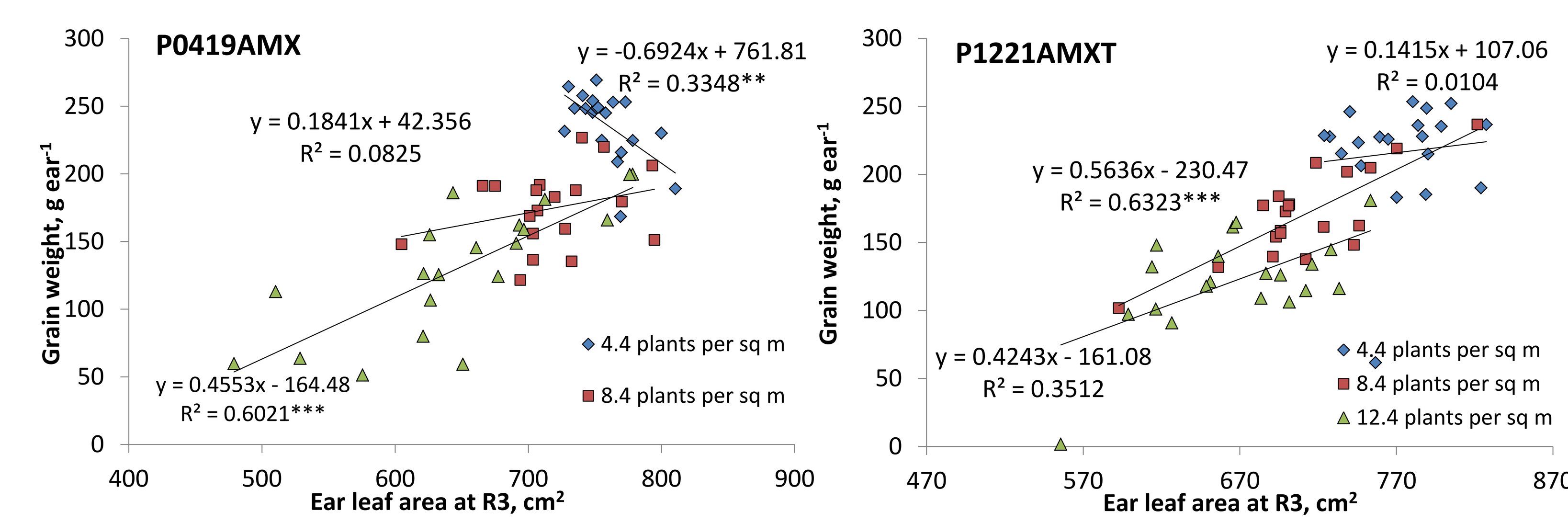

Figure 2. Correlations between ear leaf area at R3 and grain dry weight for two hybrids and at three plant densities.

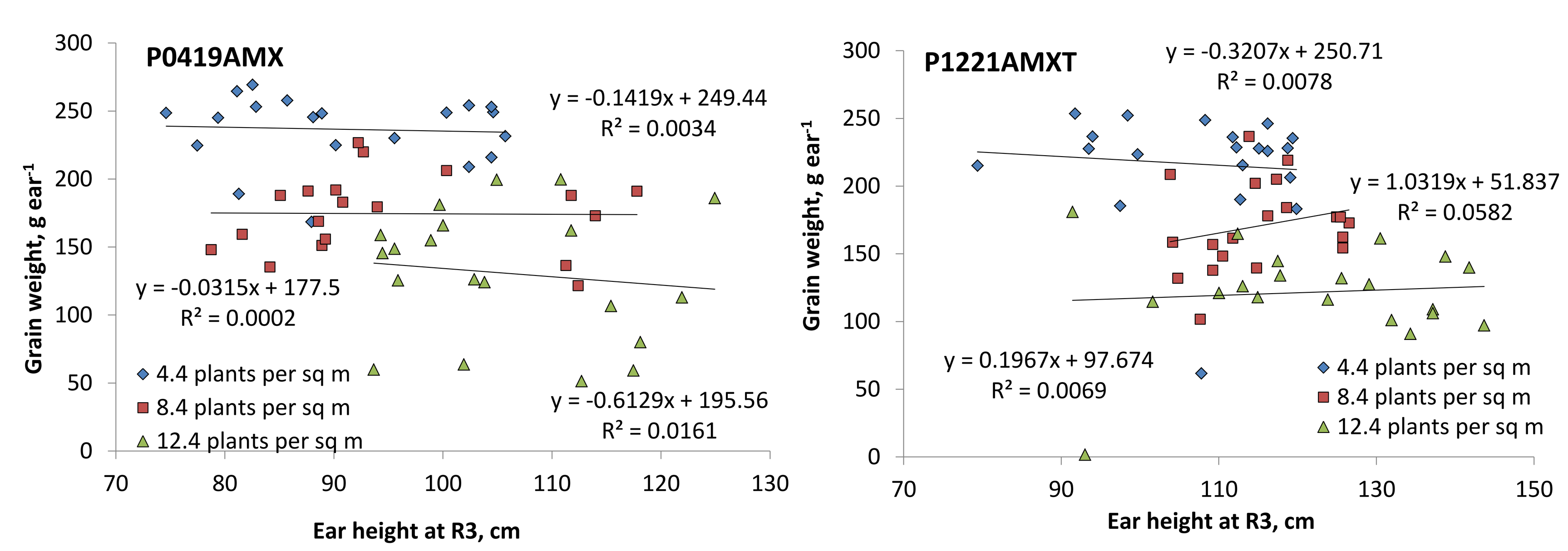

Figure 3. Correlations between ear height at R3 and grain dry weight for two hybrids and at three densities

Summary and Conclusions

- Plant density has larger effects than hybrid on stem cross-sectional area, shank cross-sectional area, mid-ear diameter, ear angle from horizontal plane, ear height, plant height, ear leaf area, available ear length, kernel number, weight per kernel, harvest index and grain dry weight per ear, but hybrid had some effect on ear angle, ear height and ear leaf area. Interactions between density and hybrid were not significant for any parameters measured (Table 1).
- Correlations between stem cross-sectional area and grain dry weight were similar for the two hybrids chosen to illustrate this (Figure 1). Among individual plants, correlations between these two parameters moved from significantly negative (smaller ears with larger stems) at low density to positive at higher densities. This may indicate that limitations on further expansion of ear size at low densities might make more resources available for plant growth, while at high densities limitations on plant size may decrease resources available for ear growth (Figure 1).
- Ear leaf area was related to grain weight per ear in a way similar to that of stem cross-sectional area for the earlier hybrid (P0419AMX), though the relative range of ear leaf area was somewhat less than that of stem area (Figure 2). The same was true for the later hybrid (P1221AMXT) except that at the low density, the negative correlation between ear leaf area and grain weight was not found. This might indicate more dependence on the ear leaf in this hybrid, but we have no explanation for that.
- Ear height of individual plants was not correlated with grain weight for either hybrid or at any density (Figure 3). This is a little surprising given the range in ear heights.
- Kernel number per ear, ear length, and kernel weight, as expected, correlated well with grain weight per ear in most cases. The fact that harvest index was correlated with individual ear weight provides a hint that plant growth limitations may have developed early enough to limit ear pollination and subsequent yield. Further work should include larger samples and perhaps other management factors that might affect yield and plant uniformity.

Table 2. Correlation coefficients by plant density and hybrid between different parameters and grain dry weight. n=20 plants.

Hybrid	Parameter	Density, plants m^{-2} 4.4	6.4	8.4	10.4	12.4
P0157AMX	Stem x-sec area at V9	-0.30	0.65	0.53	0.73	0.34
	Stem x-sec area at R2	-0.34	0.84	0.69	0.64	0.52
	Shank x-sec area at R2	0.14	0.54	0.79	0.67	0.55
	Mid-ear diameter at R2	0.51	0.54	0.89	0.45	0.72
	Ear height at R3	-0.08	0.46	0.28	-0.12	0.14
	Plant height at R3	0.33	0.75	0.89	0.33	0.47
	Ear angle from horizontal at R3	0.23	0.14	-0.36	-0.03	-0.25
	Ear leaf area at R3	-0.04	0.67	0.69	0.72	0.10
	Available ear length at R6	0.70	0.93	0.94	0.80	0.87
	Kernel number per ear at R6	0.83	0.79	0.87	0.74	0.87
	Weight per kernel	0.56	0.84	0.76	0.43	0.62
	Harvest index	0.80	0.45	0.78	0.51	0.59
P0419AMX	Stem x-sec area at V9	-0.28	0.71	0.71	0.74	0.74
	Stem x-sec area at R2	-0.60	0.49	0.56	0.70	0.85
	Shank x-sec area at R2	-0.10	0.57	0.65	0.69	0.84
	Mid-ear diameter at R2	0.22	0.03	0.84	0.68	0.90
	Ear height at R3	-0.06	0.34	-0.01	-0.10	-0.13
	Plant height at R3	0.48	0.63	0.06	0.67	0.75
	Ear angle from horizontal at R3	-0.10	-0.34	-0.61	-0.17	-0.26
	Ear leaf area at R3	-0.58	0.20	0.29	0.54	0.78
	Available ear length at R6	0.71	0.43	0.93	0.76	0.93
	Kernel number per ear at R6	0.86	0.20	0.80	0.81	0.91
	Weight per kernel	0.12	0.70	0.64	0.49	0.71
	Harvest index	0.83	-0.49	0.49	0.30	0.67
P0909CHR	Stem x-sec area at V9	0.29	0.52	0.63	0.80	0.27
	Stem x-sec area at R2	0.45	0.54	0.77	0.82	0.54
	Shank x-sec area at R2	0.54	0.66	0.73	0.82	0.61
	Mid-ear diameter at R2	0.80	0.48	0.83	0.62	0.58
	Ear height at R3	0.77	0.10	-0.11	-0.09	0.28
	Plant height at R3	0.81	0.15	0.74	0.83	0.29
	Ear angle from horizontal at R3	-0.51	-0.19	0.29	-0.32	-0.05
	Ear leaf area at R3	0.71	0.49	0.67	0.72	0.48
	Available ear length at R6	0.84	0.88	0.86	0.86	0.80
	Kernel number per ear at R6	0.92	0.78	0.88	0.91	0.82
	Weight per kernel	0.59	0.04	0.88	-0.07	0.22
	Harvest index	0.63	0.65	0.76	0.82	0.88
P1221AMXT	Stem x-sec area at V9	-0.32	0.57	0.43	0.84	0.08
	Stem x-sec area at R2	-0.53	0.57	0.71	0.87	0.48
	Shank x-sec area at R2	-0.12	0.51	0.51	0.84	0.52
	Mid-ear diameter at R2	-0.27	0.11	0.25	0.64	0.79
	Ear height at R3	-0.09	0.10	0.24	0.37	-0.45
	Plant height at R3	0.22	0.28	0.31	0.66	-0.11
	Ear angle from horizontal at R3	-0.52	-0.09	-0.32	-0.46	-0.14
	Ear leaf area at R3	0.10	0.47	0.80	0.70	0.37
	Available ear length at R6	0.87	0.58	0.90	0.90	0.80
	Kernel number per ear at R6	0.87	0.32	0.80	0.91	0.84
	Weight per kernel	0.81	0.16	0.58	0.59	0.60
	Harvest index	0.83	-0.09	0.66	0.76	0.65
P1257AMX	Stem x-sec area at V9	0.49	0.40	0.50	0.73	0.63
	Stem x-sec area at R2	0.62	0.25	0.58	0.73	0.73
	Shank x-sec area at R2	0.54	0.45	0.57	0.82	0.74
	Mid-ear diameter at R2	0.43	0.08	0.70	0.34	0.88
	Ear height at R3	0.14	0.29	0.37	-0.42	0.06
	Plant height at R3	0.37	0.50	0.51	-0.03	0.67
	Ear angle from horizontal at R3	-0.01	-0.53	-0.01	-0.55	0.04
	Ear leaf area at R3	0.69	0.65	0.66	0.60	0.80
	Available ear length at R6	0.93	0.92	0.85	0.92	0.91
	Kernel number per ear at R6	0.96	0.86	0.84	0.92	0.96
	Weight per kernel	0.22	0.70	0.68	0.77	0.79
	Harvest index	0.94	0.14	0.63	0.78	0.87

Colors denote significance:
No color = NS at p=0.05

P<0.05 P<0.01 P<0.001