Effect of Plant Morphology and Planting Methodology on Biomass Production and Compositional Characteristics in Maize

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ABSTRACT:

The ability to increase plant biomass and improve compositional traits such as digestibility is an ever-growing concern as the biofuel industry continues to develop. Altering plant morphology and planting methodologies are two potential methods to increase biomass per unit of land. It is hypothesized that both a tillering maize morphology and a planting regime which maximizes light interception by all plants will result in increased biomass production per unit of land. To test these hypotheses, genotypes with varying degrees of tillering were evaluated at two different densities (20,000 plants ha^{-1} and 70,000 plants ha^{-1}) and under two planting methodologies; traditional row-crop planting with plants 0.2 meters apart within a row and approximately 0.8 meters between rows and equivalent distance planting with equal distance between plants within and between rows while still maintaining the same planting density (70,000 plants ha^{-1}). Hybrids with variable *Corngrass1* penetrance were also evaluated to test the effect that increased digestibility has on overall performance. On a stover basis, increased tiller number resulted in increased yield. On a whole plant basis, increased tiller number resulted in increased neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL). Negative correlations were observed between stover yield and cell wall compositional traits (NDF and ADF); while positive correlations were observed between NDF, ADF and ADL, indicating variation in the total cell wall rather than specific components. Identifying developmental mutants with increased digestibility which maintain adequate yield will be crucial for the efficient production of biomass for the biofuel industry.

OBJECTIVES:

1. Determine the effect of planting geometries on whole plant yield and composition of corn plants with alternative plant morphologies.
2. Determine the effect of plant density on biomass yield and composition of corn plants with alternative plant morphologies.
3. Determine the effect of tiller production on yield and quality.
4. Compare the relative advantage of corn genotypes with diverse digestibility in terms of overall biomass yield.

Figure 1: Pictorial representation of hypothesized light interception potential under (A) row and (B) equivalent planting geometries. Evaluation of 13 hybrids with alternative plant morphologies due to the large effect mutations *Leafy1*, *Corngrass1*, and *grassy tillers1* did not reveal a significant effect of the planting geometry treatment on whole plant yield or secondary cell wall composition.

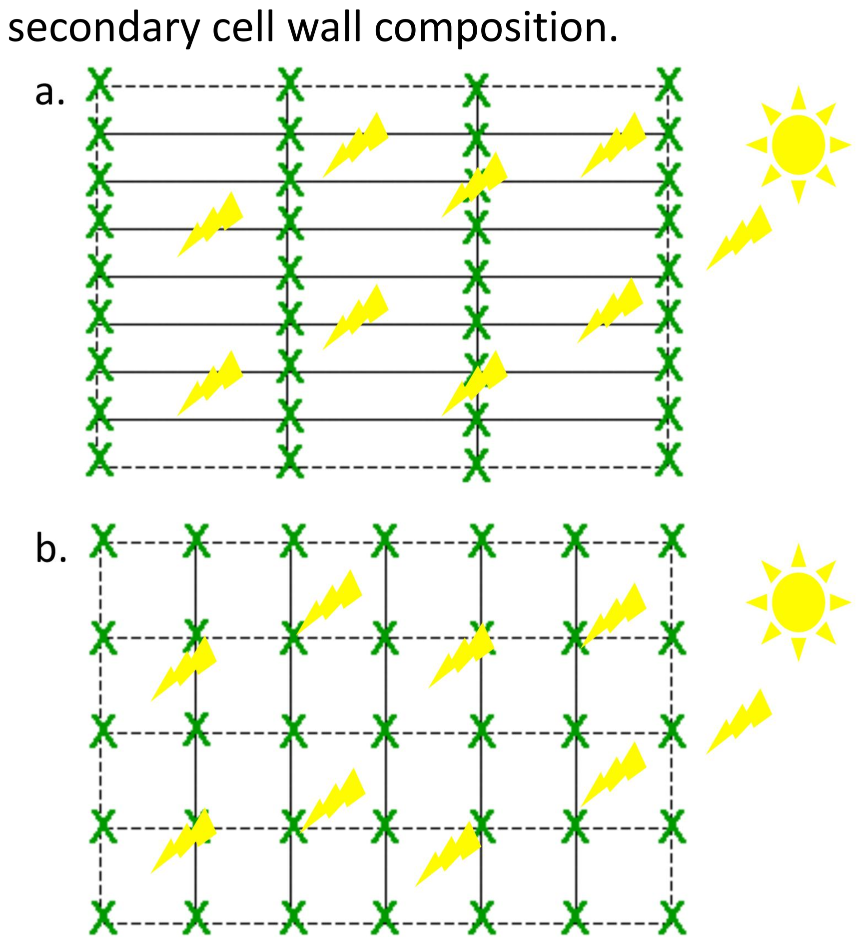


Figure 2: Effect of plant density on stove yield of corn plants with alternative plant morphologies due to the large effect mutations *Leafy1*, *Corngrass1*, and *grassy tillers1*. Hybrids were evaluated at high density (70,000 plants ha^{-1}) and low density (20,000 plant ha^{-1}), at three environments (Madison, WI 2008 and 2009 and Arlington, WI 2009) and two replications per treatment per environment. There is not a significant difference between the density treatments for every genotype.

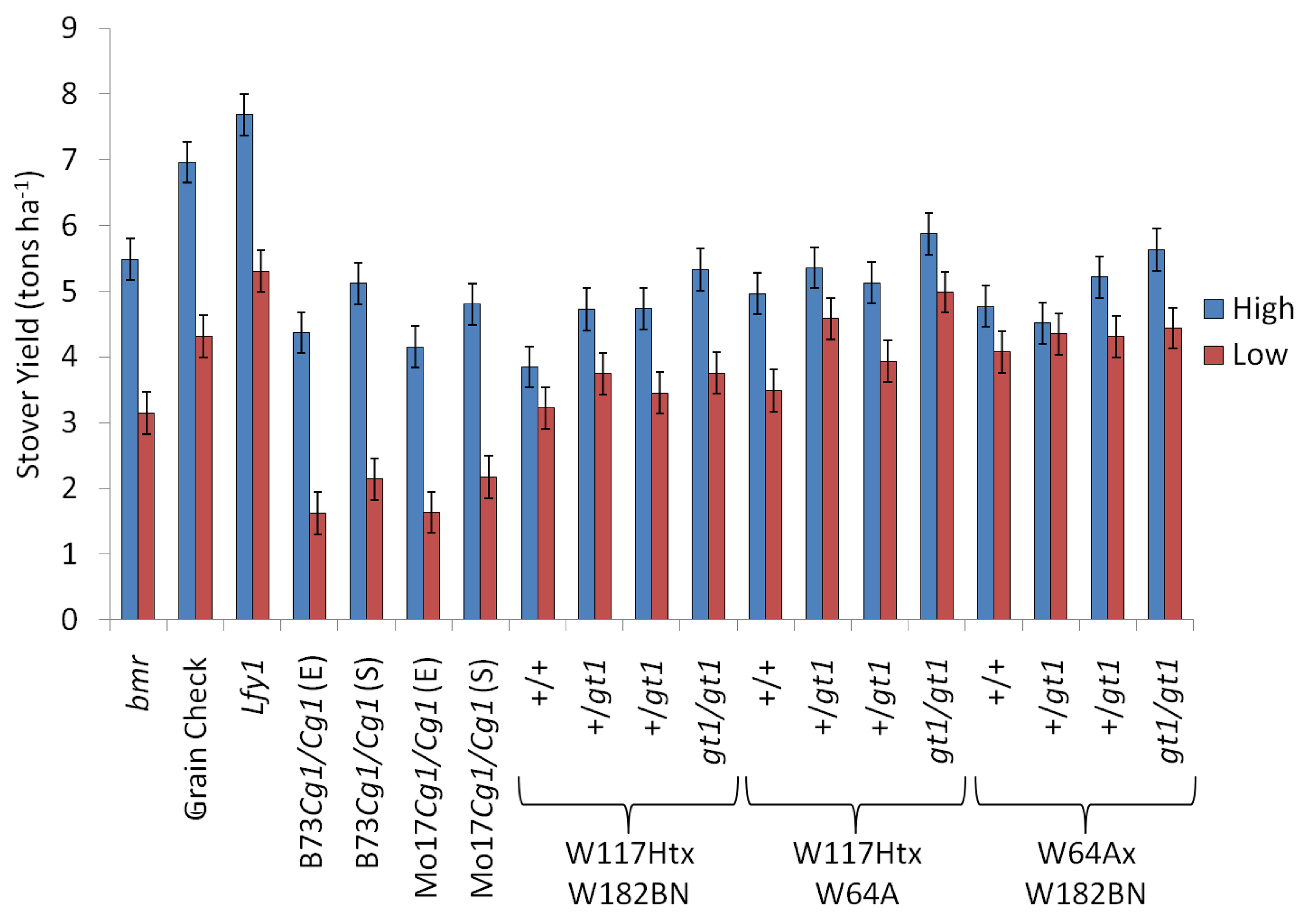


Figure 3: Stover yields of 12 hybrids with varying number of mutant *grassy tillers1* (*gt1*) alleles and three commercial checks planted at high density (70,000 plants ha^{-1}) and low density (20,000 plant ha^{-1}). Hybrids were evaluated at three environments (Madison, WI 2008 and 2009 and Arlington, WI 2009) and two replications per density treatment per environment. Tillering plants can equate biomass production of their wild-type counterparts at nearly four times higher density.

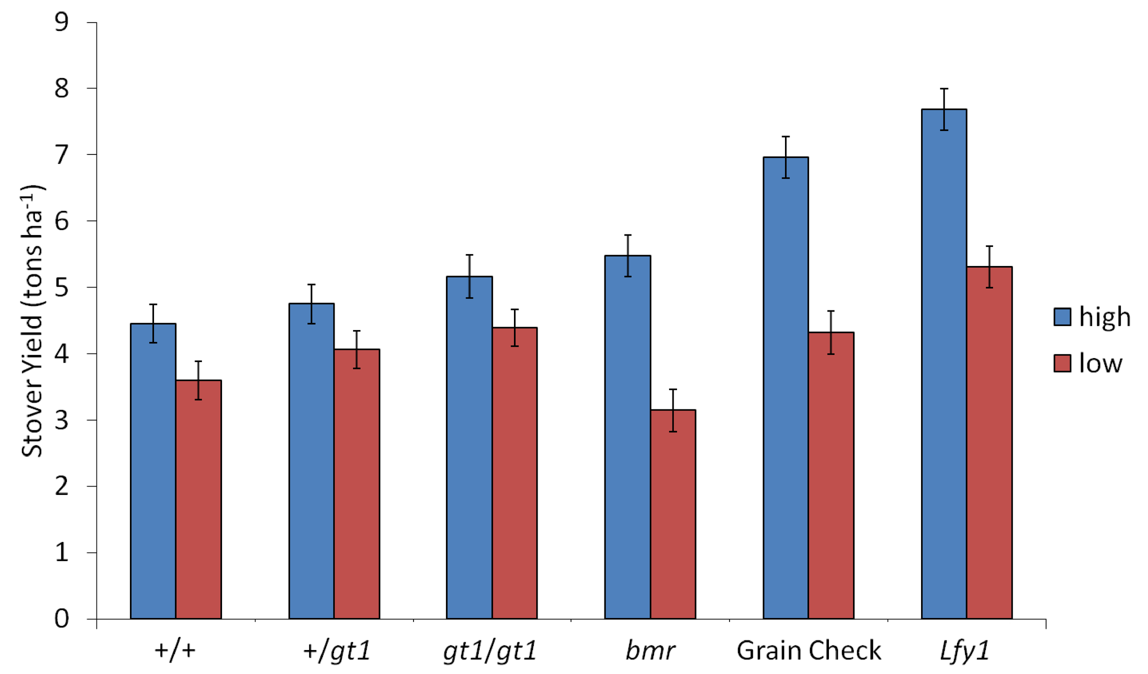


Figure 4: Neutral detergent fiber (NDF) values of 19 hybrids planted at low density (20,000 plants ha^{-1}). Higher NDF values indicate higher cell wall content. *Cg1* phenotypically-enhanced genetic backgrounds are signified as E and *Cg1* phenotypically-suppressed genetic backgrounds are signified as S. Hybrids were evaluated at three environments (Madison, WI 2008 and 2009 and Arlington, WI 2009) and two replications per environment. NDF increases with additional mutant *gt1* alleles.

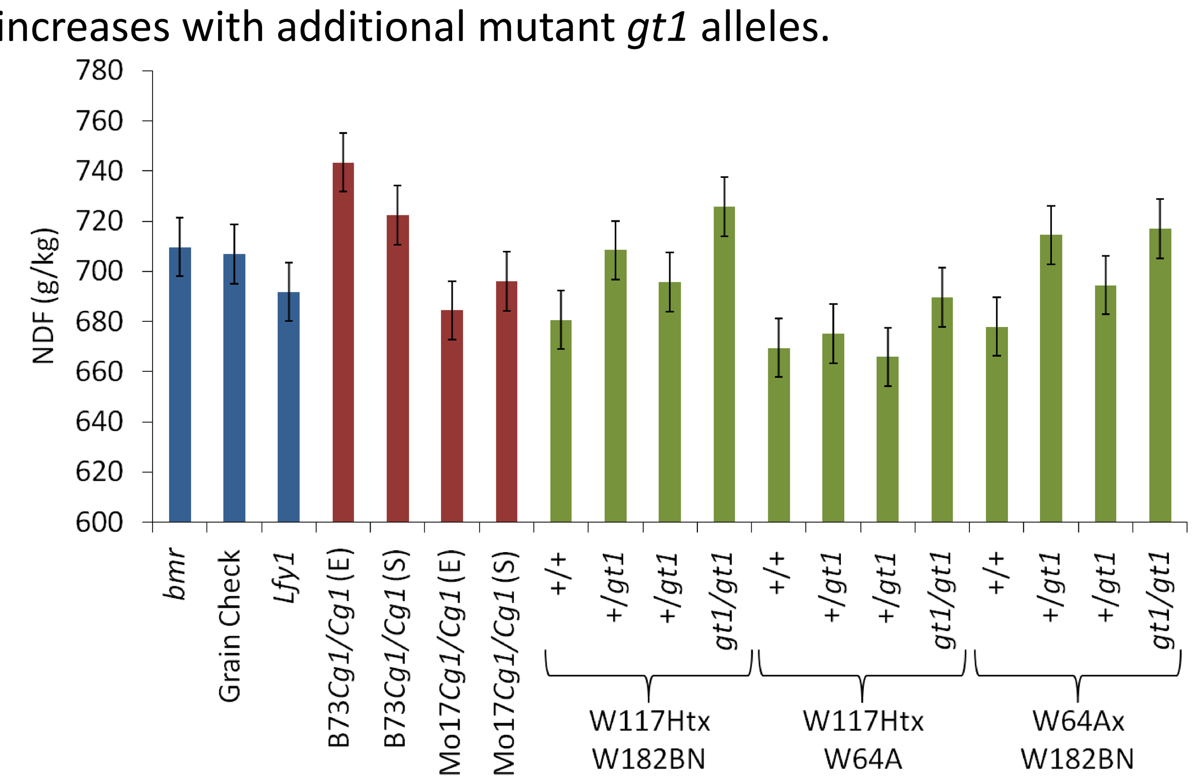
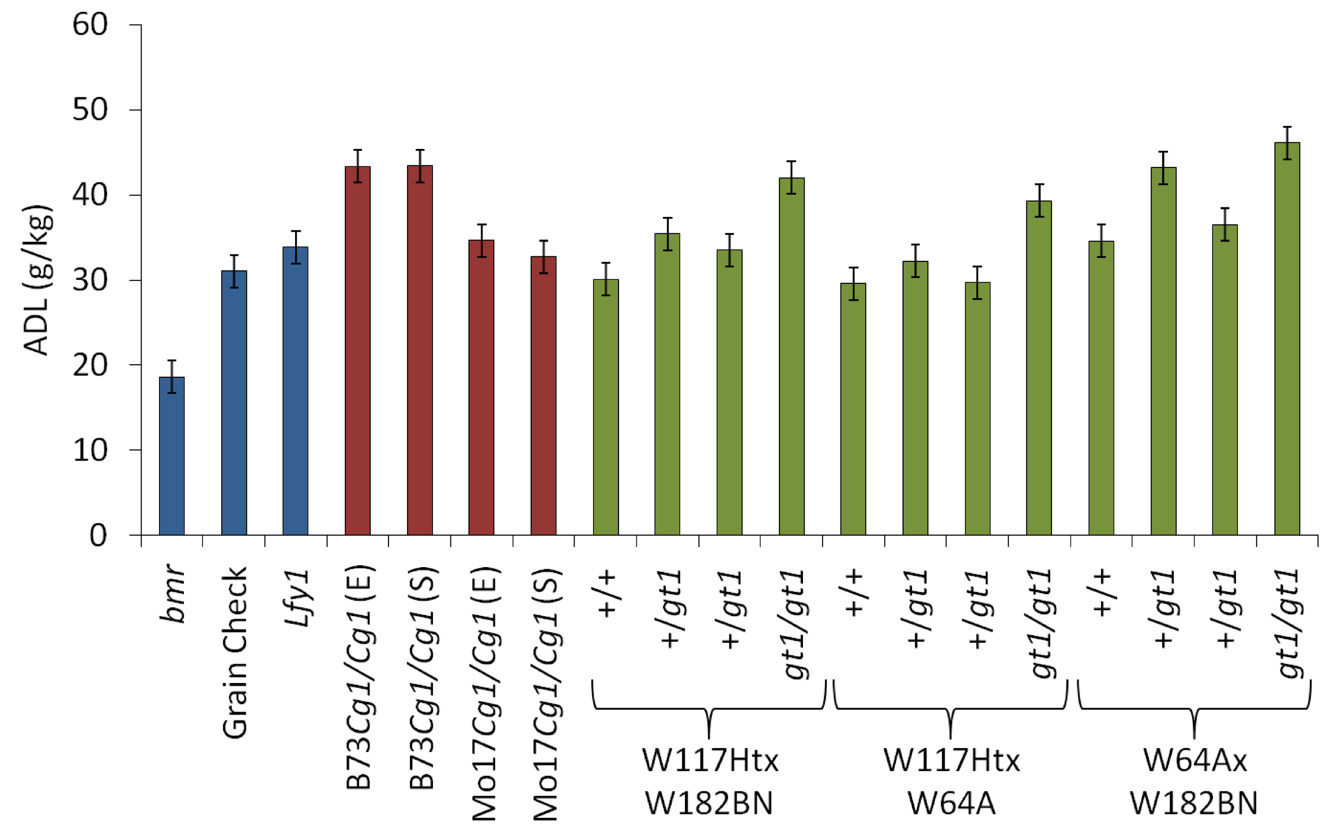


Table 1: Pearson product-moment correlations between composition and yield traits for 19 hybrids planted at low density (20,000 plants ha^{-1}). Hybrids were evaluated at three environments (Madison, WI 2008 and 2009 and Arlington, WI 2009) and two replications per environment.

	Grain Yield	Stover Yield	Whole Plant Yield	NDF	ADF	ADL
Grain Yield	-	0.82***	0.95***	-0.21*	NS	NS
Stover Yield		-	0.96***	-0.45***	-0.41***	NS
Whole Plant Yield			-	-0.35***	-0.30**	NS
NDF				-	0.93***	0.55***
ADF					-	0.67***
ADL						-

* significant at p=0.05, ** significant at p=0.01, *** significant at p=0.001, NS not significant

Figure 5: Acid detergent lignin (ADL) values of 19 hybrids planted at low density (20,000 plant ha^{-1}). *Cg1* phenotypically-enhanced genetic backgrounds are signified as E and *Cg1* phenotypically-suppressed genetic backgrounds are signified as S. Hybrids were evaluated at three environments (Madison, WI 2008 and 2009 and Arlington, WI 2009) and two replications per environment. At grain physiological maturity lignin levels in the *Cg1* mutants is greater than any of the commercial checks.



CONCLUSIONS:

-There is no effect of equivalent versus row spacing on corn plants with alternative morphologies.

-Homozygous *gt1/gt1* hybrids planted at low density were not different than their wild type counterparts planted at high density for stover yield.

-The ability of tillering plants to equate biomass production of their wild-type counterparts at nearly four times higher density demonstrates the utility in exploring alternative plant morphologies in an effort to meet the needs of the biofuel industry.

-*Corngrass1* mutants have a substantial yield penalty and the portion of the plant that survives to grain physiological maturity has high ADL and therefore lower convertibility efficiency.

-When correlations are significant between yield (grain, stover, and, whole plant) and secondary cell wall composition (NDF and ADF) the correlations are negative.

-Correlations between yield components (NDF, ADF, and ADL) when significant are positive indicating variation in total cell wall content rather than specific cell wall components.

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