

Plant Population Effects on Corn Silage Yield and Quality

by Mark Jeschke and Bill Curran

Summary

- Pioneer Hi-Bred researchers regularly conduct studies to determine the effects of crop management practices on corn silage yield and quality.
- Pioneer irrigated plant population studies conducted at LaSalle, Colorado from 2004 to 2007 found that:
 - Silage yield increased with population density and was greatest at the highest density tested: 42,000 plants/acre.
 - Silage fiber content increased with increased plant density; digestible fiber and whole plant digestibility decreased.
 - Net energy and TDN were reduced with increased plant density; however, estimated milk/acre and beef/acre increased with greater plant density.
- University results (non-irrigated) have also shown that increasing plant population increases silage yield significantly and decreases quality slightly.
- Contact your local Pioneer sales professional to help determine optimum economic plant populations for corn silage production in your area.

Introduction

Corn silage is a source of high yielding and consistent feed and is the most important feed crop for cattle in many areas of the country. Therefore, it is important to understand how silage performance is affected by agronomic practices, including hybrid selection, plant density, soil fertility, and harvest management. This *Crop Insights* focuses on plant density effects on silage yield and quality. Both Pioneer and university studies are reported.

Plant populations for optimum corn grain yield typically range from 32,000 to 36,000 plants/acre in the central Corn Belt and are higher in the northern Corn Belt. Optimum plant density generally depends on hybrid, maturity, field productivity and growing conditions. Planting to achieve these populations helps maximize utilization of soil nutrients, solar radiation and water during the growing season.

Many universities recommend increasing the target plant population of corn silage by 10 to 20% per acre compared



Recent studies by Pioneer and University researchers show that higher populations are needed to optimize corn silage yield and animal performance. (Photo by Donald Specker.)

to corn harvested for grain. Although excessive plant densities tend to decrease stalk diameter and increase the potential for stalk lodging, this is much less an issue with silage corn than grain corn because silage is harvested much earlier.

Researchers have reported consistent increases in dry matter yields with increased plant density. Quality responses have been less consistent. Generally, as plant density increases, silage fiber levels increase and digestibility decreases.

Pioneer Silage Studies

Pioneer conducts ongoing studies to determine the effect of management practices on silage performance. Irrigated studies were conducted at LaSalle, Colorado from 2004 through 2007 to determine the influence of plant population on whole plant corn silage yield and quality. Eight Pioneer® brand hybrids were tested in 2004, 2005 and 2006, and 20 hybrids in 2007, at five different plant densities and four replications. Plant densities were 18,000, 24,000, 30,000, 36,000, and 42,000 plants/acre in a 30-inch row spacing. Plots were overplanted and thinned back to the target stand. All yields are reported at 30% dry matter; quality traits are reported at 100% dry matter.

Plant Density Effects on Silage Yield

Pioneer Hi-Bred Study. Silage yield averaged across years and hybrids increased with plant density, and was greatest at 42,000 plants/acre (Figure 1). Silage yield increased 3.6% between the two highest densities, 36,000 plants/acre and 42,000 plants/acre; indicating that the optimal plant population for silage yield was 42,000 plants/acre or greater.

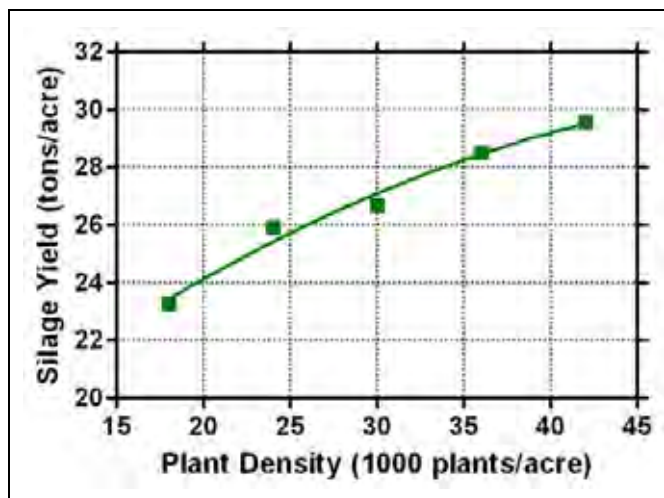


Figure 1. Influence of corn plant density on silage yield in **Pioneer Hi-Bred** irrigated studies conducted in LaSalle, Colorado from 2004-2007.

University of Wisconsin Study. Silage yield averaged across years, locations, and hybrids increased with plant density at harvest in all three regions (Figure 2).

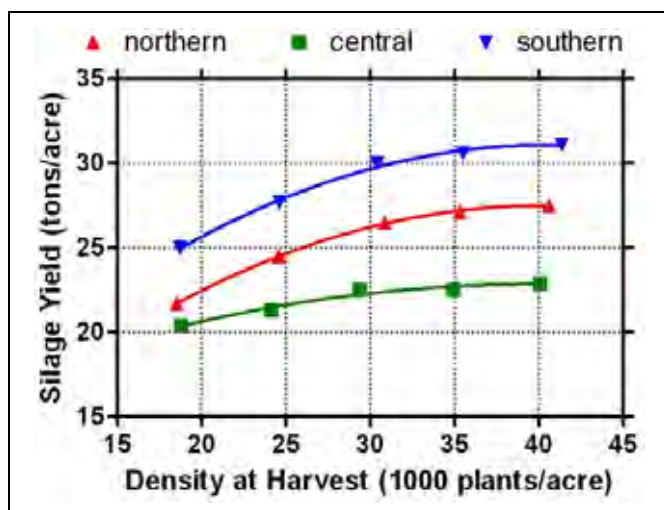


Figure 2. Influence of corn plant density on silage yield in trials conducted in three **Wisconsin** regions from 1994-1996. Data are averaged across year, location, and hybrid.

Silage yield increased very little between the two highest densities, indicating that the optimal plant population for silage yield was likely around 40,000 plants/acre.

Penn State University Study. Silage yield averaged across years and hybrids increased with population density and was greatest at 42,000 plants/acre (Figure 3). As the graph shows, yields were beginning to level off at the highest plant density tested (42,000 plants/acre).

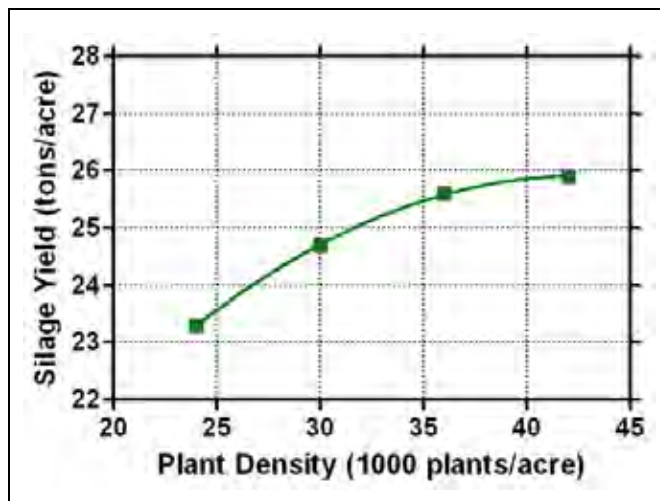


Figure 3. Influence of corn plant density on silage yield in trials conducted at **Rock Springs, Pennsylvania** in 1998 and 1999. Data are averaged across year, hybrid, and row spacing.

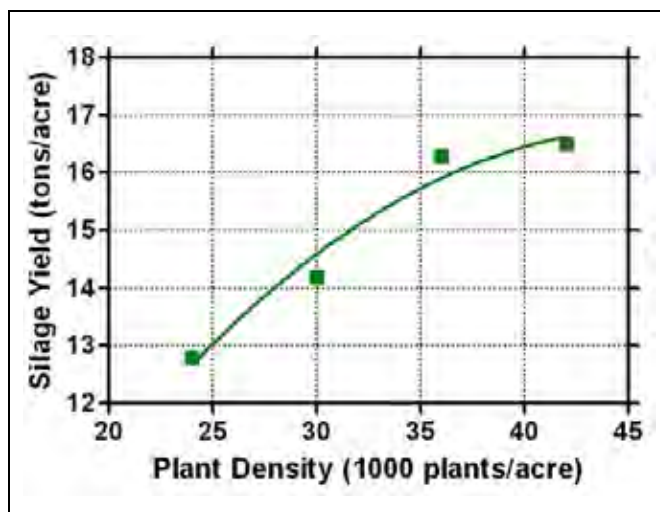


Figure 4. Influence of corn plant density on silage yield averaged over four nitrogen rates and two row spacings in trials conducted at four locations in **Maryland** from 1997-1998.

University of Maryland Study. Silage yield averaged across years, nitrogen rates, and row spacings increased with plant density and was greatest at 42,000 plants/acre (Figure 4). Silage yield increased very little between the two highest densities, suggesting an optimal plant population for silage yield of about 42,000 plants/acre.

University of Alberta Study. Silage yield averaged across hybrids increased with population density and was greatest at 50,000 plants/acre in this extreme northern environment (Figure 5). Silage yield increased 6.3% between the two highest densities, 40,000 plants/acre and 50,000 plants/acre; indicating that the optimal plant population for silage yield was 50,000 plants/acre or greater.

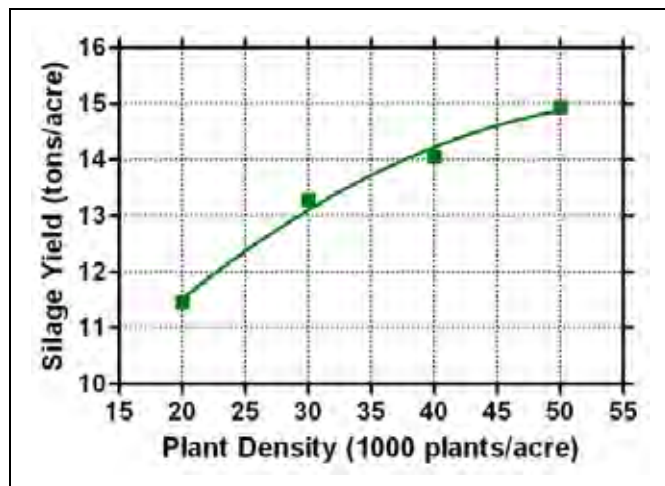


Figure 5. Influence of corn population density on silage yield in trials conducted at six sites in central Alberta in 2002 and 2003. Data are averaged across four hybrids.

Plant Density Effects on Silage Quality

Pioneer Hi-Bred Study. In the Pioneer Hi-Bred studies conducted from 2004 to 2007, whole plant corn silage quality was reduced as plant density increased (Table 1). Overall, whole plant digestibility (WPDig) decreased by 1.4 percentage points when plant density increased from 18,000 to 42,000 plants/acre. This is likely related to the increase in fiber content of the silage. Acid detergent fiber (ADF) percent and neutral detergent fiber (NDF) percent increased 5.3% and 3.0%, respectively with increased plant density. Lower plant densities resulted in improved degradable fiber percent (DigFib). The trend for crude protein (CP%) was to decrease as plant density increased.



Table 1. Influence of corn silage plant density on forage quality traits in the Pioneer Hi-Bred study¹.

Plants/acre	ADF	NDF	DigFib	WPDig	CP	Starch
	----- % -----					
18,000	22.6	39.8	46.5	72.0	7.2	30.7
24,000	22.9	39.8	46.3	71.8	7.4	30.6
30,000	23.1	40.1	45.6	71.4	7.2	31.2
36,000	23.1	39.9	45.1	71.3	7.2	32.0
42,000	23.8	41.0	45.4	70.6	7.1	30.6

¹ See appendix for description of traits.

University of Wisconsin Study. Results showed a positive linear relationship between plant density and ADF in northern and southern regions of the state and a positive linear relationship between plant density and NDF statewide (data not shown). These results suggest that increased plant fiber content at high plant density reduces silage quality.

University of Alberta Study. University of Alberta results also indicated a decline in silage quality with increased plant density (Table 2). In vitro true digestibility (IVTD) decreased 1.5% when plant density increased from 20,000 to 50,000 plants/acre. ADF and NDF increased 4.5% and 5.2%, respectively with increased plant density. Crude protein and starch decreased as plant density increased.

Table 2. Influence of corn silage plant density on forage quality traits in the University of Alberta study.

Plants/acre	ADF	NDF	DNDF	IVTD	CP	Starch
	----- % -----					
20,000	22	42.3	48.2	72.6	7.0	21
30,000	22	42.8	47.8	72.3	6.8	20
40,000	23	43.4	47.6	71.9	6.8	19
50,000	23	44.5	47.8	71.5	6.6	17

Plant Density and Animal Performance

Pioneer Hi-Bred Study. Estimated milk and beef production per acre increased as plant density was increased; however, adjusted net energy lactation and TDN decreased with increased plant density (Table 3). Adjusted milk/acre was 24% greater at a plant density of 42,000 vs. 18,000 plants/acre. Adjusted beef was 23% greater for the same comparison.

Net energy and TDN were 4% and 2% lower when 42,000 was compared with 18,000 plants/acre respectively. This

shows that lower plant densities result in better quality silage as noted by digestible fiber and whole plant digestibility values from Table 1.

Table 3. Influence of plant density on NE-L, TDN and animal performance traits in the Pioneer Hi-Bred study ¹.

Plants/ acre	Adj. NE-L (Mcal/lb)	Adj. Milk (lb/acre)	Adj. TDN (%)	Adj. Beef (lb/acre)
18,000	0.73	21,946	73.1	3441
24,000	0.73	24,314	72.8	3798
30,000	0.72	25,018	72.5	3918
36,000	0.72	26,735	72.4	4180
42,000	0.70	27,110	71.6	4219

¹ See appendix for description of traits.



In Pioneer studies, large increases in silage tons/acre at higher plant densities more than offset decreases in milk production per ton due to slightly lower silage quality.

References

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- Stanton, D., A. W. Grombacher, R. Pinnisch, H. Mason, and D. Spaner. 2007. Hybrid and population density affect yield and quality of silage maize in central Alberta. *Can. J. Plant Sci.* 87: 867-871.

Appendix

DigFib%: % digestible fiber, formerly termed dNDF. This is a 24-hour enzymatic estimate of % degradable neutral detergent fiber (as a percent of total NDF) in whole plant samples predicted by NIRS.

Starch%: % starch (DM basis) in the whole plant sample.

WPDig%: Formerly termed IVDC. Estimates 24-hour in vitro whole plant digestibility percent (DM basis) as predicted by NIRS. Feed sample starch is removed by hot water extraction followed by enzymatic degradation of the protein and fiber with purified enzymes. This method (DeBoever et.al.) reduces the variability associated with using rumen fluid collected from different cows consuming different feedstuffs over time. This is the officially approved methodology for governmental agencies registering silage hybrids in several European countries.

Adj. NE-L%: Adjusted Net Energy of Lactation (Mcal/lb, DM basis) predicted by $0.996 - (0.0126 \times \text{ADF}\%)$. Adj NE-L employs an adjusted ADF using whole plant digestibility (WPDig) as a covariate. Will not correctly value unique germplasms such as high oil corn.

Adj. Milk/Acre: Pounds of milk/acre derived from a yield, crude protein, whole plant digestibility and NDF based index (MILK95) published by Univ. of Wisconsin (*J. Prod. Ag.* 6:231-235). Animal requirements were based on a 1350 lb. cow milking 90 lbs. of milk at 3.8% fat. Whole plant digestibility inputs to MILK95 were adjusted using an 24-hour enzyme-based in vitro whole plant digestibility (WPDig) method to account for the fact not all fiber is degraded at the same rate or extent by rumen bacteria.

Adj. TDN%: % Total Digestible Nutrients (DM basis) predicted by $87.84 - (0.70 \times \text{ADF}\%)$. Adj TDN employs an adjusted ADF using whole plant digestibility (WPDig) as a covariate.

Adj. Beef/acre: Estimated pounds of beef gain per acre based on six lbs of TDN required for one lb of beef gain, with TDN adjusted to reflect whole plant digestibility (WPDig) estimates.

