FIELD FACTS

Corn Performance at Very High Plant Populations

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Introduction

Corn yields in the U.S. and Canada have increased dramatically over the last 50 years. A major contributor to this increase has been the consistent improvement in stress tolerance of hybrids, which has enhanced performance under drought and allowed growers to plant at higher populations.

The progress researchers have made in improving stress tolerance is demonstrated in a study comparing the plant population response of modern hybrids to that of older hybrids (Duvick, 1993). In this study, Pioneer® brand hybrids from the 1930s to 1990s were planted to achieve populations of 4,000, 12,000, 22,000 and 32,000 plants/acre.

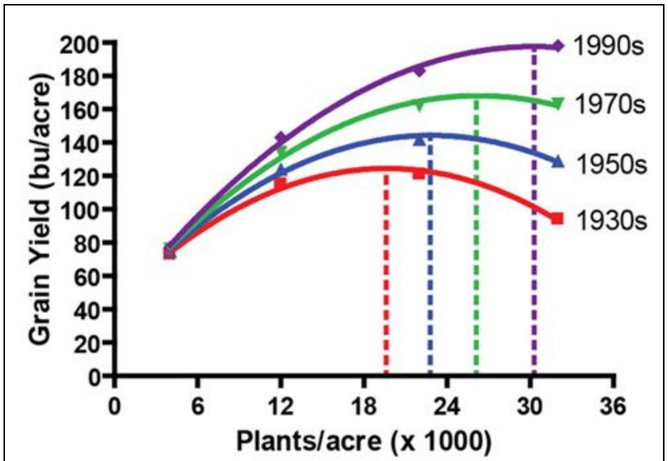


Figure 1. Grain yield response to plant population of hybrids from four eras of plant breeding (Duvick, 1993).

At very low plant populations (a low stress environment) there were no yield differences in hybrids from different decades (Figure 1). However, the optimum population to maximize grain yield was greater with hybrids from each subsequent era. The newest hybrids were much better adapted to the higher stress levels at greater populations and produced the highest yields.

Pioneer High Population Study

Pioneer Agronomy Sciences researchers have studied plant population responses in multiple environments across the U.S. and Canada for the past 20 years. Pioneer plant population research typically involves evaluation of hybrids at plant populations as high as 42,000 plants/acre. However, to characterize population response beyond this range, Pioneer conducted a study at ultra-high densities from 9,000 to 90,000 plants/acre. The impact of these populations on grain yield and secondary traits was determined.

Yield response. Results from this study showed that yield response across the range of populations was similar among hybrids (Figure 2). Corn grain yield generally increased with higher populations up to 36,000 plants/acre and declined with populations greater than 45,000 plants/acre.

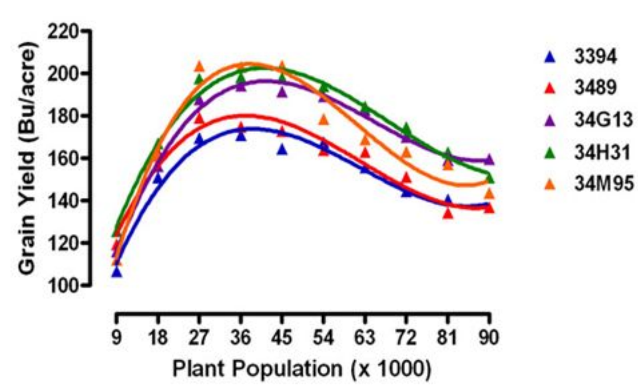
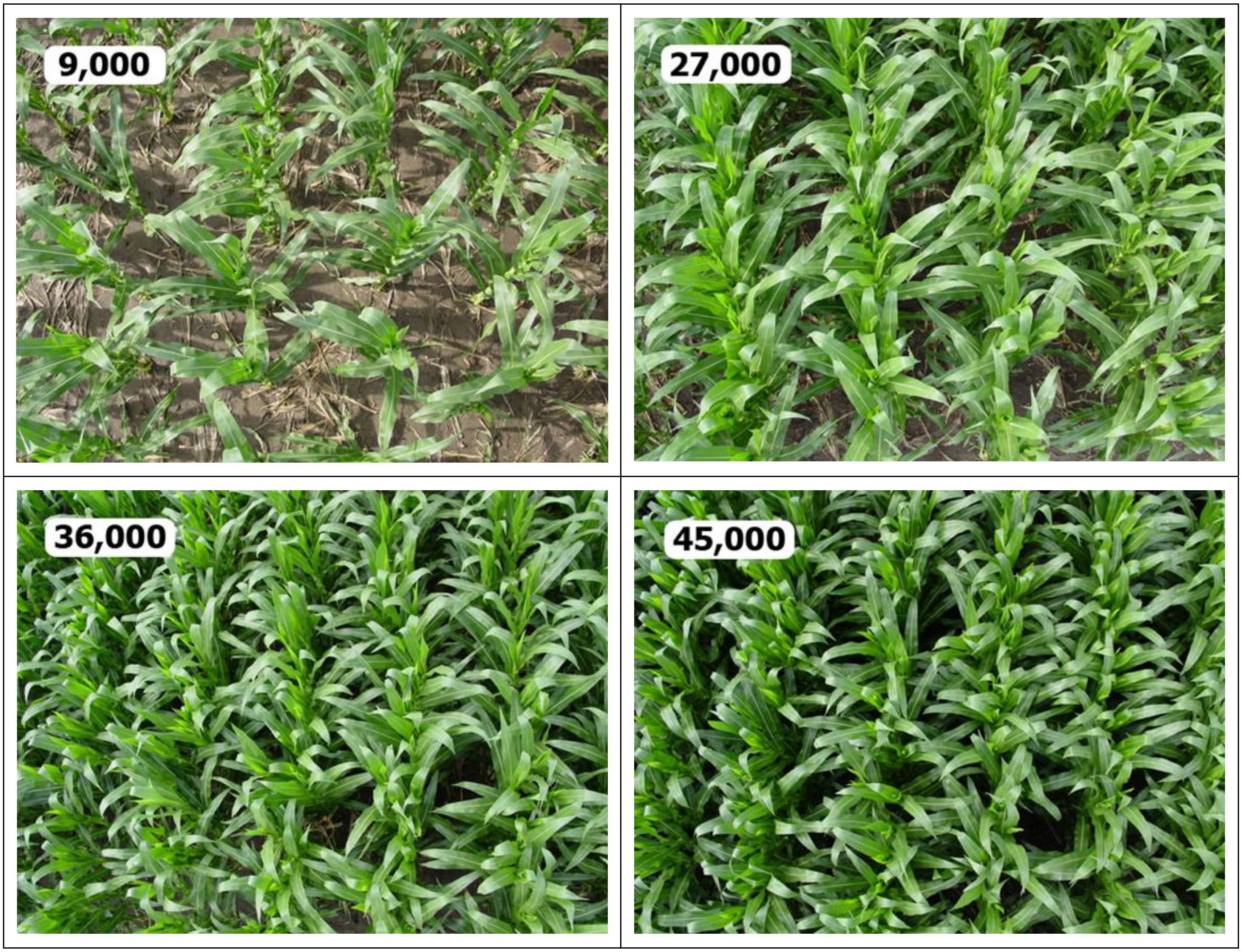


Figure 2. Average yield response of several Pioneer hybrids to plant population across five locations.


9,000
27,000
36,000
45,000

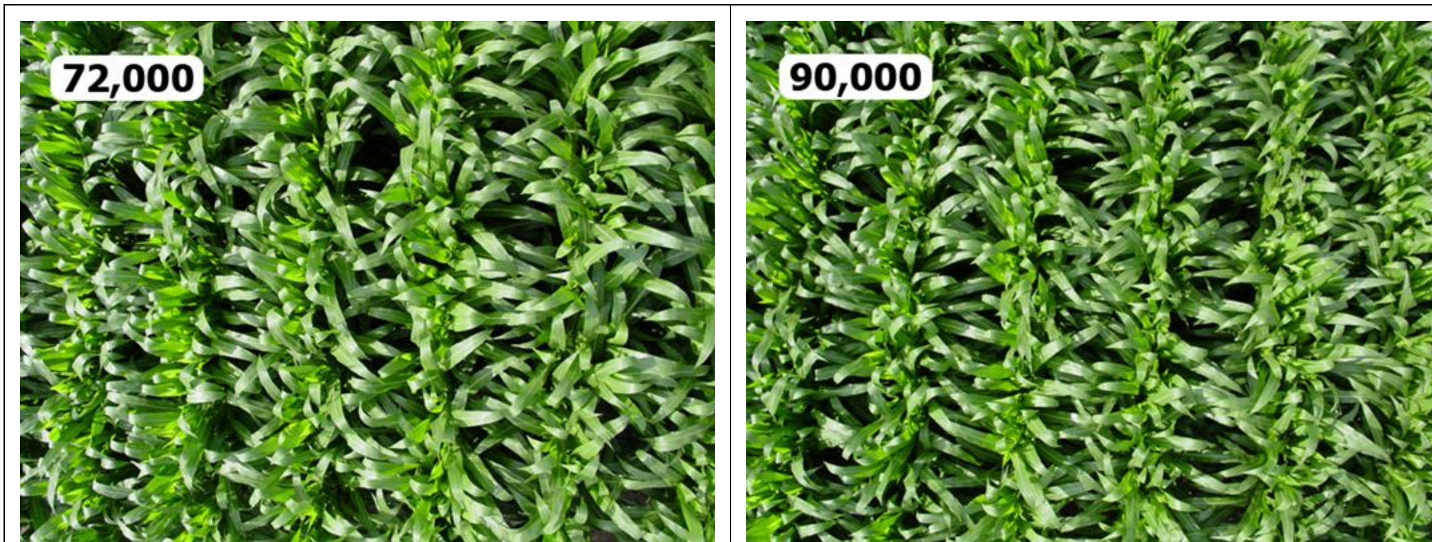


Figure 3. Aerial photos of corn canopies at 9,000, 27,000, 36,000, 45,000, 72,000, and 90,000 plants/acre (taken July 9, 2008).

Plant and ear height. Corn plant height response to plant population was similar to the grain yield response (Figure 4). Height increased with densities up to 36,000 plants/acre and declined once population exceeded 45,000 plants/acre. Ear height also increased with populations up to 36,000 plants/acre, but stayed relatively constant as population increased beyond this point, increasing only slightly at extremely high populations.

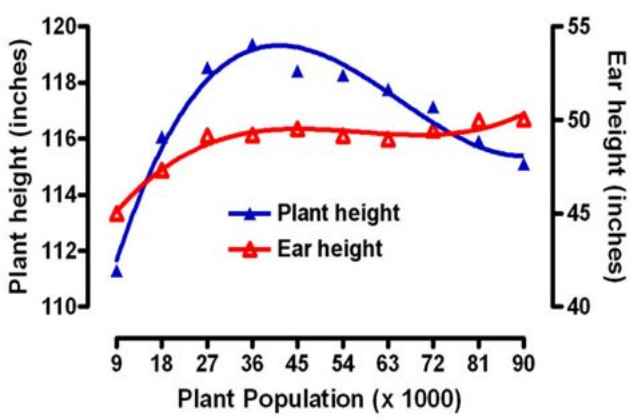


Figure 4. Plant and ear height response to plant population.

Ear characteristics. The number of kernel rows and kernels per row declined steadily with increasing plant population (Figure 5). Corn yield increased up to populations of 36,000 plants/acre, indicating that up to this point the yield increase from a greater number of ears/acre more than overcame the yield decrease due to smaller ears. The decline in yield at populations beyond 36,000 plants/acre however, indicates that corn at high populations was no longer able to produce enough ears per unit area to overcome the reduced ear size.

Figure 5. Ear size response to plant population.

Traits associated with yield. In order to understand the secondary traits associated with increasing yield (from 18,000 to 36,000 plants/acre) and those traits associated with yield loss (from 36,000 to 90,000 plants/acre) two separate correlation matrices were created (Figure 6).Traits that accounted for >50% of the phenotypic variation in yield and whether they increased or decreased in value are indicated.

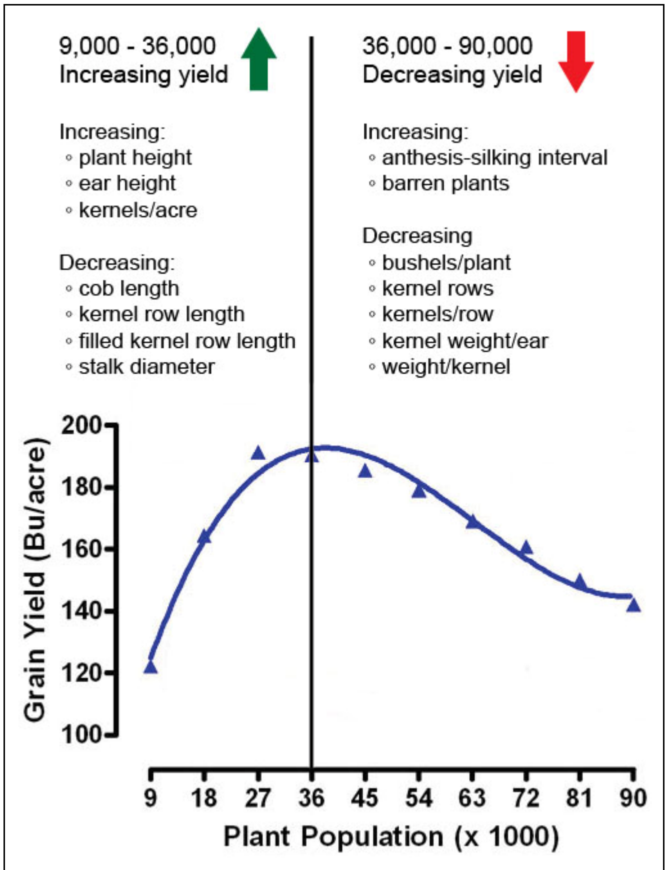


Figure 6. Correlation of secondary traits to increasing yield (9,000 to 36,000 plants/acre) and decreasing yield (36,000 to 90,000 plants/acre). Secondary traits with correlations greater than 0.7 and less than -0.7 are shown.

The yield increase from 18,000 to 36,000 plants/acre is due to an increase in kernels/acre and is negatively associated with ear size and kernel number. This isn't surprising, as common agronomic understanding holds that large yields are less likely created by 18,000 big ears as by 36,000 moderately sized ears.

The yield decline from 36,000 to 90,000 plants/acre is correlated with increased barrenness and increased anthesis-silking intervals, or ASI (Figure 7). Traits trending downward with yield in this range of plant population are: bushels/plant, kernel and ear weight, kernel rows, and kernals per row. Bushels/acre is maximized by the largest per plant yields, driven by high seed set.

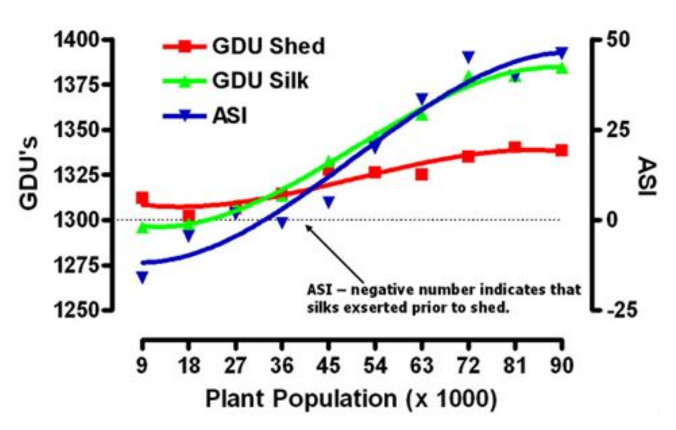


Figure 7. Silking and pollen shed growing degree units (GDU) and anthesis-silking interval response to plant population.

The anthesis-silking interval is the time lag between pollination and silking. Ideally, silks should emerge concurrently with pollen shed to insure complete pollination. As the ASI widens, the likelihood increases that late-emerging silks will not be pollinated.

ASIs increase at high plant densities due to slowed ear development relative to tassel development. This is indicative of a high level of plant stress which can result from extreme competition among plants at high densities, or other stress factors such as drought. Stress in corn slows axillary growth more than apical growth, which results in plants favoring tassel development over ear development. This asymmetry in floral development can result in incomplete kernel set, or in cases of extreme stress, barrenness, both of which can severely reduce yield.