CROP INSIGHTS

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Corn Hybrid Response to Plant Population

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Summary

- Genetic improvement of corn hybrids for ***superior stress tolerance*** has contributed to increased yields by allowing hybrids to be planted at higher plant populations.
- Corn growers continue to steadily increase plant populations. Average planting rates are now greater than 30,000 seeds/acre on most corn acres in the U.S. and Canada.
- Pioneer has conducted research studies for many years to measure how hybrids respond to plant population. During the last four years, studies were conducted across 144 environments in 17 states and three provinces.
- In these studies, high yield environments (>180 bu/acre) required higher populations for optimum yields than the more average yielding environments in the Corn Belt.
- The earliest maturity hybrids in the study (CRM<100) showed a steeper population response curve than the later maturities. Past studies have also shown that very early hybrids require higher populations for optimum yields.
- In addition to plant population, hybrid standability can be affected by hybrid, crop management and environment. Results of Pioneer research suggest that addressing those factors may be more important than reducing plant population in order to improve hybrid standability.
- This *Crop Insights* reviews recent Pioneer research on plant population effects on yield and other traits.

Introduction

The average yield of corn in the U.S. and Canada has tripled over the last half-century. Yield gains have resulted from improved hybrid genetics and better agronomic practices such as soil fertility and weed control. Among these factors, genetic improvements have contributed the most to yield gains, adding from 1.0 to 1.5 bu/acre each year. To accomplish these increases, corn breeders have selected for superior tolerance to drought and other stresses, and yield stability across diverse growing environments. A key result of enhanced stress tolerance is adaptability of hybrids to higher plant populations.

Changes in corn plant populations preferred by farmers have been dramatic (Figure 1). In just 10 years, the number of North America corn acres with seeding rates of at least 30,000 plants/acre has more than doubled, increasing from 22% of total acres in 1996 to 52% in 2005. In 2005, the major corn-producing states of Illinois, Iowa and Minnesota had average corn seeding rates greater than 30,000 seeds/acre across 65%, 75% and 80% of their corn acres, respectively.

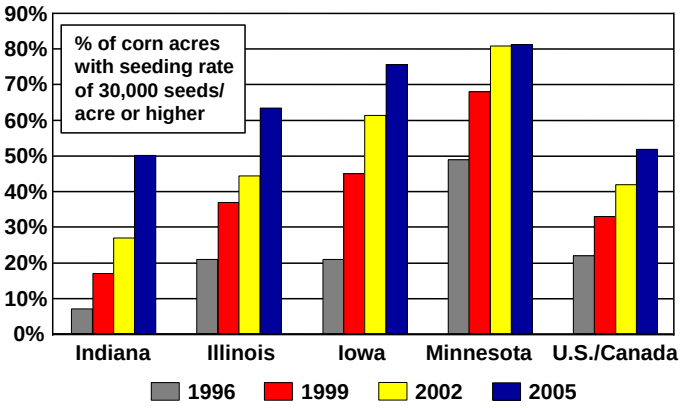

Figure 1. Percent of corn acres with seeding rates of 30,000 seeds/acre or higher. 1996-2005 Brand Concentration Survey, Marketing Research and Analysis, Pioneer Hi-Bred Int'l., Inc.

Higher plant populations increase competition among individual plants for water, sunlight and soil nutrients. Although this may lower individual plant yield, it has increased yield per unit area by optimizing these yield components:

- Number of ears per unit area
- Number of kernels per ear
- Weight of each kernel.

Pioneer Decade Study

Pioneer routinely conducts research studies designed to measure genetic improvements in corn hybrids. One such study compared the plant population response of modern hybrids to that of older hybrids (Duvick, 1993). Hybrids from the 1930s to 1990s were planted to achieve populations of 4,000, 12,000, 22,000, and 32,000 plants/acre. The grain yield responses of these hybrids to low and high plant densities are shown in Figure 2.

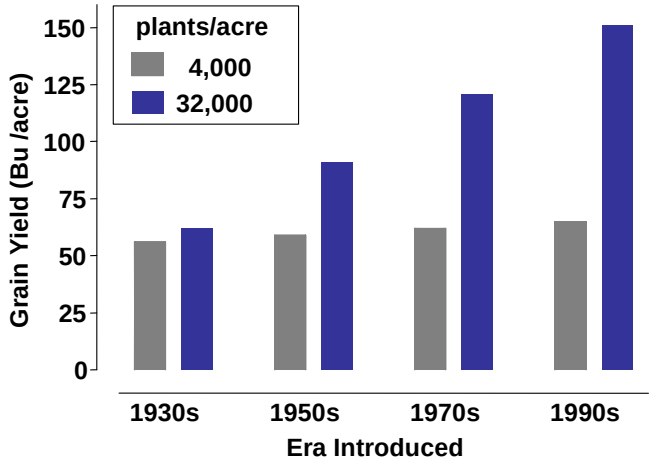

Figure 2. Grain yield response to low and high plant populations for hybrids from four eras of plant breeding, two-year average (Duvick, 1993).

At very low plant populations (a low stress environment) there were no yield differences in hybrids from different decades. However, when seeded at current populations needed to maximize grain yield per acre, hybrids showed progressively higher yields with each era of genetic improvement. The newest hybrids were much better adapted to the higher stress levels and produced the highest yields.

To achieve these genetic gains, Pioneer plant breeders over the last 50 years have focused on yield stability across a range of environments, increased stalk and root strength, increased tolerance to drought stress and high plant population stress, and resistance to barrenness. Researchers have observed that several anatomical and physiological characteristics distinguish modern corn hybrids from older hybrids including:

- Higher leaf area index, which results in the plant intercepting more sunlight
- Higher rates of leaf photosynthesis
- Higher radiation use efficiency during grain filling

Breeders' efforts and resultant hybrid changes now allow producers to plant corn at higher plant populations where maximum grain yield potential can be realized.

Pioneer Agronomy Sciences Studies

Pioneer Agronomy Sciences researchers have studied plant population responses in multiple environments across U.S. and Canada for the past 20 years. The primary goal of these studies is to determine the optimum population of hybrids to maximize harvestable grain yield. With incremental improvements in hybrid stress tolerance, the highest population required to maximize yield has continued to increase. Pioneer researchers now evaluate hybrids at plant populations as high as 42,000 plants/acre across multiple growing environments.

Continued improvements in stress tolerance have allowed corn hybrids to be grown at progressively higher populations for increased yields.

Results by Yield Level

Grouping locations with similar yields is a useful way to analyze plant population results because it can indicate which populations are needed for the yield levels growers expect to achieve. Like previous Pioneer studies, the 2002 to 2005 trials across the U.S. and Canada show that corn hybrid response to plant population is affected by yield level at very high or very low yields. However, in the yield ranges most common in major corn-producing areas, yield level effects are minimal (Figure 3).

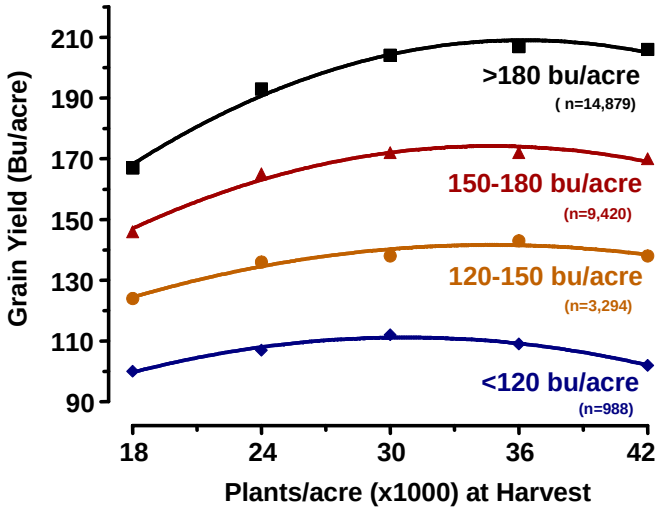

Figure 3. Grain yield response to plant population for corn hybrids by location yield level, 2002 to 2005 (n is the number of observations within a yield range.)

As the graph indicates, the response to plant population at the 120 to 150 bu/acre yield level is almost identical to the response at the 150 to 180 bu/acre level. For both of these yield groups, optimum yields occurred at about 34-35,000 plants/acre. The similarity of the two curves within the yield

range most commonly encountered in Corn Belt fields casts doubt on the effectiveness of variable-rate seeding to increase yields within this range (also see Doerge, 1999). However, for very high or very low yielding areas of fields, variable-rate seeding should be beneficial, according to these results.

Pioneer researchers conduct corn plant population trials in multiple locations across the U.S. and Canada each year.

At yield levels greater than 180 bu/acre, harvest populations near 36,000 plants/acre were needed for highest yields. This harvest population is higher than many producers with high-yielding fields are currently planting, but is similar to the current plant populations often used for irrigated acres and contest fields. At yields below 120 bu/acre, highest yields occurred at populations less than 30,000 plants/acre at harvest. Previous studies have also shown that at low yield levels, optimum yields can be attained at these substantially lower plant populations.

These population response curves show that past the point of optimum population, corn hybrid yields tend to level off rather than decrease sharply, even at lower yield levels. This is in contrast to hybrids of 30 to 40 years ago, which were much more likely to incur barrenness and significant yield losses under high plant density stress. Growers today can plant optimistically for maximum yield potential under good growing environments, with little risk of yield reductions from over-planting if stress conditions develop. For most growers, the risk of planting too few plants is greater than that of planting too many.

At all yield levels, considerations for determining a recommended planting rate should include not only the expected yield level but also the economic return. Optimum economic seeding rate based on the cost of seed and the price of grain will be addressed later in this article.

Results by Hybrid Maturity

To further clarify corn plant population response, results were grouped by hybrid maturity (Figure 4).

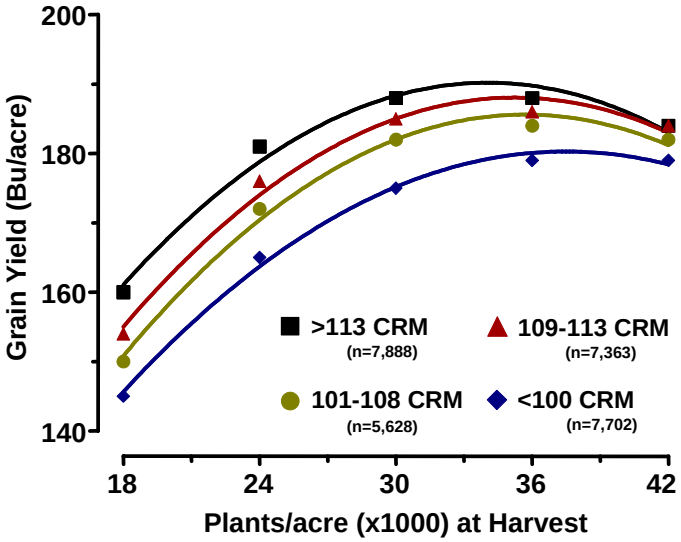

Figure 4. Grain yield response to plant population for corn hybrids from four maturity (CRM) ranges, 2002 to 2005.

This four-year data summary shows no substantial differences in the optimum plant population to achieve maximum grain yield for hybrids greater than 100 CRM in maturity. For those hybrids, an optimum harvest population of 34,000 to 36,000 plants/acre is apparent. However, the earliest hybrid group (< 100 CRM) shows a steeper response curve with a population optimum of greater than 36,000 plants/acre. Past studies have also shown that very early hybrids require higher populations for optimum yields. Researchers theorize that the disadvantages of smaller stature and lower leaf area index of early maturity hybrids are overcome by higher populations.

Hybrid Late-Season Standability Research

Increased stalk lodging is sometimes observed with high plant densities, as average stalk diameter is reduced. For this reason, Pioneer researchers conduct "late-season standability" trials across North America each year. In these plots, hybrids planted at 18, 000 to 42,000 plants/acre are left in the field past normal harvest dates. This allows researchers to evaluate hybrid standability responses to plant population after exposure to adverse environmental conditions The results showed that in these high stalk-lodging environments percent stalk lodging increased approximately 0.5% for each 1000 plant/acre increase in population (Figure 5).

Standability at harvest is also affected by factors other than plant population, including hybrid, crop management practices and environment. Figure 5 demonstrates that decreasing plant population as much as 4,000 plants per acre would only reduce stalk lodging by about 2%. Therefore, careful selection of lodging resistant hybrids combined with proper hybrid placement, soil fertility and other crop management practices may be more important than reducing plant population in maximizing harvestable corn yield.

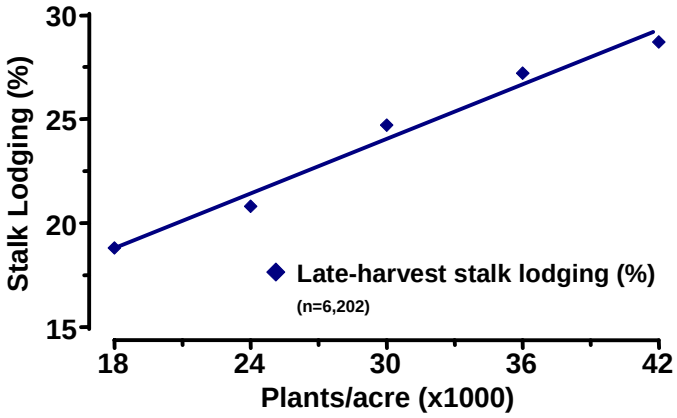

Figure 5. Late-harvest stalk lodging response of corn hybrids to plant population at locations with 10% or greater overall lodging. 25 environments, 2002 to 2005.

Optimum Economic Planting Rate

The net income response to corn seeding rate across different hybrid CRM ranges is shown in Figure 6. The net income/acre response to plant population is based on a corn grain price of $2.00/bu and a seed cost of $1.75/1000 seeds.

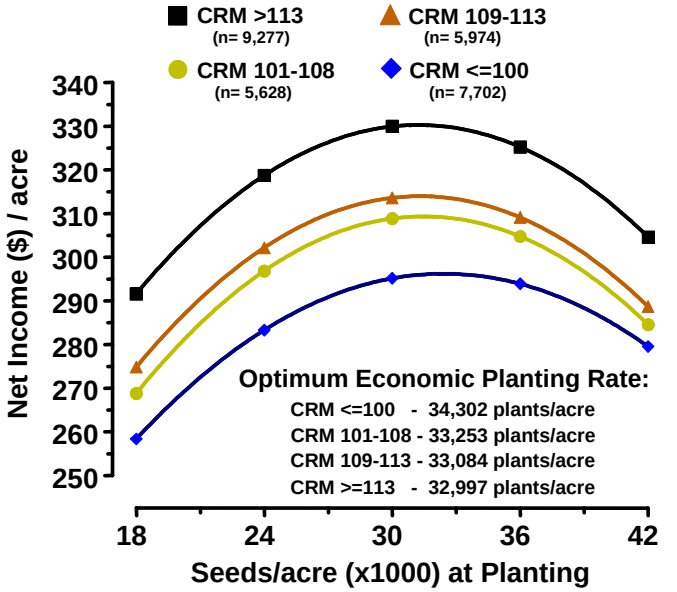

Figure 6. Four year (2002 to 2005) net income per acre in response to corn planting rates ranging from 18,000 to 42,000 seeds/acre, from four CRM ranges.

(An input cost of $1.75/1000 seeds and a corn grain price of $2.00/ bu were used. A 5% increase in the optimum planting rate and subsequent seed cost was added to account for early season stand loss.)

As the graph demonstrates, the response was similar for all four CRM zones tested. The optimum economic planting rates were approximately 34,300, 33,200, 33,100 and 33,000 plants per acre for the very early, early, medium and late hybrid maturity groups, respectively. Your Pioneer sales professional can demonstrate how economic seeding rates change with grain price and seed costs, using a decision aid.

Seeding Rate Recommendations

Environmental conditions beyond the control of the grower can often reduce plant populations below optimum levels. Late spring frost, extended wet soil conditions, or seedling pests may unexpectedly reduce plant populations. Consider the following points when choosing your seeding rate:

- Plan to drop 5 to 10% more seeds than your target population to account for germination or seedling growth losses.
- Boost target plant populations by an additional 5 to 10% when seeding early maturity hybrids, or when planting corn to be harvested as silage.
- Under extreme situations, such as planting into no-till or other tough seedbed conditions, or very early planting into cold soils, seeding rates up to 15% above target stands may be needed.
- In drought-prone areas, know your general soil and climatic conditions and make adjustments to plant population based on the risk of severe soil moisture deficiency.
- Consult your Pioneer sales professional for optimum economic planting rates of specific Pioneer® brand hybrids, hybrid placement, and the best seed treatments for disease and insect protection.
- Maintain your planter by replacing worn parts and checking adjustments so that it seeds at the desired population with consistent plant spacing.

References

Doerge, T. 1999. New opportunities in variable-rate seeding of corn. *Crop Insights* Vol. 9, No. 5. Pioneer Hi-Bred International, Inc., Johnston, Iowa.

Duvick, D. 1993. Personal communication.

Paszkiewicz, S. and S. Butzen. 2001. Corn Hybrid Response to Plant Population. *Crop Insights* Vol. 11, No. 6. Pioneer Hi-Bred International, Inc., Johnston, Iowa.