CROP INSIGHTS

PIONEER® A DUPONT BUSINESS

Optimizing Seeding Rates for Corn Production

by Steve Butzen, Agronomy Information Manager

Summary

- Higher corn seeding rates accompanied by improved stress tolerance in hybrids has contributed to incremental yield gains over time.
- Pioneer's extensive plant population trials indicate that corn seeding rates generating the most income range from about 32,000 seeds/acre at yields of 150-170 bu/acre to 38,000 seeds/acre at yields exceeding 250 bu/acre.
- Acres planted at 33,000 seeds/acre or above now exceed 30% in North America as a whole, having grown by nearly 15 percentage points in the last three years.
- Early maturity hybrids (< 100 CRM) had a higher population optimum than later hybrids in Pioneer studies.
- Optimum plant population did not differ by row width (including twin rows) in most Pioneer and university studies.
- In general, growers should drop 5% more seeds than the target population to account for germination or seedling losses.
- Extreme environments such as no-till and early planting may require increasing seeding rates by 10% over target.

Introduction

Average corn seeding rates used by growers in the U.S. and Canada have increased from about 23,000 seeds/acre in 1985 to over 30,000 seeds/acre today, or approximately 300 seeds/acre per year (Figure 1). During the same time period, average U.S. yields increased from about 105 to nearly 160 bu/acre, or 2 bu/acre per year (Figure 1).

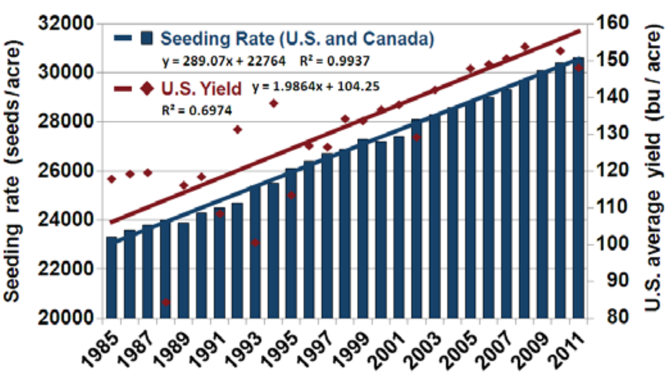

Figure 1. Average corn seeding rates reported by growers in the U.S. and Canada (Pioneer Brand Concentration Survey, 2011), and average U.S. corn yields (USDA/NASS).

Figure 2. Continued improvements in stress tolerance have allowed corn hybrids to be grown at progressively higher populations for increased yields.

These parallel trends suggest that increased seeding rates may have played a major role in corn yield increases over the last 25 years. This hypothesis is confirmed by research studies showing that higher seeding rates accompanied by improved stress tolerance in hybrids has indeed contributed to incremental yield gains over time. This *Crop Insights* will discuss hybrid improvements for stress tolerance, current seeding rate trends and optimum seeding rates for corn production.

High Density Stress and Hybrid Response

Higher plant density means increased competition between corn plants for available moisture, light and nutrients. When these vital resources are limited, interplant competition lowers individual plant yields. This is often observed when planters drop "doubles" and resulting ears are reduced in size and kernel number or weight. Another example is Pioneer's high density studies with populations as high as 90,000 plants/acre. In these studies, some individual plants have no ears due to the extreme competition.

In the case of doubles, overall yield may not be reduced if the two smaller ears can equal one "normal" ear. But the case of extreme density studies demonstrates exceeding the corn plants' tolerance for that density, resulting in yield loss. Even today's best hybrids have a plant density limit that may result in lower yields when exceeded.

Hybrid Improvements for Density Tolerance

A common stress response of open-pollinated (non-hybrid) varieties as well as early corn hybrids was "barrenness", or the inability to produce an ear. Through generations of crossing and selection in environments that stressed the corn plants, continual improvements were made. Because moisture is usually the most limiting resource in corn production, moisture-restricted environments were used to screen potential parent lines and hybrids. In addition, the practice of growing plants in high density plots was used to create higher stress (or "limiting") environments by forcing more plants to compete for the same scarce resources, primarily moisture and light.

Even as recently as 30 years ago, some of the best hybrids were prone to barrenness when population thresholds were exceeded. But changes have come rapidly since that time. Hybrids were developed with more upright leaves to capture needed sunlight in a smaller space. Many hybrids also have improved root systems for superior moisture uptake, and more efficient water utilization capabilities within the plant. These efficiencies result in successful silking and kernel formation in improved hybrids under the same moisture levels that resulted in pollination failure in older hybrids.

The end result of decades of targeted breeding is an improved ability of modern corn hybrids to produce an ear under moisture and density stress, even though ears are progressively smaller under increasing stress. This means that when plant density optimums are exceeded, yields tend to level off rather than drop abruptly. This hybrid characteristic has changed the risk/reward equation in the growers' favor. Because the risk is reduced that excess populations will decrease yields under dry conditions, growers can more optimistically plant higher populations that support increased yields when favorable conditions develop.

Documenting Hybrid Improvements

Pioneer routinely conducts research studies designed to measure genetic improvements in corn hybrids. In one such study, hybrids from the 1930s to 1990s were planted to achieve populations of 4,000, 12,000, 22,000, and 32,000 plants/acre (Duvick, 2005). The grain yield responses of these hybrids to low and high plant densities are shown in Figure 3.

Note that yields of old vs. more modern hybrids did not differ at the lowest plant population (4000 plants/acre), and differed only moderately at 12,000 plants/acre. However, at higher plant populations of 22,000 and 32,000 plants/acre, hybrids were quickly separated by era, with older hybrids unable to compete with newer hybrids under density stress encountered at those populations. This clearly demonstrates that newer hybrids are improved over older hybrids in their ability to maintain individual plant yield as populations increase. Modern hybrids also exhibit other improvements that lead to higher harvestable yields, including:

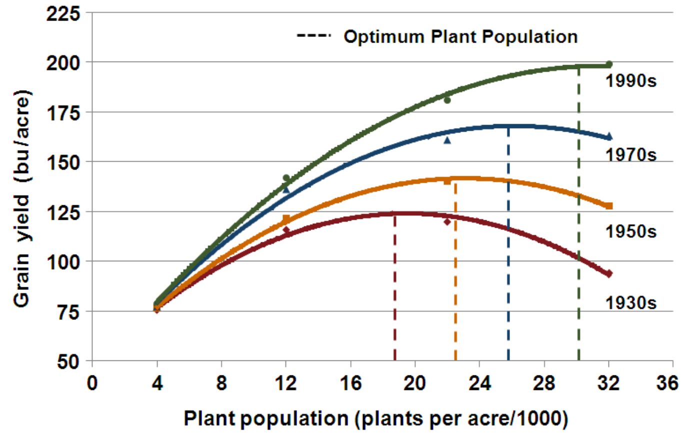

Figure 3. Grain yield response to plant populations of hybrids from four eras of plant breeding. Vertical lines indicate optimum plant populations for each era (Duvick, 2005).

- Superior stalk and root strength
- Higher leaf area index for increased light interception
- Higher rates of leaf photosynthesis
- Higher radiation use efficiency during grain filling

Current Trends in Corn Seeding Rates

The average seeding rate across the U.S. and Canada is about 30,600 seeds/acre, but average rates differ widely by state, productivity level of the field, hybrid, and grower preference. In the two major corn-producing states and in Minnesota, over half of corn acres are now seeded at rates exceeding 33,000 seeds/acre (Figure 4), and the average seeding rate in those states now exceeds 32,000 seeds/acre (data not shown). Acres planted at 33,000 seeds/acre or above now exceed 30% in North America as a whole, having grown by nearly 15 percentage points in the last three years. A Pioneer survey also revealed that growers with farms exceeding 500 corn acres report using higher seeding rates than those with smaller farms (data not shown).

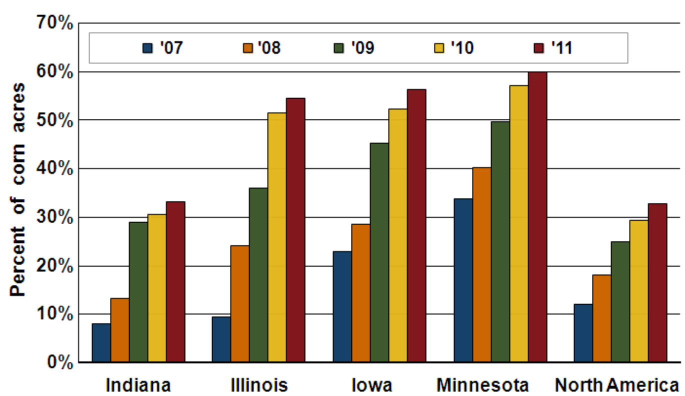

Figure 4. Percent of corn acres with seeding rates above 33,000 seeds/acre in major corn-producing states and in all of North America. Source: Pioneer Brand Concentration Survey.

Pioneer Agronomy Sciences Studies

Each year, Pioneer Agronomy Sciences researchers study plant population responses in multiple environments across U.S. and Canada. The primary goal of these studies is to determine the population of each hybrid that maximizes economic return to the grower. Hybrids are tested at several planting rates, the highest of which is intended to push hybrids far beyond their expected optimum levels.

These studies also allow researchers to evaluate more general population trends, one of which is the response of hybrids to plant populations by field productivity or “yield level” (Figure 5). The red arrows on the graph indicate the optimum economic seeding rate using a corn grain price of \$6.00 per bu, and a seed cost of \$3.00 per 1000 seeds. The economic calculation assumes that a 5% overplant is needed to achieve the target plant population.

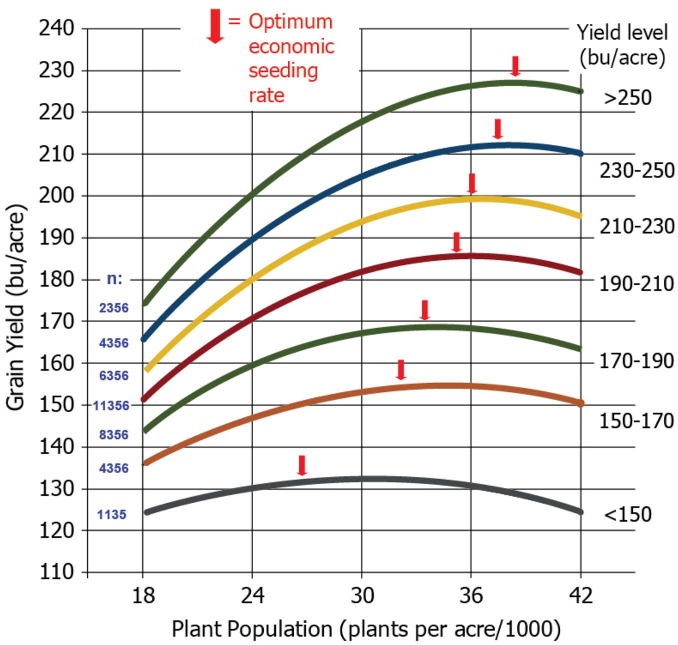

Figure 5. Corn grain yield response to plant population by location yield level, 2006 to 2010 (n is the number of observations within a yield range.)

The graph indicates that the optimum economic seeding rate was about 27,000 seeds/acre for low-yielding fields below 150 bu/acre. At yields of 150-170 bu/acre and 170-190 bu/acre, the optimum seeding rates increased to near 32,000 and 33,000 seeds/acre, respectively.

As yields increased above 190 bu/acre, the seeding rates generating the most income increased by about 1000 seeds/acre for each 20 bu/acre increment of yield (top four curves on graph). As the figure shows, optimums increased from 35,000 seeds/acre at yield levels of 190-210 bu/acre to 38,000 seeds/acre at yields above 250 bu/acre.

Figure 6. Pioneer researchers conduct corn plant population trials in multiple locations across the U.S. and Canada each year.

Results by Hybrid Maturity

Previous research has shown that hybrids of different maturity often have different population optimums, with early maturity hybrids requiring higher populations to maximize yield. Population response of four comparative relative maturity (CRM) groups is shown in Figure 7.

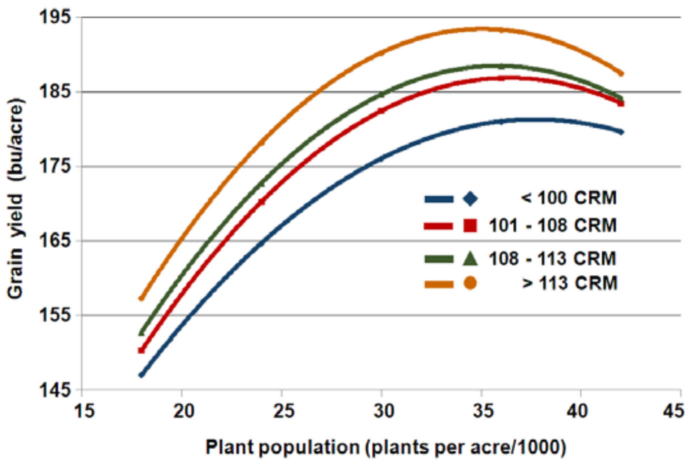

Figure 7. Grain yield response to plant population for corn hybrids from four maturity (CRM) ranges, 2006 to 2010.

These data show a fairly similar response of hybrid maturities to plant population. However, a trend can be detected for earlier hybrid maturity groups to have a slightly higher population optimum. Some researchers theorize that the disadvantages of smaller stature and lower leaf area index of early maturity hybrids are overcome by higher populations. Increasing leaf area index may be required for highest yields in northern areas with limited light availability during ear fill stages.

Plant Population and Row Width

Pioneer researchers conducted on-farm trials in 2010 comparing twin vs. 30-inch rows at several plant populations (Jeschke, 2010). In these studies, populations of 36,000 and 42,000 plants/acre were compared at seven sites in Iowa. Populations of 34,000 and 40,000 plants/acre were used at four sites in Minnesota and three sites in Illinois. None of these studies showed any significant interaction between row configuration and plant population.

Similarly, university research conducted in 2003 and 2004 in Maryland and Delaware found no evidence that plant population can be increased in twin rows to achieve higher yields than is possible in 30-inch rows (Kratochvil and Taylor 2005). A three-year twin-row study in Missouri found no interaction between row spacing and populations ranging from 25,000 to 40,000 plants/acre (Nelson and Smoot 2009). Research with narrow row corn has generally found that optimum plant population is not influenced by row spacing (Coulter 2009). However, recent research in the far-North showed a much higher optimum population for 22-vs. 30-inch rows (unpublished research progress report).

Continued research of population responses by row width is needed as new hybrids are developed. At this time, growers interested in increasing plant populations to maximize yield may want to experiment with higher seeding rates in their current row spacing before trying narrow or twin rows. Growers using narrow rows in far-northern geographies may wish to compare higher seeding rates (40,000 or more) with their current seeding rate in side-by-side trials.

Seeding Rate Recommendations

Environmental conditions may reduce plant populations below optimum levels, including seedbed conditions, adverse weather patterns, and soilborne diseases and insects. Consider the following points when choosing your seeding rate:

- Boost target plant populations by 5% when seeding early maturity hybrids.
- In general, plan to drop 5% more seeds than the target population to account for germination or seedling losses.
- Extreme environments may require increasing seeding rates by 10% over target populations. These include no-till or high-residue seedbeds, high-clay, cloddy or other tough seedbed conditions, and early planting into cold soils.
- In drought-prone areas, seeding rate targets are lower. Base your seeding rate decision on specific hybrid population response at historical yield levels of the field.
- Maintain your planter by replacing worn parts and checking adjustments so that it seeds at the desired population with consistent seed spacing.
- Consult your Pioneer sales professional for optimum economic seeding rates of each Pioneer® brand hybrid, hybrid placement, and the best seed treatments for disease and insect protection.
- Pioneer's online Planting Rate Calculator allows users to generate custom planting rate recommendations based on selected hybrid, grain price, seed cost and yield level: https://www.pioneer.com/home/site/us/agronomy/tools/planting-rate-calculator/

References

Coulter, J. A. 2009. Optimum plant population for corn in Minnesota. U. of Minn., St. Paul. [Online] http://www.extension.umn.edu/distribution/cropsystems/M1244.html

Duvick, D. 2005. The contribution of breeding to yield advances in maize (Zea mays L.). Adv Agron 86: 83–145.

Jeschke, M. 2010. Twin-row corn production. Crop Insights. Pioneer Hi-Bred Int., Inc., Johnston, IA. [Online] https://www.pioneer.com/home/site/us/agronomy/library/template.CONTENT/guid.B6436E5B-B696-7338-F3B2-DC958644F8FE

Kratochvil, R. J., and Taylor, R. W. 2005. Twin-row corn production: An evaluation in the mid-Atlantic Delmarva region. Crop Management doi:10.1094/CM-2005-0906-01-RS. [Online] http://www.plantmanagementnetwork.org/pub/cm/research/2005/twin/

Nelson, K. A. and R. L. Smoot. 2009. Twin- and single-row corn production in northeast Missouri. Crop Management doi:10.1094/CM-2009-0130-01-RS. [Online] http://www.plantmanagementnetwork.org/pub/cm/research/2009/row/