Plant Density and Yield Environment Interaction

Plant density is a main corn yield factor (along with ear number per unit area, grain number per ear, and grain weight) that affects final yield. Final plant density is the result of selecting an optimal seeding rate, which is a main crop management component influencing the economic return for corn. Compared to other crops, such as sorghum, wheat, and soybeans, seeding rate and final plant density at harvest largely influences attainable corn yield. Unlike other cereals, corn does not have the same ability to compensate when plants are missing. Modern corn hybrids usually do not produce tillers and the plant commonly generates one ear per plant at current optimum plant densities. Commercially important corn hybrids are highly dependent on plant density.

The optimal seeding rate depends on the genotype (G), environment (E), and management practices (M). Producers can observe previous corn crops and evaluate that plant density. Planting date, hybrid (genotype), row spacing, and rotations also influence the yield response to plant density. However, many different yield-to-plant density responses have been documented in the last 20 years with negative (yield decreases as plant density increases), neutral, and positive models. Identifying major yield-to-plant density response curves is a crucial element to further advance the understanding of plant density effects on yield.

Individual hybrids can respond differently, but the following guidelines may help when deciding if current seeding rates need to be adjusted. If more than about 5 percent of the plants are barren or if most ears have fewer than 250 kernels per ear, the plant density may be too high. If there are consistently more than 600 kernels per ear or if most plants have a second ear contributing significantly to grain yield, the plant density may be too low. Growing conditions influence ear number and ear size as well, so it is important to factor in the growing conditions for each season when interpreting these plant responses. Nutrient status also influences the final number of grains per ear. For example, severe nitrogen deficiency significantly influences the final number of grains, ear size, and ear number.

Do not be too concerned if a half-inch or so of the ear tip has no kernels. If kernels form to the tip of the ear, there may have been room in that field for more plants, which contributes to grain yield. Again, "tipping back" will vary with the G x E x M interaction. Potential ear size and number of kernels (1,000-1,200 per ear) are set before silking, but the final kernel count is not determined until after pollination and early grain fill due to relative success of fertilization and degree of early abortion of ovules.

Optimal seeding rates may need to be adjusted for irrigated corn if fertilizer or irrigation rates are sharply increased or decreased. For example, research at the Irrigation Experiment Field near Scandia showed that if fertilizer rates are increased, seeding rates also have to be increased to realize the maximum yield benefit.

New Review Analysis

A database was constructed from 124,374 plant density observations conducted from 2000 through 2014 in 22 U.S. states and two Canadian provinces. These trials were conducted in a split-plot arrangement with two to three replicates at each location. Plant density levels tested ranged from fewer than 10,000 to more than 40,000 plants per acre (Figure 1). Plots were uniformly fertilized with all recommended nutrients for their location. Yield response to plant density (final number of plants at harvest) under varying yield environments (less than 100 bushels per acre to more than 200 bushels per acre) was evaluated.

Averaged over all hybrids evaluated, yield response to plant density depended on the final yield environment (Figure 2). With yield environments below 100 bushels per acre, productivity was limited primarily by soil water availability. For these yield levels, response

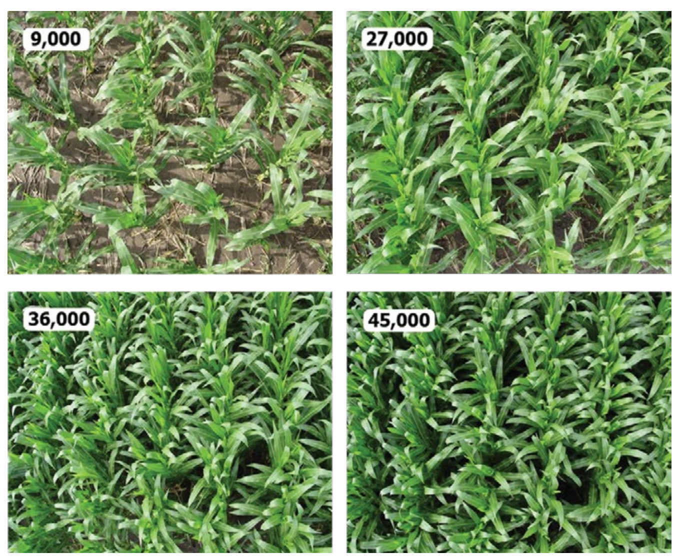

Figure 1. *Plant density studies performed from 2000 to 2014 investigated the yield response to seeding rate with plant density ranging from fewer than 10,000 to more than 40,000 plants per acre in 22 states in the United States and two provinces in Canada. Photo by Dupont Pioneer Seed Company.*

to plant density was flat to slightly negative within the plant density range evaluated. Yield response was a moderate quadratic when yield environment ranged from 100 to 150 bushels per acre; was positive and quadratic with yield level increasing to 150 to 180 bushels per acre; and lastly, yield increased almost linearly in response to plant density when yield environments were above 200 bushels per acre.

Summary

The main points of this study are:

- Optimal plant density varies with yield environment.
- Low-yielding environments (less than 100 bushels per acre) require about 20,000 plants per acre when yield limitations are caused by water supply. High-yielding environments (greater than 200 bushels per acre) generally need at least 30,000 plants per acre.

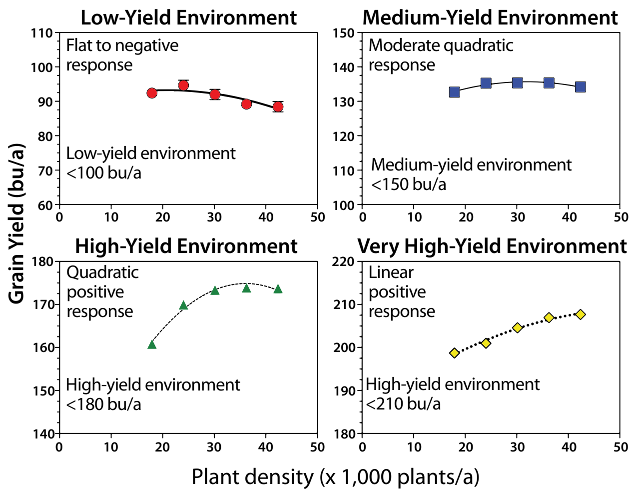

Figure 2. *Corn grain yield response to plant density in four different productivity environments: low yielding <100 bushels per acre; medium yielding 100–150 bushels per acre; high yielding 150–180 bushels per acre; and very high yielding 190–210 bushels per acre. Vertical bars for each mean observation represent the standard error. (Assefa et al., 2016, Crop Sci J).*

- Optimal plant density to maximize yield is not the same as the economically optimal density. See statements below for background.
- Optimal density varies not only between but within-field based on yields.

The responses shown in Figure 2 indicate plant densities necessary to achieve maximum yield. Plant density for highest possible yield does not always coincide with the economically optimum plant density. Hybrid agronomic factors such as lodging potential, plus grain prices and seed costs also should be considered. Farmers should consult with a seed company representative and consider these aspects when deciding the final seeding rate for corn. In addition to yield environment, final seeding rate depends on the hybrid and production practices such as planting date, seedbed condition, and residue cover.

When selecting a hybrid, keep in mind the response to seeding rate and the degree of tolerance to drought and other stresses. Also consider traits such as specific herbicide tolerance, disease and insect resistance, maturity, lodging, and overall hybrid performance.

Consult a seed company representative to determine if seeding rates for specific hybrids should be at the lower or upper end of the recommended ranges for a given environment.

Producers should consider experience and performance in previous growing seasons to determine if the seeding rate previously employed in their different fields was adequate for their respective yield environments.

References

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