Agronomic Spotlight

Considerations for Plant Populations of Modern Corn Products

- Breeders have selected to increase grain yield in corn for generations.
- Genetics that help plants sustain optimal kernel development under density pressure are present in modern corn products.
- Through breeding, corn plants have greater efficiency in converting nitrogen to grain, and adjusting ear size under stressed conditions.

Table 1. Corn Product Yield (bu/acre).

Planted (seeds/acre)	1900s Product	1970s Product	Modern Genetics
16,000	57.9	80.7	167.9
28,000	66.8	100.9	236.4
40,000	59.7	58.4	270.9

Source: Monsanto Learning Center.at Monmouth, IL. History of Corn Genetics. 2014.

Kernel Development

Yield components of corn include ears per acre, kernel rows per ear, kernels per row, and kernel size; these are influenced by genetics, agronomic practices, and environment. Genetic improvement and agronomic practices are equally credited with increases in corn yield potential in the past 50 years.[1] Corn products have individual responses to environment and density studies. Agronomic practices that enhance yield and decrease stress in higher plant densities have been studied at many levels, but perhaps 'era' studies (comparisons of older and newer corn products) have consistently demonstrated greater yields of more modern corn products (Table 1).

These yield advances are attributed to the ability of corn plants to sustain harvest index at increased plant populations. Harvest index increases as grain yield increases and is the ratio of dry matter partitioned to grain compared to the rest of the corn plant.[2] Plant breeders seek these corn products that can partition dry matter to the ear and maintain photosynthesis during grain fill.

Over time, this process of selection has led to corn products genetically disposed to produce fewer barren plants and more kernels per given area. Environmental stress, such as increased plant density, can lead to more barren plants or harvest problems with lodged plants. Compared to older, open-pollinated corn products, modern corn products consistently have greater yields and less lodging at increased plant populations.[3]

Grain yield potential appears to be optimal between 35,000 and 45,000 seeds per acre (Table 2, Figure 2). Some products realized an optimal yield at 45,000 seeds/acre while others had lower seeding rates at their highest yield according to Monsanto Learning Center data from 2015 near Monmouth, IL (Figure 2). Farmers should discuss which corn products are best suited for particular soil conditions, water availability, and nutrient resources as these factors can influence optimal plant populations.

Table 2. Effect of corn population on grain yield, kernel number, and kernel weight (Champaign, Illinois 2011).

	Grain Yield (bu/acre)		Kernel Number (per square meter)		Kernel Weight
Plants/acre (approximate)	Single Row	Twin Row	Single Row	Twin Row	(mg/kernel)
25,000	156	161	3,491	3,649	280
35,000	167	171	3,884	3,969	271
45,000	172	163	4,037	3,820	267
55,000	167	159	3,934	3,777	267

Source: Heagele, J.W., Becker, R.J., Henninger, A.S., and Below, F.E. 2014. Row arrangement, phosphorus fertility, and hybrid contributions to managing increased plant density of maize. Agronomy Journal. Vol. 106:1838-1846.

Photosynthesis

Plant populations near 45,000 plants per acre may be required to consistently achieve 300 bu/acre yield goals of the future.[5] Photosynthesis is one plant function that remains a frontier in genetic improvement that could help increase crop yield.[1] Currently, photosynthesis is being improved with leaf angle and stay-green characteristics that have been selected over years of plant breeding.

Leaves angled 75 percent with the horizontal have enough sunlight to saturate photosynthesis, and the remaining direct light penetrates lower canopy leaves.[1] There is evidence that such upward angled leaves were introduced to modern corn products through a mutation of an auxin-binding protein.[4] Auxin distribution and sensitivity is affected by red to infrared (R:FR) changes. Plants are able to detect neighboring plants by changes in R:FR light in the canopy. Close plant spacing can result in elongated growth, less branching, and redistribution of leaves to the upper canopy to avoid lower shaded leaves.

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Delayed leaf senescence, or stay-green characteristics, allow plants to continue photosynthesis during grain fill. Maintaining photosynthesis during grain fill helps increase kernel weight. Over years of genetic improvement, there has been a moderate increase in kernel weight.[2] However, corn products that have greater tolerance to disease can maintain leaf health and photosynthesize late into grain fill stages.

Nutrient Utilization

Barren plants are also caused by nitrogen (N) and drought stress. At greater populations, these resources are assumed to limit plant growth; however, modern corn products have shown greater nitrogen use efficiency and tolerance to drought stress. Drought tolerant corn products have been bred with an approach integrating multiple genes that influence drought tolerance. This multi-gene approach is used because drought-tolerance is qualitative - it depends on several genes and envrionmental conditions.

A study of N use and efficiency with corn products from four decades (1970s, 1980s, 1990s, and 2000s) demonstrated that modern corn products can utilize N more efficiently.[2] When planted under low N (approximately 63 lbs/acre) conditions, corn products released in the early 1970s and 2000s had 17 and 5.8 percent barreness, respectively.[2] Plants were still able to efficiently distribute carbon and N to the shoot and ear even without fertilization. It is thought that corn product selection over the years has led to plants with traits for enhanced metabolic pathways to the ear shoot. Smaller root systems typically develop on corn plants grown at high densities and can limit the ability of plants to reach nutrients. However, modern corn products are able to efficiently take up N and partition the nutrient to developing ears.

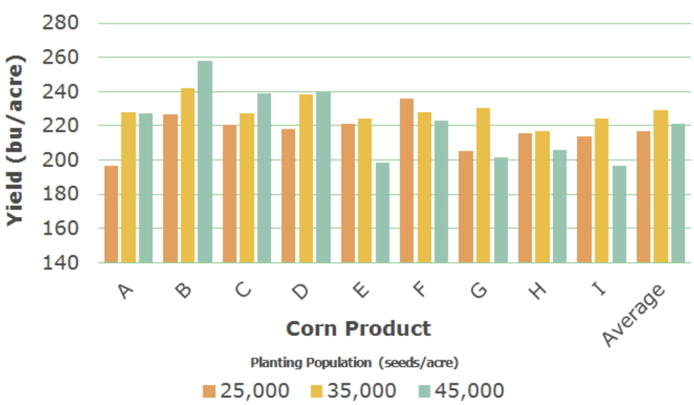

Figure 1. Response of nine corn products to increasing seeding rates: 25,000; 35,000; and 45,000 seeds/acre.

Ear Plasticity

Ear plasticity is the ability of flex, semi-flex, and limited-flex corn products to manage kernel development under a variety of conditions. Corn products with a greater degree of ear plasticity are able to increase ear size in response to lower plant densities. Determinate or 'fixed' ear type corn products typically have greater yields at high plant densities. Contrasting yield components can be observed when flex and 'fixed' ear types are evaluated. For instance, the 'flex' ear corn product can have a greater number of kernels per area, while the 'fixed' ear corn product can have heavier individual kernels under the similar conditions.[5]

Figure 2. Kernel development can be managed with corn products that have a greater degree of ear plasticity.

Summary

Plant components, characteristics, and metabolism have improved and yield potential has advanced in corn products. These achievements are attributed to genetic improvement from natural plant selection as well as changes in management practices. Genetic improvements to N uptake and use efficiency has been key to greater corn populations and fewer barren plants.

Sources

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