COLORADO STATE UNIVERSITY
EXTENSION

Optimizing Corn Plant Population for Maximum Benefits: Things to Consider

Fact Sheet 0.312 | Crop Series | Production

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Why the optimum plant population is important?

Per acre seed cost has tripled over the last 20 years, making seed cost a major input in corn production. Optimizing the plant population is a wise management decision to maximize the net return from corn production.

Similar to other grain crops, corn grain yield per acre is the function of the number of plants per acre and grain yield produced by each plant. Although grain yield per plant declines with increased population, the overall grain yield per acre goes up with increasing plant population if adequate soil moisture is available until it reaches a yield plateau. Unlike other members of the grass family such as wheat or barley, corn does not produce yield-producing tillers thus cannot compensate for a poor stand. Therefore, a suitable established plant population is necessary to obtain maximum yield and profitability.

Corn yield has been continuously increasing in the last three decades (Fig. 1), partly due to the higher population used by growers. While adequate plant population is needed to maximize yield, exceeding the optimum population results in declining yield due to competition of plants for limited resources such as sunlight, nutrients, and water while increasing the cost of production.

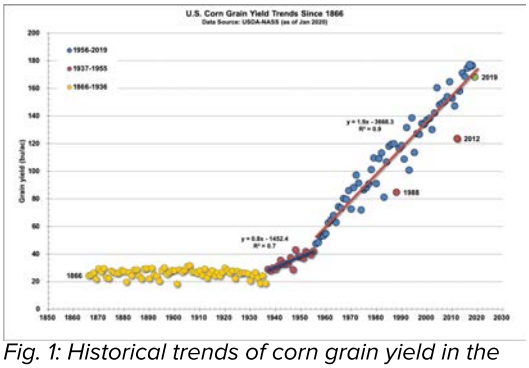

Fig. 1: Historical trends of corn grain yield in the U.S. since 1866. Graph is used with permission. Source: https://www.agry.purdue.edu/ext/corn/news/timeless/YieldTrends.html

Corn yield response to plant population

Corn yield usually demonstrates a quadratic response to plant population, which means that yield increases with a greater plant population and reaches its maximum level at a certain population. Population beyond this level oftentimes results in a yield reduction. Therefore, increasing plant population does not necessarily result in production of higher grain yield. Research studies have shown that compared to the older hybrids the modern hybrids should be seeded in higher densities to attain maximum yields (Fig.2). Modern hybrids are capable of tolerating higher populations due to better drought tolerance, enhanced stalk and root strength specifically in late season, decreased sensitivity to crowding stress, and greater disease/insect resistance.

Quick Facts

- Optimum plant population is necessary to maximize net return from corn production.
- Corn yield increases with a greater plant population and reaches its maximum level at a certain population. Population beyond this level oftentimes results in a yield reduction.
- Optimum plant population in each field depends on realistic yield potential and yield goals.
- Optimum economic population is different than optimum agronomic population and is usually several thousand fewer plants per acre. Farmers should focus on the optimum economic population rather than agronomic population to maximize the net benefit.

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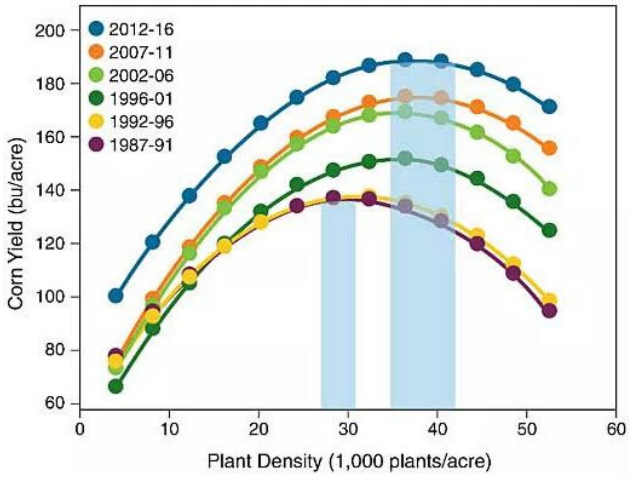

Fig. 2: Optimum agronomic plant population improvement in the last three decades averaged over all Pioneer® brand hybrids. Graph is used with permission. Source: https://www.pioneer.com/us/agronomy/corn-optimum-plant-density-trends.html

How to determine Optimum plant population

Optimum plant population is not a fixed number and can be affected by many factors. A better understanding of these factors helps to determine a meaningful population to achieve maximum yield. Major factors affecting optimum plant populations follow:

Productivity level:
Realistic yield goals are one of the major factors affecting corn optimum plant population. Optimum plant population in a low-yielding environment (i.e. 100 bu/ac) is considerably lower than the optimum population in a high-yielding environment (i.e. 300 bu/ac).

Optimum population should be determined based on realistic situation of the field in terms of productivity level. Realistic expected yield, thus the optimum plant population for a given farm is determined by the soil and environment conditions and also the level of management. As a general rule of thumb, the higher yield expectation, the higher plant population required. A research study in Illinois revealed that for every expected grain yield increase of 10 bu/ac, the optimum plant population should increase by about 800 plants per acre. However, some research concluded that the optimum plant population does not vary largely in environments with medium productivity. Based on over 95 field trials conducted in the Midwest, the average optimum plant population remained relatively unchanged for a wide range (150 -250 bu/ac) of grain yield levels (Nielsen et al., 2019).

Hybrid selection:
Modern hybrids have greater genetic potential and stress tolerance compared to the older hybrids. As shown in Fig. 2, higher plant populations are needed to fully capture the benefits of the improved genetic potential of modern hybrids.

Relative maturity of hybrids also affects the optimum plant population. Shorter-season hybrids (i.e. 85-90 days RM) usually require a 10-15% higher plant population than those suggested for full-season hybrids (≥112 RM). Hybrids differ in canopy architecture, leaf position, and ear type as well. Hybrids with upright leaves are more suitable for higher population planting because upright leaves facilitate vertical distribution of sunlight within the canopy. A flex-ear type will also allow the corn ear to increase in size under low plant density while fixed-ear type hybrids do not change the ear size much so they should be planted at a higher population.

Soil moisture availability:
Corn yield is greatly influenced by soil moisture availability thus higher yields can be expected when soil moisture is not limited. When adequate soil moisture is available to plants, either via irrigation or timely rainfall, grain yield generally benefits from an increase in plant population. Therefore, optimum plant populations are higher in irrigated conditions compared to dryland conditions in Colorado.

Planting date:
Some growers may think higher plant population may compensate for the delay in planting. However, long-term studies conducted in the Midwest has shown there is a weak relationship between planting date and optimum plant population. In other words, the optimum plant population does not change significantly between early and late planting dates. Research conducted in Indiana (Nielsen et al., 2019),

Ohio (Lindsey et al., 2015), Illinois (Nafziger, 1994), and Minnesota (Van Roekel & Coulter, 2011) concluded there was little reason to increase seeding rates if planting is delayed.

Optimum economic populations vs. optimum agronomic populations

Optimum agronomic population refers to the population that produces the highest grain yield. No yield benefit should be expected beyond this population. Optimum economic population, however, is the population that generates the highest net economic return. While optimum agronomic population depends only on yield, optimum economic population also considers the seed cost and grain price. Therefore, the economic optimum population is always lower than the optimum agronomic populations (usually several thousand fewer plants per acre). Farmers should focus on the optimum economic population rather than agronomic population to maximize the net benefit.

Example:
considering $240 for a bag of corn seed with 80,000 kernels and $3.50 per bushel for grain corn, every 1000 seed more planted per acre would be advisable only if it increases yield by >0.85 bushels per acre. In this case, if the farmer wants to increase the seeding rate from 34,000 to 38,000 kernels per acre, he must obtain at least 3.4 bushels per acre more grain yield to offset the extra seed cost. If this yield increase is not met by increasing plant population, then 38,000 plants per acre might be the optimum agronomic population whereas 34,000 plants per acre is the economic optimum population.

Seeding rate

Once the desired plant population is determined, it is necessary to choose a proper seeding rate that results in that population at harvest. Although closely correlated, plant populations and seeding rates are rarely identical in the field. Stand establishment success usually ranges from 85% to 90% of planted seeds. The mortality rate could be even higher in less favorable conditions (such as no-till fields with heavy residue). Growers

Example:
If the target plant population is 35,000 plants per acre and the establishment success rate is 95%, then the seeding rate to achieve this population would be 35000÷0.95= 36842 seeds per acre. If the success rate is 90% then the seeding rate would be 38888 seeds per acre.

It is important to test the planter accuracy during planting or evaluate crop stand after establishment. Table 1 provides a guide for this purpose:

Table 1: Chart for corn population by row width and between seed spacing

Average plant or seed space (inches)	Row spacing (inches)			
	15"	20"	30"	36"
5	83635	62726	41818	34848
5.5	76032	57024	38016	31680
6	69696	52272	34848	29040
6.5	64335	48251	32167	26806
7	59739	44805	29870	24891
7.5	55757	41818	27878	23232
8	52272	39204	26136	21780
8.5	49197	36898	24599	20499
9	46464	34848	23232	19360
9.5	44019	33014	22009	18341
10	41818	31363	20909	17424

An example of how to use this table: if the average space between seeds after planting is 5.5 inches, the seeding rate on 30-inch row spacing would be 38,016 seeds per acre.

Variable-rate seeding technology

Not all fields, or even portions of a field, have the same economic optimum plant population because of soil variability (topography, soil fertility and productivity, drainage, slope, texture, past erosion, input-related factors, among others) between fields and within a field. Variable-rate seeding technologies allow for more targeted seeding rates within a single field by allowing producers to change seeding rates in a single field on the go. This system relies on delineating management zones in a field based on historic productivity and crop performance (i.e. low, medium, and high productivity). This is usually

achieved by overlaying standardized yield data from previous crop seasons, with more cropping seasons being best. The use of calibrated yield monitors is very helpful for this purpose and helps better understand within-field variability. Other tools such as remote sensing (aerial and satellite images), ground-based sensors (soil electrical conductivity and canopy reflectance-based data), and grid soil sampling can also be used to define management zones. After the management zones are determined, pre-scribed maps can be created then executed by a variable rate capable planter. The major goal of variable-rate seeding technologies is to save seeds in less-productive zones and plant more seeds in those that are more productive to reduce overall seeding cost and increase net benefit.

Plant population for corn silage

Generally, the optimum plant population of silage corn is 10% higher than that of grain corn.

Further read

Lindsey, A. J., P. R. Thomison, R. Mullen, and Geyer, A. B., 2015. Corn Response to Planting Date as Affected by Plant Population and Hybrid in Continuous Corn Cropping Systems. Crop, Forage & Turfgrass Management 1:2014-0073. doi:10.2134/cftm2014.0073

Nafziger, E. D., 1994. Corn Planting Date and Plant Population. J. Prod. Agric. 7:59-62. doi:10.2134/jpa1994.0059

Nielsen, R.L., Camberato, J., Lee, J., 2019. Yield Response of Corn to Plant Population in Indiana. Agronomy Dept, Purdue Univ. http://www.kingcorn.org/news/timeless/CornPopulations.pdf [URL accessed May 2019]

Van Roekel, R. J., and Coulter, J. A., 2011. Agronomic Responses of Corn to Planting Date and Plant Density. Agron. J. 103:1414-1422. doi:10.2134/agronj2011.0071