High-Yield Production Practices for Corn
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Summary

• Improved hybrids and production practices are helping corn growers consistently increase yields. Since 2002, average US corn yields have increased by almost 3 bu/acre per year.

• Winning yields in the NCGA national corn yield contest have increased even more1. Many agronomic practices used by contest winners can be applied to all production fields.

• Selecting the right hybrid can affect yield by over 30 bu/acre, making this decision among the most critical of all controllable factors.

• Rotating crops is an important practice to help keep yields consistently high. Rotation can break damaging insect and disease cycles that lower crop yields.

• Maintaining adequate nitrogen fertility levels throughout key corn development stages is critical to achieving highest yields. Split applications can help reduce losses by supplying nitrogen when plant uptake is high.

• Foliar fungicide use has been an important component of high-yield corn production in recent years. Keeping fields free of stresses caused by leaf diseases and stalk rots is important to achieving top corn yields.

• Use of insecticide seed treatments and high plant populations can contribute to improved stand establishment important to high yields.

Introduction

In the 1990’s the average corn grain yield for the US increased by about 2 bu/acre each year. In more recent years, yields have increased by over 3 bu/acre per year due genetic and agronomic improvements (Figure 1). Plant breeders have not only improved hybrid yield potential, but have added transgenic insect resistance traits and improved tolerance to drought, high plant density and early season stress. Agronomic improvements include use of:

− seed treatments that include insecticides,
− glyphosate-resistant crops with glyphosate and other herbicides
− higher plant populations, and
− foliar fungicides.

Improved hybrids and superior production practices have also led to higher yields among winners (1st, 2nd and 3rd place) of the National Corn Growers Association (NCGA) national corn yield contest1. Non-irrigated yields have increased by almost five bu/acre per year and irrigated yields by over six bu/acre per year since 2002 (Figure 1). Since 2005, the average yield of the winners of the irrigated classes has exceeded 300 bu/acre (Figure 1).

Figure 1. Average corn grain yield in the US compared to average of winners (1st, 2nd and 3rd place) of the NCGA national corn yield contest, 2002 - 2009.

It is interesting to note that the average yields of NCGA winners are nearly double the average US yields (Figure 1). This gap between genetic potential and average performance can be attributed to favorable weather, high productivity of contest fields, and high-yield management practices of contest winners. This Crop Insights will summarize basic management practices employed by national contest winners from 2005 to 20091, and discuss how these practices can contribute to higher yields for all corn growers.

Hybrid Selection

Hybrids tested against each other in a single environment (e.g., a university or seed company test plot) routinely vary in yield by at least 30 bu/acre. At contest yield levels, hybrid differences may be even higher. That is why selecting the
right hybrid is probably the most important decision contest winners can make.

The yield potential of many hybrids now exceeds 300 bu/acre. But realizing that yield potential requires matching hybrid characteristics with field attributes such as moisture supplying capacity, insect and disease spectrum, maturity zone, residue cover and even seedbed temperature. To achieve highest possible yields, growers should select a hybrid with:

- Top-end yield potential. Examine yield data from multiple, diverse environments to identify hybrids with highest yield potential.
- Full maturity for the field. Using all of the available growing season is a good strategy for maximizing yield.
- Good emergence under stress. This helps ensure full stands and allows earlier planting, which moves pollination earlier to minimize stress during this critical period.
- Above-average drought tolerance (not needed under full irrigation.) This will provide insurance against periods of drought that most fields experience.
- Resistance to local diseases. Leaf, stalk and ear diseases disrupt normal plant function, divert plant energy, and reduce standability and yield.
- Traits that provide resistance to major insects such as corn borer, corn rootworm, black cutworm and western bean cutworm. Insect pests reduce yield by decreasing stands, disrupting plant functions, allowing diseases, feeding on kernels, and increasing lodging and dropped ears.

Pioneer hybrids with Herculex® I and Herculex XTRA Insect Protection traits offer proven in-plant protection against damaging corn pests.

- Good standability to reduce harvest losses.

The brand of seed corn used by contest winners is shown in Figure 2. As the graph indicates, over 75% of contest winners from 2005 to 2009 chose Pioneer® brand hybrids. In fact, contest results from the last decade show a similar percentage of Pioneer wins. Your Pioneer sales professional can help you select the top hybrids for your area with specific insect-resistant traits and other characteristics best suited for each individual field.

**Crop Rotation**

Rotating crops is one of the practices most often recommended to keep yields consistently high. Rotation can break damaging insect and disease cycles that lower crop yields. Including crops like soybeans or alfalfa in the rotation can reduce the amount of N required in the following corn crop.

The so-called “rotation effect” is a yield increase from crop rotation compared to continuous corn even though all limiting factors appear to have been controlled or adequately supplied in the continuous corn. This yield increase has averaged about 5 to 15 percent in research studies, but has generally been less under high-yield conditions. In a four-year study at the University of Minnesota, the yield increase for corn in rotation over continuous corn was 15% when yields were below 150 bu/acre, but 2.5% when yields were above 200 bu/acre. These results indicate that rotated corn is generally better able to tolerate yield-limiting stresses than continuous corn. Reduction or restriction of the root system by corn rootworm feeding and/or soil compaction in continuous corn could help explain this phenomenon.
Soil Fertility

Achieving highest corn yields requires an excellent soil fertility program, beginning with timely application of nitrogen (N) and soil testing to determine existing levels of phosphorous (P) and potassium (K) and soil pH.

Nitrogen: Corn grain removes approximately one pound of nitrogen per bushel harvested, and stover production requires a half-pound for each bushel of grain produced. This means that the total N needed for a 250 bu/acre corn crop is over 350 lbs/acre. This requirement does not have to be supplied totally by fertilizer nitrogen, however; credits can be taken for previous legume crop, manure application, mineralization of soil organic matter and N in irrigation water. Nitrogen application rates of contest winners are shown in Figure 4.

Figure 4. Nitrogen rates (actual N) used by winners of the NCGA national corn yield contest. 2005 - 2009.

The N application rates of contest winners varied greatly, but most were in the range of 200 to 350 lbs/acre (for yields averaging over 300 bu/acre). The lower rates were often supplemented with N from manure application.

In addition to meeting total N requirements, growers must also be sure that nitrogen is not limiting at any time during the growing season. N uptake by the corn plant peaks during the rapid growth phase of vegetative development between V12 and VT (tasseling). However, the N requirement is high beginning at V6 and extending to the R5 (early dent) stage of grain development.

Timing of N fertilizer applications by contest winners is shown in Figure 5. Contest winners largely avoided fall nitrogen application, most likely because this puts nitrogen at high risk of loss in humid environments. On the other hand, these growers almost universally applied nitrogen pre-plant or at planting. Most contest winners also side-dressed N. Splitting N among two or more sequential applications may be more important with the high rates needed in contest plots and other high-yield environments.

Figure 5. Timing of nitrogen application by winners of the NCGA national corn yield contest. 2005 - 2009.

Phosphorus and Potassium: Assuming soils are maintained at adequate levels, growers should add at least the level of P and K that will be removed by the crop. In addition, these nutrients should be available in the root zone of the developing seedling. Corn grain removes about 0.43 lbs of P₂O₅ and 0.27 lbs of K₂O equivalents per bushel, according to the International Plant Nutrition Institute. That means that a 250 bu/acre corn crop will remove about 108 lbs of P₂O₅ and 68 lbs of K₂O per acre.

Soil pH: The soil pH should be at 6.2 or above for growing corn. Liming raises soil pH over time. If the pH is much lower than 6.2, faster-acting limes are available to speed soil pH changes. High pH soils can reduce the availability of major nutrients as well as micronutrients. Banding P and K can improve uptake of these nutrients, particularly on soils with pH above 7.2.

Starter, Trace Element and Manure use by contest winners is shown in Figure 6.

Figure 6. Use of starter, trace elements and manure by NCGA national corn yield contest winners. 2005 - 2009.
On average, starter fertilizer was applied by half of contest winners to ensure that seedling plants had sufficient soil nutrients in the root zone for optimum early growth and development. The response to starter fertilizer has varied in research studies, and has been higher in environments with cool soil temperatures in the spring. Thus, starter may be especially important in contest plots because of the early planting practices generally employed.

Trace elements (micronutrients) were applied by nearly half of contest winners. Although these nutrients may be sufficient in most contest fields, supplying additional micronutrients, usually through foliar application, helps ensure that these essential plant nutrients are adequately supplied. The nutrients most commonly applied included zinc, boron and sulfur. Corn has high zinc requirements compared to other crops, so zinc is generally included in micronutrient formulations for corn.

About one-third of contest winners applied manure to their fields. Manure can supply significant quantities of N, P and K to the crop in a steady, slow-release form. Manure is also a good source of micronutrients. Over the long term, manure application can improve soil structure, nutrient-supplying ability and water-holding capacity by increasing soil organic matter.

**Row Width**

Contest winners overwhelmingly chose 30-inch rows for their contest plots, with a small number of winners using 20-inch rows each year, and some using twin rows on 30-inch centers (Figure 7).

**Planting Date**

Winning contest plots are usually planted as early as practical for their geography (Figure 8). Early planting lengthens the growing season, and more importantly, moves pollination earlier. When silking, pollination and early ear fill are accomplished in June or early July, heat and moisture stress effects can be reduced.

*As expected, planting dates varied significantly by region, with the late March and early April planting dates occurring in more southern states. Most planting dates later than the third week in April are due to weather delays, such as in 2008.

When planting early, stand establishment is a primary concern. Seedling diseases have increased in recent years due to earlier planting and higher levels of corn residue left on the soil surface. For this reason, Pioneer provides a stress emergence score as well as a premium seed treatment on all Pioneer brand hybrids. This seed treatment combines Dynasty® and Maxim® XL fungicides and an insecticide with a seed treatment polymer that improves plantability and reduces dust-off.

**Planting Rate**

Genetic improvement of corn hybrids for superior stress tolerance has contributed to increased yields by allowing hybrids to be planted at higher plant populations.

High plant density corn research plot.
Although higher population increases inter-plant competition and may lower individual plant yield, it has increased yield per unit area by optimizing yield components – ears per acre, kernels per ear and weight per kernel. Plant populations used by contest winners are shown in Figure 9.

Most winners planted between 36,000 and 40,000 plants/acre in the irrigated classes and between 30,000 and 35,000 plants/acre in the non-irrigated classes. To achieve desired stands, rates may need to be increased with early dates, heavy soils and high-residue seedbeds.

**Foliar Fungicide Use**

Foliar fungicide use has been an important component of most contest winning programs in recent years (Figure 10). Keeping contest plots free of stresses caused by leaf diseases and stalk rots is important to achieving maximum corn yield. Diseases like gray leaf spot, northern and southern leaf blight, and common and southern rust can quickly reduce a crop’s green leaf area, photosynthetic capacity and grain yield. In addition, reduced photosynthesis can cause depletion of stalk carbohydrates during ear fill, resulting in higher risk of stalk rots and lodging.

A 2008 Pioneer summary showed that in 430 Pioneer on-farm and university studies conducted from 1999 to 2008, a positive yield response to fungicide application occurred 80 percent of the time, with an average yield response of 7.4 bu/acre (Jeschke, 2008). For this reason, more and more growers are treating their corn acres with a foliar fungicide.

Read and follow all label instructions carefully when using fungicides. Pre-tassel applications of fungicides with non-ionic surfactants have been shown to cause malformed ears and reduced yields in some cases.

**Weed Control**

In 2008 and 2009, over 80% of winners used hybrids with the Roundup Ready® Corn 2 gene in their contest plots. Though glyphosate was included in over half of herbicide programs, it was never used alone. In fact, 75% of winners used three or more active ingredients in their herbicide program. This helped growers control weeds early, widen the window of control, and manage resistant weeds or prevent further resistance development with multiple modes of action.

Regardless of the herbicide program used, excellent weed control beginning before weeds compete with the corn crop for water, light and nutrients is essential to highest corn yields. Studies show that the “critical period” for preventing weed interference in corn to avoid yield reduction is from the V2 to V3 corn growth stage until V12 (approximately 3 weeks through 8 weeks after planting). A preemergence followed by postemergence herbicide program is likely to be the most reliable and effective under a wide range of growing environments.
Harvest Practices

Good harvest practices including timely harvest with a well-adjusted combine prevent yield from being left in the field. Early harvest is important to minimize field losses in contest plots. Machine losses can be reduced with proper combine settings, including correct concave clearance, cylinder (or rotor) speed, and separator adjustments. Closely follow your operator’s manual for initial machine settings, then check losses and re-adjust if necessary for crop and harvest conditions. Studies show that losses as low as 2 to 3 bushels per acre are possible with timely harvest and good machine adjustment and operation.

Experts recommend harvesting plots at 24 to 28% moisture to minimize losses. This includes pre-harvest losses caused by broken stalks or dropped ears, gathering losses at the corn head, and cylinder and separating losses (kernels attached to pieces of cob or loose kernels lost out the back of the combine). Although reducing harvest losses must be balanced with drying costs in non-contest fields, this is not a critical factor in contest plots.

Deep Tillage

Deep tillage was performed by about one-fourth of contest winners from 2007 to 2009. (In the national contest, deep tillage is allowed even in the no-till/strip till and ridge-till classes as long as it occurs prior to harvest of the crop grown previous to the contest plot. In these tillage classes, the soil must be left undisturbed from harvest to planting). Deep tillage implements included rippers, chisel plows, and sub-soilers. When fields are adequately dry, deep tillage can alleviate deep compaction and break up clayspans and hardpans that restrict corn root growth. Deep roots are especially important as soil moisture is depleted during mid to late summer.

Other Practices

In the last 3 contest years, the vast majority of winners used insecticide seed treatments. Some used other practices such as multiple deep tillage trips, planter calibration, soil and plant-applied insecticides, and “non-traditional” products such as root enhancers, growth regulators and growth promoters. Any practice or product is fair game in a yield contest. However, it may be difficult to evaluate the effect of individual treatments when several are applied to a single plot. This complicates identifying useful products for the future, even if improved yields are obtained in the plot.

Conclusions

Corn yields are highly dependent on moisture availability during critical growth stages. The effect of favorable growing conditions on winning corn contest plots is highlighted by the distribution of non-irrigated national winners by state and year (Table 1). As the table demonstrates, winners are often disproportionately grouped by state in a given year.

Table 1. Number of national winners of NCGA corn yield contest non-irrigated classes from several states.

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In spite of the obvious contribution of favorable weather in determining winners of the non-irrigated classes, much remains in the control of the corn grower. Hybrid selection, crop rotation, nitrogen fertility, plant population, planting date, and foliar fungicide use when needed, are critical factors in achieving highest corn yields. Perfecting these controllable factors is still the key to competing successfully in the NCGA national corn yield contest, as well as producing top yields on all production acres.

References


https://www.pioneer.com/growingpoint/agronomy/library_corn/fungicides/foliar_fungicide_effects.jsp

The author gratefully acknowledges the National Corn Growers Association for providing data for this article.

NCGA 2009 Winner’s Corn Yield Guide

1 Crop production practices for first-, second- and third-place winners of the NCGA national corn yield contest in 9 classes in 2005 to 2007, and 8 classes in 2008 to 2009 are summarized in this article. See 2010 National Corn Yield Contest Entry Form for description of classes.

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