CROP INSIGHTS

Managing Corn for Greater Yield

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Summary

- Improved hybrids and production practices are helping corn growers increase yields. Over the past 20 years, U.S. corn yields have increased by an average of 1.8 bu/acre per year.
- Winning non-irrigated yields in the NCGA national corn yield contest have increased at more than twice the U.S. average rate in the last 10 years.
- 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 reduce crop yields.
- Maintaining adequate nitrogen fertility levels throughout key corn development stages is critical in achieving highest yields. Split applications can help reduce losses by supplying nitrogen when plant uptake is high.

Introduction

Improvements in corn productivity that began with the introduction of hybrid corn nearly a century ago have continued through the present day. Over the last 20 years, U.S. corn yield has increased by an average of 1.8 bu/acre per year. These gains have resulted from breeding for increased yield potential, introduction of transgenic traits to help protect yield and agronomic management that has allowed yield potential to be more fully realized.

As growers strive for greater corn yields, the National Corn Growers Association (NCGA) National Corn Yield Contest provides a benchmark for yields that are attainable when environmental conditions and agronomic management are optimized. The average yields of NCGA winners are about double the average U.S. yields. This difference can be attributed to favorable environmental conditions, highly productive contest fields and high-yield management practices used by contest winners.

NCGA National Corn Yield Contest

The NCGA National Corn Yield Contest achieved some notable milestones during the past two seasons. A new all-time corn yield record was set in 2013 and again in 2014. Five entries exceeded 400 bu/acre in the 2013 contest, and seven in 2014.

The average yields of national winners also reached record highs in both the irrigated and non-irrigated classes. The average yield among irrigated winners topped 400 bu/acre for the first time, while the average yield among non-irrigated winners exceeded 300 bu/acre for the first time (Figure 1). In 2013, yields above 300 bu/acre were achieved in a total of 70 entries across all classes, which were located in 23 different states. In 2014, the number of 300 bu/acre entries nearly doubled to 136, located in 31 different states (Figure 2). This *Crop Insights* summarizes basic management practices employed in 2013 and 2014 NCGA National Corn Yield Contest entries that exceeded 300 bu/acre and discusses how these practices can contribute to higher yields for all corn growers.

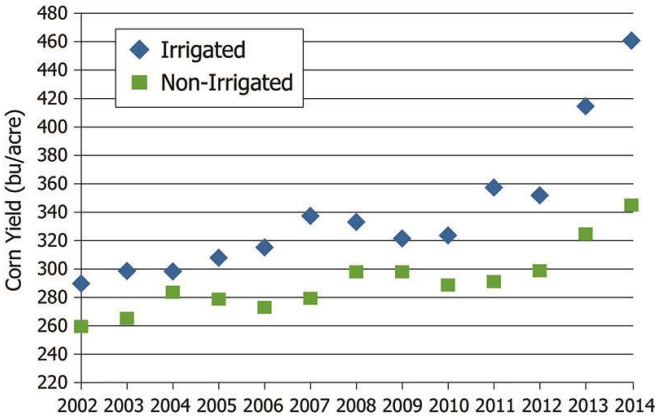

Figure 1. Average corn grain yield of NCGA National Corn Yield Contest national winners in irrigated and non-irrigated classes, 2002 to 2014.

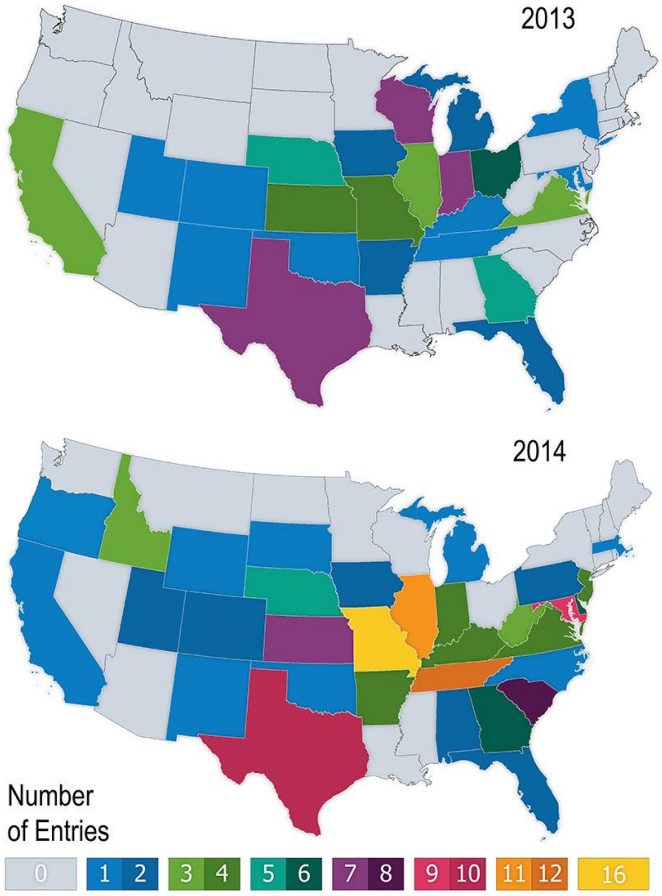

Figure 2. Locations of NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

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 can be even higher. That is why selecting the right hybrid is likely the most important management decision of all those made by contest winners.

Table 1. 2014 NCGA National Corn Yield Contest winners with yields over 400 bu/acre using Pioneer® brand products.

Entrant Name	State	Hybrid/Brand[1]	Yield (bu/acre)
David Hula	VA	**P1794VYHR** (AVBL, YGCB, HX1, LL, RR2)	**476.22**
Steven Albracht	TX	**P1883AM™** (AM, LL, RR2)	**459.45**
Dowdy Farms II	GA	**P1303HR** (HX1, LL, RR2)	**457.88**
Dowdy Farms VIII	GA	**P1739HR** (HX1, LL, RR2)	**444.15**

The yield potential of many hybrids now exceeds 300 bu/acre. Realizing that yield potential requires matching hybrid characteristics with field attributes such as moisture supplying capacity, insect and disease spectrum and intensity, 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. This will provide insurance against periods of drought that most non-irrigated 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, feeding on kernels and increasing lodging and dropped ears.
- Good standability to minimize harvest losses.

The brand of seed corn used in the highest yielding contest entries in 2013 and 2014 is shown in Figure 3. Pioneer brand products were used in the majority of entries exceeding 300 bu/acre.

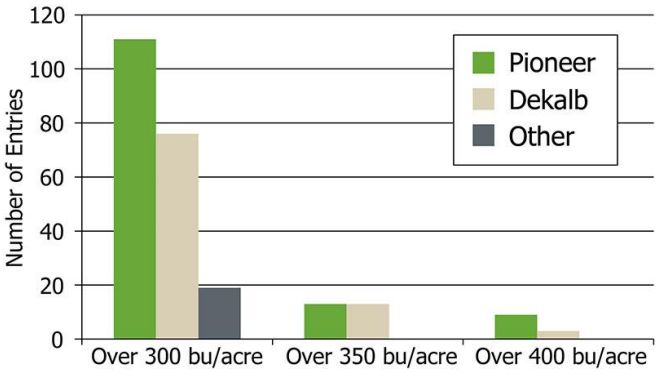

Figure 3. Seed brand planted in NCGA National Corn Yield Contest entries exceeding 300, 350 and 400 bu/acre in 2013 and 2014.

Nearly all entries above 300 bu/acre in 2013 and 2014 used a hybrid with transgenic herbicide resistance. Most included one or more Bt traits for resistance to above-ground insect pests and around half included at least one Bt trait for corn rootworm resistance (Table 2). 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.

Table 2. Transgenic traits in hybrids used in 2013 and 2014 NCGA contest entries exceeding 300 bu/acre.

Traits	2013	2014
	— % of entries —	
Herbicide resistance	100	99
Insect resistance (above ground)	93	97
Insect resistance (rootworm)	53	45

Planting Practices

Plant Population

Improvement of corn hybrid genetics for superior stress tolerance has contributed to increased yields by allowing hybrids to be planted at higher plant populations. Harvest populations in irrigated and non-irrigated national corn yield contest entries over 300 bu/acre are shown in Figure 4. Harvest populations ranged from under 30,000 to over 50,000 plants/acre, but over 85% of plots were between 32,000 and 40,000 plants/acre. The average harvest population of irrigated entries was slightly greater than that of non-irrigated entries in both years.

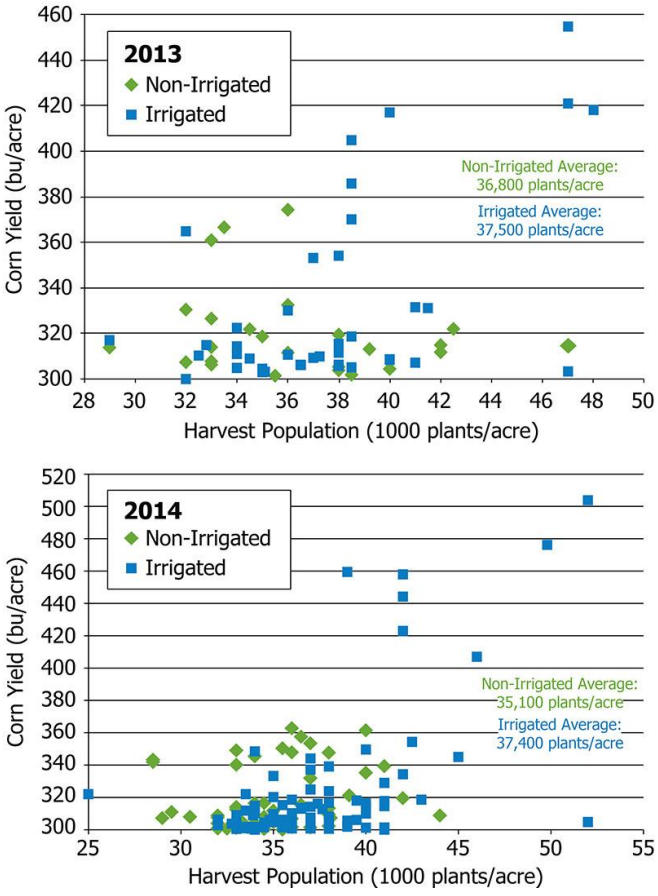

Figure 4. Harvest populations and corn yield of irrigated and non-irrigated NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 (top) and 2014 (above).

Row Width

The vast majority of corn acres in the U.S. are currently planted in 30-inch rows, accounting for over 85% of corn production. A majority of 300 bu/acre contest entries were planted in 30-inch rows (77%) (Figure 5). Narrower row configurations (15-inch, 20-inch, or 30-inch twin) were used in 14% of entries, and wider single or twin row configurations were used in 9% of entries.

Row spacings narrower than the current standard of 30 inches have been a source of continuing interest as a way to achieve greater yields, particularly with continually increasing seeding rates. However, research has not shown a consistent yield benefit to narrower rows outside of the Northern Corn Belt (Jeschke, 2013). Results from the National Corn Yield Contest demonstrate that high yields can be attained in a variety of different row configurations.

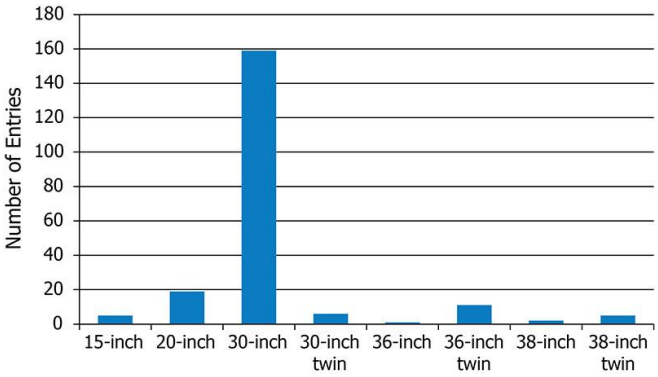

Figure 5. Row width used in NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

Planting Date

Winning contest plots are usually planted as early as practical for their geography. 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.

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, DuPont Pioneer provides a stress emergence score as well as a premium seed treatment on all Pioneer® brand hybrids. This seed treatment, called PPST 250, is an exclusive[2] combination of biological, insect and disease treatment technology and is the standard treatment program for all Pioneer brand corn products. Available exclusively on select new Pioneer brand corn products in 2015 is PPST 250 plus DuPont™ Lumivia™ insecticide seed treatment, which includes a new mode of action featuring novel insecticide technology that provides rapid feeding cessation for immediate protection of seed. Growers also have the option on selected Pioneer brand corn products to choose Poncho® 1250 + VOTiVO® treatment where nematode or enhanced insect protection are needed.

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. A majority of 300 bu/acre entries in 2013 and 2014 (65%) were planted to a crop other than corn the previous growing season (Figure 6).

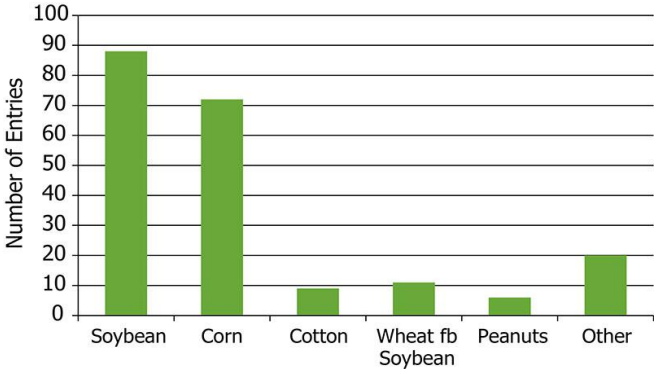

Figure 6. Previous crop in NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

The so-called "rotation effect" is a yield increase associated with crop rotation compared to continuous corn even when 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 (Butzen, 2012). Rotated corn is generally better able to tolerate yield-limiting stresses than continuous corn; however, yield contest results clearly show that high yields can be achieved in continuous corn production.

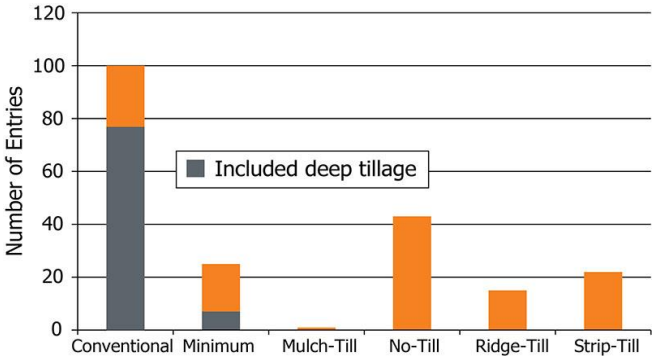

Figure 7. Tillage practices in NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

Tillage

Three of the six classes in the NCGA National Corn Yield Contest specify no-till or strip till practices; however, over 60% of the contest entries over 300 bu/acre employed conventional, minimum, or mulch tillage (Figure 7). Of these entries, most included some form of deep tillage. Deep tillage implements included rippers, chisel plows and sub-soilers. When fields are adequately dry, deep tillage can alleviate deep compaction and break up claypans and hardpans that restrict corn root growth. Deep roots are especially important as soil moisture is depleted during mid to late summer.

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), 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 300 bu/acre corn crop is around 450 lbs/acre. Only a portion of this amount needs to be supplied by N fertilizer; N is also supplied by the soil through mineralization of soil organic matter. On highly productive soils, N mineralization will often supply the majority of N needed by the crop. Credits can be taken for previous legume crop, manure application and N in irrigation water. Nitrogen application rates of contest winners are shown in Figure 8.

The N application rates of 300 bu/acre entries varied greatly, but a majority were in the range of 250 to 350 lbs/acre (Figure 8). Some entries with lower N rates were supplemented with N from manure application. As corn yield increases, more N is removed from the soil; however, N application rates do not necessarily need to increase to support high yields. Climatic conditions that favor high yield will also tend to increase the amount of N a corn crop is able to obtain from the soil through increased mineralization of organic N and improved corn root growth.

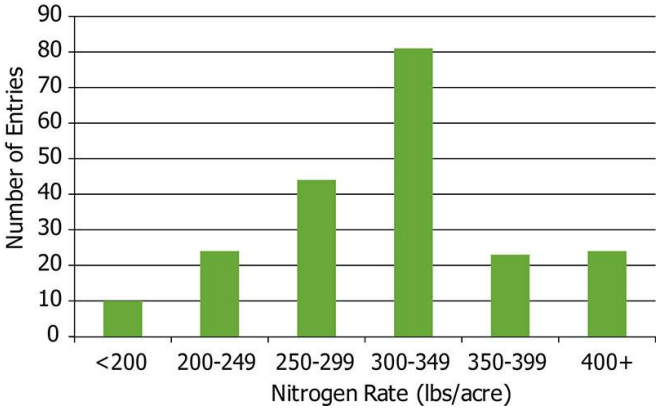

Figure 8. Nitrogen rates (total lbs/acre N applied) of NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014. (Note that N rates above 300 lb/acre are usually appropriate only for contest plots and high-yielding irrigated fields.)

Timing of N fertilizer applications can be just as important as application rate. The less time there is between N application and crop uptake, the less likely N loss from the soil will occur and limit crop yield. Nitrogen 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 in 300 bu/acre entries is shown in Figure 9. Very few included fall-applied N. Many applied N before or at planting. Over 80% of 300 bu/acre entries included some form of in-season nitrogen application, either sidedressed or applied with irrigation. Nearly all (96%) applied N at multiple timings.

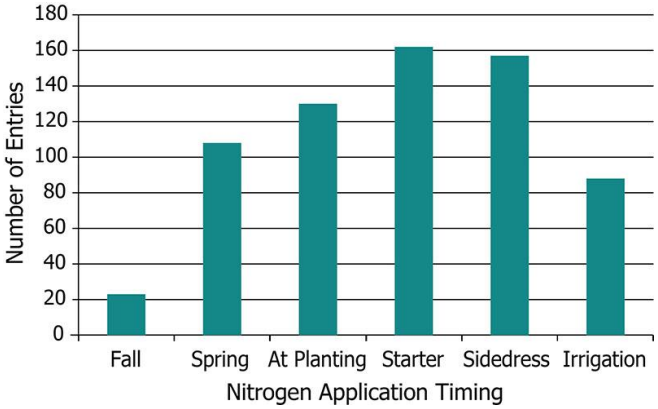

Figure 9. Nitrogen fertilizer application timing of NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

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 P_2O_5 and 0.27 lbs of K_20 equivalents per bushel according to the International Plant Nutrition Institute. That means that a 300 bu/acre corn crop will remove about 129 lbs of P_2O_5 and 81 lbs of K_20 per acre.

Micronutrients

Micronutrients were applied on nearly half of the 300 bu/acre entries (Figure 10). The nutrients most commonly applied were sulfur and zinc, with some entries including boron, magnesium, manganese, or copper. Micronutrients are sufficient in most soils to meet crop needs. However, some sandy soils and other low organic matter soils are naturally deficient in micronutrients, and high pH soils may make some micronutrients less available and therefore deficient (Butzen, 2010). Additionally, as yields increase, micronutrient removal increases as well, potentially causing deficiencies.

Sulfur is often ranked immediately behind nitrogen, phosphorus, and potassium in terms of importance to crop productivity. Mineralization is the primary source of plant-available sulfur in non-fertilized soils. Soil organic matter content greatly affects the amount of sulfur available to the crop. Sulfur fertility historically has not been a major concern on most soils; however, increased removal due to higher crop yields combined with reduced inputs from atmospheric deposition and other sources have increased the prevalence of sulfur deficiencies.

Corn has high zinc requirements compared to other crops, so zinc is generally included in micronutrient formulations for corn. Zinc may be deficient in sandy soils, other low organic soils such as those with topsoil removed or soils with high pH. Seedlings may show deficiencies during cool, wet weather.

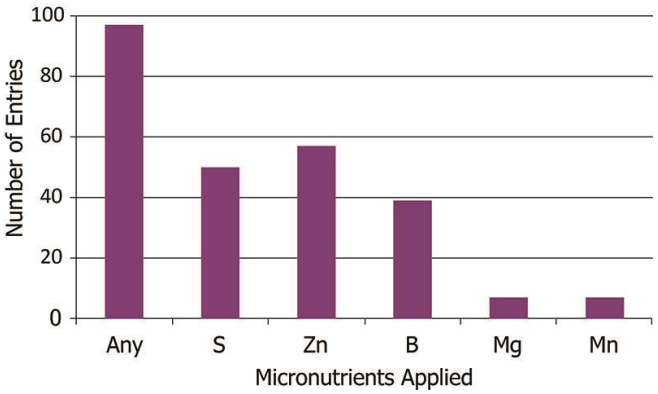

Figure 10. Micronutrients applied in NCGA National Corn Yield Contest entries exceeding 300 bu/acre in 2013 and 2014.

Crop Protection

Insect Management

The most common insect management practice among 300 bu/acre entries was the use of hybrids with traits for insect resistance. Nearly all 300 bu/acre entries included one or more traits for resistance to above-ground insect pests and nearly half included a trait for corn rootworm resistance (Table 2). Some entries also included a soil-applied insecticide or a foliar insecticide application.

Disease Management

Keeping corn free of stresses caused by leaf diseases and stalk rots is important to achieving maximum 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. Many of the 300 bu/acre entries reported using a foliar fungicide, some at more than one timing. Growers that applied more than one fungicide treatment frequently used multiple modes of action.

A 2012 DuPont Pioneer summary showed that in 475 DuPont Pioneer on-farm comparisons conducted from 2007 to 2011, a positive yield response to fungicide application occurred 80 percent of the time, with an average yield response of 7.0 bu/acre for applications between VT and R2 (Jeschke, 2012). Foliar fungicides tended to provide the greatest benefit on hybrids with less genetic disease resistance and when conditions were favorable for disease development.

Weed Management

In 2013 and 2014, nearly all 300 bu/acre entries used hybrids with the Roundup Ready® Corn 2 trait, and many also included the LibertyLink® trait. A glyphosate product was used on many of the entries; however, nearly all had more than one mode of action in their weed management program. Most included both pre- and post-emergence treatments.

Regardless of the herbicide program used, excellent weed control beginning before weeds compete with the corn crop for water, light and nutrients is essential for highest corn yields. Studies show that the "critical period" for preventing yield-reducing weed interference in corn is from the V2 to V3 growth stage until V12 (approximately three weeks through eight 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.

The foregoing is provided for informational use only. Contact your Pioneer sales professional for information and suggestions specific to your operation. Product performance is variable and subject to any number of environmental, disease, and pest pressures. Individual results may vary.

[1]All Pioneer products are hybrids unless designated with AM1, AM, AMRW, AMX, AMT, and AMXT, in which case they are brands.

[2] Seed treatment formulation exclusive to Pioneer and its affiliates.

Sources

Butzen, S. 2010. Micronutrients for Crop Production. Crop Insights Vol. 20, no. 9. DuPont Pioneer, Johnston, IA. Online: https://www.pioneer.com/home/site/us/agronomy/library/template.CONTENT/guid.7C664217-6A2C-4E51-892A-9CD61FEFC449

Butzen, S. 2012. Best Management Practices for Corn-After-Corn Production. Crop Insights Vol. 22, no. 6. DuPont Pioneer, Johnston, IA. Online: https://www.pioneer.com/home/site/us/agronomy/library/template.CONTENT/guid.BE7307F5-66CB-A8D6-A309-B191F8DF435E

Jeschke, M. 2012. Maximizing the Value of Foliar Fungicides in Corn. Crop Insights Vol. 22, no. 3. DuPont Pioneer, Johnston, IA. Online: https://www.pioneer.com/home/site/us/agronomy/library/template.CONTENT/guid.8899F662-572B-84BD-5F5F-96F177FDBA0D

Jeschke, M. 2013. Row Width in Corn Grain Production. Crop Insights Vol. 23, no. 16. DuPont Pioneer, Johnston, IA. Online: https://www.pioneer.com/home/site/us/agronomy/library/row-width-corn-grain-production/

AVBL, YGCB, HX1, LL, RR2 - Optimum® Leptra® contains the Agrisure Viptera® trait, the YieldGard® Corn Borer gene, the Herculex® I gene, the LibertyLink® gene, and the Roundup Ready® Corn 2 trait. **AM** - Optimum® AcreMax® Insect Protection system with YGCB, HX1, LL, RR2. Contains a single-bag integrated refuge solution for above-ground insects. In EPA-designated cotton growing counties, a 20% separate corn borer refuge must be planted with Optimum AcreMax products. **HX1** - Contains the Herculex® I Insect Protection gene which provides protection against European corn borer, southwestern corn borer, black cutworm, fall armyworm, western bean cutworm, lesser corn stalk borer, southern corn stalk borer, and sugarcane borer; and suppresses corn earworm. **LL** - Contains the LibertyLink® gene for resistance to Liberty® herbicide. **RR2** - Contains the Roundup Ready® Corn 2 gene that provides crop safety for over-the-top applications of labeled glyphosate herbicides when applied according to label directions. Herculex® I Insect Protection technology by Dow AgroSciences and Pioneer Hi-Bred. Herculex® and the HX logo are registered trademarks of Dow AgroSciences LLC. YieldGard®, the YieldGard Corn Borer design and Roundup Ready® are registered trademarks used under license from Monsanto Company. Liberty®, LibertyLink® and the Water Droplet Design are registered trademarks of Bayer. Poncho® and VOTiVO® are registered trademarks of Bayer. Agrisure Viptera® is a registered trademark of, and used under license from, a Syngenta Group Company. Agrisure® technology incorporated into these seeds is commercialized under a license from Syngenta Crop Protection AG. The DuPont Oval Logo, DuPont™ and Lumivia™ are trademarks or registered trademarks of DuPont. ®, ™, SM Trademarks and service marks of Pioneer. Pioneer® brand products are provided subject to the terms and conditions of purchase which are part of the labeling and purchase documents.