Agronomy Day Tours

4  Tour A
   1. Evaluating cover crop performance with drones
   2. Concentrating on nutrient loss: A review of tile drainage nutrient concentrations
   3. The science behind the official snack food of Illinois: Popcorn

7  Tour B
   1. Drones: Where we are and where we’re going
   2. On-The-Implement-Intelligent-Soil-Sensing (OTIISS)
   3. Controlling corn and soybean costs

10 Tour C
   1. Managing the evolution of herbicide resistance
   2. Fact or fiction: Do glyphosate-resistant cropping systems reduce crop health?
   3. Genetic resistance to stop losses from soybean cyst nematodes

13 Tour D
   1. Evaluating management strategies for western corn rootworm
   2. And the survey says...
   3. Updates on seedling diseases in Illinois soybeans

16 Tour E
   1. Is there a best way to fertilize corn with nitrogen?
   2. Reaching corn’s top yield potential with hybrid-specific management
   3. Continuous corn: Challenge accepted
   4. Setting yourself up for success in 20” corn rows
Assuring adequate nitrogen (N) availability during key stages of plant growth is a major factor affecting yield and profitability of corn. Nitrogen uptake by modern corn hybrids follows a sigmoidal pattern over time with limited uptake before the V8 growth stage (Figure 22). Between V8 and flowering two-thirds of total plant N uptake occurs, equal to a rate of 7 lbs of N per acre per day for at least 21 continuous days. Side-dressing N to coincide with this period of maximum uptake is a logical approach to assure adequate N availability while limiting its potential for loss. A relatively new technology known as the Y-drop allows for placement of side-dressed N directly next to the crop row, where proximity to roots and stem flow of water helps to assure availability by creating a zone of high N concentration directly in the plant’s rooting zone. Alternatively, controlled release sources such as ESN® (polymer-coated urea), and banding of the fertilizer assure adequate N availability at the right time and right place.

**Choices for N fertilization**

Different combinations of N fertilizer source, timing of application, and placement were evaluated at Yorkville, Champaign, and Harrisburg in 2017. All treatments received a total of 180 lbs of N per acre. Treatments included supplying all N upfront, either broadcasted as urea or ESN or banded as ESN 6” deep directly below the crop row before planting using RTK guidance. Additionally, split applications received 90 lbs of N preplant as broadcasted urea and 90 lbs of N side-dressed at the V8 growth stage. Side-dress applications included broadcasted urea, 28% UAN down the center of the row, or 28% placed next to the row using a Y-drop technique (Figure 23). Soil N availability throughout the season was estimated by comparing fertilized treatments yield results to unfertilized check plots, which indicated whether the growing season created conditions where the best N application timing was all upfront or split-applied.

**What worked best**

When the N availability supplied from the soil was deficient (as indicated by a low check plot yield), more N was needed upfront during the critical growth stages of kernel number and yield potential. However, in environments with high initial soil N availability, split applications increased yield, and the Y-drop method was the best way to side-dress. Supplying only half the N fertilizer in a concentrated band directly in the root zone provided enough N for the corn plant through the side-dress application timing. When broadcasting all the N upfront, ESN resulted in greater yields than urea.

An understanding of environmental and soil conditions is important when choosing N fertilization management practices.
Reaching corn’s top yield potential with hybrid-specific management

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Efficiently obtaining the maximum yield potential of a commercial corn hybrid requires correct placement in the appropriate yield environment and implementing the complementary agronomic management, including nitrogen (N) fertilizer, optimal plant density, and row arrangement (i.e., width). Our goal is to identify hybrids with greater than average yield increases with high-yield crop management (‘Racehorse’), and hybrids with acceptable yields in a low fertility environment and tolerance to nitrogen loss (‘Workhorse’).

Yield responses to management
For 2017, 48 commercial hybrids were grown at Yorkville, Champaign, and Harrisburg, Illinois under three N rates (0, 60, and 280 lbs N/acre), three plant densities (32,000, 38,000 and 44,000 plants/acre), and two-row arrangements (20” and 30”). Exceptional yields were obtained in the unfertilized (check) plots, due to higher than normal release of N from soil organic, which in turn, led to a lesser yield response to N fertilization than seen in previous years. Averaged across all sites, plant density increasing from 32,000 to 38,000 plants/acre contributed to a yield response of +10.4 bu/acre, but relatively little yield improvement (+3.1 bu/acre) was observed by further increasing density to 44,000 plants/acre. On average, narrower rows resulted in the highest yields at the highest plant population. In Champaign, yield responses to narrow rows ranged from a loss of 54.0 bu/acre to a gain of 58.2 bu/acre (Figure 24). Overall, commercial corn hybrids varied greatly in their yield response to the conditions evaluated.

Hybrid characterization
Hybrids were ranked (1-10, with 10 indicating the greatest yield increase) by their yield responses to each parameter and ‘Racehorse’ and ‘Workhorse’ indices were then estimated using a multiple regression approach to characterize hybrids for their responsiveness to intensive crop management and tolerance to low N conditions, respectively. Check plot yield was the most important in determining a hybrid’s ‘Workhorse’ index, and yield responses to high N and row spacing were the most important in determining its ‘Racehorse’ index. Figure 25 depicts two hybrids that should be managed differently. Hybrid A shows tolerance to N stress resulting in a high ‘workhorse’ index, while Hybrid B is a ‘racehorse’ hybrid requiring intensive agronomic management to achieve its top end yield.

Summary
Understanding the agronomic factors that most influence grain yield for different corn hybrids will allow growers to most efficiently produce the greatest yields. Producers can see the characterizations of each hybrid by visiting cropphysiology.cropsci.illinois.edu/research/MYP_current.html

<table>
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<tr>
<th>Check</th>
<th>RTLowN</th>
<th>RTN</th>
<th>IntPop</th>
<th>HighPop</th>
<th>RTS</th>
<th>WHI</th>
<th>RHI</th>
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Figure 25. Scores for yield of unfertilized plots (check), yield response to low N (RTLowN), yield response to high N (RTN), yield response to intermediate population (IntPop), yield response to high plant population (HighPop), and yield response to narrow row spacing (RTS) with the corresponding ‘Workhorse’ (WHI) and ‘Racehorse’ indexes (RHI) for two corn hybrids averaged across all sites. Scores range 1 to 10 with 1 indicating the least yield increase.
Dealing with excessive residue is a problem for many growers no-tilling continuous corn, or dealing with other residue situations such as increased planting populations or crops that produce greater-than-average yields. Accelerating residue degradation and synchronizing the release of nutrients tied up in residue to current crop demand could be utilized to mitigate some of corn following corn’s downfalls. The objective of this study was to test if management could reduce the continuous corn yield penalty (CCYP).

Trial design
At Urbana, IL in 2016-2018, continuous corn was compared to a corn-soybean rotation with the previous year’s corn residue sized with Calmer’s BT Chopper stalk rollers or with standard knife rollers (Figure 26). Residue was chemically managed with Extract Powered by Accomplish (Extract PBA), ammonium sulfate (AMS), or left untreated. Standard (base N and 32,000 plants/acre) and intensive (base N + protected sidedress, broadcast and banded fertilizer, foliar fungicide, and 45,000 plants/acre) input levels were evaluated across two hybrids.

Management responses
Residue decay over the winter was enhanced by 6% when the residue was sized at harvest compared to standard harvest. Seedling emergence was delayed and reduced by 4% in plots with standard residue management compared to sized residue. Chopped residue increased yield in continuous corn by 4 bu/acre and in corn rotated with soybean by 5 bu/acre, regardless of input level. Depending on hybrid, the CCYP was 30 or 38 bu/acre in the 2017 growing season. With a select hybrid, there was a 4 bu/acre increase from fall AMS and a 19 bu/acre response to Extract PBA. When combined with chopped residue, grain yield was enhanced by 27 bu/acre and 9 bu/acre if treated with Extract PBA and AMS, respectively. At the standard input level, mechanically sizing the residue alone (no chemical application) boosted corn grain yield by 7 bu/acre. Across rotation, intensive agronomic management improved grain yield by 23 bu/acre. As grain yield increased, stover biomass increased, resulting in additional residue accumulation on the soil surface (Figure 27).

Key takeaways
Hybrid selection has been shown to influence the magnitude of the CCYP. Hybrids that can tolerate continuous corn situations are probably those that are more competitive for resources, and therefore, the proper hybrid selection in combination with residue and intensive management practices has contributed to a multifaceted approach to alleviate the continuous corn yield penalty.
Setting yourself up for success in 20” corn rows

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Today, the vast majority of corn in the U.S. is planted in 30” row spacings, with narrow rows generally defined as any row spacing or configuration less than 30” row spacings. The most common narrower row spacings include 20” and 15” rows, along with twin rows that are spaced 7.5” apart (22.5” between rows, but are on 30” centers). Narrower row spacings can be used to increase plant-to-plant spacing within a row to reduce crowding at higher plant densities, thereby, allowing the crop to utilize available light, water, and nutrients (Figure 28).

Plant enough plants

In 2017, six commercial DeKalb hybrids were planted at 38,000, 44,000, 50,000, 56,000 plants per acre in a 30” and 20” row spacing at Yorkville and Champaign, IL (Figure 29). The management system that resulted in the highest grain yield of 318 bu per acre was planting 50,000 plants per acre in a 20” row spacing. In a 30” row spacing the highest yield was achieved by planting 44,000 plants per acre. On average across planting densities, plants in a 20” row spacing yielded 13 bu per acre more than when planted in a 30” row spacing, however, as planting density increased the yield advantage of the 20” rows over the 30” row spacing was greater. Planting 56,000 plants per acre at either row spacing was too high of a density and yield decreased without a sufficient amount of resources such as water or nutrients to support that many plants. There is evidence to suggest that there is a limit on how high planting density can be pushed in either a 30” or 20” row spacing without any additional fertilizer, crop protection, or irrigation.

<table>
<thead>
<tr>
<th>Row Spacing</th>
<th>Planting Density (plants/acre)</th>
<th>bushels/acre</th>
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<tbody>
<tr>
<td>30”</td>
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<td>299</td>
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<tr>
<td></td>
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<td>302</td>
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Figure 28: At the same planting density of 44,000 plants per acre, greater plant-to-plant spacing is achieved in the 20” row spacing compared to the 30” row spacing.

Select the right hybrid

Hybrids vary greatly in their response to planting density and narrower row spacings. Hybrids also vary in their plant architecture and leaf trait characteristics. Understanding which hybrids better tolerate higher planting densities and narrower row spacings along with the plant growth and leaf traits that these hybrids possess would help lead the breeding effort for selecting hybrids that will perform even better in these management systems. Hybrids that produced greater yields in response to narrower row spacings and higher planting densities tended to possess the following plant growth and leaf traits: 1) greater above-ground biomass, 2) high leaf area index, 3) upright leaves, 4) thin leaves, and 5) less leafy plants.

Ensure planting density is high enough and select a hybrid that can accommodate higher densities and narrower row spacings.