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Corn management: Understanding yield and the impact of growth variability on yield

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The 'drought of 2012' actually started impacting Iowa crops as early as August of 2011. Ominous-looking, animated maps showed the extent and slow, creeping spread of extremely dry conditions across Iowa and the Corn Belt during the fall of 2011 and the 2011/2012 winter. Spring rains were not sufficient to recharge soil moisture. Corn planting proceeded ahead of normal (Figure 1). Although much of the corn ended up in what some considered 'perfect' seed beds, sidewall compaction and other early-season problems handicapped emergence and early-season growth. Warm temperatures (especially high-night temperatures) resulted in rapid progression through crop growth stages. Dry conditions aggravated the situation. The crop silked well ahead of normal. That trend continued through the reproductive period resulting in an early harvest. As a result of the early harvest we had drier grain and reduced drying costs.

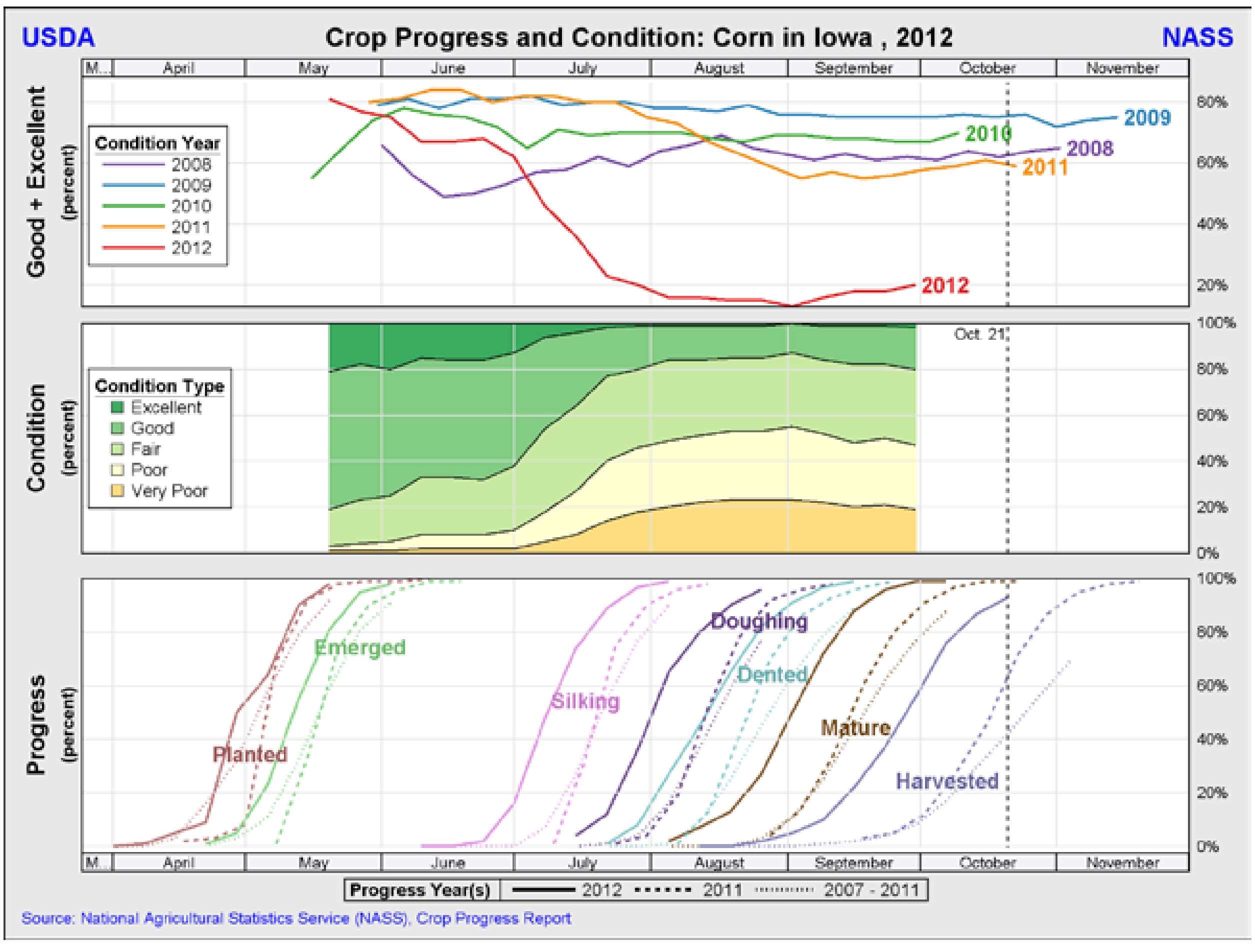

Figure 1. Iowa corn crop progress and condition, 2012. National Agricultural Statistics Service.

Statistics tell the rest of the 2012 corn crop story. Less than 20% of Iowa's corn ranked in the good to excellent category by mid-July (Figure 1). Fall USDA-NASS yield forecasts reflected the season dramatically in part due to poor conditions at silking and the rapid seed fill period the crop experienced. Figure 2 shows both Iowa and U.S. yield trends and current 2012 yield forecasts. Yield forecasts for both Iowa and the U.S. range around 22% below trend line yields. For comparison, yield in 1988, the last major drought, was about 29% below trend line. For more information on the impacts of 2012 conditions on Iowa corn, see the Integrated Crop Management News article listed in the reference section (Al-Kaisi et al, 2012; Elmore, 2012 a,b,c,d,e,f,g,h,i)

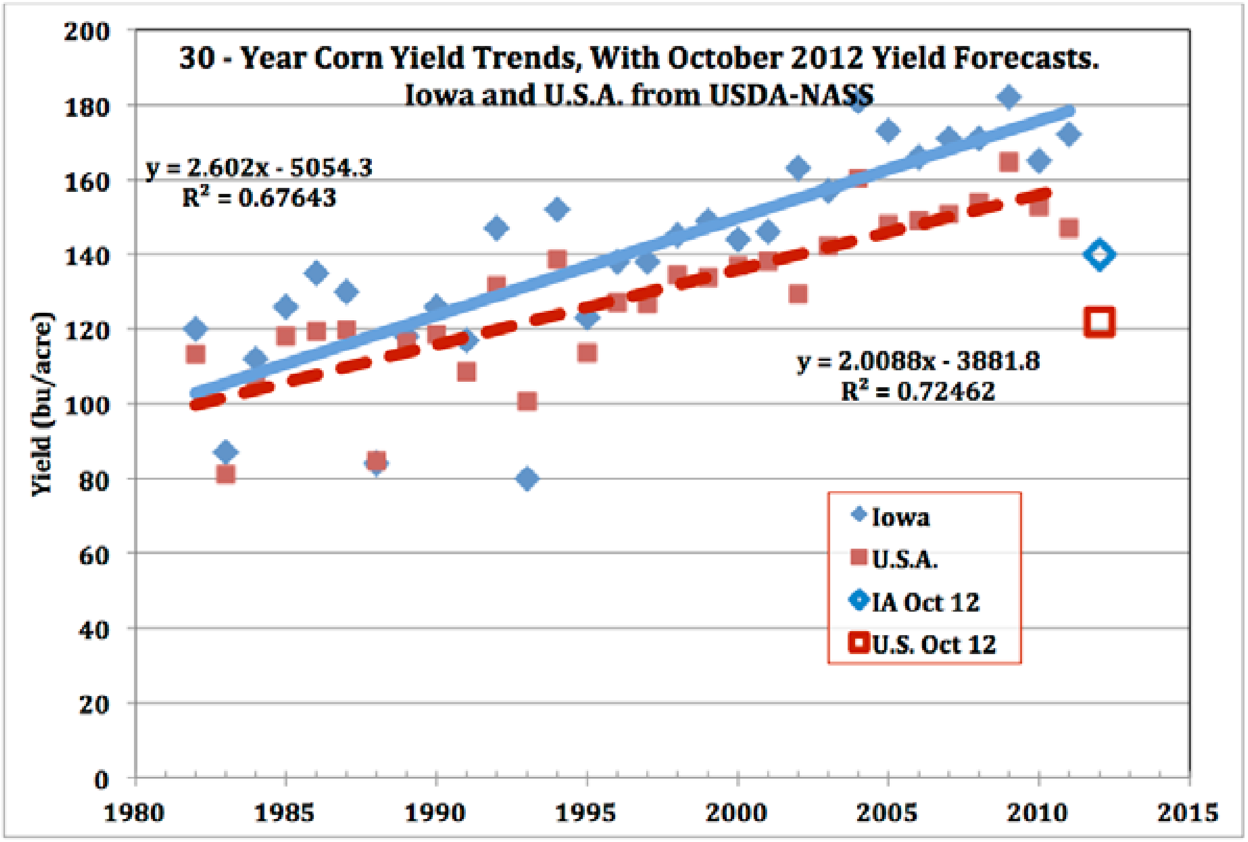

Figure 2. Iowa and U.S corn yields 1982 – 2011 with October 2012 yield forecasts. Source: USDA-NASS.

Part 1: Understanding yield

Grain yield is the summation of components in sequence that include plant population, ear numbers per plant, kernel rows per ear, kernels per row and kernel weight. Understanding the timing of determination of these important grain yield components and the stresses that occur during these vegetative and reproductive developmental times helps to understand their impact on final grain yield.

The primary ear is initiated at about V6 (Abendroth et al., 2011) and kernel rows per ear is determined around V7. Number of kernels per row is also initiated around V7 and potential kernels per row determined by about V15-V16. Total leaf area - referred to as Leaf Area Index (LAI) - is related to stresses during vegetative development. Increasing LAI correlates to increased light interception. With more light interception there is more photosynthesis (Lindquist et al., 2005). Increased photosynthesis is strongly related to increased biomass production and grain yield production (Edwards et al., 2005).

The sequence of events at the beginning of the reproductive period is important too. Anthesis silking interval (ASI) represents the timing between pollen shed and silking (R1). Grain yield is strongly affected by stresses during this period. Water stress then causes lower plant growth rates and increases the ASI. Increasing ASI results in lower grain yields by reducing the number of kernels per ear and ears per plant. Increasing light interception at silking increases kernel number per plant. Stress reduction during silking results in more kernels per plant and increased grain yield. Biotic factors like silk feeding by root-worm beetles as well as weeds and diseases add to stress during this critical time. They, thus, reduce yield through changes in final kernel numbers and/or kernel weights.

Understanding these basic concepts of plant growth and development helps us better grasp the impacts of abiotic factors we faced during the 2012 growing season: high temperatures coupled with low precipitation.

Part 2: Impact of growth variability on yield

Farmers use starter fertilizer placed 2×2 in below and to the side of planted corn seeds to increase early-season growth and promote crop development. Researchers show that starter fertilizers increase early-season growth under cool and wet conditions; however, grain yield responses have been variable (Mallarino et al., 2011). Some have shown that variability in plant emergence and growth and development reduces grain yield (Liu et al., 2004) and (Nafziger et al., 1991). Our objective was to identify how starter fertilizer affects the progression of corn development and variability in growth. A second objective was to determine the impact of variation in early-season growth and development resulting from starter fertilizer on final grain yield.

We had locations near Ames and Nashua in 2011 and 2012; our results presented in this article are from the Ames location in 2011. Our experimental treatments included three hybrids, three populations (30,000, 36,000 and 42,000 seeds ac^{-1}), and two levels of starter fertilizer (with and without 10-34-0 at a rate of 8 gal ac^{-1}). We measured stem diameter ½ inch above soil surface until V6 and between the 7th and 8th nodes after V9, extended leaf plant height, and vegetative development on ten tagged plants at V2, V4, V6, V9, V15, and R2. At each sampling date, identical measurements were collected on five plants in another row and then destructively sampled to attain plant and root dry weights. A model was created using PROC REG (SAS Institute, 2010) to estimate the biomass of the tagged plants using the stem diameter and height at each stage. Roots on destructively sampled plants were analyzed at V2 and V4 for root length, surface area, average diameter, number of tips and number of forks using WinRHIZO (Regents Instruments, 1996). Per plant grain yield components and plot yield and grain moisture were also measured.

Starter fertilizer increased the average developmental stage of corn and decreased days to silking and anthesis. Starter fertilizer increased the estimated biomass of plants at V4, V6 and V9; however, final plant size was not different. Starter fertilizer increased estimated biomass coefficient of variation (CV) at a seeding rate of 30,000 seeds ac^{-1} at stages V4, V9, and V15, however decreased estimated biomass CV at a seeding rate of 42,000 seeds ac^{-1} at stages V6. Starter fertilizer increased root biomass at V4. The seeding rate of 30,000 seeds ac^{-1} had greater root length, surface area, average diameter, number of tips and number of forks than the seeding rates 36,000 and 42,000 seeds ac^{-1}. Starter fertilizer had no effect on plot grain yield. Increased variability in growth did not result in increased variability in grain yield components, and although starter fertilizer increased early-season growth, yield was not different with starter fertilizer. However, plant grain moisture was lower with starter fertilizer and increased seeding rate increased per plant grain yield variability.

Although starter fertilizer increased variability in estimated biomass at the low population and decreased variability at the high population, there was no effect of starter fertilizer on grain yield or per plant yield variability. At the time of writing, we are finishing data collection and continuing with data analysis for the 2012 growing season. We hope to be able to present our findings from both years during the ICM conference.

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