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Corn Yield Estimates and their Predictive Value: The Art and Science of Estimating Yield

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Predicting corn yields can be challenging, but there are a number of management reasons to do this carefully. Yield estimates affect individual business decisions by helping producers develop marketing plans for their operations, determining what to produce and how and when to sell it. Estimates enable the industry to forecast transportation and storage requirements and evaluate export potential. USDA agencies use yield estimates to determine crop insurance and disaster aid payments along with other program benefits. Finally, farm organizations use the information to help form their policy positions. A consequence of yield estimates is that they can often impact markets.

Kernel development during grain filling

With the onset of pollination, the corn crop is in a critical growth and development stage for grain yield. This stage is critical because the yield components of ear and kernel number can no longer be increased by the plant and the potential size of the kernel is being determined. For the first 7 to 10 days after pollination of an individual kernel, cell division occurs in the endosperm. The potential number of cells that can accumulate starch is determined. At black layer formation (R6) 55-60 days later, no more material can be transported into the kernel and yield is determined.

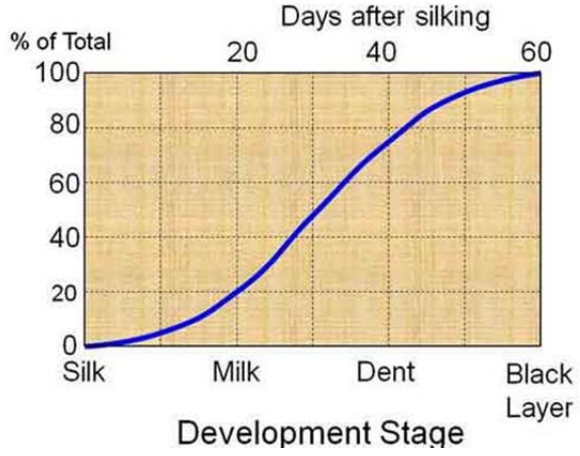

Figure 1. Typical corn kernel development in WI. Derived from (Johnson and Tanner, 1972).

Kernel weight develops in an "S" (sigmoidal) shape with an initial "lag" phase, followed by a 35 to 40 day "linear" phase and finishing with a "plateauing" phase (Figure 1). During the linear phase up to 4 to 7 bu/A is gained each day.

USDA-National Agricultural Statistics Service

The most extensive and comprehensive data collection system for crop yield in the world is the USDA-NASS. The WI sample fields (N=100) are drawn from June area corn fields. Each corn acre has one chance at being chosen. Data are collected from each sample field at monthly intervals starting in late July and continuing through December or until the sample field has been harvested. Each month, data are used to produce planted acres (August only), acres for harvest, and yield. In 2011 data will be released August 11, September 12, October 12, November 9, and the final numbers on January 11. Measurements taken include: ears/acre, ear volume (length x diameter), grain weight, and harvest loss/gleanings. The actual counts and measures are made in sample fields and with lab analysis of grain. Table 1 compares corn grain yield forecasts and their deviation from the final estimate.

Table 1. Annual corn yield (bu/A) forecasts for the U.S. and the deviation from the final estimate (USDA-NASS, 2011).

	Yield forecast				Deviation from final estimate			
	Aug 1	Sep 1	Oct 1	Nov 1	Aug 1	Sep 1	Oct 1	Nov 1
2000	142	142	140	138	5	5	3	1
2001	134	134	136	138	-4	-5	-2	0
2002	125	125	127	128	-4	-4	-2	-2
2003	140	139	142	143	-2	-4	0	1
2004	149	149	158	160	-11	-11	-2	0
2005	139	143	146	148	-9	-5	-2	1
2006	152	155	154	151	3	6	4	2
2007	153	156	155	153	2	5	4	2
2008	155	152	154	154	1	-2	0	0
2009	160	162	164	163	-5	-3	-1	-2
2010	165	163	156	154	12	10	3	2
Average					**-1**	**-1**	**1**	**0**

Yield component method

The yield component method was developed by the Agricultural Engineering Department at the University of Illinois. The principle advantage to this method is that it can be used as early as the milk stage of kernel development. The yield component method involves use of a numerical constant for kernel weight that is figured into an equation in order to calculate grain yield. This numerical constant is sometimes referred to as a "fudge-factor" since it is based on a predetermined average kernel weight.

To calculate estimated grain yield using the yield component method proceed as follows:

- Count the number of harvestable ears in a length of row equivalent to 1/1000th acre (30-inch row spacing = 17’ 5" row section).
- On every fifth ear, count the number of kernel rows per ear and determine the average.
- On each of these ears count the number of kernels per row and determine the average. (Do not count kernels on either the butt or tip of the ear that are less than half the size of normal size kernels.)
- Yield (bushels per acre) equals (ear number) x (average row number) x (average kernel number) divided by a “fudge factor” of 89.605 = bu/A.
- “Fudge-factor” is between 80 and 90 depending upon the final size of the kernel.

Ear length method

This method, developed by the University of Minnesota, is less accurate than others due to the "fudge" factor used in its calculation. It is a relatively quick and easy way to get an idea of grain yield.

Table 2. Corn grain yields for various numbers of ears in 30 feet of row and various row spacings. Values are based on an average ear dry weight of 0.5 pounds.

Number of ears in 30 feet of row	Row width (inches)				
	15	20	30	36	38
	Bushels per acre				
13	106	80	54	45	43
17	144	107	70	58	55
21	164	125	86	72	69
25	206	155	104	86	81
29	240	180	120	99	94
33	274	205	136	114	108
37	306	229	153	127	120
41	339	254	169	141	133
45	373	279	186	155	146
49	406	304	202	168	159
53	439	328	219	182	172
57	473	354	235	196	185

Table 3. Adjustment factors for estimating corn grain yield with differing average ear lengths.

Average ear length (inches)	Factor
5.0	0.4
7.0	0.8
7.5 = half pound ear	1.0
9.0	1.4

- Determine row width and measure 30-ft of length
- Count the number of ears on two adjacent rows and determine an average
- Find the yield at the intersection of row width and average ear number in Table 2.
- Husk ears from 10 consecutive plants and determine the average length of ear with kernels.
- Use Table 3 to adjust the yield if ear length is shorter or longer than 7.5 inches (half pound ear).

National Crop Insurance Services methods

Corn Stand Reduction Appraisal Method (NCIS)

Method is used to assess yield loss due to hail-induced stand reduction from the 7-leaf (V5) stage until the milk (R3) stage. The method assumes that remaining plants can partially compensate when stand loss occurs between the 7- and 10-leaf stages (V5-V8). It assumes the same level of yield compensation from remaining plants after stand loss. After the 10-leaf stage, remaining plants cannot compensate for lost plants, and yield loss equals percent stand loss.

Maturity Line Weight Appraisal Method (NCIS)

Method is used for corn grain appraisals, from the milk stage until kernels are fully mature and moisture drops below 40%. The method is based on weighing ear samples which are grouped according to maturity, and converted to bushels per acre.

Grain weight methods

The most accurate method is weighing grain from a known field area. Larger plot size improves accuracy, while smaller plots size improves precision. Grain weight methods include hand harvesting ear and shelled corn, shelling percentages and machine harvesting. Yield maps are increasingly being used to estimate yield differences.

Literature cited

Johnson, D.R., and J.W. Tanner. 1972. Calculation of the Rate and Duration of Grain Filling in Corn (Zea mays L.). Crop Sci. 12:485-486.

USDA-NASS. 2011. Crop Production Historical Track Records http://usda.mannlib.cornell.edu/usda/current/htrcp/htrcp-04-26-2011.pdf