IOWA

Redefining Corn Yield Potential

By T.S. Murrell and F.R. Childs

Determining the difference between a hybrid's yield potential and the actual yield attained helps us begin to quantify the level of stress under which a crop is grown and the yield that has yet to be exploited. By better understanding the yield potential of corn hybrids, agricultural science can better define management strategies that can increase crop production in ways that are agronomically, economically, and environmentally sound.

The Iowa Crop Improvement Association sponsors the Iowa Master Corn Grower Contest. It has been in existence since 1938 and allows producers to compete fairly with one another for high yields. The highest yields in the contest have consistently been much greater than the Iowa state average (**Figure 1**). The highest yields attained have been increasing over time, at an average rate of approximately 2.20 bu/A/yr. The Iowa state average yield has been increasing as well, but at a slower rate, about 1.64 bu/A/yr.

The yield gap between the contest winners and the state average provides an indication of the yield that has yet to be exploited by most farmers (**Figure 2**). This gap has been widening over time, an average of 0.56 bu/A/yr. For the last five years, Francis Childs has consistently won the non-irrigated class. In 1997 and 1998, he turned in state-confirmed yields of

The data presented here are part of an ongoing process by several researchers to characterize the site where Francis Childs grew 393.74 bu/A corn. Plans are being made to test current corn growth models to better understand the impacts climatological events had on yields in 1999. Soil fertility information is being reviewed and investigated.

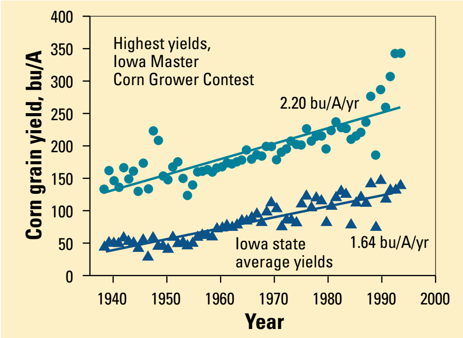

Figure 1. Highest annual corn grain yields entered in the Iowa Master Corn Grower Contest and Iowa state average corn grain yields. (Data: Iowa Crop Improvement Association and National Agricultural Statistics Service).

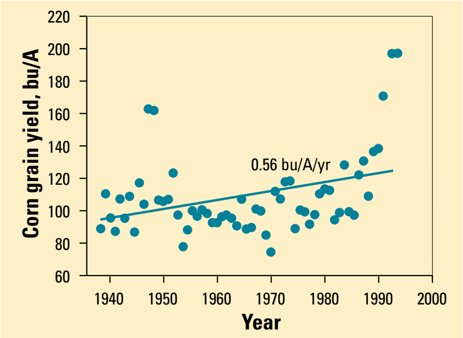

Figure 2. Annual difference between the yields attained in the Iowa Master Corn Grower Contest and Iowa state average yields. (Data: Iowa Crop Improvement Association and National Agricultural Statistics Service).

345.26 and 345.71 bu/A, respectively. In 1999, he had a state-confirmed yield of 393.74 bu/A. Mr. Childs has also won the National Corn Growers Association yield contest in the AA Non-Irrigated Class in 1997 and 1998.

The higher yields of the contest winners demonstrate that much of the corn grown in Iowa is under stress and is yielding well below what is possible. Limited yields may be related to many possible factors, such as moisture, nutrients, rooting depth, temperature, etc. What is critical to increasing yields is identifying which factors can be controlled and determining their true non-limiting levels in a given environment.

Much of the agricultural research to date has been conducted at moderate yield levels, usually below 200 bu/A. It is not known if the critical levels defined in such research are appropriate at higher production levels.

The first step in any scientific endeavor is to characterize, as fully as possible, the current state of a system one wishes to investigate. After the initial characterization, the system is then dissected into a series of controlled studies that investigate the effects of the various components as well as their interactions. The environment in which Francis Childs has been able to achieve such high yields is of particular interest to agriculture as it strives to understand corn yield potential.

Soils Information

The field yielding 393.74 bu/A in 1999 is in the Kenyon-Clyde-Floyd association (**Figure 3**). This association comprises about 51 percent of the soils in Delaware County, Iowa. Soils in this association are found in uplands. The landscape is a multilevel sequence of erosion surfaces. The Iowan-age till does not exist, but an erosion-surface complex does exist in the Iowan region. The Iowan surface formed during the time of loess deposition, about 14,000 to 20,000 years ago. Kenyon, Clyde, and Floyd soils are probably younger than 14,000 years old. A stone line, shown in **Figure 3**, marks where the Iowan surface cuts through Kansan and Nebraskan till. Kenyon soils formed from loamy sediments and in underlying glacial till on the Iowan erosion surface. Clyde and Floyd soils formed from local alluvial material coming from nearby glacial till on side slopes. The Kenyon soil is typical of soils formed under prairie grasses. The Clyde soil is typical of soils formed under prairie grasses and water tolerant plants.

The soil mapping units for the field yielding 393.74 bu/A is shown in **Figure 4**. The Kenyon soil is moderately well drained (**Table 1**) and is located on convex ridge tops and side slopes. The Clyde-Floyd complex is in the nearly level to gently sloping drainage ways. This complex is composed of both Clyde (somewhat poorly drained) and Floyd (poorly drained) soil series intermixed at a small enough scale that they could not be mapped separately. Just north of the central part of the field is a ridge, denoted by the Kenyon loam with a slope of 5 to 9 percent. Water drains from either side of this ridge into the Clyde-Floyd complex areas located near the middle

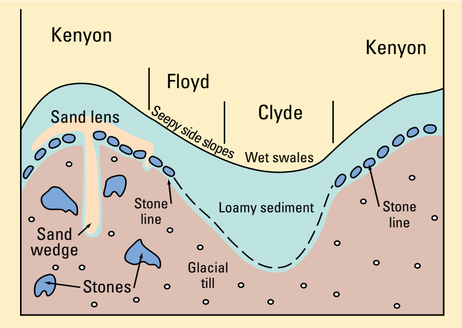

Figure 3. Parent material of the Kenyon-Clyde-Floyd association (adapted from Delaware county soil survey).

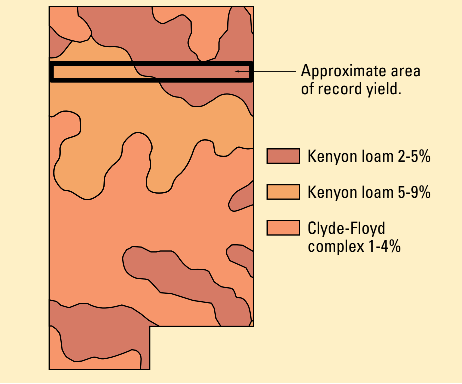

Figure 4. Soil mapping units in the field yielding 393.74 bu/A.

and both the north and south ends of the field. **Table 1** provides other characteristics of the various soils in this field. Noteworthy are the yields, defined in the soil survey, expected for each soil series when managed intensively.

Soil samples were taken to a 14 in. depth. Soil test information is still being examined and will be reported in future publications. However, soil test levels for phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), and iron (Fe) were all well into the very high range, and soil pH was near neutral.

TABLE 1. Selected soil characteristics defined in the Delaware county soil survey, issued March 1986.

	Soil series		
Characteristic	**Kenyon 2-5%**	**Kenyon 5-9%**	**Clyde-Floyd complex**
Taxonomic class	Fine-loamy, mixed, mesic, Typic Hapludolls	Fine-loamy, mixed, mesic, Typic Hapludolls	Fine-loamy, mixed, mesic, Typic Haplaquolls (Clyde) and fine-loamy, mixed, mesic, Aquic Hapludolls (Floyd)
Drainage	Moderately well drained	Moderately well drained	Somewhat poorly drained (Clyde) and poorly drained (Floyd)
Texture	Loam	Loam	Clay loam
Permeability	Moderate	Moderate	Moderate
Runoff	Medium	Medium	Low
Expected corn yield with high management	154	149	142
Capability class	IIe (moderate limitations that require moderate conservation practices to control erosion)	IIIe (severe limitations that require special conservation practices to control erosion)	IIw (moderate limitations from water interfering with plant growth)

Management Practices

The field being characterized has been in continuous corn for the past 30 years. Fall tillage (**Table 2**) is performed with a mini-moldboard plow manufactured by the Wiese Corporation. This implement was used to till the soil to a depth of 14 in., leaving about 30 percent corn residue cover. Spring tillage was performed with a field cultivator with which anhydrous ammonia (NH_3) was applied. Row cultivation is occasionally performed, although none was done in 1999 on this field.

Planting and harvest information is found in **Tables 3** and **4**. Pioneer 34G82 was planted at a population of 44,200 plants/A on April 29, 1999. Planting speed was slow to ensure even seed distribution and depth. Stand counts were taken when the corn was 4 to 5 ft. tall and revealed the population to be 44,000 plants/A (**Table 4**). The population difference is thought to have arisen from a lower than expected seeding rate, rather than from problems with emergence. Scouting of the field detected no missed seed drops from the planter. The planter plates had been retooled to ensure they were flat and could provide even distribution of seed. A trash whipper was used at planting to remove residue from an approximately 6 in. wide swath centered over the row. A seed firmer was also used to increase seed-soil contact.

TABLE 2. Tillage information associated with 393.74 bu/A corn yields, 1999.

Fall tillage:	Mini-moldboard plow (Wiese Corp.), 14 in. deep
Spring tillage:	Field cultivator used to apply NH_3, 1 pass before planting
Residue cover:	About 30%, corn residue

Fertilizer applications were split throughout the season. Bulk applications of P (180 lb P_2O_5/A) and K (120 lb K_2O/A) were made in the fall before plowing. A small amount of nitrogen (N, 50 lb/A) was also applied in the fall to stimulate corn residue decomposition. Anhydrous ammonia was applied with a cultivator in the spring at a rate of 250 lb N/A before planting. Starter fertilizer was applied 2 in. to the side and 2 in. below the seed at a rate providing 6 lb N/A, 15 lb P_2O_5/A, and 15 lb K_2O/A. One week after planting, N was applied again with herbicide at a rate of 50 lb N/A. Nitrogen was applied a final time as a late side-dress application, dribbled between the rows at a rate of 50 to 60 lb N/A.

Climatological Information

Rainfall for the growing season was 3.63 in. above average (**Table 5**). Surplus precipitation occurred in April, May and July while below average rainfall occurred in June, August and September.

Daily and cumulative growing degree data for the 1999 year as well as long-term averages (1951-1998) are presented in **Figure 5**. Dates for silking and physiological maturity were estimated from the published growing degree data required to reach these growth stages (**Table 3**). There was a period from five days before to 12 days after the estimated silking date when growing degree days (gdd) were accumulating at a rate faster than the long-term average. There was another short period of more rapid gdd accumulation from day 237 to 247. Slower than normal accumulation began around day 256 and continued to predicted physiological maturity. At predicted physiological maturity (day 268), cumulative gdd were 2,648 and 2,586 for the 1999 season and the long term average, respectively.

Daily high and low temperatures for 1999 and the long-term average (1951-1998) are shown in **Figure 6**. Maximum temperatures were generally higher than normal for a 32-day period for days 73 to 104, ending just 15 days before planting.

TABLE 3. Hybrid and planting information associated with 393.74 bu/A corn yields, 1999.

Hybrid:	Pioneer 34G82
Genetic traits:	Contains YieldGard ® (Bt) gene
Relative maturity:	106 days
Planted population:	44,200 plants/A
Growing degree days to silking:	1,340
Growing degree days to physiologic maturity:	2,580
Row width:	30 in.
Planting depth:	1.75 - 2 in.
Planting speed:	2 - 2.5 mph
Planting attachments:	Trash whipper[1] and seed firmer[2]
Planting date:	4/29/99

[1]Removes residue in approximately a 6 in. wide band centered over the row.
[2]Press wheels that provide better seed-soil contact.

TABLE 4. Harvest information associated with 393.74 bu/A corn yields, 1999.

Harvest date:	10/20/99
Length of time crop was in the field:	174 days
Harvest population:	44,000 plants/A

TABLE 5. Rainfall data.

	Precipitation amount, inches			
Month	Farmer records, 1999	Weather station records, 1999[1]	Weather station average, 1951-1998	Farmer records, average
January		2.53	1.00	–
February		0.94	1.08	–
March		0.89	2.04	–
April	5.3	4.06	3.40	+1.90
May	7.3	8.45	3.98	+3.32
June	4.1	3.86	4.57	-0.47
July	8.3	10.12	4.22	+4.08
August	3.5	4.33	4.47	-0.97
September	1.2	1.13	3.53	-2.33
October	0.0	0.59	2.50	-2.50
Growing season total[2]	24.4		20.77	+3.63

[1]Source: Midwestern Climate Center, Oelwein, IA weather station, located approximately 30 mi wnw of Manchester, IA.
[2]Rainfall data summed over the months of May through September. No April precipitation occurred after planting on April 29, 1999.

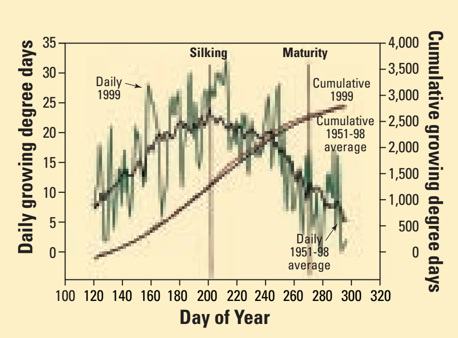

Figure 5. Daily and cumulative growing degree days (base 50ºF, ceiling 86ºF) for April 29 (day 119) - October 20 (day 293), 1999; average daily and cumulative growing degree days for the period 1951-98. Dates for silking and physiological maturity were estimated from published growing degree days **(Table 3)** needed to reach these growth stages. (Data: Midwestern Climate Center, Oelwein, IA station, located about 30 mi wnw of Manchester, IA).

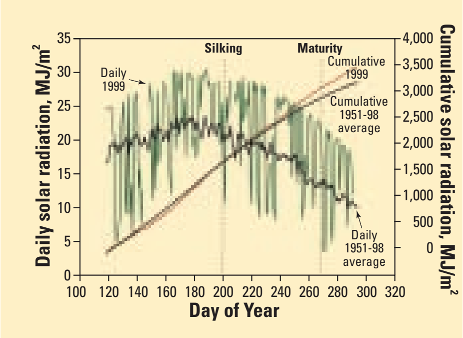

Figure 7. Daily solar radiation for April 29 (day 119) - October 20 (day 293), 1999; average daily solar radiation for the period 1951-98; 1999 missing for days 145, 147, 159, 195, 206, 207, 233, 291, and 293. Dates for silking and physiological maturity were estimated from published growing degree days **(Table 3)** needed to reach these growth stages. (Data: Midwestern Climate Center, Dubuque, IA station, located ~40 mi east of Manchester, IA).

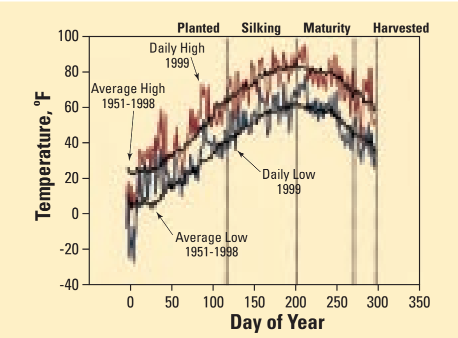

Figure 6. Daily high and low temperatures for January 1 (day 1) - October 20 (day 293), 1999; average daily high and low temperature for the period 1951-98. Dates for silking and physiological maturity were estimated from published growing degree days (Table 3) needed to reach these growth stages. (Data: Midwestern Climate Center, Oelwein, IA station, located about 30 mi wnw of Manchester, IA).

During this time, only three days, 99-100-101, had maximum temperature below normal. The maximum temperatures during this time ranged from 42 to 73ºF and 39 to 55ºF for 1999 and the long-term average, respectively. Mean maximum temperatures during this period were 56ºF (1999) and 50ºF (average). During this same period, minimum temperatures ranged from 19 to 53ºF and 22 to 35ºF, while mean minimum temperatures were 34ºF and 28ºF for 1999 and the long-term average, respectively. Minimum and maximum temperatures followed the trends discussed previously for the growing degree data.

Daily high and low solar radiation data for 1999 and the long-term average are shown in **Figure 7**. The slower accumulation of solar radiation early in the season is probably due to missing data, rather than a true effect. From approximately day 166, solar radiation accumulated faster than normal and continued this trend until harvest. Linear regression during this time period revealed average solar radiation accumulations of 20.57 MJ/m²/day for 1999 and 17.81 for the long-term average.

As we improve our understanding of the environment in which this crop was grown, we hope to better understand where research efforts should be spent to narrow the gap between yields attained and yields possible. BC

Dr. Murrell is PPI North Central Director, located at Andover, Minnesota. E-mail: smurrell@ppi-far.org. Mr. Childs is a farmer near Manchester, Iowa.