History of the US Hybrid Corn Seed Industry

Thomas Hoegemeyer, University of Nebraska-Lincoln

The history of the US corn seed industry is inseparable from the history of plant genetics and breeding. It was clear to late 19th and early 20th century scientists that Mendel's discoveries were of fundamental importance. And, it was equally clear to both scientists and policy makers that yields of maize were flat. The reasonable areas for farm expansion were exhausted—the only way we would have food/feed/fuel for growing populations was by increasing agricultural productivity. G.H. Shull's discoveries, followed by East's suggestion of double-cross hybrids in 1918 were seen as transformational technologies.

Soon, scientific investigation of the principles of genetics and plant breeding led to the establishment of significant corn research projects at many Land Grant Universities across the nation. Simultaneously, entrepreneurs saw opportunities to be involved in the growing seed industry, including the development of better hybrids and parent lines. The depression, and the droughts in 1934 and 1936, were important in driving demand for hybrids, and food supply and increasing agricultural incomes were key national goals. State and federal investment in hybrid technology and corn breeding research increased steadily, and the necessary infrastructure was built both publicly and privately.

The years of World War II, and the demand for dramatically increasing productivity, brought the meteoric growth of hybrid acceptance, and the concurrent adoption of mechanization to replace labor, which was needed in the factories and military. After the war, science again drove the progress of corn breeding, and the understanding of the principles of statistics, adoption of quantitative genetics ideas, and improved agronomy/soil fertility allowed rapid progress. C.C. Cockerham's landmark paper (Crop Science 1:47-52) clearly showed the advantages of single-cross hybrids, and sufficiently improved inbreds had recently become available to allow commercial companies to rapidly adopt single crosses. This fundamentally changed the variability among commercial hybrids available, allowing superior hybrids and better "seedsmanship" to be expressed in improved farm yield.

The widespread adoption of Tcms, and a hurricane in 1970 demonstrated the vulnerability of the US seed supply to SCLB, and other issues. This forced a return to normal cytoplasm and a huge detasseling load for SC production, winnowing small seed enterprises. A single superior inbred line, B73, dramatically change industry dynamics. This demonstrated value of better genetics and improved IPR protection, lead to massively increased private investment in both breeding and seed production technology. In the later 1980's it became increasingly obvious that transgene expression in plants was coming, and by mid-1990's several were released in the form of herbicide and insect resistant varieties. The massive cost to develop and register these popular and effective "traits" drove consolidation of the seed industry. Implications of these changes will be discussed.

History: Corn Breeding and the US Seed Industry

Tom Hoegemeyer

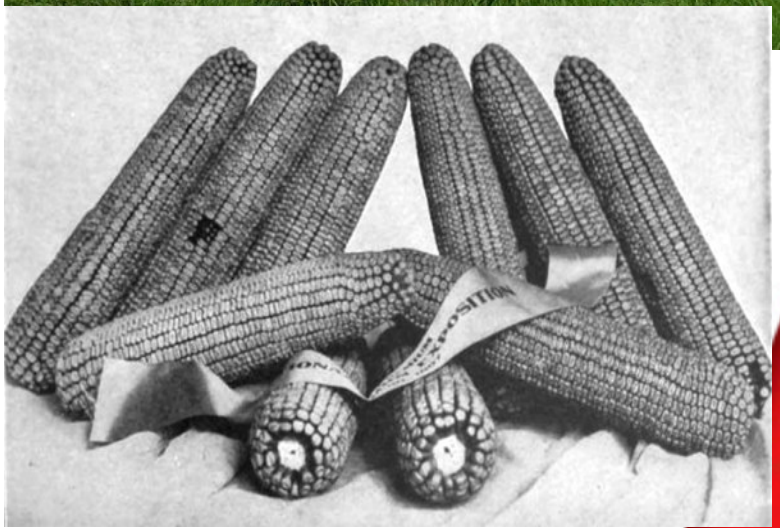
UNIVERSITY OF NEBRASKA–LINCOLN

Farmers Produced/Saved Own Seed

- First instance of a seed "industry"— Individual Farmers/Breeders ➔ Mass Selection
- Corn Shows➔ Pretty Ears
- Winning" sets of ears at big corn shows brought BIG MONEY,

  BUT…

Like picking a Derby horse by the colors



1840's thru 1920 "Seed Industry"

Farmer/Corn Show Era

- Variety Introduction, then Mass Selection

(Seed box on Wagon side)

- Farmer evaluation, then Land Grant Universities
- Mostly Farmer increasing his own seed
- Etc.
- Farmer to Farmer

Required Infrastructure

1) Breeding/Genetic Improvement

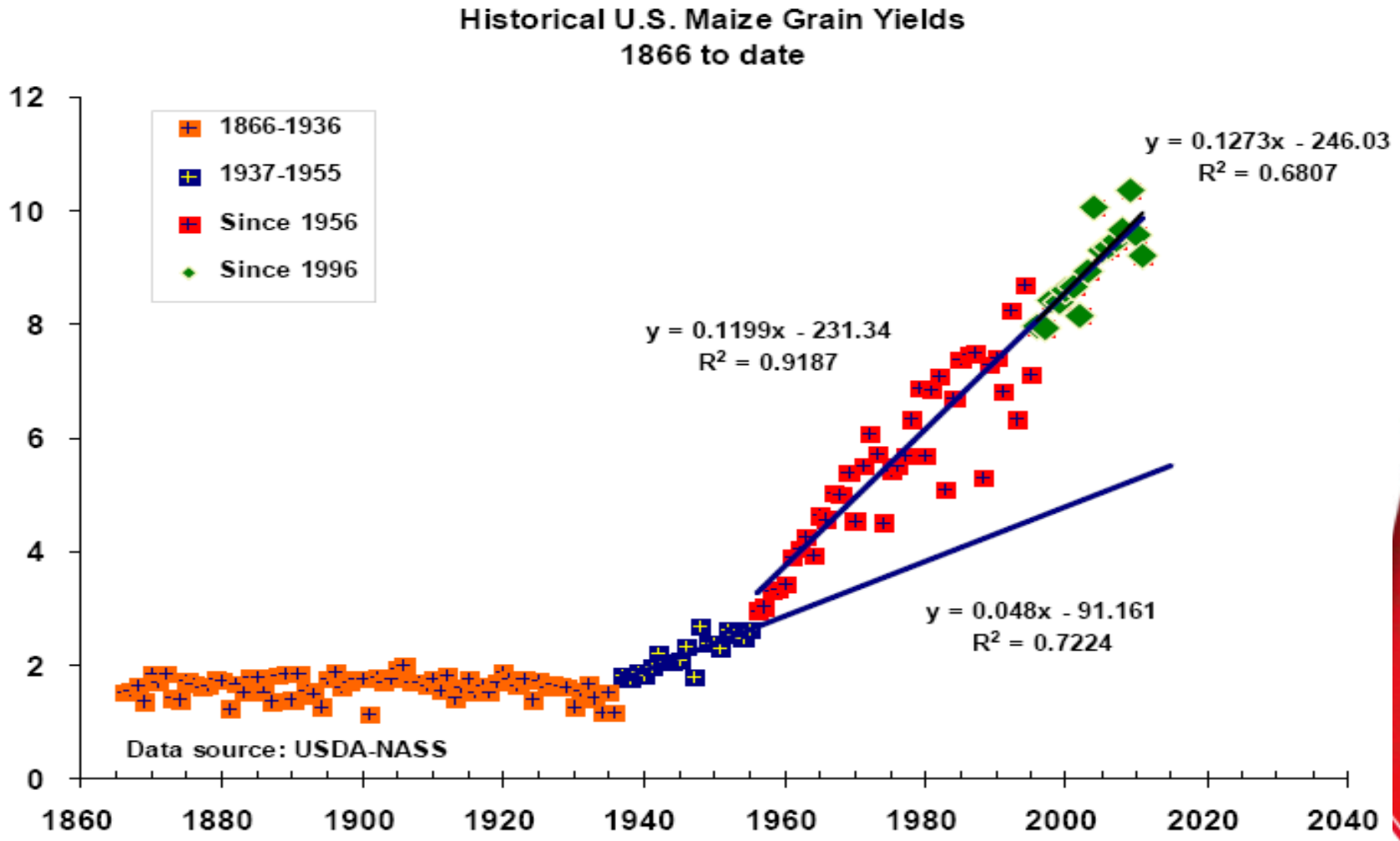
2) Testing/Evaluation

3) Foundation Seed, Increase/Certification?

4) Seed Production

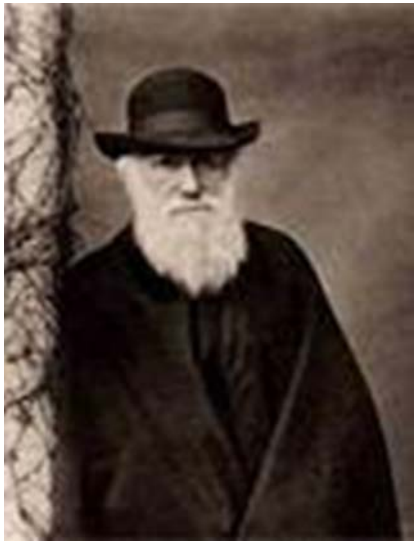
5) Sales

Mandatory Corn Breeder's Slide



Science—Genetics Drove Corn Breeding 1860-1925

Genetic/Breeding was one field



UNTIL

East—Double Cross, 1918

- Hit on the idea to overcome "poor" inbreds, lack of Agronomy

USDA/Land Grant Vision ca. 1930

Hybrid Corn is a Transformational Technology!

Proposed Structure:

A. Land Grant Universities—Genetic Improvement and Inbred Line Development, Test Hybrids, Make Recommendations

B. Foundation Seed Groups at LGU, increase lines, make Double crosses

C. Successful farmers produce hybrids for their neighborhood, township, county, or region of state

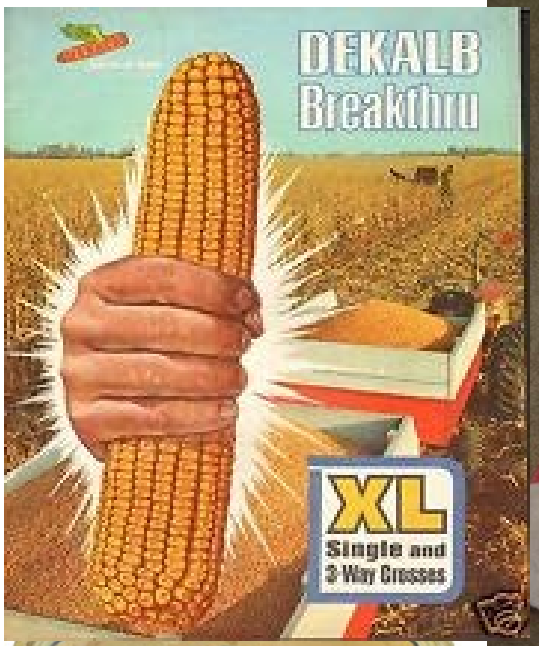
Launched Era of Entrepreneurs

- 1925 Roberts & Gunn—DeKalb
- 1925 Holbert & Funk—Funks G
- 1925 Lester Pfister—Pfister/PAG
- 1920,1926 Wallace and Baker – Pioneer
- 1933 Northrup King
- **Larger** Enterprises started inbreeding in best OP's, derived many of the landmark lines!

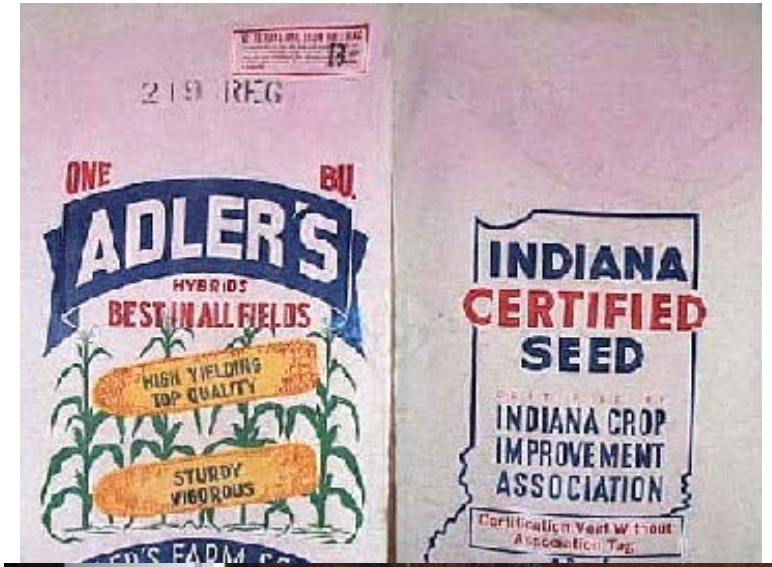
  Combined own w/public lines to make DC Hybrids.
- Hundreds of Smaller Businesses 1930s-1940s

  A few of these **bred** inbred lines, most combined "Station" lines & Single Crosses into Double Crosses. Sold Seed to neighbors, in regions.

Major Companies Formed Large, Focused Enterprises



Lots of Larger, Successful Farms recruited to produce double cross seed corn



Why did Farmers Adopt Hybrids?

- Hand harvest:

  Single Large Ears

  Standability

  Uniformity

- Best Pickers

  100 bu/day (40 bu/A)

  ➔ 2 ½ Acres at 12,000 PPA

  30% lodging = 9000 deep knee bends !

Stress Tolerance!

1934 thru 1937 droughts—SOME hybrids dramatically better!

YIELD-Secondary

Huge Land Grant Univ. Investment 1925-1940 (recovery from depression)

- By late 1930's and Early 1940's LOTs of inbreds became available: HY, 38-11, L289, L317, R4, WF9, M14, 187-2, K4, etc.
- Private Breeders also TRADED Inbred Lines!
- Numbers Problem in Double Crosses!
- 50 Inbreds
  - 25 "males"➔ 300 Single Crosses
  - 25 "females"➔300 Single Crosses

- By 1948, the infrastructure required at University foundation seed divisions was quickly overrun by numbers. Launched Era of Private Foundation Seed Companies

1930-1945 Beginning of Scientific Study of Breeding and Germplasm

- LOTS of Impact of Public Breeding, Traded Lines Freely
- Increasing inputs, Universities, seed companies.
- Expanded Foundation Seed at Land Grant, F.S companies started.
- Diffuse production in many hands, low technology
- Some Professional Sales, but Mostly Farmer to Farmer

1) Breeding/Genetic Improvement

2) Testing/Evaluation

3) Foundation Seed, Increase/Certification?

4) Seed Production

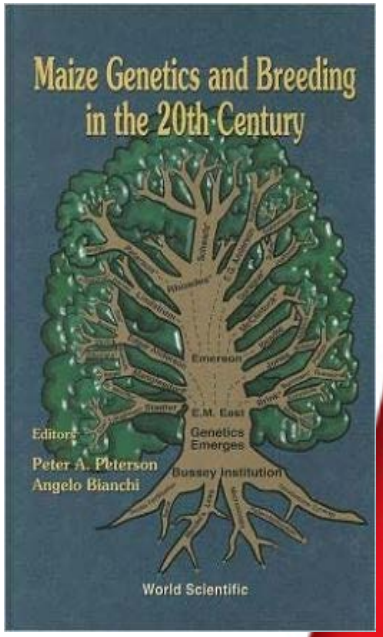
5) Sales

World War II➔ Drove Exponential Growth!

- Men in Military, Women in Factories
- Steel diverted from cars/machines to ships, tanks, planes
- Young Farmers rare, many over 60 farmers doing manual labor.
- Hybrid Corn helped War Effort

After the War, Breeding/Genetic Improvement

- 1945 thru 1965 dozens of Public scientists, working in corn.
- Both theoretical and empirical research, STATISTICS, quantitative genetics!
- Inbred lines released:
  - Improve Ag productivity
  - By-product of empirical research



Industry Status (A): 1930-1960 "Public Hybrid Companies"

Double Cross Era

- Land Grant Universities, USDA, public corn breeders
- Land Grant Universities, Variety Testing Systems
- University/Foundation Seed Divisions
- Open/Closed Pedigree Companies
- HUNDREDS of companies to Farmers

Required Infrastructure

1) Breeding/Genetic Improvement
2) Testing/Evaluation
3) Foundation Seed, Increase/Certification?
4) Seed Production/Conditioning
5) Sales

Huge Lists of Hybrids Eligible for Certification—1947 Example


IOWA

Many were Permutations of same 4 inbreds!

Industry Status B:
1930-1960 "Large Private Hybrid Firms"

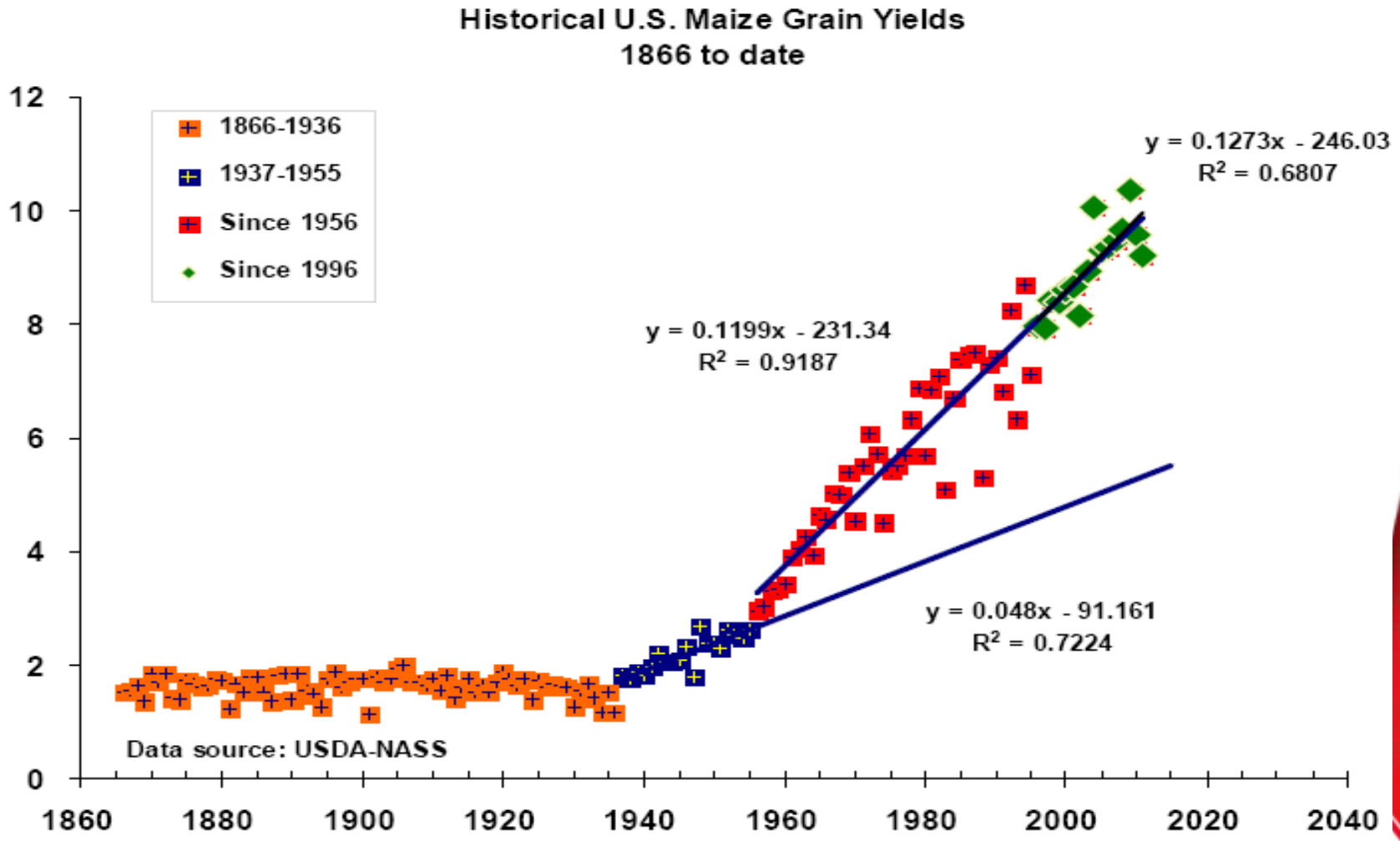
Double Cross Era

- Land Grant Universities, USDA, OWN breeders
- Built Private Testing Systems, Univ. Var. Testing
- Private Foundation Seed Divisions
- Large Investment/Multiple Locations
- Professional Sales Staff, Better Trained Farmer-dealers

Required Infrastructure

1) Breeding/Genetic Improvement
2) Testing/Evaluation
3) Foundation Seed, Increase/Certification?
4) Seed Production/Conditioning
5) Sales

Mandatory Corn Breeder's Slide



The Good Life

- Variability among Hybrids was relatively small
- Production was pretty easy (except for detasseling)
- Low technology requirement, outside of Land Grant U
- Later 1950's, 1960s➔ Reduced Detasseling due to Cms incorporation
- Differentiation: Sales, Marketing, and Hybrids in larger firms.

Public Breeding Productivity

- Lots of New & Better Inbred Lines released
  - PennState, Ohio State, Purdue, Illinois, Iowa State, Nebraska, Michigan State, Wisconsin, Minnesota, Virginia, North Carolina State, Florida State all had major breeding efforts
  - Many more smaller projects.
- Many focused on Line Development and Improvement for Agriculture in their state, as well as science.
- Effectively Competed with Private Breeding Efforts

Single Crosses 1959-1964

- Cockerham (1961) Crop Science 1: 47-52

  Showed selection gains among SC was, at least, twice as great as among DC.

- First Commercial SC sold in …… (Country?)
- Several Early SC—W64AxOh43, others

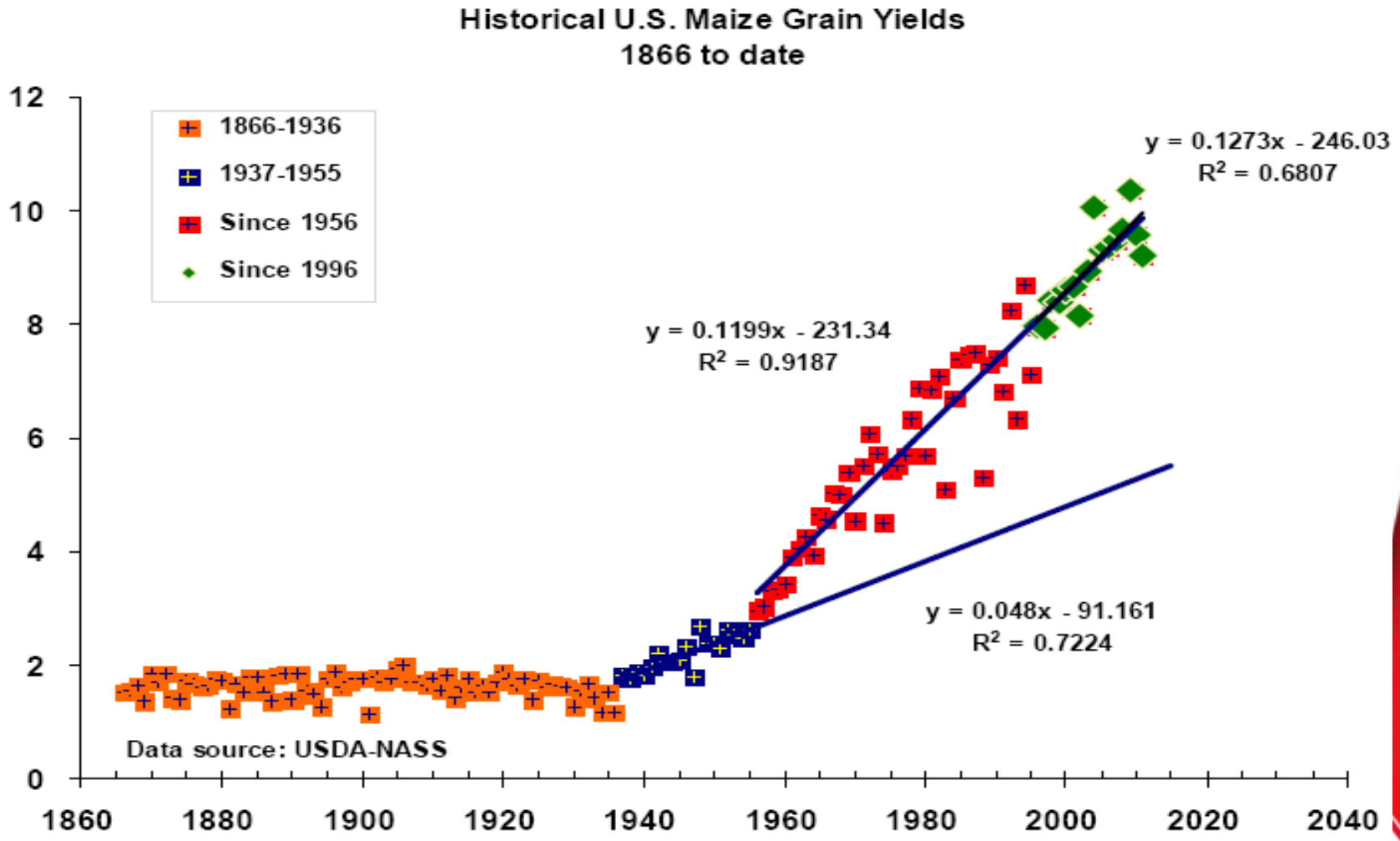
- Many New Excellent Lines Became Available➔ B14, B37, Mo17, A619, R177, N28, H49

Single Cross Impact

- N-responsiveness!
- Dramatically Increased Variability among Hybrid Performance, exposed weaknesses of inbreds!
- Dramatic difference in Seed Production Costs & Difficulty, Seed Quality MATTERED!

- Lots of smaller producers **didn't/couldn't make the transition**. Previous genetics chosen for seed field yields, etc.
- Required increased INVESTMENT from players.
- Transition from Relationship to Productivity business from 1960 to 1980.

Mandatory Corn Breeder's Slide



1970 Southern Corn Leaf Blight Fiasco

- Detasseling was LABOR INTENSIVE
- Texas MS provided an economical means to make production easy
- But SCLB ended the party!
- Aggressive new Race T caused lawsuits, re-configuration

1971-74

- Lots of struggles with seed production!
- Detasseling Returned with a Vengence.
- Genetics Issues: B37➔Rounds

  Mo17➔HUGE F & R

  Germination, Seed Size, Seed Discard & Losses
- Business Aging:

  Founders—1935 through 1945

  Second Generation "in Control" & some didn't make the transition.

Just not as easy, lost about 1/4 of Seed Companies in the "NEW" Detasseling Period!

B73: LANDMARK EVENT 1973

- I believe: launched a lobbying effort at several land grant universities➔ reduce/stop efforts to test and release inbred parent lines.
- Simultaneously, "applied" research de-funded both at state and Federal levels, focus on "basic" research

- B73 hybrids, especially B73xMo17 dominated for 5-7 years across the 110-115 day maturity region of US.
- Beat most/all other Public and Private hybrids
- "Instead of being beaten by one company's hybrid in the state trials, we are being beaten by 30 companies hybrids" Corn breeder for Major Company.
- B73 adopted by Large & Small as key parent, breeding line.

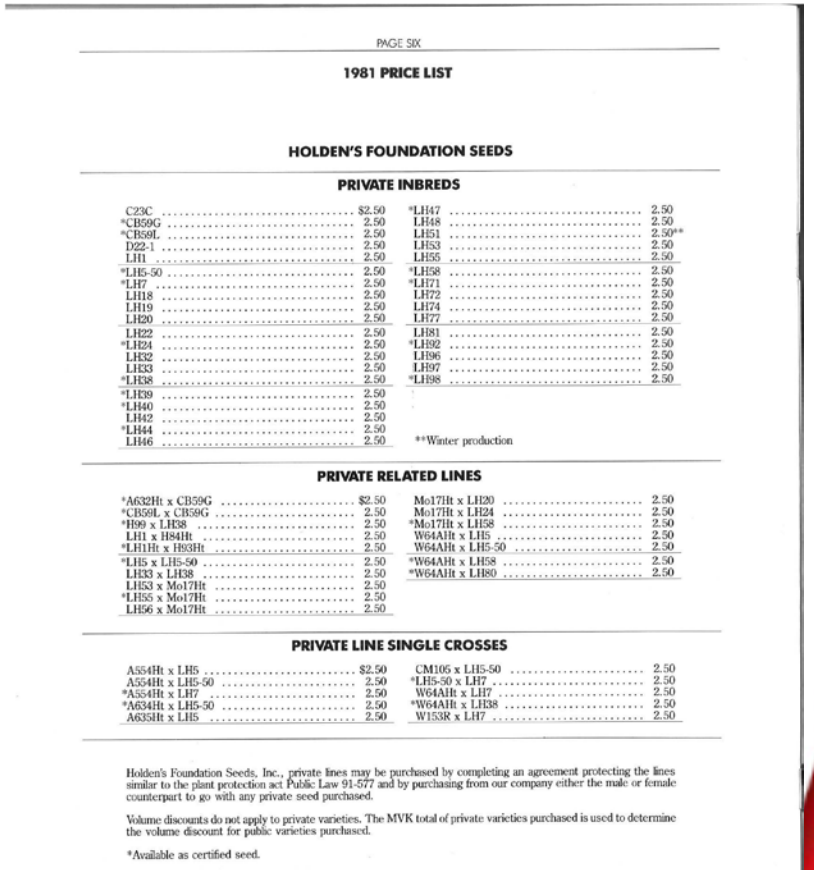
B73 x Mo17 ➔1974-1980

- Probably sold ca. 3,000,000+ units per year for 6 years
- Disruptive Force in the Seed Industry
- Probably the LAST public hybrid adopted by many of Major Seed Companies
- Dramatically showed the value of superior inbred lines.
- Launched/Dramatically increased private investment.
- (PVP act passed during this period)
- Seed Size/Investment in Equipment

Foundation Seed Companies Heyday: 1955 through 1990

- 1981 Holden's Seed Catalog:
- 35 Private Inbreds 27 Private/Pub. SC
- 61 Public Inbreds
- 55 Public related SC
- 99 Public unrelated SC

- TWC, DC not yet dead!



PAGE SIX

1981 PRICE LIST

HOLDEN'S FOUNDATION SEEDS

PRIVATE INBREDS

C23C	$2.50	*LH47	2.50
*CB59G	2.50	LH48	2.50
*CB59L	2.50	LH51	2.50**
D22-1	2.50	LH53	2.50
LH1	2.50	LH55	2.50
*LH5-50	2.50	*LH58	2.50
*LH7	2.50	*LH71	2.50
LH18	2.50	LH72	2.50
LH19	2.50	LH74	2.50
LH20	2.50	LH77	2.50
LH22	2.50	LH81	2.50
*LH24	2.50	*LH92	2.50
LH32	2.50	LH96	2.50
LH33	2.50	LH97	2.50
*LH38	2.50	*LH98	2.50
*LH39	2.50		
*LH40	2.50		
LH42	2.50		
*LH44	2.50		
LH46	2.50		

**Winter production

PRIVATE RELATED LINES

*A632Ht x CB59G	$2.50	Mo17Ht x LH20	2.50
*CB59L x CB59G	2.50	Mo17Ht x LH24	2.50
*H99 x LH38	2.50	*Mo17Ht x LH58	2.50
LH1 x H84Ht	2.50	W64AHt x LH5	2.50
*LH1Ht x H93Ht	2.50	W64AHt x LH5-50	2.50
*LH5 x LH5-50	2.50	*W64AHt x LH58	2.50
LH33 x LH38	2.50	*W64AHt x LH80	2.50
LH53 x Mo17Ht	2.50		
*LH55 x Mo17Ht	2.50		
LH56 x Mo17Ht	2.50		

PRIVATE LINE SINGLE CROSSES

A554Ht x LH5	$2.50	CM105 x LH5-50	2.50
A554Ht x LH5-50	2.50	*LH5-50 x LH7	2.50
*A554Ht x LH7	2.50	W64AHt x LH7	2.50
*A634Ht x LH5-50	2.50	*W64AHt x LH38	2.50
A635Ht x LH5	2.50	W153R x LH7	2.50

Holden's Foundation Seeds, Inc., private lines may be purchased by completing an agreement protecting the lines similar to the plant protection act Public Law 91-577 and by purchasing from our company either the male or female counterpart to go with any private seed purchased.

Volume discounts do not apply to private varieties. The MVK total of private varieties purchased is used to determine the volume discount for public varieties purchased.

*Available as certified seed.

Plant Variety Protection & IPR

- 1970 PVPA
- Diamond vs. Chakrabarty
- Patents on Genes & Organisms
- Each of these had HUGE effect on **Increasing Investment in Plant Breeding, Biotechnology**
- **Industy➔Germplasm access, security, "Minimum Distance"**

“Outside” Investment in Seed

- Lubrizol
- Standard Oil
- Pfizer
- Ciba-Geigy
- CPC, Inc
- Dow
- Etc.

- In the 70’s & 80’s, started to see more investment, especially by component processing companies.
- Biochemists/Molecular Biologists made spectacular progress during these decades.
- Will Breeding shift Laboratory “Design Science”???

1975 to1995 Lots of Players in Breeding Inbred Lines

- Major Companies scaled up dramatically to respond to new IPR climate.
- Ca. 20 Mid-range Companies Developed Significant Inbreds, some from unique sources, some from Foundation Seed Co. or University Lines

1975-1995 US Corn Seed Industry Infrastructure

- Private—Foundation Seed., Private Breeders, Professional Breeding Depts.
- BROAD National/Cooperative Testing Networks
- Owned/Private Seedstock Companies, licensed lines
- Consolidation Started, trading among Smaller/Mid-size
- Diverse, Trending to more professional, TRAINING

1) Breeding/Genetic Improvement

2) Testing/Evaluation

3) Foundation Seed, Increase/Certification?

4) Seed Production

5) Sales

"TRANSFORMATIONAL EVENTS" Transgenic Plants

- 1982 Anti-biotic Res. Tobacco
- 1987 Bt Tobacco
- 1992 Virus Res. Tobacco
- 1994 Tomato
- 1995 RR Soybean, Bt Corn, Corn, Cotton, Squash, etc.
- STACKS of Multiple Genes/Sources

- Struggle➔ Does Plant Variety Improvement Drive Value ?
- OR Do Transgenes Drive Value?

- BOTH?

Patents➔Licenses➔Franchises

- Consolidation Drivers:
- Access to Transgenes & Germplasm
- Differential Pricing to Seed Company "partners"

- COSTS To Develop Better Corn Hybrids:
- COSTS To Develop/Register Transgene:
- IP involved with Above!

- REALITY: Only Allows for 5 to 8 "Players" in long term.
- Herb., Insecticide, N, Agronomy Value➔GENETICS

Why Were “Traits” Adopted?

- Cost Saving
- Prevented Insect Damage/Yield Loss/Field Loss
- REDUCED TIME INPUT/ACRE➔ OPERATION SIZE
- Reduced need for OP insecticides
- Timing of operations less critical
- STANDABILITY
- STRESS TOLERANCE

- Again, Yield is only PART of the Acceptance!

21st Century US Corn Seed Industry Infrastructure

- Acess to Technology, Transgenes, PLUS Germplasm/Improvement
- BROAD National Testing Network
- Owned/Private Seedstock Operation
- Scale/Efficient/Reliable Systems,RIB,Bulk,etc
- Diverse, BUT NATIONAL

1) Breeding/Genetic Improvement

2) Testing/Evaluation

3) Foundation Seed, Increase/Certification?

4) Seed Production

5) Sales