



Agriculture and  
Agri-Food Canada

Agriculture et  
Agroalimentaire Canada



# What can plant breeding and research deliver? What is required to make that happen?

Ron DePauw, CM, SOM, FAIC, FCSA, PhD

Wheat Breeder

SPARC AAFC

Swift Current, SK.

[ron.depauw@agr.gc.ca](mailto:ron.depauw@agr.gc.ca)

Canada

## Outline: self pollinated crops e.g. wheat

- Global food security challenge
- Innovations for competitive Canadian agriculture and food security
- Opportunities to deliver innovations
- Innovative products past and future
- Funding R & D and ROI

*“In the next 50 years, we will need to produce as much food as has been consumed over our entire human history”*

M. Clark, CEO of the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

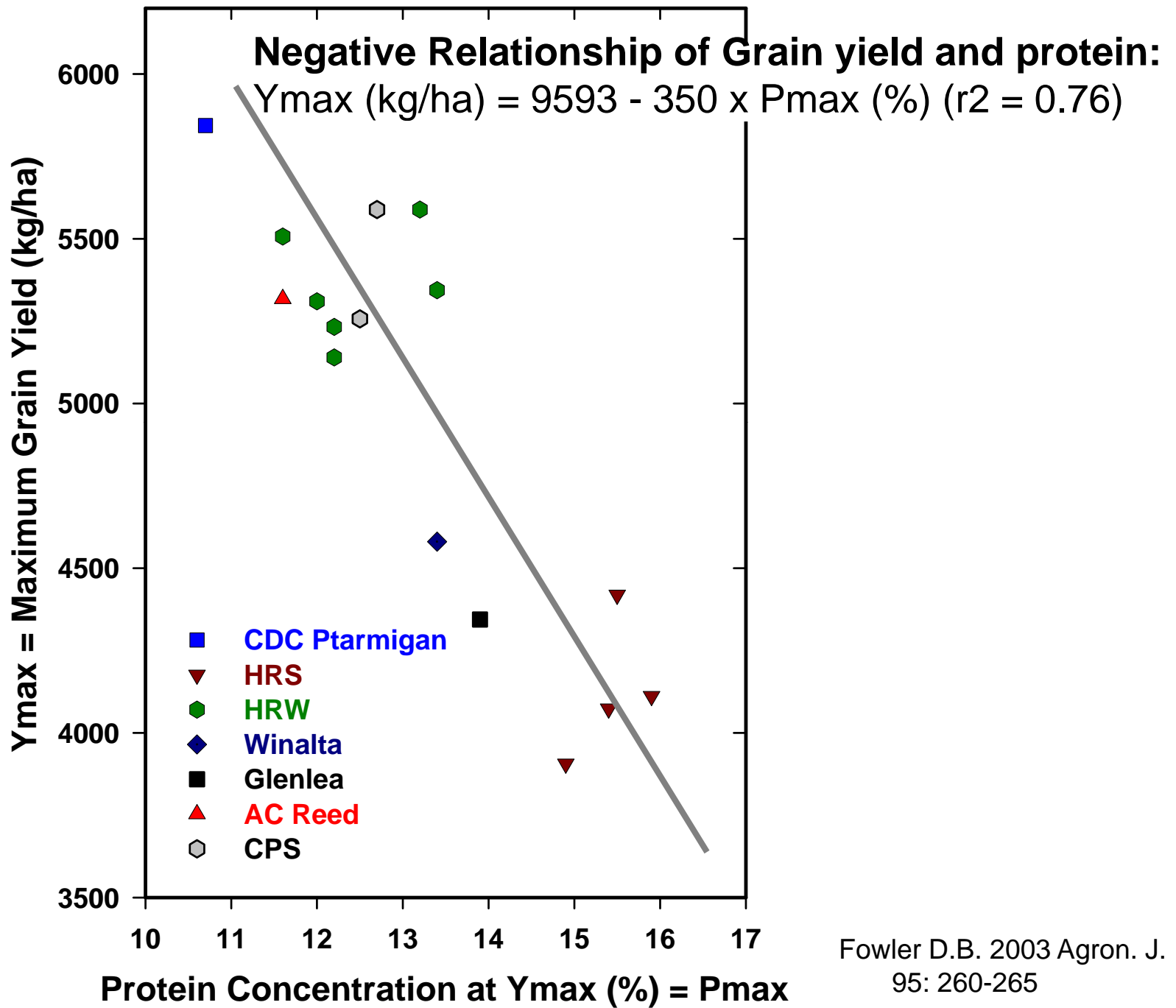
- Demand driven by population and affluence
- VS**
- Production limited by
    - Natural resource depletion: water, soils, fossil fuels, phosphorus, potassium
    - Limited arable land
    - Climate change impacts
    - Biotic and Abiotic factors
    - Opposition to technology

# Innovations to Enhance Competitiveness and Secure Food

- Increase grain yield
- Maintain protein concentration (statutory + labeling)
- Improve end-use suitability (quality)
- Improve nitrogen use efficiency
- Improve phosphorous use efficiency
- Improve water use efficiency
- Improve response to biotic stresses: FHB, rusts: Lr, Sr, Yr, sawfly, midge
- Improve response to abiotic stresses: e.g. seed bed stresses, heat shock, drought, cold, preharvest sprouting conditions,

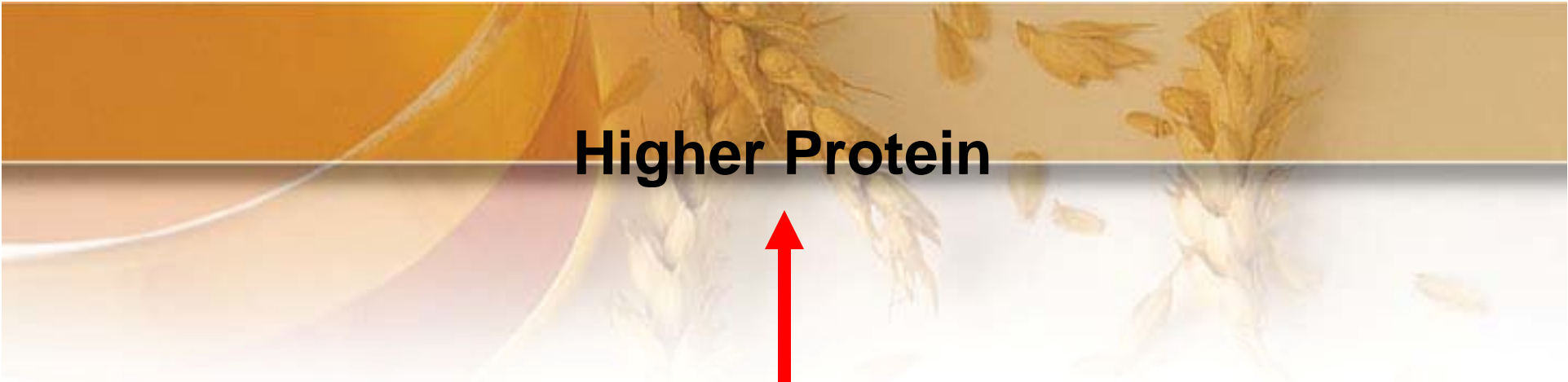
# Research Opportunities

- Genetic variability exists for all traits
- Knowledge
- Technology
- Genome sequenced (implications??)
- Transformation technology is ready to be deployed (GMO rDNA) ....traits????

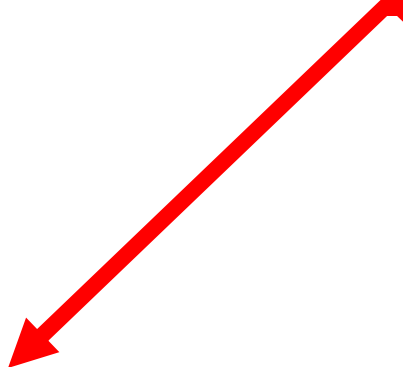


# Plant's Physiological Efficiency

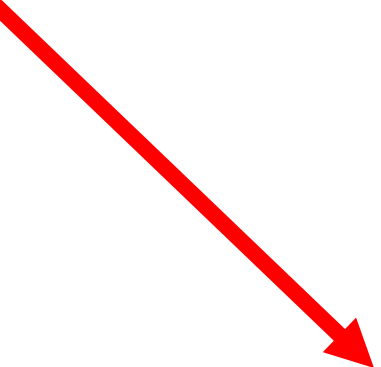
- 1 g glucose produced by photosynthesis can be used by the crop to produce
  - 0.83 g carbohydrates
  - 0.40 g protein ( $\text{NO}_3$  as the N source)
  - 0.33 g of lipid (Penning de Vries et al. 1974. J. theor. Biol. 45:339-377)
- Improve partitioning of carbohydrates
- Improve water use efficiency
- Improve nutrient use efficiency e.g. nitrogen



**Higher Protein**



**Greater Yield**



**Earlier Maturity**

# Build a Better Plant

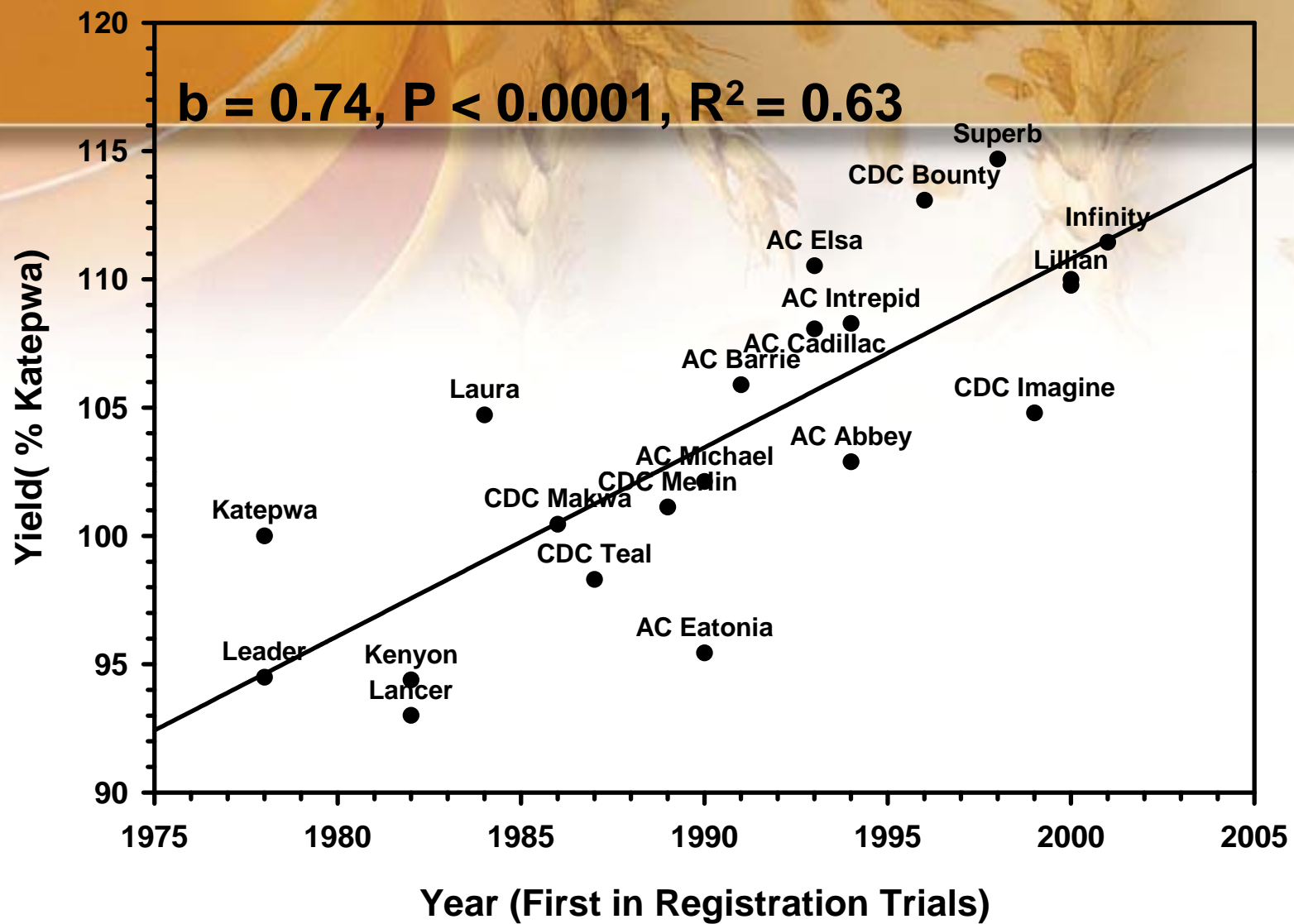
- Photosynthesis
- Physiology: drought / cold/ wet
- Resistant to diseases and insects
- Performance traits
- Productivity traits
- End use suitability traits (quality)
- Based on a very big number of genes!

# Proportion of desirable genotypes

Gene differences	Desirable Genotype Quotient (DGQ)			
	F2 (0.75) <sup>n</sup>	F4	F6	DHL (0.5) <sup>n</sup>
1	0.7500	0.5625	0.5156	0.5000
2	0.5625	0.3164	0.2659	0.2500
5	0.2373	0.0563	0.0364	0.0313
10	0.0563	0.0032	0.0013	0.0010
15	0.0134	0.0002	4.8418E-05	3.0518E-05
20	0.0032	1.0057E-05	1.7647E-06	9.5367E-07
30	1.7858E-04	3.1892E-08	2.3443E-09	9.3132E-10
40	1.0057E-05	1.0113E-10	3.1143E-12	9.0949E-13
42	5.6568E-06	3.2000E-11	8.2799E-13	2.2737E-13

# Minimum population size for single occurrence of desirable genotype

Gene differences	Minimum population size (1/DGQ)			
	F2	F4	F6	DHL/RIL
1	1	2	2	2
2	2	3	4	4
5	4	18	27	32
10	18	315	753	1024
15	75	5,600	20,653	32,768
20	315	99,437	566,658	1,048,576
30	5,600	31 million	426 million	1.1 billion
40	99,437	9.9 billion	321 billion	1.1 trillion
42	176,777	31 billion	1.2 trillion	4.4 trillion



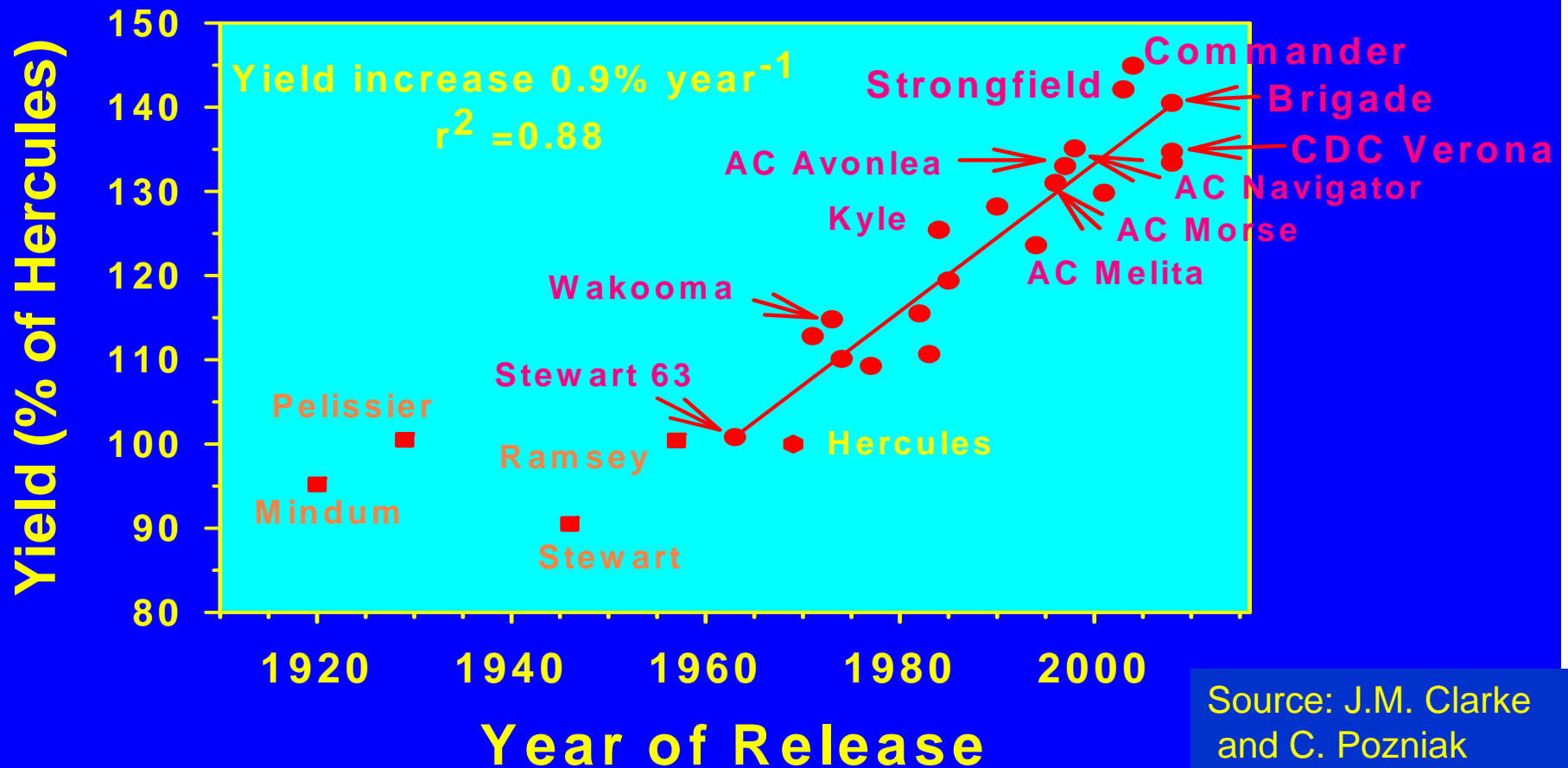
**Regression of grain yield (%) of Katepwa 1984 – 2004 on time for CWRS cultivars.**

Source: registration trial Western Bread Wheat C

# Production Traits

- Higher grain yield- Steady increase of 0.9%/yr

## Durum yield improvement in Canada 1963-2008



# **Yields can (will?) continue to climb, but ...**

- The cost per unit of improvement has risen consistently during the past 100 years
- Enthusiasm for production agriculture including plant breeding consistently declined (in the non-farm population of the rich countries)
- Funding for public sector plant breeding (and for public agricultural research in general) consistently declined worldwide

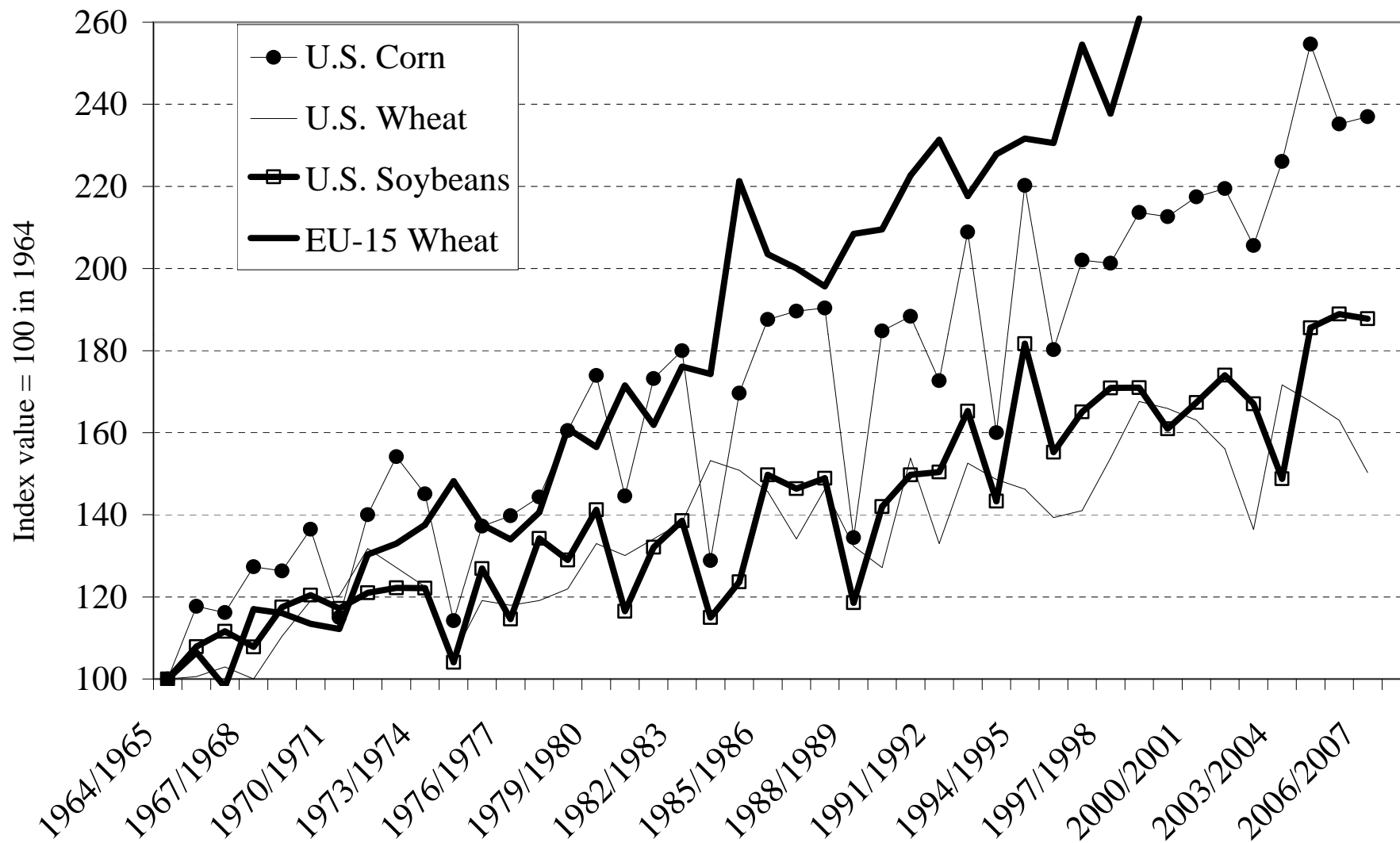
Source: D.N. Duvick, Johnston, Iowa

## What about biotechnology?

- Biotechnology's greatest contribution to plant breeding will be to increase the depth of knowledge about gene action and how to modify it to suit needs of farmers
- Biotechnology causes contrasting social problems at present; it arouses fears and raises hopes in two types of people:
  - Type 1: great fear of repressive monopolies
  - Type 2: great hope of high profit margins
  - Both types may be wrong

Source: D.N. Duvick, Johnston, Iowa

Figure 1. Yield index for U.S. corn, U.S. soybeans, U.S. wheat, and wheat in the EU-15



Source: S.Lence, S. Goggi and D. Hayes, Iowa State University

# Incremental value (per ha) of Stettler compared to check cultivars

	<b>Incremental Yield (%) of Stettler Over Other</b>	<b>Incremental Value for Yield of Stettler over other</b>	<b>Incremental Protein of Stettler over other</b>	<b>Incremental Value of Protein of Stettler over other</b>	<b>Total Incremental Value of Stettler over other</b>
<b>Katepwa</b>	<b>15</b>	<b>\$82</b>	<b>0.7</b>	<b>\$11</b>	<b>\$93</b>
<b>AC Barrie</b>	<b>11</b>	<b>\$60</b>	<b>0.4</b>	<b>\$6</b>	<b>\$66</b>
<b>Superb</b>	<b>2.6</b>	<b>\$14</b>	<b>0.9</b>	<b>\$15</b>	<b>\$29</b>
<b>Assume Stettler Yield (bus/ac)</b>	<b>35</b>				
<b>Assume Stettler Yield (t/ha)</b>	<b>2.35</b>				
<b>1CWRS 13.5% (\$/t) *</b>	<b>\$231</b>				
<b>Value of Protein per 0.1 (\$/t) *</b>	<b>\$0.69</b>				

\* CWB Average total payments 2004/05 to 2008/09

A background image showing a close-up of wheat stalks and a bowl filled with wheat, set against a warm, golden-brown gradient.

A successful effective wheat breeding program requires long term commitment and access to:

- Stable funding to employ trained competent staff
- Network of nurseries located on land in the targeted agro-ecological areas
- Non pay operating funds.
- Specialized equipment
- Capital items such as land and buildings.
- It must be preceded and undergirded by the proper political and economic climate, and governance structure.

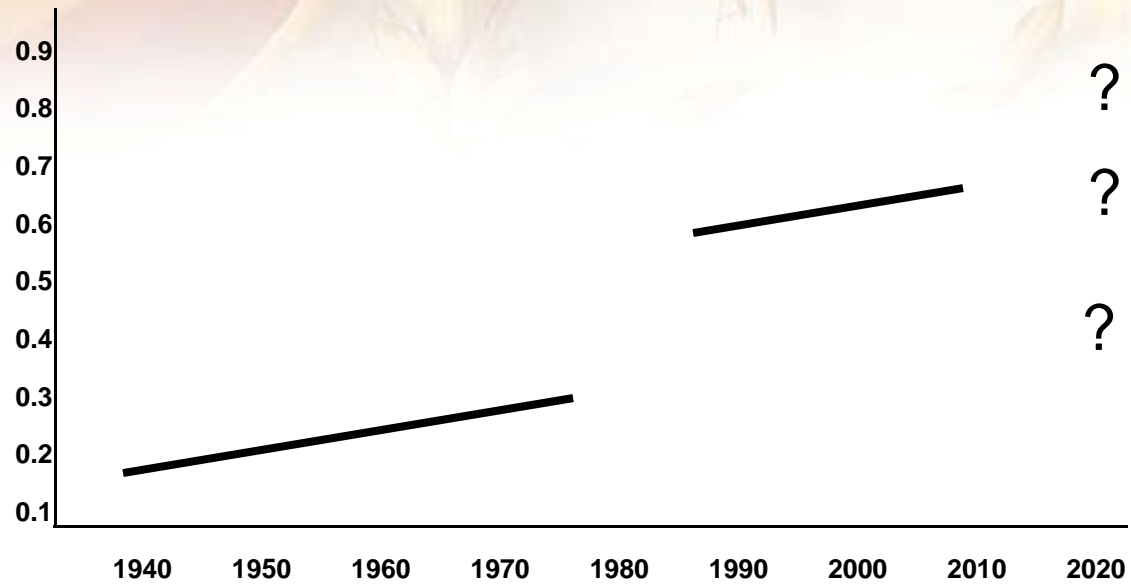
# Who pays for variety development?

- Taxpayer
- Producer
  - taxes
  - check-off or levy
  - Royalties
- Seed Companies
- The same parties benefit from improved genetics!

# Research Expenditures

- Current R&D expenditures ~\$15m / yr relative to annual value of \$5B farm gate and \$7B value added
- Canada's R&D in wheat is 2<sup>nd</sup> lowest of major wheat producing countries, and may have slipped to lowest.
- Very high return on incremental investment in wheat (R. Gray)
- Vs Canola \$50m relative to value of \$5B farm gate \$??  
B value added (to be fact checked)

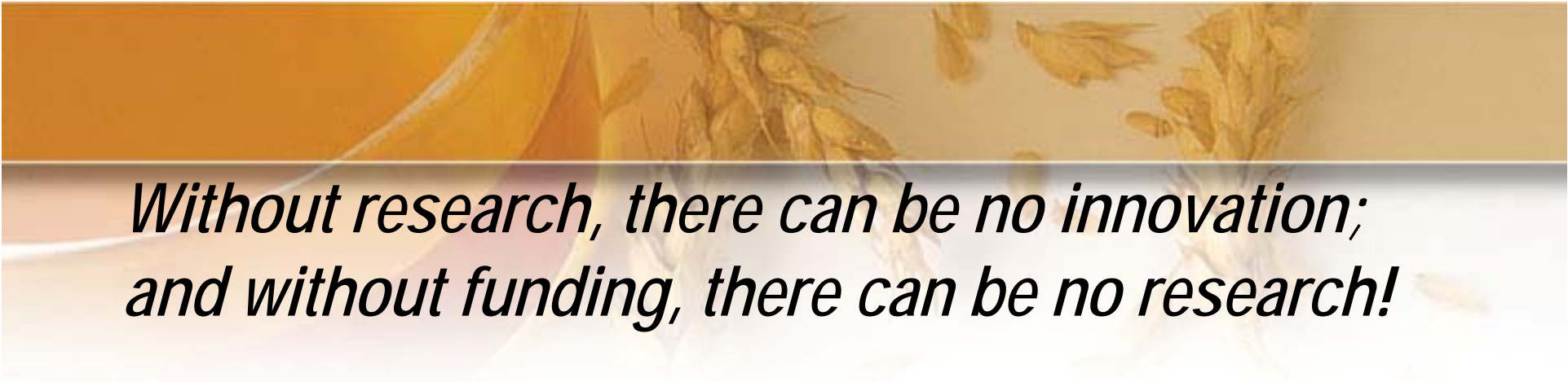
# Rate of Genetic Gain



**Each 0.1% change in rate of genetic yield gain has an approximate incremental gross value of \$5m/yr to farm gate without multiplier effect**

# Delivery Model: partnerships

- Scientific linkages
  - AAFC, universities and industry to apply science in food safety and quality, genomics, environmental protection, production systems
  - International: CGIAR, universities, other country public's
- Cultivar delivery
  - Strong commercialization program (public and private) with seed industry partners,
  - Re-investment of royalties (no longer incremental to genetic enhancement programs within AAFC)
- Partnerships
  - Industry investment : (producers, seed industry, grain marketers, processors)
- Identity preservation programs

A decorative header featuring a warm, golden-brown color palette. On the left, a portion of a white ceramic bowl is visible. The background is filled with soft-focus images of wheat stalks and individual grains, creating a textured, agricultural feel.

*Without research, there can be no innovation;  
and without funding, there can be no research!*

**Source: Grains Innovation Roundtable –  
Crop Research Funding Working Group**

# Summary

- Global food security challenge
- Innovations for competitive Canadian agriculture and food security
- Opportunities to deliver innovations
- Innovative products past and future
- Funding R & D and ROI