



# **The Genetic Contribution to Higher Soybean Yield**

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**USDA-Agricultural Research Service**

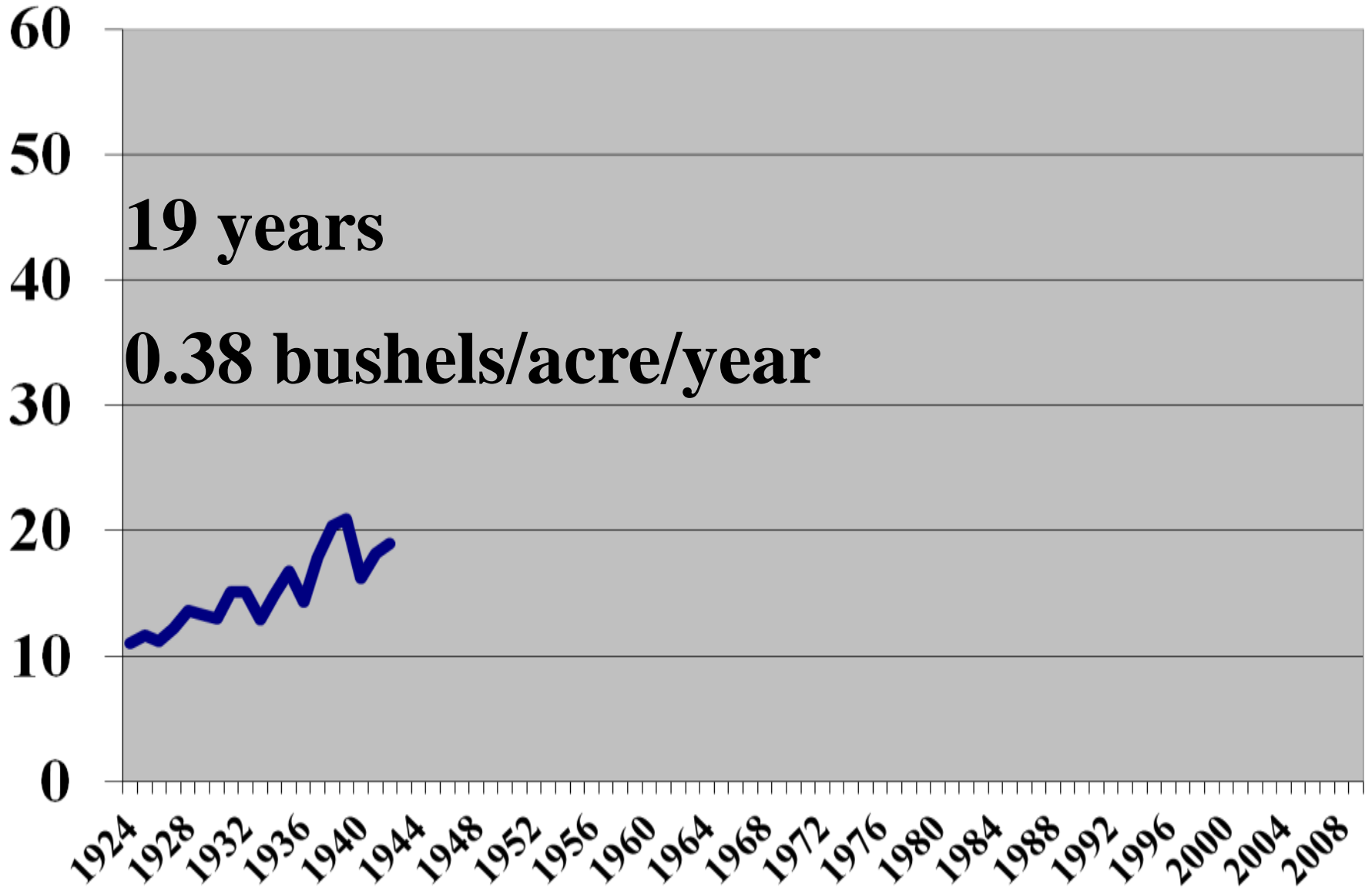
**University of Illinois**

# Eras of Soybean Breeding

- **Soybean introduction (to 1942)**
  - **Varieties introduced from Asia**
  - **Within and among variety selection**

# Changes in Soybean Yield in U.S.

Bu/A



# Eras of Soybean Breeding

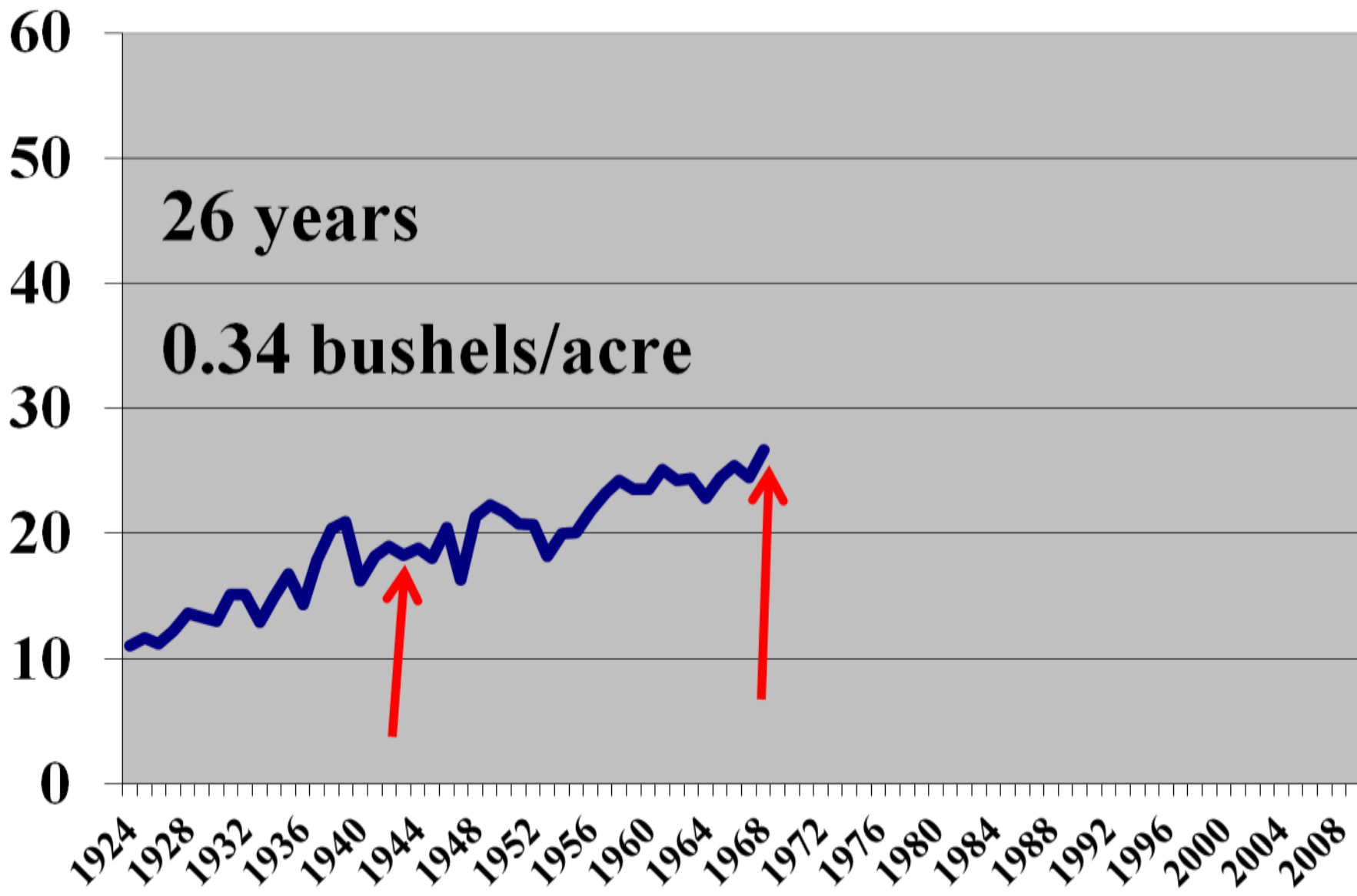
- Soybean introduction
- Scientific plant breeding (43-68)
  - 15 soybean varieties
  - Hand-harvested
  - Fewer seeds per pod

Lincoln 1943



# Changes in Soybean Yield in U.S.

Bu/A



# Eras of Soybean Breeding

- Soybean introduction
- Scientific plant breeding
- Expansion and mechanization

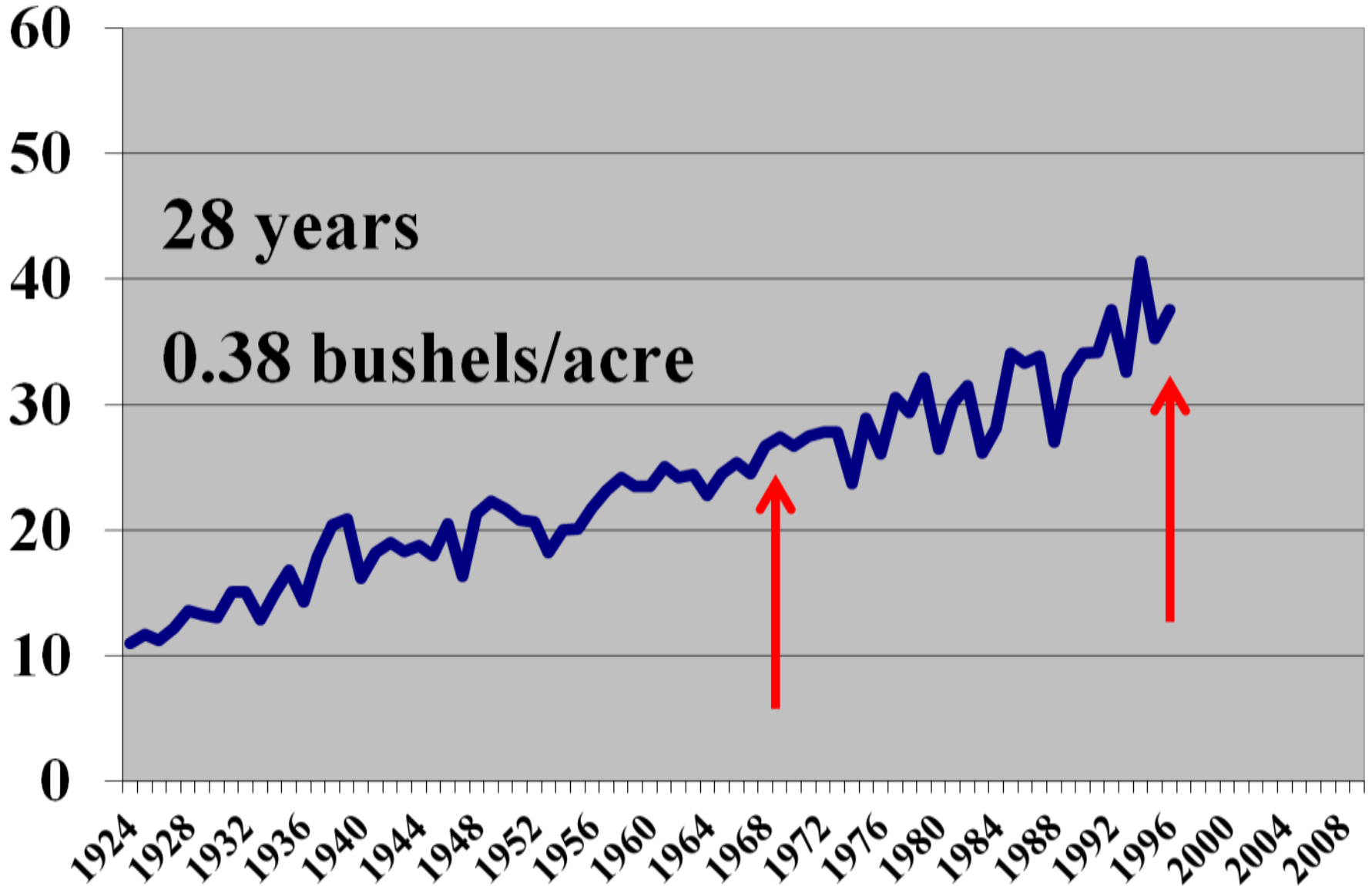


1969 to 1996  
Tractor planting and combines  
Computers for data management  
More private and public  
Transition to proprietary

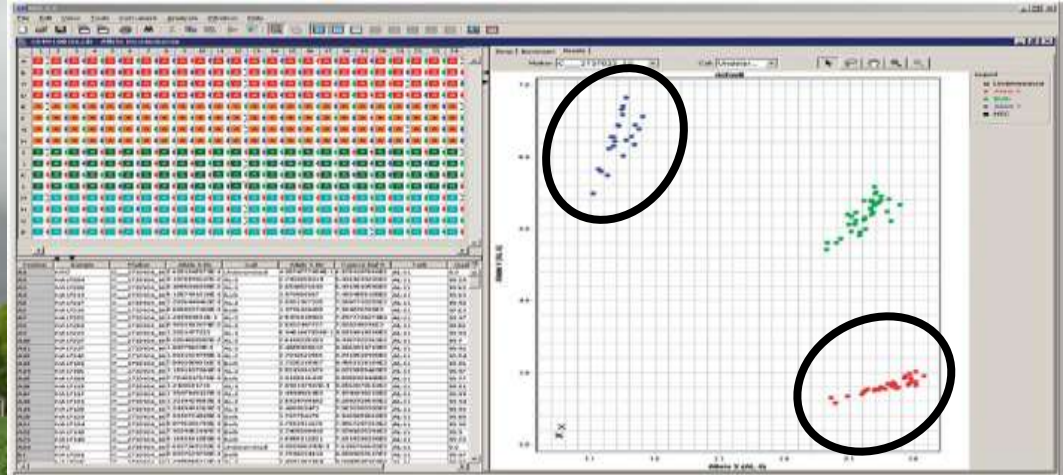


# Changes in Soybean Yield in U.S.

Bu/A



# Eras of Soybean Breeding

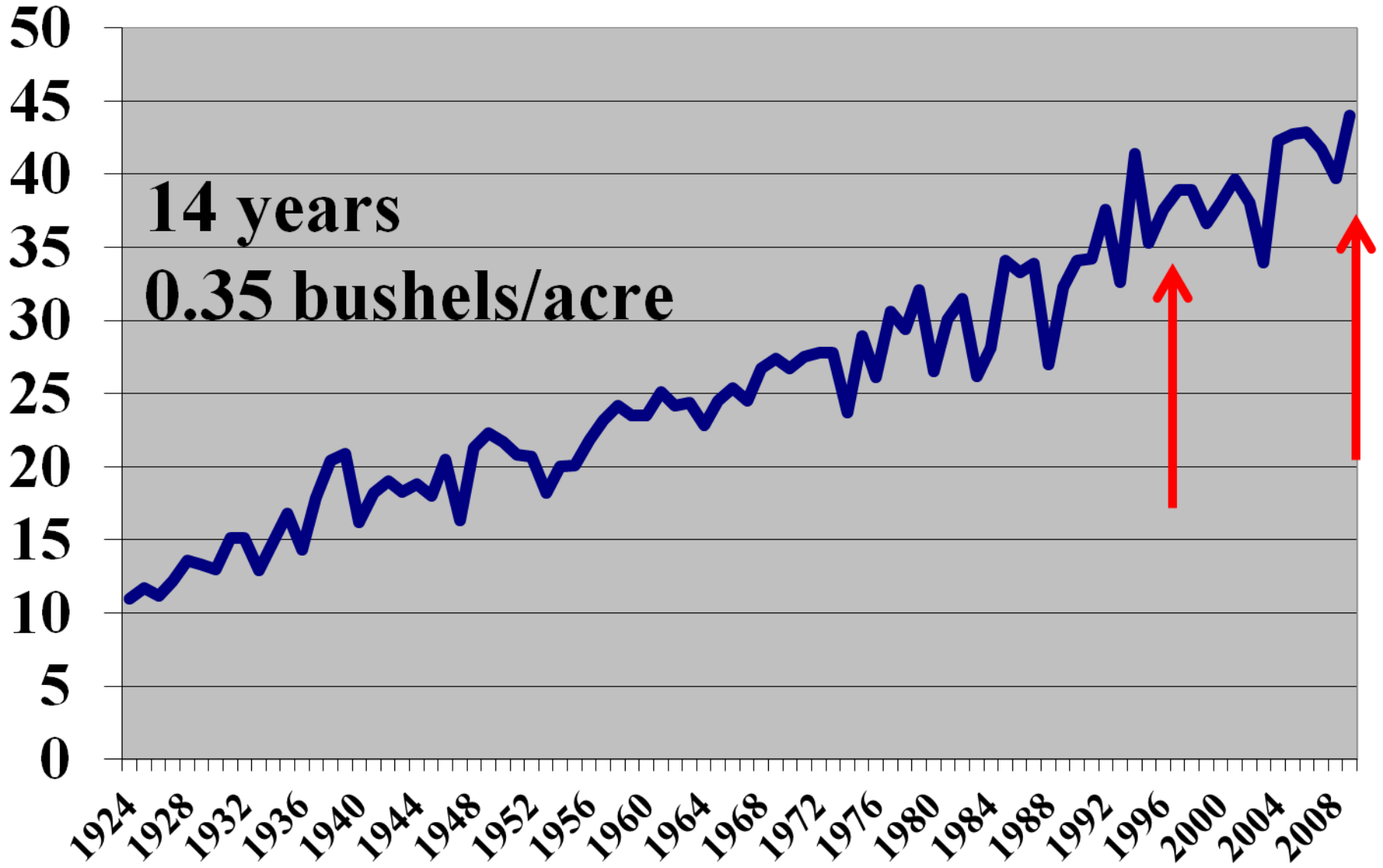


- **Transgenics**
  - Equipment adv
  - Off season nurs
  - Marker assisted
  - Increase in rese



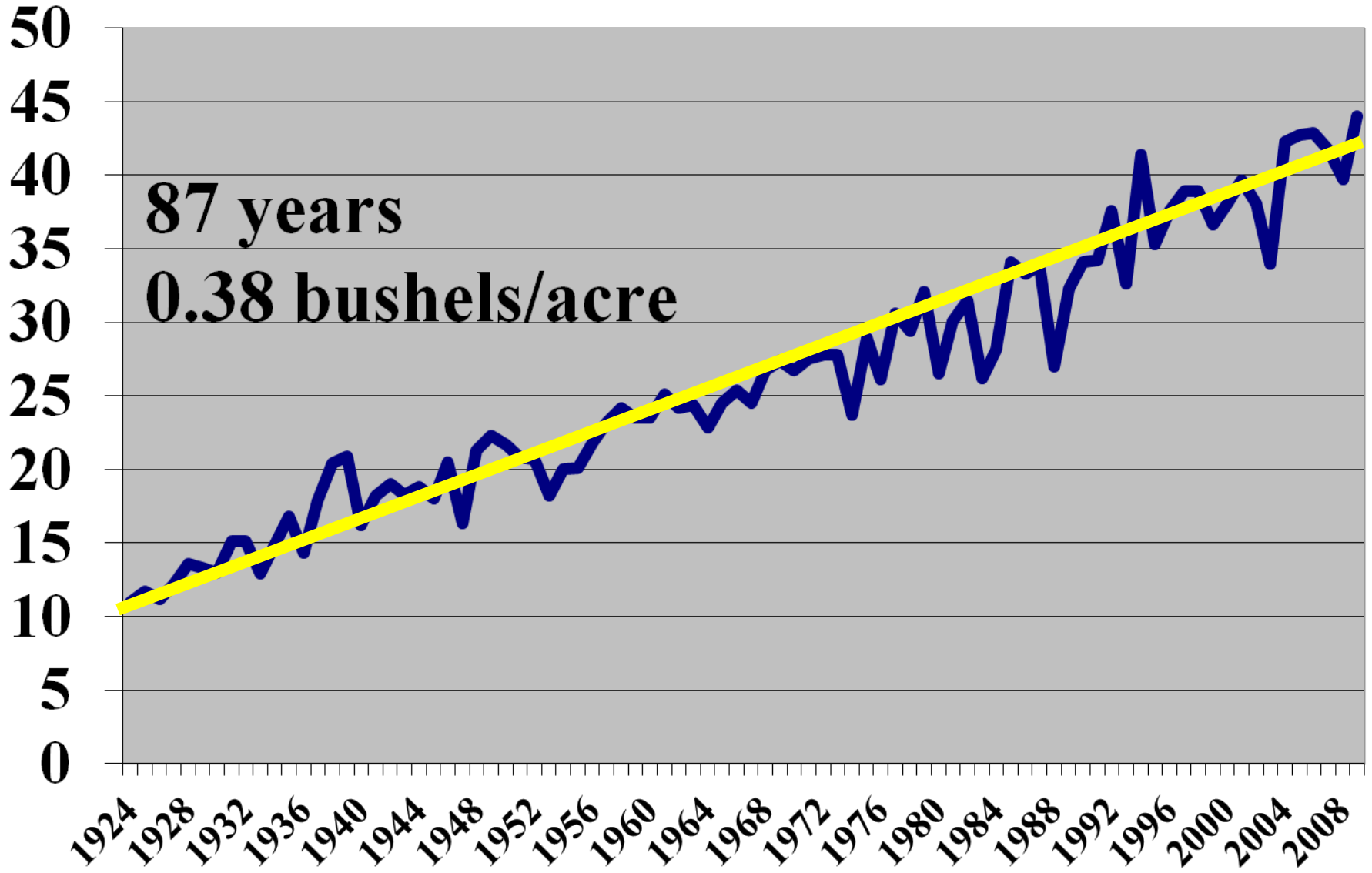
# Changes in Soybean Yield in U.S.

Bu/A



# Changes in Soybean Yield in U.S.

Bu/A



# What determines average yield?

- **Environment**

- **Rainfall**
- **Diseases and pests**
  - Soil type
- **Genetic base of crop**



potential



# Where are we?

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- ✓ We are still making progress
- ✓ Gains per unit input are decreasing
- ✓ There is potential for increase

# How do we increase yield?

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- Improve physiological efficiencies
- Provide protection from diseases and pests



# **What can plant breeders do?**

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- **Change breeding efficiency**
- **Expand the genetic base**
- **Incorporate transgenes**

# Increasing breeding efficiency

Variety development time

Selection techniques

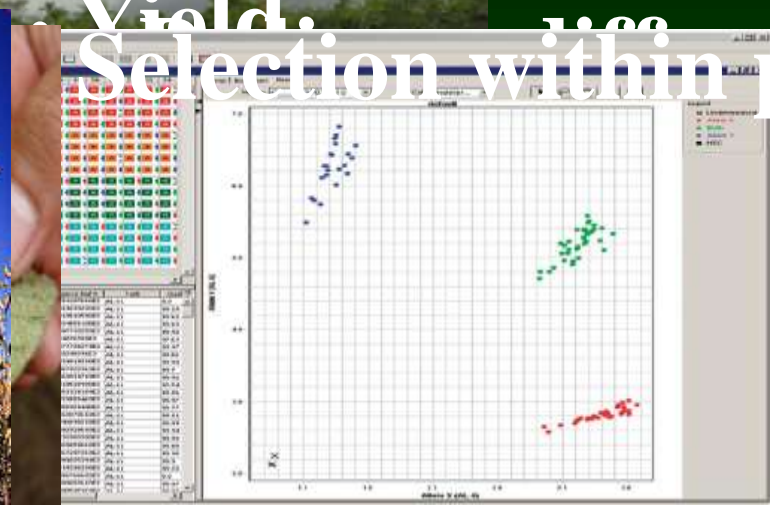
Marker assisted selection

• Disease and insect  
Parent A x Parent B

Yield

Selection within populations

ff  
ff



# **Expanding the Genetic Base**

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- **Current genetic base**

# U.S. Soybean Gene Pool

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**35** ancestors account for **96%** of genes

**5** ancestors provide **55%** of the genes

**7** crosses contributed **70%** of the genes

Pool **~85%** complete by **1954**

Pool **~95%** complete by **1970**

# **Expanding the Genetic Base**

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- **Current genetic base**
- **USDA Soybean Germplasm Collection**  
**has >17,000 germplasm lines not used**

# Types of exotic soybean germplasm

- Wild soybean
- Primitive varieties
- Early plant type
- Modern plant type



# Uniform IV Test 2007-08

## 22 locations

Entry	Pedigree	Bu/a	Mat
<b>LG04-6000</b>	<b>HS93-4118 x LG97-9912</b>	<b>59.1</b>	<b>3.9</b>
<b>LD00-3309</b>	<b>Check</b>	<b>54.7</b>	<b>0.0</b>

**Jilin 15 (PI 436682) is 13% of LG04-6000.**

**Jilin 15 was released in 1978, introduced in 1979.**

# Prelim Uniform III Test – 2009

## 11 locations

Strain	Pedigree	Exotic	Bu/a	Mat
IA3023	Check		68.2 b	0
IA4004	Check		70.4 ab	0.7
LG06-2354	LG97-9301 x S25-J5	38%	72.6 a	0.5

**LSD (0.05)**

**4.0**

PI 253665D is a 1950's cultivar from China

PI 283331 from Morocco in 1962

PI 391594 is Jilin No. 8 in 1974 (released in 1971)

# Uniform IV Test – 2010

## 15 locations

Entry	Pedigree	% exotic	Bu/a	Mat
<u>LD00-3309</u>			53.6	9/22
<b>LG06-5798</b>	LG00-3372 x <u>LD00-3309</u>	50	57.2	+5.2

LSD (0.05)

2.7

Hui nan zi hua he jia is PI 561319A  
Fen dou 31 (1990) is PI 574477

# Yield QTL Mapping



DNA marker

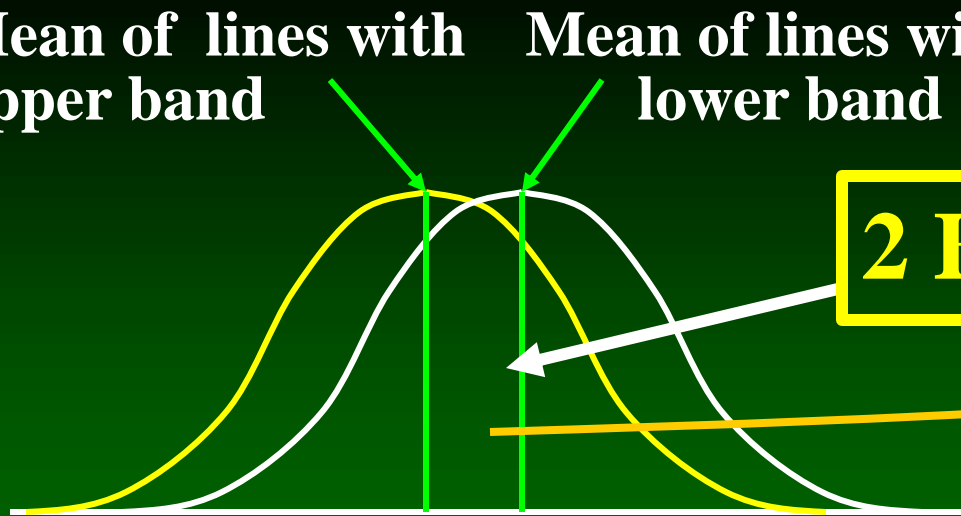
Quantitative trait locus (QTL)

Mean of lines with upper band

Mean of lines with lower band

2 Bu/A

Yield



# Confirming Yield QTL

## LD00-3309 (2) x LG01-16487

Chr 5/Chr 14	Hgt	Mat	Ldg	Bu/a	$\Delta$
<b>BB</b>	33	9-26	1.5	52.0	
<b>BA</b>	34	9-26	1.4	53.8	1.8
<b>AB</b>	34	9-26	1.5	54.4	2.4
<b>AA</b>	34	9-26	1.5	55.6	3.6

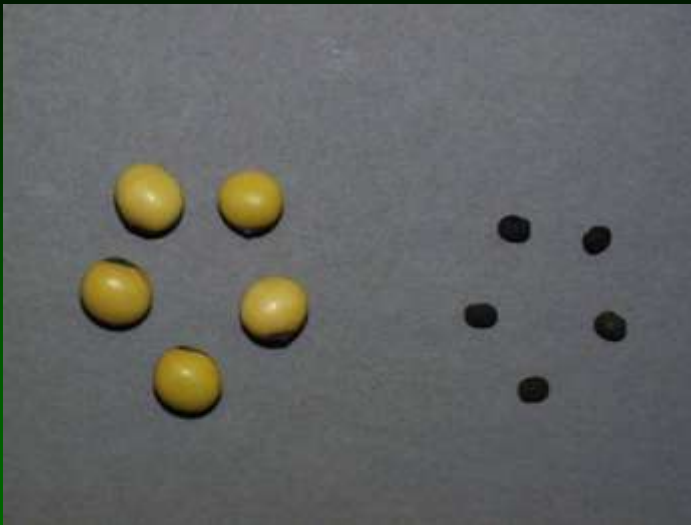
A allele from PI 68658, B allele from LD00-3309

# Exotic parents in released germplasm

- **21 high yielding, experimental lines**
- **Derived from 29 exotic parental lines**
- **29 ancestors account for 93% of gene pool**
- **50 introductions in 2011 advanced tests**
- **Potential to radically change gene pool**

# *Glycine soja*

Highly diverse  
Difficult parent



# Prelim Uniform IIB Test – 2010

## 11 locations

<u>Entry</u>	<u>Pedigree</u>	<u>Bu/a</u>	<u>Mat</u>
LG07-2309	F4 IA3023 x LG01-7728	61.9	4.2
IA 3023	Check	61.7	0

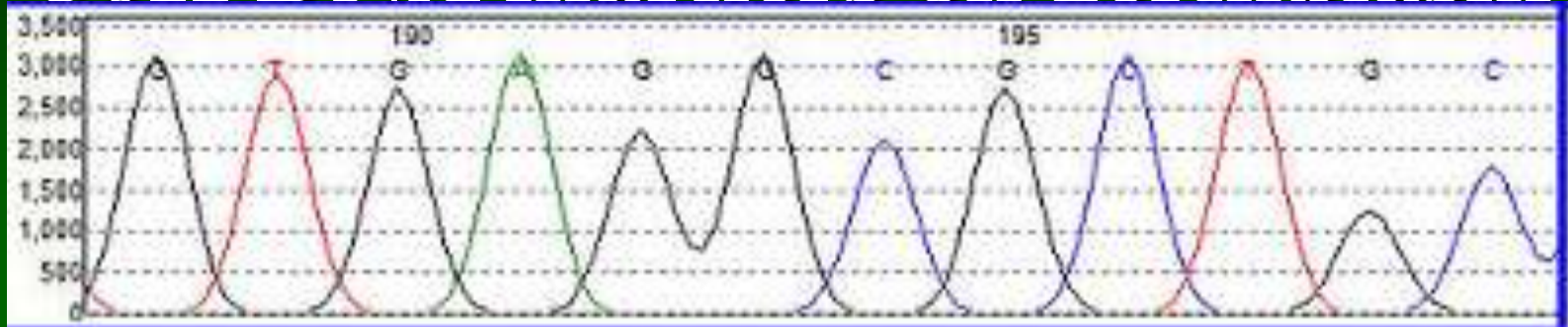
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**LG01-7728 is Williams 82 (2) x PI 479767 (*G. soja*)**

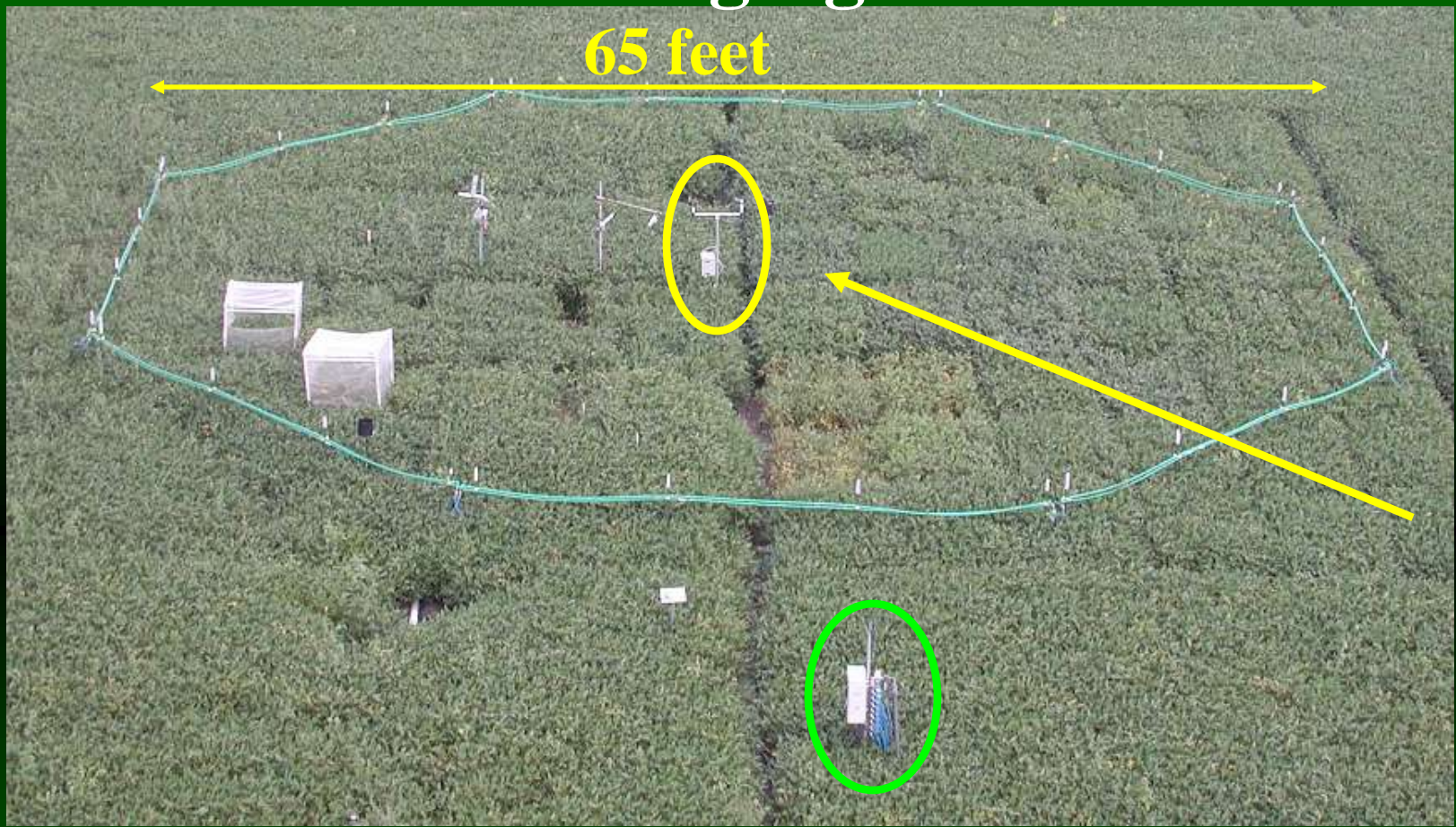
# Expanding the Genetic Base

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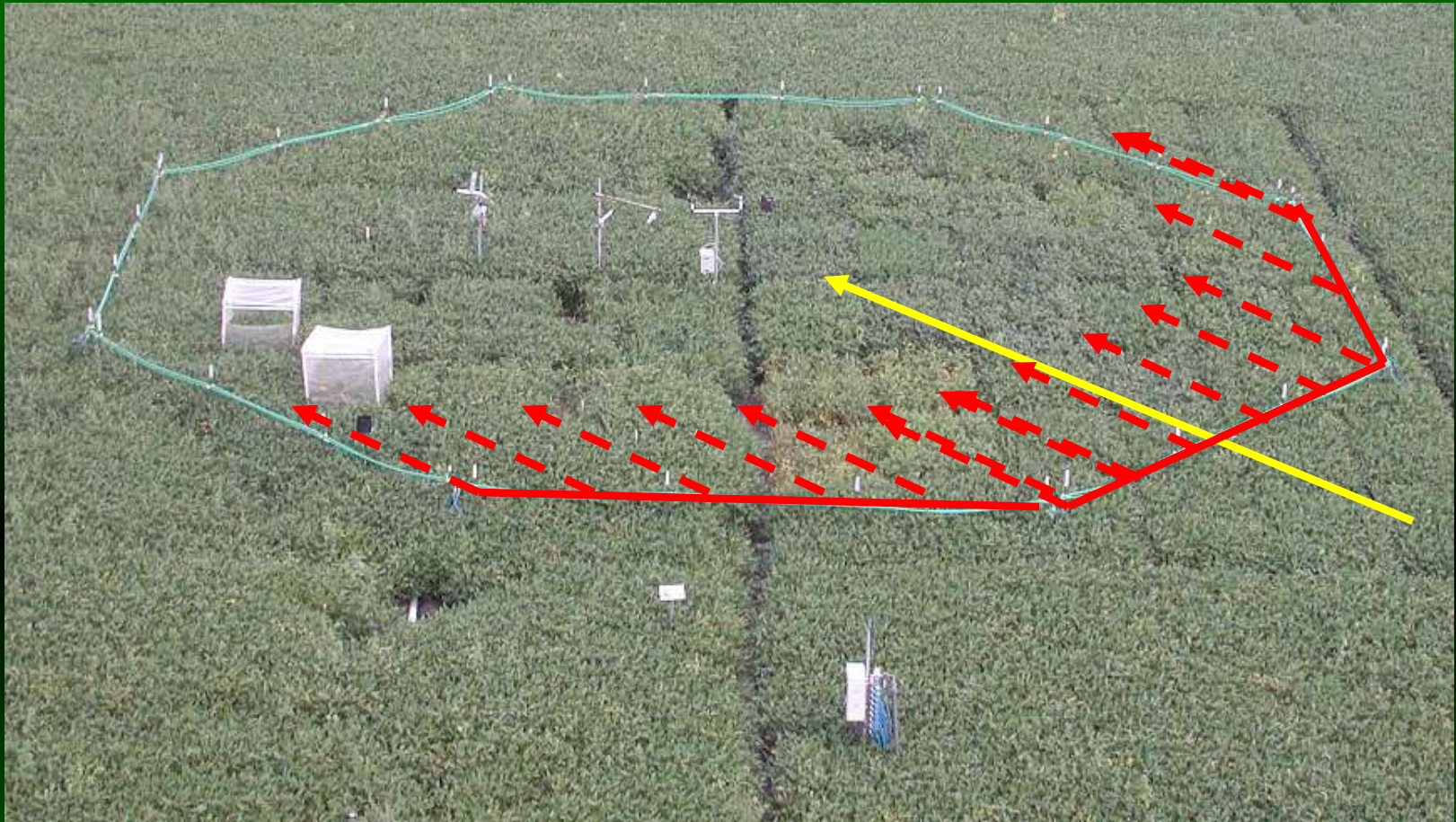
- Current genetic base
- 17,000 germplasm lines not used
- Sequencing of the soybean genome
- 50K DNA markers on germplasm

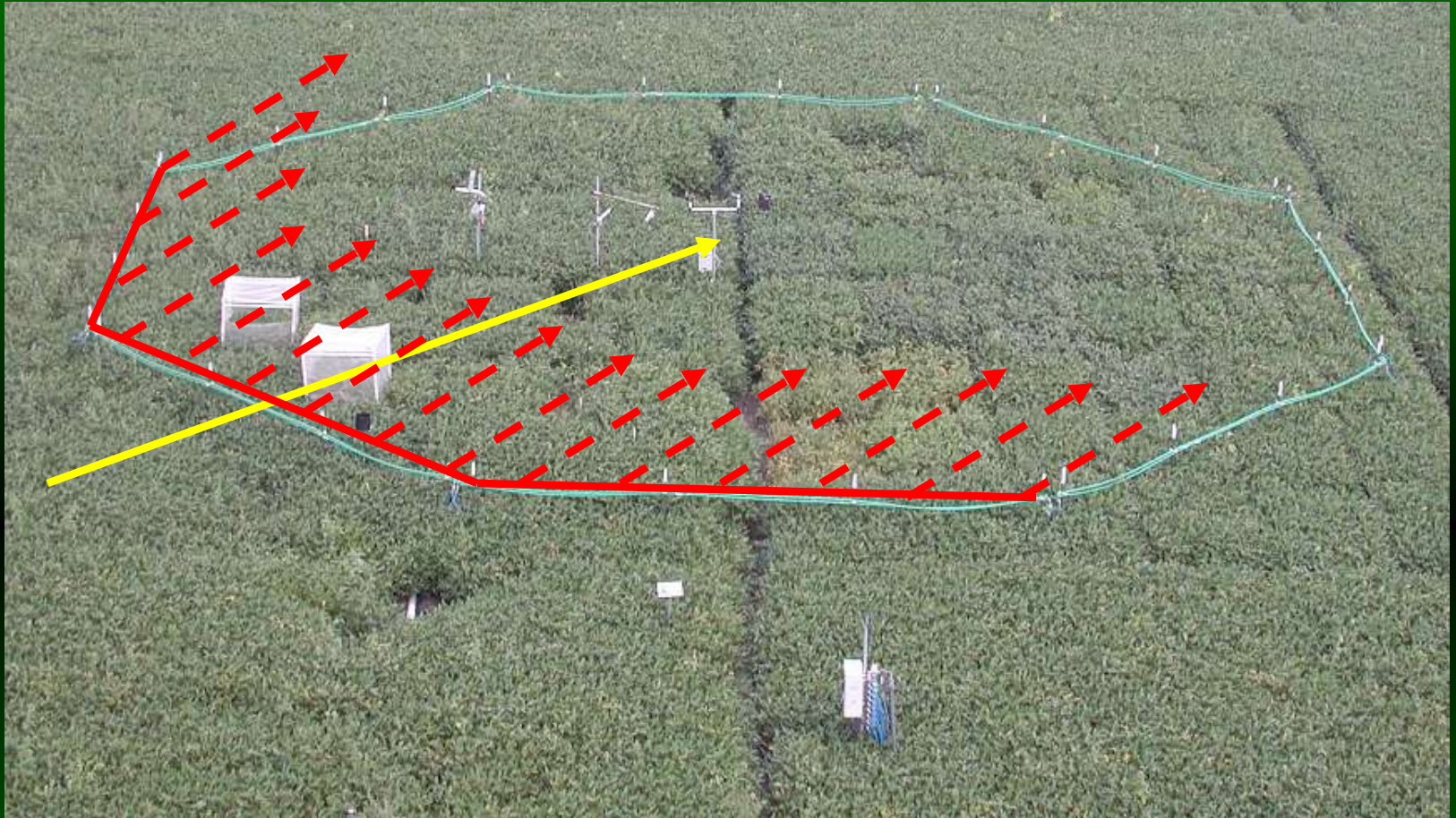


# Effects of a Changing Environment

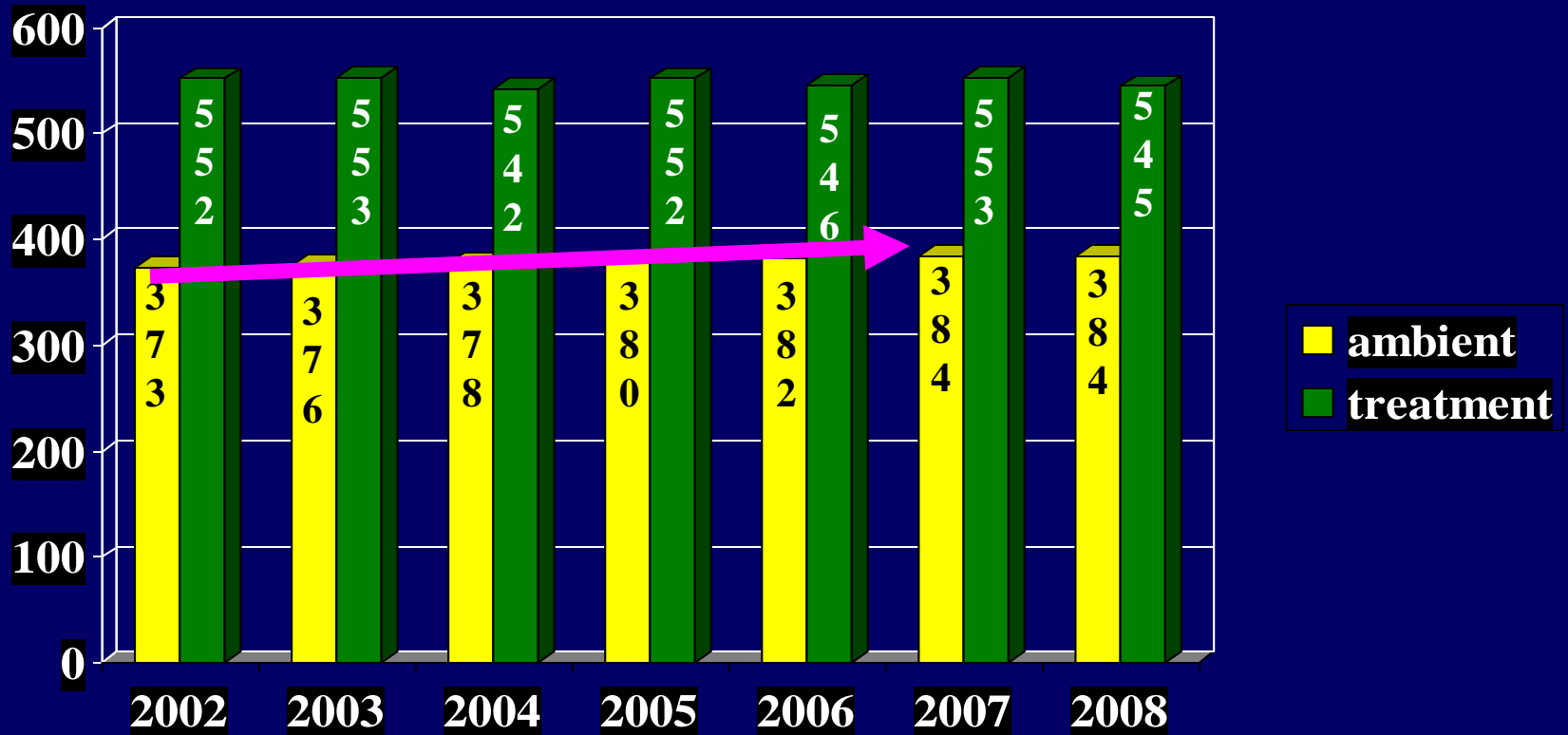


Soybean Free Air SoyFACE Concentration Enrichment





# CO<sub>2</sub> Concentration



# Differential CO<sub>2</sub> Responders

5 year averages

Entry	Bu/A	Bu/A	%Δ
Loda	53.9	66.8	24%
HS93-4118	52.7	54.5	4%



# Ozone formation

Ozone formation

Sunlight



Oxygen ( $O_2$ ) +  
Volatile Organic Compounds (VOC) +  
Nitrogen Oxides ( $NO_x$ )



Ozone ( $O_3$ )



# Ozone can consistently reach damaging levels

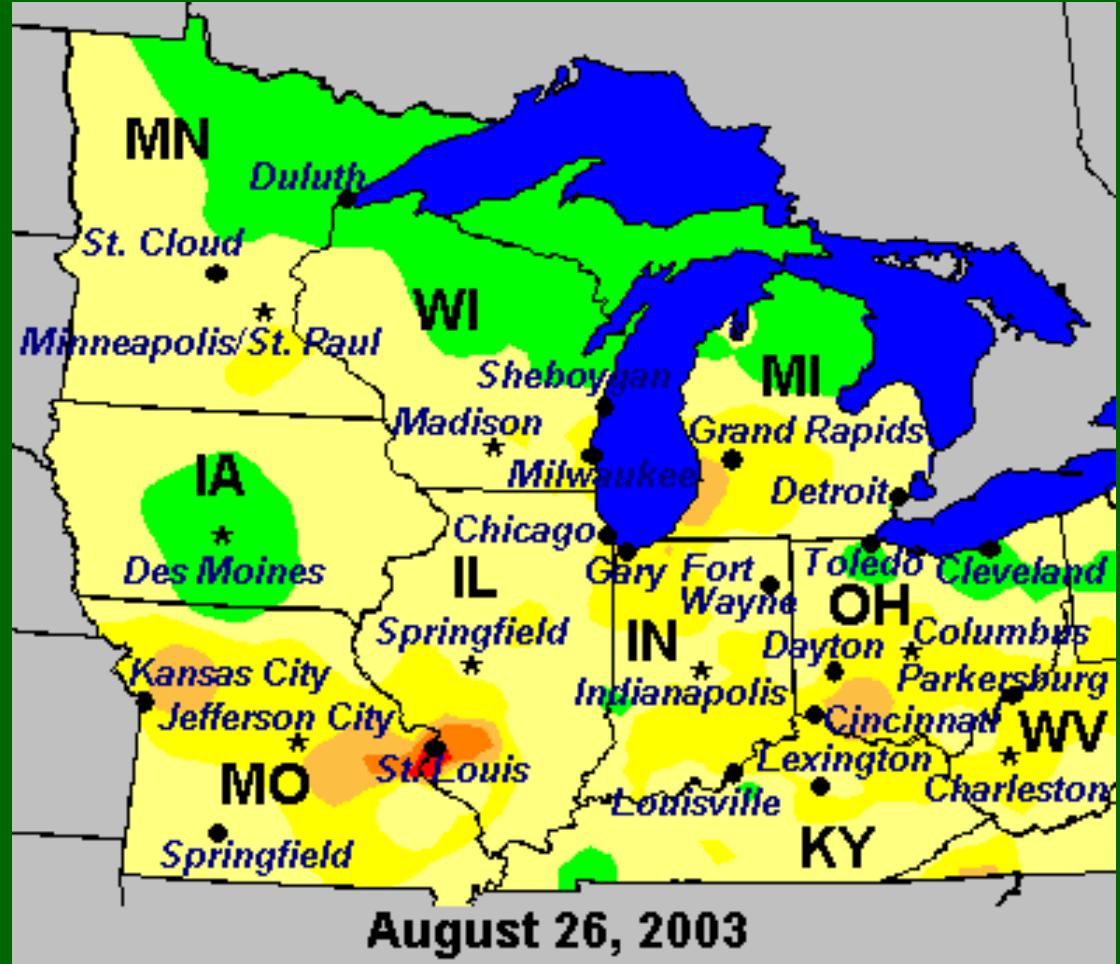
Lt yellow 61-79 ppb

Dk yellow 80-99

Lt orange 100-110

Dk orange 111-125

Red >125



# Ozone can consistently reach damaging levels

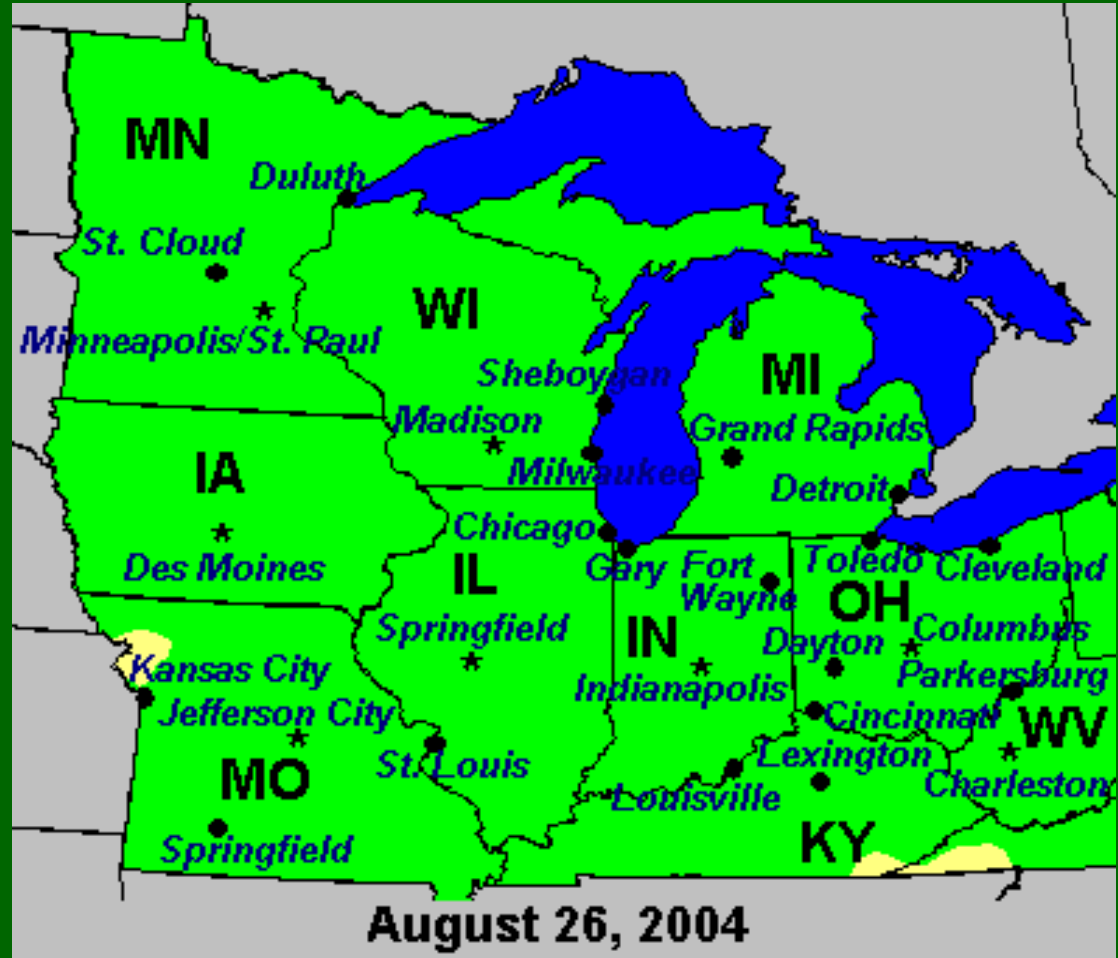
Lt yellow 61-79 ppb

Dk yellow 80-99

Lt orange 100-110

Dk orange 111-125

Red >125



# Differential O<sub>3</sub> Responders

5 year averages

Entry	Bu/A	Bu/A	% $\Delta$
Dwight	55.7	48.0	-14%
LN97-15076	47.5	44.6	-6%



# Transgenics

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- **Proprietary research**
- **Broad spectrum resistance**
- **Yield is genetically complex**

# How to Increase Soybean Yield

- Shorter variety development time +
- Selection for disease/p
- Use of transgenes ++?
- Use of exotic germplasm
- Understanding the ge



# How to Increase Soybean Yield

- Shorter variety development time +
- Selection for disease/pest resistance ++
- Use of transgenes ++?
- Use of exotic germplasm for yield ++++
- Understanding the genetics of yield ++++



# Thanks!



# Questions?

