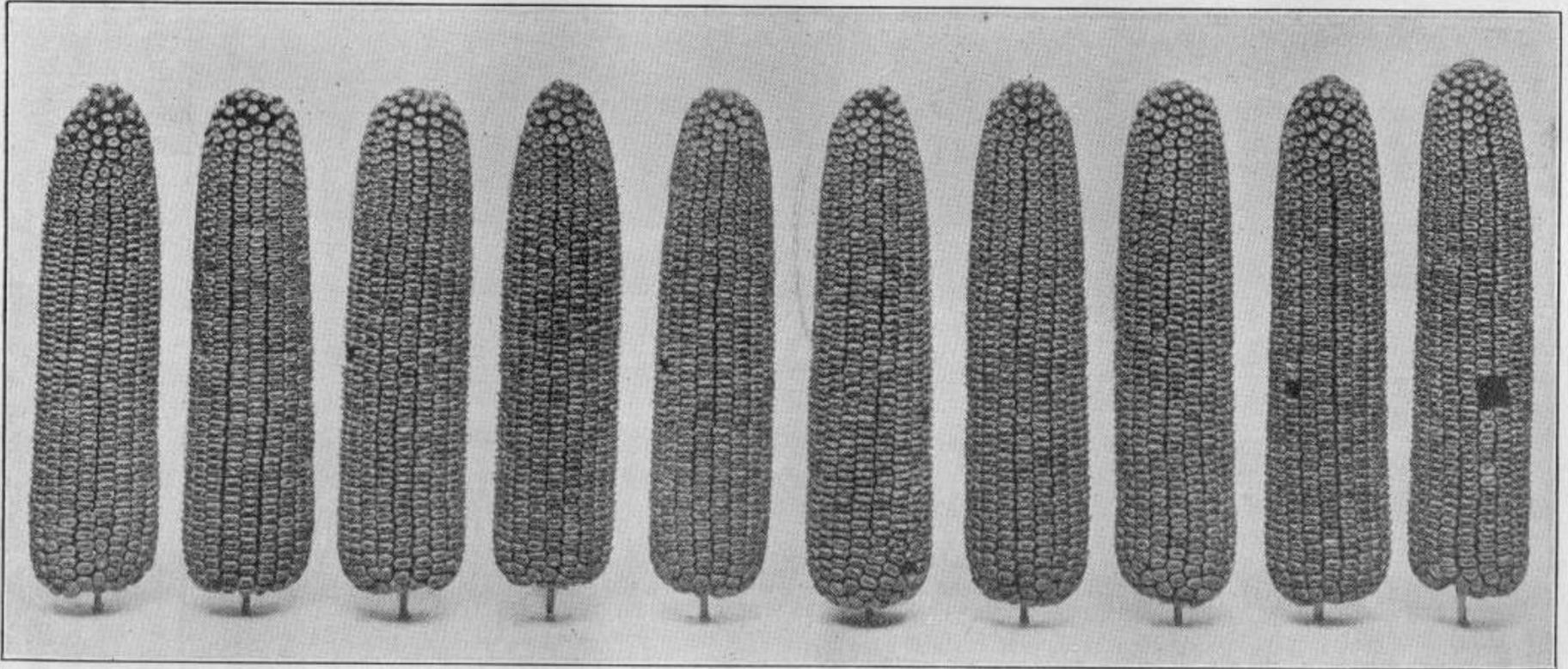


# Breeding Better Corn On-Farm



REID'S YELLOW DENT

REID'S YELLOW DENT. CHAMPION TEN EARS OF IOWA SHOWN JANUARY, 1907. GROWN BY BENNETT BROS.

Frank Kutka  
Seed We Need & NPSAS



**Maize can be nutritious and delicious!**

Mean yields and grain quality for maize varieties evaluated at 71,000/ha in three organically managed fields in New York, 2002

Variety	Yield	% CP	% Fat	% Ash
<b>White Flint</b>	1223 <sup>d</sup>	11.4 <sup>a</sup>	5.8 <sup>a</sup>	2.1 <sup>a</sup>
<b>Golden Glow</b>	2032 <sup>d</sup>	11.2 <sup>a</sup>	4.9 <sup>bc</sup>	1.6 <sup>c</sup>
<b>Nokomis Gold</b>	3687 <sup>b</sup>	10.5 <sup>b</sup>	5.0 <sup>b</sup>	1.6 <sup>c</sup>
<b>Wapsie Valley</b>	3355 <sup>c</sup>	10.6 <sup>b</sup>	4.7 <sup>c</sup>	1.7 <sup>b</sup>
Pio brand 35P12	6478 <sup>a</sup>	9.5 <sup>c</sup>	3.9 <sup>e</sup>	1.5 <sup>d</sup>
Pio brand 36B08	6716 <sup>a</sup>	9.2 <sup>cd</sup>	4.0 <sup>e</sup>	1.5 <sup>de</sup>
MC brand MC530	4321 <sup>b</sup>	8.9 <sup>d</sup>	4.5 <sup>d</sup>	1.4 <sup>e</sup>
MC brand MC540	4007 <sup>b</sup>	9.1 <sup>cd</sup>	3.9 <sup>e</sup>	1.4 <sup>e</sup>



**Maize brings to us  
the colors of the  
rainbow!**

**Dave Christensen,  
Seedweneed.com**



**And it is incredibly adaptable!**

UB MANUAL

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF  
THE COLLEGE OF AGRICULTURE  
Plant Biology

PLANT-BREEDING  
FOR FARMERS



By H. J. WEBBER.

of Agricultural Extension  
Lafayette, Indiana  
Acts of May 3 and June 26, 1914

# Developing seed for organic corn

## Key Points

- Martenses contend that seed corn needs to be better adapted for organics.
- Inbreds require higher fertility to perform best under stress.
- Margaret Smith, Cornell plant breeder, is the technology leader of this project.

By **KARA LYNN DUNN**

**A**S noted in this issue's cover story, the New York Farm Viability Institute is funding a two-year project to develop hybrid seed corn better adapted for organic corn production in the state. Mary-Howell and husband Klaas of Martens Farms, Penn Yan, N.Y., are working with Margaret Smith, Cornell University plant breeder.

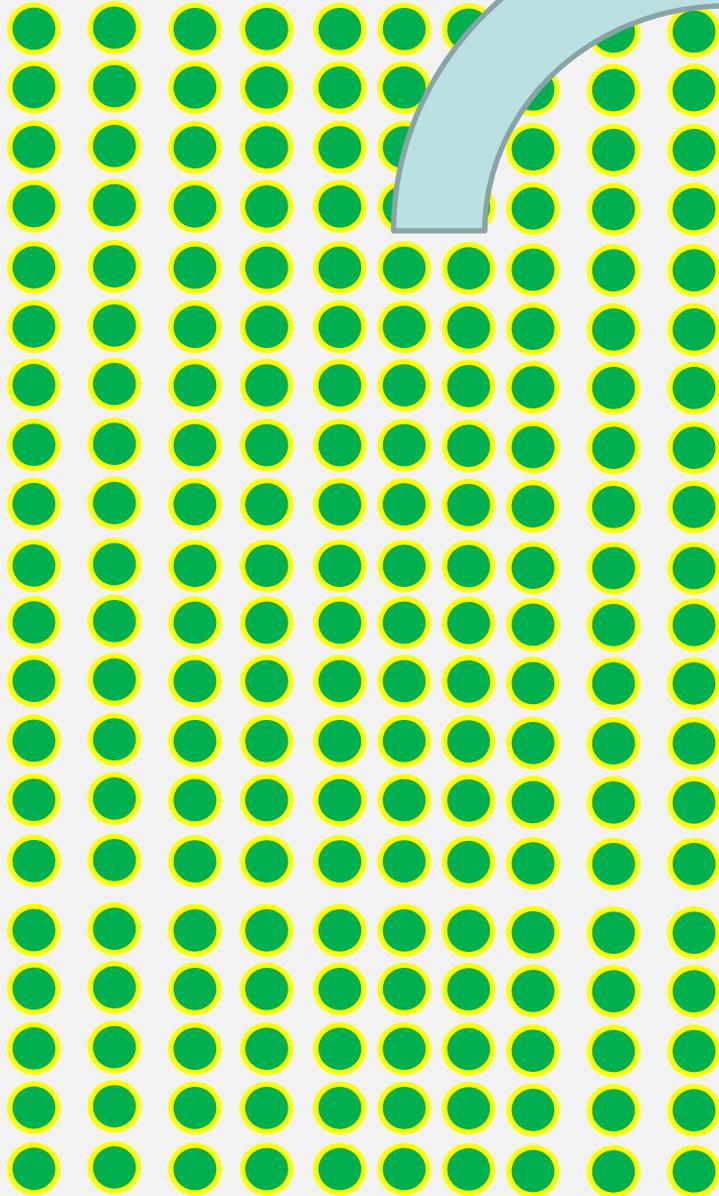
"We need seed adaptable for the area where it'll be grown," reiterates Mary-Howell, who also manages the Lakeview Organic Grain feed mill.

"Organic farmers need modern corn breeding in our hybrids to advance



PHOTO BY SPENCER TULLIS

# The Old, Casual Way



- All ears to a storage crib or bin in fall
- Select nice looking, big ears in spring
- Select ears for form
- Shell just enough ears to plant
- Plant by other corn



A plentiful harvest is pleasing.

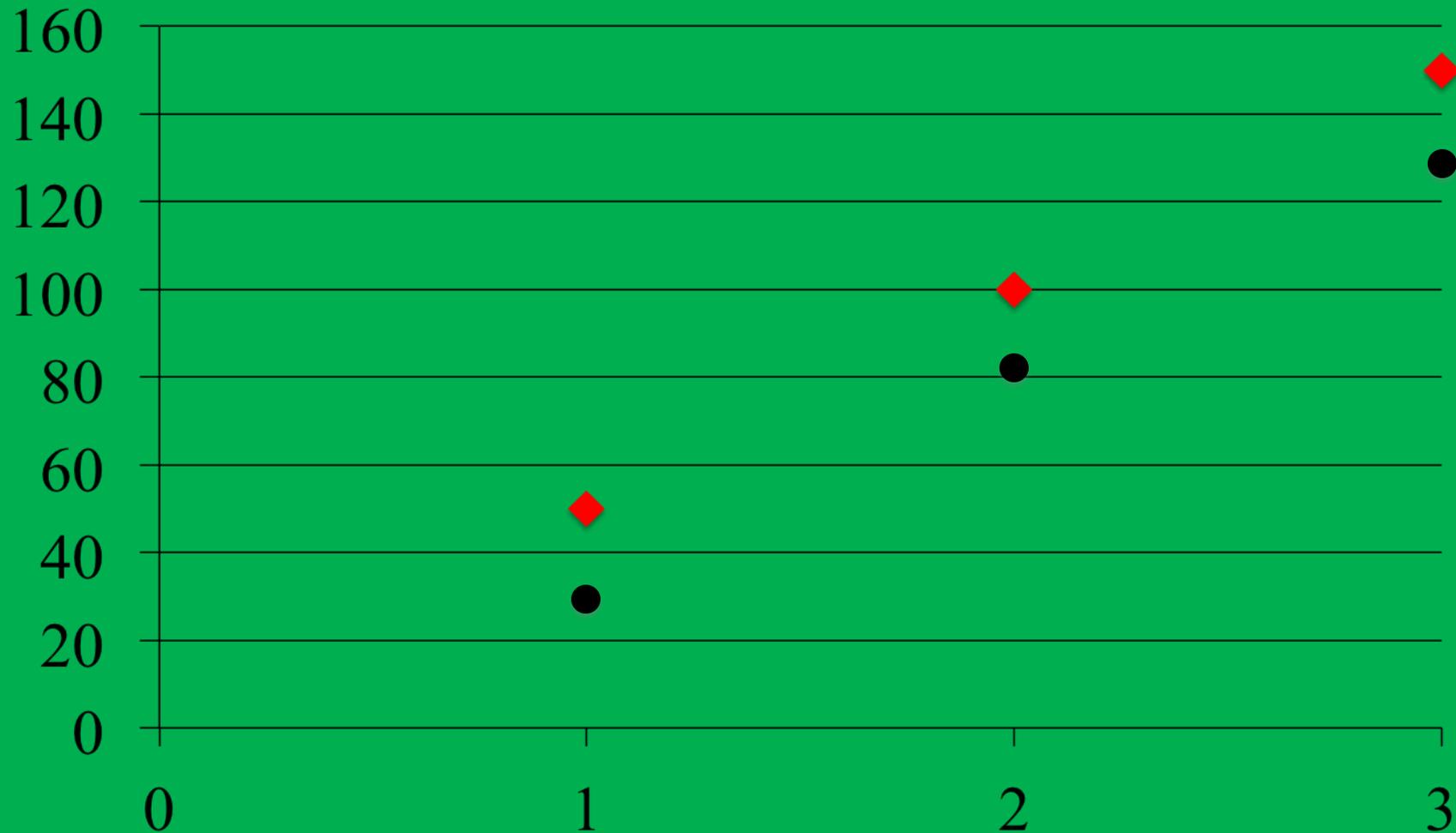
**Focus on  
YIELD,  
but don't  
forget  
quality,  
dry down,  
etc.!**

# Remember these:

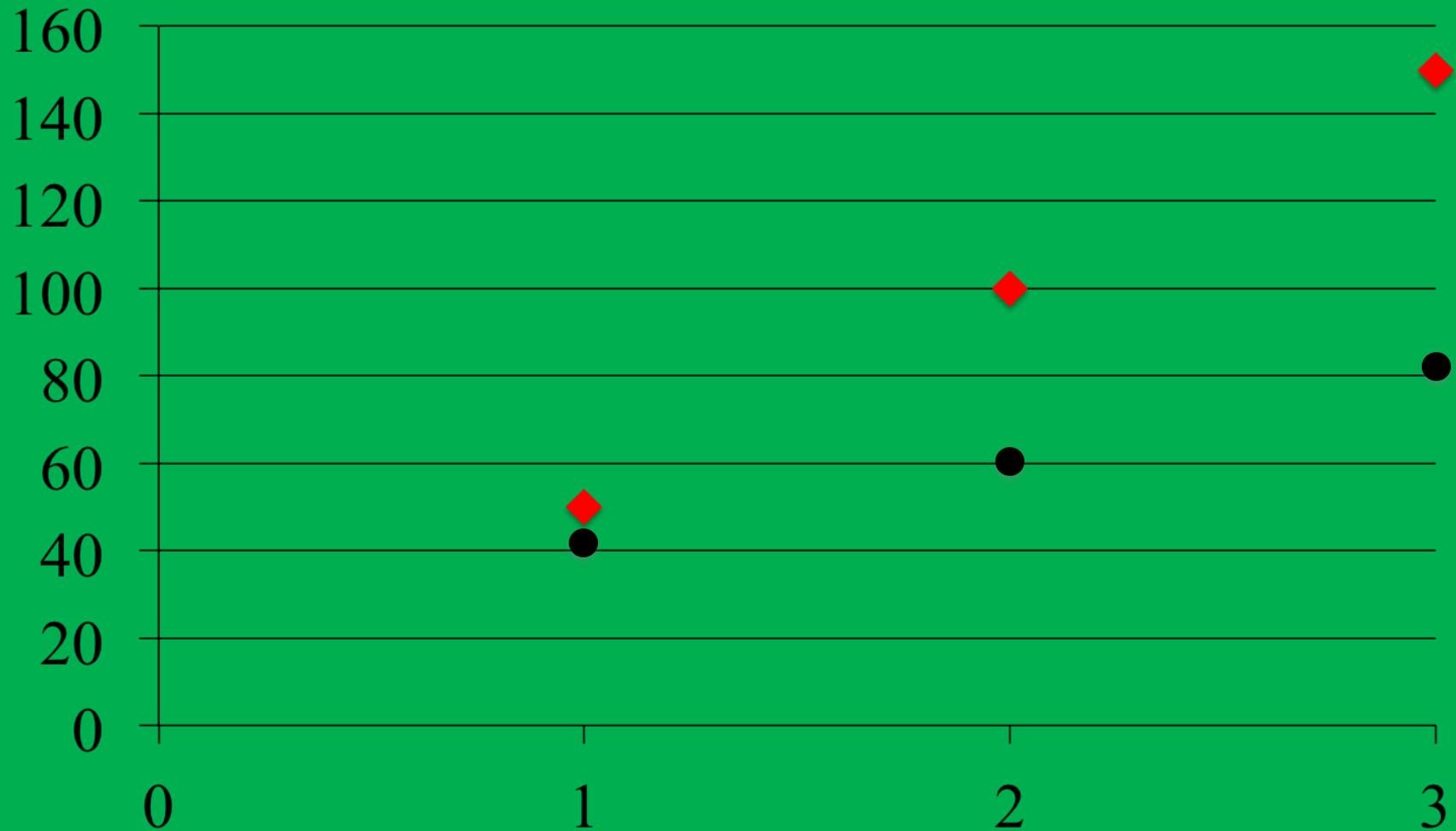
$$\mathbf{P} = \mathbf{G} + \mathbf{E}$$

$$\mathbf{G} \times \mathbf{E}$$

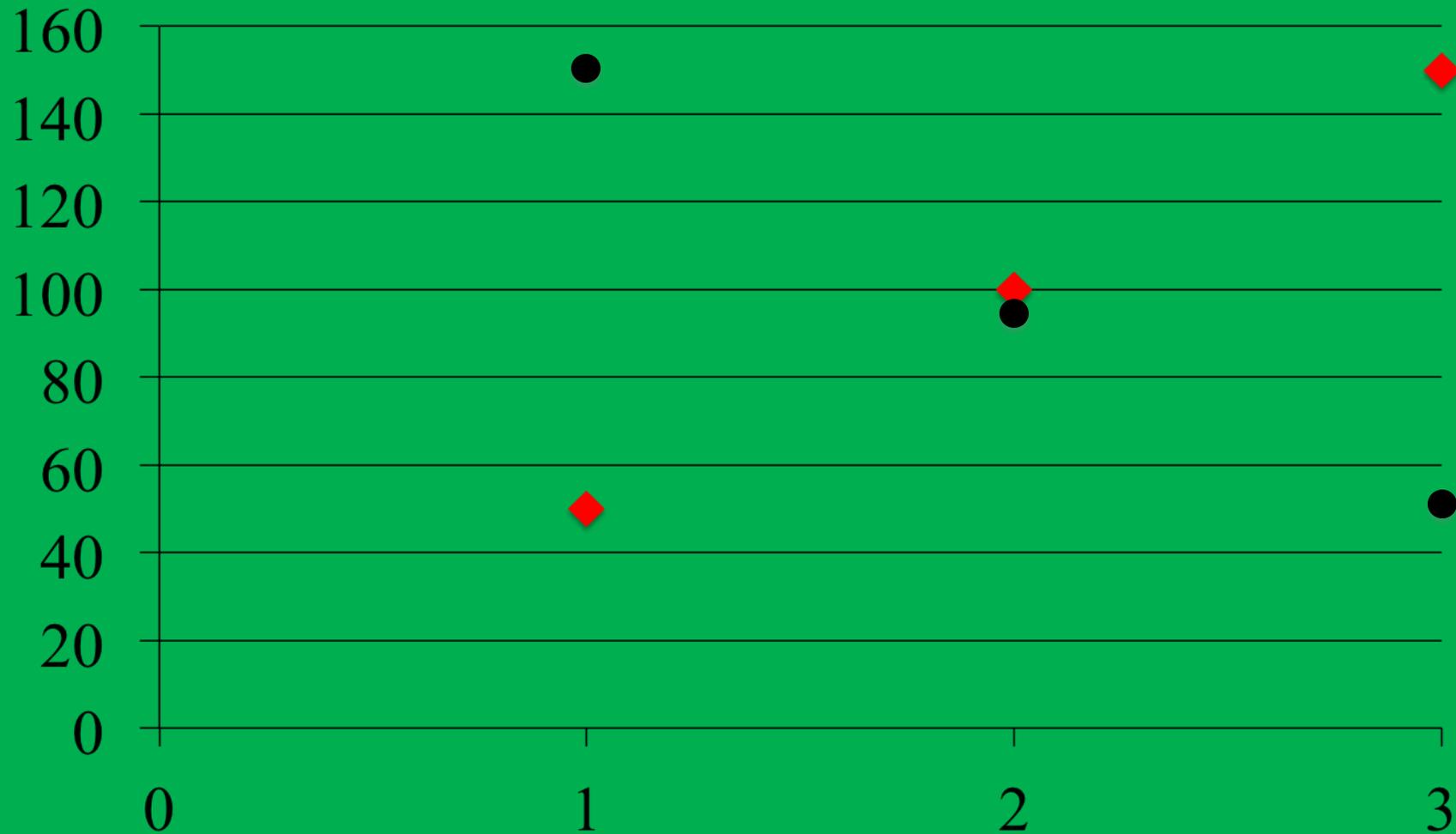
# No G x E



# G x E



# G x E



# DON'T PANIC!

**This is what breeders can tell us about expected gain from selection:**

$$\frac{Ka\sigma_A^2 + \beta}{Y \sqrt{[(\sigma_W^2/krly)+(\sigma_E^2/rly)+(\sigma_{GLY}^2/ly)+(\sigma_{GY}^2/y)+(\sigma_{GL}^2/l)+\sigma_A^2+\sigma_D^2+\sigma_I^2]}}$$

**Remember what follows...**

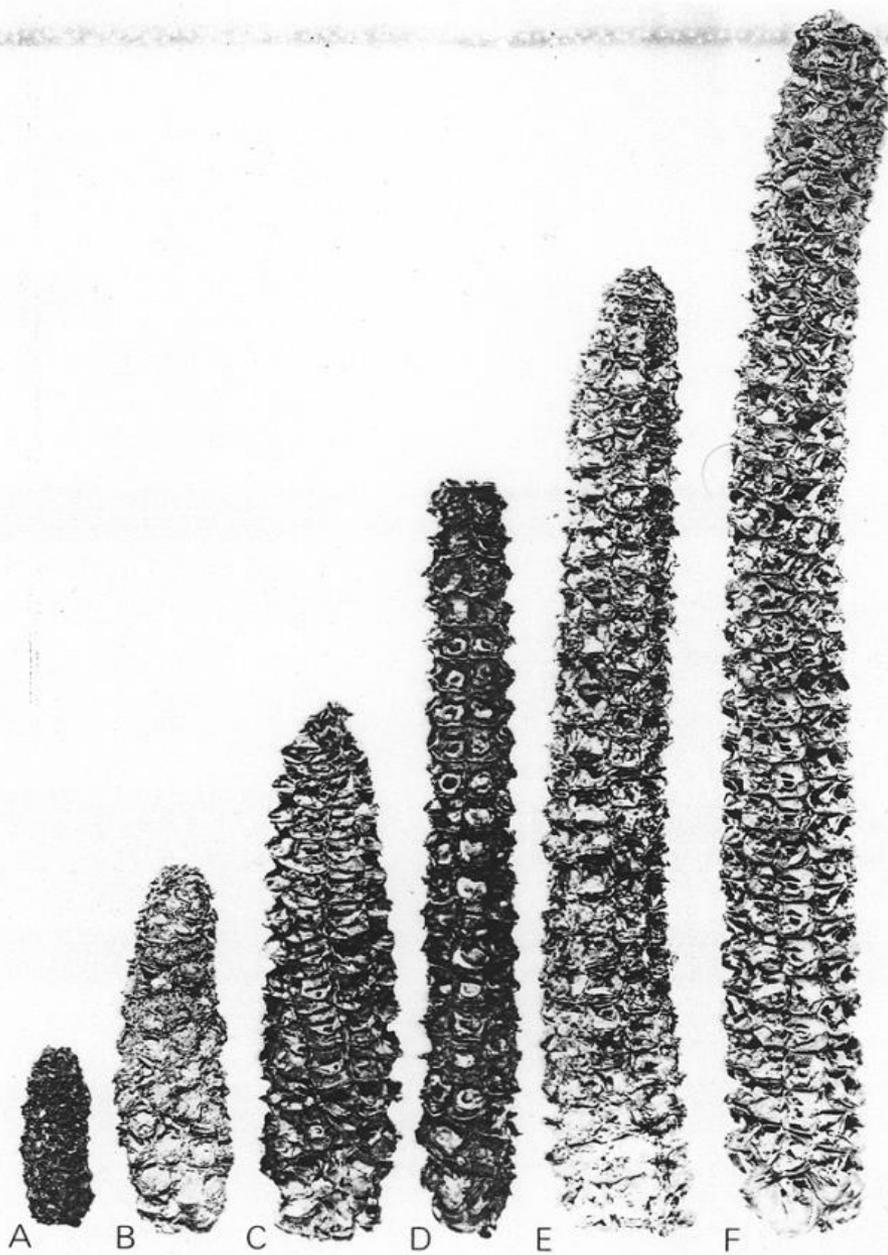
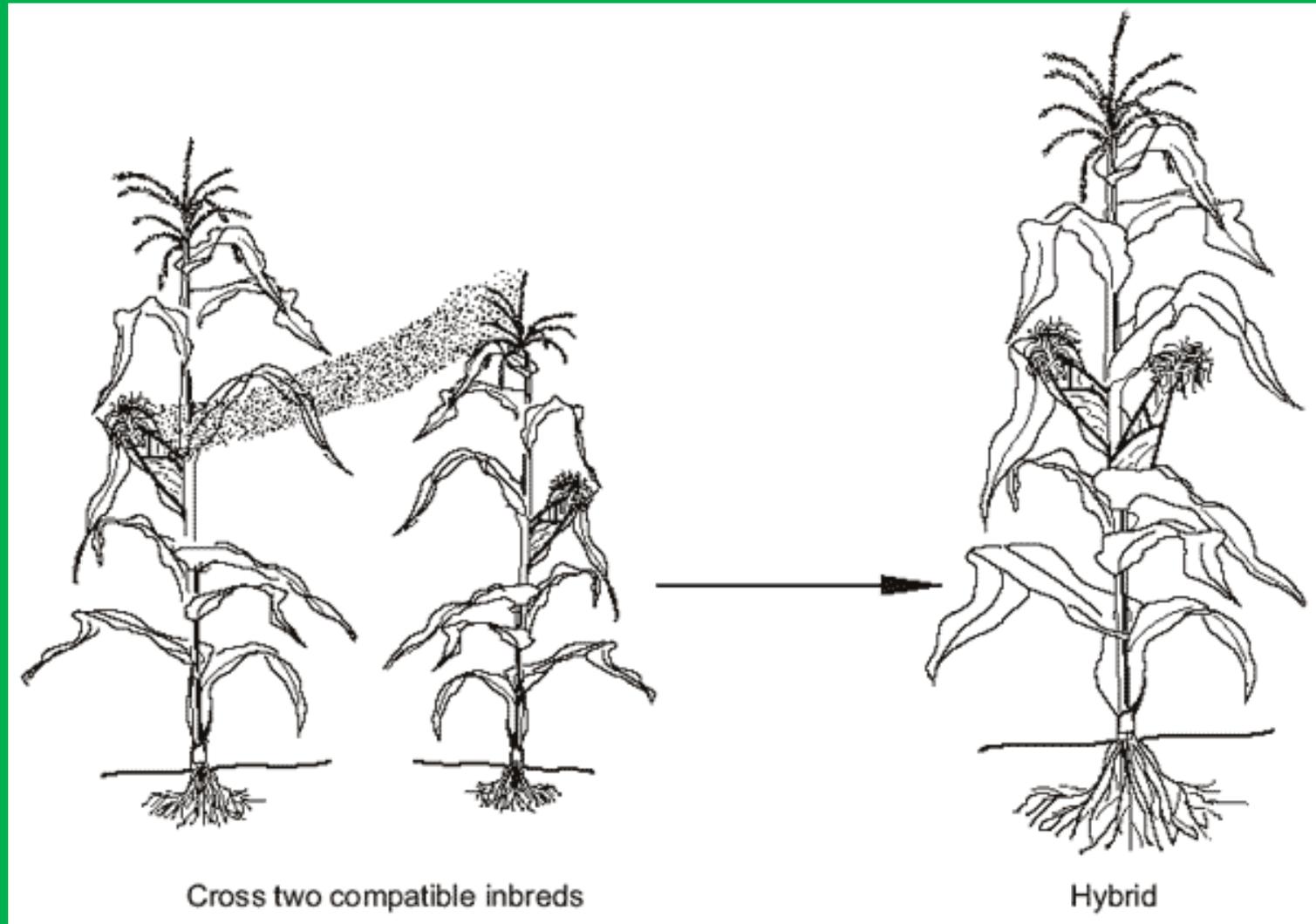


FIG. 14.7 Prehistoric cobs from Swallow Cave, Chihuahua, Mexico, illustrating an evolutionary series. *A*, pre-Chapalote from level 13 (72–78 inches). *B*, early Chapalote from level 12 (6–12 inches). *C*, Tripsacoid cob considered to be the product of introgression from teosinte and exhibiting hybrid vigor. *D*, an eight-rowed race introduced into Mexico from South America considered to be the product of introgression from *Tripsacum* and exhibiting hybrid vigor. *E* and *F*, cobs of the modern

- Greater diversity often helps
- More intensive selection speeds gain
- Prevent inbreeding
- Increase heritability
- Reduce G x E
- Select in your target environment
- Pollen Control

# Hybrid Corn: Can we save this?



# How Heterosis Works

Genotype	Locus				
	A	B	C	D	E
Breed A	A/A	b/b	C/C	d/d	e/e
Breed B	a/a	B/B	c/c	D/D	E/E
A × B (F <sub>1</sub> crossbred)	A/a	B/b	C/c	D/d	E/e

Table 1 from Olson, 1998

**How do we get a diverse population that is worth growing and closer to our goals?**

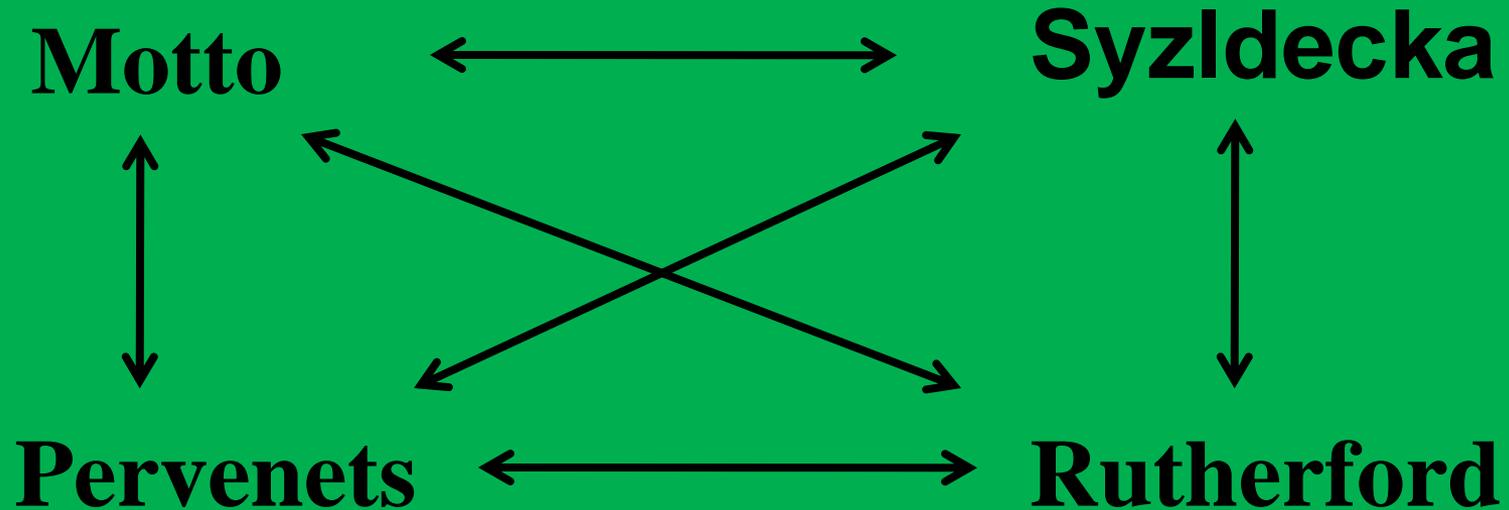
**“Composites”**

**“Synthetics”**

$$\mathbf{F2 = F1 - ((F1-P)/N)}$$

Wright's formula (1922)

# What is a “Diallel Cross”?



**A mix of varieties is a “Composite”**



Field selection is the only way to be sure of good seed corn adapted to Colorado conditions. Robert Moreland of Sligo, Weld County, selecting registered Minnesota 13 seed.

**“results indicate definitely also that synthetics may be expected to perform better than the open-pollinated variety from which they are selected and in some comparisons equal to or better than comparable double crosses [hybrids].”**

**H.K. Hayes, 1963  
A Professor's Story of  
Hybrid Corn**

**An example of a “Synthetic”:**

**Pa91, B73, B84, B77**

**H100, Mo17, N152, B79**

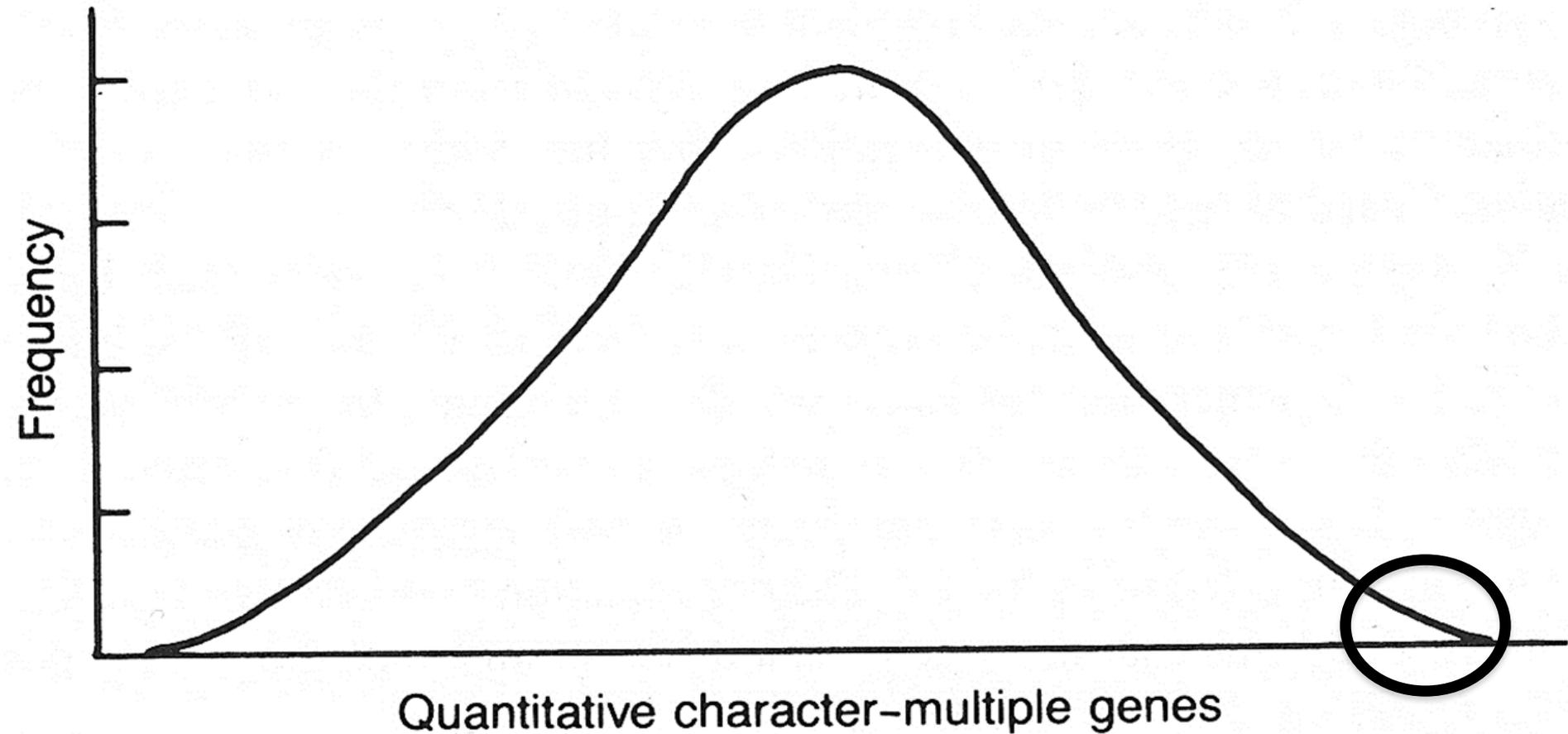
**79% of best hybrid yield**

# Selection Intensity



- Best to keep 100+ ears to prevent inbreeding
- 100 best ears of 100 plants is **NO SELECTION**
- 100 best ears of 1000 plants is 10%
- 100 best ears of 10,000 plants is 1%
- Have to be **THE BEST!**

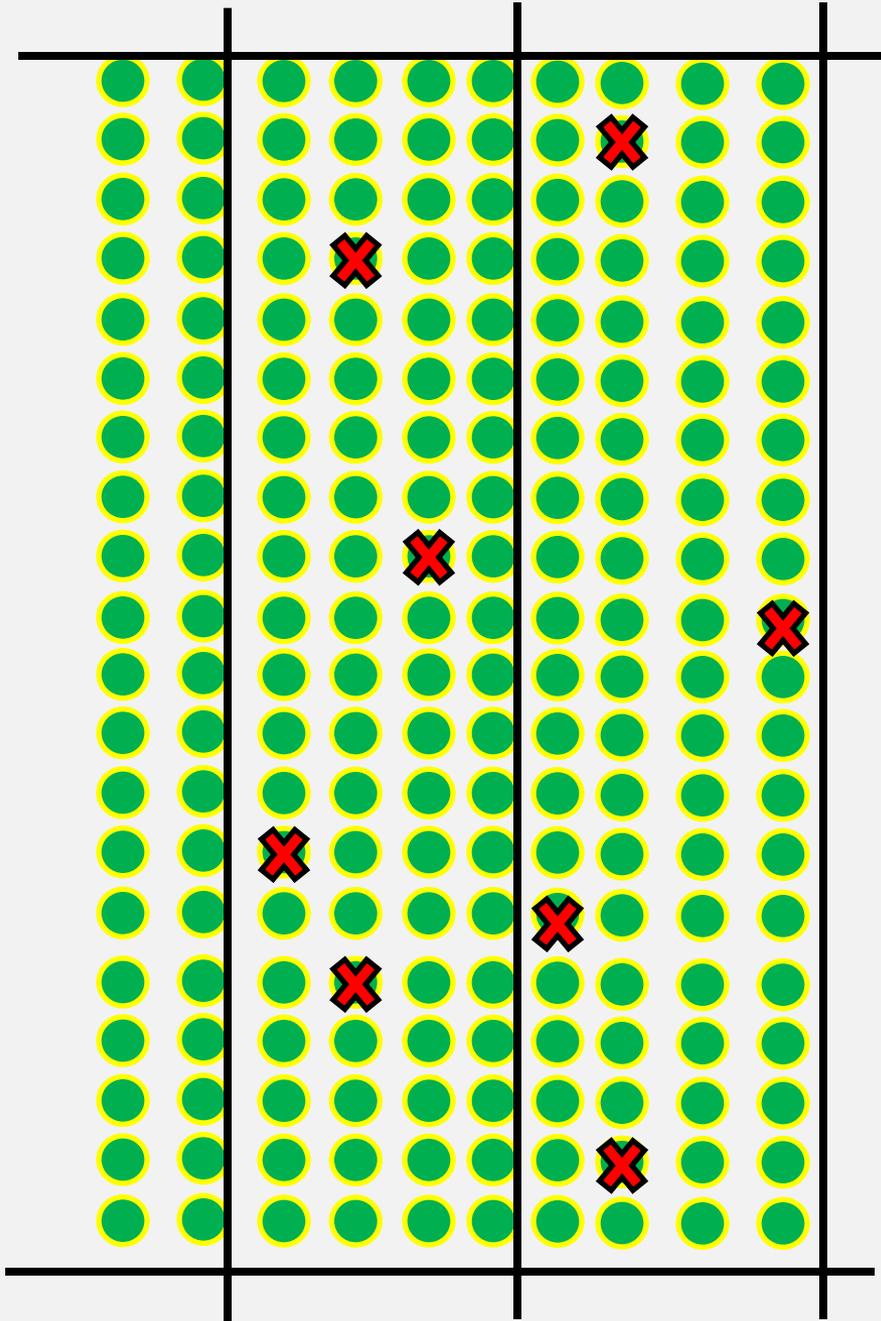
# Selection Intensity



From Fehr, W.R. 1991. Principles of Cultivar Development.

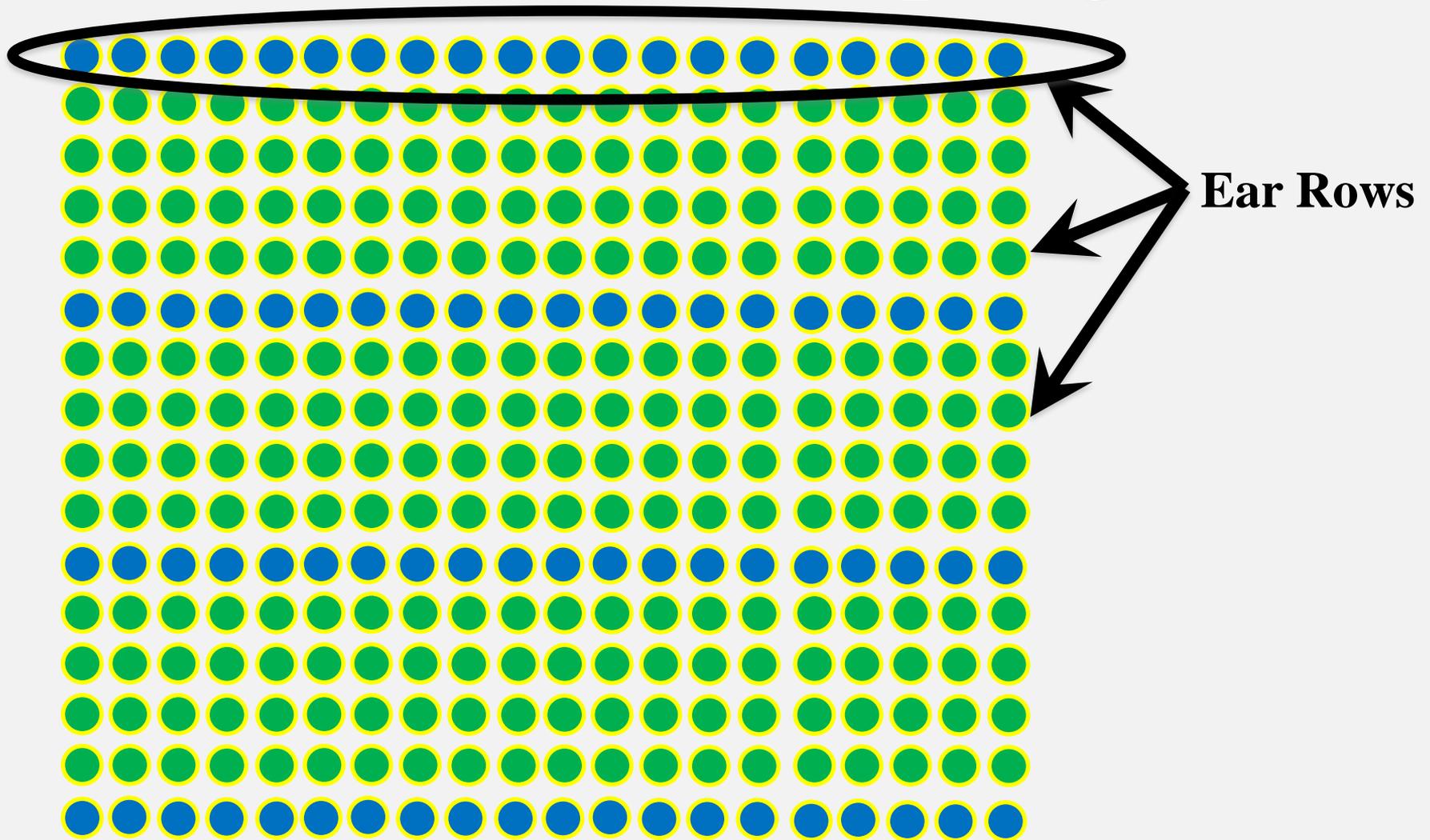
# One Way to Control E: Gridded Mass Selection

- Harvest best 1-10% of ears as seed ears from small, gridded plots across the field
- Dry and store them in a cool, dry location. Take an equal number of seeds from each ear to replant next season.
- Don't worry about ear type. Focus on yield of dry seed from healthy, upright plants (kick, pull, leave standing) grown with some stress.
- Save seed from at least 100 plants from plots spread across the field and all of its soil types

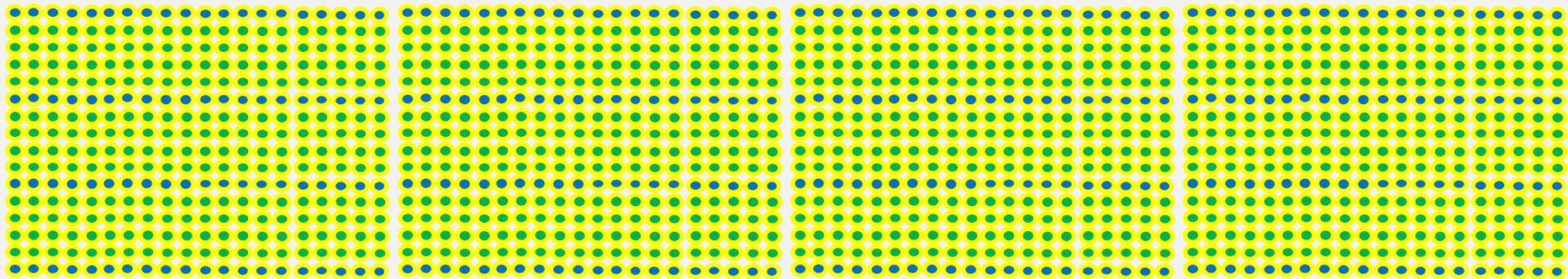
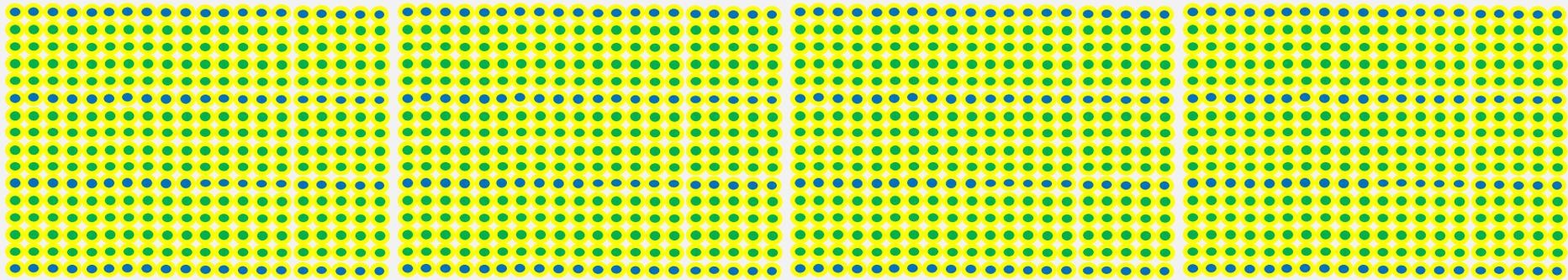
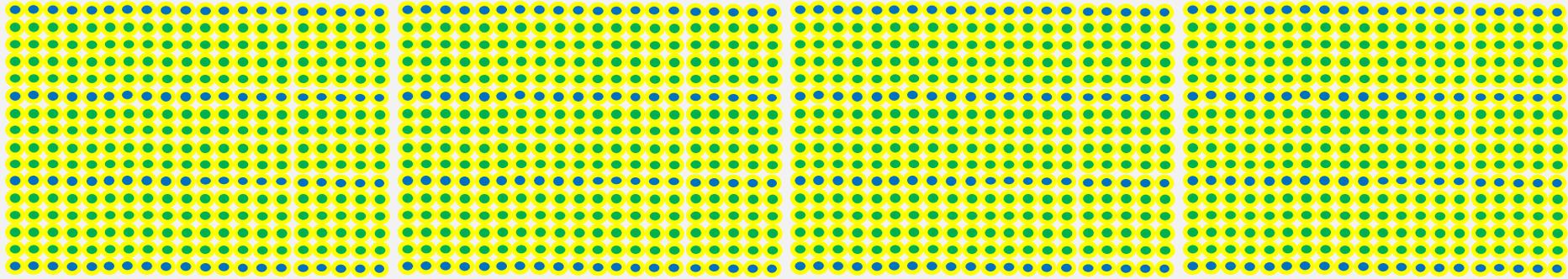


- Pick seed ears from smaller plots (these have 80 plants that are all on similar soil)
- Choose best plants in each grid, (4 plants means best 5% is selected)
- Select at least 100 plants from many gridded plots across the entire field

**What if we selected ears based on their offspring?**



# Modified Ear Row Selection

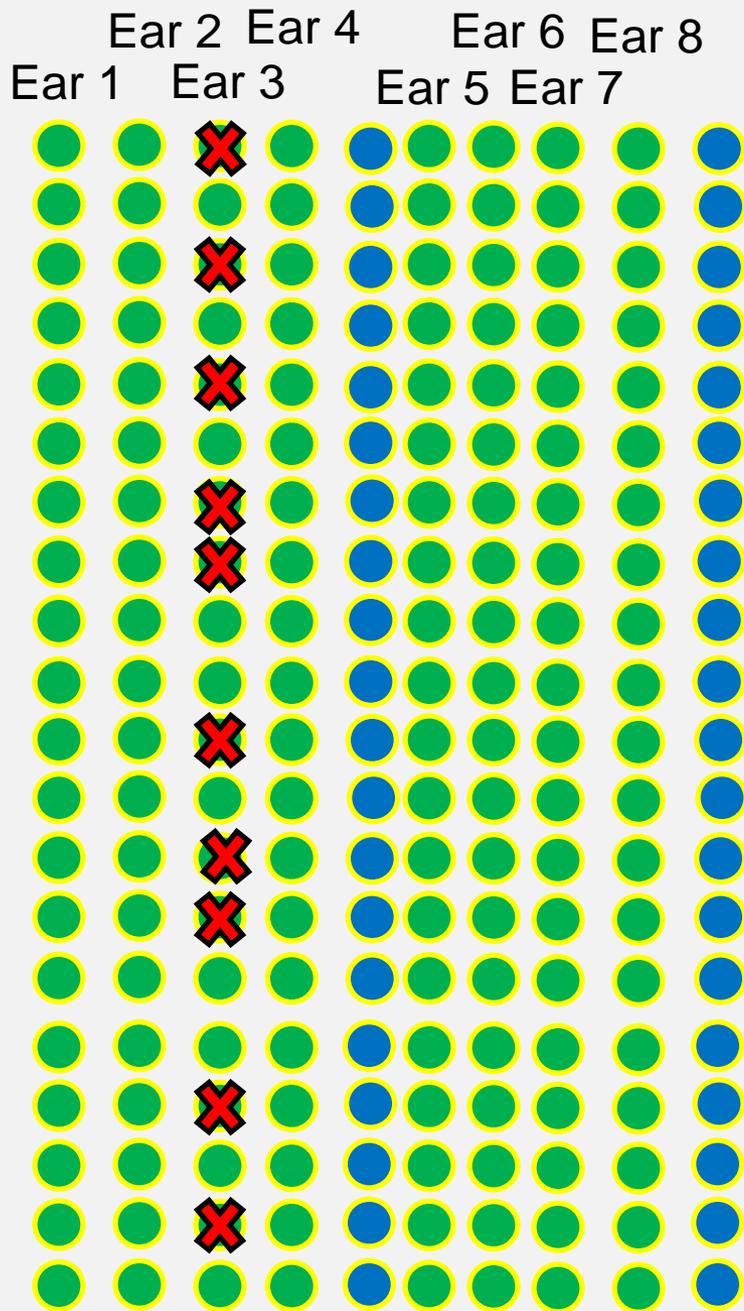


# A More Intense Method: Modified Ear To Row Selection

- Choose best 200 or more ears from a population using gridded mass selection
- The following season randomly plant short rows of 20 seeds from each of these ears (ear rows). Plant out fields like this in three locations
- One field is the crossing field. Every fifth row in the field and the border rows are planted with bulk seed from all the parent ears
- In the crossing field detassel all of the plants in the ear rows, but do not detassel the plants in the bulk rows (these are the males)

# A more intense method: Modified Ear To Row Selection

- Pick and bag by row all the ears from each of the ear rows. Make sure to mark the ten best ears in each row from the crossing field
- Weigh and moisture test all the ears from the ear rows in bulk. Determine average moisture, yield, and yield/moisture
- Ears from the twenty best parents, based on average performance, are saved for replanting



# MERS

- Ear 3 was one of the 20 best parent ears of the 200 being tested
- We will save the best 10 ears from this row
- In this way we will get 200 OP ears from the best 20 parent ears for next year's selection

# Why is MERS better?

- Looking at the offspring better evaluates each parent plant
- Randomization across three environments helps to reduce G x E effects
- A good experimental layout will help to reduce E effects on yields and other traits
- All seed has been outcrossed with bulk pollen to reduce inbreeding and evaluate “General Combining Ability”
- Much faster yield improvement is possible if the extra work can be carried out! Team approach?
- I have a new spreadsheet tool for anyone who wants to try MERS. It is preloaded with a field randomization and calculations of averages for all measured traits relative to controls throughout each field.

# What else would intensify selection?

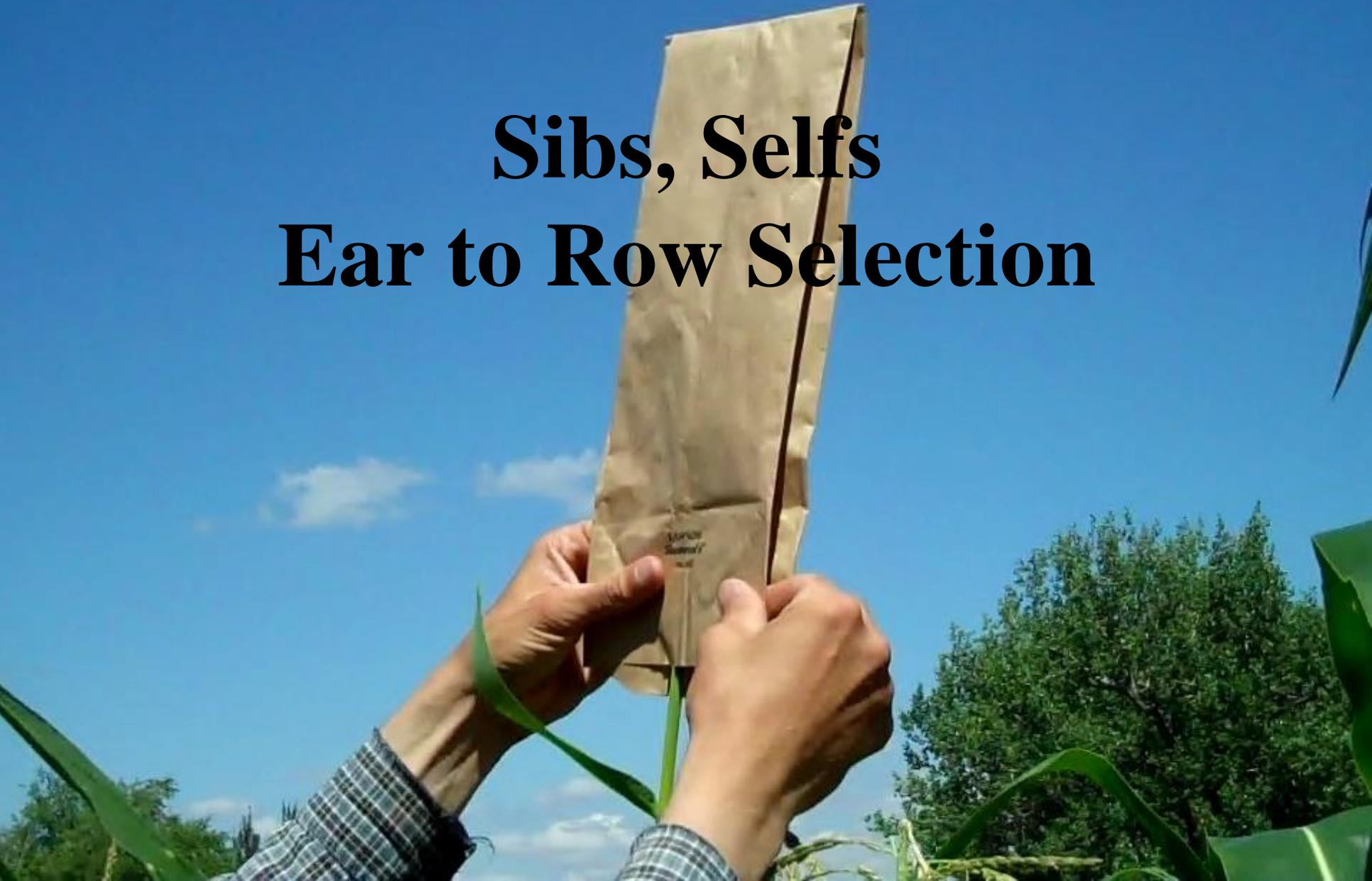
- Leave plants standing late into the season
- Weigh and reweigh the ears
- Germination tests for each ear
- Nutrient tests for each ear
- Check variety(ies) throughout the field to better evaluate environmental variation
- Use checks as a standard



**Target Environment!**

# **Pollen Control:**

**Sibs, Sels**  
**Ear to Row Selection**



# What about contamination by transgenes?



- Seed stock can become contaminated
- Seed mixing can introduce transgenes
- Transgenes can contaminate crop via pollination

LOWER BRULE FARM CORPORATION  
P.O. Box 100  
Sioux Falls, South Dakota 57108

# AKOTA POPCORN



[www.lbfcpopcorn.com](http://www.lbfcpopcorn.com)

The Harvest of the Lower Brule Sioux Tribe of South Dakota

NET WT. 3.2 OZ. (90.7g)



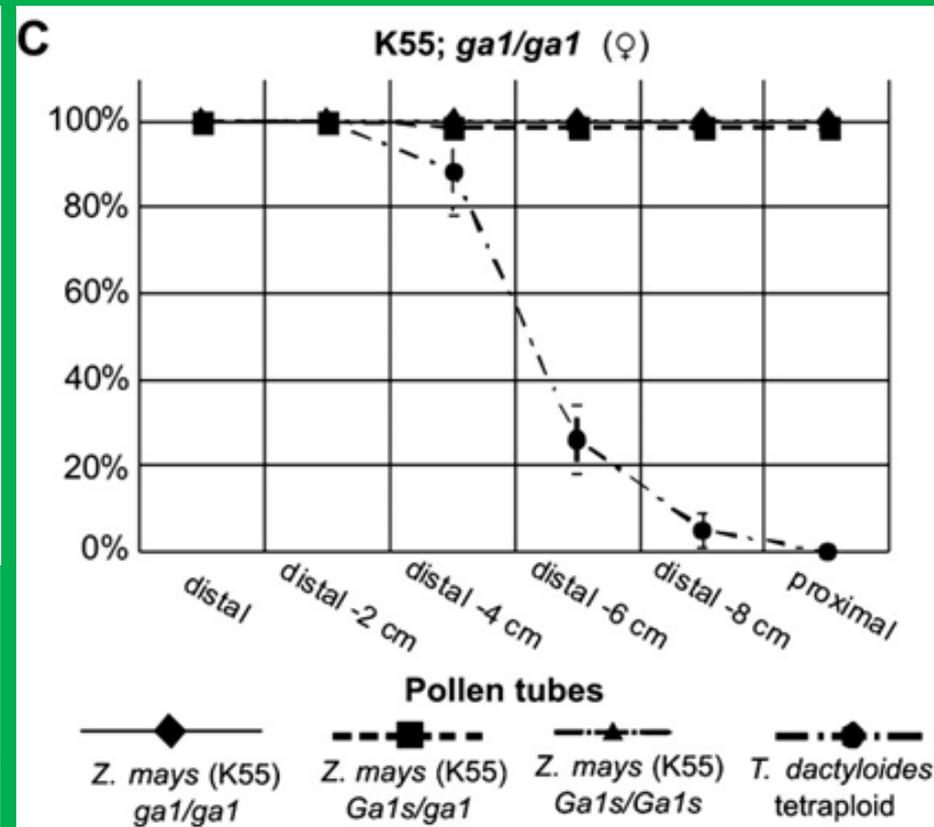
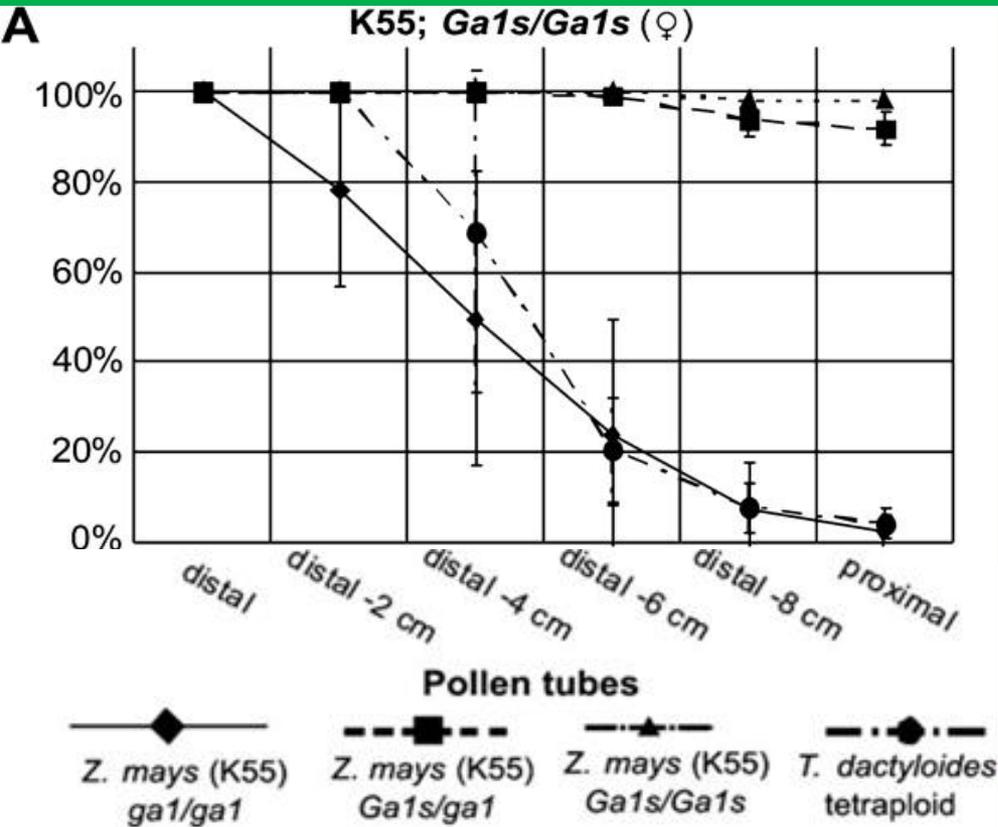
# There are 3 known strong alleles:



- Ga1<sup>s</sup>
- Ga2<sup>s</sup>
- Tcb1<sup>s</sup>

David Podoll with his Dakota Black Popcorn

# Pollen tubes growth range in silks of maize inbred line K55 harbouring different allele combinations of *Ga1s*.



Lausser A et al. J. Exp. Bot. 2009;61:673-682

# Working with Gametophytic Incompatibility Genes:

<b>Cross</b>	<b>Seed Set</b>	<b>Genotypes of Progeny</b>
<b>Ga1<sup>s</sup>Ga1<sup>s</sup> x gaga</b>	<b>None</b>	
<b>gaga x Ga1<sup>s</sup>Ga1<sup>s</sup></b>	<b>Normal</b>	<b>Ga1<sup>s</sup>gaga</b>
<b>Ga1<sup>s</sup>gaga x gaga</b>	<b>Normal</b>	<b>Ga1<sup>s</sup>gaga, gaga</b>
<b>Ga1<sup>s</sup>Ga1<sup>s</sup> x Ga1<sup>s</sup>gaga</b>	<b>Normal</b>	<b>Ga1<sup>s</sup>Ga1<sup>s</sup></b>
<b>Ga1<sup>s</sup>gaga x Ga1<sup>s</sup>gaga</b>	<b>Normal</b>	<b>Ga1<sup>s</sup>gaga, Ga1<sup>s</sup>Ga1<sup>s</sup></b>

Adapted from Thomas, W.I. 1955. Agron. J. 47:440-441.



**Dziękuję!**  
**Thank You!**  
**Merci!**

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**and on Facebook**