# On-Farm Plant Breeding for Climate Change & Regional Adaptation

The source of innovation, varietal improvement and environmental adaptation

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# Plant Breeding = Genetic Improvement

- Breeding includes everything from slight improvements of an existing variety to the creation of an entirely new variety

# Common Traits to Evaluate

- Agronomic
  - Seedling vigor
  - Plant height
  - Plant stature
  - Days to maturity
  - Harvestable fresh yield
  - Harvest window
  - Uniformity
  - Seed yield


- Culinary
  - Flavor
  - Texture
  - Appearance
  - Holding & storage qualities

# Traits to Consider for Long Term Sustainability

- Pest resistance
- Disease resistance
- Weed competitiveness
- Adaptability to poor soils
- Nutrient scavenging
- Root vigor
- Drought tolerance
- Heat and cold tolerance

# Other Crop Specific Traits to Consider

- Carrot: Tip fill
- Pepper: Sunburn on fruit
- Tomato: Cat-facing & cracking on fruit
- Winter Squash: Length of storage
- Summer Squash: Ease of harvest
- Cabbage: Inner core size
- Snap Bean: Harvest window
- Onion: Neck closure
- Flour Corn: Kernel size

# Develop Breeding Strategy

- Primary Questions
  - What are the most important traits to consider?
  - Are there existing varieties that (almost) possess these attributes?

- Improve an existing variety
  - Begin selection process: mass or single-plant selection
  - Continue mass selecting or employ progeny selection
  - Validate progress with comparison trials

- Create a new variety
  - Make initial strain crosses to establish breeding population

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# Mass selection:
## Removing unwanted plants

- Select evenly from across your field
- Start with a large population (outcrossers only)
- Make selections before pollination occurs (outcrossers only)

# Observe and Evaluate

Prioritize desired traits

e.g.

1. Dense heads
2. Late-maturing
3. Tall plants

# Go Rogue!

Only the best plants are allowed to flower, intermate, and produce seed

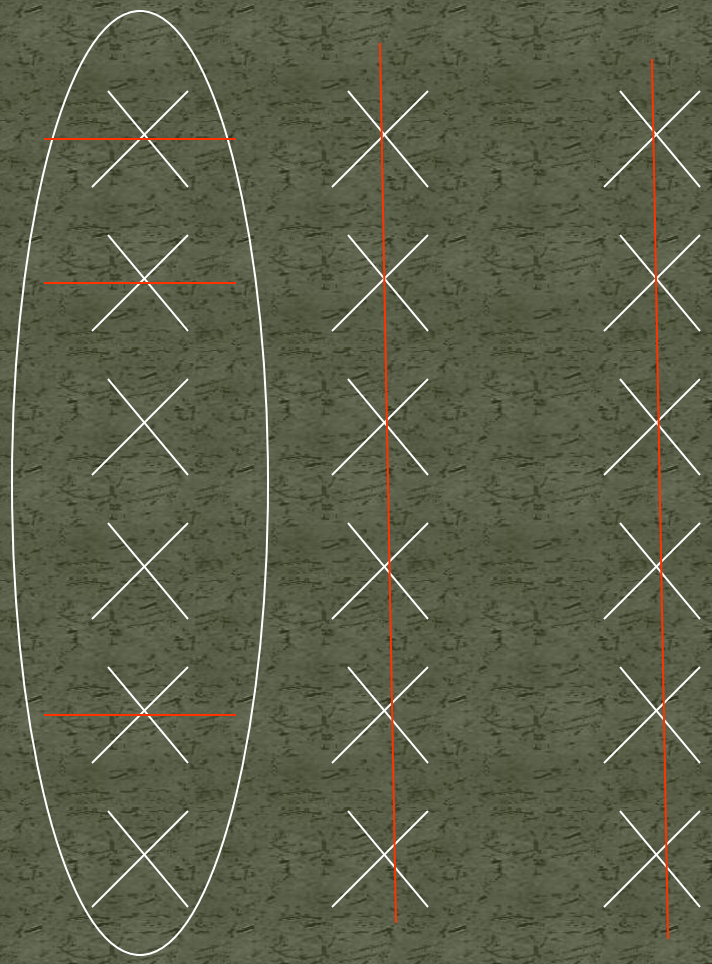
# Two Options

1) Bulk together all mature seed from remaining plants (mass selection)

2) Harvest seed from each plant separately and re-plant following year as individual families (progeny selection)

# Progeny Selection

- Save seed from only the best plants in a population
- Keep seed from each plant in individual bags
- Plant each bag of seed in separate rows (2 reps if possible)
- Select 15-20% of best families based on both reps.
- Eliminate poor families
- Eliminate 30-40% poorest plants from selected rows
- Allow remaining plants to intermate
- Bulk within families



# Red Table Beet

# Breeding Objectives

- A dual-purpose beet with:

  - Round, red, smooth-skinned roots

  - Tall, vigorous tops

- Resistance to Rhizoctonia dry rot (*Rhizoctonia solani*)


*Rhizoctonia solani*

# Create Breeding Population

- Made unique strain cross
- Combined 2 popular commercial OP's
  - 'Green Top Bunching' x Crosby Green Top'
  - Both varieties possessed desired traits
  - 'Hybrid vigor' (Heterosis) achieved
  - Original cross did not have Rhizoctonia resistance

# Mass Selection

- - 1st year roots grown in diseased soil
- - 3,000+ planted
- - Selected best 15%
- - Re-planted in disease-free soil
- - Harvested 1st generation seed & repeated process


Comparison Trial


RED AC
P
C
Red Ace
Pronto
Shiraz Tall Top


Developing & improving summer squash
- Strain Cross
- Mass Selection
- Self Pollination
- Progeny Selection

# Strain Cross

- Plant alternating rows of two genetically distinct varieties
- Allow for complete cross pollination
- Plant seed in following year from most robust plants of the variety with superior market traits

# Breeding History

## Initial strain cross - 1998

**Black Beauty (OP) X Raven (F1)**

- High plant vigor
- Med/dark green fruit
- Long harvest window
- Extremely thick vines
- Spiny leaf stems
- Many off-type fruit

- Very dark green, shiny, ridged fruit
- High lutein levels
- Open canopy
- Smooth leaf stems
- Low plant vigor
- Short harvest window

# Population Development

- Phenotypic mass selection for 4 years
- Several thousand plants grown
- Saved seed from superior 10-20 plants each generation
- Made 3 rounds of selections
  - Vigor
  - Plant type
  - Fruit type
- Final selection produced ‘Black Eel’ OP/Seeds of Change variety


Black Eel Zucchini

# Self Pollination

- Selfing attempted on 50 superior plants (from 500)
- 26 successful selfs. Kept in separate bags
- Each bag = full-sibling family

# Progeny Testing

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- All 26 full-sibling family progeny planted in rows (25-35 plants/row)
- Eliminated all but 5 families
- Rogued individuals from remaining families
- All plants then inter-mated, but families saved separately
- Repeated process for 4 years


‘Dark Star’

Dark Star Zucchini Squash

# Baja Zucchini Trial - 2006

'Dark Star' more variable fruit but higher yield and 5-6 week longer harvest time compared to commercial hybrids

Less cucumber mosaic virus & powdery mildew

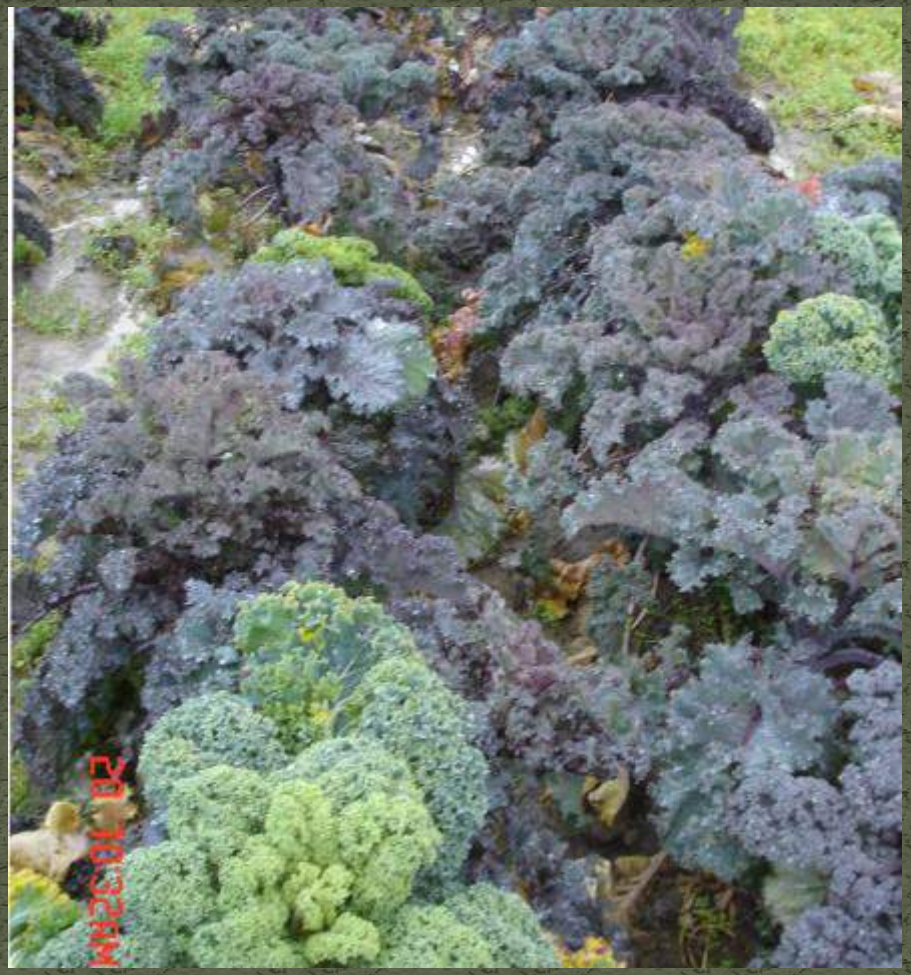
Only zucchini variety that survived two heavy freezes

# Nash's Red Kale (aka Olympic Red)

- Purple, curly-leaved type
- Downey Mildew resistance
- Upright stature
- Tall plant
- Winter hardy
- Productive
- Tender & flavorful

# Redbor F-1 Kale: the market standard

# Strain Cross → Mass Selection



- Purple plants in a large population of Vates Dwarf Curly Kale

*crossed with*

- Purple Brussels Sprouts plants

- 10 years of mass selection (1997-2006)

# 2008: A Signature Crop

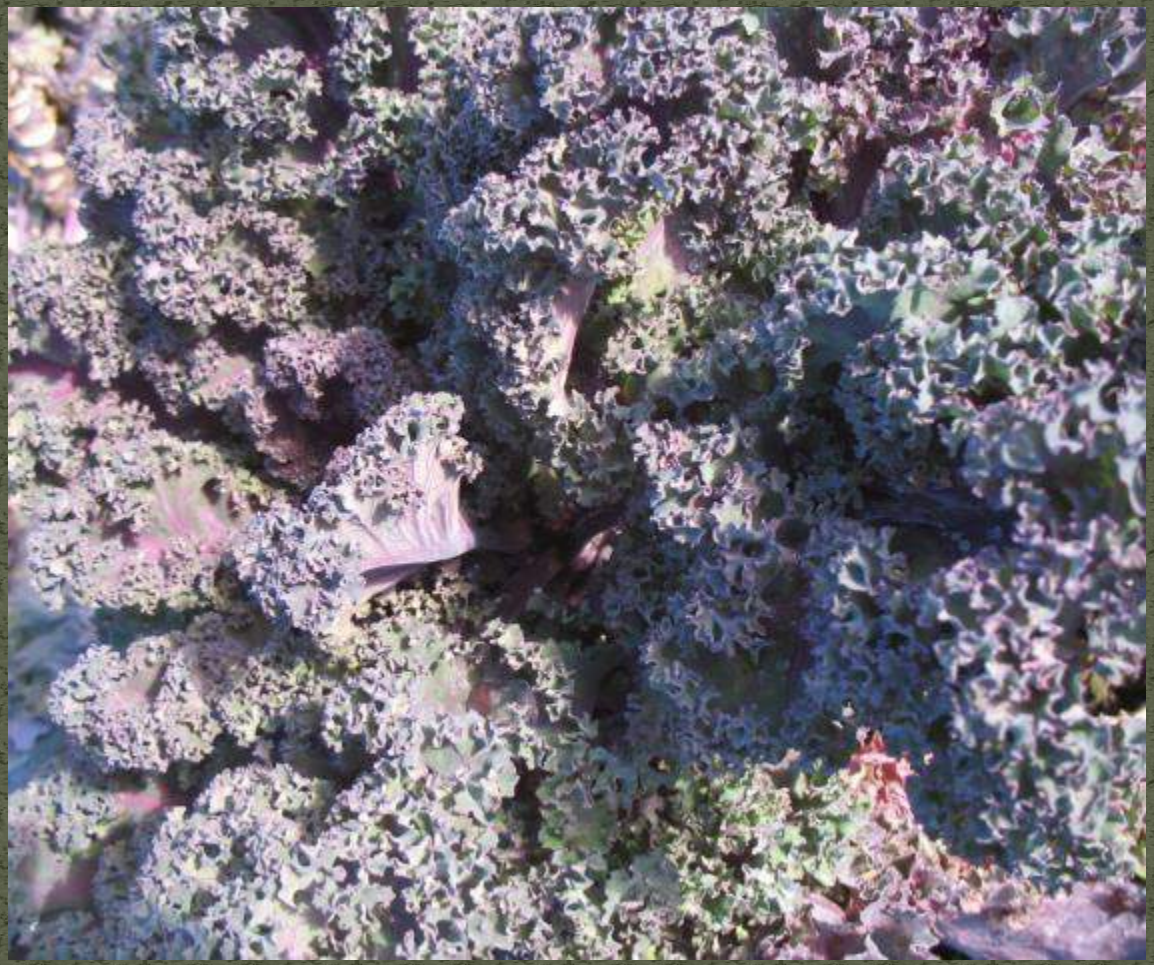
Qualities:

Tall, vigorous, open habit

95% true-to-type OP

Compared to Redbor:

- Better flavor
- More tender
- More cold tolerant
- Better Downey Mildew resistance
- Lighter color
- Less frilly leaves



# Progeny Selection
# In 2008 50 best plants identified

**Quality Traits Desired**

- Erect stature
- Purple color
- Cold hardiness

**Procedure**

- Rogued out off-types before flowering
- Allowed 50 remaining plants to inter-mate
- Saved seed from each plant in individual bags
- Subsequently planted 50 short progeny rows

# Progeny Selection

- Evaluated on a row by row basis

- Eliminated rows with:
  - green plants
  - poor curl
  - inappropriate stature
  - early bolters

# Subsequent Population

- Resulted in 13 all red rows
- Seed harvested as single row bulks
- To be planted as 13 x 2 rows and evaluated again.


HARTMAN'S
YELLOW GOOSEBERRY
NORTH DAKOTA
EARLIGOLD


Shanti Bithi
Landscape Design

# Tomato breeding: making a strain cross

- Female parent
  - Flower receptive for 1-2 days
  - Emasculate flower to expose style & stigma
- Male parent
  - Pollen on individual flower viable for several days
  - Spread petals to release pollen onto fingernail
- Rub pollen from fingernail onto stigmatic surface
- Remove all other nearby flowers
- Tie on brightly colored ribbon & label clearly


GrowVeg

# Tender Early Green x Atlantic Broccoli


Stella Blue Squash

# Scarlet Emperor Runner Bean

# Martian Jewels Corn

# Yellow Hickory King Corn

# Land races contain vast potentialities

Guarijio Azul, a flour corn from the southern Sonoran region of Mexico. Native Seeds/SEARCH.

# Red Ruffled Pimiento Pepper

# Eel River Melon

# Amarant Cabbage


Forono Beet

# Front Range Yellow Globe Onion

# OSU Sugar Snap Pea 1430