

Plant Diversity

Presented by
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Teosinte

AAAa

Plant Diversity

What is Diversity (Biodiversity)?

The varieties of organisms considered at all levels, from genetic variants belonging to the same species, through arrays of species to arrays of genera, families, and still higher taxonomic levels; includes the variety of ecosystems, which comprise both the communities of organisms within particular habitats and the physical conditions under which they live.

E.O. Wilson, 1992, The Diversity of Life

What is Diversity (continued)

Diversity signifies the integration of ecology and genetics in conservation theory. It represents diversity at all levels of biological organization-the community, the species, the organism, and the gene. It is essential for survival in time and place, and for adaptation to specific environments, in the global context.

O.H. Frankel, et al. 1995, The Conservation of Plant Biodiversity

Problems of Genetic Uniformity of Plants

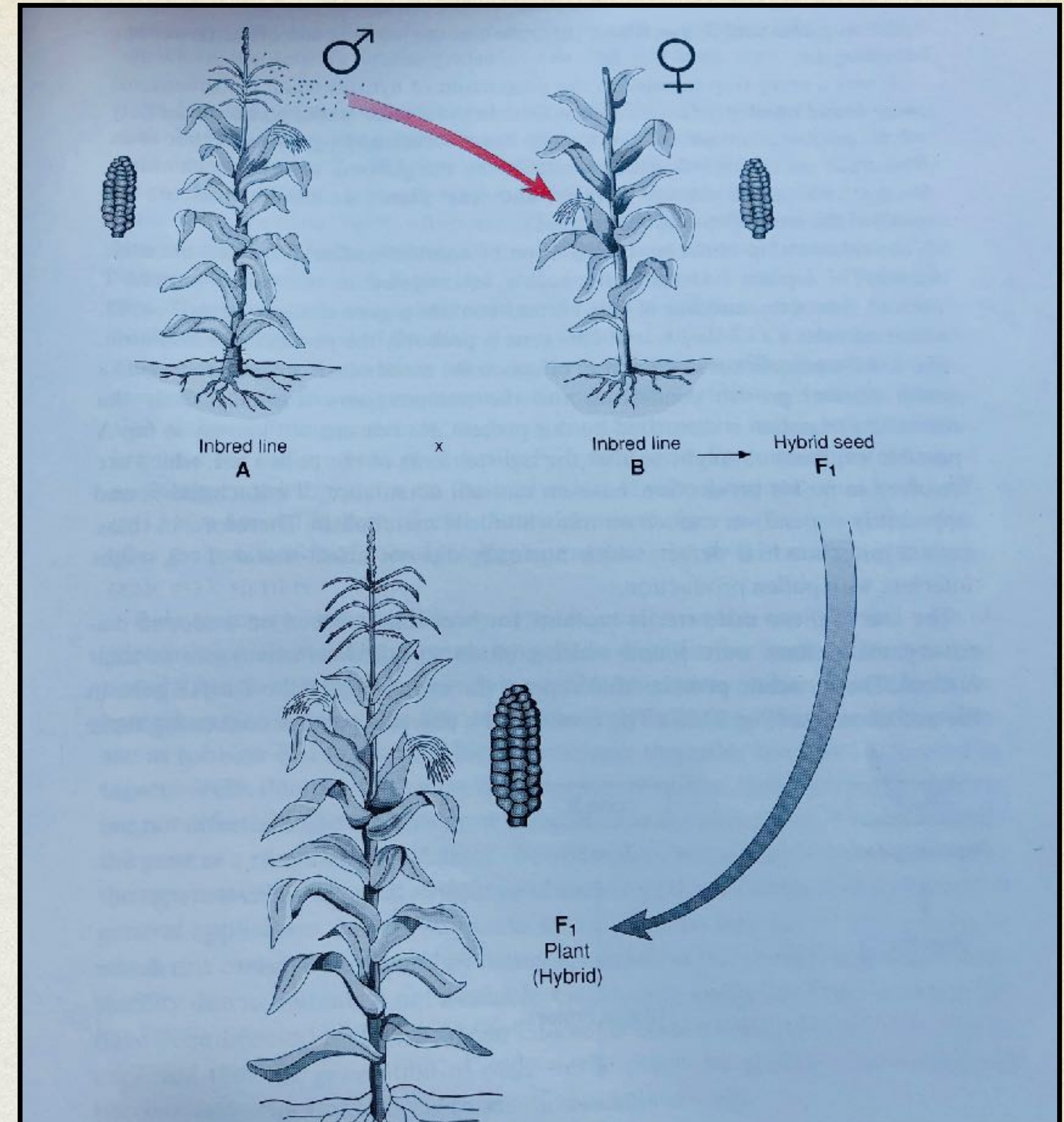
- ◆ More vulnerable to diseases, insects, and environmental changes.
- ◆ May have lower nutritional value.
- ◆ Impact ecosystems by reducing diversity at all levels.

Why are crop species uniform?

- ◆ Breeders select for uniformity (most food and industrial crops)
- ◆ Narrow genetic base used (rapid progress, high yields, etc.).
- ◆ Using diverse sources of germplasm is long term, costly, demanding of resources.
- ◆ Breeding with exotic sources results in “linkage drag”.
- ◆ Linkage drag results when a favorable gene is linked on same chromosome to unfavorable genes.

Corn Plant Pollination Method

- ✦ Pollen from tassel (anthers) of parent A.
- ✦ Crossed to silks (stigma, styles) of female B.
- ✦ Harvested seed from parent B is F1 hybrid.
- ✦ Up to 3 billion pollen grains per plant.



Description of the GEM Project

GEM= Germplasm Enhancement of Maize

- Administered by the USDA-ARS Plant Introduction Research Unit.
- Based in Ames, IA (Iowa State University), and NC State (Raleigh, NC).
- Ames Seed Bank for collection and conservation of more than 30 species.
- Maize (corn), sunflowers, canola, amaranth, quinoa, trees, shrubs, vegetables, etc. Includes wild relatives.

Objectives of the USDA GEM Project

- ◆ Implement a public-private collaborative effort to effectively utilize genetic resources to broaden the germplasm base of maize.
- ◆ Utilize genetic resources from all over the world to reduce the likelihood of global diseases, insects, environmental stress, and enhance value to growers and consumers (better nutrition, etc.).
- ◆ Enhance food security and food safety.
- ◆ Provide educational opportunities to students for research on maize diversity.

Operational Details of GEM (Win-Win)

- ◆ Companies provide “in kind support” for breeding nurseries, yield trials, disease, insect, and environmental stress evaluation.
- ◆ Universities do research, write journal manuscripts, train students.
- ◆ Germplasm released by GEM is initially shared with members only.
- ◆ Members have exclusive access to germplasm for 2 years for further breeding.
- ◆ After 2 years the seed is made available to all researchers through seed bank.

GEM Private Cooperators:

3rd Millennium Genetics
AgiWise, L.L.C.
AgReliant Genetics, LLC
BASF Plant Science Breeding, L.L.C.
Beck's Superior Hybrids, Inc.
Brandy Wine Seed Farms, LLC
FFR Cooperative
Forage Genetics
Genetic Resources, Inc
G and S Crop Services
GDU Inc.
Genetic Enterprises Int'l
Hoegemeyer Enterprises
Illinois Foundation Seeds, Inc.
JFS and Associates, LTD
MBS Genetics, LLC.
Monsanto Company
Mycogen Seeds
National Starch and Chemical Co.
PANNAR Seed
Pioneer Hi-Bred Int., Inc.
Professional Seed Research, Inc.
Schillinger Seeds
SEEDirect
Syngenta Seeds, Inc.
Terrell Seed Research
Wyffels Hybrids

(27)

GEM Public Cooperators:

Cornell University
Iowa State University
Louisiana State University
Michael Fields Agricultural Institute (NGO)
North Carolina State University
North Dakota State University
Ohio State University
Texas A&M University
University of Delaware
University of Illinois
University of Nebraska
University of Tennessee
University of Wisconsin
Truman State University
USDA-ARS: CGBRU, Tifton, GA
USDA-ARS: CGRU, Stoneville, MS
USDA-ARS: CICGRU, Ames, IA
USDA-ARS: CHPRRU, Mississippi State, MS
USDA-ARS: NCAUR, Peoria, IL
USDA-ARS: PGRU, Columbia, MO
USDA-ARS: PIRU, Ames, IA
USDA-ARS: PSRU , Raleigh, NC

(22)

GEM International Private Cooperators:

APEX-AGRI, France
Hyland Seeds, Canada
Maharlika Genetics, Mexico
MayAgro Seed Corp., Turkey
Nidera, Argentina
Nugenplasm, LLC, Indonesia
Prosemillas, Peru
Seed Asia Co., Ltd., Thailand
Sementes Biomatrix Ltda, Brazil
Semillas Tuniche, Ltda, Chile
Semilia Genetica e Melhoramento, Brazil
Sursem SA, Argentina

(12)

GEM International Public Cooperators:

Chinese Academy of Agricultural Science, China
Empresa Brasileira Pesquisa Agropecuaria (EMBRAPA), Brazil
Instituto Nacional Tecnologia Agropecuaria (INTA), Argentina
The University of Guelph, Canada

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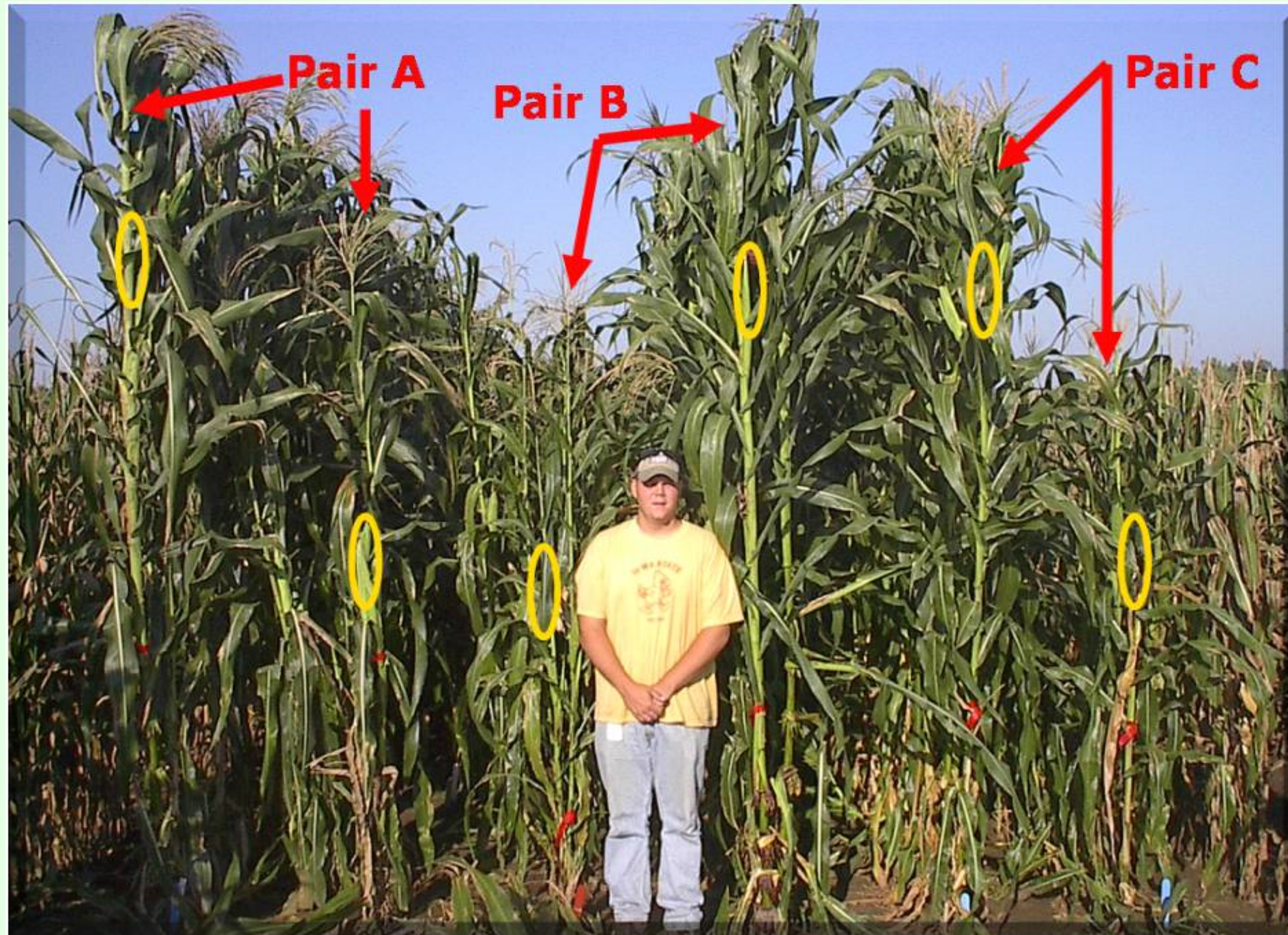


Geneticist Mike Blanco pollinates tropical exotic maize as a first step in breeding corn with improved disease resistance, nutritional quality, and bioenergy potential.

from Agricultural Research Magazine, July 2007



Photoperiod Control Study



Year 2006

Shade House – Photoperiod Control



Year 2009

Insect Evaluations

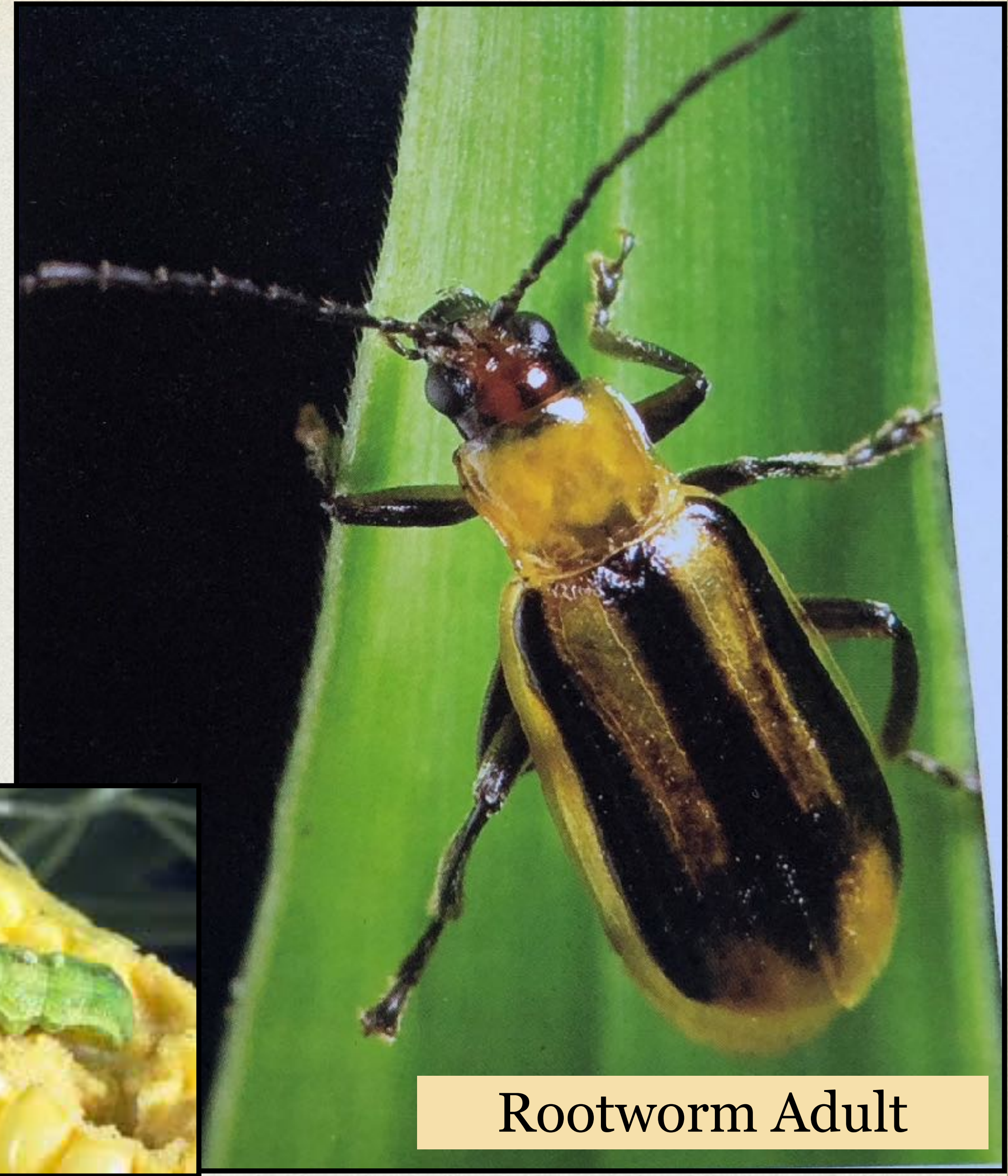
- ♦ European corn Borer, *Ostrinia nubilalis*.
- ♦ Corn Rootworm, *Diabrotica virgifera*.
- ♦ Fall Armyworm, *Spodoptera frugiperda*
- ♦ Corn Earworm, *Heliothis zea*.



Earworm



Earworm

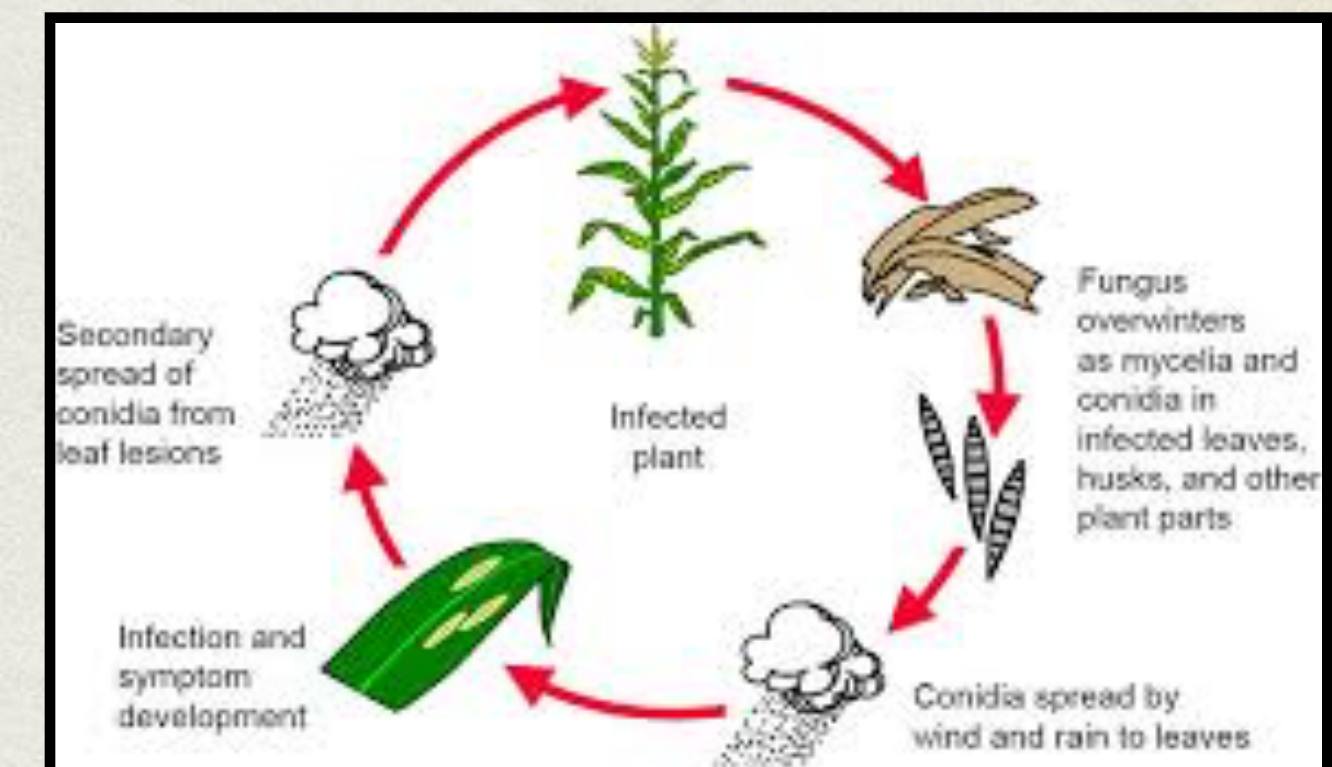


Rootworm Adult

Disease and Mycotoxin Evaluations

Anthracnose stalk rot-fungus

- Northern & Southern Leaf Blights-fungi.
- Southern Rust-fungus (now moving north).
- Fusarium and Aspergillus Ear Rot-fungus (also fumonisin and aflatoxin).
- Maize Rough Dwarf Virus (Europe, Asia, Argentina)
- Maize Lethal Necrosis Virus (Africa).





Fusarium Ear Rot



Susceptible Line



Resistant Line

GEMS-0002 Public Release

Nutritional & Health Benefits

- ♦ Grain composition- improved levels of oil, protein, and starch.
- ♦ Starch properties- “resistant starch” reported with low glycemic index which is promising for diabetes and obesity.
- ♦ Essential amino acids- increased lysine, tryptophan, methionine.
- ♦ Silks contain bioflavonoids (maysin, etc), potassium, vitamin C, and vitamin K.



Nutritional & Health Benefits (continued)

Corn silks (female styles) - for urinary tract and circulation.

- Corn silk extracts for reducing kidney stones.
- Beta-carotene is a source for provitamin A.
- Macular carotenoids - Zeaxanthin & lutein for eye health (reported in orange flint races from South America).



http://www.jeannerose.net/articles/kidney_stones_treatment.html

GEM TR-88 Dual Plot Combine





GEMS-0113 (CHIS775:S1911b-120-001)



Country: Mexico
Race: Tuxpeño
Type: 25% Tropical
Heterotic Group: Stiff Stalk
Protein: 15.8%
Oil: 4.3%
Starch: 64.9%
Density: 1.329
Other Specialty Traits:
Starch Properties &
Southern Leaf Blight Resistance

Days to Anthesis: 60
Days to Silk: 64
Husk Tightness: 7
Husk Length: 7
Cob Color: Red
Cob Length: 10-16 cm
Tassel Angle: 60°
Tassel Branches: 13
Plant Height: 152 cm
Ear Height: 91 cm



Important Agronomic Traits- the three biggest challenges

- ◆ Yield - less acreage required.
- ◆ Drought & Heat Tolerance-more important today for climate change.
- ◆ Nitrogen Use Efficiency –“NUE”-less N means less fertilizer pollution.

Iowa State Food Scientists Visit GEM Field Day



September, 2013

Three Sisters: Corn, beans, squash

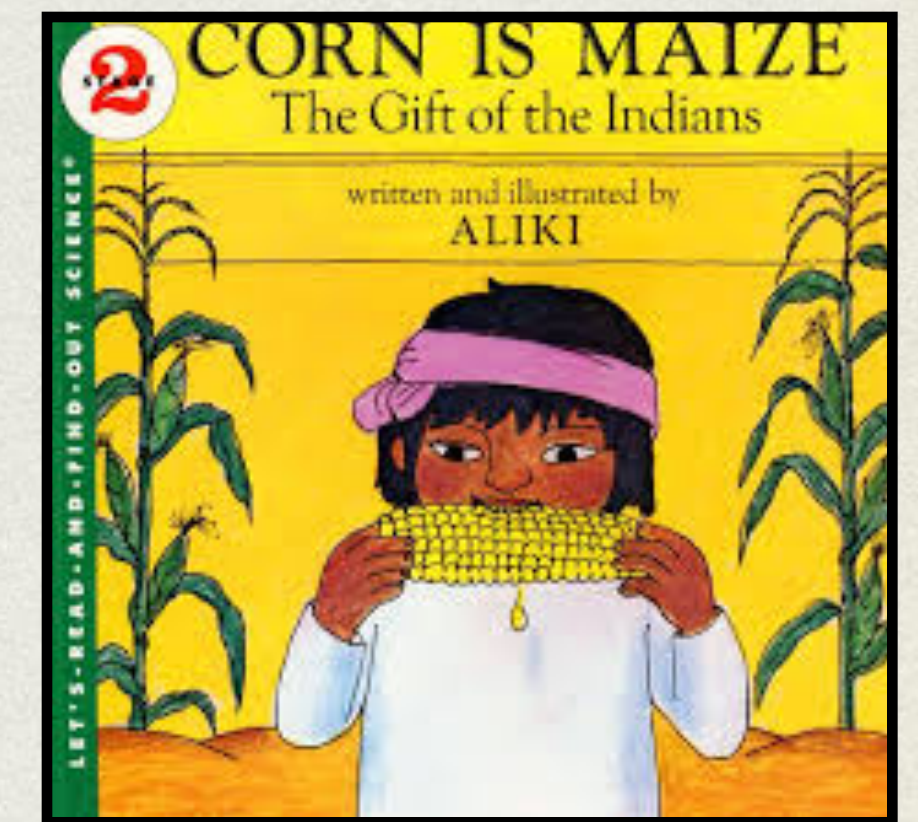
Historically used by most native American tribes for centuries.

- Corn-planted first; provides “pole” for beans.
- Beans-planted after corn emerges; fix nitrogen and provide to corn.
- Squash-planted 1 week after beans; provide mulch.
- First scientific proof that beans can fix nitrogen (*Rhizobium* sp.) in 1888.



Three Sisters: Corn, beans, squash (continued)

- ◆ Also used by the US Cavalry vegetable gardens in 1800's.
- ◆ Used today on Maya farms in the Yucatan Peninsula.
- ◆ Stimulated current research for “companion planting” and crop rotations.



Three Sisters: Corn

Striped Japonica

- ♦ Others planted at SDBG Incredible Edibles:
 - Dakota Black Corn
 - Earthtones



Blue Corn

Often called “Hopi Corn” but also used by other tribes in the southwest.

- Most Blue Corn has “floury” starch.
- Nutritional profile includes anthocyanins (antioxidant properties), 10% higher amino acid content (lysine, methionine), and higher oil content than standard yellow corn.
- Blue corn has higher niacin and reduced Pellagra deficiency in some Hopi tribes.
- Grown by small farmers for specialty food markets.



Cuzco Corn

Also called “Inca corn” for the Inca capital- Cuzco, Peru.

- Large kernels and most have “floury” starch.
- Also called “Corn Nuts” and Dientes del Caballo (horse teeth).
- Cuzco race planted in tropical Highlands 11,000 feet elevation, and average growing season temperature of 65 F. (Very low temp for corn growing).
- First gene for Common Rust resistance, *Rp1*, was identified in Cuzco race and transferred to Dent corn used in the US.



Aztec White Corn

Aztecs grew mostly white, large kernel corn but also grew Aztec Black corn used the same way as Blue Corn.

- Iroquois in NY State grew white corn. Iroquois White Corn Project today promotes usage of an heirloom white variety grown 1,400 years ago.
- White corn has low carotenoids, and low vitamin A (major criticism).
- White corn amino acid profile is often favorable.



Strawberry Popcorn

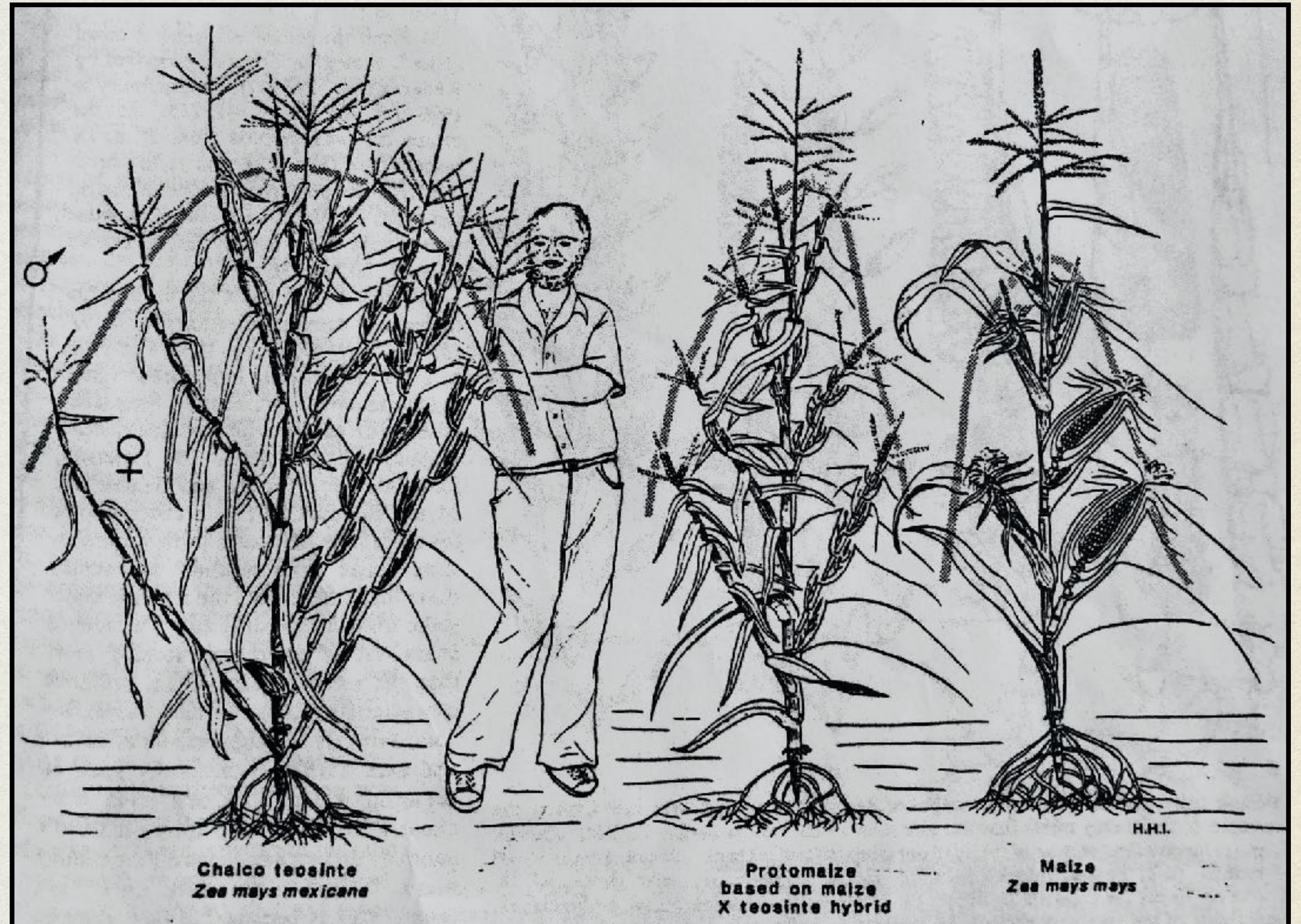
Popular ornamental popcorn that looks like strawberry

- Popcorn thought to be closely related to teosinte.
- Why does popcorn “pop”? Hard flint type kernels, internal kernel moisture, intact seed pericarp, and starch gelatinization properties cause explosion (still being studied).
- Requires 14-15% kernel moisture to pop best.
- Low calories, low fat, sugar free, and no sodium (avoid the butter).
- Popcorn has a genetic incompatibility gene which prevents cross pollination with dent corn.
- First gene reported for resistance to Northern Leaf Blight, *Ht1*, was identified in a popcorn variety and used by dent corn breeders.



Teosinte Wild Relative

- ◆ Multiple tillers.
- ◆ Multiple ears on tillers.
- ◆ Grass like appearance.



Teosinte x Corn Plant Type

- ♦ Multiple ears on the stalk.
- ♦ Small ears compared to corn.
- ♦ Very tight husks.



Teosinte x Corn Ear Type

- ♦ Small pencil size ears.
- ♦ Few rows of kernels.
- ♦ Traits from teosinte include resistance to 66 genera of insects, and many diseases including Southern Rust, Southern Leaf Blight, Maize Streak Virus, Striga (parasitic weed), flood resistance, and nutritional properties.



Teosinte and Maize Species

- ♦ *Zea mays* ssp. *mays* (Corn or Maize).
- ♦ *Zea mays* ssp. *parviglumis* (planted at SDBG).
- ♦ *Zea mays* ssp. *mexicana*.
- ♦ *Zea mays* ssp. *huehuetenangensis*.

- ♦ *Zea diploperennis* (diploid perennial).
- ♦ *Zea perennis* (tetraploid perennial).
- ♦ *Zea luxurians*.



Historical Plant Collectors

Year 1940: Colorado and Green River trip by Charles Larabee, Barry Goldwater, and Dr. Hugh Cutler .

- Cutler was a young ethnobotanist (age 28) with interest in corn, squash, beans, and native plants. During the River trip he collected 900 year old corn cobs in Anasazi Indian ruins.
- After extensive travel he published “Races of Maize in South America” while at Harvard in 1946.
- In 1988 he published “North American Indian Corn,” and became world famous for advancing our knowledge on corn racial diversity while at the Missouri Botanical Garden.
- How much influence have these 3 people had on each other?

Diversity in SDBG



Giant Timber Bamboo

Dendrocalamus giganteus

This bamboo grew here for 30 years. About 2008 it started to flower and seed. Like many bamboos after a few years it declined and so was cut down in 2013. This species is one of the two largest bamboos, growing over 100 feet tall. Native to India, Burma, and Thailand, it is used for construction, furniture, food, and crafts.

Diversity in SDBG Continued

Bamboo

- Bamboo is the tallest species of grass (Poaceae).
- fast growing land plant; 90% of growth in first year.
- very diverse plant types; runners, clumpers, timber, herbaceous, ornamental, etc.
- SDBG has largest bamboo collection of species in US.
- very similar plant type as corn.
- scattered vascular bundles in culm (stalk).
- groove on culm of temperate bamboo also found in corn.



Diversity in SDBG

Banana

- 30 different varieties on “Banana Boulevard”.
- banana is not a tree, but the world’s largest herb.
- diverse uses-eating types, and cooking (plantains).
- triploid genetics makes breeding difficult but not impossible.
- bananas now at risk for disease susceptibility due to genetic uniformity.



THANK YOU!

Hamilton Garden Team for Corn Support

- ♦ Lan Lin for sharing ideas, comments, and creative slide preparation.
- ♦ SDBG Gardening staff and conversations with many volunteers and docents.

**** Charlie Garren not in photo ****



Alice
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Karen
Mortensen

Jennifer
Meizen

Mike

Dylan
Connolly

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