Development of maize hybrids

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Outline

- Introduction
- Major steps in hybrid maize development
- Testing inbred lines in hybrid combinations
- Types of Maize Hybrids
  - Conventional Maize Hybrids
  - Non-Conventional Maize Hybrids

What is hybrid maize?

- A cross between two or more unrelated parents
- The most productive innovation in plant breeding
- It started a revolution in
  - Agricultural productivity
  - Uniformity of products
  - Fixing specific traits that serve as trade marks
  - Seed production and marketing
  - Catalyst for the establishment private sector
- By 1955 = 100% maize area in USA hybrid due to its better performance
- 1984 spread to Europe
- 1960 and 1970 in Eastern and Southern Africa

Hybrid performance and heterosis

Heterosis is expressed when two genetically unrelated parents are crossed to create a hybrid

Mid-parent heterosis (%) = [(F1-MP)/MP] x 100

High-parent heterosis (%) = [(F1-HP)/HP] x 100

- F1 = performance of the hybrid
- MP = Average performance of the parents of the hybrid
- HP = Performance of the best parent of the hybrid

Hybrid vigor: Maize lines B73 (left) and Mo17 (right) produce the hybrid F1 (center).

http://www2.iastate.edu/~nscentral/news/06/may/vigor.shtml

How do we form hybrids?

1. Crossing two or more **unrelated** inbred lines

2. Crossing an open-pollinated variety, or a synthetic to an **unrelated** inbred line

3. Crossing two **unrelated** open-pollinated varieties, or synthetics, or populations

Major steps in hybrid maize development

1. Development of inbred lines and classifying them into heterotic groups

2. Testing inbred lines in hybrid combinations

3. Evaluate the potential of selected best inbred lines for developing different types of hybrids

4. Testing and identifying superior hybrids for commercial seed production and use by farmers

Separating inbred lines into heterotic groups

- Heterotic pattern provide defined structures to breeding materials
- Simplify management of germplasm
- Provides suitable tester for assessing the breeding value of exotic germplasm
- Facilitate selection of parents for developing
  - Bi-parental crosses for inbred line development (same heterotic group)
  - Hybrid combinations for testing (opposite heterotic groups)

Testing inbred lines in hybrid combinations

- Goal of inbred line development is to identify lines that produce high-yielding hybrids
- The correlation between traits of the inbred lines and their hybrids is weak
  - Empirical and simulation studies show correlations of less than 0.40
- Inbred lines should thus be tested in crosses to identify promising parents of productive hybrids

2. Testing inbred lines in hybrid combinations

- Testing a large number of inbred lines in all possible combinations is not practically feasible
- Formula for all possible single crosses – n(n-1)/2
  - n = 10, 45 hybrids
  - n = 20, 190 hybrids
  - n = 100, 4950 hybrids
  - n = 500, 124750 hybrids
- It is necessary to identify promising lines with good combining ability before their extensive evaluation in hybrid combinations

Testing inbred lines in hybrid combinations

- Cross all inbred lines to form limited number of hybrids for testing
  - New inbred lines are crossed to a common parent referred to as a tester
  - This approach is called top-cross or testcross evaluation
  - With such a common tester parent, any difference in hybrid performance can be ascribed to differences in the combining ability of the inbred lines

Choice of tester

- An ideal tester maximizes differences among the genotypes being tested
- Tester with poor performance presumably has a low frequency of dominant favorable alleles
- However, mean performance among TC families is low
- We also want the tester to represent a potential parent of a hybrid cultivar so that YTs are not only identifying top parents, but also identifying potential new cultivars (SCA)
- Best testers have high TC and high μT

Types of Maize Hybrids

Conventional Maize Hybrids (Involve inbred parents)

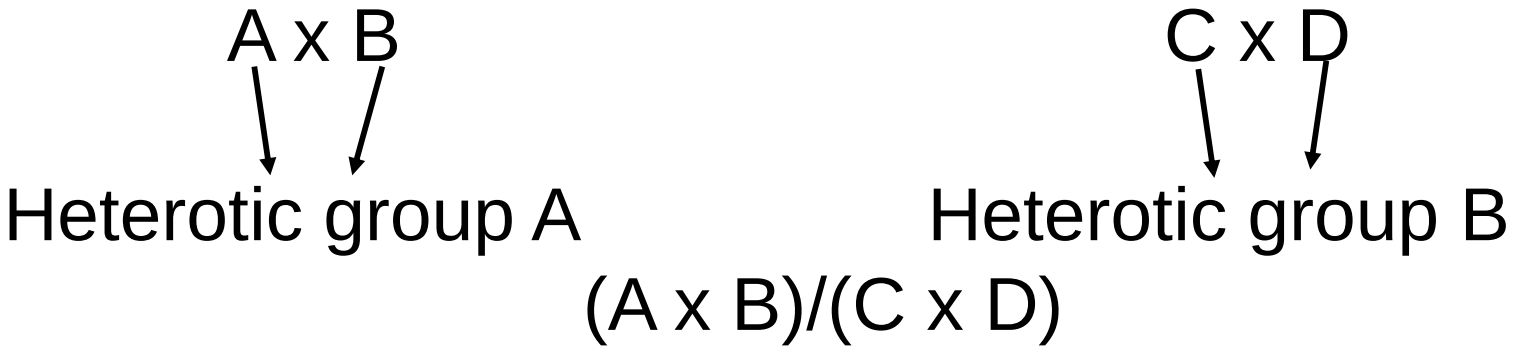
- Single Cross (A x B)
- Three-Way Cross ((A x B) x C)
- Double-Cross ((A x B) x (C x D))

Non-Conventional-Low Cost Hybrids

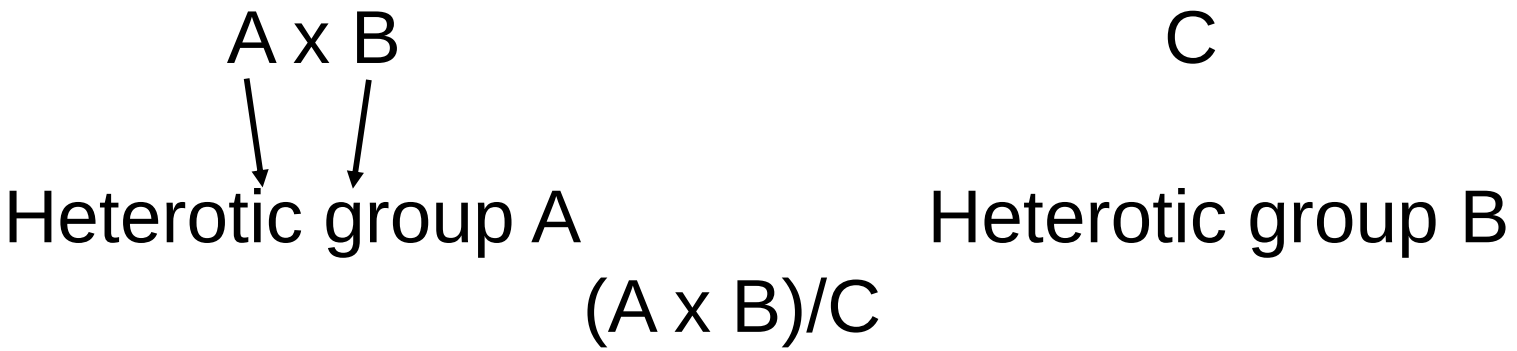
- Top-Cross (Variety x Inbred)
- Double Top-Cross (Single Cross x Variety)
- Variety cross (Variety A x Variety B)
- Synthetic cross (Synthetic A x Synthetic B)
- Population cross (Population A x Population B)

Evaluate the best inbred lines to produce different types of hybrids

Double-cross hybrid



Three-way cross hybrid



Conventional Maize Hybrids: Single-Cross

Advantages

- Production and maintenance of two parental lines is easier
- Better expression of heterosis
- Suitable for high-yield environments,
- Uniform in plant height, ear height, tasseling, silking, pollen shedding and all other characteristics
- Because of the availability of excellent inbred female parents, single-cross hybrids represent almost 90% of hybrid corn seed market

Disadvantage:

- The female parental line is usually low yielding resulting in high cost of seed production and the price of seed
- If any component is susceptible, it will affect all of the single-cross plants, resulting in lower performance
- Pollen shed occurs during a shorter period since all the plants are genetically alike, with the potential for lower yields, especially under stress conditions

Conventional Maize Hybrids

Three-Way Cross Hybrid

- This is a cross between a single-cross (A x B) hybrid as a seed parent and an unrelated inbred line (C) as a pollen parent (**A x B) x C)**

Advantages

- Lower cost of production and price to growers due to the high yield of the single-cross hybrid used as a seed parent

Disadvantage

- The hybrid is less uniform in height and other traits than the single-cross hybrid
- Requires the production and maintenance of three parental inbred lines

Conventional Maize Hybrids

Double-Cross Hybrid

- Produced by crossing two different single crosses [(**A x B) x (C x D**)], permitting breeders to bring more different desirable traits together into one hybrid than is possible in a single cross

Advantages

- The plants may be “buffered” more against unfavorable situations, which frequently occur at one or more times during the growing season
- Use of different F1 hybrids as both female and male parents produces abundant pollen and plenty of seeds and thus reduces the cost of production and price of seeds
- Double-cross plants also have a longer pollination period, which tends to provide more complete filling of the ear with seed, often resulting in higher yields.

Conventional Maize Hybrids

Double-Cross Hybrid

Disadvantage

- The hybrid is less uniform in height and other traits than the three-way cross hybrids
- Requires coordinated production of two hybrids for generating the double-cross hybrid
- Requires the production and maintenance of four parental inbred lines

Non-Conventional-Low Cost Hybrids

Top-Cross Hybrid

- It is a crossing between an open-pollinated variety (OPV) or synthetic (SYN) and an inbred line (**OPV x A or SYN x A**).

Advantages

- Use of an open-pollinated variety as a female produces plenty of seed and thus reduces the cost of production and price of seeds to growers
- The inbred parent harvested from detasseled production fields can be used as a male parent, allowing the seed company to multiply only the female parent in a separate field.

Disadvantage

- The hybrid is not very uniform for the different traits

Non-Conventional-Low Cost Hybrids

Variety-Cross, Synthetic-cross and Population-cross Hybrids

- It is produced by crossing tow unrelated open-pollinated varieties, synthetics or populations (**VAR A x VAR B or SYN A x SYN B or POPA x POPB**).

Advantages

- Use of an open-pollinated variety (synthetic) as a male produces abundant pollen that enhances seed setting
- Better synchrony between tasseling and silking
- Use of an open-pollinated variety (synthetic) as a female produces plenty of seeds and thus reduces the cost of production and price of seeds

Disadvantage

- The hybrid is the least uniform and the least productive among the group

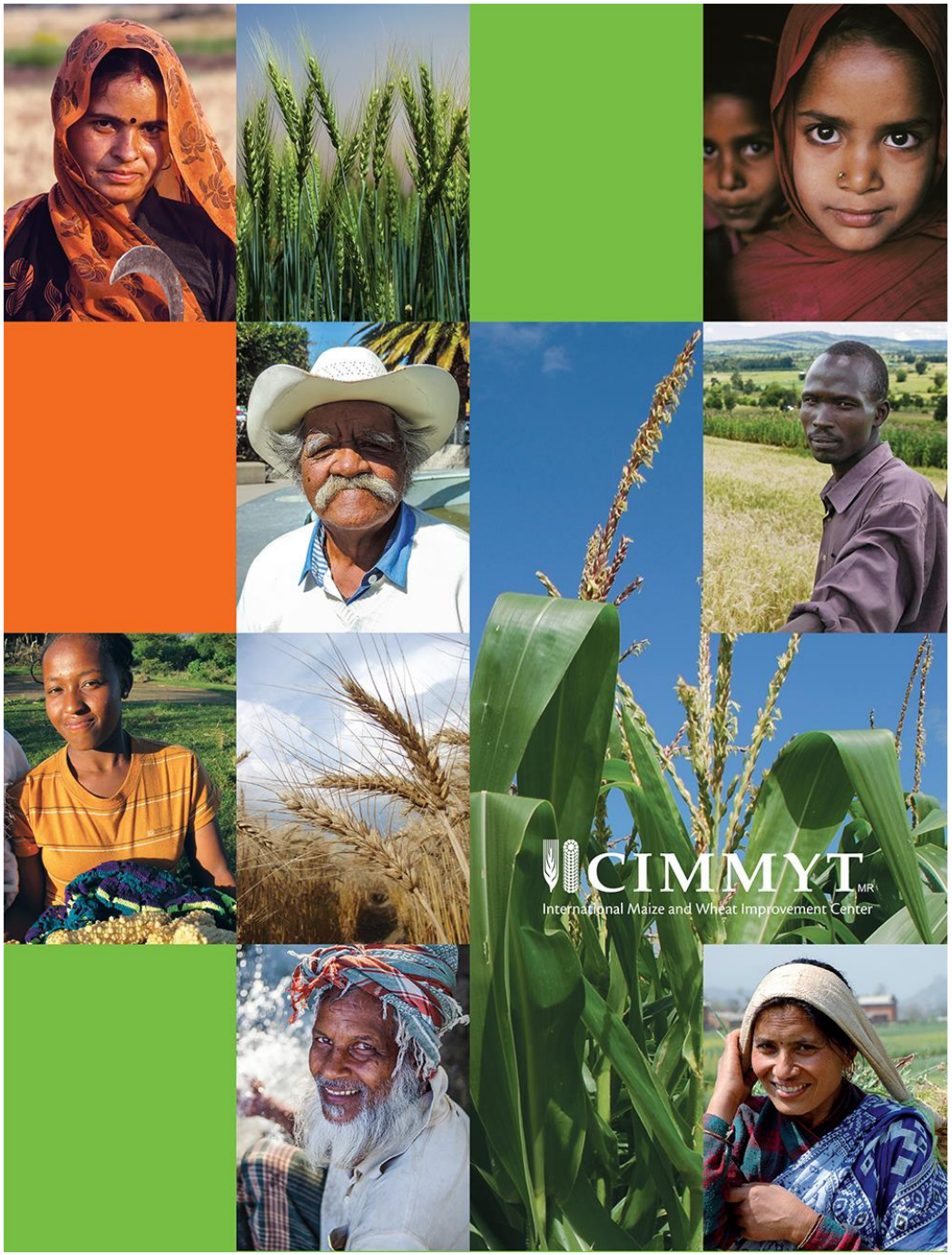
Product advancement process in CIMMYT maize breeding program

1. Stage I – breeder controlled
   - First testcross evaluation; one tester; 2 reps, 3-5 sites
2. Stage II – breeder controlled
   - Selected lines (10-20% SI) from stage I trials, 3 testers; 2 reps, 8-10 sites
3. Stage III- breeder/partner controlled
   - Selected lines from Stage II trials (10-15% SI)
   - Cross with 5-7 testers
   - 2 rep, 10-15 locations
4. Regional trial (collaboration)
   - best products from stage III
   - 2 row, 2 reps, 45-60 entries (CIMMYT, NARS and private seed), 60 sites
   - Run in partnership
5. NPT- selected hybrids evaluated in NPT by public and private partners

Summary

Target Production and Marketing Environment and Farmers Needs

- Adaptation to prevalent climatic conditions
- Resistance to major diseases and insect pests
- Resistance to parasitic plants (*Striga hermonthica*)
- Tolerance to drought and low soil nitrogen
- Resistance to stalk and root lodging (good standability)
- Cost of seed production and purchasing power of the growers



Thank you for your interest!

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