

Nomenclature

Cultivar (a.k.a. agricultural variety or simply variety): Group of genetically similar plants, which by structural features and performance may be identified from other groups of genetically similar plants within a species. Group of plants with characteristics that are distinct, uniform, and stable.

Once a new superior “experimental line” or “strain” from a given species is identified, it may be named and, seed increased and distributed as a cultivar.

Main characteristics: *Identity and reproducibility*

Population: Group of individuals:

Mapping population

Diversity population

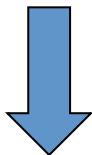
Breeding population

Cultivars by Reproductive Behavior

Self-pollination



Perfect flower



- Pure line variety (Inbred)
- Hybrids

Cross-pollination



Monoecy



Dioecy

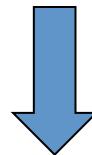


Self-incompatible

Vegetative reproduction



Apomixis/limited flowering



- Clonal variety
- Hybrids
- Mutants

- Synthetic variety – heterogeneous population (not a pure line)
- Hybrid variety, if inbred development is possible (maize)

Breeding Methods by Reproductive Behavior

Self-pollinating crops



Cross-pollinating crops



- Mass selection
- Pure line selection
- Pedigree method
- Single seed descent
- Doubled haploids
- Back-cross breeding
- Male sterility and F_1 hybrids

- Mass selection
- Open pollinated populations: phenotypic selection
- Synthetic open-pollinated populations
- F_1 hybrids
- Recurrent selection
- Genotypic Recurrent Selection
- Pseudo-backcrossing

Mass selection



- Probably the oldest method of all plant breeding methodologies.

- Farmers saved the best seed to plant the following year's crop.



Ex.: lodging, seed shattering, diseases, etc.

- The decision to select a plant as a parent of the next generation is based on the performance of that plant (phenotype).
- No progeny testing



Mass selection

Advantages

1. Simplicity
2. Low cost
3. Works well for traits with high heritability → rapid improvement

Disadvantages

1. Much less effective for traits with low heritability, because the environmental variance plays a big role ($V_p = V_G + V_E$) and there is a low probability of correctly identifying the best genotypes in the population
2. Lack of pedigree information.
3. Lack of environmental control (no blocking factors or test).
4. Inbreeding (how many individuals are selected on each cycle).

Pedigree Method

More efficient than Mass selection.

Discovered after observing that progeny derived from single plants were more uniform than bulked plants from mass selection (1981).

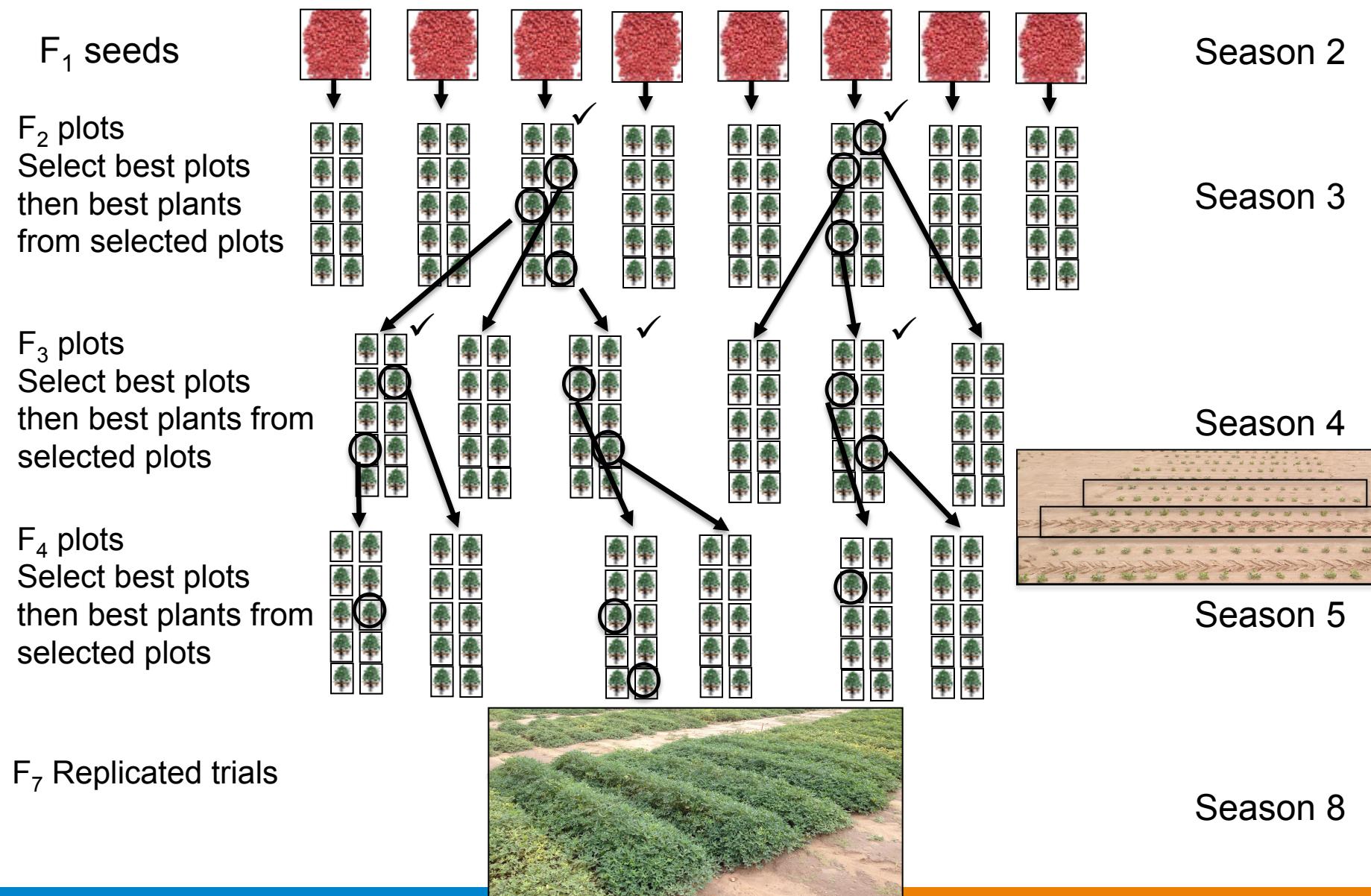
Later it become important in cross-pollinated species as well.

It begins with an F2 population and continues until uniform lines are developed.

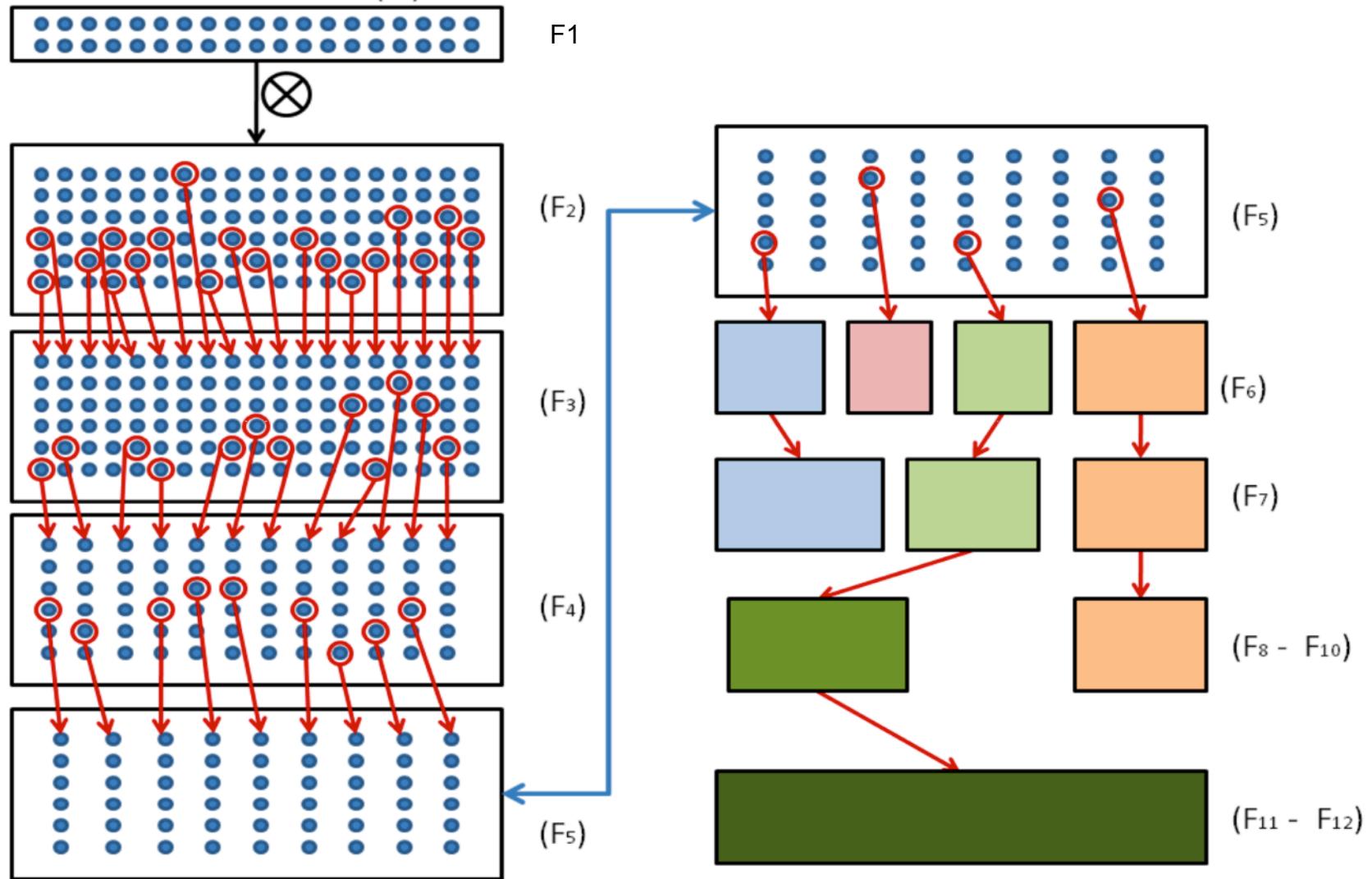
For species where individual plants can be examined and harvested separately.

Examples: Species that are (or can be) self-pollinated: Peanut, soybean, corn

Seasonal Flow of Pedigree Method



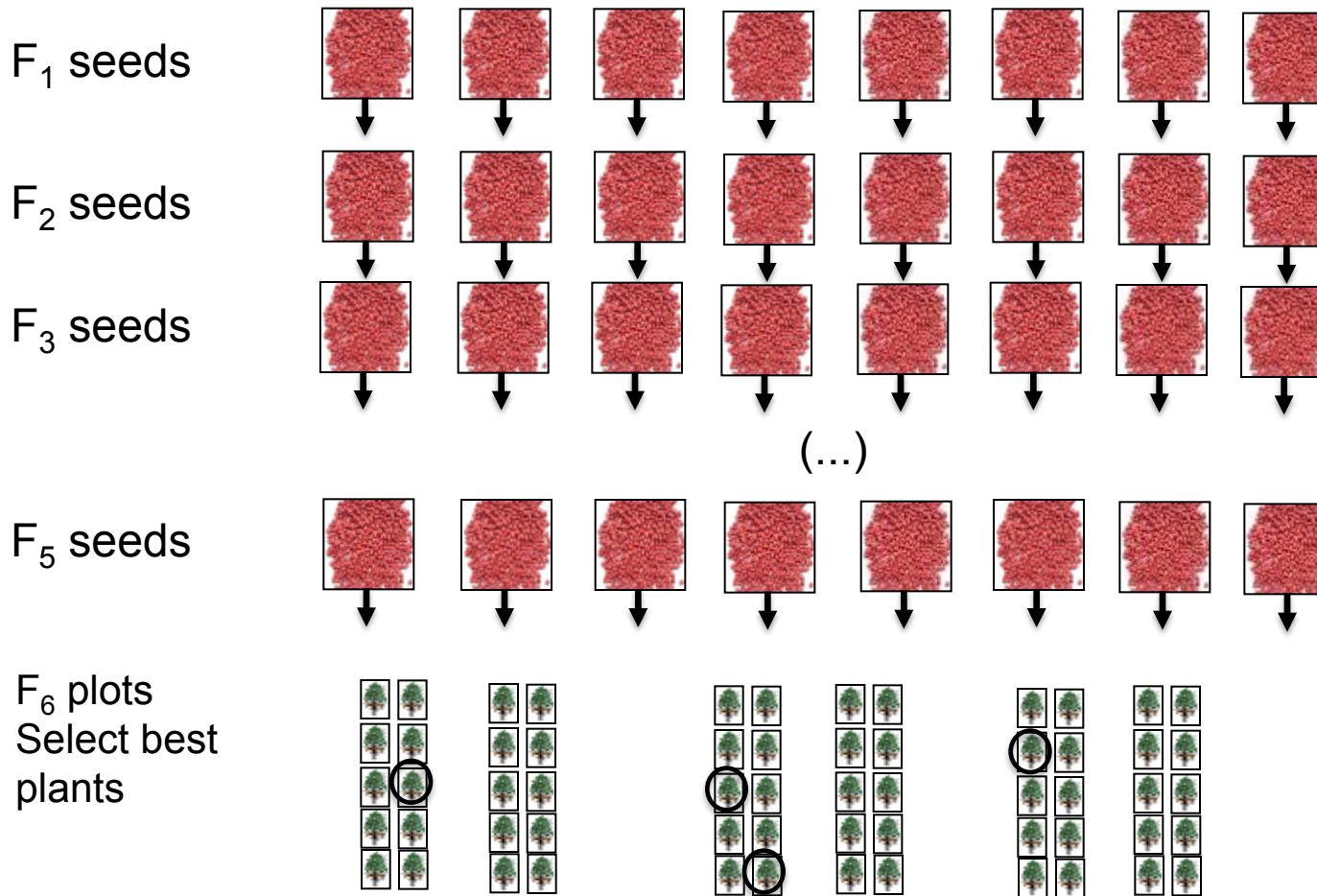
Pedigree Method



Pros and Cons of the Pedigree Method

- Advantages
 - Reduce number of inferior genotypes in selection process prior to expensive testing
 - Genetic relationships are known and can be used to maximize genetic variability among lines that are retained
- Disadvantages
 - Pedigree method (in strictest sense) cannot be used in environments where genetic variation is not expressed- may prevent use in off-season nurseries.
 - Lots of record keeping
 - Experienced persons needed to make selections
 - More resource intensive than other methods (land, labor, etc.)

Bulk-population/Single-seed descent (SSD) Method



F₇ Replicated trials

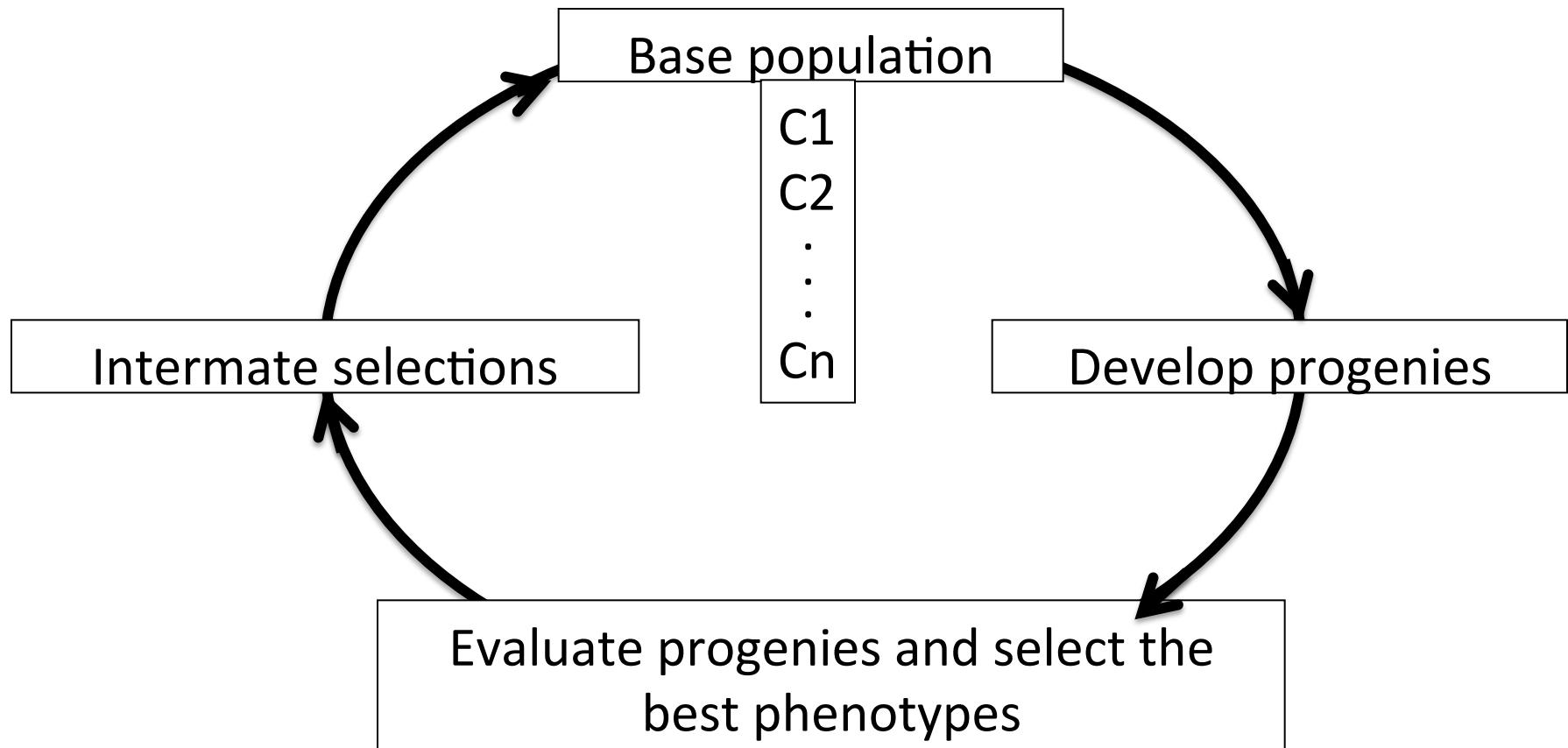


Pedigree Method vs Bulk-Population/Single Seed Descent

	Pedigree	Bulk-Population/Single Seed Descent
Selection	If selection is effective, eliminates inferior genotypes early in the process.	Retains all, or most, F_2 genotypes, even inferior ones.
	Selection in different environments in the selfing process provides opportunity for expression of genetic variation	No selection until lines are stable
Off-season nurseries	In strictest sense, cannot be used in environments where traits of interest don't express properly to allow selection	Since selection is not practiced during the early generations, environment does not matter allowing off-season nurseries to advance rapidly to homozygosity
Records	Meticulous, but allow tractability and knowledge of genetic variability among lines	Minimal
Resources	More: land, labor, materials, experienced people for selection	Less: labor, materials, experienced people for selection

Recurrent Selection

Cyclical and systematic technique in which desirable individuals are selected from a population and inter-mated to form a new population



Recurrent Phenotypic Selection

Objectives of selection

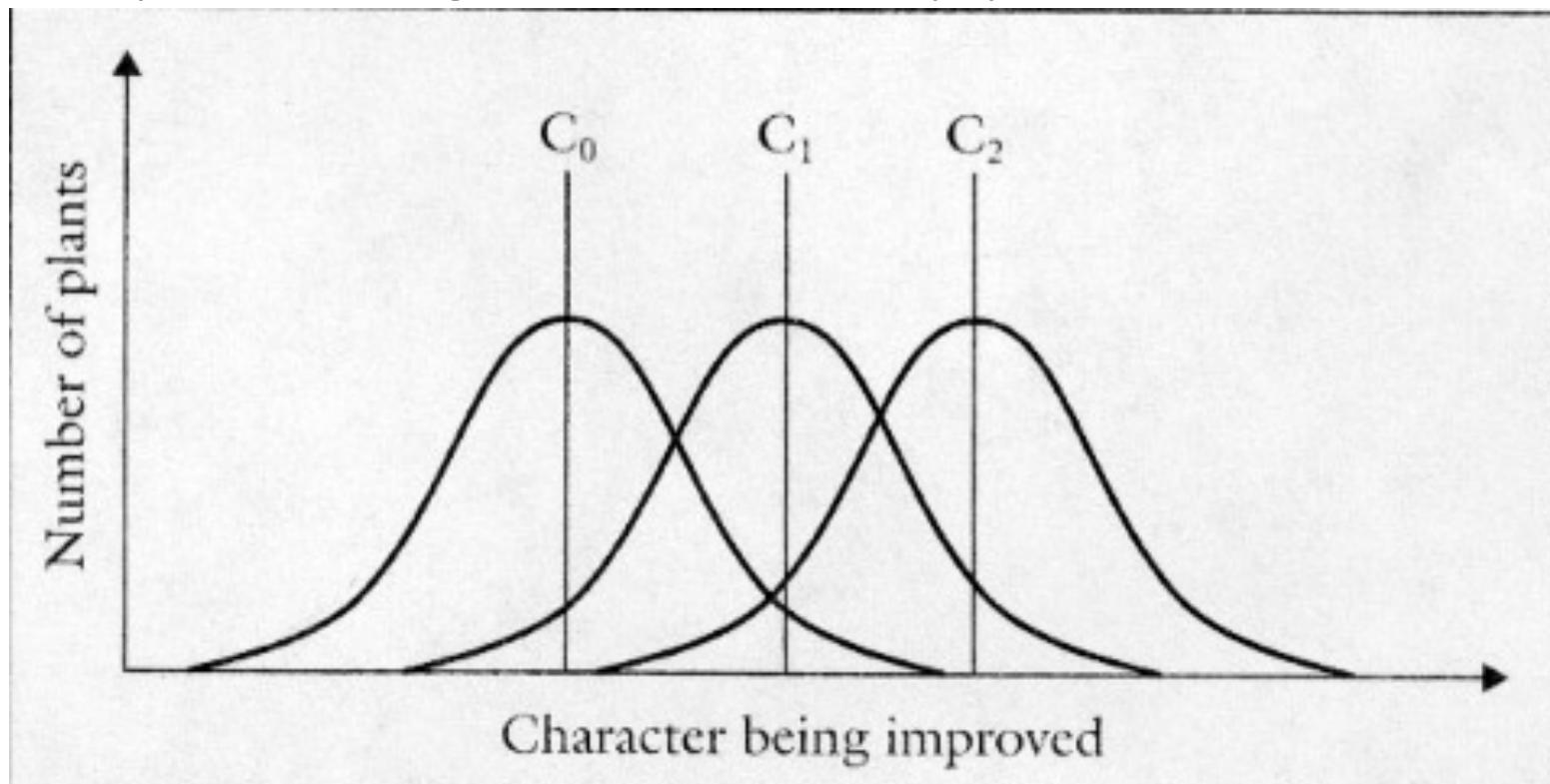
- Increase the frequency of favorable alleles, which is to increase the mean of the population in the favorable direction
- Maintain genetic variability for continued selection by inter-mating superior progenies for each cycle of selection.
- Therefore, enhancing the probability of obtaining superior cultivars from the population.

Recurrent Phenotypic Selection

Key features:

One of the oldest methods in plant breeding

Gradually concentrating desirable alleles in a population



Backcross

Method to transfer one or few genes

Used for qualitative traits (simple inheritance)

It involves hybridization but not aiming at the creation of genetic variability

Typically used when the breeder has an elite material and wants to introgress a single gene

Backcross is a breeding design where molecular markers are conventionally utilized to accelerate the process (more on that later)

Backcross

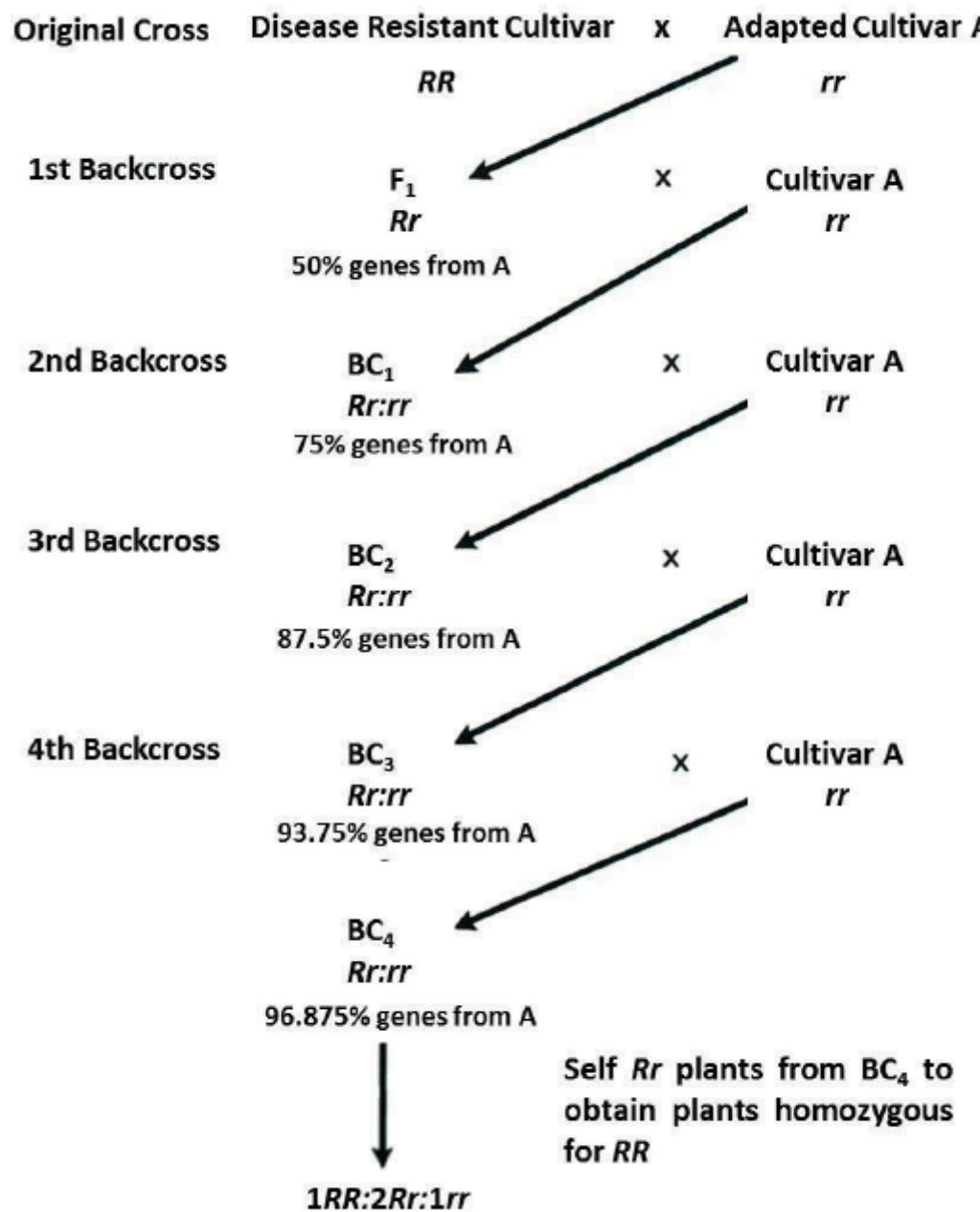
Advantages:

The resulting cultivar is (often) already well known and well received by the growers.

The crop recommendations are the same or very similar to the original elite material.

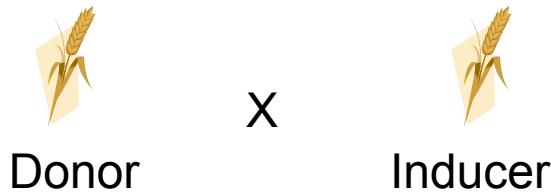
The breeding can occur in any environment where the introgressed trait is observed.

Backcross



Double Haploids

Genotype:
Aa**BBCcddEeFf**



Haploid Genotypes:

- 1) ABCdeF
- 2) aBcdEF
- 3) ABcdEf
- 4) (...)

(n)

~10% of haploid kernels

(2n)

Treatment with doubling agent

Haploid Genotypes:

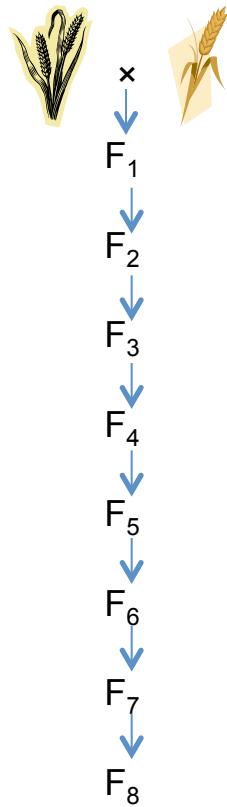
- 1) AA**BBCCddeeFF**
- 2) aa**BBccddEEFF**
- 3) AA**BBccddEEff**

Selfing



Double Haploids

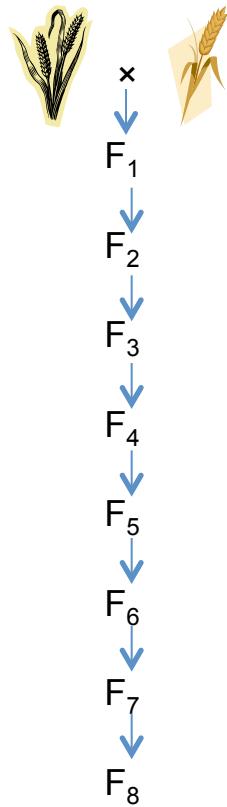
Self-Pollinating crops



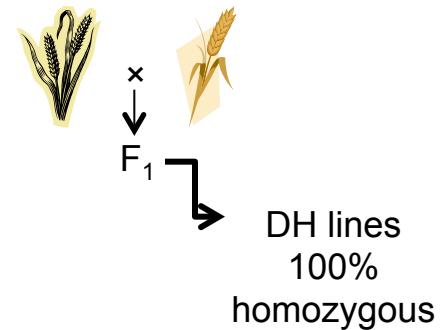
Frequency of homozygous
0 %
50 %
75 %
87.5 %
93.75 %
96.88 %
98.44 %
99.22 %

Double Haploids

Self-Pollinating crops



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Accelerates the development of new lines

Produces lines that are highly homogenous

Basic genetic and breeding concepts

Gamete: a mature reproductive cell that is specialized for sexual fusion.

Haploid (n): containing only **one set of chromosomes (n)**. Each gamete is haploid.

Diploid (2n): containing **two copies of each chromosome** (homologous chromosomes) in the nuclei, formed by the fusion of two haploid gametes.

Cross: a mating between two individuals, leading to the fusion of gametes.

Gene: the inherited segment of DNA that determines a specific characteristic in an organism.

Allele: **alternative forms of a gene**.

Locus: the **specific place on the chromosome** where a gene is located.

Basic genetic and breeding concepts

Genotype: the genetic constitution of an organism.

Phenotype: the **physical manifestation of a genetic trait** that results from a specific genotype and its interaction with the environment.

Homozygous: an individual whose genetic constitution has the **same allele** at a given gene locus (eg, AA, aa).

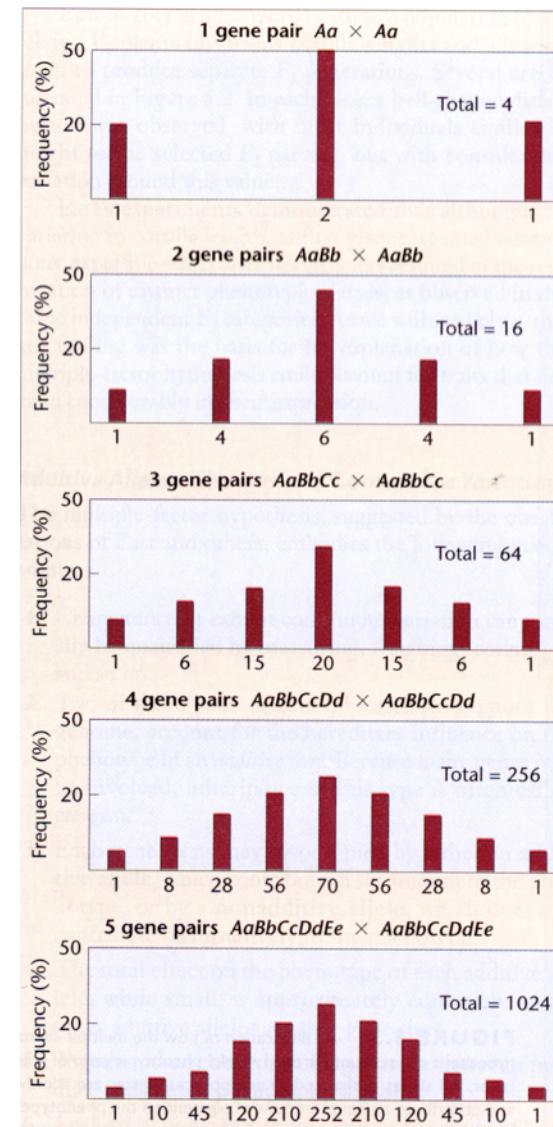
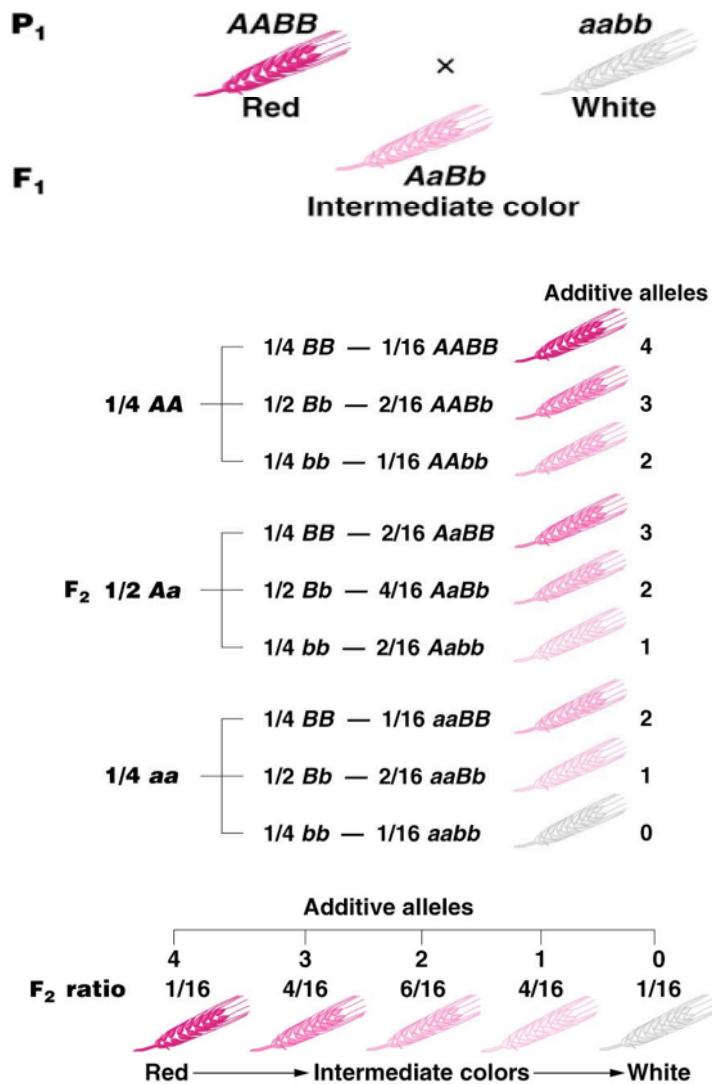
Heterozygous: an individual whose genetic constitution has **different alleles** at a given gene locus (eg, Aa).

Homogenous population: a population of individuals having the same genetic constitution (eg, a field of pure-line soybean; a field of hybrid corn).

Heterogeneous population: a population of individuals having different genetic constitutions.

Quantitative Traits and Mendel

Multi-factor or multi-gene hypothesis



Hermann Nilsson-Elhe 1909

Fig. 24-3

1. Traits with can be quantified – measured, weighed, counted, etc...
2. Two or more independent loci contribute to phenotype
3. Each gene may have either: an allele that contributes to the trait (additive) or one that DO NOT contribute (Non-additive)
4. Each gene contribute a small and equal portion to the phenotype.
5. Together, all genes can produce substantial phenotypic variation.
6. These studies require the analysis of large number of progeny in a population