Plant Breeding Principles and Methods

Dr. Avneet Kaur

We will discuss…..

Plant breeding ,its history

Objectives of plant breeding

Activities involved

Methods for self and cross pollinated crops

Hybrid production

Synthetic varities

Heterosis

Imp achievements

Undesirable consequences

Definition

- **Plant Breeding is the science of changing the traits of plants in order to produce desired characteristics.**
- ***Plant Breeding is a method of altering the genetic pattern of plants to increase their value and utility for human welfare.***
- ***Its aims to improve the various characteristics of plants so that they become more desirable agronomically and economically.***

- **Plant Breeding as Science – By understanding genes and heredity, scientists are able to select appropriate traits to more consistently express desired characteristics.**
- **Plant Breeding as Art – Breeders use their observational skills, experience, intuition and judgment to see plant differences.**
- **Plant Breeding as Business – Consistency of those important characteristics can positively impact the environment, while also ensuring the availability of a safe and nutritious food supply.**

History of Plant Breeding

- In abroad sense history of plant breeding can be divided into 4 parts
- **Pre mendelian era**: before 1900.
- **Mendelian era** :1900 to 1920.
- **Post mendelian era**:1921 to 1950.
- **Modern era**:after 1950.

Pre Mendelian Era

- **The process of bringing a wild species under human management is referred to as DOMESTICATION**.
- 9000 B.C: First evidence of plant domestication in the hills above the tigris river.
- 700 B.C: Babylonians and Assyrians hand pollinate date palm artificially.
- 1694:Camerarius of germany first to demonstrate sex in plants and suggested crossing as a method to obtain new plant types.
- 1717:Thomas Fairchild:Developed first inter specific hybrid between sweet william and carnation species of dianthus popularly known as Fair Childs Mule.
- 1766:Joseph Koelrueter of germany demonstrated that hybrid offspring received traits from both parents and were intermediate in most traits observed and produced first scientific hybrid using tobacco.

Mendelian Era

- **1900:De Varies (Holland) correns(Germany) Tschermak(Austria) Rediscovered mendel laws of inheritance independently**.
- 1900:Nilson,H(Swedish):Elaborated individual plant selection method in Sweden.
- 1903:W.L :proposed the pureline theory that provided the genetic basis for individual plant selection and also coined the terms Genotype,Phenotype and Pureline.
- 1908-1909:Hardy of England and Weinberg of Germany developed the law of equilibrium of populations.
- 1908:Devenport,C.B:First proposed dominance hypothesis of heterosis.

Post Mendelian Era

- 1923:Sex: linkage between quantitative and qualitative traits in beans.
- 1926: East,E.M and Mangelsdorf,A.J:First discovered gametophytic system of self incompatibility in *Nicotiana sanderae.*
- *1926:Vavilov,N.I: Identified 8 main centers and 3 sub centers of crop diversity. He also developed concept of parallel series of variation or law of homologous concept of parallel series of variation or law of homologous series of variation.*
- *1927:Muller mutations in fruit flies using X-rays.*
- *1927:Karpencheko developed first intergeneric hybrid between Radish and Cabbage in Russia.*
- *1928:Stadler,L.J (US):First used X-rays for induction of mutations in barley.*

Modern Era

- 1952-Jensen,N.F: First suggested the use of multi lines in oats.
- 1953- Watson,Crick,and Wilkins proposed a model for Double Helical Structure of DNA.
- 1965-Graphius, J.E: First applied Single Seed Descent (SSD) method in oats.
- 1994-FlaveSavr tomato developed as first genetically modified food produced for the market by calgene company of California.
- 1995-Bt corn developed.
- 2005-Government of India:Approved cultivation of some Bt cotton hybrids in Punjab,Haryana and Rajasthan.

Institutional Development And History Of Plant Breeding in India

- 1871-The government of India created the department of Agriculture.
- 1905-The imperial Agriculture research institute was established in Pusa,Bihar.
- 1956-Project for intensification of regional research on cotton,oilseeds and millets(PIRRCOM) was initiated to intensify research on these crops located at 17 different centres throughout the country.
- 1960-First Agricultural University established at Pantnagar,Nainital,U.P.

- 1961-The first hybrid maize varieties released by the project. ICAR initiated coordinated projects for improvement of the other crops.
- 1964-First sorghum hybrid (CSH-1) was released.
- 1965-First bajra hybrid (HB-1) was released.
- 1991-First pigeon pea hybrid (ICPH-8) was released from ICRISAT.

Popular scientists in Plant Breeding

M.S Swani Naathan

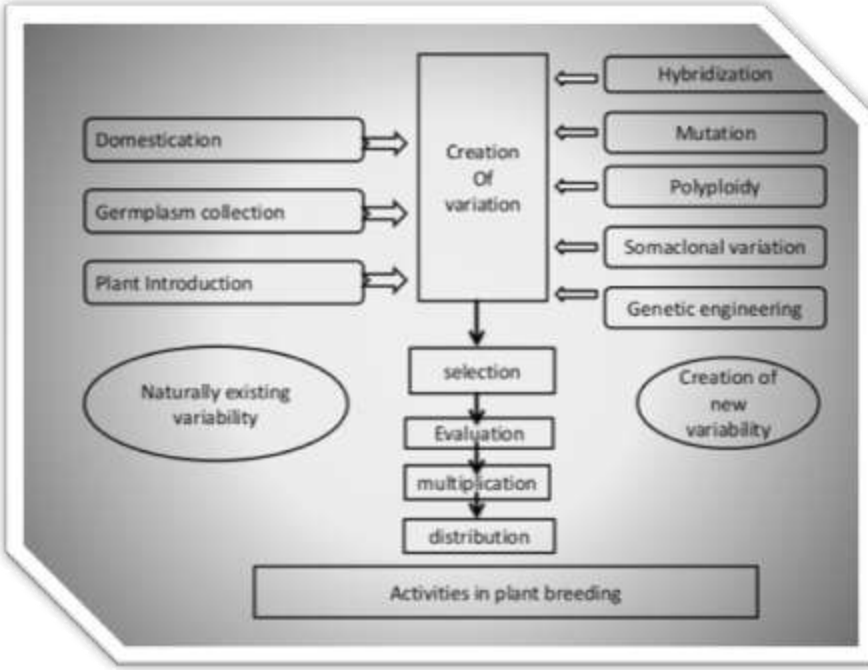
Venkataramanan

Objectives

- *Higher Yields*
- *Improved Quality*
- *Disease and Insect Resistance*
- *Change in Maturity Duration*
- *Agronomic Characteristics*
- *Photo and thermo Insensitivity*
- *Synchronous Maturity*
- *Nonshattering Characteristics*
- *Determinate Growth*
- *Dormancy*
- *Varities for New Seasons*
- *Moisture Stress and Salt Tolerances*
- *Elimination of Toxic Substances*

Activities

- Creation of Genetic Variation
- Selection
- Evaluation
- Multiplication
- Distribution



Conventional and Non Conventional Methods of Plant Breeding

Conventional Methods

- **Self Pollinated Crops**-In self-pollinated crops,selection permits reproduction only of those plants that have the desirable characteristics,i.e.,the plants that have been selected.
- **Cross Pollinated Crops**-Populations of cross-pollinated crops are highly heterozygous as well as heterogenous.They show variable inbreeding depression,ranging from low to very severe.so ,breeding methods for these crops aim at avoiding or minimising in order to escape its undesirable effects.

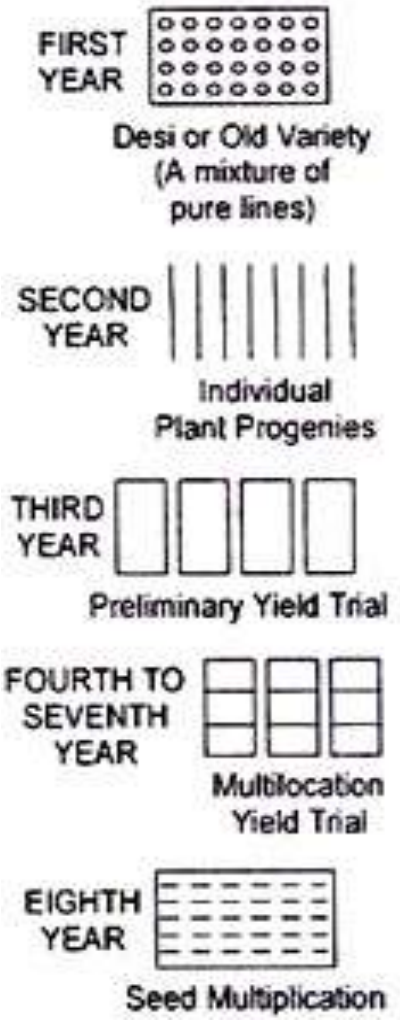
Self Pollinated Crops.

- Mass Selection
- Pureline selection
- Pedigree selection
- Bulk method
- Backcross method

Mass Selection method

In mass selection ,a large number of plants of similar phenotype are selected and their seeds are mixed together to constitute the new variety…

Mass selection method



(a) 200-3000 plants are selected on the basis of their superior and similar phenotype.

(b) Individual plant progenies are grown separately.

(c) Undesirable progenies are rejected.

(d) Remaining progenies are planted for preliminary yield trial.

(e) Low yield or inferior progenies are rejected.

(f) Replicated yield trials conducted at several locations.

(g) Inferior progenies are rejected.

(h) Disease resistance and quality tests are done.

(i) Best progeny released as a new variety.

(j) Seed multiplication and distribution are performed.

Advantages of Mass Selection

- It can be practiced both in self and cross pollinated crops.
- The varieties developed through mass selection are more widely adopted than pure lines.
- It retains considerable variability and hence further improvement is possible in future by selection.

Disadvantages of Mass Selection

•Varieties are not uniform.

•Since no progeny test is done, the genotype of the selected plant is not known.

Pure line Selection

- A pure line is the progeny of a single , homozygous ,self pollinated plant . In this method a large number of plants are selected from self pollinated crops and harvested individually, individual plant progenies from them are evaluated and best progeny is released as pureline variety.

Advantages of Pure Line Selection

- The pure lines are extremely uniform since all the plants in the variety will have the same genotype.
- Attractive and liked by the farmers and consumers.
- Pure lines are stable and longest for many years.

Disadvantages

•New genotypes are not created by pure line selection.

•This method is applicable to sell pollinated crop only.

Pedigree Method

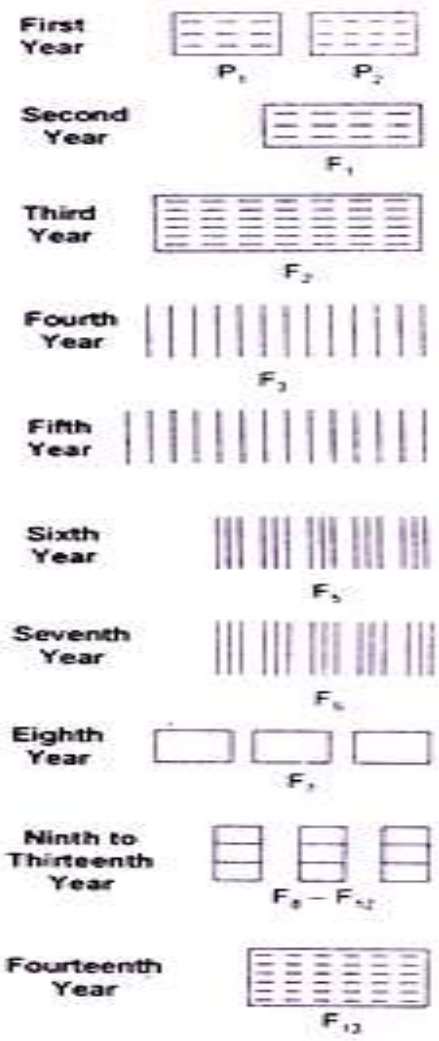
- The pedigree may be defined as a description of the ancestors of an individual and it generally goes back to some distant ancestors or ancestors in past.
- In pedigree method, individual plants are selected from F2 and the subsequent generations, and their progenies are tested.
- Pedigree Record;

  During the entire operation, a record of all the parent offspring relationship is kept: this is known as pedigree record.

  It should be simple and accurate.

	Generation	Number	Description
	F3	7911-7	Progeny in 7 row in the F3 plot
	F4	7911-7-4	Progeny in the 4 row of F4 plot selected from 7 row of F3
	F5	7911-4-14	Progeny in the 14 row selected from 4 row of F4. in the F5 plot

Procedure for Pedigree Method



Selected plants of parental variety are hybridized to get the F_1 hybrid seeds.

The hybrid seeds (10-30) are planted and the seeds of F_2 harvested in bulk.

2000-1000 seeds are space planted. 100-500 superior plants are selected and seeds are harvested from those as pedigree.

Individual plant progenies are planted in row and space planted.

Superior plants are selected.

The same procedure as in fourth year.

The individual selected plant progenies are in multi-row plots.

Superior plants are selected from those progenies.

The same procedure as in previous year.

Enough seeds to be collected from superior plants.

The preliminary yield trial and quality test has to be done.

Co-ordinated yield trials to be done.

Disease and quality tests have to be done.

Multiplication of seeds for distribution and release as a new variety.

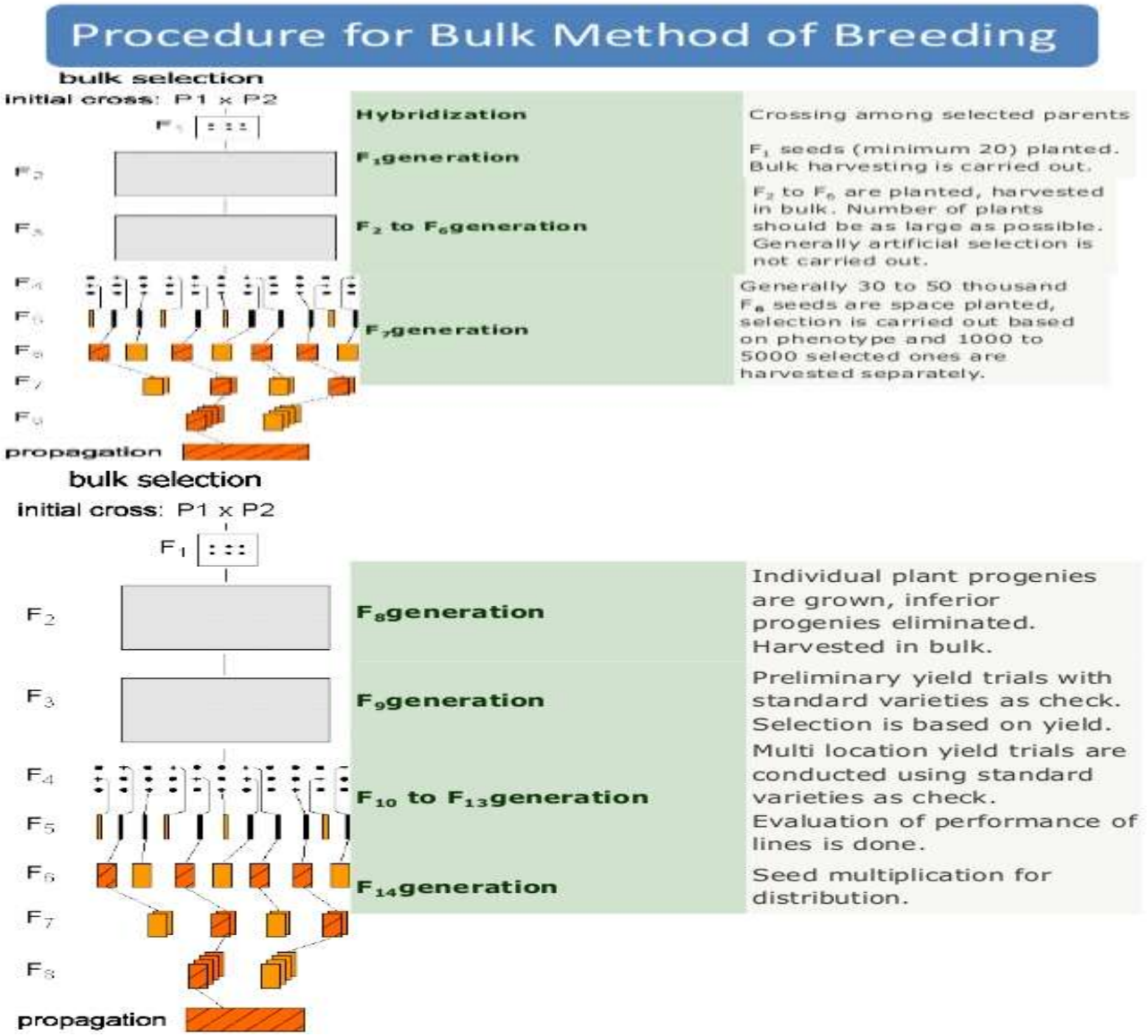
Advantages and Disadvantages of Pedigree Method

- Provide maximum opportunity for the breeder to use his skills and judgement for the selection of plants, particularly in the early segregating generations.
- Take less time then Bulk Method.
- Maintenance of accurate pedigree records take time.
- Success of this method largely depends upon the skill of breeder.

BULK METHOD

In this F2 and the subsequent generations are harvested in mass or as bulk to raise the next generation .At the end individual plants are selected and evaluated in a similar manner as in pedigree method.

Procedure for Bulk Method



Advantages and Disadvantages of Bulk Method

- This method is simple, convenient and inexpensive. It eliminates undesirable types and increases the frequency of desirable types by artificial selection.

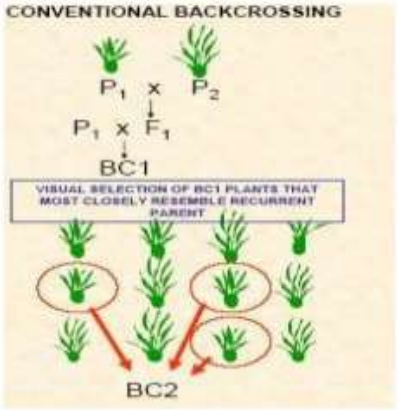
- It takes much longer to develops a new variety. It is suitable for self pollinated crops only. Natural selection may also work against desirable traits.

Back cross Method

- In back cross ,the hybrid and the progenies in the subsequent generations are repeatedly backcrossed to one of the parents of f1.The aim objective of this cross is to improve one or two specific defects of high yielding variety, which is well adapted to area and has other desirable characteristics..

Procedure of Backcross

Procedure of Backcross Breeding in Self Pollinated crops



Objective: to improve one or more defects of a high yielding variety
Let, P1 be a well adapted and high yielding variety.
P2 be another variety resistant to a specific disease; which is governed by a dominant gene. We wish to transfer this dominant gene P2 to P1
So P1 – recurrent parent (♀)
P2 – donor parent (♂)
Hybridization – The two varieties P1 and P2 are crossed
F_1 generation – Plants from F_1 seed are back crossed with recipient variety P1
First backcross generation (BC_1) – Selection is done for disease resistance and selected ones are back crossed with recurrent parent P1

Second to fifth backcross generation (BC_2 to BC_5) – Segregation for disease resistance occurs in every back cross generation. Plants are selected on the basis of similarity with recurrent parent and resistance to disease. Selected ones are back crossed with recurrent parent P1.
Sixth backcross generation (BC_6) – Disease resistance plants are selected. They are self pollinated and harvested separately.
BC_6 F_2 generation – Individual plant progenies are grown from seeds of BC_6 generation. Plants are selected on the basis of similarity with recurrent parent and resistance to disease. They are harvested separately.
BC_6 F_3 generation – Individual plant progenies are grown from seeds of above cross. As done in above step plants are selected on the basis of similarity with recurrent parent and resistance to disease but harvested in bulk.
Yield trials – Replicated yield trials are conducted with recurrent parent as a check. The newly constituted variety should be similar to variety P1 for most of the important characteristics. Seeds are multiplied for distribution.

Advantages and Disadvantages of Backcross

- It is not necessary to test the variety developed by this method because the performance of recurrent parent is already known.
- It does not require record keeping.
- It is not affected by environmental conditions.

- Undesirable genes may also be transferred to the new variety.
- Hybridization has to be done for each backcross so time required is more.
- New variety cannot be superior to the recurrent parent except for the character transfer from donor to parents.

Cross Pollinated Crops

Intrapopulation Improvement

- Mass Selection
- Modified Mass Selection
- Recurrent selection
- Reciprocal recurrent Selection
- Hybrid and synthetic varieties

Mass Selection

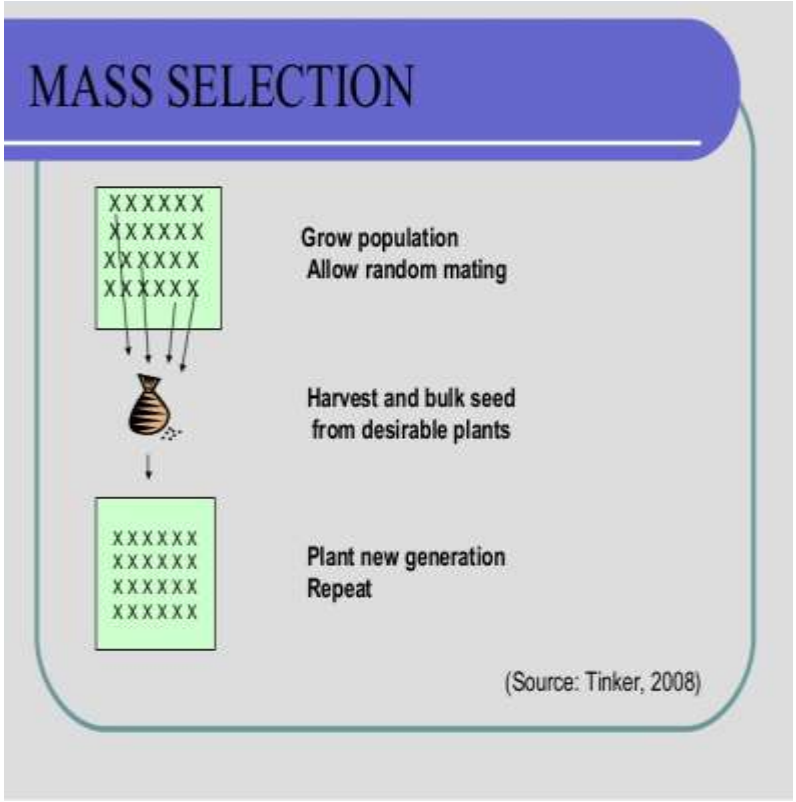
- *Selection of Individual.*
- *Sampling seed of selected individuals to plant next generation.*
- *Oldest method of crop improvement.*
- *Improvement of heterogenous native populations or landraces.*

Mass Selection

- Same form as with self pollinated crops.
- Essentially a form of maternal selection since no pollination control.
- selected desirable plants
- Bulk seed
- Repeat cycle
- With strict selection breeder will reduce populations size
- Slow genetic gain since lack pollination control.
- Must be able to ID superior phenotypes.
- Not suitable for quantitative traits.

Mass Selection

- Higher percentage of desirable genotypes.
- Method can only be used in environments where trait is expressed may not be suitable for off season winter nurseries.
- Effectiveness is function of heritability.
- Manage field to enhance differences:eg. Irrigate excessively to increase disease pressure.



Achievements

- Early varieties of bajra babapuri,jamnagar giant, pusa moti.
- Toria – increase the yielding ability by 30% and oil 56% in Abohar.
- Rai – many early ,erect to semi erect types developed, type-11.
- Yellow sarson – T-42,T-16.
- Brown sarson- 17 dwarf, 17 medium, DS-1,DS-2.
- Maize- T-41,19,jaunpuri.
- Desi cotton- C-402,C-520.
- American cotton-100F,216F.
- Castor-B-1,B-4.

Modified Mass Selection

- Also known as stratified mass selection or grid method of mass selection.
- This modification is suggested by GARDNER in 1961.
- Field is divided into several small plots, eg., having 40-50 plants each.
- Selection is done within the plots and not among the plots.
- Seeds are selected and composite to raise the next generation.

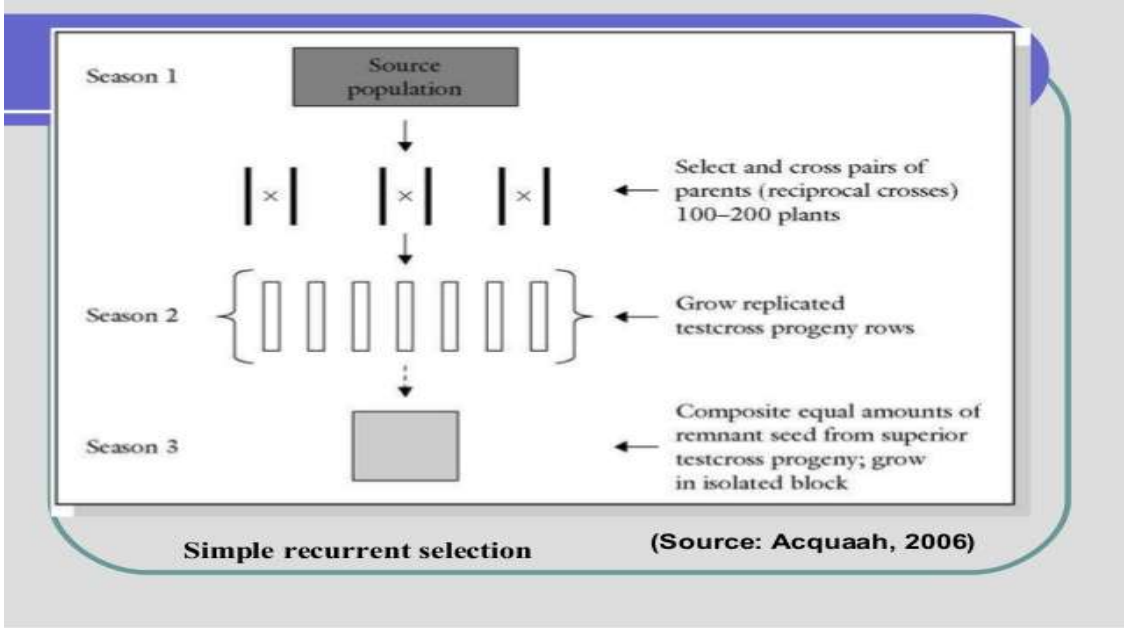
Recurrent Selection

- Designed to increase the freq. of desirable genes within a population.
- Developed in the 1940s for developing inbred lines.
- First suggested by Hayes and Garber in 1919 and independently by East and Jones in 1920.

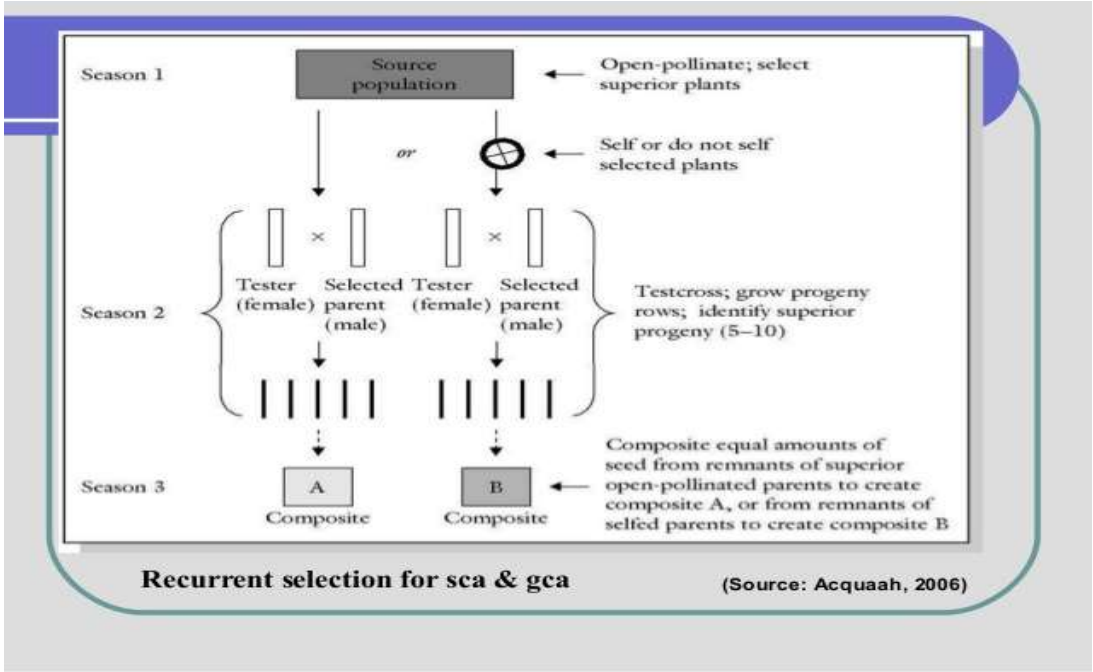
Recurrent Selection

The schemes are divided into following four types:-

- Simple recurrent selection
- Recurrent selection for GCA.
- Recurrent selection for SCA.
- Reciprocal recurrent selection.



Simple recurrent selection (Source: Acquaah, 2006)



Recurrent selection for sca & gca (Source: Acquaah, 2006)

Reciprocal Recurrent Selection

- Proposed by comstock, Robinson, and Harvey (1949) to select for both general and specific combining ability.
- General combining ability (GCA) is the ability of a breeding strain to combine favorably with many other strains or inbred lines. Analogous to ADDITIVE gene action.
- Specific combining ability (SCA) is the ability of a genotype to combine favorably with one or a few other genotypes. Analogous to DOMINANT gene action.

Reciprocal Recurrent Selection

- Although recurrent and reciprocal recurrent selection methods were originally designed and used to improve the chances of developing superior inbreds of corn, these procedures are not used explicity in private industry for that purpose today.
- Most new inbreds in SORGHUM are developed through PEDIGREE or pedigree type procedures and in CORN DOUBLED HAPLOIDS procedure have become popular since about 2000.

Hybrid Production

- Producing of heterozygous populations from the crossing of homozygous lines.
- Mostly used for cross-pollinated crops.
- The hybrid seed must be reproduced each year.
- The word HYBRID denotes a population of F1 plants derived by crossing inbreed lines,clones,open-pollinated varieties or any population that are genetically dissimilar.

Steps

- Produce inbreed lines.
- Cross the inbreed lines.
- Single cross hybrid.
  - Harvest the female rows because they have the hybrid seed.
- Double cross hybrid.
- Three way cross hybr

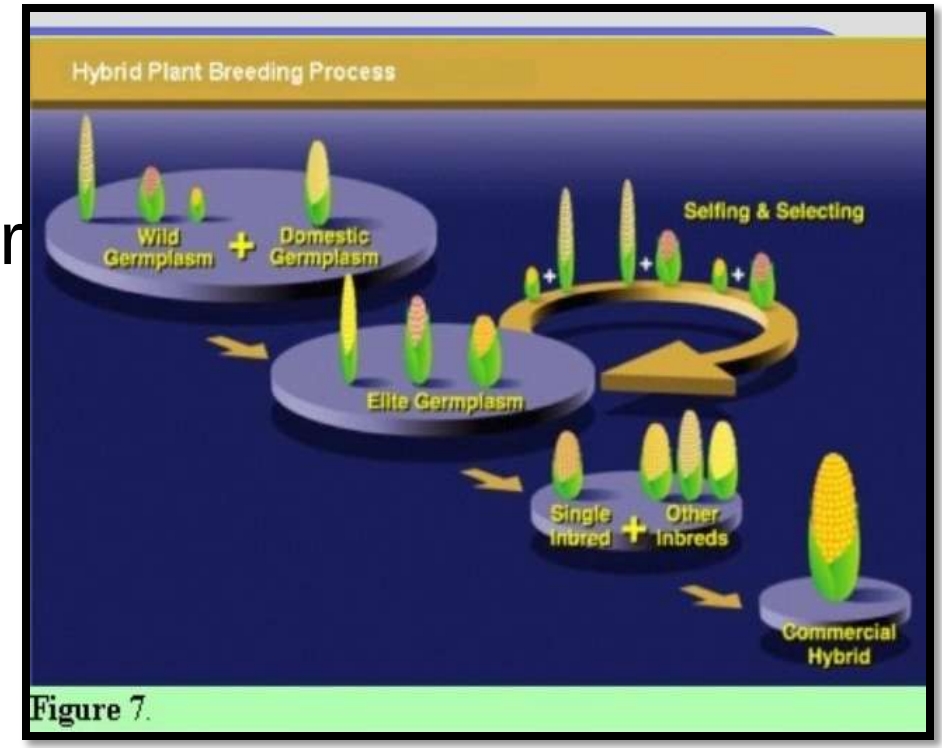


Figure 7.

Achievements

- First hybrid varieties in maize were released in 1961, viz., Ganga-1,Ganga-101, Ranjit and Deccan.
- First hybrid bajra was developed by PAU. Ludhiana in 1965 as HB-1. Subsequently,HB -3 and HB-1. Subsequently, B -3 and HB-5 were released.
- Bajra-PHB-10,PHB-11,BJ-104 and BK-560.

Synthetic Varieties

Steps involved in the production of synthetic varieties:-

Step -1 Evaluation of lines for GCA

- Topcross or polycross test for GCA; outstanding lines selected as parents.

Step -2 Production of the synthetic

Method 1. Equal seed from all the lines mixed and planted in isolation. Open-pollinated seed harvested as the synthetic variety(syn1)

Synthetic Varieties

- **Method 2**. The parental lines are planted in a crossing block. All the possible intercrosses are made. Equal seed from all the crosses mixed to produced the synthetic variety(syn1).
- **Step-3** seed multiplication
- Seed of the synthetic variety may be multiplied for one or two generations before distribution.
- Open pollination in isolation(syn2 or syn3).

HETEROSIS BREEDING

- The increased growth vigour or yield of hybrids over the parents is known as Heterosis or Hybrid vigour . It is often called **heterobeltiosis.**
- Crop breeding to manifest heterosis is called Heterosis breeding.
- It brings out the Superiority in F1 individuals but the vigour tends to decrease from F2 generation onwards.

HETEROSIS BREEDING

- Heterosis means deviation of offspring from the actual character of parents.
- In, plants heterosis appears due to development stimulation induced by the Union of gametes coming from two genetically complementing parents.

Important Achievements of Plant Breeding

- Semi dwarf Wheat and Rice.
- Nobalizations of Indian Canes.
- Hybrid Millets.
- Hybrid Cotton.
- Molecular Breeding.
- Transgenic Varieties.

Undesirable Consequences

- Genetic erosion.
- Narrow Genetic Base.
- Increased Susceptibility to Minor disease.
- Yield Platear.

QUESTIONS….

1. What is the basic difference between mass selection and pure line selection..
2. Difference between pedigree selection and back cross selection..
3. What is another name for heterosis..
4. what are important achievements of plant breeding
5. What are synthetic varieties..
6. Main methods of plant breeding involved in cross pollinated crops.


THANK YOU
DesiComments.com