# Principles and Methods of Parental Selection

# Aim of the module

At the end of the module, we should be able to:

- discuss the importance of parental selection in a pre-breeding programme; and
- describe the main methods for making parental selection based on genotypic and phenotypic information

# Introduction

- Selection for traits in breeding relies largely on:
  - the availability of heritable variation, and
  - the ability to select upon it
- Success of a pre-breeding program assumes that:
  - a trait donor or source introduces genetic variability into a breeding population and
  - trait variability is expressed in the new background, hence genetic advance
- Not all breeding programs strive to produce parents
- Not always correct to assume that a good variety will be a good parent in crosses

# Importance of selecting parents

- The judicious choice of parents to be used in crossing is
  - A prerequisite for an efficient breeding program and
  - Needed to sustain genetic progress
- Breeding programs require appropriate progenitors
  - that can be crossed and
  - Which will produce  progenies with the desirable characteristics

# Choice of parents

Two main types of criteria are adopted:

- Phenotypic
  - Characteristics of the parents such as agronomic and morphological traits, disease reaction and flowering behaviour, and
- Genotypic
  - Performance of the parents as reflected in progeny derived from them or by knowledge of genetic constitution.
- Parents must have good parental value or positive “combining ability”.

# Parental value

- A feature of the genetic constitution of a donor for desired, heritable traits
  - Complex traits are often comprised of several characteristics,
  - defining those that contribute reliably to variation is prerequisite to successful parental selection
- Evaluation that accounts for environmental effects is key to defining the genetic components of complex traits.
  - Just as the ability to distinguish among progeny that vary for these traits.
  - Accurate evaluation of progeny is the most effective means to identify superior progenitors
- Performance of progenies is dependent on features of both parents in a cross

# Genetic composition of trait donors

- Genetic composition is critical to developing parental lines with potential to transmit high levels or frequencies of a characteristic to their progeny
  - Even simply-inherited characteristics are transmitted to progeny as a series of gametes with representative haplotypes from the donor and recipient germplasm.
  - Linkage among genes influences desirable and undesirable characteristics.
  - The special case of polyploids -- the "plex" level or intragenic constitution of alleles
- Recipient germplasm must possess desirable productivity, protection or utilization traits
  - especially when the donor is from wild or un-adapted germplasm

# Combining Ability

- High performance, wide adaptability, disease resistance and yield stability are the major features taken into account for choosing parental genotypes
  - But, selecting parental lines based only on target traits is often insufficient to guarantee the presence of superior genotypes in the progeny
  - Because genetic gains that may occur in progenies of parents selected only on phenotypic attributes may be random and non-repeatable.

# Combining Ability

For quantitatively inherited characteristics, two important concepts:

- General combining ability (GCA), i.e. the average performance of parents in crosses; and
- Specific combining ability (SCA), i.e. the deviation of individual crosses from the average of the crosses
- Are used extensively in crop improvement,
  - including pre-breeding,
  - to assure the realization of breeding objectives through the efficient exploitation of available genetic variability.

# GCA and SCA

- Determinations of GCA permit the identification of genetically superior parental materials to be included in hybridization programs
- Studies of combining ability also permit the identification of superior hybrids through the use of parents with high SCA
- The genetic analyses determining combining ability further enable breeders to estimate certain genetic effects and parameters for quantitative traits in source populations for pre-breeding such as:
  - trait variance, co-variance,
  - correlations among traits,
  - the relative importance of additive and dominance variation, heritability
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# GCA and SCA

- If more of a specific trait, such as yield, is wanted
  - progeny from a parent with a positive estimate of GCA would be expected to be better for that particular trait than would progeny from a parent with a neutral or negative estimate of GCA.
- Conversely, if less of a trait were wanted, such as proportion of progeny with disease,
  - progeny from a parent with a negative estimate of GCA would be expected to be better than would progeny from a parent with a neutral or positive estimate of GCA.
- If SCA predominates,
  - then specific combinations of parents would have to be evaluated to find progeny with the desired characteristic, and considerably more testing would be required.

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# Mating Designs

- The term ‘mating design’ refers to the mating of parents
  - in one or another systematic plan of crosses
  - to determine genetic parameters and/or parental value.
- Diallel and North Carolina design II mating schemes are two examples of systematic matings that breeders use to
  - identify superior progenitors, and
  - determine genotypic components of variance which help to understand the structure of genetic variability

# Diallel design

- A set of crosses produced involving “n” lines in all possible combinations
  - The best way to determine the combining ability of parents
  - The analysis of such crosses is known as diallel analysis.
- The analysis of diallels
  - provides information on GCA and SCA of parents and their crosses, and
  - enables us to see if the reciprocal cross gives equivalent results or if there is maternal effect
- Families obtained from m♀×n♂ diallel crosses are studied in a two factorial experiment

# Methods of Diallel Designs

Method I: Assuming 5 parents for diallel crosses, we will have 25 crosses

| Scheme 1. Diallel method 1 | | | | | | |
|---|---|---|---|---|---|---|
| | | Males | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| Females | 1 | √ | √ | √ | √ | √ |
| | 2 | √ | √ | √ | √ | √ |
| | 3 | √ | √ | √ | √ | √ |
| | 4 | √ | √ | √ | √ | √ |
| | 5 | √ | √ | √ | √ | √ |

# Methods of Diallel Designs

Method II: Assuming 5 parents for diallel crosses, we will have 25 crosses

| Scheme 1. Diallel method 1 | | | | | | |
|---|---|---|---|---|---|---|
| | | Males | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| Females | 1 | √ | √ | √ | √ | √ |
| | 2 | √ | √ | √ | √ | √ |
| | 3 | √ | √ | √ | √ | √ |
| | 4 | √ | √ | √ | √ | √ |
| | 5 | √ | √ | √ | √ | √ |

# Methods of Diallel Designs

Method III: Concerns F1's and reciprocals. Assuming 5 parents, we will have 20 crosses

| Scheme 3. Diallel method 3 | | | | | | |
|---|---|---|---|---|---|---|
| | | Males | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| Females | 1 | | √ | √ | √ | √ |
| | 2 | √ | | √ | √ | √ |
| | 3 | √ | √ | | √ | √ |
| | 4 | √ | √ | √ | | √ |
| | 5 | √ | √ | √ | √ | |

# Methods of Diallel Designs

Method IV: Concerns only F1's. Assuming 5 parents, we will have10 crosses if reciprocals and selfings are ignored

| Scheme 4. Diallel method 4 | | | | | | |
|---|---|---|---|---|---|---|
| | | Males | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| Females | 1 | | √ | √ | √ | √ |
| | 2 | | | √ | √ | √ |
| | 3 | | | | √ | √ |
| | 4 | | | | | √ |
| | 5 | | | | | |

# Methods of Diallel Designs

Diallel series of crosses grown in replicated trials

- For 10 to 12 parents , RCBD should suffice
- Depending on the crop, enough seed for replicated trials will be reached in one to two years,
- Incomplete block designs should be considered if
  - the number of crosses is large and
  - the environmental variability among experimental units is great
- Despite its wide use, the disadvantages:
  - some hybrids may be difficult to obtain.
  - the workload involved in the evaluations, especially with high number of parents when analysis may become unfeasible

# Partial Diallel

- Diallel cross analysis involving a set of "n" parents in all possible combinations becomes unmanageable as the number of lines (n) increases.
- On the other hand if only a small number of parents are tested, the estimates of combining ability tend to have a large sampling error.
- These difficulties led to the development of the concept of sampling of crosses produced by large numbers of parents without affecting the efficiency of the diallel technique.
- In a normal diallel, each line is involved in (n - 1) crosses.
- Concept of the partial diallel design, only a random sample of crosses, say of the size of 's', is analyzed where 's' is less than n-1.

# Partial Diallel

| Scheme 5. Partial diallel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Males | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Females | 1 | | | | √ | √ | √ | | |
| | 2 | | | | | √ | √ | √ | |
| | 3 | | | | | | √ | √ | √ |
| | 4 | | | | | | | √ | √ |
| | 5 | | | | | | | | √ |
| | 6 | | | | | | | | |
| | 7 | | | | | | | | |
| | 8 | | | | | | | | |

# Line x tester design

- Provides information about the GCA and SCA of parents,
- is helpful in estimating various types of gene effects.
- All of these 'l' lines are crossed to each of 't' testers and thus l x t full-sib progenies are produced.
- These progenies along with or without parents, i.e., testers and lines, are then tested in a replicated trial
- For example, if there are 3 testers and 7 lines, we have 7 x 3 = 21 crosses
- For evaluation, the 21 crosses along with 10 parents, i.e., 7 lines and 3 testers, for a total of 31 entries, might be tested in a RCBD with 4 replications.

# Line x tester design

| Scheme 7. Line x Tester | | | | |
|---|---|---|---|---|
| | | Testers | | |
| | | 1 | 2 | 3 |
| Lines | 1 | √ | √ | √ |
| | 2 | √ | √ | √ |
| | 3 | √ | √ | √ |
| | 4 | √ | √ | √ |
| | 5 | √ | √ | √ |
| | 6 | √ | √ | √ |
| | 7 | √ | √ | √ |

# Design II

- The genetic information is similar to that obtained with diallel analysis.
- Different sets of parents are used as males and females.
- If a set of 8 parents is included in the design II, 16 crosses will be obtained

| **Scheme 6. Design II** | | | | | |
|---|---|---|---|---|---|
| | | **Males** | | | |
| | | **5** | **6** | **7** | **8** |
| **Females** | **1** | √ | √ | √ | √ |
| | **2** | √ | √ | √ | √ |
| | **3** | √ | √ | √ | √ |
| | **4** | √ | √ | √ | √ |

# Design II

- In this design both paternal and maternal half-sibs are produced.
- From an F1 population, n1 males and n2 females are randomly selected and each male is crossed to each of the females.
- The expectations in the analysis of variance of males and females for design II are equivalent to GCA,
- And the male x female source is equivalent to SCA of the diallel analysis.
- Because we have two sets of parents in design II, we have two independent estimates of GCA.