17. Hybridization – Aims, objectives and types of hybridization

Objective of hybridization

The chief objective of hybridization is to create variation. When two genotypically different plants are crossed, the genes from both the parents are brought together in F_1. Segregation and recombination produce many new gene combinations in F_2 and subsequent generations.

The degree of variation produced depends on the number of heterozygous genes in F_1. The number of heterozygous genes in F_1 in turn depends on number of genes for which the two parents differ. If the parents are not related they may differ for several genes.

Combination breeding

The main aim of combination breeding is the transfer of one or more characters into a single variety from other varieties. These characters may be governed by oligogenes or polygenes. In this approach, increase in yield is obtained by correcting the weaknesses in the yield contributing traits like tiller number, grains per panicle, seed weight of the concerned variety. Example for combination breeding is disease resistance achieved by backcross breeding. Pedigree method is also another example.

Transgressive breeding

Transgressive segregation is the production of plants in F_2 generation that are superior to both the parents for one or more characters. Such plants are produced by the accumulation of favourable genes from both the parents as a consequence of recombination. In this case the parents involved in hybridization must combine well with each other and preferably be genetically diverse. This way, each parent expected to contribute different plus genes which when brought together by recombination gives rise to transgresive segregation. The pedigree method as well as population approach are designed to produce transgresive segregants.

Procedure of hybridization

1. Set up your objective.
2. Selection of parents.
3. Evaluation of parents.
4. Sowing plan.

s. Emasculation and dusting.

6. Labelling and bagging.

7. Harvesting and storage of seeds.

1. Objective

Based on the requirement, set your objective. Because based on the objective only the selection of parents is done. If it is resistance breeding one of the parents must be a donor.

2. Selection of parents

Normal practice is, the female parent will be a locally adapted one in which we can bring in the plus genes. In case of intervarietal hybridization geographically diverse parents will be selected so as to get superior segregants.

3. Evaluation of parents

In case of parents which are new to the region they must be evaluated for their adaptability. Further to ensure homozygosity, they must be evaluated.

4. Sowing plan

If the flowering duration is same, simultaneous sowing of both the parents can be done. Otherwise staggered sowing is to be followed. The normal practice is to raise the ovule parent in the centre of the plot in rows and on the border pollen parent for each combination.

5. Emasculation and dusting

Emasculation is the removal of immature anthers from a bisexual flower. Depending on the crop the emasculation practice differs. Normal practice of hand emasculation and dusting of pollen is done. Depending on the time of anthesis the time of emasculation differs. For E.g. in rice the anthesis at Coimbatore takes place between 7.00 to 10.00 A.M. So the emasculation is done at around 6.30 A.M. and dusting of pollen is done immediately.

6. Labelling and bagging

Immediately after hybridization put a label indicating the parents and date of crossing. Put appropriate cover to prevent foreign pollen, contamination.

7. Harvesting and storage of seeds

Normally 15-20 days after crossing the seeds will be set. In the case of pulses the crossed pods can be easily identified by the shrunken nature of pod and seed set will be reduced. Harvest of crossed seeds must be done on individual plant basis. Seeds collected from individual plants are to be stored in appropriate containers with proper label and stored.

Distant Hybridization

When crosses are made between two different species or between two different

genera, they are generally termed as **distant hybridization (or) wide hybridization**

History

Thomas Fairchild 1717 was the first man to do distant hybridization. He produced an hybrid between two species of *Dianthus*

*Dianthus caryophyllus (*Carnation) x *D. barbatus (*Sweet william)

Inter generic hybrid produced by Karpechenko, a Russian Scientist in 1928. *Raphano brassica* is the amphidiploid from a cross between Radish *(Raphanus sativus)* and cabbage *(Brassica oleraceae).* Triticale was produced by Rimpau in 1890 itself. Triticale is an amphidiploid obtained from cross between wheat and rye. Another example is *Saccharum* nobilisation involving three species.

Hybrids in self-pollinated crops - problems and prospects

Exploitation of heterosis through F I hybrids has hitherto been the prerogative of cross- pollinated crops, chiefly due to their breeding systems favouring allogamy. However, possibilities of working for such a proposition have recently been realized in self-pollinated corps also. Indeed, exploitation of hybrid vigour in autogamous crops is easy and less time-consuming in that homozygous inbreds are already available. There is practically no difference with regard to hybrid breeding between self and cross-pollinated crops. But the prospects of hybrids in seIfers is dependant on three major considerations.

1. How high a heterotic effect can be gained under optimal production conditions.
2. In fact, a breeder's main concern is the magnitude rather than the frequency of occurrence of heterosis in crops. Thus the consideration is whether or not it is possible to obtain economically viable heterosis.
3. How much of the yield surplus due to high heterosis can offset the extra seed cost? In major self-pollinated crops like wheat, barley, rice, etc., the seed rate per unit area is exorbitant and hence the hybrid seed requirement is also more.
4. How efficient and effective is the mechanism of cross-pollination in seIfers? By nature, self-pollinated crops are shy pollinators with very poor pollen maneuverability (or movability to effect allogamy). Therefore, the efficiency (degree of allogamy) with which cross pollination can take place on a commercial scale is the true determinant of the success of a hybrid programme in seIfers.
5. Among self-pollinated crops, FI hybrids have been graduated into the farmer's field in

barely, tomato, Sorghum (often-cross-pollinated) and wheat. Briggle (1963) presented a vivid account of heterosis in wheat. Work in rice is also most encouraging (IRRI, 1972).

Methods of handling of segregating generations – pedigree method, bulk method, back cross method and various modified methods

Pedigree method

In this method, individual plants are selected from F_2 and subsequent generations and their progenies are tested. During this process details about the plants selected in each generation is recorded in Pedigree Record. By looking into Pedigree record we can know about the ancestry of the selected plants.

For maintenance of pedigree record the basic thing required is Crossing Ledger. This Ledger gives the details about parentage, Season in which the cross is made.

Sl.No.	Cross Number	Parentage
1.	XS 9801	Co2 x MS *9804*
2.	X S 9802	. Co4 x C152
3.	X S 9803	Co 1 x Co4

There are several ways to maintain the pedigree Record. The selection of plants starts from F_2 onwards. The details about selected plants can be recorded as follows. E.g. F_2 X S *9801* - 7. Here the 7 denotes seventh plant selected.

In F_3 if selection is made from the 7th plant of cross X S 9801 it can be recorded as F_3 X S 9801 - 7 - 4. The number four indicates that fourth plant of 7th plant of F_2 is selected. This can be followed till F_4 or F_5 generations. After F_4 or F_5 the selected plants are bulked to form a family.

In the pedigree record all the biometerical data like plant height, number of branches, No. of pods / plant, pod length, seeds / pod, pod weight, seed weight are recorded.

Merits of Pedigree Method

1. Gives maximum opportunity to the breeder to use his skill and judgement for the selection of plants.
2. Well-suited for characters which are simply inherited
3. Transgressive segregants can be easily identified thro' records.

4. Information about inheritance is precisely obtained.

Demerits

1. Maintenance of pedigree record is time consuming and limits handling of larger population.
2. The success in this method is largely dependent on skill of the breeder. There is no opportunity for natural selection.
3. Selection for yield in F_2 and F_3 is ineffective. If care is not taken to maintain larger population, valuable materials may be lost.

Pedigree Method Procedure

F_1 Generation

The F_1 seeds are space planted so that full expression of F_1 can be had. It is advisable to raise the parents involved in the cross to raise as border rows so that dominance and other characters can be studied. The F_1s are harvested as single plants.

F_2 generation

In F_2, 2000 to 10,000 plants per cross are planted. About 100 - 500 plants are selected and harvested on single plant basis. The selection in F 2 depends upon the skill of the breeder. The selection intensity may be 5 to 10%.

F_3 generation

Individual plant progenies are space planted. Again desirable plants are selected. From F_3 onwards the term family is introduced. The line selected from each cross is termed as family.

F_4 generation

Similar to F_3.

F_5 generation

Many families would have attained homozygosity and may be harvested as row bulk.

F_6 generation

The row bulk may be assessed in multi row trial. The families exhibiting segregation may be isolated and studied separately.

F_7 generation

RRYT

F_8 generation

PYT

CYT 3 seasons.

Basis of selection

Depending upon the objective, selection is to be made in segregating generation. For insect and disease resistance part of the seeds may be reserved in segregating generation and the rest may be subjected to epiphytotic conditions. The families exhibiting resistance may be identified and the reserve seeds may be used for further selection and testing.

Early generation testing

If superior families are identified in F_3 or F_4, they can be tested for desirable characters and this is known as early generation testing.

Shuttle breeding

This is followed especially in disease or insect resistance breeding. For e.g. at Coimbatore YMV in blackgram is in epidemic form during summer season only. Whereas at Vamban (Pudukkottai) the YMV is epidemic during kharif season. So instead of waiting for next summer at Coimbatore the materials can be tested at Vamban during kharif and thus one season is saved.

Off season nursery

Some crops may be season bound. But it may be non - season bound in certain agro - climatic zone. For e.g. *Thalai virichan cholam. (Sroxburghii)* is season bound at Coimbatore. It has to be sown during July - August and harvested during December January. But this *Sroxbughii* is non - season bound in Yercaud. So to save one season, the segregating material can be raised during Rabi summer at Yercaud. This method is otherwise known as rapid generation advancement (RGA).

Bulk Method

In this method F_2 and subsequent generations are harvested as bulk to grow the next generation. The duration of bulking may be 6 - 7 generations. Selection can be made in each generation but harvest is done as bulk. This is similar to mass selection. At the end of bulking period single plant selection is made and tested for yielding ability. If bulking period is long say 20 - 30 seasons, then natural selection acts on the homozygous lines. In this method the breeder uses his skill for selecting the plants and at the same time there is no pedigree record. This saves much time and labour.

Merits of bulk method

1. Simple, convenient and inexpensive
2. By inducing artificial epiphytotic conditions undesirable or weaker genotypes can be eliminated.
3. If bulking period is longer natural selection operates and desirable genotypes are selected.
4. No pedigree record is maintained.
5. Since large population is grown there is chance for appearance of transgressive segregants which will be superior than parents or F_2

Demerits

1. Takes much longer time to develop a new variety.
2. In short term bulk there is no chance for natural selection.
3. A large number of progenies are to be selected in each generation which requires much labour, time and space.
4. We cannot get information on inheritance.

Single Seed - Descent Method

It is the modification of the bulk method. In this method a single seed from each of the F_2 plants is collected and bulked to raise F_3 generation. Similarly single seed from each F_3 plant is collected and carried forward to F_4. This procedure is followed till F_6 or F_7. After wards single plant selection is made and studied in progeny rows.

In this Scheme the main features are:

1. Lack of selection till F_6 or F_7 when the population becomes homozygous.
2. Each F2 plant is represented till F_6 or F_7 generation.
3. In this method there are chances for reduction in population size due to pest, disease or poor germination.
4. Rapid generation advancement (RGA) can be made with the use of glass house or off season nursery.

Modified bulk method

Here selection can be practiced in F_2 and F_3 and subsequent generations. There will not be any pedigree record but superior plants are selected bulked and carried forward. In F_4 superior plants are selected and harvested on single plant basis. In F5 these single plants are studied in progeny rows and best progenies are selected and harvested. In F_6 PYT can be conducted to select best families. In subsequent generations regular trials can be conducted.

This modification of the bulk method provides an opportunity for the breeder to exercise his skill and judgement in selection. Further there is no maintenance of pedigree record which is another advantage.

Mass pedigree method

This was proposed by Harrington. It is a solution to one of the deficiencies in the pedigree method of breeding. For e.g. if the population is to be subjected to disease resistance screening like YMV and if there is no method to create artificial epiphytotic conditions, it is wasteful to study the population in pedigree method. Instead we can carry the population as a mass and test them when there is occurrence of the disease. When conditions are favourable for the disease, we can terminate the bulking and resort to single plant selection.

Comparison between Pedigree and Bulk Methods

S. No.	**Pedigree method**	**Bulk method**
1.	Individual plants are selected in F_2 and the subsequent generations and individual plant progenies are grown.	F_2 and the subsequent generations are maintained as bulks.
2.	Artificial selection, artificial disease epidemics etc., are an integral part of the method	Artificial selection, artificial disease epiphytotics etc., may be used to assist natural selection. In certain cases, artificial selection may be essential
3.	Natural selection does not play any role in the method.	Natural selection determines the composition of the populations at the end of the bulking period.
4.	Pedigree records have to be maintained which is often time consuming and laborious	No pedigree record is maintained.
5.	It generally takes 14-15 years to develop a new variety and to release it for cultivation.	It takes much longer for the development and release of a variety. The bulk population has to be

		maintained for more than 10 years for natural selection to act.
6.	Most widely used breeding method.	Used only to a limited extent.
7.	It demands close attention from the breeder from F_2 onwards as individual plant selections have to be made and pedigree records have to be maintained.	It is simple, convenient and inexpensive and does not require much attention from the breeder during the period of bulking
8.	The segregating generations are space - planted to permit individual plant selection.	The bulk populations are generally planted at commercial planting rates.
9.	The size of population is usually smaller than that in the case of bulk method.	Large populations are grown. This and natural selection are expected to increase the chances of the recovery of transgressive segregants.