

Topic:
"Alien substitution lines"

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INTRODUCTION

- **HYBRIDIZATION:**

Crossing between 2 genetically dissimilar parent is called hybridization.

- **DISTANT HYBRIDIZATION:**

Hybridization between individual from different species belonging to the same genus (interspecific hybridization) or two different genera of same family (intergeneric hybridization) is termed as distant hybridization & such crosses are known as distant crosses or wide crosses.

- This is because individuals used for hybridization in such cases are taxonomically more distantly related than different variety of same species.

HISTORY

- **Thomas Fairchild (1717):**

The first authentic record of distant hybridization for crop improvement is the production of a hybrid between Carnation (*Dianthus caryophyllus*) & Sweet willian (*Dianthus barbatus*).

- **Karpechenko (1928):**

An interesting inter-generic hybrid, *Raphanobrassica*, was produced.

- **Rimpu (1890):**

Produce first intergeneric hybrid triticales which have great potential than raphanobrassica.

INTER-SPECIFIC HYBRIDIZATION

- Ex. Nerica, an upland rice for Africa
 - *Oryza sativa* (Asian upland rice) : non-shattering , resistant to lodging, high yield potential
 - *Oryza glaberrima*(African rice): drought tolerant, disease resistant, weed-suppressing
- Nerica rice combines the best of both species.

African rice



Nerica rice



Asian rice



INTERGENERIC CROSSES

- Triticale, a new cereal created in the lab.
- Triticale, a cross(intergeneric cross) between wheat and rye , was produced by embryo rescue of the product of fertilization and a chemically induced doubling of the chromosomes.
- Embryo rescue become necessary when fertile offspring is never produced by an interspecific cross.



**Intergeneric
cross**



WHEAT



RYE



Triticale= Wheat x rye

Main features of Interspecific or Inter-generic hybridization

1. It is used when the desirable character is not found within the species of a crop.
2. It is an effective method of transferring desirable gene into cultivated plants from their related cultivated or wild species.
3. It is more successful in vegetatively propagated species like sugarcane and potato than in seed propagated species.
4. It gives rise to three types of crosses viz. a) fully fertile, b) Partially fertile and c) Fully sterile in different crop species.
5. It leads to introgression which refer to transfer of some genes from one species into genome of another species.
6. F1 hybrid between two genus are always sterile. The fertility has to be restored by doubling of chromosome through colchicine treatment.

Problems associated with wide crosses

- Cross incompatibility.
- Hybrid inviability
- Hybrid sterility.
- Hybrid breakdown.

CROSS INCOMPATIBILITY

- This is the inability of pollen grains of one species or genus to effect fertilization in another species or genes.
- There are 3 main reasons of cross incompatibility:
 - I. Lack of pollen germination.
 - II. Insufficient growth of pollen tube to reach ovule.
 - III. Inability of male gamete to unite with egg cell.
- These barriers are known as pre-fertilization barriers.

HYBRID INVIABILITY

- This refers to the inviability of the hybrid zygote or embryo. In some cases, zygote formation occurs, but further development of the zygote is arrested. In some other cases, after the completion of the initial stages of the development, the embryo got aborted.
- The reasons are :
 1. Unfavorable interactions between the chromosomes of the 2 species.
 2. Unfavorable interactions of the endosperm with the embryo.
 3. Disharmony between cytoplasm & nuclear genes.

HYBRID STERILITY

- This refers to the inability of a hybrid to produce viable offspring. The major reason for hybrid sterility is the lack of structural homology between the chromosomes of 2 species.
- These irregularities may lead to aberration in chromosome structure. Lack in homology between chromosomes may lead to incomplete pairing between chromosomes.
- Sterility caused by structural differences between chromosomes of 2 species can be overcome by amphidiploidisation using colchicines.

HYBRID BREAKDOWN

- Hybrid breakdown is a major problem in interspecific crosses.
- When F1 hybrid plants of an interspecific crosses are vigorous & fertile but there F2 progeny is weak & sterile it is known as hybrid break down.
- So hybrid breakdown hinders the progress of interspecific gene transfer.
- This may be due to the structural differences of chromosomes or problems in gene combinations.

EMBRYO RESCUE

- When embryo fails to develop due to endosperm degeneration, embryo culture is used to recover hybrid plants, i.e. known as embryo rescue.
- E.g., *H. vulgare* x *Secale cereale*
- It is generally used to overcome endosperm degeneration.

TECHNIQUES TO MAKE WIDE CROSSES SUCCESSFUL

1. SELECTION OF PLANTS

The most compatible parents available should be selected for the crosses.

2. RECIPROCAL CROSSES

Reciprocal cross may be attempted when one parental combination fails.

e.g. Mung x udid- cross compatible and Udid x mung-cross incompatible

3. MANIPULATION OF PLOIDY

Diploidization of solitary genomes to make them paired will be helpful to make the cross fertile.

4. BRIDGE CROSSES

When two parents are incompatible, a third parent that is compatible with both the parents can be used for bridge crosses and thus it becomes possible to perform cross between the original parents.

e.g. Tobacco

-*Nicotiana repanda* x *N.tabaccum*- cross incompatible

-*Nicotiana repanda* x *N.sylvestris*- cross compatible

-*Nicotiana sylvestris* x *N.tabaccum*- cross compatible

5. USE OF POLLEN MIXTURE

Unfavorable interaction between pollen and pistil in the case of wide crosses can be overcome to some extent by using pollen mixture.

6. MANIPULATION OF PISTIL

Decapitation of the style will sometimes prove helpful in overcoming incompatibility.

7. USE OF GROWTH REGULATORS

Pollen tube growth can be accelerated by using growth hormones like IAA, NAA, 2,4-D and Gibberellic acid.

8. PROTOPLAST FUSION

When fusion of gametes fails, protoplast fusion of somatic cells can be attempted.

9. EMBRYO RESCUE

Hybrid zygotes formed by wide crosses may fail to grow in a number of cases. The zygotes are taken out and grown in *in vitro* medium to overcome this problem.

ROLE OF WIDE CROSSES IN CROP IMPROVEMENT

- Wide crosses are generally used to improve crop varieties for disease & pest resistance, quality adaptation yield etc. these crosses can be even used to develop new crop species. Techniques like alien addition & alien substitution may also be effective.
- IMPROVING THE CROP PLANTS FOR
 - a) Disease & insect resistance

Crop	Character transferred	Species transferred from	Species transferred to
Cotton	Jassid resistance	<i>G.Tomentosum</i>	<i>G.Hirsutum</i>
	Blackarm resistance	<i>G.arboreum</i>	<i>G.barbadense</i>
Okra	Resistance to YMV	<i>Abelmoschus manihot</i>	<i>A. esculenta</i>
Groundnut	Resistant to leaf chewing insect	<i>Arachis monticola</i>	<i>A.hypogea</i>
Wheat	Rust resistance	<i>Agropyron</i>	<i>T. aestivum</i>
Tobacco	Resistant to mosaic virus	<i>N.repanda</i>	<i>N. tabaccum</i>

b). Improvement in quality

Crop	Character transferred	Species transferred from	Species transferred to
Cotton	Fibre length Male sterility	<i>G. Thurberi</i> & <i>G. Raimondii</i> <i>G. harkenssii</i>	<i>G. hirsutum</i> <i>G. hirsutum</i>
Potato	Starch content Frost resistance	Wild species <i>Solanum acaule</i>	<i>Cultivated Spp.</i> <i>S. tuberosum</i>
Tomato	Carotenoid content	<i>Lycopersicon</i> Wild Spp.	<i>L. esculentum</i>
Palm	Oil quality	Wild Spp.	Cultivated Spp.
Rice, Oat & Rye	Protein quality	Wild Spp.	Cultivated Spp.

C). Improvement in yield: This also been achieved through the use of wild Spp. in some crops e.g. Oat, Vigna, Arachis, Potato, Tobacco.

ALIEN ADDITION LINES

- These lines carry 1 chromosome pair from a different species in addition to a normal somatic chromosome complement of the parent species.
- When only 1 chromosome from another species is present it is known as alien addition monosome. Alien addition have also been done in rice, sugar beet, cotton, brassicas.
- The main purpose of alien addition is the transfer of disease resistance from related wild species. e.g. Transfer of mosaic resistance from *Nicotiana glutinosa* to *N. Tabacum*.
- The alien addition lines have been developed in case of wheat, oats, tobacco & several other species.
- Alien addition lines are of little agricultural importance since the alien chromosome generally carries many undesirable genes. E.g. Reduced growth & short broad leaves in addition to mosaic resistance.

ALIEN SUBSTITUTION LINES

- **When a single chromosome (not a pair) from different species in place of a single chromosome of the recipient species, known as alien substitution monosome.**
- **Alien substitution lines are of 2 types: (1) substitution of a total genome of a cultigen into the cytoplasm of an alien species (genome substitution) & (2) substitution of a single chromosome or a pair of chromosomes into the chromosome complement of a cultigen (chromosome substitution).**
- **Alien substitution lines have been developed in wheat, cotton tobacco, oats, etc**
- **In case of tobacco, mosaic resistant gene N was transferred from *N. glutinosa* to *N. tabacum* line had 24 pairs of *N. tabacum* chromosomes & 1 pair of *N. glutinosa* chromosomes.**
- **The alien substitution show more undesirable effects than alien addition & as a consequence are of no direct use in agriculture.**

LIMITATION OF DISTANT HYBRIDISATION

- 1. Incompatible crosses**
- 2. F1 sterility**
- 3. Problems in creating new species.**
- 4. Lack of homology between chromosome of the parental species.**
- 5. Undesirable linkages.**
- 6. Problems in transfer of recessive oligo-genes & quantitative traits.**
- 7. Lack of flowering in F1**
- 8. Problems in using improved varieties in distant hybridisation**
- 9. Dormancy**

ACHIEVEMENTS

- **HYBRID VARIETIES**

- Upland cotton – MCU-2, MCU-5, KHANDWA 1, KHANDWA 2, etc are derivatives of inter-specific hybridisation.
- Hybrid between Pearl millet x Napier grass- Hybrid Napier which is very popular for its high fodder yield & fodder quality e.g. Jaywant & Yashwant.
- Inter-specific hybrids in cotton- Varlaxmi, Savitri, DCH-32, NHB-12, DH-7, DH-9 etc.

THANK YOU

The background features several thick, glowing golden ribbons that swirl and loop across the frame. These ribbons have a bright, luminous center that fades to a darker gold at the edges, giving them a three-dimensional, ethereal appearance. Scattered throughout the dark gradient background are numerous small, bright golden particles and soft, out-of-focus light spots, creating a magical and celebratory atmosphere. The overall color palette is dominated by warm, golden tones against a dark, almost black background.