Wide adaptability: (i.e. drought-resistance, cold tolerance etc.), Quality improvement (E.g. Cotton (fibre) Tobacco (leaf), Yield improvement (E.g. Oats, Tobacco, Maize, S. cane), Other

characters (E g. CMS, Earliness, dwarfness morphological characters)

- Exploitation of luxuriance (heterosis) in vegetatively propagated / ornamental crops. Prolonged vegetative period, Prolonged blooming period
- Creation of Novel genotypes : New species or F1 hybrids hither to non existent in nature.

Barriers to the production of distant hybrids:-

- * Failure of zygote formation / cross incompatibility:-
 - Inability of the functional pollens of one species or genera to effect fertilization of the female gametes of another species or genera is referred to as cross incompatibility. It may be due to:
 - failure of fertilization, because the pollen may not germinate.
 - Pollen tube is unable to reach to embryo sac and hence sperms are not available for fertilization
 - The style of the female parent may be longer than the usual length of the pollen tube growth therefore the pollen does not reach the embryo sac.
 - Pollen tube may burst in the style of another species Eg. Datura
 - Pollen tubes of polyploidy species are usually thicker than those of diploid species.
- * Failure of zygote Development / Hybrid inviability:-
 - The inability of a hybrid zygote to grow into a normal embryo under the usual conditions of development is referred to as hybrid inviability. This may be due to:
 - Lethal genes:- some species carry a lethal gene, which causes death of the interspecific hybrid zygote during early embryonic development. E.g. *Aegilops umbellulata* carries a lethal gene with 3 alleles against diploid wheats.
 - Genetic Disharmony between the two parental genomes:-The genetic imbalance between the two parental species may cause the death of embryos.E.g. Cotton -*G.gossypioides* x other G. sps. Brassica – *B.napus* x *B.oleracea*.
 - **Incompatible cytoplasm**:-Embryo development may be blocked by an incompatibility between cytoplasm of the species used as female and the genome of the species used as

male. Such an interaction, more generally, leads to hybrid weakness and male sterility in the hybrids or may sometimes leads to failure of embryo developments.

- Endosperm Abortion:-Seeds from a large number of distant crosses are not fully developed and are Shrunken due to poorly developed endosperm. Such seeds show poor germination, and may often fail to germinate. When the endosperm development is poor or is blocked, the condition is generally known as endosperm abortion.
- Chromosome elimination:-In some cases of distant hybridization, chromosomes are gradually eliminated from the zygote. This generally does not prevent embryo development, but the resulting embryo and the F1 plants obtained from such crosses are not true interspecific hybrids since they do not have the two parental genomes in full. Generally. Chromosomes from one are successively eliminated due to mitotic irregularities. e.g.

Hordeum bulbosum x H. Vulgare Hordeum bulbosum x Triticum aestimum Triticum aestivum x Zea mays

✤ Failure of Hybrid seedling development / Hybrid sterility:

- Some distant hybrids die during seedling development or even after initiation of flowering. The mechanisms involved in the failure of seedling development most likely involve complementary lethal genes. e.g. 1. In cotton-certain interspecific hybrids appear normal, but die in various stages of seedling growth; some plants die at flowering. Interspecific and intergeneric F1 hybrids of wheat show both chlorosis and necrosis.
- **Hybrid sterility:** Hybrid sterility refers to the inability of a hybrid to produce viable off spring. The main cause of hybrid sterility is lack of structural homology between the chromosomes of two species.

Techniques for production of distant hybrids:

- **Choice of parents:** Genetic differences exist among parents in a species for cross compatibility. More compatible parents should be selected for use in wide crosses.
- Pollinating sufficiently large no. of flowers.
- **Reciprocal crosses:** it is better to attempt reciprocal crosses when distant crosses are not successful. e.g.: *Phaseolus aureus* and *p.mungo* are crossable only when *P. aureus* in used as

female and *P. mungo* as male. Determine the barrier and then take measures to overcome it: Longer style sps - cut the style. Use more than one strain of each sps for lethal genes Auto polyploidy (*B.olerecia* x *B. compestris*). Manipulation of ploidy – when two species of a cross differ in chromosome number, it is necessary to manipulate their ploidy. Direct crossing-use higher ploidy sp as female parent. Chromosome no. of the wild species or of the interspecies hybrid (F1) may be doubled to overcome sterility of the hybrid.

- Bridge crosses: Some times, two species say 'A' and 'C' do not cross directly. In such case a third species say 'B' which can cross with both 'A' and 'C' is chosen as a bridge species. First 'B' is crosses with 'C' and then the amphidiploid is crossed with 'A'. Bridge crosses have been used in Tobacco and wheat. e.g. *Nicotiana repanda* can cross with *N. sylvstis* but not with *N. tabacum*, *N. sylvestris* crosses with both *N. repanda* and *N.tabacum*. For transfer of genes from *N. repanda* to *N.tabacum*, *N. sylvestis* is used as bridge species.
- Use of pollen mixtures: Cross incompatibility results due to unfavourable interaction between the protein of pistil and pollen which inhibits normal germination and growth of pollen tube. This problem can be overcome by using the mixture of pollen from compatible (self) and incompatible parents.
- Manipulation of pistil: In some cases, pollen tube is short and style is very long, due to species difference. Thus pollen tube cannot reach ovule to effect fertilization. In such situation either reciprocal cross should be made or the style should be cut to normal size before pollination. This technique is successful in maize *Tripsacum* crosses, where maize style remains receptive even after cutting.
- Use of growth regulation : Some times, the pollen tube growth is so slow that the eggcell dies or the flower aborts before the male gametes reach the ovary. In such cases, growth regulators should be used to accelerate the pollen tube growth or to prolong the viability of the pistil.Use of growth regulators such as IAA; NAA; 2,4-D and GA3 etc; are promising in some wide crosses.
- Large number of crosses :The success of seed set is generally very low in widecrosses. Hence, large no. of crosses should be made to obtain crossed seeds.
- **Protoplast fusion :** The wide crosses can be obtained through protoplast fusion, when it is not possible to produce such crosses through sexual fusion.

- Embryo culture : This technique is being used widely to obtain viable interspecific or intergeneric hybrids. This is used when hybrid zygote is unable to develop. This technique has been successfully used is *Triticum*, *Hordeum*, *Phaseolun*, *Nicotiana*, *Gossypium*, *Lycopersicon*, *Trifolium*, *Cucumbita* etc.
- **Grafting :** Grafting of interspecific hybrid on to the cultivated species helps in making the cross successful.

Applications of wide hybridization in crop improvement:

- Alien addition lines: Carries one chromosome pair from a different species in addition to somatic chromosome complement. For E.g. Disease resistance in Wheat, oats, tobacco.
- Alien substitution lines: has one chromosome pair from different species in place of the chromosome pair of the recipient parent.
- **Introgression of genes:** Transfer of small chromosome segments with desirable genes. E.g. *A*. Disease resistance: In Cotton transfer of black arm disease resistance from *G. arboreium* to *G. barbadense*.

B. Wider adaptation: Cold tolerance has been transferred from wild relatives to Wheat, onion, potato, tomato and grape.

- C. Quality: Oil quality in oil palm was improved by genes from wild relatives.
- D. Changing the mode of reproduction :
- E. Yield
- Development of New crop species : E.g. Triticale

Sterility in distant hybrids:-

- Distant Hybrids show variable sterility ranging from complete fertility to complete sterility for e.g. *L. esculentum* x *L. pimpinellifolium* hybrid in completely fertile while sugarcane maize hybrid is completely sterile.
- Distant Hybrids are of two broad groups:

a) The first group includes those Distant hybrids that exhibit atleast some fertility so that than can be maintained by selfing, intercrossing among themselves or backcrossing to the parental species.

b) The second group consists of those hybrids that are completely sterile and have to be maintained clonally or by doubling their chromosome number.

The sterility of distant hybrids may be caused by cytogenetic, genetic or cytoplasmic factors.

Cytogenetic Basis of sterility: Most of the interspecific hybrids show reduced chromosome pairing and in extreme cases all the chromosomes may be present as univalents.

- The distribution of chromosome in such cases is irregular, and it leads to the formation of unbalanced gametes resulting in partial to complete sterility.
- Inter specific crosses also show rings and chains at metaphase-I (indicating translocations).
- Bridges and fragments at anaphase-I (indicating invessions)
- Loops at pachytene (indicating duplications or deletions). These cytological aberrations also reduce fertility. Fertility in such hybrids is improved by doubling their chromosome number, that is by producing amphidiploids from them.

Genetic Basis of sterility: Chromosome pairing in some interspecific hybrid is regular, but they show variable sterility which is due to genes. E.g. The F1 hybrid between foxtail millet, *setaria italica* and its wild relative. *S.viridis* showed normal pairing and regular formation of bivalents. But pollen and ovule sterilities were 70 and 50% respectively.

Cytoplasmic Basis of sterility: In some interspecific hybrids, sterility is produced by the cytoplasm. In such cases, the reciprocal crosses produce fertile hybrids. Clearly, in such cases sterility is produced by the cytoplasm such instances of hybrid sterility are known is *Epilobium*, *Oenothera*.

Limitations of Distant Hybridization:

- Incompatible Crosses
- F1 Sterility
- Problems in Creating New species
- Lack of Homoeology between Chromosomes of the Parental Species

- Undesirable Linkages
- Problems in the Transfer of Recessive Oligogenes and Quantitative Traits
- Lack of Flowering in F1
- Problems in using Improved varieties in Distant Hybridization
- Dormancy

Achievements:

- Wheat, Tobacco, Cotton
- Parbhani Kranthi: Derived from A. esculentus C.V. Pusa Sawani x A. Manihot

 Resistant to yellow mosaic vein virus, yield Kharif : 110-120 q/ha,
 Summer : 85-90 q/ha.
- Pusa Kranthi : Kharif 105-110 q/ha, Summer 75-80 q/ha.