Lecture-4

Polyembryony, apomixis, chimeras and bud- sports

Learning objective

- To get acquainted with polyembryony, apomixis, chimeras and bud- sports
- Horticultural significance of polyembryony, apomixis, chimeras and bud- sports

Polyembryony

Polyembryony means that more than one embryo develops within a single seed. It is also known as adventitious embryony (Nucellar embryony or Nucellar budding).

- Polyembryony can develop from several distinct causes. Specific cells in the nucellus or sometimes with integument have embryos. Genetically, these embryos have the same genotype as the parental plant and are apomictic.
- Adventitious embryony occurs in many plant species but is most common in citrus and mango. In these species, both zygotic and apomictic embryos are produced. In other species (e.g. *Opuntia*), no pollination or fertilization is needed.
- Polyembryony is common in mango and citrus. In trifoliate orange (*Poincirus trifoliata)* several seedlings arise from one seed.
- Of these seedlings, one seedling, usually the weakest may be sexual, and the others arise apomictically from cells in the nucellus, which are diploid copies of the mother plant.

Horticultural significance of polyembryony

Nucellar seedlings in citrus are completely free from viruses, because the embryo sac and adjoining tissues are impregnated at flowering time with some unknown powerful substances which kills all the viruses. For immediate requirement of planting material, development of nucellar lines is the quickest and easiest method. The major possible horticultural applications of polyembryony are:

- Nucellar seedlings are true-to-type seedlings
- Such seedlings are genetically uniform and can be used as virus free rootstocks
- More vigorous seedlings – continuous vegetative propagation leads to decline in vigour in citrus
- Development of virus free seedlings and bud wood
- Significance in breeding programme

Apomixis

In some species of plants, an embryo develops from the diploid cells of the seed and not as a result of fertilization between ovule and pollen. This type of reproduction is known as **apomixis** and the seedlings produced in this manner are known as apomicts.

- Apomictic seedlings are identical to mother plant and similar to plants raised by other vegetative means, because such plants have the same genetic make-up as that of the mother plant.
- Such seedlings are completely free from viruses. Plants that produces only apomictic embryo and are known as **obligate apomicts** and those which produce both apomictic and sexual seedlings are called **facultative apomicts**.

Types of Apomixis: Maheshwari (1950) classified apomixis into four groups:

1. **Recurrent Apomixis**: In this type of apomixis, the embryo develops from the diploid egg cell or from the diploid cells of the embryo sac without fertilization. As a result, the egg has normal diploid number of chromosomes, just like the mother plant (Fig.4.1).The species, where recurrent apomixis commonly occur are, *Parthenium, Rubus, Malus, Allium , Rudbeckia, Poa, Taraxacum* ,etc.
2. **Non-Recurrent Apomixis**: In this case, the embryo develops either from the haploid egg cell or from some other haploid cells of the embryo sac. In this case, haploid plants are produced, which contain only one set of chromosome of the mother plant. Hence, the haploid plants are sterile in nature and cannot be normally perpetuated into the next generation. Non-recurrent apomixis occurs only in a few species such as *Solanum nigrum, Lilium* spp. etc.
3. **Nucellar Embryony or Adventitious Embryony**: In this type of apomixes, the embryos arise from diploid sporophytic cells outside the embryo sac i.e. cells of the nucellus, integuments etc. This type of apomixis is quite common in citrus and certain varieties of mango, where fertilization occurs normally and sexual plus a number of apomictic (nucellar) embryos develop.
4. **Vegetative apomixis or bulbils**: In some species of plants, such as *Allium , Agave, Poa* etc., the flowers in an inflorescence are replaced by bulbils or vegetative buds, which sprout, while still on the mother plant and turn into new daughter plants.

Advantages

- Assured reproduction in the absence of pollinators, such as in extreme environments
- Maternal energy not wasted in unfit offspring (cost of meiosis)

- Some apomictic plants (but not all) avoid the male energy cost of producing pollen

Disadvantages

- Can't control accumulation of deleterious genetic mutations
- Usually restricted to narrow ecological niches Lack ability to adapt to changing environments

Clone

The term clone may be defined as a group of genetically uniform individuals, derived originally from a sexually produced individual or from mutations and maintained exclusively by asexual means from one ancestor.

- The common examples are Bartlett pear, Delicious apples, Sultana grapes and Dashehari mango.
- The goal of vegetative propagation is to reproduce progeny plants identical in genotype to a single plant. The biological process is known as cloning and the resulting population of plants is called a clone.
- The uniformity of individual plants, within a clonal population is a major advantage of clonal cultivars of fruit and nut crops.
- Clonal propagation helps in fixing genotypes, uniformity of population, facilitates propagation and reduces juvenile phase, combine more than one genotype into single plant (grafting) and control phases of development.
- If environmental conditions are favourable and the clone is managed properly, its trueness-to-type can be maintained for hundreds of years.

Genetic variations in a clone

Mutation

Mutation is a single-step genetic change or sudden heritable change within cells of a clone. In general, these changes take place spontaneously, in the plants regular but rare intervals.

- A mutation is a genetic change involving some part of the DNA molecule. Genetic mutations result from structural changes in the nuclear DNA of the chromosome in the nucleus. DNA also occurs in mitochondria and chloroplasts and defects here can produce genetic changes.
- Chromosomal changes may be due to chance rearrangement of the four bases in the DNA molecule (point mutation) rearrangement of different parts of the chromosomes (deletion, duplication, translocations and inversions), addition or subtraction of

individual chromosome (aneuploidy), or the multiplication of entire set of chromosome (polyploidy).

- The rate of mutation can be increased by treatment with specific mutagenic agents e.g. X-ray, gamma rays and certain chemicals.

Bud- sports or bud mutations

When mutation occur and suddenly appear as a chance in the branch of a plant, is called **bud sport or bud mutations**, because they appear to have originated within a single bud.

- Detection of a new mutant within a clone may require a series of vegetative propagated generations and multiple propagations from many buds of the same plant.
- Many 'sports' have become commercial cultivars. Mutations may affect fruit (colour, shape, time of maturity), tree structure (spur type), time of bloom, and as a host of other traits. Sometimes these mutants have highly useful horticultural traits and have given rise to important new cultivars ('Ruby Red' grapefruit, red coloured sports of apple and pear.)
- On the other hand, mutations may be undesirable and give rise to misshapen fruits, low production and susceptibility to diseases.

Chimeras

When a mutation occurs within a single cell of a clone, it initially produces an '**island** 'of mutant cells within a growing point of a stem. The plant becomes a, mixture of two different genotypes. This structural arrangement is known as **chimeras**.

- It is the most important kind of genetic variant within clones typified by various kinds of variation. The name chimera was historically given to certain unique clonal variants now known to have arisen as graft chimeras.
- Chimeras develop because of the unique architecture of the apical meristem and the strategic location of the mutation in a dividing cell near the apex of the apical meristem.
- The three important types of chimeras are based upon the distribution patterns of mutated and non-mutated cells.
- Buds arising at different positions on a sectorial chimera may produce shoots consisting of mutated and non-mutated cells, entirely of mutated cells or entirely of non- mutated cells or sectorial (rarely), mericlinal or periclinal chimeras as described herewith.

- **Periclinal chimera:** The mutated tissues occupy layers of cells that completely surround an inner core of non mutated tissue. For examples in many red colored fruit cultivars in apple (Plate 4.2), the red pigment is located only in the epidermal layers; whereas the cells of the inner tissue have alleles for green or yellow colour. Similarly, some black berry (*Rubus spp.*) cultivars are thorn less; because the cells making up the epidermis do not have this allele. Periclinal chimeras are relatively stable if propagated stem or grafting.
  - **Mericlinal chimera:** This combination is similar to the periclinal expect that the cells carrying the mutant gene occupy only a part of the outer cell layer. In case of a red mutant on a yellow delicious fruit, the surface of the fruit may have longitudinal streaks or sectors of red on an otherwise yellow surface (Plate 4.3). This type is unstable and tends to change into periclinal chimeras, revert to the non-mutated form, or continue to produce mericlinal shoots.
  - **Sectorial chimera:** The mutated cells in this combination occupy an entire sector of the stem including all layers of the shoot apex. Sectorial chimeras appear if the mutation occurs in roots and very early stages of embryos where the cells of the growing point do not occur in layers. In general, this type is unstable and tends to revert to mericlinal and periclinal chimeras.
  - **Graft Chimera:** In horticulture, a **graft-chimera** may arise in grafting at the point of contact between rootstock and scion and will have properties intermediate to those of its **parents**. A graft-chimera is not a true hybrid but a mixture of cells, each with the genotype of one of its parents is a chimera. Hence, the once widely used term "graft-hybrid" is not descriptive; it is now frowned upon. In practice graft-chimaeras are not noted for their stability and may easily revert back to one of the parents.