Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second Year)

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Course Title: Plant Anatomy and Embryology

Unit: 8 - Apomixis and Polyembryony

Module Name: Concepts, Types and Practical Application of Apomixis

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NOTES

Concepts of Apomixis

- Meiosis and syngamy are the two main characteristics of sexual reproduction or amphimixis.
- By meiosis, the diploid cells of the sporophyte give rise to the haploid gametophytes which bear male and female gametes.
- Syngamy, the fusion of haploid gametes results in the restoration of the diploid sporophytic generation.
- Thus, in sexual reproduction diploid (sporophytic) and haploid (gametophytic) phases regularly alternate each other and this is known as alternation of generations.
- In angiosperms, the gametophytic generations are very short and are represented by embryo sac on the female side and microspore or pollen grain on the male side. The remaining part of the life cycle belongs to the sporophytic generation.

- The plants where the usual sexual reproduction has been completely replaced by a type of asexual reproduction are called apomictic, and the phenomenon is known as apomixis.
- According to Winkler (1908), the term apomixis (= away from mixing) may be defined as the substitution of the usual sexual reproduction by a form of reproduction which does not involve meiosis and syngamy.
- A species may include sexually as well as apomictically reproducing individuals. Apomixis is very common in higher plants. Plants of more than 35 families are known to be apomictic, e.g. Gramineae, Rosaceae, Compositae and Rutaceae. Major cereals such as maize and wheat show apomixis.
- The most important apomictic plants are citrus, mango, mangosteen and black berries.

Types of Apomixis

There are two main types of apomixis:

1. **Vegetative reproduction**
2. **Agamospermy**

1. **Vegetative reproduction:**

- The plants propagate by a part of their body other than the seed. The structural units employed for this purpose are called propagules. Vegetative propagation includes reproduction by means of bulbils, bulbs, runners, suckers, and so on. These propagules are formed by the sporophyte only.
- Gustafsson (1946) has distinguished three types of vegetative reproduction in higher plants:

i. The propagules are formed outside the floral regions, and despite the occurrence of functioning sex organs no fertilization or seed setting takes place. Example *Agave americana* and *Elodea canadensis*.

ii. The propagules are formed outside the floral regions, and the plants are sexually sterile. *Fritillaria imperialis* and *Lilium bulbiferum* are typical representatives of this group. They propagate by means of bulbils and bulblets.

iii. The propagules are formed on the floral branches either in addition to the flowers or in place of them. The phenomenon is commonly described as vegetative vivipary. Example grasses (*Deschampsia, Festuca, Poa*) and *Allium*.

2. Agamospermy:

- The plants have retained seed as the agent of propagation but the embryo is formed by some process in which normal meiosis and syngamy have been eliminated.
- Three different types of agamospermy are recognised:

i. Adventive embryony: Embryos arise directly from the diploid sporophytic cells (nucellus or integuments). The sexual embryo sac develops normally, and the zygotic embryo either degenerates or competes with the apomictic embryos.

ii. Diplospory: An archesporium differentiates, but the megaspore mother cell develops into an unreduced embryo sac. The embryo is formed by the unfertilized egg (parthenogenesis) or some other cell of the embryo sac (apogamety).

iii. Apospory: A somatic cell in the nucellus directly forms an unreduced embryo sac, and the diploid egg parthenogenetically develops into embryo. The apomictic embryo sac may develop in addition to the haploid embryo sac derived from a functional megaspore mother cell. The latter may either degenerate at an early stage or form a sexual embryo after fertilization.

- Maheshwari (1950) has recognised the following three types of apomixis:

1. **Non-recurrent apomixis**
2. **Recurrent apomixis**
3. **Adventive apomixis**

1. **Non-recurrent apomixis:**

- The megaspore mother cell undergoes normal meiotic division and one of the four megaspores thus formed develops into haploid female gametophyte (embryo sac).
- However, there is no fertilization and the embryo develops either from the unfertilized egg (haploid parthenogenesis) or from some other cell (stimulated haploid synergid cell) of the embryo sac (haploid apogamy). The embryo, thus formed, is naturally haploid.
- The plants produced by this method are, haploid and generally sterile and do not reproduce sexually any more. Example *Solanum nigrum*, *Lilium*, *Bergenia*, *Nicotiana tabacum*, *Orchis maculata*, *Erythraea centaurium*, etc.
- The egg may fail to fertilize due to the following causes:
  (i) absence of pollen tube, (ii) inability of the tube to discharge its contents, (iii) an insufficient attraction between the male and female nuclei, (iv) an early degeneration of sperms, and (v) maturation of egg and the entrance of male gametes may not be synchronized.
- The occurrence of haploid parthenogenesis may be of considerable value in genetical studies as it enables to obtain true breeding homozygous forms.

2. **Recurrent apomixis:**

- Embryo sac may arise either from a cell of the archesporium (generative apospory) or from some other cell of the nucellus (somatic apospory).
- The nuclei of the embryo sac are usually diploid.
- The embryo arises either from the egg (diploid parthenogenesis) or from some other cell of the gametophyte (diploid apogamy). Generative apospory has been observed in *Eupatorium glandulosum*, *Parthenium argentatum*, etc. Somatic apospory has been reported in *Hieracium excelens*, *H. flagellare* and *H. aurantiacum*.

3. Adventive apomixis:

- The development of embryo from any diploid cell of the ovule lying outside the embryo sacs is referred to as adventive embryony. It is also called sporophytic budding.
- In this process there is no alternation of generations.
- The cells of the nucellus or integuments, forming adventive embryo, become densely protoplasmic and divide actively to form a small mass of meristematic cells.
- This tissue mass grows actively, pushes its way into the embryo sac and eventually gives rise to what appears to be a normal embryo.
- The zygotic as well as the adventive embryo may grow simultaneously in the same embryo sac.
- The normal (zygotic) embryo has a suspensor, whereas in the nucellar adventive embryo suspensor is absent.
- *Citrus* is the most common example of adventive embryony. As many as ten viable embryos may be found in a single seed of *Citrus*.
- Adventive embryony is also of common occurrence in the members of the Euphorbiaceae, Cactaceae, Buxaceae and Orchidaceae.
- The development of adventive embryos may take place with or without the stimulus of pollination or fertilization.
- In *Mangifera indica* and most of the species of *Citrus*, fertilization is necessary for the maturation of adventive embryos. But in *Eugenia jambos* adventive embryos originate without pollination, however, their full development is attained only if the egg is fertilized.

Practical Application of Apomixis

- Development of pure lines: Apomixis is a means of rapid production of pure lines in plants. Haploid apogamy and parthenogenesis give rise to haploid plants

which after being treated by colchicine treatment can produce diploid pure lines. These pure lines can be used in the production of high yielding cultivars and hybrids.

- Maintenance of purity: Obligate apomixis breeds retain the characteristics of the mother plant which are useful in maintaining genetic purity from generation to generation. It can maintain a genotype for several generations.
- Conservation of heterosis: Obligate recurrent apomixis is useful in conserving hybrid vigour for numerous generations. As apomixis does not permit segregation, heterosis can be easily conserved.
- Easy hybrid seed production: Apomixis offers a simple way of hybrid seed production. These seeds are automatically produced by apomictic means and there is no need for crossing. Once a hybrid is developed using an apomictic line as one of the parents, the hybrid seed production will occur automatically. It is also more affordable than conventional methods of hybrid seed production.

SUMMARY

- Apomixis may be defined as the substitution of the usual sexual reproduction by a form of reproduction which does not involve meiosis and syngamy.
- As apomixis does not involve meiosis, there is no segregation and recombination of chromosomes. Thus, it is useful in preserving desirable characters for indefinite periods.
- In obligate apomictic species, though desirable characters are preserved for quite a long time, they are deprived of evolution.
- On the contrary, in facultative apomictic species, sexual and asexual processes occur simultaneously and hence there is great significance of apomixis.