Module 4 d.

Polyploidy in Plant Breedin

- Generally all organisms have a constant chromosome number characteristics of the particular species.
- However, numerical changes in chromosomes may occur in plants

Changes in the number of chromosomes

a.Euploidy (polyploidy)

The change in the number of chromosomes which may involve loss or gain of the whole set of chromosomes is called Euploidy (polyploidy)

- **b.Aneuploidy:**

  The change in the number of chromosomes which may involve loss or gain of one or few chromosomes is called aneuploidy .Aneuploidy is the presence of an abnormal number of chromosomes in a cell.Eg, a human cell having 45 or 47 chromosomes instead of the usual 46. Types of aneuploidy are monosomy (2n-1), trisomy (2n+1) and nullisomy (2n-2)

Polypoid

- **Euploidy (polyploidy)**
  The change in the number of chromosomes which may involve loss or gain of the whole set of chromosomes is called Euploidy (polyploidy)
- **An organism that has more than two haploid sets of chromosomes is called a polypoid.**
- In plants polyploids are common.
- It is estimated that about one – third of angiosperms are polyploids.

Polyploidy

The first polyploidy was reported in Oenothera, the gigas mutant, an autotetraploid.

Oenothera(Evening primrose)

Characteristics of polyploids

- Polyploids have larger cell size than the diploids.
- Guard cells of stomata are larger and number of stomata is lower in polyploids than in diploids.
- They have larger and thicker leaves, larger flowers and fruits.
- Generally there is an increase in vigour and vegetative growth.

Origin of polyploids

- **Spontaneously :**

  Polyploids may arise spontaneously

- **Due to treatment with physical or chemical agents**

  Polyploids may arise due to the treatment

  with physical agents such as heat or cold treatment,
  with chemicals such as **colchicine**, acenaphthene,
  8- hydroxyquinone etc.

Colchicine

Colchicine – a poisinous chemical isolated from seeds (0.2 – 0.8 %) and bulbs (0.1 – 0.5%) of autumn crocus (*Colchicum autumnale*).

Effect of Colchicine

- It **block spindle formation** and thus inhibits the movement of sister chromatids to the opposite poles.
- The resulting nucleus includes all the chromatides & as a result, the chromosome number of the cell is doubled .
- colchicine **affects only dividing cells**

- **Colchicine treatment:**
- Freshly prepared aqueous solutions of colchicine (0.2% is more common)is used.
- Seeds are generally soaked

- A small cotton wool piece may be placed at the shoot tip in plants, which is daily soaked with colchicine solution.

Depending upon the level of ploidy , there are

- Triploids (3x)
- Tetraploids(4x),
- Pentaploids (5x),
- Hexaploids(6x).

Types of Polyploids

An organism that has more than two haploid sets of chromosomes is called a polypoid.

Polyploids are generally divided into two types .

i.Autoploids Eg AAAA

When all the genomes present in a polyploid species are identical

ii.Alloploids Eg AABB

When all the genomes present in a polyploid species are not identical

Types of Polyploids

Polyploids are generally divided into two types viz. Autoploids and alloploids.

i.Autoploids Eg AAAA

Eg seedless triploid water melons, tomato, grapes

ii.Alloploids Eg AABB

EgTriticale ,Raphanobrassica

Types of Polyploids

i.Autoploids:

When all the genomes present in a polyploid species are identical , it is known as autopolyploid and the situation is termed as termed as autoploidy.Eg: AAAA

Autoploidy had played only a minor role in the evolution of plants. Some of the present day crop species are autopolyploids.

Eg:potato -4x (autotetreploid)

Coffee -4x (autotetreploid)

Banana- 3x(autotriploid)-sterile & no seeds

(wild banana is diploid and produce seeds)

Eg seedless triploid water melons, tomato, grapes

Sweet potato- 6x (autohexaploid)

It has been found that auto tetraploids are more successful as crops than other forms of autopolyploids

Applications of autopolyploidy in crop improvement

1. **To produce homozygous diploid lines from monoploids (haploids)** by chromosome doubling in two years. This greatly reduces the time and labour required for the isolation of inbreds and purelines.
2. **Production of seedless fruits by using triploids**. Triploids are produced by hybridisation between tetraploids and diploid strains. The triploids are generally higly sterile . This feature is useful in the production of seedless fruits. Eg: seedless water melons, tomato, grapes
3. **Auto tetraploids may be useful in breeding** .they are larger in size and more vigorous than the diplods.
   Eg: autoteraploid barley, corn, apple, grapes.
4. **A triploid clone of tea** (*Camelia assamica*) has been released by tea research association, India for culture in the northern parts of the country. The triploid cultivar, TV29, produces larger shoots , yields more cured leaf per unit area& drought tolerant.

ii.Allopolyploidy

- When all the genomes present in a polyploid species are not identical , it is allopolyploidy
- Allopolyploids have genomes from two or more species. (eg. AA, BB).
- The present day allopolyploids were most likely produced by chromosome doubling in F_1 hybrids between two distinct species belonging to the same genus or two different genera.
- The allopolyploids produced by man are known as synthetic allopolypoids because they are synthesised by man from two distinct genus or species of plants

Production of allopolyploidy

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The production of an allopolyploid involves two steps.

1. **Production of F_1 distant hybrid**
2. **Chromosome doubling** with the help of colchicine

- In some distant hybrids, occational unreduced gamates are produced
- These unreduced gamates unite to give rise to allopolyploid progeny .
- The allotetraploid **Raphanobrassica** was obtained in this manner.
- The F 1 from the cross of *Brassica oleraceae* (Cabbage) & *Raphanus sativus* (Radish) was almost completely sterile,but produced a few seeds that gave rise to the allotetraploid Raphanobrassica

Role of allopolyploidy in crop improvement.

- Allopolyploids have been more successful as crop species than autopolyploids.

  Many of our present day crop species are allopolyploids.

- Allopolyploidy has contributed to a great extent in the evolution of plants.

EgAllopolyploidy had played a major role in the evolution of bread wheat, Triticum aestivum.

- Allopolyploidy can be used for the creation of new crop species.Eg Triticale

Role of allopolyploidy in crop improvement.

- Allopolyploidy has contributed to a great extent in the evolution of plants.

Allopolyploidy had played a major role in the evolution of bread wheat, *Triticum aestivum*.

Identity of the diploid species contributing the three genomes (**A,B** and **D** genomes) of *Tricticum aestivum* has been investigated by many workers.

It has been proposed that the sources of

A genome is *Triticum monococcum*,

B genome is *Aegilops speltoides* and

D genome is *Aegilops squarrosa*.

Aegilops speltoides **Aegilops speltoides** (a closely allied species of grass)

Triticum monococcum X ***Agilops speltoids***

2n =14(n=7) **AA** 2n =14(n=7) **BB**

↓

AB 2n =14 sterile

2n = 28(4x) ↓ spontaneous chromosome doubling

AABB ***Triticum dicoccum*** (tetraploid Emmer wheat (n=14, Amphidiploid) 2n = 28(4x)

Aegilops squarrosa **DD** X **AABB** ***Triticum dicoccum*** (tetraploid emmer wheat

2n =14, n= 7, (n=14, Amphidiploid) 2n = 28(4x)

↓

ABD sterile 2n=21

↓ spontaneous chromosome doubling

AABBDD 2n=42 (6x) n=21

Hexaploid Wheat Amphidipiploid

A possible evolutionary history of hexaploid wheat

Rye (*Secale cereale*) x Bread Wheat (*Triticum aestivum*)

Diploid Sporophyte = 14 Hexaploid Sporophyte = 42

haploid gamete: n = 7 triploid gamete: 3n = 21

Rye (n = 7) + Wheat (3n = 21) = Triticale (4n =28) —colchicine→ Triticale (8n = 56)

Rye (*Secale cereale*) x Durum Wheat (*Triticum turgidum*)

Diploid Sporophyte = 14 Tetraploid Sporophyte = 28

haploid gamete: n = 7 diploid gamete: 2n = 14

Rye (n = 7) + Wheat (2n = 14) = Triticale (3n =21) —colchicine→ Triticale (6n = 42)

Allopolyploidy can be used for the creation of new crop species.

Eg Triticale , Raphanobrassica

Triticale

- Triticale is the most successful synthetic alloploypoid.
- It is produced by crossing wheat (Tricticum species – tetraploid or hexaploid) with Rye (Secale cereal).
- Triticale has combined the favourable features of the two parental species. i.e. Yielding ability and grain qualities of wheat and the hardiness (tolerance to adverse environment) of rye.
- At present, triticale's are comparable to those of the best wheat varieties.
- Triticale is thus , the man made cereal.
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Raphanobrassica

- Production of Raphanobrassica is also a classical example of allopolyploid .
- The allotetraploid Raphanobrassica was obtained from the cross between *Brassica oleraca* (cabbage) and *Raphanus sativus* (radish).
- The aim in producing Raphanobrassica was to synthesize a crop species that would combine the root of radish and the leaves of cabbage .
- But, Raphenobrassica had leaves like raddish and roots like cabbage.
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Rhaphanobrassica

Raphanus	X	*Brassica*	=	*Raphanobrassica*
Radish		Cabbage		Rabbage
(2n = 18)		(2n = 18)		(2n = 18)
RRRRRRRRR RRRRRRRRR		CCCCCCCCC CCCCCCCCC		RRRRRRRRR CCCCCCCCC
Fertile		Fertile		Sterile (synaptic failure)

Diploid (2n) Rabbage —colchicine→ Tetraploid (4n) Rabbage

RRRRRRRRR
CCCCCCCCC

RRRRRRRRR CCCCCCCCC
RRRRRRRRR CCCCCCCCC

The Formation Of A Fertile Tetraploid Rabbage

R = radish chromosome C = cabbage chromosome