Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Third Year)

Subject: Botany

Paper Code: BOC-108

Paper Title: Cytogenetics and plant breeding

Unit: Alteration in chromosome number

Module Name: Euploidy

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Notes:

Every species has a characteristic number of chromosomes in the nuclei of its gametes and somatic cells. The gametic chromosome number constitutes a basic set of chromosomes called **genome**. The gamete cell contains single genome and is called **haploid (n)**.When male and female haploid gametes unite it results in formation of **diploid (2n)**organism.

Heteroploidy: Chromosomal aberration which results in ***change in number of whole chromosomes*** is called heteroploidy.

Types of Heteroploidy:
Euploidy: Loss or gain of whole chromosome set.
Aneuploidy: Loss or gain of part of chromosome set.

Euploidy: If any species contain multiples of basic chromosome set(x),then such species are referred as **Euploids** and phenomena is referred as Euploidy
Example:
A plant with the basic chromosome number 7, may have euploids with chromosome number 7, 14, 21, 28, 35, 42.

Types of Euploidy:

- Monoploidy (x)
- Diploidy (2x)
- Polyploidy (3x,4x,5x,6x,…)

Monoploids:

Monoploid species have single basic set of chromosomes(x). Monoploidy is common in plants and rare in animals.

Example:

Barley: $2n = 1x = 7$

Origin & production of monoploids

In angiosperms they may occur naturally due to parthenogenetic development of egg.

They may also be produced artificially mainly by distant hybridization method and anther culture method.

Morphology of monoploids:

They are generally smaller and weaker than the diploids.

They have reduced size of all vegetative and floral parts.

The size of seeds, stomata and diameter of pollen were found to be smaller than their diploids.

They show low viability.

Nuclear volume was found to be just ½ than the nucleus of diploid cell.

Cytology of monoploids:

Since chromosomes do not have their homologues, the pairing of chromosomes is not possible in zygotene stage.

In metaphase-I chromosomes appear as univalents on the metaphase plate.

In anaphase each chromosome moves independently of the other and goes to either of the two poles.

Thus chances of formation of functional gametes are very rare and high degree of sterility is observed.

If meiotic process succeeds at all, the univalent chromosomes are found scattered all over the cell.

Uses of monoploids:
They carry a single set of genes. So they are genetically pure. Thus, they can be used experimentally to a good advantage in crop improvement.
They are used for developing homozygous diploid lines.
They may be useful in isolation of mutants because the mutant allele, even if recessive, expresses itself.
Pure autotetraploid varieties of certain economic crops like potato can be produced from their monoploids.

Polyploidy:

An organism having more than two basic sets of chromosomes is known as polyploid and the phenomenon is known as polyploidy.
1/2 of total species of flowering plants are polyploids & 2/3 species of all grasses are polyploids.
A typical diploid is rare in nature.
Many of our cultivated diploids plants are actually polyploids.

Example:
In Nicotiana X=12. It has varieties with chromosome number 24(Diploid), 48(Tetraploid) and 72(Hexaploid).

Origin of polyploidy:
Doubling of the chromosomes during early stage of development of the embryo.
Union or fusion of the gametes, one or both of which due to some reason may be unreduced in chromosome number.
Two male gametes occasionally or sometimes unite with a single egg cell thus forming a triploid.
Sometimes it is caused by a large number of mutations which occur in the nature.
It may also arise by manipulation of the breeder.

Types of Polyploidy:
- Autopolyploidy
  (Multiple sets of same genome)
- Allopolyploidy
  (Multiple sets of different genomes

Autopolyploids:

Autopolyploids have ***more than two copies of the same basic set of chromosomes*.**

Example:
X: Basic chromosome set
XXX: Autotriploid
XXXX: Autotetraploid
XXXXX: Autopentaploid

Origin & production of autopolyploids

They may occur naturally or may be induced artificially.
In nature they may arise as a result of:

a. Interference with cytokinesis, one's chromosome replication has occurred.
b. Unreduced gametes produced during meiosis.

Autopolyploidy may induced in plants and animals by treatment with chemical mutagens like colchicine, radiations like x rays and temperature shocks.

Morphology of autopolyploids:

Larger in size. Leaves, flowers and fruits are larger in size.
The flowers and fruits per plant are usually less in number.
The guard cells are larger and the frequency of stomata per unit area is lower.
Pollen grains are larger.
The cells contain more chloroplasts.

Effects of autopolyploidy:

With the increase in cell size, the water content in cells increases which leads to a decrease in osmotic pressure. This results in loss of resistance against frost.
Due to slower rate of cell division, the plants growth rate decreases. this leads to decrease in auxin supply and a decrease in respiration.
Due to slow growth rate the time of blooming is delayed.
At higher ploidy level, the adverse effect become highly pronounced and lead to the death of the plants.
Autopolyploids with an even number of genomes like autotetraploids are often fully fertile, whereas those with an odd number like autotriploids are highly sterile.

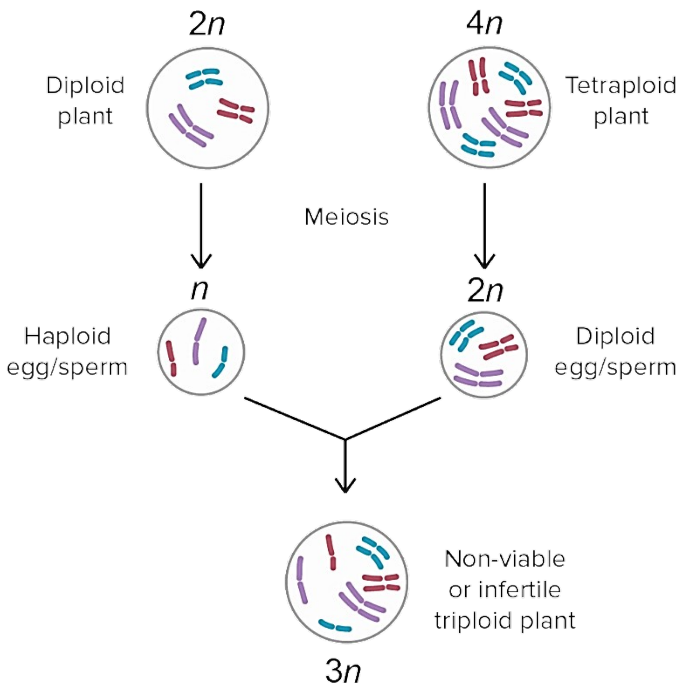
Autotriploids:

Triploids have three similar genomes (AAA) and are commonly designated as 3n plants.

Examples:
Autotriploids occur in a number of plants, e.g., Oenothera, Datura, rose, water melon, banana, sugar beet, tomato, grapes, etc.

Origin of autotriploids:

Triploids originate from hybridization between auto-tetraploids (4n) and diploids (2n).
The autotetraploid produces diploid (2n) gametes which when fertilized by a normal monoploid (n) gamete produce triploid (3n) progeny.



Characters of Autotriploids: :
They are more vigorous than normal diploids.
They are leafier and show tendency towards perenniality.
Sometimes floral abnormalities may be observed.
Pollen grains, stomatal guard cells and wood cells of xylem are larger than those of diploids.

Plants are highly sterile and seeds are formed rarely.

Cytology of Autotriploids:

Meiosis is highly irregular.
During synapsis three homologous cannot orient themselves so as to give equivalents at the two poles.
In anaphase-I two chromosomes may go to one pole and third may go to the other pole.
Meiotic products may contain either n+1or 'n' or '2n' chromosomes.
The gametes arising from triploids have unbalanced genomes.

Autotetraploids:

Autotetraploids have four similar genomes (AAA) and are commonly designated as 4n plants.

Examples:
Autotetraploids are common in rye, corn, red clover, snapdragon, Allium tuberosum etc.

Origin of autotetraploids:
They may originate in one of the following ways:

- By fusion of two diploid gametes.
- They may result from the duplication of somatic chromosomes (2n) followed by failure of mitotic division.

Characters of Autotetraploids:
Show marked phenotypic variations, great adaptability & show tendency towards perenniality.
Slower in growth & sometimes show disease resistance.
Bear large deeply colored flowers and fruits.
Have larger cells mainly epidermal cells and guard cells.
Commercially more valuable than corresponding diploids

Cytology of Autotetraploids:
It may be normal or abnormal.
When four homologous align in tetravalents, normal diploid gametes are formed.
Sometimes, two bivalent or one trivalent and one univalent may also occur.

Incomplete genomes in gametes may result in total sterility.

Allopolyploidy:

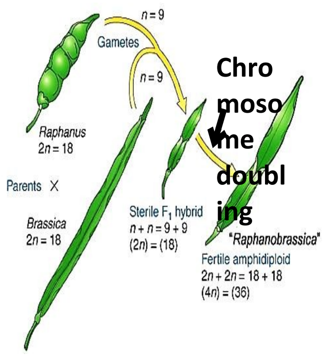
Polyploidy which results in doubling of chromosomes in a F1 hybrid which is derived from two distinctly different species then such polyploidy is called as allopolyploidy and species obtained is called allopolyploid.

Types of Allopolyploidy:

- Genome allopolyploidy
- Segmental Allopolyploidy
- Auto allopolyploidy

Genome polyploidy:

Two or more **distinct genomes are brought together** through hybridization followed by doubling of the chromosomes of the resulting hybrid. The F_1 is often completely sterile. Chromosome doubling of the F_1 hybrid produces a fertile allotetraploid called as **amphidiploid**.



Segmental Allopolyploidy:

In allopolyploid if some degree of homology (partial homology) exist between some chromosomes of one genome with chromosomes of the other genome such allopolyploids are called as segmental allopolyploids.
These chromosomes belonging to different genomes show pairing to some extent.
This indicates that segments of chromosomes and not the whole chromosomes are homologous.
Most naturally occurring polyploids are segmental polyploids.

Auto-Allopolyploidy:

This term was used by Kostoff in 1939.
Allopolyploid which shows auto-polyploidy for one or more of their genomes are referred as auto-allopolyploids.

Example:
If A and B are genomes of allopolyploid,, then auto-allopolyploid may be:

a. AAAABB,
b. AABBBB
c. AAAABBBB.

Thus auto-allopolyploidy is possible from the level of hexaploidy (6x) and above.

Example of Auto-Allopolyploidy:

Allodecaploid triticale:
It has two copies each of the three genome of bread wheat (ABD) and four copies of that of rye genome (R).
Thus the rye genome is in autotetraploid condition.