IOSR Journal Of Pharmacy And Biological Sciences (IOSR-JPBS)
e-ISSN:2278-3008, p-ISSN:2319-7676. Volume 15, Issue 3 Ser. I (May –June 2020), PP 30-38
www.Iosrjournals.Org

Polyploidy In Plants: Pharmacognosy

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Abstract: *Polyploidy or make greater in number of chromosomes have been found in living cells of plants as well as animals. Polyploidy is the strength of modern genetics or modern molecular technology in pharmacognosy to provide something new or combinations of characters in the field of plant breeding programs of medicinal plants and also for foods or crops. So the polyploidy is a perfect, popular and futuristic matter for review. Polyploidy is the most essential and useful because life on earth is present mainly, who depends on foods or crops and medicines for live their life. New significant for genome duplications should be measured with ancient ideas and new challenges of meiosis and mitosis. By the help of polyploidy we can be belief predicts which are crops and medicinal plants, usefully improved to obtained stable autopolyploids and which genomes or species adapted and merged to produce victorious new allopolyploids. This review gives information about the meaning of polyploidy, types, causes, factors which promotes polyploidy, examples, mechanisms, applications, advantages and disadvantages of polyploidy. By which we can predicts new significance for future prospective.*

Key words:- *Polyploidy, genetics, molecular technology, plant breeding, meiosis, mitosis, autopolyploidy & allopolyploidy.*

Date of Submission: 02-05-2020 Date of Acceptance: 16-05-2020

I. Introduction

- Polyploidy word is the combination of two words- 'Poly'+ 'Ploidy', in which 'Poly' means "many or more'' and 'Ploidy' means ''the number of pairs or sets of chromosomes available in cell of any living things''. So polyploidy defined as the condition at which the number of sets or pairs of chromosomes will be more than two in cell of any living things. In which one set inherited from each parents or excess of the diploid number[1]**.**

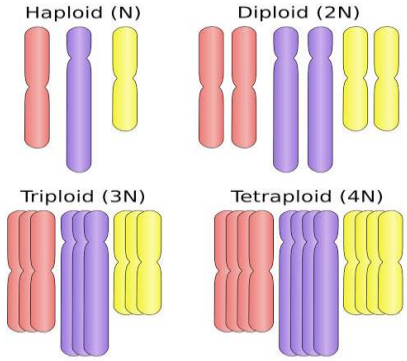

Fig. 1 Normal and Polyploids chromosomes

- Poly= many or more (may be 3,4,5,6.....etc)&Ploidy= the number of pairs or sets of chromosomes available in cell of any living things (denoted by X or N), so Polyploidy= more than two sets or pairs of chromosomes available in cell ofliving things[2].

- The number of sets or pairs of chromosomes (which is denoted by X or N).Haploid (1n= gametes or chromatids) & diploid (2n) are normal form of chromosomes but triploid (3n) & tetraploid (4n) are the example of polyploidy[3] (fig. 1).

II. Causes Of Polyploidy:-

There are four types of causes behind the polyploidy:-
2.1 Non-disjunction in mitosis
2.2 Non-reduction in meiosis
2.3 Polyspermy
2.4 Endo-replication or Endo-reduplication

2.1 Non-disjunction in mitosis:-

- As we know mitosis is the process of formation of two daughter cells from one parent cell.
- In the fig. 2 diploids (2n) has taken as an example for mitosis (generally found in early embryoin cell), in which diploids are in the form of chromatids (single strand chromosomes) then replicated and form copy of each chromatids and converted in to double strand of chromosomes.
- Undergoes to separation of chromatids for cell division with formation of spindles but due to disturbance in spindle protein, segregation of chromatids (non-disjunction) not occurs.
- Finally cell division not occurs.
- So the duplicated chromatids are present in same cell, ultimately the number of chromatids will be increased. Result is that polyploidy occurs.

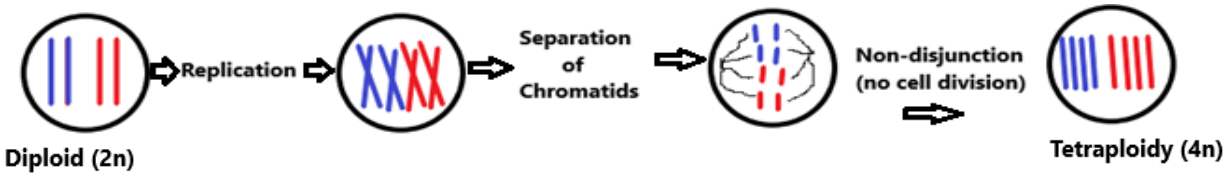

Fig. 2.1 Non-disjunction in mitosis

2.2 Non-reduction in meiosis:-

- As we know meiosis is the process of formation of four daughter cells from one parent cell.
- In the fig. 3 diploids (2n) has taken as an example for meiosis-1 (generally found in early embryoin cell), in which 1diploids contains homologous chromosomes and 1 diploids contains non-reduced chromosomes, then replicated and form copy of each chromatids and converted in to double strand of chromosomes.
- Undergoes to separation of chromatids for cell division with formation of spindles but due to non-disjunctionit formsonly 2 daughter cellsin meiosis-1.
- But during meiosis-2 this daughter cells areform haploids & triploids which further fertilized and form tetraploids (4n= 1n+ 3n)from haploids (1n) & triploids (3n), which is the example of polyploidy.

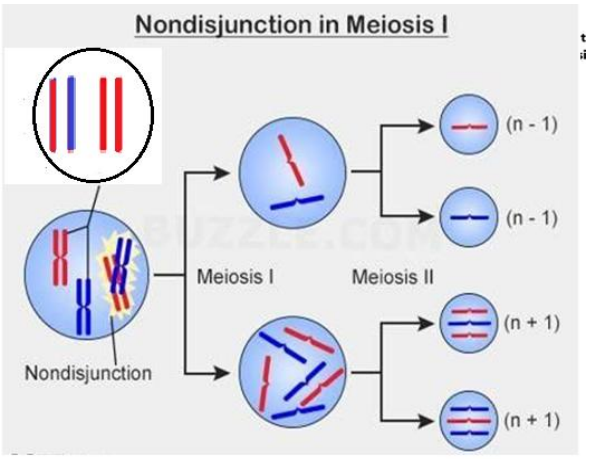

Fig. 2.2 Non-reduction in meiosis

2.3 Polyspermy:-

- If the fertilization of egg (female nuclei) is done by more than one male nuclei (in fig. 4), this condition is called Polyspermy.
- Which result is that triploid (example of polyploidy) is occurs. Very rarely polyploidy is occurs due to polyspermy.

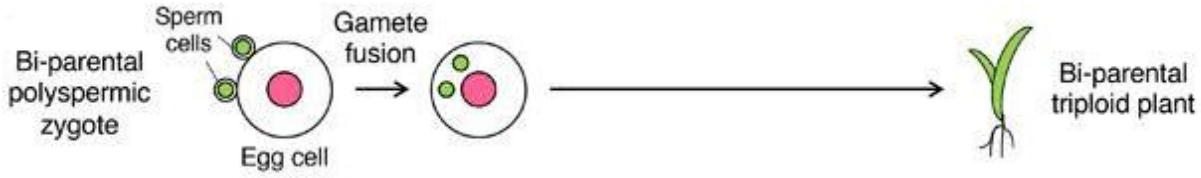

Fig. 2.3 Polyspermy

2.4 Endo-replication or Endo-reduplication:-

- When the replication of DNA occurs in which the number of chromosomes gets duplicated.
- But cytokinesis (cell-division) not occurs.
- Ultimately the increased numbers of chromosomes present in single cell.
- Result is polyploidy occurs during Endo-reduplication or Endo-reduplication [4][5].

III. Factors Promoting Polyploidy:-

There are three factors which promotes the polyploidy which are as follows:
3.1Physical factor
3.2Chemical factor
3.3 Biological factor

3.1 Physical factor:-

- Temperature :- heat temperature & cold temperature
- Centrifugation
- X-rays
- Gamma rays
- Cosmic rays
- Ionizing & non-ionizing radiations
- UV-radiations

3.2 Chemical factor:-

- Alkylating agents:- nitrogen & sulphur mustard
- Acridines
- Proflavins
- Nitrous acid
- Colchicines[6]
- Colchicines (Poisonous alkaloids):-

Extracted from bulbs (0.1-0.5%) & seeds (0.2-0.8%)
of Autumn crocus or Meadow saffron (Colchicum autumnale)
↓
Binds to spindle protein during cell division
↓
Inhibit the segregation of chromatids
↓
Increase the number of chromatids or chromosomes
↓
Polyploidy occurs (fig. 5)

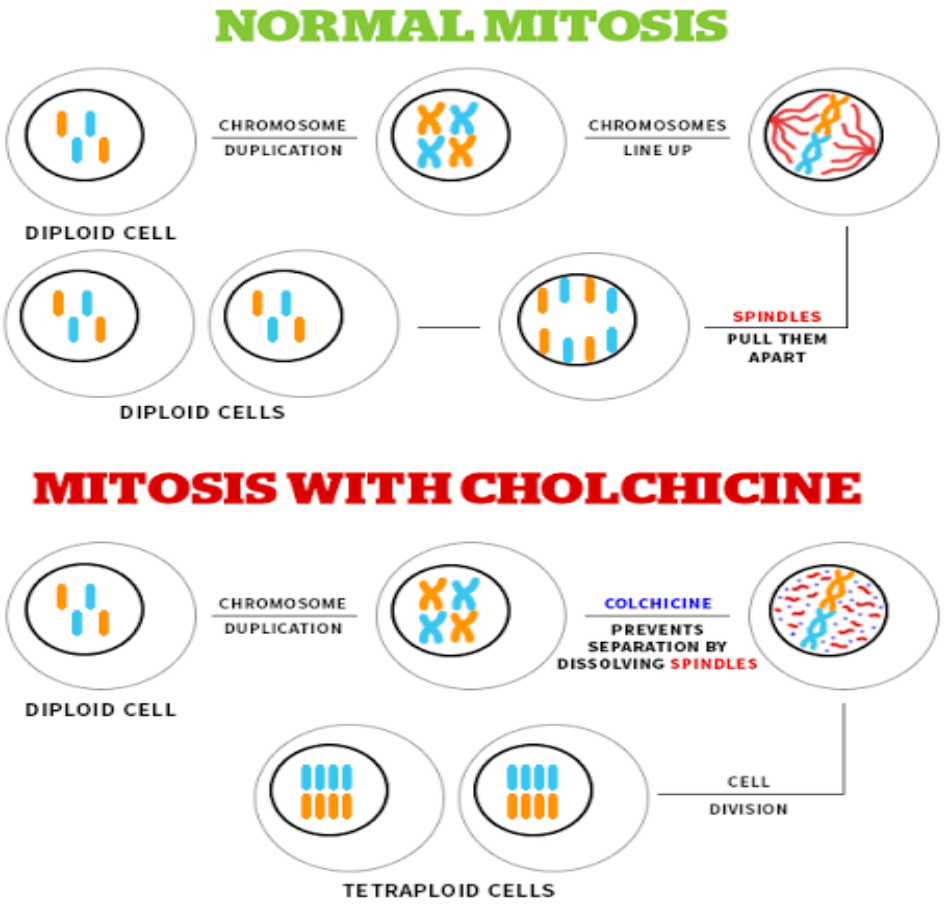

Fig. 3.2 Normal Mitosis v/s Mitosis with Cholchicine

3.3Biological factor:-

- Mode of reproduction
- Mode of fertilization
- Breeding system present (Hybridization)
- Growth habit of the plant
- Size of chromosomes[7]

IV. Types Of Polyploidy:-

They are two types as follows:-

4.1 Euploidy
4.1.1 Autopolyploidy
4.1.2 Allopolyploidy
4.2 Aneuploidy

4.1 Euploidy: -

Itis the types of polyploidy with multiple numbers of sets of chromosomes which is complete in numbers to a specific species depending upon the combination of the genomes. It is further classified in to 2 types:-

4.1.1Autopolyploidy:-

- 'Auto' means self or same species.
- 'Polyploidy' means the multiplication the number of chromosomes.
- So the multiplication the number of chromosomes between in same species is called "autopolyploidy".

- In fig. 4.1 2n=6 is taken as diploid parent species in example of autopolyploidy.
- Then this species undergoes to self fertilization but due to error or chromosomal variations by non-disjunction gametes form 4n=12 tetraploid offspring.

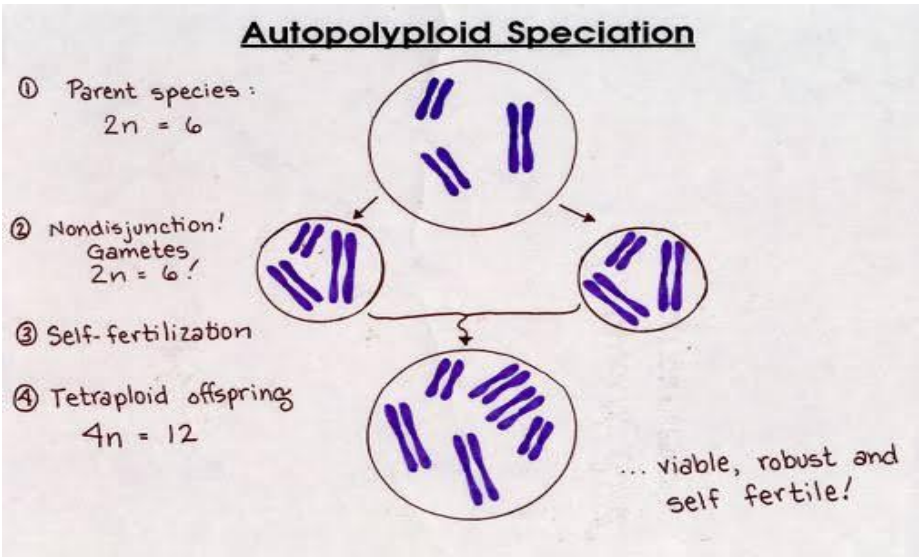

Fig. 4.1.1 Autopolyploidy

4.1.2Allopolyploidy:-

- 'Allo' means other or different species.
- 'Polyploidy' means the multiplication the number of chromosomes.
- So the multiplication the number of chromosomes between in different species is called "allopolyploidy".
- In fig. 4.2 2n=6 is taken as diploid parent species-A & 2n=4 is as diploid parent species-B in example of allopolyploidy.
- Then the species-A & species-B undergoes to hybridization but due to meiotic error or chromosomal variations by non-disjunction gametes (2n=4)of species-B (2n=4)and hybridised with normal gametes (n=3) of species-A (2n=6)which produced hybrid with 7 chromosomes. When this hybrid which contains unreduced gametes with 7 chromosomes, further undergoes to hybridization with normal gametes (n=3) of species-A (2n=6) which produced viable fertile hybrid (2n=10)[8][9][10].

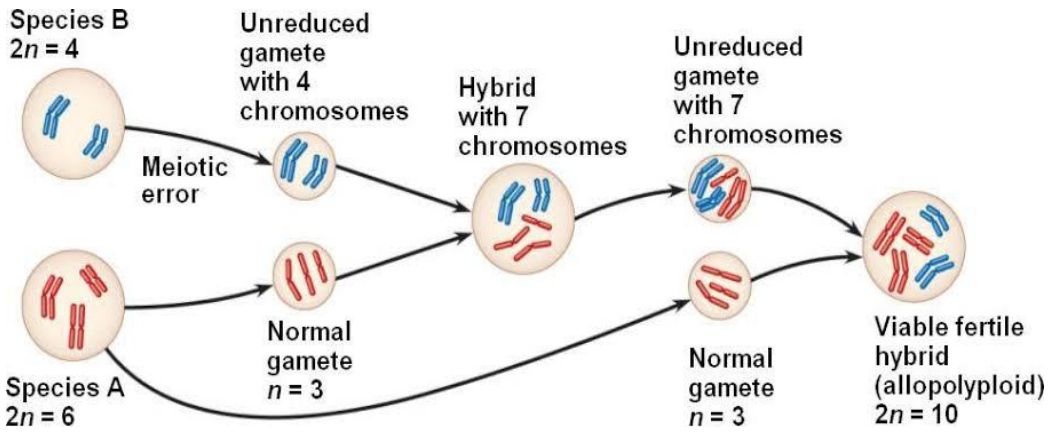

Fig. 4.1.2Allopolyploidy

4.2 Aneuploidy: -In this polyploidy, it contains one or more specific chromosomes either an addition or subtraction to the total number of chromosomes. Result is that it forms univalent and multivalent during meiosis of euploids.

They are further classified as:-
4.2.1 Monosomy= 2n-1
4.2.2 Nullisomy= 2n-2
4.2.3 Trisomy= 2n+1
4.2.4 Tetrasomy= 2n+2
4.2.5 Pentasomy= 2n+3

V. Examples Of Polyploidy:-

- Diploid= Rice (2n= 24)
- Triploid= Banana (3n= 33)
- Tetraploid= Potato (4n= 48)
- Hexaploid= Wheat (6n= 42)
- Octaploid= Sugarcane (8n= 80)[11]

VI. Mechanisms Of Polyploidy Formation:-

6.1 In fig. 6 the mechanisms of polyploidy can be understand in which diploid genome species-AA & species-BB are taken as an example.

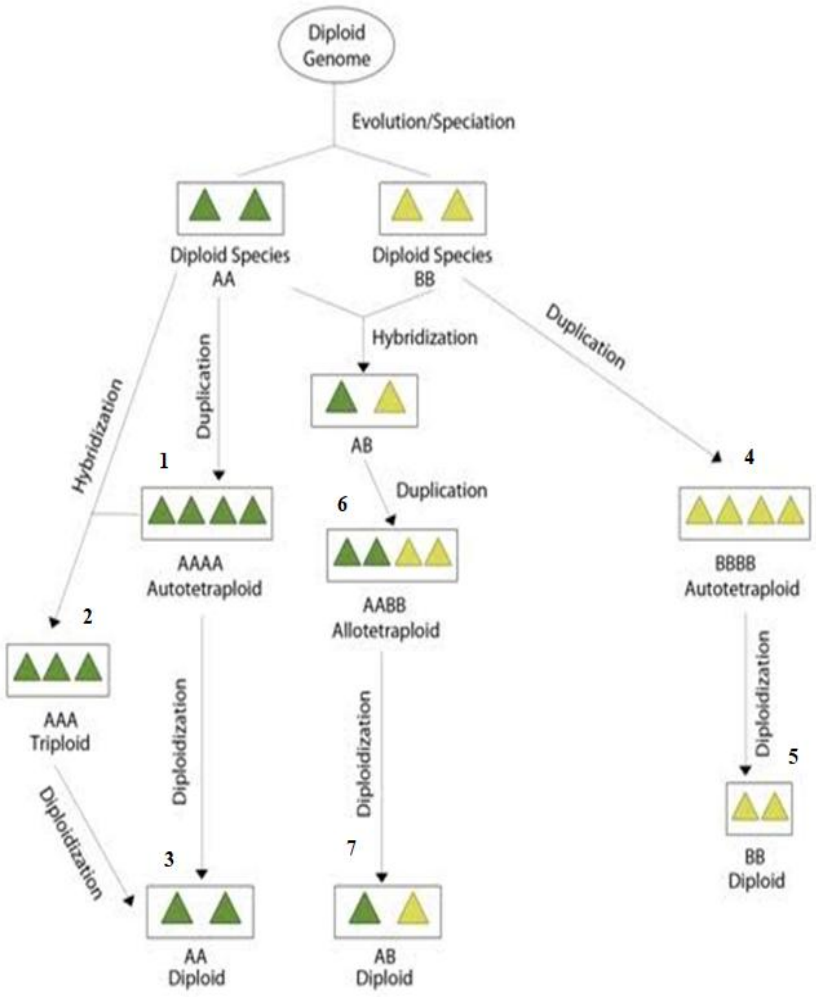

Fig. 6Mechanisms of polyploidy formation

6.2 **In case-1** diploid species-AA self fertilized and duplicated but due to non-disjunction form tetraploid species-AAAA (autopolyploid).

6.3 **In case-2** diploid species-AA & tetraploid species-AAAA undergoes to hybridization which produces triploid species-AAA.

6.4 **In case-3** tetraploid species- AAAA & triploid species-AAA undergoes to diplodization and forms their diploid species-AA.
6.5 Diplodization is the process by which polyploids converts into the diploids.
6.6 **In case-4** diploid species-BB self fertilized and duplicated but due to non-disjunction form tetraploid species-BBBB (autopolyploid).
6.7 **In case-5** tetraploid species-BBBB undergoes to diplodization and forms their diploid species-BB.
6.8 **In case-6** diploid species-AA & diploid species-BB undergoes to hybridization & duplication which gives tetraploid species-AABB (allopolyploid) from different species.
6.9 **In case-7** tetraploid species-AABB undergoes to diplodization and forms their diploid species-AB[12][13].

VII. Application Of Polyploidy:-

There are many applications of polyploidy which are as below:-
7.1 Mutation breeding
7.2 Seedless fruits production
7.3 Bridge crossing
7.4 Ornamental & forage breeding
7.5 Disease resistance through aneuploidy
7.6 Industrial application of polyploidy

7.1Mutation breeding: -Polyploidy can rise the mutation frequency due to alteration in the nucleotide sequence of the genome.

7.2Seedless fruits production: - Example: Seedless watermelon& orange fruits, tomatoes etc can be produced.

Fig. 7.2 Seedless fruits production by polyploidy

7.3Bridge crossing: -Transitional crosses can be going through. In which two different characters of plants species gets in to one single offspring plant by the help of bridge crossing.
Examples: a) Superior tall fescue grass **X**Italian ryegrass &
b) Tall fescue **X**meadow grass.

Fig. 7.3 Bridge crossing between polyploidy plants

7.4 Ornamental & forage breeding:- Polyploidy canincrease the cell size of plants which phenomenon is called 'Gigas'.The chromosomes doubling (polyploidy) can increase larger seeds & seed protein and alsoraise water not biomass of the plant or part of the plant. Example: ornamental crops such as marigolds, used to improve their quality, size &blossoms.

Fig. 7.4 Ornamental& forage breeding in polyploidy

7.5Disease resistance through aneuploidy:-Addition & deletion of chromosomes from the normal sets of chromosomes is called 'aneuploidy'. By which we can produce the disease resistance plants.

7.6 Industrial application of polyploidy:-By the help of polyploidy also can synthesise the sex hormones like-corticosteroids, production of terpenes & resistance to pests and pathogens[14].

VIII. Advantages Of Polyploidy:-

- Enlargement & increased vigour which is strength of the plant.
- Production of sterile triploids seedless fruits,generally by the help of vegetative propagation except seedling & fertilization.
- Restoring fertility in hybrids.
- Overcoming barriers in hybridization.
- Enhancing pest resistance, disease resistance &stress tolerance plants.

IX. Disadvantages Of Polyploidy:-

- Inbreeding in polyploids which reduces cross compatibility in plants.
- Effect of polyploidy on sterility.
- Effect of polyploidy on inheritance & population genetics[15][16].

X. Conclusion:-

Here, this review provides an up-to-date information about the polyploidy and we can better understand about the correlations of polyploidization with change in plants as well as environment like stress and many other fields. That has guide to a raise in recognition of their short-term adaptivity potential. Also we can know very well about how once polyploidy has been occurs, then the duplicated genes have unique retention character. Which can explain key longer-term evolutionary transitions can produce a general raise in new species and makes biological complexity? The great significance of polyploidy in the world of plant can be visualize by in the field of medicinal plants like resistance to different diseases and provide vigor hybrids in stress through the combinations of required characters into one species from different species, in the field of commercial crops such as sugarcane, wheat, oats, cotton, pear, apples, tobacco etc, in the industrial field such as production and synthesis of many hormones and enzymes and in the field of ornamental plants can be improved their size, quality and blossoms by the help of gigas. So the overall conclusion is that by the help of polyploidy in genetics or molecular technology in pharmacognosy we can easily tackle future challenges in the area of development in new diseases treatment, diversity in plants such as medicinal, crops and agricultural and diversity of environment as global warming and climate change.

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Manorama Ratre. "Polyploidy In Plants: Pharmacognosy". *IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS)*, 15(3), (2020): pp. 30-38.