

Lecture: - 16

POLYPLOIDY

The somatic chromosome number of any species, whether diploid or polyploid, is designated as $2n$, and the chromosome number of gametes is denoted as n . An individual carrying the gametic chromosome number, n , is known as haploid. A monoploid, on the other hand, has the basic chromosome number, x . In a diploid species, $n=x$; one x

16.1 Autopolyploid:

- If all the genome present in an individual are identical in nature i.e. known as autopolyploid. Autopolyploid is also known as single species polyploid or single polyploid.

16.2 Allopolyploid:

- When two or more than two different genome are present in an individual is known as allopolyploid. It is also called amphidiploid because it contains two copies of different genome.

16.3 Effect of polyploidy:

- Increase in vigor and size
- Polyploidy plants will having more fresh weight than normal plant because it contain more water.
- Growth rate is reduced as compared to normal plant.

16.4 Origin and production of doubled chromosome numbers:

- **Spontaneous:** chromosome doubling occurs occasionally in somatic tissues and unreduced gametes are produced in low frequencies.
- **Production of adventitious buds:** decapitation in some plants leads to callus development at the cut ends of the stem. Such a callus has some polyploid cells and some of the shoot buds regenerated from the callus may be polyploid. In solanaceae 6-36% of adventitious buds are tetraploids. The frequency of polyploid buds may be increased by the application of 1% IAA at the cut ends as it promotes callus development.

- **Treatment with physical agents:** Heat or cold treatment centrifugation , x-ray or gamma ray irradiation may produce polyploids. Exposing the plants or ears of maize to a temperature of 38-45 oC at the time of the first division of zygote produce 2-5 % tetraploid progeny.
- **Regeneration in vitro:** polyploidy is a common feature of the cells cultured in-vitro.
- **Colchicine treatment:** Colchicine treatment is the most effective and the most widely used treatment for chromosome doubling.

16.4 Morphological and cytological features of auto polyploid:

- Polyploids have larger cell size than diploids. Guard cells of stomata are larger the number of stomata per unit area is less in polyploids than diploids.
- Pollen grains of polyploids are generally larger than those of the corresponding diploids.
- Polyploids are generally slower in growth and later in flowering.
- Polyploids usually have larger and thicker leaves, and larger flowers and fruits which are usually less in number than in diploids.
- Polyploids generally show reduced fertillity due to irregularities during meiosis and due to genotypic imbalance lead into physiological disturbances.'
- In many cases autopolyploidy leads to increased vigour and vegetative growth.
- Different species have different levels of optimum ploidy. For sugarbeet the optimum level is 3x, sweetpotato 6x while for timothy grass it is between 8-10x.
- Autopolyploid generally have a lower dry matter content than diploids.

16.5 Application of Auto polyploidy in Crop improvement:

Triploids:

- Triploids are produced by hybridization between tetraploid and diploid strains.
- They are generally highly sterile, except in a few cases.
- This feature is useful in the production of seedless watermelons. In certain species, they may be more vigorous than the normal diploids, e.g., in sugar beets.
- Ex: **Seedless watermelons** are produced by crossing tetraploid (4x, used as female) and diploid (2x, used as male) lines, since the reciprocal cross (2x x 4x) is not successful. The

triploid plants do not produce true seeds; almost all the seeds are small, white rudimentary structures like cucumber (*cucumis stivus*) seeds. But few normal size seeds may occur which are generally empty. For good seed setting pollination is essential. For this purpose diploid lines are planted in the ratio 1 diploid : 5 triploid plants.

- **Triploid sugar beets:** Among root crops triploid sugar beets apparently represent the optimum level of polyploidy because $3n$ plants have longer roots than diploid and also yield more sugar per unit area.
- **Tetraploid rye:** the advantage of tetraploid over its diploid counterpart are large kernel size, superior ability to emerge under adverse condition and higher protein content. Tetraploid rye varieties have been released for cultivation. E.g. Double steel, Tetra petkus.

16.6 Limitations of autopolyploidy:

- Larger size autopolyploids generally contain more water and produce less dry matter content than diploids
- High sterility with poor seed setting is observed
- Due to complex segregation, progress through selection is slow
- Monoploids and triploids cannot be maintained except through clonal propagation
- The varieties cannot be produced at will
- Effects of autopolyploidy cannot be predicted.

16.7 Segregation in Auto tetraploids :-

- Segregation in autotetraploids is much more complex than in diploids. Depending upon the number of dominant alleles present, they are referred as simplex ($Aaaa$), duplex ($AAaa$), triplex ($AAAa$), Quadruplex ($AAAA$) and nulliplex ($aaaa$).
- On selfing a simplex will produce two types of gametes Aa and aa in 1:1 ratio due to random chromosome segregation.
- Self pollination of such a simplex would produce. There genotypes $AAaa$, $Aaaa$ and $aaaa$ in the ratio 1:2:1 giving the phenotypic ratio of 3 : 1. while produces 3 types of gametes viz., AA , Aa and aa in the ratio of 1:12:15 due to random chromatid segregation selfing of a simplex in such a case is expected produce the following progeny.

Quadraplex	AAAA	1
Triplex	AAAa	24
Duplex	AAaa	174
Simplex	Aaaa	360
Nulliplex	aaaa	225

Total 784

Allopolyploidy :

Morphological and extological features of allopolyploids:

- Allopolyploids combine the morphological and physiological characteristics of the parent species but it is very difficult to predict the precise combination of characters that would appear in the new species.
- Many allopolyploids are apomictic, Ex : Tulips, Solanum
- The chromosome pairing in the new species depends upon the similarities between the chromosomes of the parental species. Chromosomes with such similarities are known as homologous chromosomes. After chromosome doubling, the allopolyploid would have two homologous chromosomes for each chromosome present in the F1 hybrid, comparable to the diploid species. Such allopolyploid is referred as amphidiploid or Allotetraploid. Fertility of Allopolyploids can be improved by hybridization and selection.

Application of allopolyploidy in crop improvement:-

- Utilization as a Bridging species : Amphidiploids serve as a bridge in transfer of characters from one species to a related species, generally from a wild species to cultivated species.
- Creation of New crop species. Ex : Triticales, Raphanobrassica, Triticum turgidum x secale cereale.
- Widening the genetic base of existing Allopolyploids

Limitations of Allopolyploidy:-

- The effects of allopolyploidy cannot be predicted. The allopolyploids have some features from both the parental species, but these features may be the undesirable ones, e.g., Raphanobrassica, or the desirable ones, e.g., Triticale.
- Newly synthesized allopolyploids have many defects, e.g., low fertility, cytogenetic and genetic instability, other undesirable features etc.
- The synthetic allopolyploids have to be improved through extensive breeding at the polyploidy level. This involves considerable time, labour and other resources.
- Only a small proportion of allopolyploids are promising; a vast majority of them are valueless for agricultural purposes.