Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-23: Features and Limitations of Autopolyploids

Welcome back, so we will continue again. So now we will be discussing about the morphological, and cytological features of autopolyploids, means how morphologically they are distinct, or what are the cytological features might be available over there. So, these are the few facts, first of all the autopolyploids have larger cell size, and more number of stomata per unit area, that is very important point, the cell size are larger, I have mentioned earlier also, and more number of stomata per unit area, unit leaf area is available. Then pollen grains are comparatively larger than those of corresponding diploids, the size of the pollen grains are larger over here in the polyploids. Then slow growth rate, and delayed flowering that is observed sometimes. Then large and thick leaves in polyploid species, some polyploid orchids are also available, there also the thick leaves are available, and the large size flowers, and fruits are available but those are less in number.

Then generally increase in vigor and vegetative growth, mostly the polyploid species show initial vigor, too much vigor initial growth is fine, vegetative growth is fine, but the reproductive ability is supposed to be poor over there. Another important thing the increase in vigor, and growth may not be represented in increased dry matter, the vigor is more suppose the initial growth is high, but a lot of water molecules are available inside of their cells. The dry matter content might not be increased, or after some initial vigorous growth it might show some stunted growth, or improper growth in the reproductive stage or in the later stage. The next one it show reduced fertility, as compared to diploid that is obvious because, once the gametes are formed in this

polyploid species then the chromosomal segregation will be hampered, ok, maybe in one pole, only from a triploid species maybe in one pole two chromosomes are going, in another pole one chromosome is going, maybe in one pole three chromosomes are going, in another pole none of the chromosome is going.

So, in this way different permutations combinations may be aroused, then a lot of fertility related issues are observed compared to diploid species. Now let us discuss, about the cytological features which vary with the level of polyploidy. So, in monoploids the chromosome number, the chromosome does not pair, and their distribution at anaphase I is random leading to almost complete male sterility, very important point. In monoploid the chromosome does not pair, in monoploid what is available? Basic set of chromosomes are available as single copy. Ok! So, no pair means, pairing option is there suppose chromosome 1, 2, 3, 4 up to chromosome 7, all the chromosomes is available in single copy.

So, pairing is not at all possible right, and during anaphase I if you think about the meiosis I, anaphase I, its part in meiosis I. So, during anaphase I once the homologous chromosomes are separated, here no homologous chromosome is available. So, maybe at one pole one chromosome is going, at another pole nothing is going. While, in this pole suppose the chromosome number 7 is going, and over here no chromosome number 7 is going. So, in this way almost complete male sterility is observed.

This will be in one pole, this will be in another pole. In this way complete male sterility could be observed. Now let us think about the triploids, how could be the cytological features? In triploid means, 3 sets of chromosomes are there right. So, in 3 sets of chromosomes are there suppose, let me draw these 3 chromosomes are there.

So, in metaphase I, in metaphase I homologous chromosome pair in the metaphase plane. So, here as 3 chromosomes are there, some typical scenarios might be there, and in the gamete either all these 3 will go, or 2 will go, or 1 will go, or none of them will go, 4 different scenarios might be there because, the pairing process will be disturbed. And

in this way the trivalent, bivalent, univalent these things might be formed, and if trivalent is there, therefrom we can gradually develop trisomic, double trisomic those things. In case of tetraploid, in tetraploid, relatively it is easier. In tetraploid, 4 chromosomes are there for each set it can form univalent, bivalent, trivalent and quadrivalent.

So, if it is univalent or bivalent it can sustain easily by pairing with such type of gametes, having univalent or bivalent chromosomes. Now, autotetraploid are more successful as crops than other forms of poly, autopolyploid, autotetraploid because, here univalent and bivalents, if they are formed, they can sustain easily, or once they fuse with other univalent or bivalents, we may not see any problem in their next generation. In case of potato, groundnut there we found that autotetraploids are better compared to other autopolyploid like autopentaploid, autotetraploid those things. Now coming to the applications of autopolyploidy in crop improvement. So, let us discuss about monoploids and haploids only.

First they are used for developing homozygous diploid lines, following chromosome doubling in 2 years. Very important point, they are used for developing homozygous diploid lines, following chromosome doubling in 2 years. In monoploid what happens, in monoploid single set of chromosomes is available. Suppose these 3 chromosomes are available in a monoploid species. So, if we apply colchicine treatment, or somehow if we double the chromosome number, whatever the genes available over here capital A small b small c small d capital E capital F all the genes could be converted into its homozygous form.

If all the chromosomes are just doubled, no new allele could come from any other parent, right? So, by chromosome doubling we can develop an individual like this, where capital A capital A small b small b small c small c means, it will be fully homozygous. Homozygous plant could be developed easily, right? It greatly reduces the time required for isolation of inbred and pureline. I know, you know now inbred lines, you know about pureline in self-pollinated crops.

So, in this way we can develop inbreds or purelines where, where our target is to get the homozygous individuals, the homozygosity should be maximized there. Then they may be useful in isolation of mutants, some mutants could be isolated from this monoploid and haploid. Then selection based on haploids, or haploid derived diploids may be expected to be more efficient than, based on diploids. So, if we develop the diploid from such type of haploids by chromosome doubling or those things, our selection process might be easier compared to normal diploid. Because the normal diploid in spite of capital A capital A it might be capital A small a, our screening might be difficult whether it is completely homozygous or it is heterozygous in nature.

So, if we develop from this way, by chromosome doubling by polyploidization then the selection will be more effective. Then in autotetraploid species like potato the breeding is relatively much easier at haploid level than, at tetraploid level. Means we can attempt the breeding at haploid level thereafter, we can play different genes, once the adequate sets of chromosomes or adequate sets of targeted genes will be coming, specifically their alleles will be coming, then we can do the chromosome doubling part. Ok! So, managing those things at tetraploid level is more difficult rather than working at the haploid level. Then let us discuss, about triploids.

Triploids are produced by crossing tetraploid and diploid strains. Maybe, you can recall if we have tetraploid individual in its gamete, 2 chromosomes will be available while, from a diploid individual within its gamete 1 chromosome will be available. Now if they fuse, we can easily develop the triploidy. So, by crossing tetraploid and diploid strains, now they are highly sterile except a few cases. So, mostly they are sterile in nature because once they will form the gamete, the bridge formation might be taken place, then at one end 2 chromosomes may go at one end 1 chromosome may go.

Some chromosome may be lagged behind, different scenarios might be generated. This feature is useful in production of seedless watermelon means, as here the reproduction process will be disturbed means, their gamete production, gamete formation will be hampered. So, for certain crops where seedless is the target, we can attempt it in seedless

watermelon, in seedless banana triploids are very much beneficial. Then triploids are more vigorous than normal diploids, in some crops like sugar beets. Now coming to tetraploids, first of all it is useful in breeding and it improve quality, sometimes it can overcome self-incompatibility making distant crosses and use directly as varieties.

So, tetraploids are relatively stable since the beginning of our different ploidy related discussion we are telling that triploid is not too much viable, in reproductive perspective then in pentaploid also it is difficult, but tetraploid are found to be highly beneficial in potato and some other crops it was found to be highly beneficial. So, in some times the through tetraploid we can reduce the self-incompatibility also. Then in banana autotetraploids are inferior to triploids, in that they have weaker leaves and increased fertility. Autotetraploids are inferior to triploids that they have weaker leaves and increase fertility, but are useful in breeding of disease resistance banana, by crossing tetraploid banana with diploid disease resistant plant. Means although tetraploid bananas are relatively weaker leaves, they are having relatively weaker leaves they are sometimes used in banana crossing by crossing the tetraploid with the diploid one. Ok!

The diploid one is used as disease resistant parent and it is crossed with the autotetraploid. So, that easily we can develop the triploid individuals. Ok! Now tetraploid maize has 43% more carotenoid pigment, and vitamin A than the diploid counterpart. The carotenoid content vitamin A content is more than autotetraploids are larger in size, and more vigorous than diploids. Autotetraploids are larger in size and more vigorous than diploids, in some crops like forage crops and ryegrass. Ok!

Now let us discuss about the limitations of autopolyploidy. First of all, the larger size of autopolyploids is generally accompanied with a higher water content. So, the crops do not always produce more dry matter. So, it is a very important point, because the cell size is increased. Ok! The leaf size is increased, leaves become thickened in the autopolyploid species, but it has been found that although the size is larger it is mostly accompanied with higher water content, more water content is available in different tissues.

So, ultimately the dry matter production is not at all increased, that is one of the limitations, then they can show high sterility and poor seed set that is very important point. Mostly, in case of triploid this problem is observed, they can show high sterility and poor seed set. The triploids cannot be maintained, except thorough, except through clonal propagation. So, as in the triploid species the seed set is not done, and let us take the example of watermelon, seedless watermelon or in case of banana, those are mostly triploid in nature and we can see the poor seed formation, because during meiosis the gamete formation will be disturbed. So, here only one option is there, we have to maintain the triploid species through clonal propagation.

Ok, means in case of banana clonal propagation is done, the baby of the banana plant known as sucker means, we have to cut it we have to plant it to a different place. Ok! Now, it takes long time to raise the fertility in autotetraploid crops. In autotetraploid crops, it takes a long time to raise the fertility means, once we play with this type of crop for a couple of generation, then gradually its chromosome settles, and it start pairing in autotetraploid basically, each basic set of chromosomes will be available in 4 copies. So, 2 copies will go to an end, and 2 copies will go to another end. For such type of acclimatization, few times is needed few generations are needed. Ok!

Even effects of autopolyploidy cannot be predicted means, we cannot tell whether its leaf size will be larger, its root will be larger, ok, or its flower will be bigger in size, that things cannot be predicted. Now, new polyploids can rarely be used directly in crop production. Suppose, we have attempted some polyploid formation by colchicine treatment, or by other chemicals in very less percentage those polyploid crops which we could generate, could be directly utilized in crop production. So, that might be used for some molecular analysis from genetic analysis, that.. which chromosome might be responsible for disease resistance or yield maintenance; those things, that thing could be understood by different breeding strategies, but directly we cannot use it in crop production. So, these are the references of this particular class. Thank you.