Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-22: Autopolyploidy

Welcome back. So, we will continue again. Now coming to Euploidy. Ok! Euploidy means having complete sets of chromosomes either as single means, single set that is monoploidy or multiple sets that is polyploidy. The standard condition we can designate as diploidy. Then euploidy possesses a chromosome number, that is precisely a multiple of that species basic chromosome number it is a very important point.

So, in euploidy the basic chromosome number it is fixed, and its multiplication is available this is about the euploidy. However, in aneuploids have an abnormal chromosome number, that is not an exact multiple of the basic chromosome number for the species. What you have learnt in the previous slide? in case of trisomy, in case of monosomy ok! those are aneuploids there the chromosome number was not in the exact multiple of the basic chromosome number of that species. Now in eukaryotes, although it has been discussed once again earlier the monoploid scenario is there one basic chromosome set is available.

In diploid, two chromosome sets are available, in polyploid more than two chromosomes of each set is available triploid, tetraploid, pentaploid we are discussing the different types of ploidy level over here. Now some other facts regarding polyploidy an organism or individual having more than two basic sets of chromosomes is called polyploid means, basic sets of chromosomes are designated as x right. If more than two basic sets are there that is known as polyploid. So, if $2n = 2x$ what we have observed in case of rice ok, that is diploid in nature, but if more than two basic sets are there suppose

we are having 3x we are having 4x or, we are having an individual having $2x_1$ and $2x_2$ means basic sets of chromosome is coming from two different species there also it will be polyploid. So, about one third of flowering plants exhibit polyploidy, about one third means close to 33% they exhibit polyploidy, and in certain wild grass species the polyploidy has been observed up to 70% of their population.

However, in animals the polyploidy is rare, due to its lethal effects which hinder the survival, and reproduction because, later on we will be discussing if polyploidy is there then, gamete formation might be hampered different sets of chromosomes might be available in gametes, that will not be uniform. So, their survival might be difficult. The first polyploidy was reported in *Oenothera*, *Oenothera lamarckiana* the gigas mutant it was found to be an autotetraploid, and thereafter different scientist different cytogeneticist they gradually worked on other different species, and they found a large number of polyploid species in the plant kingdom. Now these are the few characteristics of polyploids. First of all, vigor and size many polyploids display increased vigor, larger size and enhanced growth compared to their diploid counterparts.

Many polyploid display increased vigor, vigor means the initial growth become very high. Ok! Then enhanced growth in case of polyploid banana, in case of triploid banana, you can see the enhanced growth of the fruit, even the leaf size of the plants could be larger compared to the diploid one. The next one is increased genetic diversity that is the very important point polyploids can exhibit increased genetic diversity due to the presence of multiple chromosome sets, providing potential advantages for adaptation and evolution. Ok! So, let us assume we have a diploid species having chromosome number $2n = 2$ and we have a polyploid species having chromosome number $2n = 4$. Now here one set of homologous chromosomes is there over here.

So, suppose in both of the chromosome at a particular loci capital A allele is available. While in this polyploid species initially capital A allele was available in all the genomes. Now you know that mutation is inevitable, and it can occur anytime within the genome. And due to mutation A_1 allele has been formed over here, and A_2 allele has been formed

over here. So, in this particular polyploid individuals not only capital A allele is there along with capital A allele, A_1 allele, A_2 allele this two are also available.

Now what is allele, I think that is known to us suppose over here some gene sequence, some codon sequences were available within the genome while, in A_1 allele within that codon suppose some stop codon has been generated. In A_2 allele may be at the beginning another stop codon has been generated. So, these two alleles cannot produce a particular protein, let us assume, this one was the normal one A allele. Now here, it is told that the genetic diversity definitely, the diversity will be more because, three different types of alleles will be there, and it is providing the potential advantage for adaptation and evolution. Now suppose in this particular crop, a specific fungus can cause infection, and for any plant microbe interaction, any fungal infestation any bacterial infestation or viral infestation a gene to gene hypothesis is involved there.

So, for proper infection definitely, whatever the elicitors is being produced by the plants, or whatever the effector proteins produced by the fungus, or whatever that should be recognized by the plant system, otherwise the infection could not be generated, infections could not be multiplied amplified. Ok! So, suppose A gene means, suppose A allele is governing a particular protein, that can recognize that fungal protein, and once this recognition is taken place, thereafter the fungus can cause invasion. Ok! It can cause the infection on the leaf, but if you think about this particular polyploid one here, along with capital A, other different alleles are there. So, from this allele the desired protein is not being formed. So, that protein cannot interact with the particular effector molecules being produced by the fungus, and the interaction will not be effective, and the disease resistance symptom could be observed over there.

So, in this way if more, if large number of alleles might be there, at least for certain genes, the adaptations and evolution process will be improved. Then infertility or reduced fertility, that is another important point later on we will be discussing, because some polyploids face challenges in reproduction due to problem in meiosis, resulting in reduced fertility or sterility. Suppose, we are talking about triploid, in diploid what

happens in diploid, once the gametes are formed, each chromosome will go to a different pole, right? Means, each of the sperm or egg cell will be having one set of chromosomes. Now, if triploid chromosome is available over here, then its pairing will be, will not be proper because, in meiosis I homologous chromosome pairing is taken place. Ok! So, if pairing is not proper then, at one end maybe 2 chromosomes can go while, at another end 1 chromosome can go.

In addition to that we may see some dicentric condition, dicentric bridge formation, those things so ultimately, the separation of chromosome, the separation of homologous chromosome might be hampered. And in this way, maybe in some of the gametes, one chromosome might be missing, if one chromosome is missing then all the sets of gene available in that chromosome will not be available. So, ultimately, we may see some viability problem, the pollen grains may not sustain properly after fertilization, the embryo could be aborted, those things might be generated. Ok! Now talking about the adaptability, we have discussed these things over here, because the polyploid species may demonstrate enhanced adaptability to changing environmental condition, aiding their survival in diverse habitats. And polyploids have larger cell size than diploids because the large number of chromosomes should be available on the cell right.

So, somehow the cell size has to be increased. Now how autopolyploid and allopolyploids are developed. Ok! In case of autopolyploid, it has an extra set of chromosomes, from the same species means the extra set of chromosomes is coming from the same species. Ok! For example, a triploid plant resulting from the duplication of its own chromosome set. While in case of allopolyploid, it arise from the hybridization of two different species, resulting in a hybrid with combined chromosome set.

I have discussed about the development of wheat that's a allopolyploid. There two different species, their genome, their chromosome has come together and finally, a hybrid has been formed. For instance, when two related, but distinct plants bred and their chromosomes double, creating a new species with combined genetic material, whatever

we have discussed during the discussion of allopolyploid, or the common bred wheat development. Ok! So, in this way in allopolyploid from two different species means, from different basic sets of chromosomes will be coming. While in case of autopolyploid single basic set of chromosomes will be available in more than two copies. Ok!

Now these are the other facts about autopolyploidy. First, autopolyploidy involves an organism having multiple sets of chromosomes from its own species. Having multiple sets of chromosomes from its own species means, the same basic set of chromosomes will be there, may be in triplicate, in 4 times, whatever. It arises due to errors during cell division, leading to increased genetic material. During cell division, ok, somehow at one end one set, means one chromosome was supposed to go in a particular pole, suppose, two chromosomes have reached.

In this way in a gamete, if two chromosomes are there of a particular set then, in next generation we may see such type of autopolyploid. Then this process can enhance genetic diversity, and is significant in plant evolution often resulting in new traits or adaptation. So, these are some examples of autopolyploid in plants. So, different plant species show the polyploidy nowadays like autotriploid. Triploid means three sets of chromosomes are there from same genome 3x.

It is available in banana, sugarcane, apple, watermelon. Then autotetraploid means 4 copies of the same genome 4x chromosome is there. It is available in rye, grapes, alfalfa, potato, coffee and groundnut. You guys can recall some typical examples like autotriploid banana, autotetraploid potato. Ok! Then autopentaploid means 5 sets of chromosomes are there.

In wheat and potato some autopentaploids are available. Then autohexaploid, major example is wheat, in addition to that some of the oat species and cotton also we can see autohexaploidy. Then autooctaploid in strawberry, we can see autooctaploidy. Ok! These number of chromosomes from a particular set will be available, 8 sets are there. So, now let us discuss about the origin and production of the autopolyploidy, how they

are originated?

So, their origination is spontaneous. The chromosome doubling occurs occasionally, in somatic tissues and unreduced gametes are also produced in low frequency. So, what is means, what has been told over there, that chromosome doubling occurs occasionally in somatic tissue. In somatic tissues suppose we are talking about 2n = 2. Ok! In a somatic cell this is the scenario 2n = 2 is available.

Now somehow the chromosome doubling has been taken place. Suppose the chromosome replication has been taken place, but cell division has not been done. So, here it might be having 4 chromosomes, if the chromosome doubling taken place properly, but cell division is not there. So, if gamete is formed from here, if gamete is formed from this somatic cell, ok, in gamete, chromosome number will be half. So, here 2 chromosomes will be available in each of the gamete.

Along with that some other variations might be there, 1 chromosome might be there, 3 chromosomes might be there. So, let us think that only 2 chromosomes are forming from these particular individuals, where the chromosome number has been doubled, due to some reason. Now, if this gamete fuse with a normal gamete having single chromosome, ultimately, we can get an individual where the chromosome number will be 3 means autotriploid could be generated. Ok! In this way in nature spontaneously autotriploid, or other different polyploids could be generated. Ok! Now, let us talk about the production of adventitious buds.

In some solanaceous species, the decapitation means if we capitate the plant top part, it leads to callus formation, at the cut end of the stem. And within those calluses some of the cells were found to be polyploid in nature, and buds generated from those callus may be polyploid. So, in nature from the adventitious buds, such type of polyploid species could be generated. Then application of 1% IAA indole acetic acid, indole 3 acetic acid can increase the frequency of callus formation, and polyploid buds in tomato. Let us discuss, about some physical agents which can cause polyploidy.

Heat or cold treatments, x-ray or gamma ray irradiation, can produce polyploids at low frequency. And heat treatment has been successfully used in some of the crops like barley, wheat, rye to develop polyploids. Now coming to in- vitro regeneration, we will be discussing about the plant tissue culture later on, but during those in- vitro process where, the plants are grown in controlled environmental condition under aseptic condition, by providing some specific media. Then we can grow callus and suspension culture from different explants, and some of those callus or cells produced during the suspension culture might be polyploid. And it has been found in *Nicotiana*, Datura, rice and different crops species. Ok!

In this way the polyploids are also generated, during the tissue culture practice. Now coming to another important thing, that is mostly used by different plant breeders, different scientist that is colchicine treatment. It is the most effective and most widely used treatment for chromosome doubling. It has been used with great success in large number of crops species, belonging to both dicot and monocot groups. It is poisonous chemical, it is a poisonous chemical isolated from the seeds or bulbs from autumn crocus that is *Colchicum autumnale*.

So, how does it work? It basically blocks spindle fiber formation, and thus inhibit the movement of sister chromatids to opposite pole. Ok! You know that spindle fibers are necessary for cell division, and somehow this colchicine block the spindle fiber formation and the sister chromatids cannot move to the opposite pole. So, they stay together, and in this way the chromosome doubling is taken place. It affects only dividing cells. So, it should be applied when the tissue is actively dividing. Ok!

So, in actively dividing tissue if we apply colchicine, some of the scientist may apply colchicine by using cotton plug, some of them can apply colchicine in the media in tissue culture in this way. They can treat their different explants to generate the polyploid plants. Other chemicals not commonly used mostly colchicine is used those are ethyl mercury chloride, sulphanilamide, acenaphthene, etc. So, those could be used for

chromosome doubling also, could be used to generate the autotriploids. So, these are some facts, like the presence of multiple sets of homologous chromosome allow the formation of bivalents during meiosis.

The presence of multiple sets of homologous chromosome, if multiple sets are there then the bivalent formation is taken place. Bivalent means at a particular direction 2 chromosomes may go together. Ok! So, if 2 chromosomes of a particular set go together in a particular pole, in this way ultimately, we can go to the polyploid species generation. Then during cell division these chromosomes pair randomly, leading to what is known as polysomic inheritance. So, another term is coming that is polysomic inheritance.

So, how polysomic inheritance is taken place? So, suppose in a particular individual, ok, generally 2 sets of chromosomes are supposed to come. So, other than 2 sets one additional set has come. So, the genic balance might be disturbed. Mostly this polysomic inheritance is observed due to improper separation of the homologous chromosome, but sometimes due to translocation and those things also polysomic inheritance could be observed means, certain chromosomal part is available more than 2 copies within an individual. Ok! So, this random pairing causes alleles a specific gene locus to segregate randomly a phenomenon observed in natural population.

If you think about the *Oenothera lamarckiana* or those crops there random pairing are available, or random pairing are observed between different chromosomes. Ok! So, suppose this are 2 homologous chromosomes, ok, they should pair in this way. But if 3 chromosomes are there, suppose A gene is here, A gene is here initially the scenario was this. Now in this way type of pairing might be there AA BB, and here B, here A. If 4 chromosomes might be there, in this way another pairing could be there.

So, in this way the polysomic inheritance is basically initiated due to improper pairing between the chromosomes. Now coming to the adaptability, they may demonstrate enhanced adaptability to changing environmental conditions, aiding their survival in diverse habitats which has been discussed before. Now polysomic inheritance serves as a

distinct trait, or characteristics for distinguishing autopolyploids. In autopolyploids these polysomic traits are mostly found.