Course Name: Basics of Crop Breeding and Plant Biotechnology

Professor Name: Dr. Joydeep Banerjee

Department Name: Agricultural and Food Engineering

Institute Name: Indian Institute of Technology Kharagpur

Week: 05

Lecture-21: Polyploidy – Introduction

Hello everybody. Welcome to SWAYAM NPTEL online course on Basics of Crop Breeding and Plant Biotechnology. Today we will be discussing what is polyploidy and reverse breeding and, this is the lecture one on that, and today mostly we will discuss about the polyploidy especially, autopolyploidy. So, these are the concepts which will be covered today. First of all, what is polyploidy and what are the importance of polyploidy in plant breeding, will be discussed over here. Then the types of changes in chromosome number, what are the different types of changes, what are their nomenclature will be discussed over here.

Then euploidy and aneuploidy will be discussed. Then polyploidy and characteristics of polyploid will be discussed. Then gradually we will move into the autopolyploid. Two different types of polyploids are mostly available autopolyploid and allopolyploid.

So then autopolyploid part will be discussed. Then the morphological and cytological features of autopolyploid will be discussed, and finally the limitations of autopolyploid will be discussed, in this particular class. So let us start the polyploidy in plant breeding. So, these are some features which we should know before discussing the polyploidy, and which are associated with plant breeding. So, most of the crop species have diploid chromosome number.

So the crop species, what mostly we consume most of them like rice, then mango, tomato, potato, not potato, rice, mango, tomato. So, most of them are diploid in chromosome number. So, what is diploid, what is haploid, what is monoploid? gradually we will come into that part once again. So, in diploid basically each chromosome is available in two copies. Two copies of each chromosome especially, two copies of each basic chromosome are available in diploid species.

Now the chromosome number remains constant generation after generation. That is the important point that is true for most of the crop species. So let us assume, we are discussing about rice. We know that in rice 7 pairs of chromosomes are available. Suppose one plant is there it has 7 pairs of chromosome means 2n = 14 is the chromosome number. Ok! Where n equals to 7 while one rice variety is being crossed with another rice variety, that is also having 2n = 14 chromosome number.

We are discussing about the chromosome number. So now if you think about the mitosis, what happens during mitosis? In mitosis whatever the chromosomes available in a cell during metaphase stage, they lie on the metaphase plate and then, each chromatid of each and every chromosome, two chromatids are there those chromatids are separated and, they move to a different pole. So, in this way during mitosis from one cell after division, two cells are produced and their chromosome number remains same. Ok! If the chromosome number initially was 2n = 14 here also it will be 2n = 14 during mitosis. While during meiosis, meiosis is taken place in reproductive tissue.

We have discussed mitosis and meiosis earlier. During meiosis once the gametes are formed then two stages are there, meiosis I and meiosis II. In meiosis I, what happens basically, the homologous chromosome they move to a different pole. While in meiosis II it is almost equivalent to mitosis. So, at the end of meiosis from one cell basically, four cells are produced. Ok!

If initially, condition was 2n = 14 here, will be having n = 7, n = 7 chromosome number will be half, n = 7 and n = 7. In this way after meiosis from a cell, four cells are produced. Now here it is written that, the chromosome number remains constant generation after generation. Suppose this is a particular rice variety here pollen grains have been formed and, the chromosome number in pollen grains are 7, n = 7, n = 7. While this is another rice variety here, from egg cells have been produced through meiosis, there also chromosome number will be n = 7.

So once the fusion or fertilization will be taken place between male and female gamete ultimately, a zygote will be formed there, chromosome number will be 2n = 14, sorry. In this way the chromosome number remains same generation after generation. Now irregularities in cell division leads to changes in chromosome number. We were discussing about cell division, we were discussing about mitosis and meiosis, cell division. If the chromosomal movement become irregular, ok, then, this number might be changed in the gamete, this number might be changed in the somatic cells also.

So irregularities in cell division leads to changes in chromosome number. These chromosomal aberrations contribute, to crop evolution and improvement. Means, in this way if chromosome number is doubled, if only a particular chromosome is tripled in a particular individual, in this way the genetic combination will be also changed, Ok! And finally, during the course of crop evolution different new crops could be generated or, it has been generated also. Later on, during this particular topic you can understand how the evolution has a big role and the polyploidy, through polyploidy different crop species have been evolved, ok, those things you can understand.

So now some other features first of all, non-homologous chromosome within a genome are distinct in morphology and, gene content typically not pairing with each other. This is another important thing what we are telling, that non-homologous chromosomes within a genome are distinct in morphology. In rice, I was mentioning that 7 pairs of chromosomes are there. Suppose this is chromosome number 1, this is chromosome number 2, in this way this is chromosome number 6 and suppose this is the chromosome number 7. 7 pairs of chromosomes are there in rice as we are discussing.

So what is being told over here, that non-homologous chromosome these 2 chromosomes, are homologous each chromosome is having a pair, ok, but chromosome number 1 and chromosome number 2 they are non-homologous chromosome and, it is told that the non-homologous chromosome within a genome are distinct in morphology. Here you can see, that different sizes are there, this one is the longest chromosome, this one is the medium chromosome and, this one is the smallest chromosome. In this way different sizes are there, so their morphology is found to be different and they are differing in gene content. So, suppose over here we had A, B and C genes are there. In its homolog A, B, C gene will be available while, in another chromosome that is chromosome number 2 may be D, E different genes are available.

So A and B genes cannot pair with D or E genes, so they are not pairing, that is told over here. Next one a diploid species has 2 complete sets of chromosomes. A diploid species rice, we are discussing as a diploid species ok, 2 complete sets of chromosomes are available. While a diploid species if we have to discuss about a diploid species suppose chromosome number 1, has been available 3 times means, 3 chromosomes, 1 is available then, chromosome 2 is available 3 times, that is the triploid species. In this way all the basic number of chromosomes, what it had here, what was the basic number of chromosomes 7, ok, each chromosome was available 2 times while, in case of triploid each chromosome is having 3 times.

In case of tetraploid, each chromosome is having 4 times in this way. So now we will be discussing about different types of chromosome number. First of all, somatic chromosome number, what is somatic cell? Somatic cell is our body cell like in case of human beings in our hand, in our heart tissue, in our legs, ok, the somatic chromosome number is available. Generally, it is mentioned as 2n it is diploid in nature. Then coming to haploid, haploid once the gametes are formed ok then the somatic chromosome number is half.

You have means, I think you guys can recall the meiosis process, suppose this is the diploid scenario 2 pairs of chromosomes were there, this is 2 pairs of chromosomes were there, ok, in diploid condition within the somatic cell within the body cell. So, once the reproduction is taken place once the gametes are formed during meiosis 1, 1 homologous chromosome will go to a particular end from this pair, 1 homologous chromosome will go to that end from this pair. While in another pole this and, this chromosome will move. So, in this way after meiosis 1 this will be the scenario. In meiosis II what happens? the chromatids will be separated again and, from this cell another two cells will be produced. Ok!

So, in this way once the chromosome number was 2n = 4 over here, the chromosome number is 2n = 4. So, through meiosis whatever will be having 4 cells will be produced from a cell and, their chromosome number will be n = 2. Ok! So, that is the haploid number, an individual with half of the somatic chromosome number. Whatever may be the chromosome available in the somatic cell, during gamete formation chromosome number will be half. Ok! Now coming to the gametic chromosome number.

So, in gamete this type of chromosome number will be available, that is also designated as n. Now coming to another important thing, that is basic chromosome number. Ok! So far, we are mostly discussing about rice, it has 7 pairs of chromosomes. Now let us start our discussion on another crop wheat. Ok! In wheat basically, if you later on, we will discuss the origin of wheat, but still for your understanding we need to discuss it once again.

In wheat basically, the common bread wheat that is *Triticum aestivum* it is known as hexaploid wheat. Ok! So, in this wheat it has been found that by different scientist, by different researchers, it has been means, it has been documented that the genome of 3 different crops have come together in bread wheat, common bread wheat. So, let us assume, this is the genome of a particular crop, ok, suppose this is the crop X while another crop will be having, that is crop Y. First, I am drawing it then, I will discuss it once again. So, during wheat development process what happens? Suppose one crop was crop X another one was crop Y.

In crop X the basic set of chromosomes was 7 and each chromosome was present in 2 copies. Ok! So, the basic set, basic chromosome number is designated by x. So, in this particular one the crop X the chromosome constitution was 2n = 2x = 14, ok, means 2n is the diploid condition. Here the basic set of chromosomes is available also 2 copies, ok, 2x its equivalent to 14. While in another crop, crop Y its gene content is different, you can see its green in color, ok, all the chromosomes are shown as green. Ok!

Here also basic chromosome number is designated by x in this one, also 2n = 2x = 14. The gene content over here, and the gene content over here are different. So, once these 2 crops have been crossed together then, initially what type of gametes will be produced from here? One set of chromosomes will be coming, let us assume, this red one has come from here, and other different chromosomes have come, and this one also have come from this parent. Ok! So, from this parent it will be available in a gamete while, from another parent this chromosome will come, and another chromosome will come this one, right? But as their gene content is differing, what we were mentioning before, ok, means because these are non-homologous chromosome, it is coming from the basic chromosome of a particular crop and the green one is coming from the basic chromosome of another crop.

So, they cannot pair, but once the gamete from this, and this will fuse, these things will come within a particular cell, within a zygote. So, due to the influence of nature due to the evolution finally, those chromosomes have been doubled in nature. So, finally, once it has been doubled then in this way a tetraploid wheat forms initially suppose this one was a diploid wheat thereafter a tetraploid wheat formed. In tetraploid wheat two sets of chromosomes are available. The chromosome coming from crop X as well as chromosome coming from crop Y in two copies.

Now suppose in nature another crop was there, later on we will mention about the name of those crops where from the modern-day wheat has been developed. Another crop was there, there also basic chromosome number that is x it was 7 and here also 2n = 2x = 14 was there. So, over there again new type of chromosome was available, then within the nature the cross has been made between this tetraploid wheat and this one. So, here from if gamete is produced, only single chromosome will be available, and here from single chromosome from each of the pair will be coming, and after formation of zygote from these and these gametes, gametes produced from this one and gamete produced from this one. So, ultimately, we will be having an individual where all sets of chromosomes will be available in single copies.

So through evolution all the chromosomes have been doubled and finally we can get the hexaploid wheat. So, in hexaploid wheat basically 2n = 6x = 42 means each chromosome is available in two copies, but there the chromosome has come from three different species the crop X, the crop Y and, this is the third one suppose this is crop Z. From three different species the chromosome has come together to make the hexaploid wheat. So, the basic chromosome number of wheat is 7, but if you think about the somatic chromosome number its 2n = 42. So, basically it is written in this way, in 2n then it is 6x because coming from three different species, and it is available in two copies from each species and finally 42 chromosomes are there.

So now, another term that is monoploid, monoploid means single set of chromosomes is available. Suppose from this one, from the crop X, ok, from the crop X, if single sets of chromosomes are available that is known as monoploid, ok, means, whatever the gamete will be produced from here that will be monoploid while, the gamete produced from hexaploid wheat, that will not be monoploid, because here within that gamete the red chromosome, green chromosome and blue chromosome all the chromosomes will be there. So, it will not be monoploid. In monoploid single basic set of chromosomes will be available, in one copy, ok, and another one is diploid, that is known to us that single chromosome is available in two copies. Now let us discuss, about the changes in chromosome number. Ok!

So basically broadly two types of changes are observed in chromosome number one, is euploidy another one is aneuploidy. So, in euploidy basically the whole set of chromosomes is available, either as single copy or as multiple copy. Ok! Generally, we consider the situation as diploid. Generally, two sets of chromosomes are available means, mostly the diploid things are normal. So, in euploidy other things, what we have to consider that is monoploid means, single set of chromosome single basic set of chromosomes will be available over there.

Then haploid, in haploid that is the gametic chromosome number, from a diploid or polyploid species. In case of rice where 2n = 14 their haploid number will be n = 7. In case of wheat, where 2n = 6x = 42 here, haploid number will be n = 21. Ok! In this way the haploid and monoploid are different. In monoploid, in wheat the monoploid number is also n = 7 in case of rice and n = 7 in case of wheat.

But over here, the haploid number is different. Now coming to the polyploid, in polyploid basically the number of basic sets of chromosomes are available in more than two copies, or two copies of basic sets are coming from a number of crops species. So based on that, two types of polyploid are there, one is autopolyploid and, another one is allopolyploid, ok, later on we will be discussing once again in detail. Now coming to aneuploidy, so in euploidy, whatever we have to recall here, total basic set will be available, either as single copy or in multiple. While in case of aneuploidy, we have to think about a particular chromosome, either a particular chromosome is more or, a particular chromosome is less in number. Ok! So, it can be classified into two-way hypoploidy and hyperploidy.

Hyper means higher; in hyperploidy a particular chromosome number is increased, while in case of hypoploidy a particular chromosome number is reduced. Suppose here, it is written monosomic, mono means one in monosomic basically, suppose let us, take the example of rice where, 2n = 14. Under monosomic condition it is written as, 2n -1 here chromosome number will be 13 in monosomic condition. How means 7 in 14, 7 pairs of chromosomes are there chromosome number 1, 2, 3, 4 up to 7 each chromosome available in two copies. Suppose we have got a particular rice where chromosome 1 is available as single copy only, while rest of the chromosomes are available in two copies.

All the chromosomes are available in two copies, but chromosome 1 is available as single copy, that is known as monosomic condition. Ok! So, this is a nullisomic 2n – 2.

Ok! Over here suppose a particular chromosome is not at all available within that particular individual chromosome number 1 is missing. So, rest of the chromosomes are available in two copies, rest of the chromosomes are available in two copies, but chromosome number 1 is completely missing that is known as the nullisomic condition. Ok!

So it is designated in this way. In this way we can have some rice variety, that might be double monosomic. Double monosomic is basically designated as 2n - 1- 1 means two different chromosomes. Suppose chromosome number 1, and chromosome number 5 is available single copy, that could be told as double monosomic. Ok! In this way different hypoploidy are available in plant species in crops species.

Now let us discuss, about the hyperploidy. Here the chromosome number will be more. Ok! Suppose, one of its important examples is trisomic. In trisomic suppose a rice variety we are having their chromosome number 1 is available in three copies. Chromosome number 1 is available in three copies while rest of the chromosomes are available in two copies that is known as trisomic.

It is hyperploidy right. A particular chromosome has been increased. So, in this way tetrasomic could be there, double trisomic could be there, different scenario could be aroused.