Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-03: Mendelian Genetics

Welcome back. So, we will continue again discussing another one important aspect which was initially explained by Gregor Johann Mendel. That is the Test Cross. So, in the last class we have discussed that, he collected pea seeds from different parts of the Europe, and he initially found that different contrasting traits were available in those pea seeds and, based on those phenotypic traits finally, he performed different experiments and finally, he postulated two laws the Law of Segregation and Law of Independent Assortment. Now, we are coming into the Test Cross, another important thing that was deciphered from his experiment. So, what is this Test Cross? Test Cross, it is the cross made between the individuals with the unknown genotype means, the genotype of the individual is unknown to us and, it is crossed with another individual which is homozygous recessive in nature. Ok! Means one genotypes genetic constitution is not known to us, while another one is recessive homozygous in nature. Ok!

If you recall the last class, we have discussed about flower color right, the purple flower color could be available in case of capital P capital P as well as, in case of capital P small p, both were purple in nature. Ok! While the small p small p individuals were white in color, the flower color was white. Now the purpose of Test Cross is to know the purity of this particular parent. Suppose we are having a plant that is making purple flower, purple flower. Ok!

So, we do not know whether it is homozygous dominant or whether it is heterozygote in nature because, capital P is dominant over small p in both the case we can see purple

flower. So, let us see if a cross is made between capital P and small p suppose, this is our unknown genotype. So, in this case we will be having F_1 of capital P small p, isn't it? The capital P chromosome will be coming from this parent and, small p will be coming from this parent because, in Test Cross one parent is fixed, that is the homozygous recessive individual that is known to us, this one is unknown. Ok! So, if F_1 is also purple, then we can tell that the parent was not heterozygote. So, if parent is heterozygote what could be the answer? Suppose parent is this capital P and small p that will also be purple flower if it is crossed with small p small p, then if we make the checker board suppose this plant is used as a male plant.

So, small p and small p these two types of gametes (same) will be produced, and from the female plant will be having capital P and small p types of gametes. So, after fusion you will get capital P small p, small p small p. So, what will be the ratio capital P small p: small p small p it will be 1: 1 it means, it will be purple flower and it will be white flower. So, if we get 1: 1 ratio in next generation of test cross then, we can tell it that it is a pure hybrid, but if it is not a pure hybrid, if it is just the homozygous dominant then we will not get any ratio it will be fully purple in nature that is the test cross for a single gene. So, now let us see how the test cross could be done for two genes. Ok!

Suppose we are having two genes capital A small a and capital B small b suppose, this is our expected F_1. Ok! We are trying to analyze this particular plant through Test Cross. Ok! So, it is having tall and yellow seed. Let us assume where A, capital A, is responsible for tall character, small a is responsible for dwarf character, the capital B is responsible for yellow seed and small b is responsible for green seed. Ok! So, this is our expected F_1 we are trying to know whether it is true F_1 or not.

So, we are planning this test cross. So, in spite of being F_1 it could be capital A capital A capital B capital B also because it will also be tall and yellow, right? Capital A capital A capital, B capital B because, capital A is responsible for tall and capital B is responsible for yellow. Now this unknown plant which is expected to be F_1 is being crossed with the recessive homozygote small a small a, small b small b that is known to

us, in test cross right recessive homozygote. You can see over here; it is crossed with the recessive homozygote. It will be, what will be it is character, it will be dwarf as well as it will be green.

So, suppose I am explaining two different scenarios in first case capital A capital A, capital B capital B is crossed it is small a small a, small b small b. Let us see, what will be happening here? And in another case capital A small a, capital B small b is crossed with small a small a, small b small b. Let us see what is happening there? So, in this case, from this parent what will be the gametes? Only capital A and capital B gametes will be formed right? And from another parent small a small, b gametes will be formed.

So, ultimately, we will be having capital A small a, capital B small b only one type of individual will be observed and it will be tall and yellow right. But in this case from this one how many gametes will be produced? capital A capital B, capital A small b, small a capital B and small a small b. This type of gametes could be made from this one and, from this one if it is used as a male parent only one types of gametes will be produced and after fusion, we will get capital A small a, capital B small b. Then capital A small a, small b small b then, small a small a, capital B small b and small a small a, small b small b. So, what will be its features? Let us see here, capital A and capital B both dominant allele dominant alleles of both the genes are available.

So, it will be tall and yellow what will be happening with this one? It will be tall and green, small b small b is there. In this case small a small a is there. So, it will be dwarf and yellow because, capital B allele is present and, in this case, it will be dwarf and green. So, in test cross if it is a true $F_{1,}$ if it is a true hybrid for one gene, we will see 1: 1 ratio, for 2 genes we will see 1: 1: 1: 1 we will see this ratio, here we are observing it. So, this is the test cross.

So, that is used to know whether the F_1 is true F_1 or not. So, now we will discuss the branching method to determine the different types of gamete formation. Ok! Till now just we have discussed about 2 genes only. So, if 3, 4 genes are stay together if we have

to make gametes for them how can we make that? Suppose we are having a particular parent its genotype is capital A capital A, capital B small b, capital C small c, small d small d. Ok! It is being crossed with another parent its genotype is small a small a, capital B capital B, capital C small c and, small d small d.

So, suppose we have to make cross between these 2 parents ok, this is the parent 2 and this is the parent 1. So, if we have to make cross first what we need to think, first we need to make the gametes, what will be the gametes produced from this one? What will be the gametes produced from this one? So, we are trying to make gametes producing from these particular individuals, through branching method for A gene only; one allele is there right. For B gene 2 alleles are there, for C gene 2 alleles are there, for D gene only one type of allele is there. So, from here basically this type of gametes could be produced it will be capital A capital B capital C small d, it will be capital A capital B small c small d, it will be capital A small b capital C small d and it will be capital A small b small c small d.

So, if you see carefully for these 2 genes B and C basically, heterozygotes are available. So, for this gene, B gene, it will be separated. So, 2 types will be produced for C genes also, 2 types will be produced. So, 2 × 2 ultimately, 4 types of gametes will be produced in P_1. So, let us see what will be happening in P_2?

In P_2 for A gene only one type is there, for B gene also one type is there, for C gene capital C and small c is there and, for D gene small d small d is there, only one type of allele. So, basically from here 2 types of gametes will be produced, capital A small a capital B capital C small d and here, from small a capital B small c small d, these 2 types of gametes will be produced. Now if you have to cross between P_1 and P_2, one plant will be used as a male, one plant will be used as a female, let us assume that P_2 we are being used as a male parent. So, 2 types of gametes will be produced here, small a capital B capital C small d and here, it will be small a capital B small c small d and, here from in P_1 plant will be having this 4 genotypes capital A capital B capital C small d, capital A capital B small c small d, capital A small b capital C small d and, capital A small b small

c small d, right? So, fusion we can get different genotypes like, if this and this fuse these 2 gametes fuse, will get capital A small a capital B capital B capital C capital C and small d small d, right?

Here after fusion will be getting capital A small a then, capital B capital B, capital C small c and, small d small d. So, in this way we can make the next generation, what type of individuals we will be getting? Ok! If we fuse next 2, capital A and small a will be coming capital A small a, capital B capital B, capital C small c and, small d small d, after these 2 fusion will be having capital A small a capital B capital B small c small c small d small d after this, 2 capital A small a capital B small b capital C capital C small d small d, this one capital B small b capital C small c small d small d and, these 2 capital A small a capital B small b capital C small C small d small d. If these two-fuse capital A small a capital B small b small c small c small d small d. So, in this way you can try also how we can make gametes from two different parents, and if we make a cross between these two plants what type of genotypes we could get. Ok! Now we will discuss about another two important things associated with the Mendelian genetics.

First one is independent assortment versus linkage means, how the linkage can play some role which will go against the Mendelian principle means, basically the Mendelian principle cannot describe these things properly. Ok! So, what happens during independent assortment? We have studied the Law of Independence, the Law of Independent Assortment of Mendelian principle. Ok! So, suppose this is a particular chromosome, homologous chromosome, it has capital A gene here capital B gene here. It is coming from one parent and small a and small b is coming from another parent. So, over here also, over here also capital A is here small a is here, here also in this arm capital B is here and small b is here.

If you just think it is a chromosome and, it is another chromosome these two are sister chromatids of this chromosome means, same allele is available over here and here, right, over here and here. So, now over here also, in the blue one the capital B allele was available, in the orange one the small b allele was available, at these loci. Ok! So, over

here if crossing over is taken place, I have told that during meiosis, in the pachytene stage of prophase I, the crossing over is taken place. So, after crossing over within the non-sister chromatids of the homologous chromosome, some genetic material is exchanged. So, if such type of exchange is taken place here, we had capital A gene. Ok! Here we had small a, here we had capital B, here we are having small b, because the orange part has come from this non-sister chromatid. Ok! While we will be having capital B here and small b here.

So, basically here this exchange could be possible ok, similar type of exchange could be possible for A gene also means ultimately, we can get capital A and small a, could be separated. Ok! The recombination of capital A small a, could be observed in this case, because once this is separated in one case, in one end, we will be having small a and capital B small b both can go right, thereafter, once it will be separated small b and capital B could be separated. So, ultimately, I am making it clearer suppose what will be happening, what will be happening? Suppose here capital B here small b was there I am mentioning it once again here, we had capital B here, this type of things I am not writing here, we had small b. So, after this exchange capital B will be here, small b will be here, capital B will be here, small b will be here, right? So, during meiosis I this two chromosome will be separated, it will go to two different poles and thereafter, once the gamete will be formed then, here from will be having an individual with capital B, will be having an individual with small b.

Here also we can get similar type of things capital B and small b means this two could be separated, this two could be exchanged, but let us assume over here, two genes are available in this way; capital A capital B and this chromosome small a small b. Ok! Here capital A was over here, the capital A and capital B their transmission was independently taken place, took place over here, these two genes are staying together almost. So, here we can see capital A capital B in this arm we can see small a small b. Now over here it will be clearer, in this arm capital A capital B will be here, as the orange part has come here small a and small b come over here. In this case capital A capital B has come, in this case small a small b was there.

So, basically here between this two gene capital A and capital B could not be separated means, capital A and capital B will stay together all the time while, small a and small b will stay together all the time means, these two genes are tightly linked. If they are tightly linked, if the crossing over cannot be taken place between these two genes, then it cannot be separated. So, Mendel described about those genes, which are not so much tightly linked, he was able to describe those genes, but if tight linkage is there then, two genes could not be separated means, the independent assortment will not be followed if two genes are tightly linked recombination, but capital A or small a and capital B or small b do not exchange means, these things cannot be taken place. Ok! Now another thing which Mendel could not describe at that time will come into that, first of all, can we see complete dominance for all the genes in nature? So, let us discuss about these things, this is about the partial dominance or incomplete dominance.

Suppose, we have a parent capital R capital R that is giving a red colored flower while, we have another parent; small r small r that is giving white colored flower. Ok! So, if cross is made between this two earlier, so far what we have discussed the complete dominance was there. Ok! In F_1 we were getting the character of a particular parent, right? Here in F_1, in F_1 generation we are getting pink colored flower. Ok! Means it is neither similar to this one, neither similar to that one. So, this is known as the incomplete dominance or partial dominance. Ok! Means no allele, neither capital R nor small r, no allele is showing its full form over there. Ok! Some mixed reaction is being occurred. So, in this case if the selfing is done, if we go to next generation in F_2 generation if the selfing is done in this generation, what will be happening?

So, there from all two types of gametes will be produced capital R and small r. So, male gametes will be produced these two types and female gametes will also be produced of these two types. After fusion of these two will be having capital R capital R will be having capital R small r and, will be having small r small r. So, if you see about the phenotype, what will be the phenotype here, the phenotypic ratio will be 1: 2: 1, 1 red, 2 pink and 1 white. What will be the genotypic ratio? It will also be 1: 2: 1.

So, if you recall the complete dominance there, the phenotypic ratio was 3: 1, right? Because, the dominant homozygous and heterozygous were similar phenotype were of similar phenotype. So, here it is different. So, in case of incomplete dominance we can see phenotypic ratio 1: 2: 1 and genotypic ratio 1: 2: 1. These things could not be explained by Mendelian principle. Ok! So, now we will be discussing some of the few important formulas what we can recall from the Mendelian discussion, and later on you could use it in different types of numerical.

First of all, number of different gametes produced by F_1. Suppose we have a F_1 capital A small a, this is an F_1. So, how many gametes it will make capital A and small a, these two types of gametes will be produced means, 2. If this is our F_1 how many gametes it will make capital A capital B, capital A small b, small a capital B and small a small b, right, means 4. So, it is ratio is 2^n means 2, n is the number of gene segregating.

If 1 gene is segregating it will be 2^1 that is 2. If 2 genes are segregating it will be 2^2 that is 4. So, in this way number of different gametes produced by F_1 could be calculated. Now number of individuals in the perfect F_2. Ok! So, in a perfect F_2 4 types of individuals could be observed suppose this one is selfed, Ok!

This is F_1, it is selfed. So, after crossing these two types of gametes will be produced male gamete and female gametes also. So, capital A capital A, capital A small a, capital A small a and small a small a. So, these 4 types of individuals will be observed. So, number of individuals in perfect F_2 will be 4^n, ok! Now number of different genotypes in F_2 if you see this one how many genotypes, we could get in F_2 it will be either capital A capital A, capital A small a or small a small a.

It means 3 types of genotypes, Ok! The phenotype may be depending on the complete dominance or incomplete dominance. So, the genotype will be 3 right. So, 3^n will be the number of genotypes in F_2. Now number of different homozygous genotypes in F_2. In F_2, will be having 2 different genotypes homozygous genotypes that is 2^n, n is the number of

genes segregating.

Now coming to the number of different phenotypes in F_2. In F_2, if complete dominance is there ok, then we will get only two types of phenotypes means capital A capital A and capital A small a. They will give the same feature ok, while small a small a will give another feature, the homozygous recessive will give another feature. So, number of different genotypes in F_2 if complete dominance is there, it will be 2^n. If it is incomplete dominance, partial or over-dominance or incomplete dominance then it will be 3^n.

Because in complete dominance this two will behave similarly capital A capital A and capital A small a; in case of partial dominance or over-dominance, incomplete dominance this type of ratio phenotypic ratio will be observed ok! So, that is it for today's class. Thank you.