Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-17: Genetic Basis of Heterosis and Inbreeding Depression

Welcome back, so we will continue again. So now we will discuss about the over-dominance hypothesis of heterosis. Earlier we have discussed about the dominance hypothesis. According to dominance hypothesis, what you observe that the recessive alleles, if the effect of the recessive alleles are masked by the dominant counterparts, then we can see heterosis in F_1. So, the performance of F_1, over both of its parents due to the masking effect of the dominant allele. Now, we will discuss about the over-dominance hypothesis.

It was proposed by East and Shull in 1908, and it is also known as single gene heterosis or super-dominance theory, since heterosis for a single gene. So, according to this hypothesis, heterozygotes at least in some of the loci, are superior to both the homozygotes. Thus, heterozygote capital A small a would be better than capital A capital A or small a small a. So, if we just consider the dominance hypothesis, here what we found? Here we found that, if these two plants are crossed, if these two plants are crossed, some deleterious alleles are available over here, some deleterious available in plant 2.

So in F_1 we will be getting capital A small a, and capital B small b. So, the deleterious allele they cannot show its effect, because it is masked by its dominant counterparts. So, we are getting the F_1 hybrid, or F_1 vigor means, the heterosis is observed in F_1. So over here capital A capital A is almost equivalent to, or equivalent to capital A small a. But

according to over-dominance hypothesis, if this one is crossed with this, we can see heterosis means, if heterozygote is available over there, that would be better than both the homozygotes.

So, it is known as single gene heterosis, for each and every gene, you can see heterozygotes are being formed, in F_1 if two parents are differing in their genetic constitution. So, if heterozygotes are formed, then it would be better, according to over-dominance hypothesis. So before going to third one the epistatic hypothesis, let me explain the over-dominance hypothesis once again. So according to this hypothesis, the masking effect of dominant allele over the recessive allele is not coming into the picture. According to this hypothesis, the heterosis is due to the heterozygote itself.

Once the heterozygote is formed in F_1, then we can see heterosis. So, if we had two plants capital A capital A small b small b, that is crossed with small a small a capital B capital B. Over here, we will be getting capital A small a capital B small b like this. But the thing is that for A gene, this is the homozygous dominant condition, another parent had homozygous recessive condition. For B genes, this parent was having homozygous recessive condition, this parent was having homozygous dominant condition.

But in F_1 for both the genes, the heterozygote is available. So, it would be better for both the genes compared to both the parents, we can see heterosis over here. So, that is the explanation of over-dominance hypothesis. Now coming to the third one, that is the epistatic hypothesis of heterosis. In most of the crops, it is observed that, in number of genes, in number of genes, they interact with each other, they supplement or complement each other.

And finally, they will show that different characters those are epistatic in nature means, non-allelic interactions between 2 genes or more genes, that is the epistasis. So according to this hypothesis, suppose one parent was having this genotype, another parent was having these genotypes. So over here, capital A small a capital B small b is coming. So, if capital A gene, if the A gene and B gene, they are epistatic in nature, they show some

epistatic character, if a particular character is governed by these 2 genes. Suppose, maybe in one day 1 have told suppose, this is a substrate available in a plant.

Once an enzyme A works over there, then we can see the intermediate, we can see the intermediate. On that intermediate, if another enzyme B works, then we can see the final product. We can see the final product. So, if you see about this plant, if you think about this parent over here, capital A capital A is there means, intermediate will be produced, but capital B gene is not available. So, we may not get the final product.

While in this plant, in the plant 2, there small a small a gene is there. So, the intermediate will not also be produced, only the substrates will be available. But in F_1, both the enzymes will be functional, and finally we can see the from substrate to final product formation. So, we can see the heterotic effect. So in this way the epistatic hypothesis works.

Now we will discuss, about the similarities between dominance and over-dominance hypothesis, because dominance and over-dominance hypothesis are mostly discussed, and epistatic hypothesis is pretty new. And most of the scientists who are working in this particular field, they found that epistatic hypothesis also plays very crucial role, in case of different cross-pollinated species. Now let us discuss, the similarities between dominance and over-dominance hypothesis. So according to both the hypothesis, inbreeding causes inbreeding depression means, if our genetic constitution was this, if we do inbreeding, so definitely we will be getting this type of plants, we will be getting this type of genotypes, we will be getting this type of individuals. So according to both and so on.

So according to both the hypothesis, if inbreeding is done, we can see inbreeding depression, because it may show deleterious effect over here, it may show deleterious effect over here. Or according to some hypothesis, according to over-dominance hypothesis, here both the genes are available in dominant homozygote condition. So, there also we can see inbreeding depression because according to over-dominance hypothesis, the heterozygotes are superior. So, if we do inbreeding, inbreeding

depression is observed. Next one outcrossing will restore vigor and fertility.

So if outcrossing is done, so means, if selfing is prevented, inbreeding is prevented, we are crossing our target plants with a different individual, having a different set of alleles, maybe their genetic constitution was A' A' and B' B'. It is a new allele of B gene or A gene. If we do such type of outcrossing, then we can restore the vigor and fertility. So heterosis depends on the genotype that is very important point. Suppose, a cross is made between capital A capital A small b small b with capital A capital A small b small b.

Suppose a cross is made between these two plants. So, from here, here from capital A and small b gametes will be produced, here from capital A and small b gametes will be produced, after fusion will be getting capital A capital A small b small b again. So, no heterosis is expected. So heterosis basically depends on the genotype of the plants, which are being crossed. Now we will discuss, the difference between the dominance and over-dominance hypothesis.

So first difference, the heterozygotes are equivalent to the dominant homozygotes, according to dominance hypothesis. So, the heterozygotes are equivalent to the dominant homozygotes, according to dominance hypothesis. So, suppose this is crossed with this. So, both of the parents had recessive homozygotes in, parent 1 it had recessive homozygotes for B gene, in parent 2 it was having recessive homozygotes for A gene. So according to dominance hypothesis, we are discussing this part.

According to dominance hypothesis, the recessive homozygotes are deleterious. So, if the recessive homozygotes, their function or their impact is masked by the dominant allele, if the impact of the recessive allele is masked by the dominant counterpart, then we can see betterment, then we can see heterosis. So here capital A small a will be equivalent to capital A capital A, means, the dominant homozygotes will be equivalent to the heterozygote. This is better, F_1 will be better, why? Because capital A small a will be = capital A capital A and capital B small b will be equivalent to capital B capital B. So both the better things are coming in F_1, according to dominance hypothesis.

But according to over-dominance hypothesis, the heterozygotes are greater than both the homozygotes, dominant homozygotes as well as recessive homozygotes. So according to over-dominance hypothesis, why F_1 is better? Because here for A gene homozygous dominant condition was available, in this parent the homozygous recessive condition was available. While, in parent 1 for B gene homozygous recessive condition was there, while, in parent 2 the homozygous dominant condition here was here. But in F_1, we are having the heterozygotes for both the genes, so we will get heterosis. So in simple way, according to dominance hypothesis, the heterozygosity is not the main factor.

The main factor is the masking of the deleterious effect of the recessive allele by the dominant counterpart. While, according to over-dominance hypothesis, the heterosis is due to the heterozygosity. So, in dominance hypothesis, inbreds as vigorous as F_1 might be isolated. We know that, some objections were there, how the objections were overruled, we have discussed also. But if the linkage is not at all available, between the 2 genes, if the traits, what we are discussing, what we are considering between 2 parents, if that trait is controlled by a single gene, then according to dominance hypothesis the inbreds as vigorous as F_1 might be isolated.

We may get some of the individuals having capital A capital A capital B capital B that will be equivalent to capital A small a capital B small b, according to dominance hypothesis. But it is not possible to isolate any inbred as vigorous as over-dominance hypothesis. Because according to over-dominance hypothesis, the heterozygotes are superior. See if we do inbreeding, if we develop inbreds, definitely homozygosity will be increased over there. So, it will not be superior like the heterozygote individuals.

So, the superior inbreds like F_1 could not be isolated according to over-dominance hypothesis. Third one is according to dominant hypothesis; inbreeding depression is due to homozygosity of harmful recessive genes. So, according to dominant hypothesis, the inbreeding depression is due to homozygosity of the harmful recessive gene. Suppose, we had this plant, suppose we have this plant and we are doing selfing means, we are doing

highest level of inbreeding. So, what we will be getting? We will be getting some individuals having capital A capital A small b small b, some will be capital A capital A capital B capital B, some will be small a small a capital B capital B, some will be small a small a small b small b and so on, if selfing is done for one generation.

So according to dominance hypothesis, inbreeding depression is due to homozygosity of harmful recessive allele. So according to dominance hypothesis, if selfing is done, this one will be harmful, means harmful allele is available in homozygous recessive condition. Over here harmful alleles are available in homozygous recessive condition. Over here harmful alleles are available in homozygous recessive condition and these are the reason for getting inbreeding depression, not this one, but due to the homozygosity of the deleterious genes, recessive alleles of the deleterious genes will get inbreeding depression according to dominance hypothesis. Then following over-dominance hypothesis, the heterosis is due to consequence of heterozygosity itself, means if heterozygosity is there, then we can see heterosis, ok! and heterosis is not due to the masking effect of the recessive gene.

So let me rephrase it once again. Suppose, it was selfed, according to dominance hypothesis, ok, according to dominance hypothesis we will be getting capital A capital A capital A small a and small a small a. So, it will be deleterious, and the heterosis will be due to the masking effect of this one, while according to over-dominance hypothesis, the heterozygosity will show the superiority, over both of the homozygous conditions. So, this is just the explanations of difference between dominance and over-dominance hypothesis. Now, let us try to make a cross between two different individuals, and we will try to see whether, the cross will be heterotic following different hypothesis. Suppose we are having a plant capital A capital A capital B capital B and small c small c.

We have one plant and we are crossing it, this is our plant 1 and we are crossing it with another plant having genotype small a small a capital B capital B and capital C capital C, this is our plant 2. So, what type of gametes will be produced from here? Capital A capital B and small c gametes will be produced from here, while, from this parent we will

be having small a capital B and capital C. This allele will be produced from here, this gamete will be produced from here. So, if cross is made means, these two gametes will fuse. What we will be getting in F_1? We will be getting capital A small a capital B capital B and capital C small c because capital B allele is available in both the parents.

Here from capital A is coming, here from small a is coming, and here from small c is coming, here from capital C is coming. So, this will be our F_1 individuals. Now let us see, according to dominance hypothesis, what will be the scenario of this particular F_1? Let us think, about the A gene only. According to dominance hypothesis what we know? The capital A capital A is equivalent to capital A small a, right? according to dominance hypothesis.

So according to dominance hypothesis this plant will be equivalent to this one in respect to A gene. It will be equivalent to this plant in respect to B gene. While, if you think about the C gene, C gene also here deleterious C gene was available the recessive homozygous condition. Over here the deleterious effect has been masked by the dominant allele. So, it will be better for C gene also, according to dominance hypothesis from one parent, the parent 1.

Let us think, about the plant 2 or parent 2. For A gene it is definitely superior, because the deleterious effect has been masked. The deleterious effect has been masked over here, by the dominant counterpart. For B gene it will be equivalent, for C gene also, it will be equivalent, because capital C capital C will be equivalent to capital C small c, according to dominance hypothesis. So, we can see heterosis according to dominance hypothesis, right? Now according to over-dominance hypothesis, what we will see?

So, according to over-dominance hypothesis, capital A small a is superior to both of the homozygotes, right? The capital C small c is superior to both the homozygotes i.e. known to us, capital B capital B, it is same in both the parents and the F_1. So, we are not considering this, because in both the parents no variation was available, due to this particular gene. Now let us think, about our F_1 according to over-dominance hypothesis.

Here, capital A small a is available. If you see plant 1 here, homozygous dominant was prevailed. In plant 2 the homozygous recessive condition was there. So capital A small a will be superior. Capital B capital B it is same from both the parents.

So we will not consider it. For this gene capital C small c again, it will be superior because one parent was homozygous recessive, one parent was homozygous dominant. So, according to over-dominance hypothesis also, we can see heterosis over here, right? Now suppose we are making another attempt, we are making another cross, where one parent had this genotype and another parent had this genotype. Let us see, what will be our F_1? Here from capital A and capital B gametes will be produced, here from small a and small b gametes will be produced.

So in F_1 we will see capital A small a capital B small b. The heterozygote condition will be there. Now if we think about the dominance hypothesis, according to dominance capital A small a will be equivalent to capital A capital A, and capital B small b will be equivalent to capital B capital B. So this F_1 will be similar to this parent, right? Because here capital A capital A was there, capital B capital B was there.

So according to dominance hypothesis, no heterosis will be there in this case, right? Because this one will be equivalent to capital A capital A, this one will be equivalent to capital B capital B. The superiority of F_1 over both the parents will not be obtained here. Let us see, what will be happening according to over-dominance hypothesis? According to over-dominance hypothesis, what we know, the heterozygotes are superior over both the homozygotes.

So this one the capital A small a will be superior to this parent, as well as this parent while, capital B small b it will be superior for this parent as well as this parent. So, according to over-dominance hypothesis, we can see heterosis. While according to dominance hypothesis, no heterosis is observed, is not it? Now, if we cross between these two plants where no genetic variation is available. So let us see, let us go to F_1, here from

these two alleles will be coming here, from these two alleles will be coming and in F_1 will be getting capital A capital A small b small b. So here, can we see any heterosis as these two parents were not too much diverse and no heterozygotes have been formed over here.

So heterosis could not be observed. So, neither according to dominance hypothesis, we can see heterosis because capital A capital A will be equivalent to this parent, it will be equivalent to this parent also, no heterosis will be observed small b small b here according to over-dominance also. According to both the hypothesis no heterosis will be observed over here. So these are the references of this particular part, if you have to do the heterosis and inbreeding depressions in plants. So, these are the different reference the plant breeding books by B.D. Singh and by Phundan Singh. Thank you all.