Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-10: Merits and Demerits of Backcross Breeding and Cytoplasm Transfer Through Backcross breeding

Welcome back. So, we will continue again. So, now we will discuss about the Merits and Demerits of backcross breeding. First of all, if we think about the merits of backcross breeding, the new variety is almost identified because of the expected outcome. If we just consider our previous discussion from 'Swarna' variety by initial crossing with 'Tetap' and backcrossing it with 'Swarna' again and again, finally we got a variety similar to 'Swarna' means its appearance will be similar to 'Swarna', its maturity will be similar to it, the seed type will be similar to 'Swarna', just it will be resistant to sheath blight of rice ok!

So, the outcome is expected. So, it is highly accepted by the farmers easily, it is highly accepted by the consumers, easily! whatever the output of backcross breeding. Next one the Extensive Yield Test not needed, at least 5 years can be saved through backcross breeding method. If you recall the backcross breeding method from F_1 onwards we are crossing it with the recurrent parent again and again.

If you recall the pedigree method there before multi-location trial, we had to do preliminary yield trial for a couple of generation. Here, the preliminary yield trial is not at all needed because in each and every generation either we are doing selfing or we are crossing with the recurrent parent. So for most of the genes, the homozygosity is achieved through the backcross breeding process. So, the extensive yield trial at least in case of the preliminary yield trial is not needed. So, the breeder can save few years.

Next one it is not dependent on the environment. We have discussed about the backcross for the dominant gene transfer and backcross for the recessive gene transfer. So, in both the gene transfer method either the dominant allele or the recessive allele is playing the pivotal role for the particular trait concern. Until and unless the environment is involved there, then our result will not be dependent on the environmental factors through backcross breeding because one condition we should consider. Ok! before initiating backcross process the trait should be highly heritable. For the highly heritable trait the environment will have least impact.

So, ultimately whatever the product will be observing, we will be getting after backcross, that will not be also dependent on the environment. Next one, it is preferred by the farmers as they know the recurrent variety. I have mentioned earlier because 'Swarna' which was used in the backcross breeding method in our previous discussion it is already popular ok! We try to we try to sort out the defect of 'Swarna' variety through backcross breeding method. So, the ultimate product of the backcross is preferred by the farmers also.

Then this is the only method for interspecific gene transfer or cytoplasm transfer. Suppose we need to cross between *Oryza sativa* and *Oryza rufipogon* ok! in between two different species, *Oryza sativa* and *Oryza rufipogon*, it is a wild rice, also suppose some specific trait is available we are interested to transfer from it. So, only backcross breeding method we should consider over here. For transferring cytoplasm backcross is the only method to transfer the cytoplasm later on we will discuss it once again.

Then the transgressive segregants may be obtained in case of pedigree selection also we could get transgressive segregants. So, backcross breeding also we may get some transgressive segregants. These are the merits of backcross breeding. Now let us discuss the demerits of backcross breeding. First of all the new variety will not be superior to the existing variety that is an important point because nowadays the population of the globe is increasing day by day.

We need to increase our food production, we need to get those varieties which are more tolerant and at the same time they can produce more yield. So, the variety which is being used now, if we have to consider that variety in backcross breeding, after 10 to 12 years of backcrossing and those process once we will get a new variety, by that time the population will be increased enormously. So, we need to get some new type of variety, but through backcross breeding new variety will not be too much superior to the existing variety except the trait we are transferring. Rest of the trait will be similar to the recurrent parent. Next one, the clearly linked gene may be transferred to new variety ok. Suppose we are discussing about 'Swarna' and 'Tetap' right?

'Tetap' was sheath blight of rice resistance and this one was susceptible right? Now we try to introduce the sheath blight of resistance gene from 'Tetap' into 'Swarna'. Finally, we got a variety 'X' through backcross breeding that is similar to 'Swarna', that is supposed to be similar to 'Swarna' where the sheath blight of rice resistance trait is supposed to be introduced. But if, wherever the sheath blight of rice resistant gene is located in 'Tetap'; if close to that region of the chromosome another gene which is responsible for stickiness is available on the chromosome! Suppose along with the resistant gene this stickiness gene is staying in very close proximity, then this whole part will be transferred in 'Swarna' variety; means although the variety 'X' will be resistant the sheath type will be converted into sticky nature ok!

So, if the closely linked undesirable genes are there then it could be transferred through backcross breeding also; it is an important demerits of backcross breeding. Next one, hybridization is done for each backcross breeding, each backcross generation, which is very difficult and costly. Already we have discussed about the crossing in rice the rice flowers are relatively smaller, but if you think about the lentil flower, those are very tiny, those are.. those belongs to leguminosae family. So, we have to remove each and every florate separately the standard, kill, both of those different florate should be removed and then we have to do emasculation for doing backcross in each and every generation that is very difficult. Next one, by the time backcross variety is developed recurrent parent may be replaced, that is the point what we are discussing over here because the overall process take at least 10 to 12 years.

So, by that time a new variety could be developed that could replace or not ok! So, ultimately whatever will be observed, will be the outcome of the backcross breeding, that might not be useful to the market. Now we will discuss that how cytoplasm is transferred through backcross breeding. So, generally cytoplasm transfer is done for some specific reason and we will discuss about the transfer of cytoplasm which is responsible for male sterility ok! In some crop we need to induce or we need to introduce the sterility.

So, then we can make hybrid seed easily like in case of rice, rice is self-pollinated in nature. If somehow we introduce male sterile gene or male sterile cytoplasm in rice then we can easily cross that rice with another variety. The crossing could be easier and we will get F_1 the hybrid seed easily. So, in rice this type of male-sterile application has a huge impact. So, suppose we have one parent and this is the male sterile cytoplasm and this is the nuclear part of this particular parent.

While in another parent, our cytoplasm it not male-sterile, it is male-fertile in nature, our cytoplasm is male-fertile in nature. This is the nucleus available, nuclear material available in parent 2. So, suppose we are willing to transfer the cytoplasm of this male-sterile in the new progeny and so that the nuclear part will be coming from parent 2 and the cytoplasm will be coming from parent 1. So, with this approach if we have to do cytoplasmic male sterile if we have to transfer cytoplasm, then the male sterile line should be used as a female parent because the male sterile line cannot produce viable pollen grains. So, it should be used as a female parent only.

So, let us assume we had made the cross. So, if we make the cross, this is used as a female parent and this one is used as a male parent we have made a cross. In F_1 what we will be getting? We will be getting the cytoplasm from the female parent this is the male-sterile cytoplasm and in F_1 50% of chromosome will be coming from this parent P_1 and 50% will be coming from P_2. So, the nuclear part will be like this 50% is coming from P_2 and 50% coming from P_1 while the cytoplasm is coming from the female parent only. Now we are crossing the F_1 again with our P_2, we are doing backcross over here because we are just interested to take the cytoplasm.

So, this parent is used as a donor parent and this parent is used as a recurrent parent. This is our recurrent parent, after this cross we will get one backcross generation you can tell in backcross what will be the cytoplasm type? It will be the cytoplasm. This parent will be used as a female parent where from the cytoplasm is coming and this one will be used as a male parent over here. So, our cytoplasm will be male-sterile cytoplasm if we think about the nuclear part, almost 75% of the genetic part will be close to the recurrent parent. Just only 25% will be similar to the donor parent.

So, again we have to cross it with the recurrent parent after this cross this one will be used as a female while this recurrent parent will be used as a male plant and over here almost 87.5% will be coming from the recurrent parent. So, if you carefully see in this way due to backcrossing in each and every generation our nuclear part is almost being similar to the recurrent parent, only minor amount will be there from the donor parent at the nuclear part. So, we have to do again backcross for a couple of generation and finally, in this way we can transfer the cytoplasm from donor parent into our targeted recurrent parent. Ultimately this is our targeted output, we will be having an individual, their cytoplasm will be male sterile in nature while the nuclear part will be similar to the recurrent parent.

In this way suppose we have a rice variety popular rice variety ‘Swarna’ there we can transfer the cytoplasm from a donor plant a donor wild rice plant. So that the ‘Swarna’ rice variety newly developed ‘Swarna’ like rice variety could be used in hybrid breeding or hybrid seed production easily. So, in this way cytoplasm could be transferred through backcross breeding method also. Now we will discuss that how backcrossing improves homozygosity. So, earlier we have discussed that selfing improves homozygosity right.

Now in F_1 homozygosity is 0% and heterozygosity is 100%. Now selfing has been done in F_1. In F_2 that is first generation of selfing we will get homozygosity 50% heterozygosity 50%. In F_3 generation we will see homozygosity 75% and heterozygosity 25%. In this way homozygosity is increased. Now let us see what will be happening in case of backcross.

What is backcross? The F_1 is crossed with any one of its parents. So, this is one plant and this is another plant we are crossing this two we are getting F_1. F_1 is this, backcross has not started yet. So, we are crossing F_1 with any one of its parents. What we will be getting? We will be getting capital A small a and capital A capital A. Only one type of allele will be produced.. one type of gamete will be produced from here and here from two gametes will be produced capital A and small a. These two will fuse, these two will fuse finally, we will be having these two individuals in BC_1 generation first backcross generation.

So, if you see over here, what is the percentage of homozygosity? 50% homozygosity is there. Let us go to the next generation of backcrossing. Suppose all the plants are being crossed with capital A capital A once again. In BC_2 we will get capital A small a and capital A capital A. So, if you carefully see over here, here 50% was homozygous.

So, this from here this 50% plant, from this 50% plant only A gamete will be produced; while from our recurrent parent A gamete will be produced. So, after fusion we are getting 50%, while from here two types of gametes will be produced capital A and small a upon fusion will be having capital A capital A as well as capital A small a. So, ultimately capital A capital A will be 50%, plus 50% of its product means 25% means ultimately we will be getting 75% capital A capital A and capital A small a will be only 25%. So, I am just rephrasing it once again. From this particular plant 50% directly will be produced means initially it was 50% right? In its progeny, in its backcross two generation 50% directly will be coming from there while from rest 50% 25% will be capital A small a and 25% will be capital A capital A.

So, overall in backcross two generation also we are getting 75% homozygosity and 25% heterozygosity. So, if we compare it the homozygosity improvement, let us wipe off this and improvement through backcross. In BC_1 generation what did we get? In BC_1 generation we got 50% homozygosity. In BC_2 generation we got 75% homozygosity. So, it is similar to selfing, the improvement in homozygosity percentage is similar to selfing. In selfing, also in F_2 that is first selfing generation we had 50% homozygosity, in F_3 that is second selfing generation we had 75% homozygosity.

It means the improvement in homozygosity is similar through backcrossing as well as selfing, but is there any difference? Yes there is difference. If you recall selfing, in selfing we are getting this, this as well as this. So, two types of homozygotes are produced through selfing, two types of homozygotes are produced ok! while through backcross if you just recall backcross, only one type of homozygote is being produced. It means the homozygosity improvement is same in backcross and selfing, but the homozygosity for the targeted allele, definitely this as well as this is not our target, any one of them will be our target either A or small a. So, the homozygosity is increased through backcross and selfing in a similar way, but the homozygosity for the target allele is attained faster through backcross. Here the homozygosity of the target allele is attained faster.

If we try for the recessive allele, suppose this one is being crossed with a recurrent parent of this genotype. So, over here we will get capital A capital A and small a small a, the homozygosity for this will be 50%. This is BC_1 generation, in BC_2 generation this one will be 25% and this one will be 75%. So, homozygosity of our desirable allele will be increased in much faster way through backcross breeding method. So, these are the references of our backcross discussion. You guys can go through the B.D. Singh book or you can go to the another important book that is based on the plant breeding theory and practices, several new breeding approaches are being discussed over there and I hope you have understood the dominant and recessive gene transfer method. So, thank you.