Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture-13: Recurrent Selection

Hello everybody. Welcome to SWAYAM NPTEL course on Basics of Crop Breeding and Plant Biotechnology. Today in Principles of Conventional Plant Breeding, we are going to discuss on Recurrent Selection. So, in this particular lecture this concepts will be covered. First we will be discussing about combining ability, then we will discuss the GCA and SCA that is General Combining Ability and Specific Combining Ability. Then we will be discussing about recurrent selection.

So, then different types of recurrent selection will be discussed. So, through this recurrent selection we can identify superior inbred lines. So, inbred lines are developed in case of cross-pollinated species. So, that by using those inbred lines later on we can develop hybrids of synthetic varieties.

Then the advantages and disadvantages of recurrent selection will be discussed in this particular course also. So, first let us start with the combining ability. So, the combining ability is the ability of a particular genotype to combine with another genotype of the plant. And based on its progeny performance we can tell that a plant is having good combining ability or not. So, two types of combining abilities are there one is general combining ability that is GCA, another one is specific combining ability that is SCA.

In case of general combining ability suppose four different plants are crossed with a particular plant ok! One plant is common and here four different plants are there. So, based on its average performance we can determine the general combining ability of each

and every plant means what is the ability of a particular plant to make progeny compared to the average performance; in this way it is determined basically. While in case of specific combining ability, it is this test done between two individual plants maybe plant 1 and plant 2 they will be cross separately even plant 3 and plant 4 they are being crossed separately and their progeny are being compared in this way specific combining ability test is done anyway. So, we will be discussing these things later on. So, in this combining ability first of all the identification of the best performing lines and selection of parental lines for future crosses are the two fundamental objectives in plant breeding.

So, these two objectives are basically fulfilled by understanding the combining ability, the best performing lines... Its identification and selection of the parental lines for preparation of hybrids or synthetic varieties. Next combining ability is the ability of the cultivar to combine among each other in hybridization process so that the desirable gene or characters are transmitted to their progenies. So, one plant has to combine properly with another plant so that all of its different genes can combine well and the characters for which we are doing the selection, it is transmitted to the next generation. It is indeed an estimation of the value of the genotypes that is the parental lines on the basis of their offspring performance. So, based on the progeny performance will determine that this parents had better combining ability. Sorry...

Then GCA and SCA, that is general combining ability and specific combining ability: they play significant roles in inbred line development and population development in crop improvement, inbred line evaluation and population development in crop breeding. So, let us discuss about the general combining ability. So, first of all GCA, the general combining ability, is the average performance of the genotypes in a series of hybrid combinations. It is the average performance of the genotypes in a series of hybrid combinations. So, later on we will discuss it once again.

So, it is an effective tool used in selection of parents based on the performance of their progenies. Usually the F_1 progenies are considered, but it has also been used in F_2 and later generations also based on the progeny performance. Next it is associated with

additive gene effect. So, that is very important point, it is associated with additive gene effects. The additive gene action involves the cumulative effect of alleles at different gene loci with each allele independently contributing to the overall phenotype, means the alleles of a particular gene is not having an impact on the alleles of another gene all of them are working independently.

The more favorable alleles present, greater is the expression of the trait in a proportional manner ok! If the favorable alleles are more, then if those favorable alleles are associated with a particular trait then we can see the enormous effect the effect, will be better over there. Then it involves the independent and additive contribution of alleles to the phenotype ok! The additive gene action contributes to the overall genetic variance and influences the predictability of the breeding outcome. So, in case of specific combining ability some... we will be discussing about some features of specific combining ability.

First it is the unique interaction between specific parental combinations plant 1 and plant 2 will be crossed together, plant 3 and plant 4 will be crossed and their progeny will be evaluated. So, it is the unique interaction between specific parental combinations. Next it is crucial in understanding which crosses produce offspring with exceptional traits. If plant 3 and plant 4 their progeny performance is better; so, we can tell that the plant 3 and plant 4 is having more… I mean, better SCA specific combining ability.

The breeders use this method to identify the promising hybrid combinations and in turn develop the input populations with superior characteristics. It is non-additive in their effect. So, SCA that is specific combining ability is non-additive in their effects while the GCA was additive in nature. So, non-additive effects arise from interactions between alleles at different loci or from combinations of alleles in hybrid individuals ok! So, interactions either some interactions is there between 2 alleles or 2 genes available in 2 different loci… they are playing some role over there.

So, dominant gene action occurs when the presence of a dominant allele mask the effect of the corresponding recessive allele we know it. And the phenotype is expressed even if

only one copy of the dominant allele is present in the genotype that is clear from the Mendel's theory also. While epistatic interaction is found where the effect of one gene is dependent on the presence of alleles at another gene ok. Suppose 2 genes are there one is A gene one is B gene. If the effect of A gene depends on the involvement of B allele different B alleles; capital B or small b then we can tell it as epistatic interaction ok!

2 genes are controlling a feature ok! So, now gradual will move into the recurrent selection. So, some basic concepts we have discussed so far on GCA and SCA then gradual will be move to the recurrent selection. Why recurrent selection is done? To identify suitable parents,that can combine well so that we can finally, develop the hybrid varieties of synthetic varieties mostly in case of cross-pollinated crops. So, recurrent selection… it was this idea was initially suggested by Hayes and Garber in 1919 then East and Jones they independently also suggested the idea of recurrent selections.

The procedure of recurrent selection was first described by Jenkins in 1940. So, the term recurrent selection was given by Hull in 1945 and thereafter the isolation of superior inbreds for developing hybrids was started through recurrent selection, different types of recurrent selection were developed later on. So, Hull defined recurrent selection as re-selection generation after generation because if we recall the backcross breeding there also we used one parent as a recurrent parent, recurrent means it is being used again and again. So, here the Hull defined these as re-selection generation after generation, means there is a scope of selection again after a couple of generation, with inbreeding of selects to provide genetic recombination where in breeding is done. Then the term inbreeding of selects typically refers to the self-pollination or inter-mating of selected plants within a cycle.

Suppose a number of a group of plants are there, they are from, we are identifying some of them, maybe we are identifying these… we are identifying these. In next generation its progeny is being grown and we are making cross among them. So, definitely some level of inbreeding will be developed. So, selfing is the highest level of inbreeding development, but through recurrent selection also some level of inbreeding is developed.

Now recurrent selection represents a vital breeding technique commonly employed in agriculture.

It is mostly done in case of cross-pollinated crops. This systemic and repetitive approach is geared towards ameliorating the genetic composition of a population over multiple generation means we can modulate the genetic constitution of a population over a multiple generations. One set of selection could be done after 2 to 3 years, another set of selection could be done. So, in different generations we can modify it. So that, it will be more ameliorated, means it is quality will be more enhanced more improved.

The primary aim of recurrent selection is to elevate favorable traits. So, we should be having some targets we may think about the crop yield, we may think about the disease resistance or some specific characters; means protein content or plant height whatever… all while ensuring the preservation of genetic diversity within the population. So, this is another important thing which is true in cross-pollinated crops. We have to preserve the genetic diversity within the population. So, now coming to different types of recurrent selection.

Basically 4 types of recurrent selections are there. First one is simple recurrent selection, next one is recurrent selection for general combining ability…. we have discussed general combining ability. Then we will be discussing about the recurrent selection for specific combining ability and finally, we will discuss about the reciprocal recurrent selection. So, in simple recurrent selection what are the features of simple recurrent selection? First it does not include any tester. If you recall the test cross analysis right? In test cross analysis, the F_1 was crossed with a homozygous recessive parent right? In self-pollinated crop in Mendel's theory… according to Mendel's theory the means Mendel's gave the concept of test cross also.

So there, a tester parent was used... you can recall its genotype was recessive homozygous in nature, but over here in cross-pollinated species here also a tester genotype will be used. In case of cross-pollinated species as a tester basically a

population is used it is not a single parent which is homozygous recessive. Here a population is used. So, different types of populations will be used in case of GCA and SCA. Recurrent selection for GCA, recurrent selection for SCA later on we will be discussing. In simple recurrent selection no tester parent, that is the common parent is used which is crossed with different targeted plants.

Then main features: first no use of tester variety, then no combining ability assessment is done. This is very simple method simple recurrent selection no combining ability, whether a plant, what we are choosing is a good combiner? Is a bad combiner? We cannot judge from here. Then selection is based on phenotype. Then it is used to assess highly heritable characters, characters which are highly heritable in nature? Means mostly contributed by the genes, environment will be having least impact on those traits. Those traits could be improved through simple recurrent selection and completion of one selection cycle requires two seasons, mean in two seasons... in very short period of time we can finish one selection cycle.

So, it is very simple method, let us discuss about it. So, in first year we have to grow in this way, different plants.. different plants are grown in the field and then based on morphology, based on phenotype, we have to identify some of the plants. Suppose these are the plants we are identifying from different rows and once we identify these plants at the early stage, then we have to bag the plants, we have to close the plants. So, that the pollen grains from other plants cannot come to this plants ok! We have to bag it. These specific plants, thereafter the selfing is done all. The selected plants are self-pollinated and their seeds are harvested separately.

So, its seed could be harvested. Maybe this is plant 1, this is plant 2, this is plant 3, this is plant 4 their seeds will be harvested separately. So, this is our original population this is our original population. So, once we have identified some plants, their selfed seeds we have collected separately, we have to go to the second year. In second year what we will do… the individual plant progenies are planted. In this way the progenies of plant 1, the progenies of plant 2, the plant 3, plant 4 it will be grown ok. And after growing these

plants, all possible intercrosses are made means some plants from plant 1 is crossed with plant 2, some from plant 2 is crossed with plant 3, some from plant 3 is crossed with plant 1.

In this way we have to make cross by ourself in all possible combinations, it means all possible intercrosses are made. Thereafter equal amount of seeds from all intercrosses are composited from each and every cross. P_1 x P_2, P_2 x P_3 and from P_3 x P_1 we are having seeds and equal amount of seeds from all intercross are composited ok! This is the intercrossing block. So, once we composite the produce of each and every intercross, then we can grow it in third year that is the composited intercross seeds are planted over here. So, if you recall, just the earlier slide, in 2 means in 2 year... one selection cycle could be completed ok! So, this is the initial selection could be completed over here, then we can go or we can start further selection again over here. We can identify some specific plants, it could be selfed, its seed could be grown as a row in next generation then we can attempt again intercross. All possible intercross could be attempted.

So, in this way the simple recurrent selection could be finished in 2 year and it could be repeated. Now, coming to the recurrent selection for general combining ability. So, what are the features? GCA and SCA we have discussed earlier they play significant role in inbred line evaluation and population development in crop breeding right? So, sorry… recurrent selection for GCA is a breeding method, breeding method to improve trait performance in plants. It uses a tester having broad genetic base.

Here a tester plant is used, means a tester population is used having broad genetic base. Means highly heterozygous populations and heterogeneous populations. So, different plants will be there, their genotypes will be heterozygous and they will be heterogeneous; means this plant's feature will be different from this plant's feature. So, the heterogeneous population so, broad genetic base is used in case of recurrent selection for GCA, recurrent selection for generating combining ability. So, we need to have a tester having broad genetic base that is very important point. So, it is crossed with a known genotype and involves half-sib crosses and we have to select parents having good

combining ability.

The parents having good combining ability is choose from here. This approach is effective for traits with moderate to high heritability. You have seen the simple recurrent selection, that was true for traits which are highly heritable in nature ok! Here it is good for those traits with moderate to high heritability ok! It aims to enhance the genetic potential of parental lines in hybrid breeding programs.

How is the genetic potential of the parental lines? Means whether they have good combining ability or not? General combining ability will be tested over here. So, it could be utilized in hybrid breeding programs. By repeatedly selecting and recombining lines with high GCA, breeders can develop hybrid varieties with improved and stable performance ok! Because in hybrid varieties, in cross-pollinated crop each and every year different mixed genetic combinations will be raised right? If our parent which are being used for hybrid selection or hybrid development, if they are having good general combining ability then in next year in the hybrid seed its performance will be stable, it will be improved.

The main features the genetic improvement of quantitative traits could be done through it. Then here selection is based on test cross performance that is very important. Test cross is initiated over here, means test cross is done in case of recurrent selection for GCA, recurrent selection for SCA as well as reciprocal recurrent selection. That test cross performance is very crucial and based on that we need to select, we need to select the parents. Then focus is on general combining ability more effective with incomplete dominance and less effective with over-dominance that is another thing. It is more effective for incomplete dominance or partial dominance, but it is less effective with over-dominance. Then... applicable to assess additive gene interactions and each selection cycles requires 3 seasons or years.

In simple recurrent selection 2 seasons or years were required, here 3 seasons or years are needed. So, let us see the process. So, in first year we have to grow the plants and

then based on phenotype we have identified some plants, let us assume we are taking this plants we are selecting these plants… P_1, P_2, P_3 these plants are being selected ok. So, over here we will be having a tester population… tester. It is an open pollinated variety, is mostly used for recurrent selection for GCA having broad genetic base ok! So, here once we are selecting these plants, first of all we need to bag these plants, means the selfing is done in these plants… the selfing is done for these plants: plant 1, plant 2, plant 3 as well as the pollen grains of this plants are used to cross different plants in the tester.

Suppose these 3 plants are crossed with P_1 pollen grains, these 3 plants are crossed with P_2 pollen grains ok! So, in this way we will be developing the test cross progeny, means the pollen grains of this plant is used to cross these 3 plants, the pollen grains of this plant is used to cross these 3 plants. In this way we have to develop the test cross progeny. So, in next year we will go to the replicated yield trial, means whatever the test cross progeny we are getting that will be analyzed in replicated yield trial in different replications in multi-locations this trial is done. And based on this replicated yield trial we need to identify some better parents may be P_1 is performing better or P_3 is performing better.

So, we can identify those lines from here means; P_1 crossed with this tester its performance. Suppose it's superior. The P_3 crossed with the tester is performing well, then we can choose it. So, once we are identifying this P_1 line, P_3 line then if you recall in first year we have done selfing of this plant also. Those selfed seeds will be grown over here in this manner… means the selfed seeds of the selected plants will be grown in this way in the intercross block in third year. And thereafter all possible intercross is being made, all possible intercross is being made and once the all possible intercross is made then one cycle is completed in 3 years. So, first year we will be identifying the plants we will selected some of the individuals, we will self it and their pollen grains will be utilized separately to cross a number of tester plants. We will get the test cross population we will evaluate the test cross population based on that we will identify this plants.

So, that in third year the selfed progeny will be grown in the intercrossing block and all possible intercross could be done and their seeds of equal amount will be composited and ultimately we can go to fourth year. Then fourth year onwards we can repeat the same process again. So, now coming to the recurrent selection for specific combining ability. First of all, recurrent selection for specific combining ability is a breeding strategy that focuses on selection of parents with desirable interactions when they are combined to create superior hybrid offspring. When they are combined to create superior hybrid offspring means specific plants are crossed, this method aims to improve the specific genetic effects that lead to outstanding traits in hybrid varieties. So, here if you recall the recurrent selection for GCA their broad genetic base was used; here we have to use narrow genetic base means here will be using a single inbred lines… is used over here as a tester parent.

So, main features the genetic improvement of polygenic traits could be done, then selection based on test cross performance is done focus will be on specific combining ability, then effectiveness in gene interaction i.e. I mean … if gene interaction is there it will be more effective, then applicable to non-additive gene action and each selection cycle requires 3 seasons or years, each selection cycles requires at least 3 seasons or years. So, let us discuss this process once again. So, in first year again we have to grow different plants in first year first we are growing different plants and from this field based on morphology we are identifying some of the plants. So, we are identifying plant number A, we are identifying plant B from here, plant A was here, we are identifying plant C over here. Suppose in first year we need to identify few plants. 100 to 200 plants are selected based on its phenotype.

Once we have identified those plants then we have to close it we have to bag the plants. So that, random crossing is prevented ok! So, that none of the plants from here can cross this, should be stopped once we are doing bagging. So, then we have to do self-pollination of this plants. The selfing is done, also in addition to that the pollen grains of this plants are collected to cross different individuals available in the tester as we have done in the GCA also. What was the difference in case of recurrent selection for GCA

we had a broad genetic base tester parents ok!

Here the tester is inbred line its type is almost similar, the genetic base is narrow. So, this inbred line suppose all these lines are crossed with plant A, this 3 plants are being crossed with plant B… in this way the test cross progeny will be developed over here. So, by crossing the selected plant with the plant available in the inbred lines as the tester, which is being used as a tester ok! So, this test cross will be evaluated in next year in second year this test cross will be used this is the second year. So, the test cross… whatever the cross we are observing it will be evaluated in multiple locations and in replication also from there we need to identify some specific combinations, means whether (PA) parent A crossing with this particular inbred is making good progeny or not ok!

So, plant A maybe it is good, suppose plant X it is also good; while plant B might be inferior. So, we do not have to consider plant B if it is inferior then we do not have to consider it further. So, in now we are coming to third year what we will do in third year? Based on this evaluation, based on second years performance in replicated yield trial we need to choose the plant A or plant X from here the plant A plant X we have chosen from here. So, we have the selfed seed of those plant right? The selfing was done in the first year also. So, those selfed seeds will be grown in this way the selfed seeds will be grown in row and thereafter we have to attempt all possible intercross.

So, that plants available over here it will be crossed with this one it will be crossed with this one while the plants available over here, will be crossed with this one will be crossed with this one in this way we have to attempt all possible intercross. And once the intercross is done in this generation we have to collect the seeds of all this intercross separately, we have to mix equal amount of seeds from this intercrosses and then we will go to next generation we can mix it and we can grow the next generation. If you recall in case of the simple recurrent selection in 2 years one cycle was completed; while in case of recurrent selection for GCA in 3 years it was completed, in recurrent selection for SCA also in 3 years the base selection process is completed. So, thereafter we can start the

second selection process again, we can identify some plants we can do selfing as well as we can cross it with the tester having the genetic constitution of a particular inbred ok! And then we can test the test cross progeny in next year and thereafter based on this test cross progeny performance we can choose the selfed seeds and we can make intercrossing among them.

So, in this way the recurrent selection for SCA that is specific combining ability is done. Thank you.