Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture 11: Mass-selection

Hello everybody, welcome to the basics of crop breeding and plant biotechnology. Course is Principles of Conventional Plant Breeding. Today we will discuss regarding the lecture that is on population improvement and mass-selection. We will discuss about the mass-selection today. So, in this particular class we will be covering the population improvement. So, in self-pollinated crop mostly we are looking to develop some homozygous plants at the end of the breeding process.

While in case of cross-pollinated crop as the population becomes heterozygous, population is mostly heterozygous and heterogeneous in nature. So, we need to improve the overall population, not a single plant improvement will be conducted over there. So, the population improvement is needed. So, from today onwards gradually we will move into the several breeding strategies or breeding approaches for cross-pollinated crop species.

Then we will discuss about the mass-selection, then what are the different objectives of mass-selection will be discussed, then different types of mass-selection will be mentioned over here, then what are the determining factor in mass-selection that will be discussed and then different procedures of mass-selection will be discussed in detail and what are the different modifications of mass-selections available without progeny testing or different modifications of mass-selection with progeny testing will be discussed. Then, what are the application, what are the different applications of mass-selection will be

covered over here. So, first we will discuss about the population improvement. So, if you think about the self-pollinated crop, there.. what is the genetic constitution in the self-pollinated crop as selfing is done years after years, generation after generation. So, it becomes homozygous.

Already you have read that selfing improves homozygosity. So, the population structure becomes homozygous in nature and it has been found that in the self-pollinated plants the homozygous balance is maintained ok! If somehow due to mutation a new allele is generated, during the course of the time in 3 to 4 generations or 5 generations those alleles will become homozygous also within the population. And finally, once we are doing selection, once we are conducting any breeding methodologies then at the end of that we are getting the homozygous individuals in case of self-pollinated species. While in case of cross-pollinated species they try to maintain heterozygous balance ok!

So, before discussing the heterozygous balance we need to know another thing that is that is 'genetic load'. Genetic load is nothing, but the sum total of deleterious alleles available in an individual ok! the sum total of deleterious allele available in an individual. So, as most of the cross-pollinated species are highly heterozygous and heterogeneous in nature. So, it has been found that in cross-pollinated species the deleterious alleles are more, more deleterious alleles are available. So, the genetic load is more.

So, if homozygosity comes over there then the population will be divided into distinct classes ok! And ultimately it is detrimental for the crop because within a field, suppose within a field 5000 plants are available. In each and every generation open pollination is taken place because those are cross-pollinated species the pollen grains from plant number 1 can go to the plant number 5, from plant number 25 it can come to plant number 5; in this way different alleles could be mixed. And the deleterious alleles if it comes in homozygous condition then it will be detrimental for the plant growth right? The yield will be minimized, the disease severity will be more. So, the cross-pollinated species.. they try to maintain the heterozygous balance within that while the self-pollinated one they maintain homozygous balance.

Now due to heterozygous balance maintenance in cross-pollinated species the inbreeding depression is also found means, if small a small a or small b small b this type of alleles will be accumulated due to inbreeding in cross-pollinated species, that will be more detrimental. So, we can see the inbreeding depression, due to inbreeding the reduction in growth yield and other parameters we can observe that is inbreeding depression. So, in cross-pollinated species the inbreeding is not generally preferred because they maintain the heterozygous balance. So, what could be the breeding methods for cross-pollinated species? First of all, in cross-pollinated species we are not targeting for a particular plant we are targeting a whole population. So, population improvement is needed.

So, that through population improvement within a field suppose 5000 plants are there. So, within those 5000 plants some dominant allele is available some recessive alleles are available for different genes. So, our target is to get better combination. Suppose for this allele different counter parts are there. Different recessive alleles different mutant alleles have been developed. It may be available .. within the population. So, our target will be summing of the desirable alleles in the next generation.

So that if D1 is better compared to D2 then we can take this type of plants; the plants having this allele. So, the frequency of the desirable alleles should be increased through population improvement and another strategy is that is development of hybrid and synthetic varieties. So, first we need to make we have to do the population improvement. So, the desirable alleles frequency will be increased then gradually we need to identify some inbred lines ok! inbred lines are developed in case of cross-pollinated species.

So, what are inbred lines? Inbred lines are developed by crossing between related individuals in cross-pollinated species, because selfing is more deleterious and selfing is the highest level of inbreeding means inbreeding.

So, somehow if the related plants, means which are related by descent, maybe one parent was common or two parents were common, if they are mated for a couple of

generations then finally we can develop inbred lines. So, that is another objective of breeding strategies in cross-pollinated species. So, in population improvement then we have to identify suitable inbred lines then using those suitable inbred lines we can go to hybrid and synthetic variety development ok! Now, in population improvement if we discuss about the population improvement, basically two methods are followed. First without progeny testing next with progeny testing.

So, without progeny testing the population improvement method, that is known as mass-selection since long time this mass-selection is done in plant breeding and this mass-selection is applicable for self-pollinated crop as well as cross-pollinated crop. In both types of crops the mass-selection could be conducted. So, for self-pollinated crop different breeding strategies we have mentioned earlier like pure line selection, pedigree method, back cross method. So, this is at the junction part you can tell. So, mass-selection could be conducted for self as well as cross-pollinated species and thereafter mostly our discussion will be related to the cross-pollinated species.

And with progeny testing, once the progeny testing is done that is known as family selection different parts are there; half-sib selection, full-sib selection gradually we will discuss those things. So, in mass-selection that is the oldest method of crop improvement and which is applicable for both self- and cross-pollinated species. So, in this method the individual plants are selected on the basis of the observable phenotypic traits, means based on the morphology we need to identify some plants from the field. It may be in self-pollinated one, it may be in cross-pollinated one from a mixed population. So, the population should be mixed otherwise which one should I select, our selection will not be effective.

So, some variation should be there the population should be mixed. So, that based on phenotype we will identify few plants. Next the seeds from these plants are then combined or bulked their seeds are bulked together ok! So, suppose we are identifying 20 plants/ 50 plants, their seeds will be combined and will grow in next generation. So, this process allows for selection of individuals with desired traits based on morphology.

Based on morphology we are identifying individual plants having desired traits, maybe the plant phenotype is up to the mark, maybe the crop size is up to the mark. So, based on that we have to do selection ok. Then gradually improving the overall genetic makeup of the population over successive generation. So, through mass-selection gradually the genetic makeup of the population is increased. Suppose I am giving just an example, suppose within a field we have capital A capital A small b small b, we have capital A capital A capital B small b and we have capital A capital A capital B capital B.

This type of combinations may be available in cross-pollinated species ok! Some heterozygous individuals, some homozygous individuals that might be there. We do not know for which genes which type of genetic combinations is being available. So, suppose based on morphology we are observing these two. So, in our next generation the small b allele is being reduced if it is deleterious ok! So, in successive generation our suitable pair a, suitable alleles frequency will be more.

So, the frequency of the better allele will be more ok! that is the objective of population improvement, that is done through mass-selection. So, let us discuss about the objectives of mass-selection. First of all, to increase the frequency of the superior genotypes from a genetically variable population. So, the population has to be genetically variable and the frequency of superior genotypes we are increasing, means the frequency of better alleles we are increasing, that is the first objective. Next one to purify a mixed population with different genotypes.

If you recall the experiment of Johanssen's who gave the pure line theory. So, he started his experiment by taking the princess bean seeds from market right? Different sized seeds were there. So, mass-selection could be effective in case of self-pollinated as well as cross-pollinated crop species. So, suppose we got this size seeds, the medium size seed and small size seeds. Suppose we have all these type of seeds in the field.

So, the population is mixed population. So, there from based on morphology we can

select some of them that is done in case of mass-selection. So then our population structure will be improved. Next one to develop a new cultivar by improving the average performance of the population. As mass-selection is mostly considered in case of cross-pollinated species.

So, the average performance of the population is determined, not for a single plant. So, let us discuss what are the different features associated with mass-selection. How will be the genetic constitution? In case of self-pollinated crop, a mass selected variety is homozygous, but heterogeneous in nature because it is a mixture of several pure lines. In last slide I was discussing about different sized princess bean. Suppose one is of this size, one is medium size, one is small size.

If we think about their genetic constitutions maybe this one was capital A capital A capital B capital B, its genotype was capital A capital A small b small b, its genotype was small a small a small b small b just assume. So, we are discussing the self-pollinated crops now. So, what will be the ultimate product of mass-selection in self-pollinated crop? We will be getting homozygous, but heterogeneous population. Here from we may identify this one or this one. So, both will be homozygous capital A capital A capital B capital B and capital A capital A small b small b both will be homozygous, but the population will be heterogeneous means different genetic combinations are there.

For different alleles the homozygosity is available. While in case of cross-pollinated crop, the variety which is the outcome of this mass-selection that is the mixture of homozygous and heterogeneous; homozygous as well as heterozygous individuals ok! Its genetic constitution will be homozygous or heterozygous, but the population will be heterogeneous in nature. In cross-pollinated one a number of plants are being grown. So, any one of them can cross another parent ok!

So, in this way the genetic constitution of the population for certain genes it may be homozygous for most of the genes it will be heterozygous ok! So, homozygous as well as heterozygous individuals will be there, but the population will be heterogeneous in

nature ok! Some plants will be tall, some plants will be medium, some plants will be relatively shorter ok! but the better should be selected that is the point. Now, let us discuss about the adaptations ok! First mass selected varieties have wide adaptations ok.

Suppose we had this particular genotype, we had this genotype and we had this genotype. We are talking about the cross-pollinated individuals the cross-pollinated species these three types of genetic constitution were available. And maybe this capital B is responsible for some disease resistance, while small b is responsible for susceptibility ok! So, we will try to select this plant and this plant based on morphology, because in mass-selection we are selecting based on the morphology, based on the phenotype in the field. So, in this case the capital B small b as well as capital B capital B is coming into the next generation its adaptability will be more.

Why? Suppose after a couple of years after a couple of years, new race came for this particular disease and the new race is being susceptible to capital B allele, but it is being tolerant to the small b allele. Suppose a new race is coming and their capital B is susceptible and small b is tolerant. So, under that circumstances this genotype will play the pivotal role, it will give you some particular yield ok! at least some yield you will be getting from here because this plant will be killed over there. So, in this way as different genetic constitutions are available, the mass selected varieties have wide adaptations. The varieties are more stable against environmental changes.

Next one, the mass selected varieties have broader genetic base. From the beginning we are talking about this one, if you think about the self-pollinated one, if you think about the cross-pollinated one the genetic base is broader means not all genes are having and the similar types of alleles are available for all the genes. So, different alleles of different genes are available that is the genetic base is more. So, its adaptability is also more in cross-pollinated species compared to the self-pollinated one because in cross-pollinated species the heterozygosity is maintained. So, if this as well as this available within the population, it may be tolerant to certain disease, it may be tolerant to certain environmental stress.

So, some balance will be there, the adaptation will be more while in case of self-pollinated it will be either this or this. So, maybe under one circumstances it will be killed, under different circumstances this plant might be killed, but in cross-pollinated one the balance could be maintained. Next one, let us discuss about the variation. The variations is in both genetic and phenotypic traits are present in the population of mass selected varieties, means whatever we are selecting based on our morphology some genetic variation and phenotypic variation might be there which facilitates their adaptability to varying environmental conditions. Means, if different genotypes are available capital A small a, capital A capital A; in this combination its adaptability will be more to varying environmental conditions and this variations arise due to natural genetic combinations and lack of strict control over mating in the breeding process.

As in cross-pollinated species the mating is not controlled, the open pollination is taken place. Any plants available in this field in cross-pollinated species, any plant can donate its pollen to a different plant. So, in this way all the genes available within this population can be mixed together, the genetic recombination could be taken place. As there is no strict control of inbreeding or close breeding, if close breeding is done then homozygosity will be increased.

So, variation will be available over there. Next one is selection. Selection is effective due to heritable variations. So, we need to target for those traits in mass-selection where those traits are controlled by heredity, by genetic factors mostly; not the environmental factors. So that, our selection will be effective.

Let us discuss about the quality. Due to genetic variety and environmental influences, mass selected type seeds have varying qualities because genetic variations are there and environmental influence might play some role over there. So, different qualities could be there, we are discussing about this sized seeds, the moderate sized seeds and small sized seeds; maybe after mass-selection we have selected this two. So, genetic variety genetic variation is there and some environmental influence might be there; because if you think

about the pod formation in a pulse crop or in any bean crop the pods … sorry the seeds which will be grown at the center part those will be larger; while those will be growing at this terminal part those will be relatively smaller. So, this kind of environmental factors might be there, but we have to initially select the plants ok! So, some environmental influences, some genetic variations might be there and to regularly prepare seeds of desired quality it could be necessary to continue with selection and refinement.

So, suppose we are getting a mixture of seeds means larger, medium, smaller are there. So, after one round of selection we can do the mass-selection again and again; we can repeat the process. So, that our quality will be improved. Next one, let us discuss about resistance we have already discussed that the mass selected variety are less prone to the attack of new diseases due to genetic diversity ok. So, if this is the constitution while another one is having this and this, this one; if it is selected its genetic constitution is more for both the genes dominant as well as recessive values are there.

So, it can tolerate the disease in a better way compared to this one. They are more resistant or tolerant to new diseases. Let us discuss about the maintenance. First periodic removal of off-type plants is very essential to maintain the yield of mass selected varieties. Means, as we are mostly discussing about the cross-pollinated species, in each and every year due to recombination some inferior plants will be generated.

So, those things could be considered as off-type; we need to remove it. So that, those inferior alleles will be, their frequency will be minimized in the population. Next let us discuss about the types of mass-selection. So, two types of mass-selections are there one is positive mass-selection another one is negative mass-selection. In positive mass-selection first the desirable plants are selected from mixed population we need to choose the desirable plants which are showing good morphology.

It may be for yield, it may be for plant height, it may be for flowering time whatever means the desirable plants are chosen only. Their seeds are mixed together to grow further generation. This process is continued for several generations and land races are

used as base material. Suppose some chickpea land races is available, some farmer is growing that chickpea genotype maybe for last 20 generations, last 20 years. So, within those land races due to mutation or due to introgression some new seeds might be available.

So, we can try to purify it through the positive mass-selection. All the seeds will be grown, there from some suitable plants will be chosen, its seeds will be mixed and grown in next year. So, in this way we can purify it. Then let us discuss about the negative mass-selection. In negative mass-selection only the undesirable off-type plants are removed from the field.

In positive we selected only the desirable one, but here we are just removing the off-types from the field and rest are allowed to grow. It is generally used for varietal purification in seed production. Suppose at the end of some process, some breeder would like to purify a variety. Suppose he has developed a major lines through mass-selection at the end, at the last cycle he is observing some plants are getting longer, some plants are showing longer plant height, some plants are extremely stunted in nature.

So, those off-types could be removed. It is generally used for varietal purification in seed production and it helps in maintaining the genetic purity, means the inferior allele could be minimized. Now the success of mass-selection will depend on these following things. First of all, variability in the base population until and unless there is variability, all the plants will be having same genotype their phenotype might be similar also if environmental influence is very less then which one should be selected that would be difficult. So, variability is very important for any types of selection in mass-selection also, as here selection is done based on the phenotype.

Next one, inheritance of character to be improved. So, the character for which we are doing the selection it may be for yield, it may be for plant height, it may be for flowering time. What character we are choosing, they should be highly inherited from one generation to next generation i.e. it should be highly heritable in nature. And third/last

one, the oligogenic recessive characters are preferred than polygenic characters ok! Oligogenic recessive characters are preferred than polygenic characters. Suppose we are choosing small a small a small b small b plants ok!

Here a and b these two genes govern the flower colour. Suppose we are trying to select the plants based on morphology, which plants are making white flower, maybe the white flower could be controlled by these two genes. So, here our selection process will be easier compared to the polygenic character. Suppose 5 genes are there a, b, c, d and e suppose 5 genes are there, then getting homozygous recessive for all of these genes in cross-pollinated species will be difficult scenario. For getting an individual having small a, small a, small b, small b, small c, small c, small d, small d and small d, small d will be difficult because it is a cross-pollinated species for at least for a couple of genes the dominant allele could come right? in each and every plant. So, if the character is controlled by polygenic traits our selection will be difficult. So, we need to choose for oligogenic traits and if it is associated with the recessive character, recessive alleles then it must have to be controlled by oligogenic traits.

Otherwise if suppose for all the genes it is in recessive homozygous conditions except one, then also we can see the inferior effect, the plants may be considered inferior… in the plant if all genes are needed, in case of that particular polygenic character ok! So, the oligogenic traits are preferred.