Course Name: Basics of Crop Breeding and Plant Biotechnology

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Lecture- 19: Population Genetics (Part - II)

Welcome back, so we will continue again. Now, we will be discussing about the random mating of individuals. Earlier we have discussed about the random fusion of gametes right, if capital A and small a gamete, they fuse together randomly. Now, we are having a Hardy-Weinberg population, ok! in this population different types of genotypes are there, suppose for A gene, two alleles are there, capital A and small a, these two alleles are available. Ok! So, how many genotypes we will be having? We will be having capital A capital A genotype, we will be having capital A small a genotype, and we will be having small a small a genotype, right? We will be having these genotypes. So, in this population having these genotypes, now we are assuming that they are intermating freely, what we had? We had the frequency of capital A allele is small p and frequency of small a allele is small q. Ok!

In addition to that, this is known to us, what will be the frequency of capital A capital A, if these two fuse together, we will be having p^2, what will be the frequency of capital A small a? Its frequency will be 2 pq, because pq + pq, and the frequency of small a small a individual was q^2 ok, that one was known to us. Now we are talking about random mating. So, in random mating capital A capital A could mate with capital A capital A plants ok, then capital A capital A it could mate with capital A small a, then capital A capital A could mate with small a small a, then capital A small a could mate with small a small a, then capital A small a could mate with capital A small a, also similar type of genotype this one, this one right? then small a small a can mate with small a small a. This type of mating is possible among these genotypes right, this can mate with this, this can mate with this and this, then it can mate with this, it can so selfing and it can mate with this, this type of combinations is possible right.

Now we will try to calculate what will be the frequency of this cross, if this cross is arises in next generation, what could be the frequency? Ok! So, what will be the frequency of this cross? Its frequency we know the frequency of this one is p^2, this one is also p^2. So, its frequency will be p^2 x p^2 i.e. p^4. We know its frequency is p^2 and its frequency is 2pq. Now the frequency of this particular cross will be basically 2 times of that $2(p^2x2pq)$.

Now, why, because out of these 2 plants capital A capital A could be used as a male parent in one cross, it could be used as a female parent in another cross. So, its probability will be multiplied with 2 means, these 2 plants can be used in a reciprocal way, right? So, its overall frequency will be $4p^3q$. Now, what will be the cross of this one, capital A capital A its frequency is p^2 and capital A small a its frequency is q^2. So, here also capital A capital A could be used as a male or female plant while, small a small a could be used as a female or male plant.

So, it will be also multiplied with $2(p^2xq^2)$ and its frequency will be $2p^2q^2$. Over here also we can see the reciprocal difference. So, the frequency of capital A small a is 2pq the frequency of small a small a will be q^2 and these things will be multiplied with $2(2pq$ x $q^2)$, because it could be used as a male or female this one could be used as a female or male. So, we are multiplying it with 2. It will be $4pq^3$.

Now over here it will be 2pq x 2pq, right? So, it will be $4p^2q^2$. Now, over here what will be the combination, over here its frequency is q^2, and its frequency is q^2 means, will be getting q^4. So, this type of things, this will be the frequency of different crosses, different possible crosses over here. Ok! Now, let us to see means, let us see that, what will be the genotype which will be produced by these different crosses? Ok!

So, 3 types of genotypes could be possible, one either it will be a capital A capital A, or it will be capital A small a, or it will be small a small a, right? So, out of this cross the cross number 1, out of this cross will be getting only capital A capital A. So, this will be the frequency of individuals having genotype, capital A capital A p^4, from here. Now over here in cross number 2 what will be produced, in cross number 2 from this particular cross we may get capital A capital A as well as capital A small a, right?

From this parent 2 types of gametes will be produced while, from this parent only one gamete capital A will be produced. So, after fusion we may get capital A capital A or capital A small a. So, whatever we are getting, the frequency we are dividing, it means it will be $2p^3q$, and it will be $2p^3q$, because we had this one, we are, we have divided it into 2 parts because, 2 types of offspring will be produced in 1: 1 ratio. Now, over here from this cross, from the cross number 3, what will be getting will be getting, only capital A small a, only capital A small a, individuals will be produced. So, over here we can write this $2p^2q^2$.

Now, we are going to cross number 4, in cross number 4, what will be getting capital A small a is being crossed with small a small a, here from only one type of allele will be produced, only small a allele will be produced, small a gamete will be produced, here from 2 gametes will be produced capital A and small a. So, after fusion we will be getting, capital A small a and small a small a in 1:1 ratio. So, we are dividing it into 2 parts, we will be getting $2pq^3$ and $2pq^3$, right? it will be distributed into 2 parts. Now, let us discuss the cross number 5, over here, over here this is a typical type of cross, monohybrid cross you can say. Ok! 2 types of gametes will be produced from here, capital A and small a, 2 types of gametes will be produced from here capital A small a, after fusion will be getting 3 different genotypes capital A capital A, capital A small a, as well as small a small a, in 1: 2: 1 ratio, isn't it?

If you recall the monohybrid cross 1: 2 : 1 genotypic frequency will be available, capital A capital A ,capital A small a, and small a small a. Ok! That will be true for this cross number 5. So, here whatever we are getting we will distribute it accordingly, capital A capital A, it will be p^2q^2. Then capital A small a, it will be $2p^2q^2$ and small a small a sorry, will be p^2q^2. Now let us discuss, the cross number 6, here small a small a is being crossed with small a small a, only 1 type of progeny will be produced, only single types of gametes are produced from these 2 parents. Ok!

So q^4 will come over here q^4. Now let us see, this one was our original population it was random mating; after mating we got these progenies. So, let us see next generation, what frequency we are observing? For this one, what we are getting we are getting, p^4+ $2p^3q$ $+p^2q^2$ ok. It means, $p^2(p^2 + 2pq + q^2)$, right?

So, it is equivalent to $p^2 (p+q)^2$; p^2 X1; because we know that p + q = 1. It means in next generation we are getting same frequency of capital A capital A, that one was p^2 in the earlier generation. Now let us think about this one here we are getting $2p^3q + 2p^2q^2 + 2pq^3 + 2p^2q^2$. If we take $2pq (p^2 + pq + q^2 +pq) = 2pq (p^2 + 2pq + q^2) = 2pq (p+q)^2 = 2pq$, right, because this is (p+q=1), over here in case of small a small a. ok! So, in this scenario $2pq^3 + p^2q^2 + q^4 = q^2$ if we take as common it will be $q^2 (2pq + p^2 + q^2)$,right means, $q^2(p + q)^2 = q^2$.

So, in this way we can tell that the genotype frequency, as well as the gene frequency remain constant, generation after generation, if the random mating is taken place among the individuals within a population according to, Hardy-Weinberg equilibrium, but there should not be any selection mutation, migration or genetic drift. Now, this is the basics of Hardy-Weinberg population, we are assuming, that all the individuals in the population are in diploid condition, diploid means each chromosome are having 2 copies, ok, each set of chromosomes is having 2 copies basic set, is having 2 copies means diploid in nature. So, let us assume, this is a particular chromosome suppose, this is chromosome 7 and 7′ i.e. the homolog of chromosome 7. Ok! So, in these 2 chromosomes from our initial discussion, if we think about our initial discussion a particular allele is available over here this is supposed, the capital A allele and its mutant allele is small a. So, in this way it will be available in the population, once the gamete will be formed the frequency of this particular allele, if it determines the seed shape round, and if determines the seed shape wrinkle, it will be having a particular frequency, and that frequency will be maintained because during gamete formation this particular chromosome will move to a particular gamete while, this chromosome will move to a different gamete and they may freely intermate among themselves. Ok!

So, what we got from here random union of gametes is taken place. So, according to that, $p + q = 1$, where, p is the frequency of the dominant allele, p is the frequency of the dominant allele generally, for the dominant allele we determine we think the frequency is small p, and for recessive allele its frequency is generally considered as small q. Ok! Now in case of genotypes i.e. in Hardy-Weinberg equilibrium, there it will be $p^2 + 2pq + q^2 = 1$, where p^2 is the frequency of homozygous dominant individuals, q^2 will be the frequency of homozygous recessive individuals, and 2pq is the frequency of heterozygous individuals, what we have discussed earlier. Now, let us discuss that how many genotypes will be there for two or more allele of a gene. Ok! Earlier, we were discussing about two different alleles of a particular gene, ok, suppose a gene has two allele capital A and small a, its frequency p, its frequency was q, right?

So, in this way we are able to calculate the frequency of different genotypes, ok! and how many genotypes will be there? Here we found that three genotypes are there. So, maybe we can write the three genotypes in this way, two alleles are available of a particular gene, and before that we are adding one. So, we are getting three genotypes if two alleles are available, if three alleles are available, what will be the scenario, suppose we are telling that for B gene three alleles are there, for B gene three alleles are there B_1 B_2 and B_3 these three alleles are there. Ok! So, different combinations will be there means if different combinations are there, how can we calculate it, an example has been given over here, capital A capital B and capital C these three alleles have been considered for a particular gene. Let us forget about this, suppose a gene X it has three alleles capital A capital B and capital C, three different alleles are produced for this particular gene X it's just a name right?

So, the frequency of capital A is small p the frequency of capital B is small q and frequency of capital C allele is small r means, those are not capital means those are different alleles the frequency of A allele, B allele, and C allele is small p small q and small r. While the same allele will be available, as male gametes and female gametes and upon fusion we may get this type of combination capital A capital A these two could fuse, capital A capital B this type of combination will be there, capital A capital C this could arise, capital A capital B could arise, then fusion of capital B capital B could be raised, in this way, these different constitutions could be available from this checker board. Now, what will be the different types of genotypes available over here? Ok! Here 3 alleles are available of a particular gene. So, before that we will be 1+2+3, in this way 2 alleles are available, we just added 1+2, here three alleles are available.

So, we have to add two previous numbers 2 and 1 (1+ 2+ 3). So, it will be equivalent to 6. So, are we getting six different types of genotypes over here, yeah, because capital A capital A will be produced, capital A capital B will be produced, second type capital B capital B will be produced, third type then capital A capital C will be produced, fourth type capital A capital C this is fourth type, capital B capital C will be produced, this is fifth type and capital C capital C will be produced, that is sixth type. So, six different types of genotypes will be produced, if three alleles are there for a particular gene, but we must have to consider that the scenario will be true for diploid organisms means, in one plant suppose this is the homologous chromosome and this is another plant its homologous chromosome. So, in one plant suppose capital A capital A these two alleles are there, in one plants capital A capital B alleles are there means, if these are the different alleles of gene X.

So, in this way in the same homologous chromosome at the same loci those alleles should be available.