Course Name: Basics of Crop Breeding and Plant Biotechnology

Professor Name: Dr. Joydeep Banerjee

Department Name: Agricultural and Food Engineering

Institute Name: Indian Institute of Technology Kharagpur

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Lecture-02: Mendelian Genetics

Welcome back. So, we will continue again. Now gradually we are discussing the Law of Segregation once again. So, suppose we are having two parents the parent 1 and parent 2. The parent 1 having one pair of chromosomes, chromosome 1 and 1' while the parent 2 is also having one pair of chromosomes. In parent 1, suppose over here, capital A allele is available ok, the capital A form of a particular gene is available.

So, and in its homolog also capital A is available ok. So, it will be homozygous dominant, it will be homozygous kind of thing, means similar type of allele is available in parent 1. Let us assume in parent 2, small a is available over here and in its homolog chromosome also small a allele is available. So, it is also homozygous, let us assume this is the recessive allele ok.

So now, if the crossing is made between parent 1 and parent 2. So, we will be having F_1. In F_1, 1 chromosome will be coming from parent 1 and 1 chromosome will be coming from parent 2. Because the chromosome number is half during meiosis, after meiosis the fertilization is taken place and finally, we are having this F_1 generation. So, in F_1 generation one set of chromosomes is coming from the parent 1 and another set of chromosomes is coming from parent 2. So now, suppose it is going to next generation ok.

So, this F_1 individual is going to next generation, it is forming gametes, how the gametes will be formed? So, if you think about the metaphase I, what happened earlier in

metaphase I? The homologous chromosomes were separated. So, you can see 2 homologous chromosomes are here, one is having capital A allele and one is having small a allele. Those will be staying here in the metaphase plate in anaphase I, basically it will be separated, capital A will be separated in one way and small a will be separated in another way. And in telophase I, basically 2 different cells are formed, one will be having capital A allele, one will be having small a allele.

Next we are progressing to metaphase II, in metaphase II here suppose small a was here, here, capital A was here, from here 2 small a available in 2 chromatids. So, gradually it will be separated gradually, it will be separated during anaphase II. While from this cell, gradually capital A and capital A available on 2 different chromatids will be separated and finally, once we will move to the telophase II, 4 cells will be produced. Ok! From this first 2 cells, from these first 2 cells will be having small a allele and from these 2 cells, will be having capital A allele. So, that is the Law of Segregation what is that, I am rephrasing it once again. 2 alleles staying together in F_1 generation they do not mix with one another, but during gamete formation in next generation they are separated in equal proportion, that is the law of segregation. Ok!

Now, after Law of Segregation, we should discuss about the monohybrid cross. So, monohybrid cross, mono name means 1. So, this cross is associated with a particular gene. Suppose, we have a particular parent where capital P capital P is there, that is 2 dominant alleles of a gene, it is giving purple color flower. While 2 recessive allele of a particular gene, the small p allele is there, that is making small p small p genotype and it is observing that the flower color is white.

So, if we make a cross between these 2 in F_1,will be having capital P small p, because capital P will be coming from this parent and small p will be coming from this parent, the chromosome number will be half and in F_1, definitely we will get capital P small p and as capital P is the dominant allele it will govern the phenotype. So, we can see the purple flower in F_1 generation. Now in monohybrid cross, 2 hybrids, capital P small p is a hybrid. So, cross is made between 2 hybrids or we can do selfing of a particular hybrid.

If you do selfing, this hybrid plant will make male gamete as well as it will make female gamete also.

So, now let us see what is happening. In F_2 generation, if selfing is made in this particular plant. So, the male gametes and female gametes will be produced. These are the male gametes will be having from this plant, capital P and small p while; the female gametes will be having also capital P and small p. Now let us think that random fusion of gametes are taken place.

So, this capital P would fuse with capital P to make capital P capital P. We are observing that it is producing purple flower. If small p fuse with capital P will be having again capital P small p, it will be having purple flower as capital P is dominant in nature. Now, if capital P is fused with small p, will be having capital P small p, there also we can see a purple flower and if small p and small p fuse together then we can see small p small p individuals having white flower. So, this is the monohybrid cross.

Now, if you see what is the phenotype in a monohybrid cross according to Mendelian principle? If you think about the phenotype, 3 purple flowers are there 1, 2 and 3 and 1 white flower is there. So, the phenotypic ratio will be 3:1. If you think about the genotypic ratio, that is 1: 2: 1 because genotype 1 genotype is capital P capital P, 2 genotype is capital P small p and 1 genotype is small p small p. So, 1: 2: 1 is the ratio of genotypic ratio according to monohybrid cross.

Now, gradually we are moving into the Law of Independent Assortment. So, Mendel postulated two laws, one is Law of Segregation, we have discussed, then Law of Independent Assortment. So, according to this law, how different traits….. means the monohybrid or Law of Segregation was associated with a particular trait ok. So, according to independent assortment, how different traits or alleles of different genes segregate and assort independently of one another during the formation of gametes, those things will be discussed. Means, two traits are considered together and how they are segregating during gamete formation.

So, the key points of this law we will be discussing first allele separation, next is independent assortment and third one is random alignment. Ok! So, first let us discuss about the allele separation. So, let us assume as I have mentioned earlier, during the Law of Independent Assortment discussion, we will be considering at least two genes, means more than one genes are considered. So, suppose, we are having two parents one is having genotype capital R capital R, one is having capital R capital R capital Y capital Y genotype and another one is having small r small r small y small y genotype. Ok! So, just we can assume that two sets of chromosomes are there. Ok! chromosome number 1, 1' and 2, 2'.

So, in 1 and 1', the capital R capital R allele is available and in 2, 2' the capital Y capital Y allele is available in the parent 1. While in the parent 2, if you think about these two chromosomes, over here small r small r allele is available and over here small y and small y alleles are available, in this way, two different parents are there. So, now the gametes are formed, the chromosome number will be half capital R and capital Y will be coming over here and from another plant the small r small y will be coming. So, after fusion of this gametes, finally, we are having the F_1 capital R small r capital Y small y because capital R capital Y will be coming and small r small y will be coming from here. So, after fusion will be having capital R small r capital Y small y. Ok!

So, this is the F_1 generation. Now, we are trying to make the gametes from this F_1 for next generation, ok! So, basically, we are trying to make the gametes from F_1 generation to generate F_2 individuals, to generate F_2 populations. So, from here two types of gametes will be produced by them… I mean four types of male gametes will be produced and four types of female gametes will be produced also, right? So, capital R capital Y, capital R small y, small r capital Y and small r small y.

So, these type of gametes will be produced by male and this type of female gametes will also be produced capital R capital Y, capital R small y, small r capital Y and small r small y. Now, we are assuming that random fusion of gametes are taken place. So, what is

happening let us see. So, after fusion of these capital R capital Y and capital R capital Y, will be having capital R capital R capital Y capital Y after fusion of these two will be having capital R capital R capital Y small y. After fusion of these two, will be having capital R small r capital Y capital Y.

After fusion of these 2, will be having capital R small r, capital Y small y, after fusion of these 2 will be having capital R capital R, capital Y small y. After fusion of these 2, will be having capital R small r capital Y capital Y. After fusion of these 2, will be having capital R small r capital Y small y. In this case, we will see capital R small r capital Y small y. In this case, we will see capital R, from here small r capital Y and small y.

You guys can try to do this fusion by yourself also. If you carefully see all of these genotypes what I have written here, all is having at least one capital R and at least one capital Y. So, now capital R is responsible for round colored seed, sorry, round seed type ok! So, you can see in all this case, the round seeds are available. While its recessive form small r.

So, capital R is governing round seed type and small r is governing wrinkled seed type. While the capital Y is governing yellow cotyledon and small y is governing green cotyledon, ok! So, in all this cases which is mentioned here is having capital R that is responsible for round seed type and capital Y that is responsible for yellow cotyledon color. Now, let us see about the next set of fusions. Because we will be having capital R capital R small y small y.

In this case, we will be having capital R small r small y small y. In this case, we will be having capital R small r small y small y. In these three cases, we are having capital R at least 1. So, the seed shape is round, but for y gene we are getting small y small y. So, all are green in nature, because small y is responsible for green character, green cotyledon color. Ok!

Now, in these three cases what will be the genotype? It will be small r small r capital Y

capital Y. In this case, it will be small r small r capital Y small y. In this case, it will be small r small r capital Y small y. So, in these three cases at least one capital Y is available capital Y is dominant. So, we are getting yellow color, but for R gene the seed shape we are getting small r small r in all these three cases.

So, these three are wrinkled in nature not round these three are wrinkled in nature. In last case, we will be having a particular genotype where small r small r small y small y will be available. So, this is the recessive homozygote for both the genes. The recessive traits wrinkled, the recessive trait green for both the gene, the recessive alleles will be available in two copies. Here we will see the green color as well as wrinkled seed type. Ok!

So, this will be the type of F_2 generation, means if selfing is done in F_1 then this type of gametes will be produced, this type of gametes will be produced and finally, this type of phenotype will be observed in next generation. So, ultimately, what observation we are getting that phenotypically we are getting 9 round and yellow seed, 3 round and green seed, 3 wrinkled and yellow seed and 1 wrinkled and green seed, in this way that is the phenotype. Ok! Genotypically, you can see this type of difference, a lot of genotypic difference is there. So, now, this thing we have discussed about. Then we have discussed about the allele separation. Now, we are talking about the independent assortment.

So, two genes are considered here, first of all for seed shape it was either round or wrinkled, ok! Suppose, if you think about the F_1, in F_1 the genotype was capital R small r capital Y small y this was the genotype of the F_1 in the previous slide. So, suppose we are just considering the capital R small r gene. We are just considering the seed shape. So, how the segregation of this particular gene could be taken place? So, for this F_1 two types of gametes will be produced, male gametes capital R and small r, female gametes also capital and small r, due to their fusion will be having capital R capital R, two capital R small r and one small r small r.

So, for seed shape, what will be the frequency? How many of them will be round? This

one will be round capital R capital R, these two will also be round because capital R allele is there. So, $3/4^{th}$ individuals will be round, while $1/4^{th}$ will be, $1/4^{th}$ will be wrinkled in nature. So, the ratio is 3:1. How capital Y small y will be segregated let us see, that is responsible for color, cotyledon color. Here also, two types of male gametes and two types of female gametes could be produced.. capital Y small y and capital Y small y it will be small y.

So, after fusion, will be having capital Y capital Y, will be having capital Y small y will be having capital Y small y and small y small y. So, ultimately for cotyledon color, this one, this one as well as this one all will be having at least one dominant allele that is responsible for yellow cotyledon. So, in $3/4^{th}$ case, will be observing yellow cotyledon while in $1/4^{th}$ case will be observing green cotyledon, isn't it? The ratio will be 3:1. Now, if these two genes are considered together, here we have considered separately. Now, we are just calculating the probability together, what could be the probability of getting round and yellow, what could be the probability of getting round and yellow together it will be $3/4 \times 3/4$.

So, $3/4 \times 3/4$ it will be 9/16 the round and yellow the probability of round and green, round and green it will be $3/4 \times 1/4$ that is 3/16, then wrinkled yellow, what will be its probability, wrinkled is 1/4 yellow is 3/4. So, its probability will be 3/16 and wrinkled green its probability will be $1/4 \times 1/4$ that is 1/16. And if you recall in the last slide, the round yellow was 9, the round green was 3, the wrinkled yellow was 3 and wrinkled green was 1. So, this ratio we observed in the last slide. So, this is the independent segregation of two different genes.

Now, we will discuss about the random alignment ok. If the chromosomes are aligned randomly, how different gametes could be produced from there. Ok! So, according to random alignment, you know each and every chromosome different loci are there. Different locus of each and every genes are available. And they could be aligned differentially in metaphase I during meiosis, because in meiosis, I have mentioned about two phases the meiosis I and meiosis II, in meiosis I and meiosis II. So, in meiosis I

basically the chromosome number is separated, while in meiosis II the chromosome number remain intact.

So, if you see about the arrangement 1 and arrangement 2 what will be happening? In arrangement 1 if you see carefully during metaphase I, suppose in the two longer chromosome the capital R allele is here and small r allele is here. Ok! While in these two shorter chromosomes, capital Y allele is here and small y allele is here and it is staying in this way in the metaphase plate. So, in anaphase I, it will be separated in such a way that capital R and capital Y will be going in this pole and small r and small y will be going in this pole. Ok! So, thereafter once the metaphase II will be formed, we will be having capital R capital R in the two chromatids of a chromosome and capital Y capital Y in the two chromatids of a chromosome. And therefrom, two gametes will be formed all will be capital R capital Y, capital R capital Y.

While from this end small r small y is separated and these two chromatids, finally, will be separated and will be having small r small y and small r small y. So, ultimately, initially we had capital R small r capital Y small y right. What we are having? We are having capital R capital Y and small r small y. These two types we could get from chromosome arrangement 1. So, now if the arrangement differs here; the arrangement 2 is there.

Here, in the first case, the alignment is same, the capital R in this side and small r in this side. While for the chromosome number 2, the small y is here and capital Y is here. This is the arrangement in the metaphase plate. So, in this side, small r capital Y will be going and in this side capital R and small y will be going right? So, once the gamete is formed hereform will be having capital R small y capital R small y and herefrom will be having small r small y small r small y.

So, this is the metaphase I that basically determines this type of differential arrangement. So, herefrom capital R small r capital Y small y was there and therefrom we are having the gametes capital R small y and small r capital Y. So, in total, from this individual we

can get four types of gametes capital R capital Y, small r small y, capital R small y and small r capital Y isn't it? This two from arrangement 2 and this two from arrangement 1. So, in this way, due to random alignment we can see that two or more different genes which are present in different part of the chromosome that can, that can form the gamete separately that is the actual things associated with the independent assortment. Ok!

So, up to this we will discuss today. So, thereafter, we can discuss the next part means how the other things are associated with Mendelian genetics? Ok! Thank you.