Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Third Year)

Subject: Botany

Course Code: BOC 108

Course Title: Cytogenetics and Plant Breeding

Unit: Unit 10 - Quantitative Inheritance

Module Name: Quantitative inheritance: Concept and mechanism

Module No: 52

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Notes

Mendel performed his experiments with garden pea plants which was concerned with the traits having complete dominance and hence the laws of inheritance were proved. Mendel's laws explained the inheritance patterns of contrasting forms of a trait. These traits showed discontinuous variation. The plants were either tall or short; flowers were either purple or white, axial or terminal in position and the seeds were either wrinkled or smooth. These were regarded as qualitative traits. But, the phenotypic traits of different organisms may be of two kinds; Qualitative traits and quantitative traits.

The qualitative traits are responsible for the distinct phenotypes and are said to exhibit discontinuous variations. Qualitative traits may be under the genetic control of two or many alleles of a single gene with little or no environmental modifications to obscure the gene effect.

There may be some phenotypes like the skin colour in humans which cannot be placed in two extreme categories but show a spectrum of different phenotypes in a population. Such characters are called qualitative characters. Quantitative characters are determined by two or more pairs of genes. They have an additive or cumulative effect. These genes are called cumulative genes or polygenes or multiple factors.

The organisms possessing quantitative traits have a range of phenotypes and are said to exhibit continuous variations. A single phenotypic character governed by more than one pair of genes is called polygenic character or quantitative character.

In polygenic inheritance or quantitative inheritance each gene has a certain amount of effect. So, more is the number of dominant gene, the greater is the expression of the character. Polygenic character or quantitative characters show continuous variation. Polygenes are two or more different pairs of nonallelic genes, present on different loci, which influence a single phenotypic character and have an additive or cumulative effect.

The quantitative traits are economically important measurable phenotypic traits of degree such as height, weight, skin pigmentation, susceptibility to pathological diseases or intelligence in humans. They are also called as **metric traits**. They do not show clear cut differences between individuals and forms a spectrum of phenotypes which blend from one type to another to cause continuous variations. In contrast to qualitative traits, the quantitative traits may be modified variously by environmental conditions and are usually governed by many genes each contributing such a small amount of phenotype that their individual effects can't be detected by Mendelian methods but only statistical methods.

This kind of inheritance is known as Inheritance of polygenes/ quantitative inheritance/multiple factor inheritance/multiple gene inheritance/ Polygenic inheritance. The branch of genetics which deals with the inheritance of quantitative traits is called "Quantitative Genetics". Quantitative genetics is based on measurements of individuals within a population of organisms.

Multiple Factor Hypothesis

British statistician and geneticist Ronald A. Fisher gave the Multiple Factor Hypothesis. For polygenic traits, the phenotype of an individual depended on its genotype at all relevant loci with each allele adding or subtracting a small amount. Fisher also proposed that many environmental factors influenced the trait by adding or subtracting effects in a manner similar to that of all genetic loci.

Fisher's Hypothesis explained the following features:

The multiplicity of factors contributing to a trait accounted for the variability among phenotypes. This variability arises from the large number of genotypes and environments that are possible when many factors are involved.

Fisher's hypothesis suggested an explanation for the bell-shaped nature of many frequencies distribution. If a trait is influenced by two types of alleles, plus and minus, defined according to whether they added or subtracted an effect, Mendelian segregation should lead to many individuals carrying only plus or minus. Thus, extreme values of the trait, corresponding to the trait, of the frequency distribution should be rare whereas intermediate values are close to the mean should be common.

Fisher's principle of additivity explained why offspring of crosses between phenotypically different parents often had intermediate phenotypes. One parent might have a large number of plus alleles, the other a large number of minus alleles, and their offspring would have a mixture of both types. Such an offspring would therefore be expected to be phenotypically in between the parents.

Main points of Fisher's Hypothesis

- The characters that exhibit continuous variation can usually be quantified by measuring, weighing etc.
- Two or more pairs of genes located throughout the genome account for the hereditary influence on the phenotype in the additive way, because many genes will be involved.
- Each gene locus may be occupied by either an additive allele which contributes a constant amount to the phenotype, or by a non- additive allele which does not contribute quantitatively to the phenotype.
- The total effect on the phenotype of each additive allele, while small is approximately equivalent to all other additive alleles at other gene sites.
- Together the genes controlling a single character produce substantial phenotypic variation
- Analysis of polygenic traits requires the study of large number of progeny from population of organisms.