Course: Fundamentals of Genetics
Class: - Ist Year, IInd Semester
Lecture No. XIII
Title of topic: - Gene interaction- Pleiotropism and Pseudo alleles
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Pleiotropism

Not only is it true that a phenotype can be influenced by many genes, but it is also true that a gene can influence many phenotypes. When a gene affects many aspects of the phenotype, it is said to be **pleiotropic.**

"The phenomenon of multiple phenotypic expression of a single gene is called pleiotropism."

For example:-

1. The tomato mutant gene *'ls'* suppresses the growth of

a) The axillary shoot

b) The development of petals in flower

c) It produces apocarpous pistil and dilatory anthers. According to Williams this gene suppresses the growth of meristematic tissue at the apex regardless of its position. For this reason, a single gene produces many fold effects.

2. In human, the gene for disease ***phenylketonuria*** has pleiotropic effect and produces various abnormal phenotypic traits, collectively called syndrome. For example, the affected individuals have excess quantity of amino acid ***phenylalanine*** in their urine, cerebrospinal fluid and blood. They have short stature, mental retardation, widely spaced incisors, pigmented patches on skin, excessive sweating and non-pigmented hairs and eyes.

Pseudo alleles (Morgan 1928 and Lewis 1948)

Pseudo alleles refer to distinct, but closely linked and functionally related genes. A cluster of pseudo alleles is known as pseudo allelic series or complex locus or a complex region.

When two or more genes have functional similarity they may behave like two or more alleles of the same gene. Such pseudo alleles can usually be identified as individual genes by selective breeding studies.

Characteristics of pseudo alleles

1. Pseudo alleles govern different expressions of the same character.
2. Pseudo alleles occupy a complex locus, which is divided into sub loci.
3. They exhibit low frequency of genetic recombination by crossing over.
4. They exhibit cis-trans position effect.

Example:- Red eye colour of Drosophila has different mutants like white and apricot. They affect pigmentation i.e. affect the same character. So, they are allelic. They can undergo recombination, i. e. they are nonallelic.

Iso alleles

An allele that is similar in its phenotypic expression to that of other independently occurring allele is known as isoallele. Isoalleles are two types.

a. **Mutant isoalleless**: Such alleles act within the phenotypic range of a mutant character.

b. **Normal isoalleles**: such alleles act within the phenotypic range of a wild character.

Lecture No. XIV

Gene Interaction: - "The phenomenon of two or more genes affecting the expression of each other in various ways in the development of a single character of an organism is known as gene interaction."

Frequently, genes exhibit independent assortment but do not act independently in their phenotypic expression; instead, the effects of genes at one locus depend on the presence of genes at other loci. This type of interaction between the effects of genes at different loci (genes that are not allelic) is termed **gene interaction**.

Most of the characters of living organism are controlled/ influenced/governed by a collaboration of several different genes.

Types of gene interaction:- Gene interaction are two types-

a) Allelic/non epistatic gene interaction- This type of interaction gives the classical ratio of 3:1 or 9:3:3:1.

b) Non allelic/ epistatic gene interaction- In this type of gene interaction genes located on same or different chromosome interact with each other for their expression.

Epistasis:-

When two or more genes influence a trait, an allele of one of them may have an overriding effect on the phenotype. When an allele has such an overriding effect, it is said to be *epistatic* to the other genes that are involved; the term **epistasis** comes from Greek words meaning to "stand above".

"Epitstasis is a phenomenon in which the expression of one gene is masked or prevented by another non-allelic gene." The gene which prevents the expression of another gene is called epistatic gene, the gene whose expression is masked is called hypostatic gene.

Epistasis should not be confused with dominance. Epistasis is the interaction between different genes (non-alleles) where as dominance is the interaction between different alleles of the same gene.

Epistatic interactions (Modification of 9:3:3:1 ratio)

When epistasis is operative between two gene loci, the number of phenotypes appearing in the offspring from di-hybrid parents will be less than four.

here are six types of epistatic ratios commonly recognized, three of which have 3 phenotypes and the other three having only 2 phenotypes.

(i) Dominant epistasis or Masking gene interaction (12:3:1)-

In dominant epistasis, a dominant allele at one locus can mask the expression of both alleles (dominant and recessive) at another locus, it is known as dominant epistasis.

When the dominant allele at one locus, for example A allele, produces a certain phenotype regardless of the allelic condition of the other locus, then the 'A' locus is said to be epistatic to the B-locus. Furthermore, the dominant allele A is able to express itself in the presence of either B or b, then this epistasis is said to be dominant epistasis. Only when the genotype of the individual is homozygous recessive at the epistatic locus (aa) can the alleles of the hypostatic locus (B or b) be expressed.

Thus the genotypes A-B- and A-bb produces the same phenotype, where as aaB- and aabb produce two additional phenotypes. The classical 9:3:3:1 ratio becomes modified into a 12:3:1 ratio.

Example-In sorghum, the nature of the grain is either pearly or chalky. When a plant with pearly grains and another with chalky grains are crossed the F_1 is pearly. In the F_2 there is segregation of 3 pearly: 1 chalky. Similarly, the colour of the grain either red or white. When a plant with red grains in crossed with white grains the F_1 in red and the F_2 shows a segregation of 3 red: 1 white. Red colour of the grain masks another character i.e., the pearliness or chalkiness of grain. When the colour of the grain is white, it is possible to say whether it is pearly or chalky but when the colour is red it is not possible to find out whether it is pearly or chalky.

(ii) Recessive epistasis (9:3:4) or Supplementary gene interaction

In recessive epistasis the recessive allele of ne locus masks the expression of both dominant and recessive alleles at another locus. It is known as recessive epistasis.

Supplementary gene

Gene which by itself has no effect but qualitatively alters the effect of another gene is the supplementary gene. If the recessive genotype at one locus (aa) suppress the expression of alleles at the B-locus, the A-locus is said to exhibit recessive epistasis over the B locus. Only if the dominant allele is present at the 'A' locus can the alleles of the hypostatic B locus be expressed. The genotypes A-B- and A-bb produce two additional phenotypes. The 9:3:3:1 ratio becomes a 9:3:4 ratio.

Example- Coat colour in mice is either agouti, black or albino. Agouti Colour is commonly occurring one (wild type) and is characterized by colour banded hairs. The hair near the body is gray followed by yellow band and finally the distal part is either black or brown. The agouti and black coat colour in mice is controlled by 'A' and 'a' alleles respectively. Another non allelic dominant gene 'C' controls the production of an enzyme which converts a colourless precursor into melanin pigment and is required for the production of any pigment. The homozygous recessive 'cc' lacks the enzyme, no melanin is produced and the animal is white coated.

(iii) Duplicate genes with cumulative effects (9: 6: 1) or Additive gene interaction

Two non-allelic genes have similar effect when they are separate, but produced enhanced effect when they come together. Such gene interaction is known as duplicate genes with cumulative effect.

If the dominant condition (either homozygous or heterozygous) at either locus (but not both) produces the same phenotype, the F_2 ratio becomes 9: 6: 1.
where the epistatic genes are involved in producing various amounts of substance such as pigment, the dominant genotypes of each locus may be considered to produce one unit of pigment independently. Thus genotypes A-bb and aaB produce one unit of pigment each and therefore have the same phenotype. The genotype aabb produces no pigment, but in the genotype. A-B- the effect is cumulative and two units of pigments are produced. The 9 : 3 :3 :1 ratio is modified into 9 : 6 : 1 ratio.

Example-In a Cross between two light purple grains *i.e.*, P_1 and P_2 the F_1 was with dark purple grains. The F_2 segregated for 9 dark purple: 6 light purple: 1 white. Light purple of the grains is evidently due to the presence of a dominant gene P_1 or another dominant gene P_2. The two non-allelic dominant genes P_1 and P_2 possess an additive effect and the colour of the grain is dark purple when the genes P_1 and P_2 are present together. When both the dominant genes are absent, the colour of the grain is white.

iv. Duplicate Dominant genes (15:1) or Duplicate gene interaction

Duplicate genes are two pairs of alleles either alone or together produce the same effect. They are identical genes but are situated on two different pairs of chromosomes. Each gene is dominant to its allele but does not add to the effect of the other.

Example- Floating habit in rice. When a non floating rice strain is crossed with a floating strain, the F_1 is non floating. The F_2 segregates for 15 non floating and 1 floating habit. The presence of a single dominant allele of any one of the two genes governing the trait produces the dominant phenotype i.e., non floating habit while recessive phenotype i.e., floating habit is produced only when both the genes are in the homozygous recessive state. The 9: 3: 3: 1 ratio is modified in to a 15:1 ratio if the dominant alleles of both loci each produce the same phenotype without cumulative effect.

(v) Duplicate Recessive Genes (9:7) or Complementary Gene Interaction

Complementary genes

Non allelic genes that act together to produce a phenotype different from that produced by either alone.

In the case where identical phenotypes are produced by both homozygous recessive genotypes, the F_2 ratio becomes 9:7. The genotypes aa B-, A-bb and aabb produce one phenotype. Both dominant alleles, when present together, complement each other and produce a different phenotype.

Example- In sweet pea, the development of purple flowers requires the presence of two dominant genes P_1 and P_2. When either P_1 and P_2 or both the genes in homozygous recessive condition produce white flowers. Since both the dominant alleles P_1 and P_2 when present together, they complement each other and produce a new phenotype and hence called complementary genes.

vi. Dominant and Recessive interaction (13:3) or Inhibitory gene interaction

In this type a dominant allele at one locus can mask the expression of both alleles at second locus. Only two F_2 phenotypes result when a dominant genotype at one locus (e g. A-) and the recessive genotype at the other (bb) locus produce the same phenotypic effect. Thus A-B-, A-bb and aabb produce one phenotype and aaB- produces another in the ratio of 13:3.

Example - Node colour in sorghum. In sorghum, when crosses were made between plants with purple node and green node, the F_1 was with purple node. The F_2 segregated for 3 purple and 1 Green. In certain other crosses between plants with purple node and green node, the F_1 was with green node. Since purple is dominant over green, the F_1 is expected to be purple, but it is observed to be green, the gene for purple node is unable to express itself probably because of the presence of another gene. This gene is called inhibitory gene. It is capable of inhibiting the production of purple colour. Plants are purple, only if they possess the gene for purple colour, in the absence of the inhibitory gene. In the presence of the inhibitory gene, plants with the gene for purple are unable to exhibit the purple colour and are only green. Plants, which do not have the gene for purple colour, are also green whether they have the inhibitory gene or not.