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# Lecture – 13

## Qualitative & Quantitative traits and Multiple factor hypothesis

**by**

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# QUALITATIVE AND QUANTITATIVE CHARACTERS



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The phenotype of any individual can be classified into two types:

1) Qualitative characters and 2) Quantitative characters

**1. Qualitative characters:** The characters that show discontinuous variation and which cannot be measured easily are known as qualitative characters. These are also known as classical mendelian traits.

Eg: Corolla colour – Red      white or pink → no continuous variation

Seed shape – Round      wrinkled → variation is not continuous

**2. Quantitative characters:** those showing continuous variation and which can be measured easily. These characters are also known as metric traits.

The data obtained from such characters is known as quantitative data. This data can be subjected to statistical analysis and the branch of science which deals with such analysis is known as quantitative genetics or biometrical genetics.

Eg: Yield, Plant height



aa bb cc  
(pure white line)

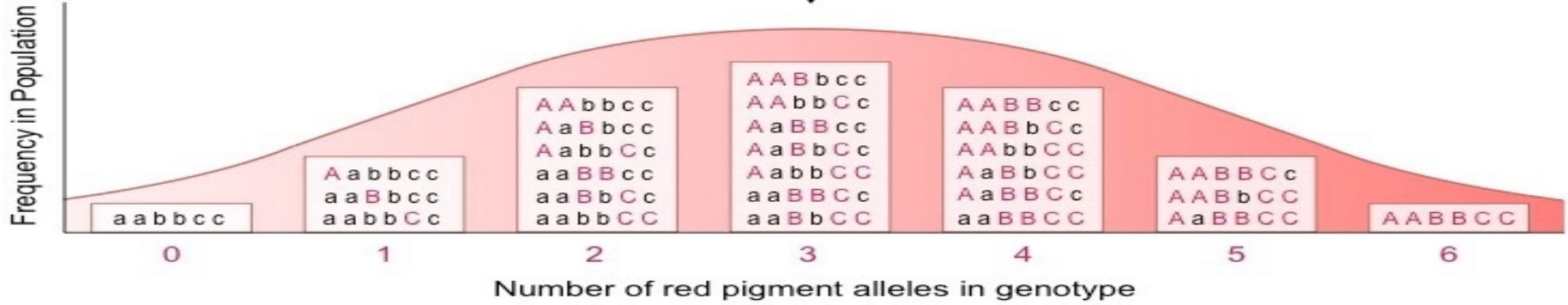
×

AA BB CC  
(pure red line)



Aa Bb Cc  
(medium red)

Self-fertilization



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# Differences between quantitative and qualitative characters



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	<b>Quantitative characters</b>	<b>Qualitative characters</b>
<b>Deals with</b>	Traits of degree Eg: Plant height, seed weight, yield etc.	Traits of kind Eg: Corolla colour, seed shape, appearance etc
<b>Variation</b>	Continuous	Discontinuous
<b>Effect of individual gene</b>	Small and undetectable	Large and detectable
<b>No. of genes involved</b>	Several (polygenic)	one or few (mono /oligogenic)
<b>Grouping into distinct Classes</b>	Not possible	Possible
<b>Effect of environment</b>	High	Low
<b>Metric measurement</b>	Possible	Not Possible
<b>Statistical analysis</b>	Based on mean, variance, standard deviation etc	Based on ratios and frequencies
<b>Stability</b>	Low	High
<b>Transgressive segregation of F 2</b>	Yes	No
<b>Dominance effect</b>	No	Yes
<b>Cumulative effect of each gene</b>	Yes	No



# Historical

- ❖ **Francis Galton**- "*Law of ancestral inheritance*"
- ❖ **In 1902, Yule** suggested that "*Law of ancestral inheritance*" may be due to operation of Mendelian principles in random mating population.
- ❖ **Pearson (1904)** countered that Mendelian principles could not explain "*Law of ancestral inheritance*"
- ❖ **de Vries and Bateson**, Continuous variation was non heritable rather it produced by environmental factors.
- ❖ **Johannsen (1903)** put the concept of Pureline for seed size in rajma. Result revealed that a part of variation in quantitative trait was heritable, but a substantial portion of it was due to environment and hence not heritable.
- ❖ **In 1908-09, Nilsson-Ehle** presented the multiple factor hypothesis to explain his result on inheritance of seed colour in wheat and oat.



# MULTIPLE FACTOR HYPOTHESIS

- ❖ Swedish Geneticist H. Nilsson Ehle in 1909 explain inheritance of kernel colour in wheat and oats.
- ❖ In studies on inheritance of kernel colour in wheat, he obtained 3:1, 15:1 and 63:1 ratio between coloured and white seeds from different crosses.
- ❖ It is clear from these ratios that the seed colour was governed by one (3:1 ratio in F<sub>2</sub>), two (15:1 ratio in F<sub>2</sub>) or three (63:1 ratio in F<sub>2</sub>) genes.
- ❖ When he crossed a dark red strain to a white strain (or variety), he observed that all the F<sub>1</sub>s were medium red (intermediate between the parental types). But in F<sub>2</sub> generation only one out of the sixteen were of parental types.
- ❖ However, on a closer examination of the coloured seeds, he found that there was a marked difference in the intensity of their colour.
- ❖ Therefore, the red seeds depending on the intensity of red colour could be classified into four distinct classes as dark red, medium red, red and light red in the ratio of 1:4:6:4.
- ❖ So finally 15:1 ratio turned into 1:4:6:4:1

Parents :

Red Wheat

x

White Wheat

$R_1 R_1 R_2 R_2$

x

$r_1 r_1 r_2 r_2$

Gametes

$R_1 R_2$

+

$r_1 r_2$

$F_1$

Medium

$R_1 r_1 R_2 r_2$

Gametes

$R_1 R_2$

$R_1 r_2$

$r_1 R_2$

$r_1 r_2$

Male gametes

♂  
♀

	$R_1 R_2$	$R_1 r_2$	$r_1 R_2$	$r_1 r_2$
$R_1 R_2$	$R_1 R_1 R_2 R_2$ <b>Dark Red</b>	$R_1 R_1 R_2 r_2$ <b>Red</b>	$R_1 r_1 R_2 R_2$ <b>Red</b>	$R_1 r_1 R_2 r_2$ <b>Medium Red</b>
$R_1 r_2$	$R_1 R_1 R_2 r_2$ <b>Red</b>	$R_1 R_1 r_2 r_2$ <b>Medium Red</b>	$R_1 r_1 R_2 r_2$ <b>Medium Red</b>	$R_1 r_1 r_2 r_2$ <b>Light Red</b>
$r_1 R_2$	$R_1 r_1 R_2 R_2$ <b>Red</b>	$R_1 r_1 R_2 r_2$ <b>Medium Red</b>	$r_1 r_1 R_2 R_2$ <b>Medium Red</b>	$r_1 r_1 R_2 r_2$ <b>Light Red</b>
$r_1 r_2$	$R_1 r_1 R_2 r_2$ <b>Medium Red</b>	$R_1 r_1 r_2 r_2$ <b>Light Red</b>	$r_1 r_1 R_2 r_2$ <b>Light Red</b>	$r_1 r_1 r_2 r_2$ <b>White</b>

**Phenotypic ratio:** 1 Dark Red: 4 Red: 6 Medium Red: 4 Light red: 1 white

**Genotypic ratio:** 1  $R_1 R_1 R_2 R_2$ : 2  $R_1 R_1 R_2 r_2$ : 1  $R_1 R_1 r_2 r_2$   
 : 2  $R_1 r_1 R_2 R_2$ : 4  $R_1 r_1 R_2 r_2$ : 2  $R_1 r_1 r_2 r_2$   
 : 1  $r_1 r_1 R_2 R_2$ : 2  $r_1 r_1 R_2 r_2$ : 1  $r_1 r_1 r_2 r_2$

**Table 4.1. Genotypic and phenotypic ratios in F<sub>2</sub> obtained due to a cross  $R_1R_1R_2R_2 \times r_1r_1r_2r_2$ .**

Genotype	Genotypic ratio	Phenotype	Phenotypic ratio
$R_1R_1R_2R_2$	1	red (like) P <sub>1</sub>	1
$R_1R_1R_2r_2$	2		
$R_1r_1R_2R_2$	2	darker than F <sub>1</sub> and lighter than P <sub>1</sub>	4
$R_1r_1R_2r_2$	4		
$R_1R_1r_2r_2$	1	(intermediate between P <sub>1</sub> and P <sub>2</sub> )	6
$r_1r_1R_2R_2$	1		
$R_1r_1r_2r_2$	2	lighter than F <sub>1</sub>	4
$r_1r_1R_2r_2$	2		
$r_1r_1r_2r_2$	1	colourless	1

} coloured (15/16)

} colourless (1/16)





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S.No.	No. of Alleles for red colour	Phenotype	Frequency	Genotype	Frequency
1.	4	Dark Red	1	R1 R1 R2 R2	1
2.	3	Red	4	R1 R1 R2 r2	2
				R1 r1 R2 R2	2
3.	2	Medium Red	6	R1 R1 r2 r2	1
				R1 R1 r2 r2	4
				r1 r1 R2 R2	1
4.	1	Light Red	4	R1 r1 r2 r2	2
				r1 r1 R2 r2	2
5.	0	White	1	r1 r1 r2 r2	1



# Assumptions of Nilsson-Ehle for multiple factor hypothesis

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- ❖ In crosses showing 15:1 in F<sub>2</sub>, seed colour is governed by two genes
  - ❖ One of the alleles of each colour gene produce seed colour is called **Positive allele** (denoted by capital letter, R<sub>1</sub>, R<sub>2</sub> etc.) while othe allele does not produce any colour, is known as **Negative allele** (denoted by small letter, r<sub>1</sub>, r<sub>2</sub> etc.).
  - ❖ These genes do not show dominance so that heterozygote for colour gene e.g., R<sub>1</sub>r<sub>1</sub> is intermediate in colour between two homozygotes (R<sub>1</sub>R<sub>2</sub> and r<sub>1</sub>r<sub>2</sub>)
  - ❖ Each of the positive alleles has small, almost equal, effect on seed colour.
  - ❖ The effect of positive alleles are additive. Thus the intensity of seed colour depends on the number of positive allele of all the gene responsible for seed colour.

**Thus, a character governed by several genes; the positive alleles of all the genes governing the trait are similar to each other in their action (effect), and that their effects are additive or cumulative in nature- MULTIPLE FACTOR HYPOTHESIS.**



# Quasiquantitative characters

Characters governed by polygenes, but showing discrete variation. E.g. No. of branches per plant, no. of pods per plant, tiller no per plant, etc.

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*THANK YOU*