Unit 7:Biostatistics

Measures of Dispersion-

Standard Deviation

B. Sc (P) Life Science III year Semester VI

DSE-1: Analytical Techniques in Plant Sciences

Dr Madhu Rani

Department of Botany, DBC, DU

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com

Contact/Whatsapp- 9412209655

- When the deviate scores are squared in variance, their unit of measure is also squared.
  - E.g.- If weights of individuals are measured in Kg, then the variance of the weights would be expressed in Kg^2 (or squared Kg)
- Since dealing with squared units of measure are often problematic, the square root of variance is often used.
  - **The standard deviation is the square root of variance**

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$$\text{Standard deviation} = \sqrt{\text{variance}}$$

$$\text{Variance} = \text{standard deviation}^2$$

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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Definition of Standard deviation (SD)

Standard deviation of a series is '<u>the positive square root of the arithmetic mean of the squares of deviations of the various items from the arithmetic mean of the series</u>'.

- It is also called root mean square deviation.
- It is represented by Greek symbol σ and in short form by **SD**.
- It represents the extent to which individual values differ from the average or Mean.
- It is based on all observations.

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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Calculation of Standard deviation

Formula

$$\sigma^2 = \frac{\sum(X-\bar{X})^2}{N} \quad \text{or} \quad \sigma^2 = \frac{\sum(X-\mu)^2}{N}$$

Where

σ^2 = population variance,

X = a variable,

$\bar{X}$ or μ = population mean, and

N = total number of variables.

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
Contact/Whatsapp- 9412209655

Merits of SD

- It summarizes the deviation of a large distribution from Mean in one figure.
- It is most reliable and dependable Measure of Dispersion.
- It helps in calculating the Standard Error.
- It helps in finding the suitable size of sample for valid conclusions.
- It is less affected by fluctuations in sampling.
- SD is rigidly defined, and its values are always definite.

Demerits of SD

- It gives more weightage to extreme value and left to the values that are closer to mean.
- The process of acquiring deviations and then taking square root involves lengthy calculations. Hence its calculation is not easy.

Significance of SD

- It is the most widely used measure of dispersion.
- It is based on all the observations.
- The squaring of the deviations remove the drawbacks of ignoring the signs of deviations in computing the Mean Deviation. $(X - \bar{X})^2$
- SD is best among all the measures of dispersion, because it is least affected by fluctuations of sampling.
- A large value of SD shows that the measurement of frequency distribution are widely spread out from the Mean, while small values of shows that observations are closely spread in the vicinity of Mean.
- SD indicates whether the variation of difference of any individual observation from the Mean is natural or real due to some specific reasons.
- It helps in finding the Standard Error which determines whether the difference between the Means of two similar samples is by chance for real.

Calculation of SD

Step 1- arithmetic mean is calculated using the formula… μ or $\bar{X} = \frac{\sum X}{N}$

Step 2- **Deviation** or difference of each observation from the Mean is calculated using the formula…. $dx = X - \bar{X}$

Step 3- This difference between observation and Mean is squared… $dx^2 = (X - \bar{X})^2$

step 4- All the squared values are added to calculate the sum of squared deviations, i.e., $\sum dx^2$ or $\sum (X - \bar{X})$

Step 5- Calculate the variance (σ^2) by using the formula… where N -1 is the number of observations minus one. $\sigma^2 = \frac{\sum dx^2}{N - 1}$

Step 6-Find the square root of the variance to get Standard Deviation.

$$SD = \sqrt{\frac{\sum dx}{N - 1}}$$ i.e., $SD = \sqrt{Variance}$

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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Calculation of SD from ungrouped data

1. Indirect method.

2. Direct method.

1. Indirect method- SD is obtained from Mean using the following formula:

When N ≥ 30 $\sigma = \sqrt{\frac{\sum dx^2}{N}}$

When N < 30 $\sigma = \sqrt{\frac{\sum dx^2}{N - 1}}$

Where *dx* or *x* = deviation obtained from actual Mean, i.e., $(X - \overline{X})$

N = total number of observations

2. Direct method- SD is obtained from Assumed Mean (A) instead of Actual Mean ($\overline{X}$). SD is calculated by using the above-mentioned formulae, replacing $\overline{X}$ with A .

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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Calculation of SD from grouped data

For grouped data, SD is calculated either using Arithmetic Mean (Long method) or Assumed Mean (Short method) using the following formula:

Long method

$$SD = \sqrt{\frac{\Sigma f x^2}{\Sigma f}}$$

or

$$SD = \sqrt{\frac{\Sigma f (X - \bar{X})^2}{\Sigma f}}$$

Where $x = (X - \bar{X})$

f = mid-point of each class

X = Variables

Short method

$$SD \text{ or } \sigma = i.\sqrt{\frac{\Sigma f . x'^2 . c^2}{\Sigma f}}$$

Where x' = Deviation calculated from Assumed Mean

c = correction

i = Class interval

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Coefficient of Standard Deviation

Coefficient of SD is obtained for comparative study. The following formula is used.

$$\text{Coefficient of SD} = \frac{\text{Standard Deviation}}{\text{Arithmetic Mean}} = \frac{\text{SD}}{\overline{\text{X}}}$$

Practice problem

A biologist was interested in the average height and standard deviation of a plant species. The following data are the heights for a sample of $n = 20$ plants.

The average height is 10.53 cm, rounded to two places. Find the sample standard deviation, rounded to two decimal places.

10	11	9.5	10	11	10	11.5	11	10.5	11.5
9	10	10.5	11.5	11	9.5	10.5	11	11	10.5

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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Solution

The variance may be calculated by using a table. Then the standard deviation is obtained by taking the square root of the variance.

Data	Freq.	Deviation	Deviation²	Freq. X Deviation²
X	f	$(X-\bar{X})$	$(X-\bar{X})^2$	$f \times (X-\bar{X})^2$
9	1	$9 - 10.525 = -1.525$	$(-1.525)^2 = 2.325625$	$1 \times 2.325625 = 2.325625$
9.5	2	$9.5 - 10.525 = -1.025$	$(-1.025)^2 = 1.050625$	$2 \times 1.050625 = 2.101250$
10	4	$10 - 10.525 = -0.525$	$(-0.525)^2 = 0.275625$	$4 \times 0.275625 = 1.1025$
10.5	4	$10.5 - 10.525 = -0.025$	$(-0.025)^2 = 0.000625$	$4 \times 0.000625 = 0.0025$
11	6	$11 - 10.525 = 0.475$	$(0.475)^2 = 0.225625$	$6 \times 0.225625 = 1.35375$
11.5	3	$11.5 - 10.525 = 0.975$	$(0.975)^2 = 0.950625$	$3 \times 0.950625 = 2.851875$
				The total is 9.7375

The sample variance, σ^2, is equal to the sum of the last column (9.7375) divided by the total number of data values minus one, which is 19.

$$\sigma^2 = \frac{9.7375}{19} = 0.5125$$

The **sample standard deviation** σ is equal to the square root of the sample variance:

$\sigma = \sqrt{0.5125} = 0.715891$

Rounded to two decimal places, σ **= 0.72**.

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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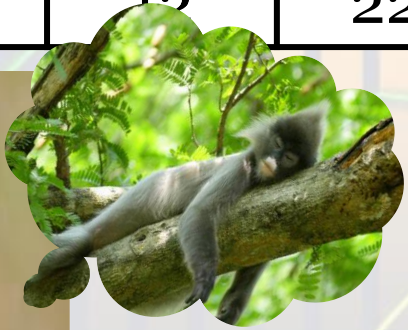
Example -2. Calculate the Standard Deviation from the following observations related to yield of seeds (gm) per plant in a species.

240.12	240.13	240.15	240.12	240.17
240.15	240.17	240.16	240.22	240.21

Example -3. Calculate the Mean and Standard Deviation from the following data.

Leaf length (cm)	90-99	80-89	70-79	60-69	50-59	40-49	30-39
Frequency	2	12	22	20	14	2	1



Submit the answers in Google classroom till 24th April 2020

Dr Madhu Rani (BOTANY) e-mail - madhupriya1999@gmail.com
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