2018 Rule Proposal 15

Purpose of Proposal

To add clarity to **13.3 Conducting the non-mechanical seed count;** Section b. "Calculate the variance, standard deviation and coefficient of variation"; and add an example on how to calculate each.

Present Rule

Conducting the non-mechanical seed count. (adapted from: International Seed Testing Association, Rules for Seed Testing, Chapter 10. Weight Determination).

b. Calculate the variance, standard deviation and coefficient of variation as follows:

$$\textbf{Variance} = \frac{N\Sigma x^2 - (\Sigma x)^2}{N(N-1)}$$

Where x = weight of each replicate in grams
N = number of replicates
Σ = sum of
Standard deviation (s) = square root of Variance

$$\textbf{Coefficient of variation} = \frac{\text{Standard deviation}}{\text{Mean weight of 100 seeds}} \times 100$$

Proposed Rule

13.3 Conducting the non-mechanical seed count (adapted from: International Seed Testing Association, Rules for Seed Testing, Chapter 10. Weight Determination).

   a. No change in "a.".

b. Calculate the sample variance, standard deviation and coefficient of variation[1]

The purpose of calculating the coefficient of variation (**CV**) is to find the ratio of standard deviation (**s**) to mean ($\bar{x}$) of a seed sample representing a population. The **CV** measures the dispersion of the sample data (i.e., replications) from the mean. The more dispersion of the data from its mean, the less representative it is of the seed sample under investigation, and consequently the less reliable the data set.

The following steps should be used to calculate the CV:

   1. Calculate the mean ($\bar{x}$) of the data set (i.e., replications).
   2. Calculate the variance (s^2) for the data set.
   3. Calculate the standard deviation (**SD** or **s**) for the data set.
   4. Calculate the ratio of the **SD** to the mean of the data set by dividing $s/\bar{x}$.

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[1] Since weight measurements are made on a seed sample representing the population, sample mean, variance and, standard deviation ($\bar{x}$, s^2 and **s**, respectively) are calculated as estimates of the true population mean, variance and standard deviation (μ, σ^2, and σ, respectively).

Step 1. Calculate the mean of the data set [*i.e., weight (g) of 8 replications of 100 seeds each*]

$$Mean\ (\bar{x}) = \frac{\Sigma x}{n}$$

Where 'Σx' is the sum of seed weight of replications; and 'n' is the number of replications (i.e., 8).

Step 2. Calculate the variance **(s²)** of the data set (replications)

$$\text{Variance (s}^2) = \frac{\Sigma\ (x-\bar{x})^2}{n-1}$$

Where '$\Sigma\ (x-\bar{x})^2$' is the sum of squares, calculated as the total of each data point [i.e., wt. (g) of a replication] minus the mean (of the 8 replications); and 'n-1' is the number of data sets (replications) minus 1 (i.e., degrees of freedom).

Step 3. Calculate the standard deviation (**SD**) of the data set (replications)

$$\text{Standard deviation (SD)} = \sqrt{\frac{\Sigma\ (x-\bar{x})^2}{n-1}}$$

Simply, it is the square root of the variance.

Step 4. Calculate the coefficient of variation **(CV)** percentage, i.e., the ratio of the SD to the mean by dividing **s/ $\bar{x}$** multiplied by 100.

$$\mathbf{CV} = \frac{Standard\ \ Deviation\ \ (s)}{Mean\ \ (\bar{x})\ of\ 100\ seeds}\ x\ 100$$

Example:

Eight replications of 100 seeds each were randomly drawn from a ryegrass sample. The weight (g) of the replications (listed in Table 1) was 0.1321, 0.1269, 0.1401, 0.1299, 0.1320, 0.1297, 0.1417, and 0.1319.

Calculate the coefficient of variation for the eight replications, interpret the results and determine the weight of purity and bulk examination.

Hint: you can use MS Excel in calculating the mean, the variance, the standard deviation and the CV.

*However, we will show the step-by-step calculation for those who prefer to use calculators (**Table 1**).*

   Step 1: calculate the sample mean

   Mean ($\bar{x}$) = (0.1321+0.1269+0.1401+0.1299+0.1320+0.1297+0.1417+0.1319)/8 = ***0.1330***

   Step 2. Calculate the variance

   Variance (s²)= {[(0.1321- 0.1330)² + (0.1269- 0.1330)² + (0.1401- 0.1330)² + (0.1299- 0.1330)² + (0.1320- 0.1330)² + (0.1297-0.1330)² + (0.1417- 0.1330)² + (0.1319 -0.1330)²] / (8-1)}
   = ***0.00002669***

Step 3: calculate standard deviation (*SD or s*)

Standard deviation (*s*)= $\sqrt{0.00002669}$

= 0.00517

Step 4: calculate coefficient of variation CV (%)

CV (%) = Standard Deviation (s) / Mean ($\bar{x}$)
= 0.00517 / 0.1330
= 3.8844
= 3.9%

Interpretation of results

The coefficient of variation, 3.9%, does not exceed 6.0 for chaffy seeds (ryegrass), i.e., replications are within tolerance. The result of the seed count can be used to calculate the weight of purity analysis and bulk examination.

Weight of 2500 seeds (for purity analysis) is 0.1330 x 25 = *3.325g*
Weight of 25,000 seeds (for bulk/noxious weed examination) = 3.325 x 10 = *33.25g*

Table 1. Calculation of mean, variance, standard deviation and coefficient of variation.

*Rep.**	*Wt. 100 seeds (g)*	$\Sigma(x-\bar{x})^2$	*Variance* $(s^2) = \dfrac{\Sigma(x-\bar{x})^2}{n-1}$	$SD = \sqrt{\dfrac{\Sigma(x-\bar{x})^2}{n-1}}$	*CV (%) = (0.00517/0.1330) *100*
1	0.1321	$(0.1321\text{-}0.1330)^2$			
2	0.1269	$(0.1269\text{-}0.1330)^2$			
3	0.1401	$(0.1401\text{-}0.1330)^2$			
4	0.1299	$(0.1299\text{-}0.1330)^2$	0.00018683/ (8-1) = *0.00002669*	$\sqrt{0.00002669}$ = *0.00517*	*3.8844*
5	0.1320	$(0.1320\text{-}0.1330)^2$			
6	0.1297	$(0.1297\text{-}0.1330)^2$			
7	0.1417	$(0.1417\text{-}0.1330)^2$			
8	0.1319	$(0.1319\text{-}0.1330)^2$			
Σ (Sum)	*1.0643*	*0.00018683*			
Mean ($\bar{x}$)	*0.1330*				

* n = 8

Harmonization

This formula is already used by ISTA. The rule is proposed to show the step-by-step (systemic) calculation for easier understanding of the formula to those who prefer to use calculators. In addition, we add an example to demonstrate the application of the formula in a real situation.

Supporting evidence

The formula we used in this proposal to calculate mean, variance, standard deviation, and coefficient of variation appears in almost every statistical book and website. Such references as:

- Steel, R.G., J.H. Torrie, and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3rd ed. McGraw-Hill College, USA.

- Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York.

- https://www.khanacademy.org/math/statistics-probability/displaying-describing-data/sample-standard-deviation/v/statistics-sample-variance

- https://explorable.com/statistical-variance

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