Size of an Experiment – The Number of Replicates to Use

The size of the experiment can be influenced by increasing or decreasing the number of replicates.

Calculation of the number of replicates depends on:

1. An estimate of σ^2 obtained from previous experiments.
2. The size of the difference (δ) to be detected.
3. The assurance with which it is desired to detect the difference (i.e., Power of the test = 1-β).
4. The level of significance to be used in the actual experiment (i.e., Type I error).
5. The test required, whether a one-tail or two-tail test.

To determine the number of replicates to use, the following formula should be used:

$$\#reps = 2\left(Z_{\alpha/2} + Z_{\beta}\right)\left(\frac{\sigma}{\delta}\right)^2$$

where: $Z_{\alpha/2}$ is associated with the Type I error
Z_{β} is associated with the Type II error
δ is the true difference to be detected, and
σ is obtained from previous experiments

Subscripts for Z are based on acceptable Type I and Type II errors
Values for $Z_{\alpha/2}$ and Z_{β} can be found in the Z table (Appendix table I, pages 604-605).

Example
You want to determine the number of replicates needed in an experiment to detect a 10 bu/a difference in yield between barley varieties with the probability of a Type I error = 0.05 and the probability of a Type II error=0.20. Also, based on previous experiments you know the variance for barley yield trial experiments is 50.

Step 1. Look up the $Z_{\alpha/2}$-value for α=0.05.

Since this is a two-tail test, you need to find the Z-value when the probability is 0.025 (i.e., 0.05/2)

- Look for the table value of 1 - 0.025, which is 0.9750.
- When the table value is 0.97500, the $Z_{0.05/2}$ value will be 1.96.

Step 2. Look up the $\mathbf{Z_{\beta}}$-value when the probability is 0.20.

- Look up in the table the Z-value 1 – 0.20, which is 0.80.
- The value closest to 0.80 is 0.79954, and this occurs when the Z-value is 0.84.

Step 3. Solve for the number of replicates

$$\#reps = 2\left(Z_{\alpha/2} + Z_{\beta}\right)\left(\frac{\sigma}{\delta}\right)^2$$

$$= 2(1.96 + 0.84)\left(\frac{\sqrt{50}}{10}\right)^2$$

$$= 2.8$$

Therefore, you should use 3 replicates.