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 $\sigma^2$ obtained from previous experiments.
2. The size of the difference ($\delta$) to be detected.
3. The assurance with which it is desired to detect the difference (i.e., Power of the test = 1-$\beta$).
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:

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

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

Subscripts for $Z$ are based on acceptable Type I and Type II errors
Values for $Z_{\alpha/2}$ and $Z_{\beta}$ 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 $\alpha=0.05$.

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 $Z_{\beta}$-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

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

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

\[= 2.8\]

Therefore, you should use 3 replicates.