ΑΡΙΣΤΟΤΕΛΕΙΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ
ΘΕΣΣΑΛΟΝΙΚΗΣ

ΓΕΩΠΟΝΙΚΗ ΣΧΟΛΗ
Α.Π.Θ.

# Split Block Arrangement (or Strip Plot)

Επιστημονική Επιμέλεια:

Δρ. Γεώργιος Μενεξές

Τομέας Φυτών Μεγάλης Καλλιέργειας
και Οικολογίας
Εργαστήριο Γεωργίας

# Remarks

The split block arrangement is especially suited for two factor experiments in which the desired precision for measuring the interaction effect between two factors is greater than either of the two factors.

This is accomplished with the use of three plot sizes:

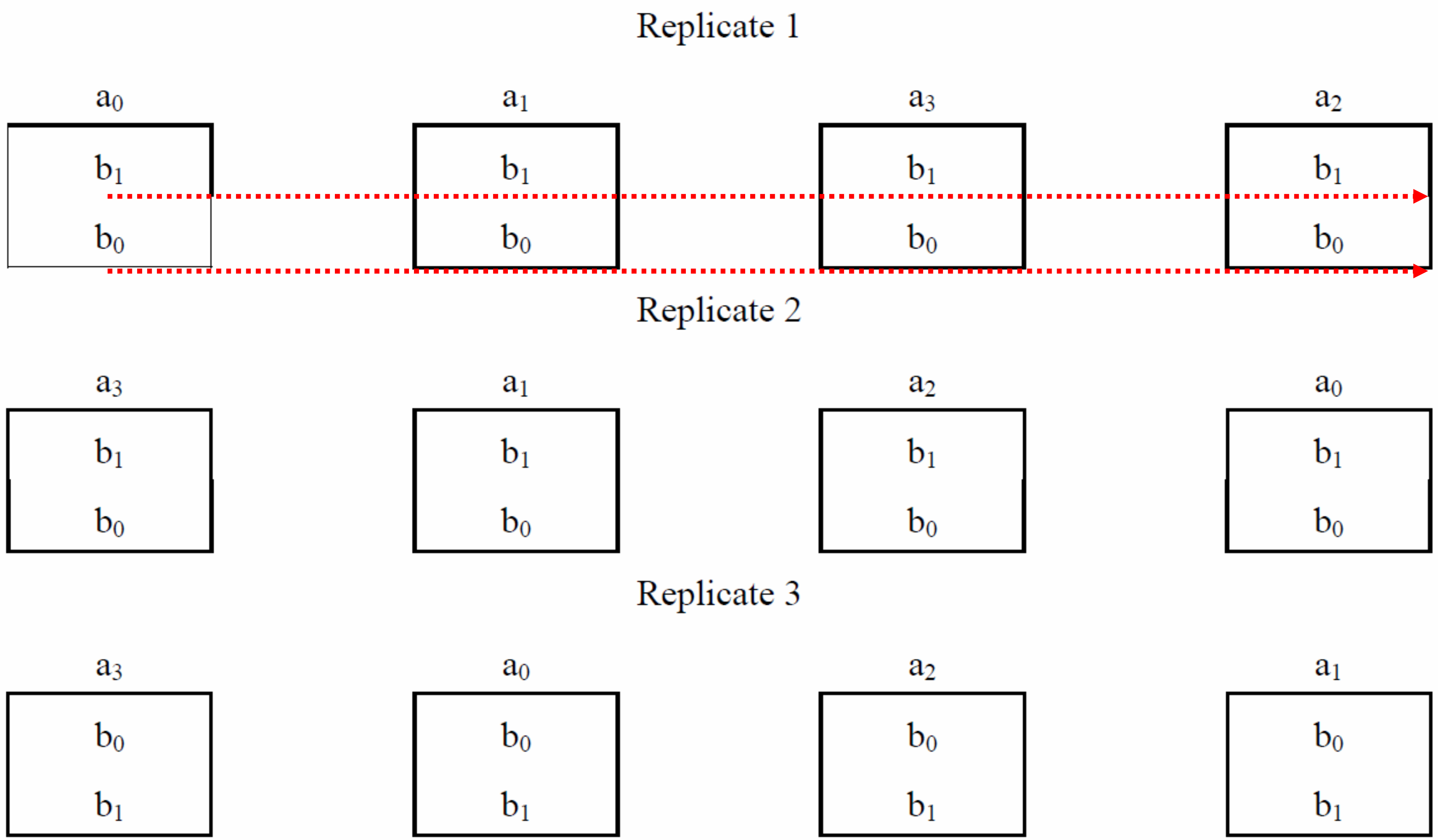
1. Horizontal strip for the first factor
2. Vertical strip for the second factor
3. Intersection plot for the interaction

# Randomization

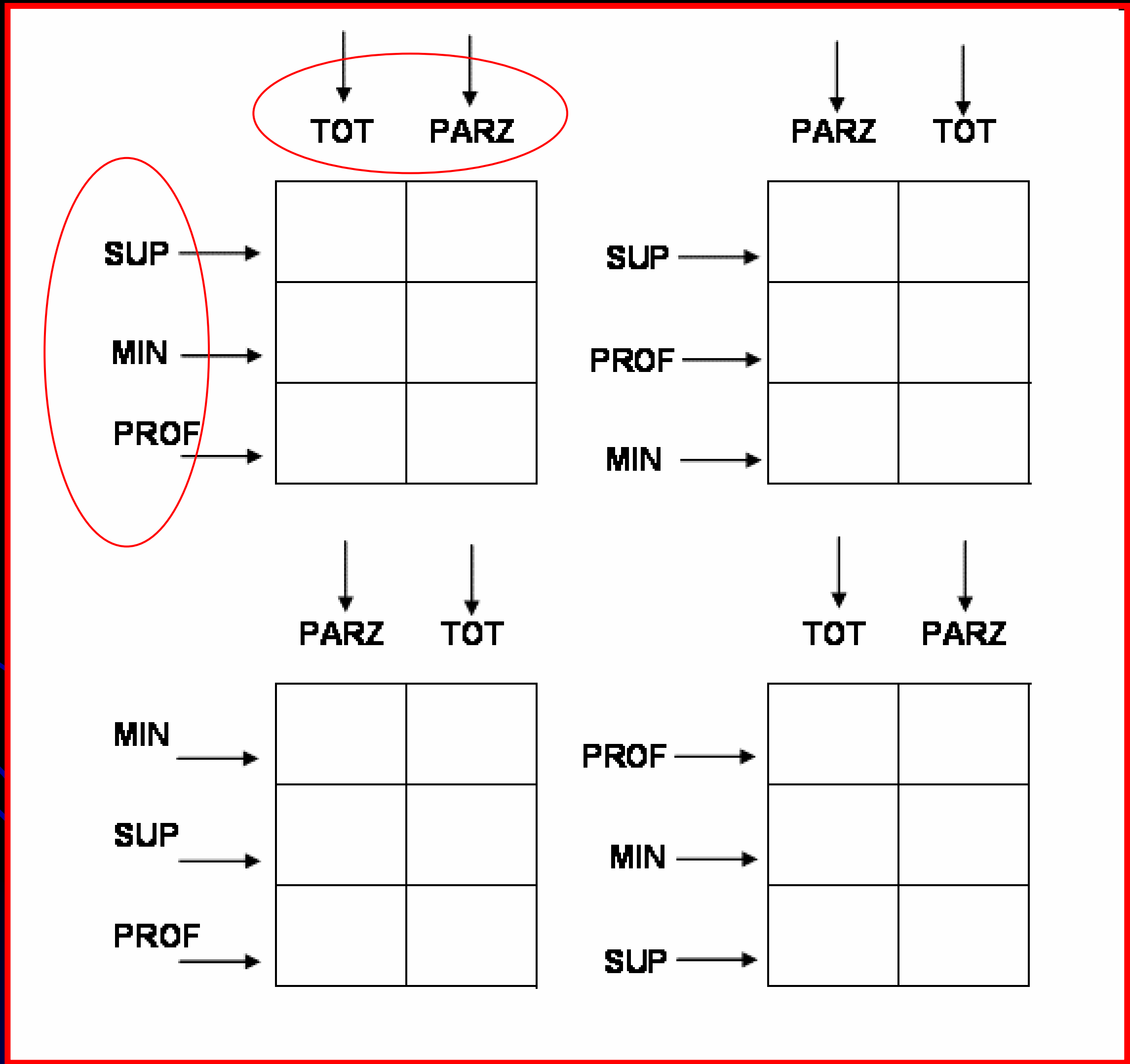
In general, it does not matter which factor you choose to use as the horizontal or vertical factor.

1. Randomly assign treatments to horizontal strips.
2. Randomly assign treatments to vertical strips.

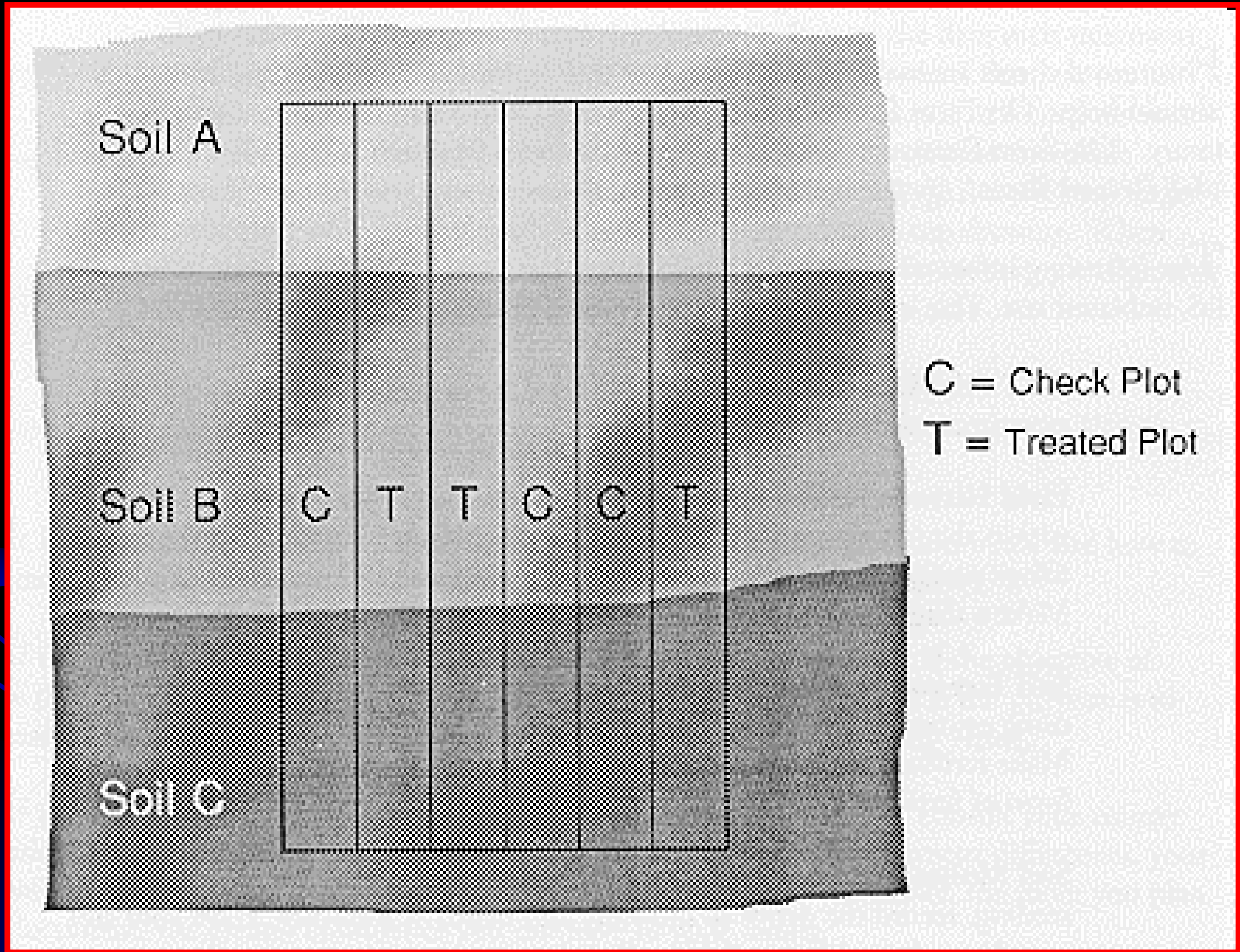
# Example (1)


Replicate 1
a0 a1 a3 a2
b1 b0
Replicate 2
a3 a1 a2 a0
b1 b0
Replicate 3
a3 a0 a2 a1
b0 b1

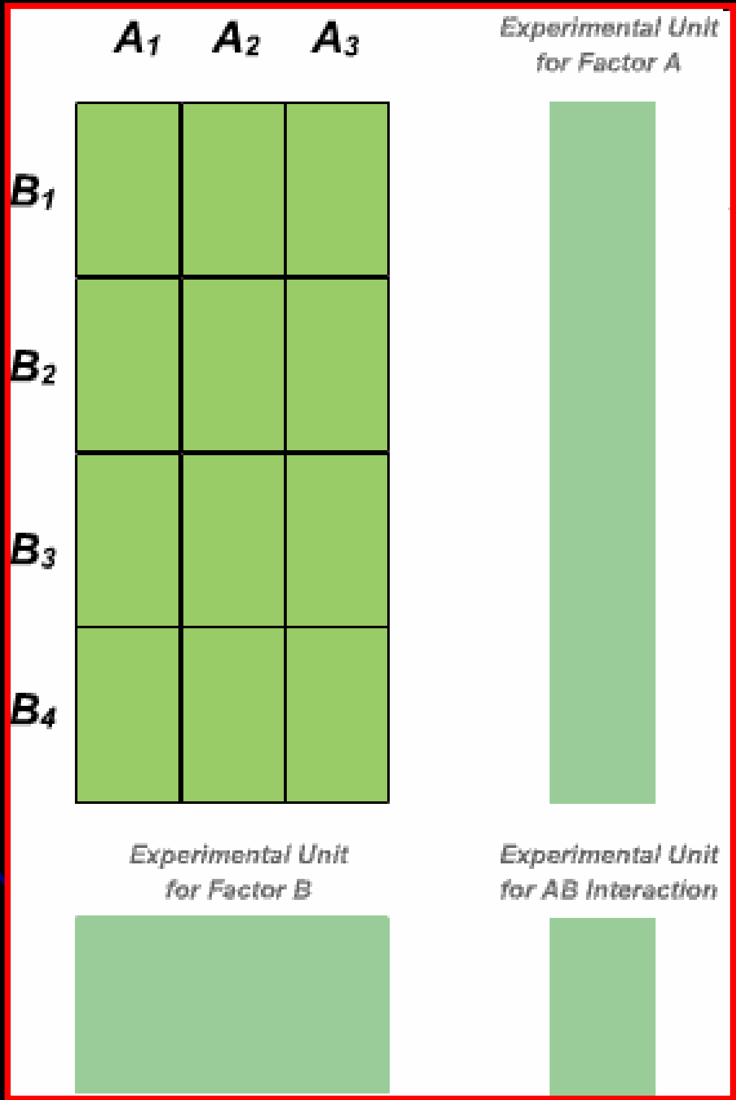
# Example (2)


TOT
PARZ
SUP
MIN
PROF
PARZ
TOT
SUP
PROF
MIN
PARZ
TOT
MIN
SUP
PROF
TOT
PARZ
PROF
MIN
SUP

# Example (3)



# Example (4)



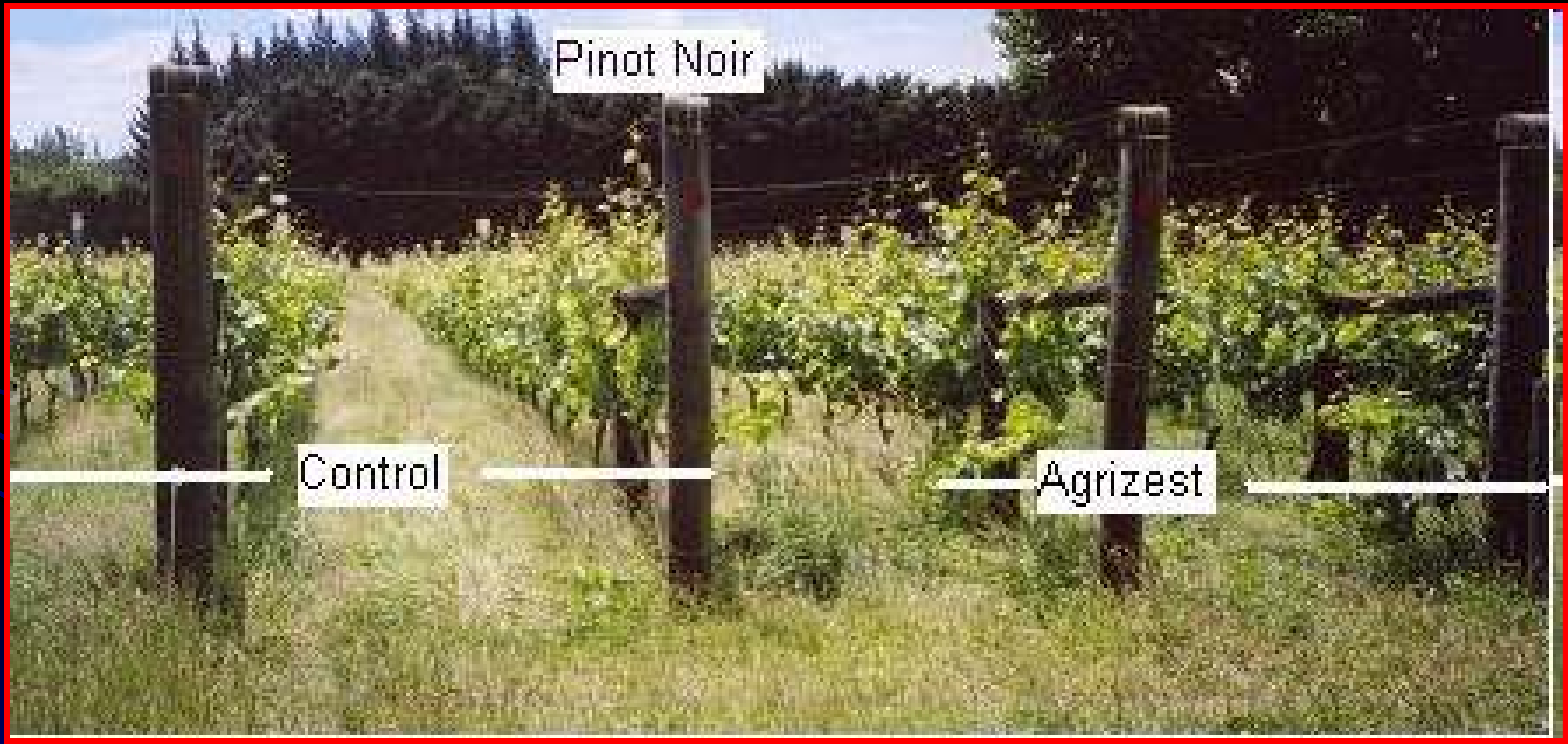
A1 A2 A3
B1
B2
B3
B4
Experimental Unit for Factor A
Experimental Unit for Factor B
Experimental Unit for AB Interaction

# Example (5)

# Example (6)

# Example (7)

# Example (8)



# Example (9)

# ANOVA Table

The example to be given will be for an RCBD with factor A as the horizontal factor and factor B as the vertical factor. Factor A and B will be considered fixed effects.

| Source of variation | df | Expected mean square |
|---|---|---|
| Replicate | r-1 | $\sigma^2 + a\sigma^2_\theta + b\sigma^2_\gamma + ab\sigma^2_R$ |
| A (horizontal factor) | a-1 | $\sigma^2 + b\sigma^2_\gamma + r\sigma^2_{AB} + rb\sigma^2_A$ |
| Error (a) = Rep x A | (r-1)(a-1) | $\sigma^2 + b\sigma^2_\gamma$ |
| B (vertical factor) | b-1 | $\sigma^2 + a\sigma^2_\theta + r\sigma^2_{AB} + ra\sigma^2_B$ |
| Error (b) = Rep x B | (r-1)(b-1) | $\sigma^2 + a\sigma^2_\theta$ |
| AxB | (a-1)(b-1) | $\sigma^2 + r\sigma^2_{AB}$ |
| Error (c) = Rep x A X B | (r-1)(a-1)(b-1) | $\sigma^2$ |
| Total | rab-1 | |

# Numerical Example

| | | Vertical Whole Plots ($B_k$) | | | | |
|---|---|---|---|---|---|---|
| | | $b_0$ | $b_1$ | $b_2$ | $b_3$ | Horizontal Plot totals |
| Replicate 1 | $a_0$ | 13.8 | 15.5 | 21.0 | 18.9 | $69.2 = Y_{11.}$ |
| | $a_1$ | 19.3 | 22.2 | 25.3 | 25.9 | $92.7 = Y_{21.}$ |
| Vertical Plot Total $Y_{.1k}$ | | 33.1 | 37.7 | 46.3 | 44.8 | $161.9 = Y_{.1.}$ |
| Replicate 2 | $a_0$ | 13.5 | 15.0 | 22.7 | 18.3 | $69.5 = Y_{12.}$ |
| | $a_1$ | 18.0 | 24.2 | 24.8 | 26.7 | $93.7 = Y_{22.}$ |
| Vertical Plot Total $Y_{.2k}$ | | 31.5 | 39.2 | 47.5 | 45.0 | $163.2 = Y_{.2.}$ |
| Replicate 3 | $a_0$ | 13.2 | 15.2 | 22.3 | 19.6 | $70.3 = Y_{13.}$ |
| | $a_1$ | 20.5 | 25.4 | 28.4 | 27.6 | $101.9 = Y_{23.}$ |
| Vertical Plot Total $Y_{.3k}$ | | 33.7 | 40.6 | 50.7 | 47.2 | $172.2 = Y_{.3.}$ |

# Preliminary Preparation

Treatment Totals Table

| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | $\Sigma A_{i..}$ |
|---|---|---|---|---|---|
| $a_0$ | 40.5 | 45.7 | 66.0 | 56.8 | 209.0 |
| $a_1$ | 57.8 | 71.8 | 78.5 | 80.2 | 288.3 |
| $\Sigma B_{..k}$ | 98.3 | 117.5 | 144.5 | 137.0 | 497.3 |

# Calculations (1)

Step 1. Calculate Correction Factor:

$$CF = \frac{Y_{...}^2}{\text{rxaxb}} = \frac{(497.3)^2}{3x2x4} = 10{,}304.47$$

Step 2. Calculate Total SS

$$\text{Total SS} = \sum Y_{ijk}^2 - CF$$

$$= (13.8^2 + 19.3^2 + 13.5^2 + \ldots + 27.6^2) - CF$$

$$= 516.2$$

# Calculations (2)

Step 3. Calculate Replicate SS

$$\text{Rep SS} = \frac{\sum Y_{.j.}^2}{axb} - CF$$

$$= \frac{(161.9^2 + 163.2^2 + 172.2^2)}{(2x4)} - CF$$

$$= 7.87$$

# Calculations (3)

Step 4. Calculate A SS

$$\text{A SS} = \frac{\sum Y_{i..}^2}{rxb} - CF$$

$$= \frac{(209.0^2 + 288.3^2)}{(3x4)} - CF$$

$$= 262.02$$

# Calculations (4)

Step 5. Calculate Horizontal Whole Plot SS

$$\text{Horizontal Whole Plot SS} = \frac{\sum Y_{ij.}^2}{b} - CF$$

$$= \frac{(69.2^2 + 92.7^2 + \ldots + 101.9^2)}{4} - CF$$

$$= 274.92$$

Step 6. Calculate Whole Plot Error SS = Error(a) SS

Horizontal Whole Plot SS - A SS - Rep SS = **5.03**

# Calculations (5)

Step 7. Calculate B SS

$$\text{B SS} = \frac{\sum Y_{..k}^2}{ra} - CF$$

$$= \frac{(98.3^2 + 117.5^2 + 144.5^2 + 137.0^2)}{(3x2)} - CF$$

$$= 215.26$$

# Calculations (6)

Step 8. Calculate Vertical Whole Plot SS

$$\text{Vertical Whole Plot SS} = \frac{\sum Y_{.jk}^2}{a} - CF$$

$$= \frac{(33.1^2 + 37.7^2 + ... + 47.2^2)}{2} - CF$$

$$= 225.605$$

Step 9. Calculate Vertical Whole Plot Error SS = Error(b) SS

Vertical Whole Plot SS - B SS - Rep SS = **2.475**

# Calculations (7)

Step 10. Calculate AxB SS

$$\text{AxB SS} = \frac{\sum Y_{i.k}^2}{r} - \text{CF - A SS - B SS}$$

$$= \frac{(40.5^2 + 45.7^2 + \ldots + 80.2^2)}{3} \text{ - CF - A SS - B SS}$$

$$= 18.7$$

Step 11. Calculate Error(c) SS = Total SS - Rep SS - A SS - Error(a) SS - B SS - Error(b) SS - AxB SS =

=**4.765**

# Calculations (8)

Step 12. Make ANOVA Table (Assuming A and B are fixed effects)

| SOV | df | SS | MS | F (A and B fixed) |
|---|---|---|---|---|
| Replicate | 2 | 7.87 | 3.935 | |
| A | 1 | 262.02 | 262.02 | A MS/Error(a) MS = 104.183** |
| Error(a) | 2 | 5.03 | 2.515 | |
| B | 3 | 215.26 | 71.753 | B MS/Error(b) MS = 174.158** |
| Error(b) | 6 | 2.474 | 0.412 | |
| AxB | 3 | 18.70 | 6.233 | AxB MS/Error(c) MS = 7.850** |
| Error(c) | 6 | 4.764 | 0.794 | |
| Total | 23 | 516.12 | | |

# Calculations (9)

<u>LSD's for Split Block Arrangement</u>

1. To compare two horizontal means averaged over all vertical treatments (.e.g. $a_0$ vs $a_1$)

$$t_{\alpha/2,\ \mathrm{Error(a)\ df}} \sqrt{\frac{2Error(a)MS}{rb}}$$

$$= 4.303\sqrt{\frac{2(2.5150)}{3X4}}$$

$$= 2.79$$

# Calculations (10)

2. To compare two vertical means averaged over all horizontal treatments (.e.g. $b_0$ vs $b_1$)

$$t_{\alpha/2,\ \mathrm{Error(b)\ df}} \sqrt{\frac{2Error(b)MS}{ra}}$$

$$= 2.447\sqrt{\frac{2(0.412)}{3X2}}$$

$$= 0.907$$

# Calculations (11)

3. To compare two horizontal means at the same level of the vertical factor (e.g. $a_0b_0$ vs $a_1b_0$)

$$t_{ac'}\sqrt{\frac{2[(b-1)Error(c)MS + Error(a)MS]}{rb}}$$

*and*

$$t_{ac'} = \frac{(b-1)Error(c)MS(t_{\alpha/2,Error(c)df}) + Error(a)MS(t_{\alpha/2,Error(a)df})}{(b-1)Error(c)MS + Error(a)MS}$$

$\therefore$

$$t_{ac'} = \frac{(4-1)(0.794)(2.447) + 2.515(4.303)}{(4-1)0.794 + 2.515} = 3.4$$

$$\text{and LSD} = 3.4\sqrt{\frac{2[(4-1)0.794 + 2.515]}{3x4}}$$

$$= 3.072$$

# Calculations (12)

4. To compare two vertical means at the same level of the horizontal factor (e.g. $a_0b_0$ vs $a_0b_1$)

$$t_{bc'}\sqrt{\frac{2[(a-1)Error(c)MS + Error(b)MS]}{ra}}$$

*and*

$$t_{bc'} = \frac{(a-1)Error(c)MS(t_{\alpha/2,Error(c)df}) + Error(b)MS(t_{\alpha/2,Error(b)df})}{(a-1)Error(c)MS + Error(b)MS}$$

$\therefore$

$$t_{bc'} = \frac{(2-1)(0.794)(2.447) + 0.412(2.447)}{(2-1)2.447 + 0.412} = 2.447$$

$$\text{and LSD} = 2.447\sqrt{\frac{2[(2-1)0.794 + 0.412]}{3x2}}$$

$$= 1.551$$

# Calculations (13)

5. To compare two vertical means at different levels of the horizontal factor (e.g. $a_0b_0$ vs $a_1b_3$)

$$t_{abc'}\sqrt{\frac{2[(a-1)(b-1)Error(c)MS+(b-1)Error(b)MS+(a-1)Error(a)MS]}{rab}}$$

*and*

$$t_{abc'}=\frac{(a-1)(b-1)Error(c)MS(t_{\alpha/2,Error(c)df})+(b-1)Error(b)MS(t_{\alpha/2,Error(b)df})+(a-1)Error(a)MS(t_{\alpha/2,Error(a)df})}{(a-1)(b-1)Error(c)MS+(b-1)Error(b)MS+(a-1)Error(a)MS}$$

$\therefore$

$$t)_{abc'}=\frac{(2-1)(4-1)(0.794)(2.447)+(4-1)0.412(2.447)+(2-1)2.515}{(2-1)(4-1)\,0.794+(4-1)0.412+(2-1)2.515}1=3.208$$

$$\text{and LSD}=3.208\sqrt{\frac{2[(2-1)(4-1)0.794+(4-1)0.412+(2-1)2.515]}{3x2x4}}$$

$=2.294$

# Bibliography


- Steel, R. & Torrie, J. (1986). *Principles and Procedures of Statistics: A Biometrical Approach*. Singapore: McGraw-Hill Book Company.
- Gomez, K. & Gomez, A. (1984). *Statistical Procedures for Agricultural Research*. Singapore: John Willey & Sons, Inc.