Estimate the missing value in RCBD

The researcher cannot obtain the full result when the experiment loses any value in the RCBD, so when a value is missing we can extract it during the following law:

$$\boldsymbol{M.V.} = \frac{(\boldsymbol{t} \times \boldsymbol{Yi}) + (\boldsymbol{r} \times \boldsymbol{Yj}) - \boldsymbol{Y..}}{(\boldsymbol{t}-\mathbf{1})(\boldsymbol{r}-\mathbf{1})}$$

M.V. = missing value

t = number of treatments

r = number of blocks

Yi = the sum of the observations treatment

Yj = the sum of observations block

Y..= total summation

Example \ an experiment was conducted using a randomized complete block design, and some observations were missing, calculate the value of those missing values?

Treats	**R1**	**R2**	**R3**	**R4**	**Yi**
t1	6.7	6.4	---	6.4	**19.5**
t2	6.5	6.6	6.8	6.5	26.4
t3	6.3	6.2	6.4	6.5	25.2
Yj	19.5	19.2	**13.2**	19.2	**71.1**

Sol\

$$\boldsymbol{M.V.} = \frac{(\mathbf{3} \times \mathbf{19.5}) + (\mathbf{4} \times \mathbf{13.2}) - \mathbf{71.1}}{(\mathbf{3}-\mathbf{1})(\mathbf{4}-\mathbf{1})} = \mathbf{6.7}$$

Relative Efficiency between RCBD & CRD

This can be expressed by the following equation:

$$\boldsymbol{R.E.\% = \frac{(r-1)MSr + r(t-1)MSe}{(rt-1)MSe} \times 100}$$

Example:

Experiment data were analyzed to compare the four levels effect of urea fertilizer on the average yield of sunflower plants. The experimental design was the randomized complete design with five blocks. The results after the analysis were as in the following ANOVA table, and the researcher wanted to ensure the appropriateness of the design used in the experiment?

S.O.V.	d.f.	S.S.	M.S.	F. cal.
Block	**4**	**21.46**	**5.36**	
Treat	**3**	**134.45**	**44.83**	**20.46****
Error	**12**	**26.26**	**2.19**	
Total	**19**	**182.17**		

$$\boldsymbol{R.E.\% = \frac{(5-1)5.36 + 5(4-1)2.19}{(5\times 4-1)2.19} \times 100 = 131\%}$$

This result means that the RCBD is more efficient than the CRD by 30%, meaning that the use of 130 repetitions in the complete random design gives the same result for the RCBD when using 100 repetitions, in other words, the cost is greater by using the CRD compared to the RCBD.

Latin square design

A CRD assumes that there is no variability in the experimental units. The only source of variability in the data is the treatments and the remaining variability is the error. On the other hand, an RCB design assumes that other than the treatments, there is one source of variability in the experimental units and this variability in the experimental units is controlled by forming blocks of homogeneous experimental units. In this case, the sources of variability in the data are the treatments and the blocks (or replications) and the remaining part of the variability is the experimental error.

This section is devoted to designs which control two sources of variability in the experimental units. When there are two sources of variability in the experimental units, we need to form blocks in two directions, perpendicular to each other. The two blocking systems are cross classified as rows and columns and the intersection of rows and columns is a cell or the experimental unit. Following on the example of four grazing systems and 16 experimental units (animals), one source of variability in the animals could be the initial body weight. The other source of variability could be their physiological behavior. For instance, the calving age or the number of lactations could be another source of variability in the experimental material. The physiological behavior and the initial body weights are the two sources of variability in the animals and need to be controlled by proper designing of experiment.

Advantages of the LS Design

1. You can control variation in two directions.
2. Hopefully you increase efficiency as compared to the RCBD.

Advantages of the LS Design

1) The number of treatments must equal the number of replicates.

2) The experimental error is likely to increase with the size of the square.

3) Small squares have very few degrees of freedom for experimental error.

Linear Model for Latin square design (LS Design)

$$y_{ijk} = \mu + t_i + b_i + + e_{ij}$$

y_{ijk} \ Observations

μ \ The mean.

t_i \ The effect for being in treatment.

b_i \ The effect for being in columns.

c_k \ The effect for being in rows.

e_{ijk} \ Random error.

Analysis of Latin square design

S.O.V	df	SS	MS	F cal.
Rows	r - 1	$= \frac{\sum yi^2}{r} - C.F$		
Columns	r - 1	$= \frac{\sum yj^2}{r} - C.F$		
treats	r -1	$= \frac{\sum ti^2}{r} - C.F$	$= \frac{SS_t}{df_t}$	$= \frac{MS_t}{MS_e}$
Error	(r -1)(r - 2)	$= SS_T - SS_t - SS_r - SS_c$	$= \frac{SS_e}{df_e}$	
Total	$r^2 - 1$	$= \sum Yijke^2 - C.F$		

Not\ df (error) = df(T) – df (R + C + t)

Ex\ In an experiment conducted to study the amount of milk production for four breeds of cows, with different ages and different weights. The data in the table shows the amount of yield in kg for the experimental unit.

Treats		Columns				∑Yi	∑ti	Means
		C1	**C2**	**C3**	**C4**			
Rows	**R1**	t1 4	t2 3	t3 4	t4 1	12	t1 21	5.25
	R2	t2 5	t3 2	t4 3	t1 6	16	t2 16	4.0
	R3	t3 4	t4 2	t1 5	t2 5	16	t3 14	3.5
	R4	t4 6	t1 6	t2 3	t3 4	19	t4 12	2.0
∑Yj		19	13	15	16		Y.. = 63	

$$C.F. = \frac{(Y..)^2}{n}$$

$$= \frac{(63)^2}{16} = 240.06$$

$$SS_c = \frac{\sum Yi^2}{r} - C.F$$

$$= \frac{(12)^2 + \ \dots + \ (19)^2}{4} - 240.06 = 6.19$$

$$SS_r = \frac{\sum Yj^2}{r} - C.F$$

$$= \frac{(19)^2 + \ \dots + \ (16)^2}{4} - 240.06 = 4.69$$

$$SS_t = \frac{\sum ti^2}{r} - C.F$$

$$= \frac{(21)^2 + \dots + (12)^2}{4} - 240.06 = 11.19$$

$$SS_T = \sum Yijk^2 - C.F$$

$= (4)^2 + (3)^2 + \dots + (4)^2 - 240.06 = 32.94$

$$SS_e = SS_T - SS_t - SS_r - SS_c$$

$= 32.94 - (11.19 + 6.19 + 4.69) = 10.87$

S.O.V	df	SS	MS	F cal.	F tab.
Rows	3	6.19			
Columns	3	4.69			
Treats	3	11.19	3.73	2.06	4.76
Error	6	10.87	1.81		
Total	15	32.94			

Since (F cal.) is less than (F tab.), it means that there is no significant difference between the breeds on the milk yield.