Randomized Complete Block Design (RCBD)

The randomized complete block design (RCBD) is one of the most widely used experimental designs in agriculture research. The design is especially suited for field experiments where the number of treatments is not large and there a clear factor, which homogenous sets of experimental units can be identified.

The purpose of blocking is decreasing the experimental error, this is done by grouping the experimental units into blocks such that variability within each block is minimized and variability among blocks is maximized. Since only the variation within a block becomes part of the experimental error.

Advantages of randomized complete block designs

1) Complete flexibility (Can have any number of treatments and blocks).

2) Provides more accurate results.

3) Statistical analysis is easy even with missing data.

Disadvantages of randomized complete block designs

1) Not used it with large numbers of treatments.

2) Not used it with when complete block contains more variability.

3) Interactions between block and treatment effects increase error.

Not\ the randomized complete block design is one of the most widely used designs. If it will control the variation in a particular experiment, there is no need to use a more complex design.

The randomization process for a RCBD is applied independently to each of the blocks by the following steps:

Step1. Divide the experimental area into (r) equal blocks, where(r) is the number of replications.

Step2. Subdivide the first block into (t) experimental plots, where (t) is the number of treatments. Number the (t) plots from 1 to t, and assign (t) treatments at random. Repeat it for each of the remaining blocks.

Linear Model for Randomized Complete Block Design (RCBD)

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

y_{ij} \ Observations

μ \ The mean.

t_i \ The effect for being in treatment.

b_i \ The effect for being in block.

e_{ij}\ Random error.

Analysis of variance

There are three sources of variability in a RCBD:

(i)Treatment, (ii) replication (or block) and (iii) experimental error.

Note\ there is one more than that for a CRD, because of the addition of replication, which corresponds to the variability among blocks.

To collected Analysis of variance we should follow the steps:

Step 1. Group the data by treatments and replications and calculate treatment totals (Ti), replication totals (Rj) and grand total (T).

Step 2. Construct the outline of the analysis of variance

Step 3. Compute the correction factor and the various sums of squares (SS) given in the above table as follows

Source of variation	Degree of freedom (*df*)	Sum of squares (*SS*)	Mean square (MS)	*F*
Replication	***r* - 1**	***SSR***	***MSR***	
Treatment	***t* - 1**	***SST***	***MST***	***MST/MSE***
Error	**(*r* - 1)(*t* - 1)**	***SSE***	***MSE***	
Total	***rt* - 1**	***SSTO***		

The steps in forming the analysis of variance table for a CRD are:

1) CF = $\frac{Y_{..}}{N}$

2) SSt = $\frac{\sum ti^2}{r} - \mathrm{CF}$

3) SSr = $\frac{\sum ri^2}{t} - \mathrm{CF}$

4) TSS = $\sum y_{ij}^2 - \mathrm{CF}$

5) SSe = TSS – (SSt + SSr)

6) dft = T-1
dfT= N-1
dfr = R-1
dfe = dfT – (dft + dfr)

7) MSt = SSt / dft
MSe = SSe / dfe

8) F_{cal} = MSt / MSe

Ex\ A researcher studied the effect of seven levels for a particular vitamin on animals groups to measure weight gain. These animals were divided into four groups according to their ages. Find if there a significant effect of vitamin levels on weight gain?

Not \ $F_{0.05}$= 2.66

Treats	R1	R2	R3	R4
t1	1.8	2.3	2.1	1.9
t2	1.8	1.9	2.1	2.8
t3	2.1	2.3	2.5	2.4
t4	2.4	2.5	2.7	2.3
t5	2.5	2.8	2.6	2.7
t6	2.5	2.4	2.7	2.7
t7	2.6	2.7	2.9	2.8

Sol \

Treats	R1	R2	R3	R4	∑ti
t1	1.8	2.3	2.1	1.9	**8.1**
t2	1.8	1.9	2.1	2.8	**8.6**
t3	2.1	2.3	2.5	2.4	**9.3**
t4	2.4	2.5	2.7	2.3	**9.9**
t5	2.5	2.8	2.6	2.7	**10.6**
t6	2.5	2.4	2.7	2.7	**10.3**
t7	2.6	2.7	2.9	2.8	**11**
∑ri	**15.7**	**16.9**	**17.6**	**17.6**	**67.8**

C.F = $\frac{(67.8)^2}{28}$ = **164.17**

SS_T = (24)2+(52)2+ … +(162)2−164.17 =166.98−164.17= **2.81**

$$SS_t = \frac{(8.1)^2 + \ldots + (11)^2}{4} - 164.17 = \frac{663.52}{4} - 164.17 = \mathbf{1.71}$$

$$SS_r = \frac{(15.7)^2 + \ \ldots \ + \ (17.6)^2}{4} - 164.17 = \frac{1151.16}{7} - 164.17 = \mathbf{0.35}$$

SS_e = 2.81 – (1.71 + 0.35) = **0.75**

$df_t = 7 - 1 = 6$
$df_r = 4 - 1 = 3$
$df_T = 28 - 1 = 27$
$df_e = 27 - (6 + 3) = 18$

$$MS_r = \frac{SS_r}{df_r} = \frac{0.35}{3} = \mathbf{0.12}$$
$$MS_t = \frac{SS_t}{df_t} = \frac{1.71}{6} = \mathbf{0.29}$$
$$MS_e = \frac{SS_e}{df_e} = \frac{0.75}{18} = \mathbf{0.04}$$

$$F_{cal} = \frac{MS_t}{MS_e} = \frac{0.29}{0.04} = \mathbf{7.25}$$

Analysis of Variance (ANOVA Table)

S.O.V	df	SS	MS	F cal.	F tab.
Blocks	3	0.35	0.12		
treats	6	1.71	0.29	7.25*	2.66
Error	18	0.75	0.04		
Total	27	2.81			