

Randomised Block Design (RBD)

Working Rule:

Set the null hypothesis H_0 : There is no significance difference between the treatments.

Step: 1 Find T = The total value of observations

Step: 2 Find the Correction Factor C . $F = \frac{T^2}{N}$

Step: 3 Calculate the total sum of squares and find the total sum of squares

$$TSS = (\sum X_1^2 + \sum X_2^2 + \sum X_3^2 + \dots) - C.F$$

Step: 4 Find column sum of squares $SSC = \left(\frac{(\sum X_1)^2}{N_1} + \frac{(\sum X_2)^2}{N_2} + \frac{(\sum X_3)^2}{N_3} + \dots \right) - C.F$

Where N_i = Total number of observation in each column ($i = 1, 2, 3, \dots$)

Step: 5 Find Column sum of squares $SSR = \left(\frac{(\sum Y_1)^2}{N_1} + \frac{(\sum Y)^2}{N_2} + \frac{(\sum Y_3)^2}{N_3} + \dots \right) - C.F$

Where N_j = Total number of observation in each ROW ($j = 1, 2, 3, \dots$)

Step: 6 $SSE = TSS - (SSC + SSR)$

Step: 7 Prepare the ANOVA to calculate F – ratio

Source of variation	Sum of Degrees	Degrees of Freedom	Mean Square	F - Ratio
Between Columns	SSC	c - 1	$MSC = \frac{SSC}{c-1}$	$F_c = \frac{MSC}{MSE}$ if $MSC > MSE$ $F_c = \frac{MSE}{MSC}$ if $MSE > MSC$
Between Rows	SSR	r - 1	$MSR = \frac{SSR}{r-1}$	$F_c = \frac{MSR}{MSE}$ if $MSR > MSE$ $F_c = \frac{MSE}{MSR}$ if $MSE > MSR$
Error	SSE	(r - 1)(c - 1)	$MSE = \frac{SSE}{(r-1)(c-1)}$	

Step: 8 Find the table value (use chi square table)

Step: 9 Conclusion:

Calculated value < Table value, then we accept null hypothesis.

Calculated value > Table value, then we reject null hypothesis.

PROBLEMS ON TWO WAY ANOVA TABLE

1. Three varieties A, B, C of a crop are tested in a randomized block design with four replication. The plot yields in pounds as follows.

A6	C5	A8	B9
C8	A4	B6	C9
B7	B6	C10	A6

Analysis the experiment yield and state your conclusion.

Solution:

Set the null hypothesis H_0 : There is no significance difference between the rows and columns.

Varieties	Yields				
	1	2	3	4	Total
A	6	4	8	6	24
B	7	6	6	9	28
C	8	5	10	9	32
Total	21	15	24	24	84

TEST STATISTIC:

Varieties		1	2	3	4	Total	X_1^2	X_2^2	X_3^2	X_4^2
		X_1	X_2	X_3	X_4					
Y_1	A	6	4	8	6	24	36	16	64	36
Y_2	B	7	6	6	9	28	49	36	36	81
Y_3	C	8	5	10	9	32	64	25	100	81
Total		21	15	24	24	84	149	77	200	198

Step:1 Grand Total $T = 84$

Step: 2 Correction Factor $C.F = \frac{T^2}{N} = \frac{(84)^2}{12} = 588$

Step: 3 Calculate the total sum of squares and find the total sum of squares

$$TSS = (\sum X_1^2 + \sum X_2^2 + \sum X_3^2 + \dots) - C.F$$

$$= (149 + 77 + 200 + 198) - 588$$

$$= 624 - 588 = 36$$

Step: 4 Find column sum of squares $SSC = \left(\frac{(\sum X_1)^2}{N_1} + \frac{(\sum X_2)^2}{N_2} + \frac{(\sum X_3)^2}{N_3} + \dots \right) - C.F$

$$SSC = \left(\frac{(21)^2}{3} + \frac{(15)^2}{3} + \frac{(24)^2}{3} + \frac{(24)^2}{3} \right) - 588 = 18$$

Step: 5 Find Row sum of squares $SSR = \left(\frac{(\sum Y_1)^2}{N_1} + \frac{(\sum Y)^2}{N_2} + \frac{(\sum Y_3)^2}{N_3} + \dots \right) - C.F$

$$SSR = \left(\frac{(24)^2}{4} + \frac{(28)^2}{4} + \frac{(32)^2}{4} + \dots \right) - 588 = 8$$

Step: 6 SSE = Residual sum of squares

$$= TSS - (SSC + SSR)$$

$$= 36 - (18 + 8) = 10$$

Step: 7 Prepare the ANOVA to calculate F – ratio

Source of variation	Sum of Degrees	Degrees of Freedom	Mean Square	F - Ratio
Between Columns	SSC=18	$c - 1$ $= 4 - 1 = 3$	$MSC = \frac{SSC}{c-1} = 6$	$F_c = \frac{MSC}{MSE} = 3.6$
Between Rows	SSR=8	$r - 1$ $= 3 - 1 = 2$	$MSR = \frac{SSR}{r-1} = 4$	$F_R = \frac{MSR}{MSE} = 2.4$
Error	SSE = 10	$(r - 1)(c - 1)$ $2 \times 3 = 6$	$MSE = \frac{SSE}{(r - 1)(c - 1)} = 1.667$	

Step: 8 d.f for (3, 6) at 5% level of significance is 4.76

d.f for (2, 6) at 5% level of significance is 5.14

Step: 9 Conclusion:

Calculated value $F_c < \text{Table value}$, then we accept null hypothesis.

There is no significance difference between the columns.

Calculated value $F_R < \text{Table value}$, then we accept null hypothesis.

There is no significance difference between the rows.

2. Four varieties A, B, C, D of a fertilizer are tested in a randomized block design with four replication. The plot yields in pounds as follows.

A 12	D 20	C 16	B 10
D 18	A 14	B 11	C 14
B 12	C 15	D 19	A 13
C 16	B 11	A 15	D 20

Analysis the experimental yield.

Solution:

Set the null hypothesis H_0 : There is no significance difference between the rows and columns.

Varieties	Yields				
	1	2	3	4	Total
A	12	14	15	13	54
B	12	11	11	10	44
C	16	15	16	14	61
D	18	20	19	20	77
Total	58	60	61	57	236 (T)

TEST STATISTIC:

Varieties		1	2	3	4	Total	X_1^2	X_2^2	X_3^2	X_4^2
		X_1	X_2	X_3	X_4					
Y_1	A	12	14	15	13	54	144	196	225	169
Y_2	B	12	11	11	10	44	144	121	121	100
Y_3	C	16	15	16	14	61	256	225	256	196
Y_4	D	18	20	19	20	77	324	400	361	400
Total		58	60	61	57	236	868	942	963	865

Step:1 Grand Total $T = 236$

Step: 2 Correction Factor $C.F = \frac{T^2}{N} = \frac{(236)^2}{16} = 3481$

Step: 3 Calculate the total sum of squares and find the total sum of squares

$$\begin{aligned}
 TSS &= (\sum X_1^2 + \sum X_2^2 + \sum X_3^2 + \dots) - C.F \\
 &= (868 + 942 + 963 + 865) - 3481 \\
 &= 3638 - 3481 = 157
 \end{aligned}$$

Step: 4 Find column sum of squares $SSC = \left(\frac{(\sum X_1)^2}{N_1} + \frac{(\sum X_2)^2}{N_2} + \frac{(\sum X_3)^2}{N_3} + \dots \right) - C.F$

$$\begin{aligned} SSC &= \left(\frac{(58)^2}{4} + \frac{(60)^2}{4} + \frac{(61)^2}{4} + \frac{(57)^2}{4} \right) - 3481 \\ &= 841 + 900 + 930 + 812 - 3481 = 2 \end{aligned}$$

Step: 5 Find Row sum of squares $SSR = \left(\frac{(\sum Y_1)^2}{N_1} + \frac{(\sum Y)^2}{N_2} + \frac{(\sum Y_3)^2}{N_3} + \dots \right) - C.F$

$$\begin{aligned} SSR &= \left(\frac{(54)^2}{4} + \frac{(44)^2}{4} + \frac{(61)^2}{4} + \frac{(77)^2}{4} \right) - 3481 \\ &= 729 + 484 + 930.25 + 1482.25 - 3481 \\ &= 144.5 \end{aligned}$$

Step: 6 SSE = Residual sum of squares

$$\begin{aligned} &= TSS - (SSC + SSR) \\ &= 157 - (2 + 144.5) = 10.5 \end{aligned}$$

Step: 7 Prepare the ANOVA to calculate F – ratio

Source of variation	Sum of Degrees	Degrees of Freedom	Mean Square	F - Ratio
Between Columns	SSC=2	$c - 1$ $= 4 - 1 = 3$	$MSC = \frac{SSC}{c-1}$ $= 0.666$	$F_c = \frac{MSE}{MSC} = 1.74$
Between Rows	SSR=144.5	$r - 1$ $= 4 - 1 = 3$	$MSR = \frac{SSR}{r-1}$ $= 48.16$	$F_R = \frac{MSR}{MSE} = 41.51$
Error	SSE = 10.5	$(r - 1)(c - 1)$ $= 3 \times 3 = 9$	$MSE = \frac{SSE}{(r - 1)(c - 1)}$ $= 1.6$	

Step: 8 d.f for (9, 3) at 5% level of significance is 8.82

d.f for (3, 9) at 5% level of significance is 3.86

Step: 9 Conclusion:

Calculated value $F_c < \text{Table value}$, then we accept null hypothesis.

There is no significance difference between the columns.

Calculated value $F_R > \text{Table value}$, then we reject null hypothesis.

There is a significance difference between the rows.