2.2 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

$$\text{TSS} = \left(\sum {X_1}^2 + \sum {X_2}^2 + \sum {X_3}^2 + \ \ldots\right) - C.F$$

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

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

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

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

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 = $\frac{SSE}{r-1}$	$F_c = \frac{MSR}{MSE}$ 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

$$\text{TSS} = \left(\sum {X_1}^2 + \sum {X_2}^2 + \sum {X_3}^2 + \ . \ . \ . \right) - C.F$$

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

$= 624 - 588 = 36$

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 x 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 $F_c <$ Table value, then we accept null hypothesis.

There is no significance difference between the columns.

Calculated value $F_R <$ 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

$$\text{TSS} = \left(\sum X_1{}^2 + \sum X_2{}^2 + \sum X_3{}^2 + \ . \ . \ .\right) - C.F$$

$$= (868 + 942 + 963 + 865) - 3481$$

$$= 3638 - 3481 = 157$$

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

$$\text{SSC} = \left(\frac{(58)^2}{4} + \frac{(60)^2}{4} + \frac{(61)^2}{4} + \frac{(57)^2}{4}\right) - 3481$$

$$= 841 + 900 + 930 + 812 - 3481 = 2$$

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

$$\text{SSR} = \left(\frac{(54)^2}{4} + \frac{(44)^2}{4} + \frac{(61)^2}{4} + \frac{(77)^2}{4}\right) - 3481$$

$$= 729 + 484 + 930.25 + 1482.25 - 3481$$

$$= 144.5$$

Step: 6 SSE = Residual sum of squares

= TSS – (SSC + SSR)

= 157 – (2 +144.5)= 10.5

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 x 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 $F_c <$ Table value, then we accept null hypothesis.

There is no significance difference between the columns.

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

There is a significance difference between the rows.