RANDOMISED BLOCK DESIGN (RBD) (or) TWO WAY CLASSIFICATION

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

A	6	C	5	A	8	B	7
C	8	A	4	B	6	C	9
B	7	B	6	C	10	A	6

Analysis the experimental yield and state your conclusion.

Soln:

Varieties — Yields

A	6	4	8	6
B	7	6	6	9
C	8	5	10	9

	x_1	x_2	x_3	x_4	Total	x_1^2	x_2^2	x_3^2	x_4^2
y_1	6	4	8	6	24 Sy_1	36	16	64	36
y_2	7	6	6	9	28 Sy_2	49	36	36	81
y_3	8	5	10	9	32 Sy_3	64	25	100	81
	$\overline{21}$ Σx_1	$\overline{15}$ Σx_2	$\overline{24}$ Σx_3	$\overline{24}$ Σx_4	$\overline{84}$ Sy_4	$\overline{149}$ Σx_1^2	$\overline{77}$ Σx_2^2	$\overline{200}$ Σx_3^2	$\overline{198}$ Σx_4^2

Step 1: Formulating H_0 and H_1

H_0: There is no significant between yields and varieties

H_1: There is significant between yields and varieties.

Step 2: To find N & T

$N = n_1 + n_2 + n_3 + n_4$

$= 3 + 3 + 3 + 3 = 12$

$T = \Sigma x_1 + \Sigma x_2 + \Sigma x_3 + \Sigma x_4$

$= 21 + 15 + 24 + 24$

$= 84$

Step 3: Correction factor, CF.

$$C.F = \frac{T^2}{N} = \frac{84^2}{12} = 588$$

Step 4: $TSS = \Sigma x_1^2 + \Sigma x_2^2 + \Sigma x_3^2 + \Sigma x_4^2 - C.F$

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

$= 36$

Step 5: $$SSC = \frac{(\Sigma x_1)^2}{n_1} + \frac{(\Sigma x_2)^2}{n_2} + \frac{(\Sigma x_3)^2}{n_3} + \frac{(\Sigma x_4)^2}{n_4} - C.F.$$

$$= \frac{21^2}{3} + \frac{15^2}{3} + \frac{24^2}{3} + \frac{24^2}{3} - 588$$

$= 18$

$$SSR = \frac{(\Sigma y_1)^2}{n_1'} + \frac{(\Sigma y_2)^2}{n_2'} + \frac{(\Sigma y_3)^2}{n_3'} - C.F$$

$$= \frac{24^2}{4} + \frac{28^2}{4} + \frac{32^2}{4} - 588$$

$= 8$

Step 6: $SSE = TSS - SSC - SSR$

$= 36 - 18 - 8$

$= 10$

Step 7: Anova table.

Source of Variation	Sum of squares	Degrees of freedom	Mean Sum of Squares	F-Ratio
Column	SSC : 18	C-1 : 4-1 = 3	MSC : 18/3 = 6	$F_c = \frac{6}{1.6} = 3.75$, $F_\alpha(3,6) = 4.76$
Row	SSR : 8	r-1 : 3-1 = 2	MSR = 8/2 = 4	$F_R = \frac{4}{1.6} = 2.5$
Error.	SSE : 10	(c-1)(r-1). 3×2 = 6	MSE = 10/6 = 1.6	$F_\alpha(2,6) = 5.14$

Step 8: Conclusion:

$F_c = 3.75 < 4.76 = F_\alpha$, H_0 is accepted

$F_R = 2.5 < 5.14 = F_\alpha$, H_0 is accepted

(ie) There is no significant difference between yields & varieties.

1) The yield of four strains of a particular variety of wheat was planted in five randomized blocks in kgs per plot is given below.

Strains	Blocks 1	2	3	4	5
A	32	34	34	35	36
B	33	33	36	37	34
C	30	35	35	32	35
D	29	22	30	28	28

Test for difference between blocks and difference between strains.

Origin: $x_{ij} - 30$

Strains ↓ / Blocks →	1	2	3	4	5
A	2	4	4	5	6
B	3	3	6	7	4
C	0	5	5	2	5
D	-1	-8	0	-2	-2

x_1	x_2	x_3	x_4	x_5	total	x_1^2	x_2^2	x_3^2	x_4^2	x_5^2
2	4	4	5	6	21	4	16	16	25	36
3	3	6	7	4	23	9	9	36	49	16
0	5	5	2	5	17	0	25	25	4	25
-1	-8	0	-2	-2	-13	1	64	0	4	4
4	4	15	12	13	48	14	114	77	82	81
Σx_1	Σx_2	Σx_3	Σx_4	Σx_5		Σx_1^2	Σx_2^2	Σx_3^2	Σx_4^2	Σx_5^2

Step 1: Formulating H_0 and H_1:

H_0: There is no significance diff between blocks and strains.

H_1: There is significance diff between blocks and strains.

Step 2: To find T & N:

$$T = \Sigma n_1 + \Sigma n_2 + \Sigma n_3 + \Sigma n_4 + \Sigma n_5$$
$$= 4 + 4 + 15 + 12 + 13 = 48$$

$$N = n_1 + n_2 + n_3 + n_4 + n_5$$
$$= 4 + 4 + 4 + 4 + 4 = 20$$

Step 3: Correction factor, C.F.

$$C.F = \frac{T^2}{N} = \frac{48^2}{20} = 115.2.$$

Step 4: $TSS = \Sigma n_1^2 + \Sigma n_2^2 + \Sigma n_3^2 + \Sigma n_4^2 + \Sigma n_5^2 - C.F$

$$= 14 + 114 + 77 + 82 + 81 - 115.2$$
$$= 252.8$$

Step 5: $SSC = \frac{(\Sigma n_1)^2}{n_1} + \frac{(\Sigma n_2)^2}{n_2} + \frac{(\Sigma n_3)^2}{n_3} + \frac{(\Sigma n_4)^2}{n_4} + \frac{(\Sigma n_5)^2}{n_5} - C.F$

$$= \frac{4^2}{4} + \frac{4^2}{4} + \frac{15^2}{4} + \frac{12^2}{4} + \frac{13^2}{4} - 115.2.$$
$$= 27.3.$$

$$SSR = \frac{(\Sigma y_1)^2}{n_1'} + \frac{(\Sigma y_2)^2}{n_2'} + \frac{(\Sigma y_3)^2}{n_3'} + \frac{(\Sigma y_4)^2}{n_4'} + \frac{(\Sigma y_5)^2}{n_5'} - C.F$$

$$= \frac{21^2}{5} + \frac{28^2}{5} + \frac{17^2}{5} + \frac{-13^2}{5} - 115.2$$

$$= 170.4$$

Step 6: $SSE = TSS - SSC - SSR$

$$= 252.8 - 27.3 - 170.4$$

$$= 55.1$$

Step 7: Anova table.

Source of Variations	Sum of square	Degrees of freedom	Mean sum of square	F-Ratio
Column	SSC: 27.3	c-1: 5-1 = 4	MSC: $\frac{27.3}{4}$ = 6.825	$F_C = \frac{6.825}{4.59}$ = 1.486; $F_\alpha(4,12)$ = 3.26
Row	SSR: 170.4	r-1: 4-1 = 3	MSR: $\frac{170.4}{3}$: 56.8	$F_R = \frac{56.8}{4.59}$ = 12.37; $F_\alpha(3,12)$ = 3.49
ERROR	SSE: 55.1	(c-1)*(r-1) 4*3 = 12,	MSE: $\frac{55.1}{12}$ = 4.59	

Step 8: Conclusion:

If $F_C < F_\alpha$ H_0 is accepted.

$F_R < F_\alpha$, H_0 is accepted.

Hence, there is no significance diff between blocks and steams.

5) A Tea Company appoints four salesman A, B, C and D and observes their sales in three seasons, summer, winter and monsoon. The figures (in lakhs) are given in the following table.

Seasons	Salesman A	B	C	D	Seasons total
Summer	36	36	21	35	128
Winter	28	29	31	32	120
Monsoon	26	28	29	29	112
Salesmans total	90	93	81	96	360

i) Do the salesman significantly differ in performance?

ii) Is there significant difference between the seasons.