



UNIT - 2 DESIGN OF EXPERIMENTS
LATIN SQUARE DESIGN

Latin Square Design

1) An agriculturist wants to test the effect of four different fertilizers A, B, C & D on the yield of paddy. In order to eliminate sources of error due to variability in self-fertility he used the fertilizers in a Latin square arrangements given below where the numbers indicate yields in quintals per unit area. Perform an analysis of variance to decide whether there is a difference b/w the fertilizers at 5% level of significance.

A 18	C 21	D 25	B 11
D 22	B 12	A 15	C 19
B 15	A 20	C 23	D 24
C 22	D 21	B 10	A 17

Solution:-

Null Hypothesis: H_0 : There is no difference between fertilizers.

Alternative Hypothesis: H_1 : There is a difference b/w fertilizers.

Level of Significance: $\alpha = 5\% = 0.05$

$$N = 16, n = 4$$

$$CF = \frac{T^2}{N} = \frac{49}{16} = 3.062$$

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Subtract '18' from each entries to shift the origin

X \ Y	X ₁	X ₂	X ₃	X ₄	Total	X ₁ ²	X ₂ ²	X ₃ ²	X ₄ ²
Y ₁	0	3	7	-7	3	0	9	49	49
Y ₂	4	-6	-3	1	-4	16	36	9	1
Y ₃	-3	2	5	6	10	9	4	25	36
Y ₄	4	8	-8	-1	-2	16	64	64	1
Total	5	2	1	-1	7	41	58	147	87

TSS! Total sum of squares = $\sum X_1^2 + \sum X_2^2 + \sum X_3^2 + \sum X_4^2 - CF$

= 41 + 58 + 147 + 87 - 3.06

= 329.94

SSC = $\frac{(\sum X_1)^2}{c_1} + \frac{(\sum X_2)^2}{c_2} + \frac{(\sum X_3)^2}{c_3} + \frac{(\sum X_4)^2}{c_4} - CF$

= $\frac{(5)^2}{4} + \frac{(2)^2}{4} + \frac{(1)^2}{4} + \frac{(1)^2}{4} - 3.06$

= 4.6875

SSR = $\frac{(\sum Y_1)^2}{r_1} + \frac{(\sum Y_2)^2}{r_2} + \frac{(\sum Y_3)^2}{r_3} + \frac{(\sum Y_4)^2}{r_4} - CF$

= $\frac{3^2}{4} + \frac{(-4)^2}{4} + \frac{(10)^2}{4} + \frac{(-2)^2}{4} - 3.06$

= 32.25 - 3.06 = 29.19

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To find SST: Sum of squares of treatments

					Total
A	0	2	-3	-1	$\sum x_1 = -2$
B	-3	-6	-8	-7	$\sum x_2 = -24$
C	4	3	5	1	$\sum x_3 = 13$
D	4	3	7	6	$\sum x_4 = 20$

$$SST = \frac{(\sum x_1)^2}{4} + \frac{(\sum x_2)^2}{4} + \frac{(\sum x_3)^2}{4} + \frac{(\sum x_4)^2}{4} - CF$$

$$= \frac{(-2)^2}{4} + \frac{(-24)^2}{4} + \frac{(13)^2}{4} + \frac{(20)^2}{4} - 3.06$$

$$= 287.25 - 3.06 = 284.19$$

$$SSE = TSS - SSC - SSR - SST$$

$$= 329.94 - 29.19 - 4.69 - 284.19$$

$$= 11.87$$

Source of Variation	Degrees of freedom	Sum of Squares	Mean Sum of Squares	F-Ratio	F _α
Between rows	r-1 = 3	SSR = 29.19	$\frac{29.19}{3} = 9.73$	$F_r = \frac{9.73}{1.98} = 4.92$	$F_{\alpha}(3,6) = 4.76$
Columns	c-1 = 3	SSC = 4.69	$\frac{4.69}{3} = 1.56$	$F_c = \frac{1.98}{1.56} = 1.27$	$F_{\alpha}(3,6) = 4.76$
Treatments	t-1 = 3	SST = 284.19	$\frac{284.19}{3} = 94.73$	$F_T = \frac{94.73}{1.98} = 47.8$	$F_{\alpha}(3,6) = 4.76$
Error	$(n-1)(n-2) = 3 \times 2 = 6$	SSE = 11.87	$\frac{11.87}{6} = 1.98$		

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$$\therefore F_R = 4.92 > F_{\alpha}(3,6) = 4.72$$

$$F_C = 1.27 < 9.94 = F_{\alpha}(6,3)$$

$$F_T = 47.8 > 4.76 = F_{\alpha}(3,6)$$

Conclusion!

Difference b/w rows is significant (Reject H_0)
Difference b/w columns is not significant (Accept H_0)
Difference b/w fertilizers is highly significant (Reject H_0)