ASSIGNMENT - BIOSTATS

- RBD & LSD

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RANDOMIZED BLOCK DESIGN (RBD)

Exercise

The yield of rice (in kg) with five fertilizers tested in four blocks using RBD is given in the following layout. Analyse the data and interpret.

Block 1	Block 2	Block 3	Block 4
B 10	C 13	A 19	D 20
C 16	A 21	D 24	E 36
A 20	D 21	E 32	B 9
D 23	E 31	B 10	C 13
E 33	B 11	C 14	A 24

SOLUTION

Restructuring to a table with Rows = Blocks & Columns = Treatments

Treatments →

Block	A	B	C	D	E	
Block 1	20	10	16	23	33	102
Block 2	21	11	13	21	31	97
Block 3	19	10	14	24	32	99
Block 4	24	9	13	20	36	102
	84	40	56	88	132	

Here we'll consider 2 hypotheses :-

H_{10} : The rows (blocks) are homogenous

H_{20} : The treatments are homogenous

Step 1 : Correction Factor (CF)

$$CF = \frac{(GT)^2}{N} = \frac{\left(\sum Y_{ij}\right)^2}{N} = \frac{400^2}{20} = \frac{160000}{20} = 8000$$

Step 2 : Total Sum of Squares (TSS)

$$TSS = \sum Y_{ij}^2 - CF = 9286 - 8000$$
$$= 1286$$

Step 3 : Treatment Sum of Squares (SST)

$$SST = \frac{1}{r}\sum T_i^2 - CF$$
$$= \frac{84^2 + 40^2 + 56^2 + 88^2 + 132^2}{4} - 7068.8$$
$$= \frac{12288 + 1600 + 3136 + 7744 + 17424}{4} - 7068.8$$
$$= \frac{42192}{4} - 7068.8 = 10548 - 7068.8$$
$$= 1240$$

Step 4 : Block Sum of Squares (SSB)

$$SSB = \frac{1}{t}\sum B_j^2 - CF$$
$$= \frac{102^2 + 97^2 + 99^2 + 102^2}{5} - 8000$$
$$= \frac{10404 + 9409 + 9801 + 10404}{5} - 7068.8$$
$$= \frac{40018}{5} - 7068.8 = 8003.6 - 8000 = 3.6$$

Step 5 : Error Sum of Squares (SSE)

$$SSE = TSS - SST - SSB$$
$$= 1286 - 1240 - 3.6 = 42.4$$

Step 6 : Degrees of Freedom

Total df $= N - 1 = 19$

Treatment df $= t - 1 = 4$

Block df $= r - 1 = 3$

Error df $= (t-1)(r-1)$
$= 12$

Step 7 : Mean Squares

$$MS_{Tr} = \frac{SST}{df_{Tr}} = \frac{1240}{4} = 310$$

$$MS_{Bl} = \frac{SSB}{df_{Bl}} = \frac{3.6}{3} \simeq 1.20$$

$$MS_E = \frac{SSE}{df_E} = \frac{42.4}{12} = 3.533$$

Step 8 : F – ratios

$$F_{Tr} = \frac{MS_{Tr}}{MS_E} = \frac{310}{3.533} = 87.73585$$

$$F_{Bl} = \frac{MS_{Bl}}{MS_E} = \frac{1.20}{3.533} = 0.33962$$

Step 9 : ANOVA Table

Sources of variation	SS	df	MS	F-value
Treatments	1240	4	310	87.736
Blocks	3.6	3	1.20	0.34
Error	42.4	12	3.533	
Total	1286	19		

From the F-table,

$f_{0.05,4,12} = 3.26 < F_{Tr}\ (87.736)$

$f_{0.05,3,12} = 3.49 > F_{Bl}\ (0.34)$

Hence the Treatment (Fertilizer) effect is highly significant. Hence we reject H_{20}

But the Block Effect is not significant & does not capture any large source of variation. Hence we accept H_{10}.

LATIN SQUARED DESIGN (LSD)

Exercise

An experiment was carried out to determine the effect of claying the ground on the field of barley grains; amt. of clay used were as follows:

- A : no clay
- B : clay at 100 per acre
- C : clay at 200 per acre
- D : clay at 300 per acre

The yields were in plots of 8 mtrs by 8 mtre and are given in the table.

Row/Col	C1	C2	C3	C4	Row total
R1	D 29.1	B 18.9	C 29.4	A 5.7	83.1
R2	C 16.4	A 10.2	D 21.2	B 19.1	66.9
R3	A 5.4	D 38.8	B 24.0	C 37.0	105.2
R4	B 24.9	C 41.7	A 9.5	D 28.9	105.0
Column total	75.8	109.6	84.1	90.7	GT = 360.2

Here we'll have 3 null hypotheses :-

H_{10} : Rows are homogenous

H_{20} : Columns are homogenous

H_{30} : Treatments are homogenous

SOLUTION :

Treatment Totals :

$T_A = 30.8$ $\quad$ $T_C = 124.5$

$T_B = 86.9$ $\quad$ $T_D = 118.0$

No. of treatments $t = 4$

No. of replications for each treatment $r = 4$

$N = t^2 = 16$ observations

Grand Total $GT = 360.2$

Step 1 : Correction Factor (CF)

$$CF = \frac{(GT)^2}{N} = \frac{360.2^2}{16} = \frac{129744.04}{16}$$

$$= 8109.0025$$

Step 2 : Total Sum of Squares (TSS)

$$TSS = \sum Y_{ij}^2 - CF$$

$$= 10052.08 - 8109.0025 = 1943.0775$$

Step 3 : Treatment/Clay Sum of Squares (SST)

$$SST = \frac{1}{r}\sum_{1}^{t} T_i^2 - CF$$

$$= \frac{1}{4}\left(30.8^2 + 86.9^2 + 124.5^2 + 118.0^2\right) - CF$$

$$= \frac{36960.49}{4} - CF = 9240.1225 - 8109.0025$$

$$= 1372.1225$$

Step 4 : Row Sum of Squares (RSS)

$$RSS = \frac{1}{t}\sum_{1}^{t} R_j^2 - CF$$

$$= \frac{1}{4}\left(83.1^2 + 66.9^2 + 105.2^2 + 105.0^2\right) - 8109.0025$$

$$= 259.3125$$

Step 5 : Column Sum of Squares (CSS)

$$CSS = \frac{1}{t}\sum_{1}^{t} C_k^2 - CF$$

$$= \frac{1}{4}\left(75.8^2 + 109.6^2 + 84.1^2 + 90.7^2\right) - 8109.0025$$

$$= 155.2725$$

Step 6 : Error Sum of Squares (ESS)

$$ESS = TSS - (SST + RSS + CSS)$$

$$= 1943.0775 - (1372.1225 + 259.3125 + 155.2725)$$

$$= 156.37$$

Step 7 : Degrees of Freedom

Total df $= N - 1 = 16 - 1 = 15$

Treatment df $= t - 1 = 3$ = Row df = Column df

Error df $= (t-1)(t-2) = 3 \times 2 = 6$

Step 8 : Mean Squares & F-Statistics

$$MS_{Tr} = \frac{1372.1225}{3} = 457.37417$$

$$MS_{Row} = \frac{259.3125}{3} = 86.43750$$

$$MS_{Col} = \frac{155.2725}{3} = 51.75750$$

$$MS_E = \frac{156.37}{6} = 26.06166$$

$$F_{Tr} = \frac{MS_{Tr}}{MS_E} = \frac{457.37417}{26.06166} \simeq 17.55$$

$$F_{Row} = 86.43750/26.06166 \simeq 3.32$$

$$F_{Col} = 51.75750/26.06166 \simeq 1.99$$

P.T.O.

Step 9 : ANOVA Table

Source of Variation	SS	df	MS	F
Treatments	1372.1225	3	457.3742	17.55
Rows	259.3125	3	86.4375	3.32
Columns	155.2725	3	51.7575	1.99
Error	156.3700	6	26.0617	
TOTAL	1943.0775	15		

From the F-Table,

$F_{0.05, 3, 6} = 4.76$

Now $F_{Tr} = 17.55 > 4.76 \Rightarrow$ Treatment Effect is Highly Significant i.e. clay levels differ in yield $\Rightarrow$ H_{30} is rejected

$F_{Row} = 3.32 < 4.76 \Rightarrow$ Row effect is not significant at 5%. $\Rightarrow$ H_{10} is accepted

$F_{col} = 1.99 < 4.76 \Rightarrow$ Column effect not significant $\Rightarrow$ H_{20} is accepted

Hence the amt. of clay (treatment) has a statistically significant effect on barley yield in this experiment.

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RBD-LSD Assignment

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Contents

1. RBD Exercise

```r
# Creating dataset
df <- data.frame(
  Block = rep(paste0("Block", 1:4), each = 5),
  Fertilizer = c("B","C","A","D","E",
                 "C","A","D","E","B",
                 "A","D","E","B","C",
                 "D","E","B","C","A"),
  Yield = c(10,16,20,23,33,
            13,21,21,31,11,
            19,24,32,10,14,
            20,36,9,13,24)
)

# ANOVA
model <- aov(Yield ~ Fertilizer + Block, data = df)
summary(model)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## Fertilizer   4 1240.0  310.00   87.74 8.89e-09 ***
## Block        3    3.6    1.20    0.34    0.797
## Residuals   12   42.4    3.53
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the above ANOVA table, we can see that the p-value for Fertilizer is less than 0.05, indicating that there are significant differences among the means of different fertilizers. However, the p-value for Block is greater than 0.05, suggesting that there are no significant differences among the blocks.

2. LSD Exercise

```r
# Create a data frame for the Latin square
df <- data.frame(
  Row = rep(c("R1","R2","R3","R4"), each = 4),
  Col = rep(c("C1","C2","C3","C4"), times = 4),
  Tr  = c("D","B","C","A",
          "C","A","D","B",
          "A","D","B","C",
          "B","C","A","D"),
  Yield = c(29.1,18.9,29.4,5.7,
            16.4,10.2,21.2,19.1,
            5.4,38.8,24.0,37.0,
            24.9,41.7,9.5,28.9)
)

# Fit the Latin square ANOVA model: Yield ~ Tr + Row + Col
model <- aov(Yield ~ Tr + Row + Col, data = df)
summary(model)
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## Tr           3 1372.1   457.4  17.550 0.00225 **
## Row          3  259.3    86.4   3.317 0.09854 .
## Col          3  155.3    51.8   1.986 0.21760
## Residuals    6  156.4    26.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the ANOVA table above, we can see that the p-value for Treatment (Tr) is less than 0.05, indicating that there are significant differences among the means of different treatments. The p-values for Row and Column are greater than 0.05, suggesting that there are no significant differences among the rows and columns.