**Lecture.17**

**Latin square design – description – layout – analysis – advantages and disadvantages.**

## Latin Square Design

When the experimental material is divided into rows and columns and the treatments are allocated such that each treatment occurs only once in each row and each column, the design is known as L S D.

In LSD the treatments are usually denoted by A B C D etc.

For a 5 x 5 LSD the arrangements may be

| | | | | |
|---|---|---|---|---|
| ***A*** | ***B*** | ***C*** | ***D*** | ***E*** |
| ***B*** | ***A*** | ***E*** | ***C*** | ***D*** |
| ***C*** | ***D*** | ***A*** | ***E*** | ***B*** |
| ***D*** | ***E*** | ***B*** | ***A*** | ***C*** |
| ***E*** | ***C*** | ***D*** | ***B*** | ***A*** |
| **Square 1** | | | | |

| | | | | |
|---|---|---|---|---|
| | ***B*** | ***C*** | ***D*** | ***E*** |
| ***B*** | ***A*** | ***D*** | ***E*** | ***C*** |
| ***C*** | ***E*** | ***A*** | ***B*** | ***D*** |
| ***D*** | ***C*** | ***E*** | ***A*** | ***B*** |
| ***E*** | ***D*** | ***B*** | ***C*** | ***A*** |
| **Square 2** | | | | |

| | | | | |
|---|---|---|---|---|
| ***A*** | ***B*** | ***C*** | ***D*** | ***E*** |
| ***B*** | ***C*** | ***D*** | ***E*** | ***A*** |
| ***C*** | ***D*** | ***E*** | ***A*** | ***B*** |
| ***D*** | ***E*** | ***A*** | ***B*** | ***C*** |
| ***E*** | ***A*** | ***B*** | ***C*** | ***D*** |
| **Square 3** | | | | |

## Analysis

The ANOVA model for LSD is

$$Y_{ijk} = \mu + r_i + c_j + t_k + e_{ijk}$$

$r_i$ is the $i^{th}$ row effect

$c_j$ is the $j^{th}$ column effect

$t_k$ is the $k^{th}$ treatment effect and

eijk is the error term

The analysis of variance table for LSD is as follows:

| Sources of Variation | d.f. | S S | M S | F |
|---|---|---|---|---|
| Rows | t-1 | RSS | RMS | RMS/EMS |
| Columns | t-1 | CSS | CMS | CMS/EMS |
| Treatments | t-1 | TrSS | TrMS | TrMS/EMS |
| Error | (t-1)(t-2) | ESS | EMS | |
| Total | $t^2$-1 | TSS | | |

**F table value**

$F_{[t-1),(t-1)(t-2)]}$ degrees of freedom at 5% or 1% level of significance

Steps to calculate the above Sum of Squares are as follows:

Correction Factor $(CF) = \frac{(GT)^2}{(t)^2}$

Total Sum of Squares $(TSS) = \sum (y_{ijk})^2 - CF$

Row sum of squares $(RSS) = \frac{1}{t}\sum_{i=1}^{t} (R_i)^2 - CF$

Column sum of squares $(CSS) = \frac{1}{t}\sum_{j=1}^{t} (C_j)^2 - CF$

Treatment sum of squares $(TrSS) = \frac{1}{t}\sum_{K=1}^{t} (T_k)^2 - CF$

Error Sum of Squares = TSS-RSS-CSS-TrSS

These results can be summarized in the form of analysis of variance table.

Calculation of SE, SE (d) and CD values

$$SE = \sqrt{\frac{EMS}{r}}$$

where r is the number of rows

$SE(d) = \sqrt{2}\ SE$ .

CD= SE (d). t

where t = table value of t for a specified level of significance and error degrees of freedom

Using CD value the bar chart can be drawn and the conclusion may be written.

**Advantages**

- LSD is more efficient than RBD or CRD. This is because of double grouping that will result in small experimental error.

- When missing values are present, missing plot technique can be used and analysed.

**Disadvantages**

- This design is not as flexible as RBD or CRD as the number of treatments is limited to the number of rows and columns. LSD is seldom used when the number of treatments is more than 12. LSD is not suitable for treatments less than five.

**Because of the limitations on the number of treatments, LSD is not widely used in agricultural experiments.**

**Note: The number of sources of variation is two for CRD, three for RBD and four for LSD.**

## Questions

1. In a Latin Square design the number of rows will be equal to
   a) No. of columns b) No. of Treatments
   c) No. of Replications d) No. of Columns & Number of Treatments

**Ans: No. of Columns & Number of Treatments**

**2.** In a Latin Square design with 5 treatments the number of experimental units will be equal to
   a) 25 b) 20 c) 24 d) 36

**Ans: 25**

3. If the number of experimental units is 36 then the number of rows will be equal to 6.
**Ans: True**

4. The error degrees of freedom in LSD with t treatments will be (t-1)(t-2).
**Ans: True**

5. If the experimental material is homogeneous then LSD can be adopted.
**Ans: False**

6. In a LSD each treatment should occur only once in each row and each column.
**Ans: True**

7. Furnish the ANOVA model for LSD.

8. What is a Latin Square Design?

9. State the advantages and disadvantages of LSD.

10. Explain the computational procedure of LSD?