**Practical No: 10**

**OBJECT:** The following is the 5****5 Latin square design for data taken from a experiment with sugarcane. The five treatments were A= no. manure; b = an inorganic manure; C, D and E = three levels of farm yard manure. Plan and yield of sugarcane (In a suitable unit) per plot.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Row |  |  | Column |  |  |
| I | II | III | IV | V |
| I | A  52.5 | E  46.3 | D  44.1 | C  48.1 | B  40.9 |
| II | D  44.2 | B  42.9 | A  51.3 | E  49.3 | C  32.6 |
| III | B  49.1 | A  47.3 | C  38.1 | D  41.0 | E  47.2 |
| IV | C  43.2 | D  42.5 | E  67.2 | B  55.1 | A  45.3 |
| V | E  47.0 | C  43.2 | B  46.7 | A  46.0 | D  43.2 |

Analyze the above data to find if there are any treatment effects.

**WORKING EXPRESSION:**

When the experimental material is divided into rows and columns and the treatments are allocated such that each treatment occurs only once in a row and once in a column, the design is known as Latin Square Design. In LSD the number of rows and number of columns are equal. Hence, the arrangement will form a square. It follows all principles of design of experiment.

Lay out of LSD: In LSD the treatments are usually denoted by alphabets like A, B, C ……etc. For Latin squares with five treatments the arrangement may be as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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** |

Mathematical Model:

𝒚𝒊𝒋𝒌 = 𝝁 + 𝜶𝒊 + 𝜷𝒋 +𝜸𝒌 + 𝒆𝒊𝒋𝒌 (𝒊 = 𝒋 = 𝒌 = 𝟏, 𝟐 , 𝟑 … . . 𝒎)

were,

𝑦𝑖𝑗𝑘 = the response from the unit in the 𝑖 𝑡ℎ 𝑟𝑜𝑤, 𝑗 𝑡ℎ𝑐𝑜𝑙𝑢𝑚𝑛 𝑎𝑛𝑑 𝑟𝑒𝑐𝑒𝑖𝑣𝑖𝑛𝑔 𝑡h𝑒 𝑘 𝑡ℎ 𝑡𝑟𝑒𝑎𝑡𝑚𝑒𝑛𝑡.

𝜇 = 𝐺𝑒𝑛𝑒𝑟𝑎𝑙 𝑚𝑒𝑎𝑛 𝑒𝑓𝑓𝑒𝑐𝑡

𝛼𝑖 = 𝑖 𝑡ℎ𝑟𝑜𝑤 𝑒𝑓𝑓𝑒𝑐𝑡

𝛽𝑗 = 𝑗 𝑡ℎ𝑐𝑜𝑙𝑢𝑚𝑛 𝑒𝑓𝑓𝑒𝑐𝑡

𝛾𝑘 = 𝑘 𝑡ℎ 𝑡𝑟𝑒𝑎𝑡𝑚𝑒𝑛𝑡 𝑒𝑓𝑓𝑒𝑐t

**Hypothesis Setting:**

Null hypothesis (𝑯𝒐𝑹), 𝑯𝒐𝑪 𝐚𝐧𝐝 (𝑯𝒐𝑻): There is no significant difference between rows, columns, and treatments.

Alternative hypothesis (𝑯𝟏𝑹), 𝑯𝟏𝑪 𝐚𝐧𝐝 (𝑯𝟏𝑻): There is significant difference between rows, columns, and treatments.

**Statistical Analysis:**

Total Sum Square (TSS) = Sum of Square due to row (SSR) + Sum of Square due to column (SSC) + Sum of Square due to treatment (SST) + Sum of Square due to error (SSE)

TSS = SSR + SSC + SST + SSE

**ANOVA Table:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **s.v** | **d.f** | **s.s** | **M.S. S** | **Fcal** | **Ftab** |
| **ROW** | **m-1** | **SSR** | **MSR=SSR/m-1** | **MSR/MSE** | **Fα{(m-1), (m-1) (m-2)}** |
| **COLUMN** | **m-1** | **SSC** | **MSC=SSE/m-1** | **MSC/MSE** | **Fα{(m-1), (m-1) (m-2)}** |
| **TREATMENT** | **m-1** | **SST** | **MST=SST/m-1** | **MST/MSE** | **Fα{(m-1), (m-1) (m-2)}** |
| **ERROR** | **(m-1) (m-2)** | **SSE** | **MSE=SSE/(m-1) (m-2)** |  |  |
| **TOTAL** | **-1** | **TSS** |  |  |  |

Practical No: 10

Name: Aakash Shrestha

Roll No.: 02

Subject: Statistics

Date: 2080/04/21

Faculty: BSc. CSIT 3rd Semester

**OUTPUT:**

UNIANOVA Values BY Treatments Row Column

/METHOD=SSTYPE(3)

/INTERCEPT=INCLUDE

/POSTHOC=Treatments Row Column(TUKEY)

/EMMEANS=TABLES(OVERALL)

/EMMEANS=TABLES(Treatments)

/EMMEANS=TABLES(Row)

/EMMEANS=TABLES(Column)

/CRITERIA=ALPHA(.05)

/DESIGN=Treatments Row Column.

**Univariate Analysis of Variance**

|  |  |  |  |
| --- | --- | --- | --- |
| **Between-Subjects Factors** | | | |
|  | | Value Label | N |
| There are 5 treatments A,B,C,D,E | 1.00 | A | 5 |
| 2.00 | B | 5 |
| 3.00 | C | 5 |
| 4.00 | D | 5 |
| 5.00 | E | 5 |
| There are 5 Rows | 1.00 | Row 1 | 5 |
| 2.00 | Row 2 | 5 |
| 3.00 | Row 3 | 5 |
| 4.00 | Row 4 | 5 |
| 5.00 | Row 5 | 5 |
| There are 5 columns | 1.00 | Column 1 | 5 |
| 2.00 | Column 2 | 5 |
| 3.00 | Column 3 | 5 |
| 4.00 | Column 4 | 5 |
| 5.00 | Column 5 | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tests of Between-Subjects Effects** | | | | | |
| Dependent Variable: Values | | | | | |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Corrected Model | 673.075a | 12 | 56.090 | 2.213 | .092 |
| Intercept | 53296.340 | 1 | 53296.340 | 2103.144 | .000 |
| Treatments | 348.238 | 4 | 87.060 | 3.435 | .043 |
| Row | 141.078 | 4 | 35.270 | 1.392 | .295 |
| Column | 183.758 | 4 | 45.940 | 1.813 | .191 |
| Error | 304.095 | 12 | 25.341 |  |  |
| Total | 54273.510 | 25 |  |  |  |
| Corrected Total | 977.170 | 24 |  |  |  |
| a. R Squared = .689 (Adjusted R Squared = .378) | | | | | |

**Estimated Marginal Means**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **There are 5 treatments A, B, C, D, E** | | | | |
| Dependent Variable: Values | | | | |
| There are 5 treatments A,B,C,D,E | Mean | Std. Error | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| A | 48.480 | 2.251 | 43.575 | 53.385 |
| B | 46.940 | 2.251 | 42.035 | 51.845 |
| C | 41.040 | 2.251 | 36.135 | 45.945 |
| D | 43.000 | 2.251 | 38.095 | 47.905 |
| E | 51.400 | 2.251 | 46.495 | 56.305 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **There are 5 Rows** | | | | |
| Dependent Variable: Values | | | | |
| There are 5 Rows | Mean | Std. Error | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| Row 1 | 46.380 | 2.251 | 41.475 | 51.285 |
| Row 2 | 44.060 | 2.251 | 39.155 | 48.965 |
| Row 3 | 44.540 | 2.251 | 39.635 | 49.445 |
| Row 4 | 50.660 | 2.251 | 45.755 | 55.565 |
| Row 5 | 45.220 | 2.251 | 40.315 | 50.125 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **There are 5 columns** | | | | |
| Dependent Variable: Values | | | | |
| There are 5 columns | Mean | Std. Error | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| Column 1 | 47.200 | 2.251 | 42.295 | 52.105 |
| Column 2 | 44.440 | 2.251 | 39.535 | 49.345 |
| Column 3 | 49.480 | 2.251 | 44.575 | 54.385 |
| Column 4 | 47.900 | 2.251 | 42.995 | 52.805 |
| Column 5 | 41.840 | 2.251 | 36.935 | 46.745 |

**Post Hoc Tests**

**There are 5 treatments A, B, C, D, E**

|  |
| --- |
| **Multiple Comparisons** |
| Dependent Variable: Values  Tukey HSD |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (I) There are 5 treatments A,B,C,D,E | (J) There are 5 treatments A,B,C,D,E | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| A | B | 1.5400 | 3.18379 | .987 | -8.6081 | 11.6881 |
| C | 7.4400 | 3.18379 | .199 | -2.7081 | 17.5881 |
| D | 5.4800 | 3.18379 | .458 | -4.6681 | 15.6281 |
| E | -2.9200 | 3.18379 | .885 | -13.0681 | 7.2281 |
| B | A | -1.5400 | 3.18379 | .987 | -11.6881 | 8.6081 |
| C | 5.9000 | 3.18379 | .390 | -4.2481 | 16.0481 |
| D | 3.9400 | 3.18379 | .731 | -6.2081 | 14.0881 |
| E | -4.4600 | 3.18379 | .639 | -14.6081 | 5.6881 |
| C | A | -7.4400 | 3.18379 | .199 | -17.5881 | 2.7081 |
| B | -5.9000 | 3.18379 | .390 | -16.0481 | 4.2481 |
| D | -1.9600 | 3.18379 | .970 | -12.1081 | 8.1881 |
| E | -10.3600\* | 3.18379 | .045 | -20.5081 | -.2119 |
| D | A | -5.4800 | 3.18379 | .458 | -15.6281 | 4.6681 |
| B | -3.9400 | 3.18379 | .731 | -14.0881 | 6.2081 |
| C | 1.9600 | 3.18379 | .970 | -8.1881 | 12.1081 |
| E | -8.4000 | 3.18379 | .124 | -18.5481 | 1.7481 |
| E | A | 2.9200 | 3.18379 | .885 | -7.2281 | 13.0681 |
| B | 4.4600 | 3.18379 | .639 | -5.6881 | 14.6081 |
| C | 10.3600\* | 3.18379 | .045 | .2119 | 20.5081 |
| D | 8.4000 | 3.18379 | .124 | -1.7481 | 18.5481 |
| Based on observed means.  The error term is Mean Square(Error) = 25.341. | | | | | | |
| \*. The mean difference is significant at the .05 level. | | | | | | |

**Homogeneous Subsets**

|  |  |  |  |
| --- | --- | --- | --- |
| **Values** | | | |
| Tukey HSD | | | |
| There are 5 treatments A, B, C, D, E | N | Subset | |
| 1 | 2 |
| C | 5 | 41.0400 |  |
| D | 5 | 43.0000 | 43.0000 |
| B | 5 | 46.9400 | 46.9400 |
| A | 5 | 48.4800 | 48.4800 |
| E | 5 |  | 51.4000 |
| Sig. |  | .199 | .124 |
| Means for groups in homogeneous subsets are displayed.  Based on observed means.  The error term is Mean Square(Error) = 25.341. | | | |
| a. Uses Harmonic Mean Sample Size = 5.000. | | | |
| b. Alpha = .05. | | | |

**There are 5 Rows**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Multiple Comparisons** | | | | | | |
| Dependent Variable: Values  Tukey HSD | | | | | | |
| (I) There are 5 Rows | (J) There are 5 Rows | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| Row 1 | Row 2 | 2.3200 | 3.18379 | .946 | -7.8281 | 12.4681 |
| Row 3 | 1.8400 | 3.18379 | .976 | -8.3081 | 11.9881 |
| Row 4 | -4.2800 | 3.18379 | .671 | -14.4281 | 5.8681 |
| Row 5 | 1.1600 | 3.18379 | .996 | -8.9881 | 11.3081 |
| Row 2 | Row 1 | -2.3200 | 3.18379 | .946 | -12.4681 | 7.8281 |
| Row 3 | -.4800 | 3.18379 | 1.000 | -10.6281 | 9.6681 |
| Row 4 | -6.6000 | 3.18379 | .292 | -16.7481 | 3.5481 |
| Row 5 | -1.1600 | 3.18379 | .996 | -11.3081 | 8.9881 |
| Row 3 | Row 1 | -1.8400 | 3.18379 | .976 | -11.9881 | 8.3081 |
| Row 2 | .4800 | 3.18379 | 1.000 | -9.6681 | 10.6281 |
| Row 4 | -6.1200 | 3.18379 | .357 | -16.2681 | 4.0281 |
| Row 5 | -.6800 | 3.18379 | .999 | -10.8281 | 9.4681 |
| Row 4 | Row 1 | 4.2800 | 3.18379 | .671 | -5.8681 | 14.4281 |
| Row 2 | 6.6000 | 3.18379 | .292 | -3.5481 | 16.7481 |
| Row 3 | 6.1200 | 3.18379 | .357 | -4.0281 | 16.2681 |
| Row 5 | 5.4400 | 3.18379 | .464 | -4.7081 | 15.5881 |
| Row 5 | Row 1 | -1.1600 | 3.18379 | .996 | -11.3081 | 8.9881 |
| Row 2 | 1.1600 | 3.18379 | .996 | -8.9881 | 11.3081 |
| Row 3 | .6800 | 3.18379 | .999 | -9.4681 | 10.8281 |
| Row 4 | -5.4400 | 3.18379 | .464 | -15.5881 | 4.7081 |
| Based on observed means.  The error term is Mean Square(Error) = 25.341. | | | | | | |

**Homogeneous Subsets**

|  |  |  |
| --- | --- | --- |
| **Values** | | |
| Tukey HSD | | |
| There are 5 Rows | N | Subset |
| 1 |
| Row 2 | 5 | 44.0600 |
| Row 3 | 5 | 44.5400 |
| Row 5 | 5 | 45.2200 |
| Row 1 | 5 | 46.3800 |
| Row 4 | 5 | 50.6600 |
| Sig. |  | .292 |
| Means for groups in homogeneous subsets are displayed. | | |
| a. Uses Harmonic Mean Sample Size = 5.000. | | |
| b. Alpha = .05. | | |

**There are 5 columns**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Multiple Comparisons** | | | | | | |
| Dependent Variable: Values  Tukey HSD | | | | | | |
| (I) There are 5 columns | (J) There are 5 columns | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| Lower Bound | Upper Bound |
| Column 1 | Column 2 | 2.7600 | 3.18379 | .904 | -7.3881 | 12.9081 |
| Column 3 | -2.2800 | 3.18379 | .949 | -12.4281 | 7.8681 |
| Column 4 | -.7000 | 3.18379 | .999 | -10.8481 | 9.4481 |
| Column 5 | 5.3600 | 3.18379 | .478 | -4.7881 | 15.5081 |
| Column 2 | Column 1 | -2.7600 | 3.18379 | .904 | -12.9081 | 7.3881 |
| Column 3 | -5.0400 | 3.18379 | .534 | -15.1881 | 5.1081 |
| Column 4 | -3.4600 | 3.18379 | .810 | -13.6081 | 6.6881 |
| Column 5 | 2.6000 | 3.18379 | .920 | -7.5481 | 12.7481 |
| Column 3 | Column 1 | 2.2800 | 3.18379 | .949 | -7.8681 | 12.4281 |
| Column 2 | 5.0400 | 3.18379 | .534 | -5.1081 | 15.1881 |
| Column 4 | 1.5800 | 3.18379 | .986 | -8.5681 | 11.7281 |
| Column 5 | 7.6400 | 3.18379 | .181 | -2.5081 | 17.7881 |
| Column 4 | Column 1 | .7000 | 3.18379 | .999 | -9.4481 | 10.8481 |
| Column 2 | 3.4600 | 3.18379 | .810 | -6.6881 | 13.6081 |
| Column 3 | -1.5800 | 3.18379 | .986 | -11.7281 | 8.5681 |
| Column 5 | 6.0600 | 3.18379 | .366 | -4.0881 | 16.2081 |
| Column 5 | Column 1 | -5.3600 | 3.18379 | .478 | -15.5081 | 4.7881 |
| Column 2 | -2.6000 | 3.18379 | .920 | -12.7481 | 7.5481 |
| Column 3 | -7.6400 | 3.18379 | .181 | -17.7881 | 2.5081 |
| Column 4 | -6.0600 | 3.18379 | .366 | -16.2081 | 4.0881 |
| Based on observed means.  The error term is Mean Square(Eror) = 25.341. | | | | | | |

**Homogeneous Subsets**

|  |  |  |
| --- | --- | --- |
| **Values** | | |
| Tukey HSD | | |
| There are 5 columns | N | Subset |
| 1 |
| Column 5 | 5 | 41.8400 |
| Column 2 | 5 | 44.4400 |
| Column 1 | 5 | 47.2000 |
| Column 4 | 5 | 47.9000 |
| Column 3 | 5 | 49.4800 |
| Sig. |  | .181 |
| Means for groups in homogeneous subsets are displayed.  Based on observed means.  The error term is Mean Square(Error) = 25.341. | | |
| a. Uses Harmonic Mean Sample Size = 5.000. | | |
| b. Alpha = .05. | | |

**RESULTS:**

**Post Hoc Test:**

For Treatments: There are five treatments A, B, C, D, E.

For A, B and D all values of p are greater than 0.05.

For C: i.e., (0.05>0.045)

For E: i.e., (0.05>0.045)

For Rows: There are five rows.

For all five rows the p-value is greater than 0.05.

Hence, all are equal. So, it is not necessary to write it.

For Column: There are five columns.

For all five columns, the p-value is greater than 0.05.

Hence, all are equal.

From test of Between – Subjects / ANOVA Table

P-value for Treatments = 0.043

P-value for Rows = 0.295

P-value for Columns = 0.191

**Decision:**

For Treatment: P-value = 0.043 < α = 0.05.

Hence, we accept H1T.

For Rows: P-value = 0.295 > α = 0.05.

Hence, we accept HoR.

For Column: P-value = 0.191 > α = 0.05.

Hence, we accept HoC.

**CONCLUSION:**

Hence, we have calculated 5x5 Latin Square Design for data taken for experiment with sugarcane. There are 5 rows and column which means d.f for row, column and treatment are equal. We have calculated post Hoc tests where the mean difference is significant at 0.05. From the ANOVA table we can say that we have accepted H1T for treatment and we have accepted HoR and HoC for Rows and Columns respectively. Hence at last we came to conclusion that there is no significant difference between rows and columns and there is no significant difference between treatments.