Statistical Analysis of Research Stations Effect on the Yield of Varieties of Cowpea

Amalare, A.A.¹ and Adeyemo R.G.²

¹Department of Mathematics and Statistics, Lagos State Polytechnic, Ikorodu, Lagos State, Nigeria.
²Department of Statistics, College of Physical Sciences, Federal University of Agriculture, Abeokuta, Nigeria.

ABSTRACT
A design of experiment is a plan to collect measurement or observation according to a prearranged plan in such a way as to provide the basic for valid inference. This work was carried out to examine the research station effect on the yield of Cowpea varieties. The station are four locations in Nigeria (Kaduna, Shika, Mokwa and Kano). Eight different varieties of Cowpea were considered (Tg 1910-8F, Tg 1844 – 1E, Tg1019 – 2E, Tg1904 – 6F, Tg1910 – 2F, Tg1448 – 2E, Tg1908 – 1F, and Tg1740 – 2F). The data are secondary data, collected from International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State. The result showed that research locations has no significant effect on the yields of cowpea varieties. The use of Randomized Complete Block Design (RCBD) design in Kaduna station, Shika station, Mokwa station and Kano station had 27.2%, 109.9%, 63.04% and 53.7% gain in experimental precision respectively.

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such that the variability within the blocks is less than the variability between blocks. Then, participants within each block are randomly assigned to treatment conditions. This design reduces variability and potential confounding. It produces a better estimate effect.

**Derivation of Parameters in the Model**

\[ Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij} \]

The derivation of \( \mu, \alpha_i \) and \( \beta_j \) are obtained using the least square approach.

\[ Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij} \]

\[ e_{ij} = Y_{ij} - \mu - \alpha_i - \beta_j \]

Differentiating with respect to \( \mu \)

\[ \frac{\partial \bar{Y}}{\partial \mu} = \sum_{i=1}^{t} \sum_{j=1}^{r} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ \frac{\partial \bar{Y}}{\partial \alpha_i} = \frac{1}{t} \sum_{j=1}^{r} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ \frac{\partial \bar{Y}}{\partial \beta_j} = \frac{1}{b} \sum_{i=1}^{t} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ \frac{\partial Y_{ij}}{\partial \beta_j} = \frac{1}{b} \sum_{i=1}^{t} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ \frac{\partial Y_{ij}}{\partial \alpha_i} = \frac{1}{t} \sum_{j=1}^{r} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ \frac{\partial Y_{ij}}{\partial \mu} = \frac{1}{b} \sum_{i=1}^{t} (y_{ij} - \mu - \alpha_i - \beta_j) = 0 \]

\[ S = \sum_{i=1}^{t} \sum_{j=1}^{r} e_{ij}^2 = \sum_{i=1}^{t} \sum_{j=1}^{r} (y_{ij} - \mu - \alpha_i - \beta_j)^2 \]

**The Analysis of Variance Table**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degree of Freedom</th>
<th>Sum of Square</th>
<th>Mean Square</th>
<th>F-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>(t-1)</td>
<td>SST</td>
<td>SST/t-1</td>
<td>MST/MSE</td>
</tr>
<tr>
<td>Block</td>
<td>(r-1)</td>
<td>SSB</td>
<td>SSB/r-1</td>
<td>MSB/MSE</td>
</tr>
<tr>
<td>Error</td>
<td>(t-1)(r-1)</td>
<td>SSE</td>
<td>SSE/(t-1)(r-1)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>(rt-1)</td>
<td>SSTOTAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypothesis Testing**

The equality of the treatment effects tested in order to show whether there are significant differences in the cowpea varieties (Treatments) as against the alternative hypothesis. This can be shown mathematically

**Treatments**

Ho: \( \alpha_1 = \alpha_2 = \ldots = \alpha_8 = 0 \)
H1: \( \alpha_1 \neq \alpha_2 \neq \ldots \neq \alpha_8 = 0 \) for at least one of the varieties

**Blocks**

Ho: \( \beta_1 = \beta_2 = \ldots = \beta_8 = 0 \)
H1: \( \beta_1 \neq \beta_2 \neq \ldots \neq \beta_8 \neq 0 \) for at least one of the block.

**Blocking Efficiency**

Blocking is the process by which experiment materials are portioned into sets or blocks of homogeneous units. The purpose of this is to reduce experimental error by isolating all possible sources of variation. Blocking maximizes the differences among plots of the same block as small as possible. The result of every RCBD experiment is examined to see the achievement of this objective. The relative efficiency (RE) is computed to determine the magnitude of the variation in experimental error due to blocking.

\[ R.E = \frac{(r-1)EB + r(t-1)EE}{(rt-1)EE} X 100 \]

Where

\( EB = \) Block Mean Square or Replication Mean Square
\( EE = \) Error Mean Square in RCBD analysis of variance

If R.E > 100 we say RCBD is more efficient than CRD
If R.E = 100 we say, RCBD = CRD
If R.E < 100 we say, CRD is more efficient than RCBD.

**Blocking Efficiency for Experiments**

The relative efficiency (RE) due to blocking for the design under experiment may be computed as follows:

Relative Efficiency for Experiment I (Kaduna)

\[ R.E = \frac{(r-1)EB + r(t-1)EE}{(rt-1)EE} X 100 \]

Where \( EB = 66389 \) \( EE = 17404 \) \( t = 8 \) \( r = 4 \)

Then,

\[ \frac{(4-1)66389 + 4(8-1)17403}{(4x8-1)17403} = 127.2% \]

The use of RCBD design at Kaduna station produced 27.2% increase in experimental precision.

Relative Efficiency for Experiment II (Shika)

\[ R.E = \frac{(r-1)EB + r(t-1)EE}{(rt-1)EE} X 100 \]

Where \( EB = 156154 \) \( EE = 12640 \) \( t = 8 \) \( r = 4 \)

Then,

\[ \frac{(4-1)156154 + 4(8-1)12640}{(4x8-1)12640} = 209.9% \]

There was a gain of 109.9% in experimental precision with use of RCBD at Shika.

Relative Efficiency For Experiment III (Mokwa)

\[ R.E = \frac{(r-1)EB + r(t-1)EE}{(rt-1)EE} X 100 \]

Where \( EB = 124235 \) \( EE = 16534 \) \( t = 8 \) \( r = 4 \)

\[ \frac{(4-1)124235 + 4(8-1)16534}{(4x8-1)16534} = 127.2% \]

There was a gain of 109.9% in experimental precision with use of RCBD at Shika.
Then,
\[(4 - 1) 124235 + 4(8 - 1) 16534 \times 100 = 163.04\%\]

The use of RCBD design at Mokwa station produced 63.04% gain in experimental precision.

**Relative Efficiency for Experiment IV (Kano)**

\[R_E = \frac{(r-1)Eb + r(t-1)Ee}{t(r-1)Ee} \times 100\]

Where \(Eb = 117592\), \(Ee = 18252\), \(t = 8\), and \(r = 4\)

Then,
\[(4 - 1) 117592 + 4(8 - 1) 18252 \times 100 = 153.7\%\]

The relative efficiency has gained 53.7% in experimental precision.

**Discussion of Results**

The analysis showed that experiment I, II, III, and IV (Kaduna, Shika, Mokwa and Kano) have no significant effect on the yields of cowpea varieties in all research stations at 5% level of significance. The use of RCBD design in Kaduna station, Shika station, Mokwa station and Kano station had 27.2%, 109.9%, 63.04% and 53.7% gain in experimental precision respectively and the use of RCBD design at all stations produced 110.4% increase in experimental precision.

**Appendix**

**Analysis of Variance Table**

**Response: observation**

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr(&gt;F)</td>
<td>Treatment</td>
<td>7</td>
<td>40402</td>
</tr>
<tr>
<td></td>
<td>treatment</td>
<td>3</td>
<td>199167</td>
</tr>
<tr>
<td></td>
<td>block</td>
<td>3</td>
<td>156154</td>
</tr>
<tr>
<td></td>
<td>Residuals</td>
<td>12</td>
<td>352775</td>
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</tbody>
</table>

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1

**Data view from experiment II (SHIKA)**

**Analysis of Variance Table**

**Response: observation**

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr(&gt;F)</td>
<td>Treatment</td>
<td>3</td>
<td>922368</td>
</tr>
<tr>
<td></td>
<td>treatment</td>
<td>3</td>
<td>12872.3</td>
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<tr>
<td></td>
<td>block</td>
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<td>12139.1</td>
</tr>
<tr>
<td></td>
<td>Residuals</td>
<td>12</td>
<td>154468</td>
</tr>
</tbody>
</table>

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1

**Data view from experiment III (MOKWA)**

**Analysis of Variance Table**

**Response: observation**

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
</tr>
</thead>
<tbody>
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<td>13254</td>
</tr>
<tr>
<td></td>
<td>treatment</td>
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<td>14538</td>
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<tr>
<td></td>
<td>block</td>
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</table>

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1

**VARIETY VI (TG 1448-2E)**

**Analysis of Variance Table**

**Response: observation**

<table>
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<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
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</thead>
<tbody>
<tr>
<td>Pr(&gt;F)</td>
<td>Treatment</td>
<td>3</td>
<td>14335</td>
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<tr>
<td></td>
<td>treatment</td>
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</table>

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1

**VARIETY VII (TG 1908-1F)**

**Analysis of Variance Table**

**Response: observation**

<table>
<thead>
<tr>
<th>Df</th>
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<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr(&gt;F)</td>
<td>Treatment</td>
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<td>19548</td>
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<tr>
<td></td>
<td>treatment</td>
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<td>6516.1</td>
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Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1
Residuals  12  226964  18914

Variety VIII (Tg 1740-2F)

Analysis of Variance Table
Response: observation

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
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<th>Pr(&gt;F)</th>
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</thead>
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<td>11056.4</td>
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<td>0.3459</td>
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<tr>
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<td>109028</td>
<td>9085.7</td>
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<td></td>
</tr>
</tbody>
</table>

Data view from all locations

Analysis of Variance Table
Response: observation

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>7</td>
<td>73385</td>
<td>10484</td>
<td>1.7753</td>
<td>0.11179</td>
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<tr>
<td>Block</td>
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<td>46801</td>
<td>7.9253</td>
<td>0.000185 ***</td>
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<td>Residuals</td>
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<td></td>
</tr>
</tbody>
</table>

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

References

- R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.