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Statistical Analysis of Research Stattions Effect on the Yeild of Varieties of Cowpea

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ABSTRACT

A design of experiment is a plan to collect measurement or observation according to a pre arrange 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.

Introduction

Cowpea, vigna unguiculata (L.) Walp is a grain legume grown mainly in the Savanna regions of the tropics and subtropics in Africa, Asia and South America. The value of cowpea lies in its high protein content and ability to tolerate drought. As a legume, cowpea also fixes atmospheric Nitrogen, allow it to grown on and improve poor soils. All the parts of Cowpea are used for food nutritious, providing protein, vitamins, and minerals. Cowpea grain contains about 25% protein, making it extremely valuable where many people cannot afford protein foods such as meat and fish.

According to FAO, about 7.56 million tonnes of cowpea are produced Worldwide annually on about 12.76million hectares. Sub-Saharan African accounts for about 70% of total World production. This work was carried out to examine the environmental effect on the yield of Cowpea varieties. The environments are typified by four locations namely 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.

Data

The data are secondary data, collected from International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State.

Method

Complete Randomized Design (CRD)

Complete Randomized Design is a design in which treatments are assigned completely at random so that each experimental unit has equal chance of receiving any one treatment. Any difference among the experimental units receiving the same treatment is considered to be experimental error.

The Statistical Model is

$$y_{ij} = \mu + \alpha_i + e_{ij}$$

$$e_{ij} = (y_{ij} - \mu - \alpha_i)$$

$$s = \sum_{i=1}\sum_{j=1} e_{ij}^2 = \sum_{i=1}\sum_{j=1}(y_{ij} - \mu - \alpha_i)^2$$

$$\frac{\delta s}{\delta \mu} = -2\sum_{i=1}^{t}\sum_{j=1}^{r}(y_{ij} - \mu - \alpha_i)$$

$$Min\ \frac{\delta s}{\delta \mu} = -2\sum_{i=1}^{t}\sum_{j=1}^{r}(y_{ij} - \mu - \alpha_i) = 0$$

$$\sum_{i=1}^{t}\sum_{j=1}^{r} y_{ij} - \sum_{i=1}^{t}\sum_{j=1}^{r}\mu - \sum_{i=1}^{t}\sum_{j=1}^{r}\acute{a}_i = 0$$

$$y.. - N\hat{\imath} - \sum n_i \alpha_i$$

$$\hat{\imath} = \frac{Y..}{N} = \bar{Y}..$$

$$\frac{\ddot{a}s}{\ddot{a}\acute{a}_i} = -2\sum_{j=1}^{r}(y_{ij} - \hat{\imath} - \acute{a}_i)$$

$$Min\ \frac{\ddot{a}s}{\ddot{a}\acute{a}i} = -2\sum_{j=1}^{r}(y_{ij} - \hat{\imath} - \acute{a}_i) = 0$$

$$\sum_{j=i}^{ni} y_{ij} - \sum_{j=i}^{ni}\hat{\imath} - \sum_{j=1}^{ni}\propto i = 0$$

$$yi. - ni\hat{\imath} - ni \propto i = 0$$

$$\propto i = \frac{yi.}{ni} - \hat{\imath}$$

$$\acute{a}i = \overline{yi.} - \overline{y..}$$

Randomized Complete Block Design (RCBD)

The Randomized Complete Block Design is a bit of odd duck. The design itself is straight-forward randomized complete block design is one of most widely used designs in Agricultural research, the design is used when the experimental units can be grouped such that the number of units in a group is equal to the number of treatments.

With Randomized Complete Block Design, the experimenter divides participants into subgroups called blocks,

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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

$Y_{ij} = \mu + \alpha_i + \beta_j + e_i$

The derivation of μ, α_i and β_j are obtained using the least square approach.

$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$

$e_{ij} = Y_{ij} - \mu - \alpha_i - \beta_j$

$$S = \sum_{i=1}^{t}\sum_{j=1}^{r} e_{ij}^2 = \sum_{i=1}^{t}\sum_{j=1}^{r}\left(y_{ij} - \mu - \alpha_i - \hat{a}j\right)^2$$

Differentiating with respect to μ

$$\frac{\ddot{a}s}{\ddot{a}i} = -2\sum_{i=1}^{t}\sum_{j=1}^{r}\left(y_{ij} - \mu - \alpha_i - \hat{a}j\right) = 0$$

$$\sum_{i=1}^{t}\sum_{j=1}^{r} yij - bt\hat{i} - b\sum \acute{a}i - t\sum \hat{a}j = 0$$

$$\sum_{i=1}^{t}\sum_{j=1}^{r} yij - bt\hat{i} = 0$$

$$\frac{\Sigma\Sigma yij}{bt} = \hat{i}$$

$$\frac{\ddot{a}s}{\ddot{a}\acute{a}_i} = -2\sum_{j=1}^{r}\left(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}i\right)$$

$$\sum yi. - b\hat{i} - b\acute{a}i - \sum \hat{a}j$$

$$\frac{\Sigma yi.}{b} = \frac{b\hat{i}}{b} = \acute{a}i$$

$$\frac{\Sigma yi.}{b} = \hat{i} = \acute{a}i$$

$$\frac{\ddot{a}s}{\ddot{a}\hat{a}j} = -2\sum_{i=0}^{r}\left(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}i\right)$$

$$\sum y.j - t\hat{i} - \sum \acute{a}i - t\acute{a}i$$

$$\frac{\Sigma y.j}{t} = \frac{t\hat{i}}{t} = \hat{a}j$$

$\Sigma Y_{.j}$ - $t\mu$ = β_j t t

$$\frac{\Sigma y.j}{t} - \hat{i} = \hat{a}$$

$$Smin = \sum_{i=1}^{t}\sum_{j=1}^{r} e_{ij}^2 = \sum_{i=1}^{t}\sum_{j=1}^{r}\left(y_{ij} - \mu - \alpha_i - \hat{a}j\right)^2$$

$$= \sum_{i=1}^{t}\sum_{j=1}^{r}(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}_j)\, y_{ij} - \hat{i}\sum\sum(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}_j) - \sum \acute{a}_i\,(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}_j) - \sum \hat{a}_j(y_{ij} - \hat{i} - \acute{a}_i - \hat{a}_j)$$

$$= \sum\sum y_{ij}^2 - \hat{i}\sum\sum y_{ij} - \sum \acute{a}_i \sum y_i - \sum \hat{a}_i \sum y_{.j}$$

$$= \sum\sum y_{ij}^2 - \frac{\sum\sum y_{ij}^2}{bt} - \sum\left\{\frac{y_{i.}^2}{t} - \frac{Y_{..}^2}{bt}\right\} y_{i.} - \sum\left\{\frac{Y_{.j}^2}{b} - \frac{Y_{..}^2}{bt}\right\} Y_{.j}$$

$$\left[\sum\sum Y_{ij}^2 - \frac{Y_{..}^2}{bt}\right] - \left[\frac{\sum Y_{i.}^2}{t} - \frac{Y_{..}^2}{bt}\right] - \left[\frac{\sum Y_{.j}^2}{b} - \frac{Y_{..}^2}{bt}\right]$$

Total Sum of Square Treatment Sum of Square Block Sum of Square

Error Sum of Square = Total SS - Treatment SS - Block SS

Total SS = Treatment SS + Block SS + Error SS

The Analysis of Variance Table

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-Ratio
Treatment	t-1	SST	SST/t-1	MST/MSE
Block	r-1	SSB	SSB/ r-1	MSB/MSE
Error	(t-1)(r-1)	SSE	SSE/(t-1)(r-1)	
Total	(rt -1)	SSTOTAL		

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: $\alpha_1 = \alpha_2 = . . . = \alpha_8 = 0$

H1: $\alpha_1 1 \neq \alpha_2 \neq . . . \neq \alpha_8 = 0$ for at least one of the varieties

Blocks

Ho: $\beta_1 = \beta_2 = . . . = \beta_8 = 0$

H1: $\beta_1 \neq \beta_2 \neq . . . \neq \beta_8 \neq 0$ 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 completed 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 (R.E) 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,

$$\frac{(4-1)\ 66389 + 4(8-1)\ 17403}{(4x8-1)\ 17403}\quad X\quad 100$$

= 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,

$$\frac{(4-1)\ 156154 + 4(8-1)\ 12640}{(4x8-1)\ 12640}\quad X\quad 100$$

= 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

Then,

$$\frac{(4-1)\ 124235\ \ + 4(\ 8-1)\ 16534}{(4x8-1)\ \ 16534}\ \ X\ \ 100$$

= 163.04%

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

Relative Efficiency for Experiment IV(Kano)

$$R.E = \frac{(r-1)Eb + r(t-1)\ Ee}{(rt-1)Ee}\ X\ 100$$

Where Eb = 117592 Ee = 18252 t = 8 r = 4

Then,

$$\frac{(4-1)\ 117592\ \ + 4(\ 8-1)\ 18252}{(4x8-1)\ \ 18252}\ \ X\ \ 100$$

= 153.7%

The relative efficiency has gained 53.7% in experimental precision with the use of RCBD.

Relative Efficiency for all Experimental Stations

$$R.E = \frac{(r-1)Eb + r(t-1)\ Ee}{(rt-1)Ee}\ X\ 100$$

Where Eb = 1062340 Ee = 85627 t = 8 r = 4

Then,

$$\frac{(4-1)\ 1062340\ \ + 4(\ 8-1)\ 85627}{(4x8-1)\ \ 85627}\ \ X\ \ 100$$

= 210.4%

The use of RCBD design at all stations produced 110.4% increase in experimental precision.

Discussion of Results

The analysis showed that experiment I, II, III, and IV (Kaduna, Shika, Mokwa and Kano) have no significant effecton the yields of cowpea varieties in all research stations at 5% level of significant. 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

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Treatment	7	40402	5772	0.3316	0.93604	
block	3	199167	66389	3.8148	0.01505	*
Residuals	53	922368	17403			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Data view from experiment II (SHIKA)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Treatment	7	50722	7246	0.5733	0.7743	
block	3	468461	156154	12.3543	3.063e-06	***
Residuals	53	669901	12640			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Data view from experiment III (MOKWA)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Treatment	7	153719	21960	1.3282	0.2555950	
block	3	372706	124235	7.5140	0.0002795	***
Residuals	53	876296	16534			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Data view from experiment IV (KANO)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
treatment	7	79722	11389	0.6240	0.7337742	
block	3	352775	117592	6.4428	0.0008423	***
Residuals	53	967342	18252			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Analysis of Cowpea Varieties From Research Station to Another

Variety I (Tg 1910-8F)

Analysis of Variance Table

Response: observation

T

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	63797	21266	0.7676	0.5339
Residuals	12	332447	27704		

Variety II (Tg 1844-1E)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	97268	32423	2.3042	0.1288
Residuals	12	168856	14071		

Variety III (Tg 1019-2E)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	13254	4418.1	0.3432	0.7946
Residuals	12	154468	12872.3		

Variety IV (Tg 1904-6F)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	43613	14538	0.4933	0.6936
Residuals	12	353676	29473		

Variety V (Tg 1910-2F)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	14335	4778.4	0.3579	0.7845
Residuals	12	160221	13351.7		

VARIETY VI (Tg 1448-2E

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	19548	6516.1	0.2396	0.8671
Residuals	12	326355	27196.3		

Variety VII (Tg 1908-1F)

Analysis of Variance Table

Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	32434	10811	0.5716	0.6444

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	12	226964	18914		

Variety VIII (Tg 1740-2F)
Analysis of Variance Table
Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	3	33169	11056.4	1.2169	0.3459
Residuals	12	109028	9085.7		

Data view from all locations
Analysis of Variance
Analysis of Variance Table
Response: observation

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Treatment	7	73385	10484	1.7753	0.111791	
Block	3	140402	46801	7.9253	0.000185	***
Residuals	53	312979	5905			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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