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A MULTIPLE COMPARISON OF MEANS ANALYSIS ON YIELD OF CROPS

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ABSTRACT

This research is basically on a multiple comparison of means analysis in yield of crops, using Federal College of Agriculture, Akure, Ondo-state as a case study. Data was collected on twelve (12) independent samples.The statistical tool used is ANOVA for two factors experiment and the test statistics used is F-test. The result of the analysis shows that at 5% significant level for the crops, there was no block effect (since F_{cal}<F_{tab}, i.e. 0.8571 < 4.76) and therefore accepts the null hypothesis for the crops, but there was treatment effect at 5% significant level (since F_{cal}>F_{tab}i.e. 6.2374 > 5.14), and then concluded by rejecting the null hypothesis for the fertilizers. Further analysis using multiple comparisons of means on fertilizers (Post Hoc test) by Fisher's Least Significant Different revealed that Fertilizer B (NPK 15-15-1-5) has the highest mean yield, which lead to the rejection of the null hypothesis on treatments, based on the research.

Keywords: Blocking Factor, Variability, Response, Treatment, Experimental Error, Randomization, Parameters.

I. INTRODUCTION

In completely randomized design (CRD), there is no restriction on the allocation of the treatments to experimental units/plots. But in practical life there are situations where there is relatively large variability in the experimental material. It is possible to make block (in simpler sense groups) of the relatively homogeneous experimental materials or treatments. The design applied in such situations is named as randomized complete block design (RCBD). The randomized complete block design may be defined as the design in which the experimental materials/treatments is divided into blocks/groups of homogeneous experimental units (experimental units have same characteristics) and each block/group contains a complete set of treatments which are assigned at random to the experimental units/plots.

Actually RCBD is a one restriction design, used to control a variable which is influenced by the response variable. The main aim of the restriction is to control the variable causing the variability response. Efforts of blocking are done to create the situation of homogeneous within block. A blocking is a source of variability. An example of blocking factors might be the gender of a patient (by blocking on gender) this is source of variability controlled for leading to greater accuracy. RCBD is a mixed model in which a factor is fixed and other is random. The main assumption of the design is that there is no contact between the treatment and block effect.

Randomized complete block design is said to be complete design because in this design, the experimental units/plots and numbers of treatment are equal. Each treatment occurs in each block.

The main objective of blocking reduce the variability among experimental units/plots within a block as much as possible to minimize the variation among block, the design will not contribute to improve the precision in detecting treatment differences.

OBJECTIVES

The main objectives of this research work are:

1. to determine whether there will be significant difference at 5% significance level in yields due to the treatments i.e. treatment effect
2. to also determine whether there will be significant difference at 5% significant level in yields due to blocks(crops) i.e. block effect
3. to make recommendation of the important of this application method

RESEARCH HYPOTHESIS

The research hypothesis is commonly called the alternative hypothesis and it is represented by the symbol H_i. It is the proposition we always wish to confirm from the data. It is the alternative hypothesis that is available when the null hypothesis has been rejected.

Research hypothesis could be simple hypothesis, that is, when the alternative statement is directional or composite, that is, when the alternative statement is not directional. The simple hypothesis is also called one tailed/sided test and the composite hypothesis is also called two tailed test.

Our hypothesis would be based on the following:

For treatment (fertilizer)

H_o: $Ʈ_i = 0$ $ɏ_i$ Vs H_i: $Ʈ_i \neq 0$ for at least one 'i'

For block(crop)

H_o: $\beta_j = 0$ $ɏ_j$ Vs H_i: $\beta_j \neq 0$ for at least one 'j'

II. REVIEW OF RELATED LITERATURE

AN INTRODUCTION TO ON-FARM RESEARCH

On-farm field scale agronomic research is not a new phenomenon. For example in the 1940's and 1950's, most open pollinated corn varieties were placed by high yielding hybrids across North America. During this time, obvious yields differences among the hybrids become less and apparent, requiring more precise comparisons. The field strip test was institutionalized to fill this on-farm research need. However, debate then increased among scientist as to the relative merits of conducting such research, compared with highly controlled small plot research replicated and randomized over relatively few locations with field variability tightly controlled Duvick (1991).

Over the past 15 years, on-farm research has received few prominences in agricultural systems research which attempts to reduce environmental damage and to increasingly serve the need of society, including the farmer Anderson and Lockeretz (1991). Collaboration between university researchers, farmer and producer organizations has increased through program such as the United States Department of Agriculture's Low-input / sustainable Agriculture program where such collaboration is requisite to funding approval. This agency has channeled unprecedented federal funds to groups doing on-farm research Anderson and Lockeretz (1992).

In Ontorio, research has been carried out on farm fields for some years by agribusiness, focusing on crop varieties and pesticide trials. In the mid to late 1980's, research and long term demonstration programs such as Tillage (2000), partners in Nitrogen and the Technology Evaluation and Development Program(SWEEP) were initiated in Ontario.

Many would agree that research at a system level (whether cropping system or ecosystem) involves a wide number of variables with dynamic relationships. Many would also agree, along with the majority of farmers, that research receives an added and a needed degree of relevance when seen to be applicable at a field and a farm scale. However, the connection between where research takes place and what it can achieve is not always clear. To ensure an effective use of research resources, it is important that the most appropriate study design be used to achieve stated objectives. Similarly, the options for statistical analysis may not be well understood or accommodated in the study design.

The review of the on-farm research methodology literature allows researchers to gain a collective insight to the approach tried by others, and should help to streamline on-farm research techniques and efforts to move standardized protocol.

III. METHODOLOGY

The research methodologies include systematic and scientific process of gathering, recording and analyzing data about problems and issues relating to human existence on earth. The data being collected in this research was through transcription from record, which is a form of secondary data at the Federal College of Agriculture, Akure on twelve independent samples. The method of data analysis is F-test (ANOVA) for two factors experiment.

MODEL OF RANDOMIZED COMPLETE BLOCK DEISGN (RCBD)

To every design of experiment (DOE), there must be model, but that for Randomized Complete Block Design (RCBD) is as below:

$Y_{ij}= \mu + \tau_i + \beta_j + e_{ij}$,

Where: τ_i is the effect of treatment 'i'.

$Y_{ij}$is the observation in block 'j' receiving treatment 'i'

μ is the overall mean/grand mean.

β_j is the effect of block 'j'.

e_{ij} is the random error which is assumed to be independently and normally distributed with mean zero and constant variance i.e. $e_{ij} \sim N(0, \sigma^2)$

ESTIMATIONS OF PARAMETERS

The parameters here is this research i.e. in randomized complete block design are β_j, μ, τ_i and e_{ij}. In doing this, we use the model, that is,

$Y_{ij}= \mu + \tau_i + \beta_j + e_{ij}$, so,

$e_{ij} = Y_{ij} - \mu - \tau_i - \beta_j$,

Substituting in estimates produces the residual $\hat{e}_{ij} = e_{ij} = Y_{ij} - \hat{\mu} - \hat{\tau}_i - \hat{\beta}_j$

Goal: find$\hat{\mu}$, $\hat{\tau}_i$, and $\hat{\beta}_j$ that maximize L.

$L = \sum_{i=1}^{a} \sum_{j=1}^{b} \hat{e}_{ij}^2 = \sum_{i=1}^{a} \sum_{j=1}^{b} (yij - \hat{\mu} - \hat{\tau}i - \hat{\beta}j)^2$.

Solution: solve the normal equation

$\frac{\partial L}{\partial \hat{\mu}} = -2\sum_{i=1}^{a} \sum_{j=1}^{b} (yij - \hat{\mu} - \hat{\tau}i - \hat{\beta}j) = 0$

$\frac{\partial L}{\partial \hat{\tau}i} = -2\sum_{j=1}^{b} (yij - \hat{\mu} - \hat{\tau}i - \hat{\beta}j) = 0$, for i = 1, 2..., a

$\frac{\partial L}{\partial \hat{\beta}j} = -2\sum_{i=1}^{a} (yij - \hat{\mu} - \hat{\tau}i - \hat{\beta}j) = 0$, for j = 1, 2..., b

After distributing the sum and then simplifying, we get:

- $Y_{..} = ab\hat{\mu} + b\sum_{i=1}^{a} \hat{\tau}i + a \sum_{j=1}^{b} \hat{\beta}j$
- $Y_{i.} = b\hat{\mu} + b\hat{\tau}i + \sum_{j=1}^{b} \hat{\beta}j$ for i = 1, 2..., a
- $Y_{.j} = a\hat{\mu} + \sum_{i=1}^{a} \hat{\tau}i + a\hat{\beta}j$ for j = 1, 2..., b

For (i), (ii), and (iii), there is a total of 1+a+ b equation. If you sum the a equations in (ii), you get (i). If you sum the b equations in (ii), you also get (i). Thus, the rank is a+b-1 which implies that the μ and each τ_i and β_j are not estimable. To get estimates of μ and τ_i and β_j, we must impose 2 constraints. We will use $\sum_{i=1}^{a} \hat{\tau}i = 0$ and $\sum_{j=1}^{b} \hat{\beta}j = 0$.

Substituting of these constraints into (i), (ii), and (iii) yields;

(1) $ab\hat{\mu} = Y_{..}$ (2) $b\hat{\mu} + b\hat{\tau}_i = Y_{i.}$ (3) $a\hat{\mu} + a\hat{\beta}_j = Y_{.j}$

Then, from (i), we have

$\hat{\mu} = \frac{y_{..}}{ab} = \bar{Y}_{..}$

Substitution of $\hat{\mu} = \bar{Y}_{..}$in (2) yields:

$b\bar{y}_{..} + b\hat{\tau}_i = y_{i.} \rightarrow \bar{y}_{..} + \hat{\tau}_i = \bar{y}_{i.} \rightarrow \hat{\tau}_i = \bar{y}_i - \bar{y}_{..}$

Substitution of $\hat{\mu} = \bar{Y}_{..}$in (3) yields:

$a\bar{y}_{..} + a\hat{\beta}_j = y_{.j} \rightarrow \bar{y}_{..} + \hat{\beta}_j = \bar{y}_{.j} \rightarrow \hat{\beta}_j = \bar{y}_{.j} - \bar{y}_{..}$

IV. DATA AND ANALYSIS

STATISTICAL PRESENTATION AND COMPUTATION

The data presented is a table presentation.

TABLE: DATA

	Maize	Rice	Cassava	Barley
Urea	4.5	6.4	7.2	6.7
NPK 15-15-15	8.8	7.8	9.6	7.0
Poultry manure	5.9	6.8	5.7	5.2

Source: Department of Agronomy, Federal College of Agriculture, Akure

TABLE: COMPUTATIONS OF DATA

	Maize	Rice	Cassava	Barley	$Y_{i.}$	$\bar{Y}_{i.}$
Urea	4.5	6.4	7.2	6.7	24.8	6.2
NPK 15-15-15	8.8	7.8	9.6	7.0	33.2	8.3
Poultry manure	5.9	6.8	5.7	5.2	23.6	5.9
$Y_{,j}$	19.2	21.0	22.5	18.9	$Y_{..}$ =	81.6
$\bar{Y}_{,j}$	6.4	7.0	7.5	6.3	$\bar{Y}_{..}$ =	6.8

Where:

$Y_{i.}$ is the row/treatment total

$Y_{,j}$ is the column/block total

$\bar{Y}_{i.}$ is the row/treatment mean

$\bar{Y}_{,j}$ is the column/block mean

$\bar{Y}_{..}$ is the overall/grand mean

$Y_{..}$ is the overall/grand total.

The correction factor (CF), $Y_{..}^2/bt = 81.6/4(3) = 6{,}658.56/12 = 554.88$

Therefore, CF = 554.88

$$SST = \Sigma Yij2 - (Y..2/bt)$$
$$= (4.5)2 + (6.4)2 + (7.2)2 + (6.7)2 + (8.8)2 + (7.8)2 + (9.6)2 + (7)2 + (5.9)2 + (6.8)2 + (5.7)2` + (5.2)2 - 554.88\ 577.96 - 554.88 = 23.08$$

Therefore SST = 23.08

$SSt = (\Sigma Y_{i.}^2/b) - (Y_{..}^2/bt) = [(24.8)^2 + (33.2)^2 + (23.6)^2]/4 - 554.88 = 2{,}274.24/4 - 554.88 = 568.56 - 554.88 = 13.68$

Therefore SSt = 13.68

$SSb = (\Sigma Y_{,j}^2/t) - (Y_{..}^2/bt) = [(19.2)^2 + (21)^2 + (22.5)^2 + (18.9)^2]/3 - 554.88 = 1{,}673.10/3 - 554.88 = 557.7 - 554.88 = 2.82$

Therefore SSb = 2.82

SSE = SST – SSt – SSb = 23.08 – 13.68 – 2.82 = 6.58

Therefore SSE = 6.58

Mst = SSt/(t-1) = 13.68/2 = 6.84

Msb = SSb/(b-1) = 2.82/3 = 0.94

Mse = SSE/(t-1)(b-1) = 6.58/6 = 1.0966

F_1 = Mst/Mse = 6.84/1.0966 = 6.2374

F_2 = Msb/Mse = 0.94/1.0966 = 0.8571

TABLE: ANALYSIS OF VARIANCE FOR YIELD

Source of variation	Degree of freedom	Sum of squares	Mean square	F- ratio	F –tab
Fertiliser	2	13.68	6.84	$6.2374 = F_1$	$F_{0.05}(2,6) = 4.76$
Crop	3	2.82	0.94	$0.8571 = F_2$	$F_{0.05}(3,6) = 5.14$
Error	6	6.58	1.0966		
Total	11	23.08			

HYPOTHESIS TESTING

Step1: STATEMENT OF HYPOTHESIS

For treatment (fertilizer)

H_o: $\text{Ʈ}_i = 0$ ɏ$_i$ Vs H_i: $\text{Ʈ}_i \neq 0$ for at least one ‘i’

For block(crop)

H_o: $\beta_j = 0$ ɏ$_j$ Vs H_i: $\beta_j \neq 0$ for at least one ‘j’

Step2: TEST STATISTICS

F- test (ANOVA for RCBD) is the test statistics used.

Step3: LEVEL OF SIGNIFICANT

The level of significant, denoted by α is at 5% or 0.05

Step4: reject H_o if $F_{cal} \geq F_{tab}$

Step5: For crop, since $F_{cal} < F_{tab}$ i.e. $0.8571 < 4.76$, we do not reject the null hypothesis at 5% level of significance, and conclude that there is no significant difference in yields due to the crops. i.e. $\beta_j = 0$ ɏ$_j$.

For fertilizer, since $F_{cal} > F_{tab}$ i.e. $6.2374 > 5.14$, we do not accept the null hypothesis at 5% level of significance, and conclude that there is significant difference in yields due to the fertilizers i.e. $\text{Ʈ}_i \neq 0$ for at least one ‘i’.

The confidence interval for the three fertilizers indicates that it is likely that Fertilizer B produces higher mean yields than either Fertilizer A or C.

Post Hoc Tests

Fertilizer

Multiple Comparisons

Yields

LSD

					95% Confidence Interval	
(I) Fertilizer	(J) Fertilizer	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
fertilizer A	fertilizer B	-2.1000^*	.74050	.030	-3.9119	-.2881
	fertilizer C	.3000	.74050	.699	-1.5119	2.1119
fertilizer B	fertilizer A	2.1000^*	.74050	.030	.2881	3.9119
	fertilizer C	2.4000^*	.74050	.018	.5881	4.2119
fertilizer C	fertilizer A	-.3000	.74050	.699	-2.1119	1.5119
	fertilizer B	-2.4000^*	.74050	.018	-4.2119	-.5881

From the above SPSS result, it shows that fertilizer B produced the highest mean yield, leading to the rejection of the null hypothesis H_0.

V. SUMMARY

From the analysis of the experiment in the previous chapter, it shows that there is a significant difference in the use of Urea, NPK 15-15-15, and Poultry manure (dung) and that these has a great impact in the yields of crops. The field study shows that application of the 'factors' Urea, NPK 15-15-15 and Poultry manure significantly increase in the yields of crops (Maize, Rice, Cassava, and Barley).

VI. CONCLUSION

Based on the result of the statistical analysis carried out in previous chapter three, at 5% level of significance of which $F_{cal}>F_{tab}$ i.e. 6.2374 > 5.14 for the factors level revealing that there is at least one significant difference on the effect of Urea, NPK 15-15-15, and Poultry manure on the yields of crops (four different crops). After this test, some reasonable facts can be deducted viz:

The null hypothesis for Urea, NPK 15-15-15, and Poultry manure was rejected at 5% level of significance. This can simply be interpreted that the effect of these factors (treatment) are significantly different from each other in the application of different factor- Urea, NPK 15-15-15; poultry manure in the yields of crops (Maize, Rice, Cassava, and Barley).

By calculating the averages or means of each treatment, it is discovered that the treatment B, which is NPK 15-15-15 has the highest or greatest possible yields, causing the null hypothesis to be rejected, which was revealed by Post Hoc tests (LSD) using SPSS based on the research.

Similarly, the null hypothesis of the block (crops) was accepted at 5% level of significance i.e. $F_{cal}<F_{tab}$ (0.8571 < 4.76), within the block at this level indicates that; there is no significant different within the blocks based on the research.

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