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On The Goodness of Four Types of Organic Fertilizers Using the Split Plot Design and the Two-Way Block Design with Interactions

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Abstract This study investigated the goodness of four (4) different types of organic fertilizers on crop (maize) yield. Data on kilograms of maize yield for the 2014/2015 planting season from four separate farms in which the four (4) different types of organic fertilizer (poultry droppings, piggery manure, extract from farm product and cassava sediment) were applied were collected from the Department of Soil Science, Akwa Ibom State University. SPLIT PLOT DESIGN and TWO-WAY ANOVA WITH INTERACTIONS models were used in carrying out the analysis. Hypothesis that was tested to ascertain whether there was a significant effect of the four types of organic fertilizer on maize yield indicated that, for both models, there was significant effect. When a pair-wise comparison via Least Significant Difference (LSD) was carried out to determine which of the four types of organic fertilizer was the best. For both models, results showed that extract from farm product was the best.

Keywords: *Extract from farm, manure, organic fertilizer, Pair –way comparison, split plot Design*

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1. Introduction

In agriculture, fertilizer plays a major role when it comes to boosting the productivity of crop yield. The importance of fertilizers (inorganic and organic) in the maintenance and improvement of soil productivity particularly under intensive cultivation has been well documented in various literatures. Fertilizers are classified into two main categories namely; the organic and inorganic fertilizers. The organic fertilizers are valuable byproducts of farming and allied industries derived from plant and animal sources and may contain water, urea, some micronutrients, humid acid etc; while chemical or inorganic fertilizers are fertilizers that are produced from mineral deposits or manufactured from synthetic compounds. They include NPK, Phosphate etc.

In the past few decades, chemical or inorganic fertilizers have widely spread throughout the world and focus and dependence on it by farmers was very high. However, it is now realized that in fields under intensive monoculture which receive heavy applications of chemical fertilizers alone, there is a slow decline in productivity. This has necessitated the growing focus and attention that is today being given to organic manure. Many studies have demonstrated that application of manure (organic fertilizer) will produce crop yield that is equivalent or superior qualitatively and quantitatively to those obtained with chemical fertilizers Xie and MacKenzie [1], Motavalli et al., [2], Eck et al., [3] and Pimpini et al. [4]. Enwall, Philippot and Itallin [5] mentioned that organic fertilizer has long term solution because the nutrient have slow release in the soil with a natural cycle and makes them available to plants for longer time (over months or years). CAST [6] and Zhang J et al [7] in their separate research work, gave reason for the better response of crops to manure than to chemical fertilizer and concluded that it was attributed to the fact that manure supplied nutrient faster than chemical manure, hence, improved soil conditions better than those of commercial fertilizer. Alexander [8] on his part posited that organic manure or fertilizer is a source of many essential elements, even if each organic fertilizer has different concentration of nutrients. Mclnitire et al [9] concluded in their study that organic fertilizers modifies soil's structure and helps to improve water holding capacity, aeration viability and drainage. Studies by Abeysekerra *et al.* [10] documented that organic manures enhances the mineral nitrogen content in the soil. Singh and Singh [11]; Ray and Gupta [12]; Sharma *et al.,* [13], Thakur *et al.* [14] reported that organic matter is an important soil component influencing the physical, chemical and microbiological properties of soil to a great extent and all physical properties of soil are affected by changes in organic matter levels of soil. Sharma, [15] said that the application of organic manures have significant effect on growth and development of crop plants. Silva et al [16] said that organic manure contains the nutrient necessary for better development of crops, that it is a good energy source for soil microorganisms and because of its high content of NPK, it enhances soil fertility. Thomas [17] and Waddington [18] said that organic fertilizer or manure also acts as a substrate for soil microorganism which leads to increased microbial activity thereby increasing the rate of organic material decomposition and releasing of nutrients for plant uptake. According to Nasef et al [19], Palade et al [20], Khahd and Safei [21] and Bhata and Shukla [22], it improves the physical properties of the soil as well as causing significant increase in soil carbon and nitrogen exchange capacity leading to the release of ca, mg, and k which invariably enhances crop yield and productivity.

In their studies, Tuzel [23], Sommerfeldt and Cheng [24] and Cheng et al [25] investigated the effect of cattle manures (animal waste) on soil biological properties and concluded that the use of cattle manures could significantly increase the number of fungi, actinomycetes, bacteria, phosphate-solving bacteria, organic phosphor-mineralizing bacteria, phosphor solubility, mineralization of phosphor as well as enzyme respiration and activity in soil. Youssef, El-Fouly and Mohamedien [26] obtained the best results for Pumice treatment with cattle manure by comparing eight cultivation environments for lettuce. In his experiment using manure in the form of processed organic humus, the quality of tomatoes was observed to have increased compared to the time when manure was merely used. He also showed that the use of poultry manure led to increased plant height and fruit sizes in tomatoes cultivated in low tunnels. Leonard [27] and William et al [28] all concluded that farmers in some cities favor organic manure (urban wastes) since their effect once applied might last for 2 or 3 years. Boateng and Oppong [29] reported improved soil physical properties by the addition of farm-yard manure to it. In Kenya, the value of manure is approximately five times that of its chemical fertilizer equivalent value Lekasi et al. [30]. Bationo and Mokwunye [31] also noted that the addition of organic materials either in the form of manure or crop residues, has beneficial effect on soil's chemical and physical properties and that the use of farmyard manure can reduce nutrient deficiency in soils. Koppen and Eich [32] noted that K and P deficiencies were reduced when farmyard manure was applied and with rising pH values, the Mn content of the soil declined.

The potential of manure, especially poultry litter, to neutralize soil acidity and raise soil pH has been established. Long term field and greenhouse studies have demonstrated the liming effect of animal manure in acid and neutral soils. Compost is also a slow-release fertilizer. Compared with fresh manure, its N is in a more stable form and not susceptible to loss of NH_3 gas [27]. The nutrient value of compost varies a lot and depends on what it is made from. Aside from N, P and K, it supplies varying amounts of secondary nutrients and micronutrients. In addition, some compost contains other growth-promoting substances such as B vitamins, natural hormones and organic acids. Harris et al [33] said that compost that has been made from a variety of materials is likely to provide the best spectrum of nutrients. Lopez-Real [34] in his study, showed that market waste co-composted with saw dust improves crop yield considerably while Cross and Strauss [35] showed that soil nutrients is greatly improved with the use of urban waste.

Some researchers in their studies tested the superiority of organic manure over inorganic fertilizers on some economic and food crops. For instance, Engindeniz and Tuzel [36] experimented on the use of green manure for tomatoes production and concluded that it gives better yield than when commercial manure was used. Singh and Singh [11], Zhang et al [7] and Gaur and Verma [37] demonstrated the response of manure on rice (Oryza sativa) – wheat (Triticum aestivum) production and concluded that it was extremely very significant while Ghafarinejad [38] reported high quality yield of cucumber and other lettuce with the use of organic fertilizer.

Several authors also worked on the comparative analysis of the goodness of some of the organic manures. In their experiment on lettuce, Turhan, Sevgican and Tuzel [39] examined three sources, namely, animal manure, compost, and phosphor-compost. The results indicated that all plant growth factors were affected by the organic fertilizer sources among which the animal manure and phosphor-compost exerted the highest impact on the crop production. . The study of three organic fertilizers, namely, cow, swine, and poultry manure, revealed that the use of such fertilizers could increase the lettuce yield up to 37%, 43%, and 98%, respectively. The recycling of nitrogen from poultry manure was found to be 38-82%, urea 51-69%, cow and swine manure 10-25%.

In conclusion, the use of organic fertilizer for farming is fast gaining global acceptance in agriculture. Its main objective is to create a balance between the interconnected systems of soil organisms, plants, animals and humans, improvement of environmental conditions and public health, and very importantly, the need to reduce cost of fertilizing crops.

2. Methodology

Two models, the Split-Plot design model and the Two-way ANOVA with interaction models were adopted for this work. In arriving at the results, SPSS, MINITAB and EXCEL-SOLVER computer softwares were used in the analysis of the data.

2.1. The Model for the Split Plot Design is Given by

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \lambda_k + (\beta\lambda)_{jk} + \epsilon_{ijk} \text{ ; for}$$

$$\begin{cases} i = 1....r \\ j = 1....t \\ k = 1....s \end{cases} \quad (1)$$

- y_{ijk} Is the response of k^{th} replicate of the i^{th} level of factor α and the j^{th} level of factor β
- μ Is the overall mean.
- λ_k Is the random effect of the k^{th} replicate with $\lambda_k \sim N(0, \delta^2)$
- β_j Is the fixed effect of the j^{th} level of factor β

- $(\beta\lambda)_{jk}$ Is the whole plot error
- α_i Is the effect of the i^{th} level of factor α
- $(\alpha\beta)_{ij}$ Is the fixed interaction effect of the i^{th} level of factor α and j^{th} level of factor, β
- $\in_{ijk}$ Is the subplot error, and $(\beta\lambda)_{jk}$ and $\in_{ijk}$ are independent

2.2. The Layout of Split Plot Design of an Experiment

$$
\begin{array}{cccc}
b_1 & b_2 & b_3 & b_r \\
\begin{matrix} t_1 & t_2 & t_3 & \cdots & t_r \end{matrix} & \begin{matrix} t_1 & t_2 & t_3 & \cdots & t_r \end{matrix} & \begin{matrix} t_1 & t_2 & t_3 & \cdots & t_r \end{matrix} & \begin{matrix} t_1 & t_2 & t_3 & \cdots & t_r \end{matrix} \\
\begin{pmatrix} x & x & x & \cdots & r \\ x & x & x & \cdots & r \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x & x & x & \cdots & r_x \end{pmatrix} &
\begin{matrix} I_1 \\ I_2 \\ \vdots \\ I_r \end{matrix}\begin{pmatrix} x & x & x & \cdots & r \\ x & x & x & \cdots & r \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x & x & x & \cdots & r_x \end{pmatrix} &
\begin{matrix} I_1 \\ I_2 \\ \vdots \\ I_r \end{matrix}\begin{pmatrix} x & x & x & \cdots & r \\ x & x & x & \cdots & r \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x & x & x & \cdots & r_x \end{pmatrix} &
\begin{matrix} I_1 \\ I_2 \\ \vdots \\ I_r \end{matrix}\begin{pmatrix} x & x & x & \cdots & r \\ x & x & x & \cdots & r \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x & x & x & \cdots & r_x \end{pmatrix}
\end{array}
$$

Table 1. ANOVA table for Split Plot Design

Source	D.F	Sum of Squares	Mean Squares
Block Row (R_i)	$(r-1)$	$\frac{\sum_{i=1}^{r} T_{i..}^2}{ts} - \frac{T_{...}^2}{rts}$	$\frac{SS_R}{r-1}$
Whole- Plot (W_j)	$(t-1)$	$\frac{\sum_{j=1}^{t} T_{.j.}^2}{rs} - \frac{T_{...}^2}{rts}$	$\frac{SS_w}{t-1}$
Whole –Plot Error (WR_{ij})	$(t-1)(r-1)$	$\frac{\sum_{i=1}^{r}\sum_{j=1}^{t} T_{ij.}^2}{s} - \frac{\sum_{i=1}^{r} T_{i..}^2}{ts} - \frac{\sum_{j=1}^{t} T_{.j.}^2}{rs} + \frac{T_{...}^2}{rts}$	$\frac{SS_{wR}}{(t-1)(r-1)}$
Sub –Plot (B_k)	$(s-1)$	$\frac{\sum_{k=1}^{s} T_{..k}^2}{rt} - \frac{T_{...}^2}{rts}$	$\frac{SS_B}{s-1}$
$(W-P(S-P)_{WB}$	$(t-1)(s-1)$	$\frac{\sum_{j=1}^{t}\sum_{k=1}^{s} T_{.jk}^2}{t} - \frac{\sum_{j=1}^{r} T_{.j.}^2}{rs} - \frac{\sum_{k=1}^{s} T_{..k}^2}{rt} + \frac{T_{...}^2}{rts}$	$\frac{SS_{WB}}{(s-1)(t-1)}$
S-P Error	$t(r-1)(s-1)$	*By subtraction*	$\frac{SS_E}{t(s-1)(r-1)}$
Total	$trs-1$ *trs -1*	$\sum_{i=1}^{r}\sum_{j=1}^{t}\sum_{k=1}^{s} Y_{ijk}^2 - \frac{T_{...}^2}{rts}$	

From the above, we have

Table 2. Complete ANOVA table for Split Plot Design

Source	Sum of Squares	D.F	Mean Squares	F-Ratio
Block Row (R_i)	SS_R	$(r-1)$	$\frac{SS_R}{r-1}$	$\frac{SS_R}{r-1} / MS_{WR}$
Whole- Plot (W_j)	SS_w	$(t-1)$	$\frac{SS_w}{t-1}$	$\frac{SS_w}{t-1} / MS_{WR}$
Whole –Plot Error (WR_{ij})	SS_{wR}	$(t-1)(r-1)$	$\frac{SS_{wR}}{(t-1)(r-1)}$	
Sub –Plot (B_k)	SS_B	$(s-1)$	$\frac{SS_B}{s-1}$	$\frac{SS_B}{s-1} / MS_E$
$(W-P(S-P)_{WB}$	SS_{WB}	$(t-1)(s-1)$	$\frac{SS_{WB}}{(s-1)(t-1)}$	$\frac{SS_{WB}}{(s-1)(t-1)} / MS_E$
S-P Error	SS_E	$t(r-1)(s-1)$	$\frac{SS_E}{t(s-1)(r-1)}$	
Total	SS_T	$trs-1$		

2.3. Hypothetical Statement

1. For the fixed effect of the i[th] level of factor α
   Ho: $\alpha_i = 0$ for all i.
   VS
   $H1$: $\alpha_i \neq 0$ for at least one α_i ; i = 1, 2....
2. For the fixed effect of the j[th] level of factor β
   Ho: $\beta_j = 0$ for all j.
   VS
   $H1$: $\beta_j \neq 0$ for at least one β_j ; j = 1, 2....
3. For the whole plot error
   Ho: $\alpha\beta_{ij} = 0$ for all ij.
   VS
   $H1$: $\alpha\beta_{ij} \neq 0$ for at least one $_{ij}$; i = 1, 2..., j= 1, 2....
4. For the random effect of the k[th] replicate with λ_k
   Ho: $\lambda_k = 0$ for all k.
   VS
   $H1$: $\lambda_k \neq 0$ for at least one λ_k ; k = 1, 2....
5. For the fixed interaction effect of j[th] random effect of β and k[th] replicate with λ_k
   Ho: $\beta\lambda_{jk} = 0$ for all jk.
   VS
   $H1$: $\beta\lambda_{jk} \neq 0$ for at least one $\beta\lambda_{jk}$; j = 1, 2....; k = 1, 2....

The F-value shall be compared with the critical values of $F_{(\alpha)}$, where α is the desired level of significance.

2.4. Decision Rule

1. Reject Ho, the hypothesis of no difference or of no relationship between the variables if $F_{cal} > F_{(\alpha)}$,

2. Accept Ho, the hypothesis of no difference or of no relationship between the variables if $F_{cal} < F_{(\alpha)}$

3. The Model for Two Way ANOVA with Interactions

The model is given as;

$$y_{ijk} = \mu + \delta_i + \theta_j + (\delta\theta)_{ij} + \in_{ijk} \text{ ; for } \begin{cases} i = 1....a \\ j = 1....b \\ k = 1....n \end{cases} \quad (2)$$

- y_{ijk} Is the observation or respond of the i^{th} treatment in the j^{th} block in the k[th] replicate
- μ Is the overall mean.
- δ_i Is the true effect of the i^{th} treatment of factor A
- θ_j Is the true effect of the j^{th} treatment of factor B
- $(\delta\theta)_{ij}$ Is the interaction between i^{th} level of factor A and j^{th} level of factor B
- ε_{ijk} Is the error term $\sim N(0, \delta^2)$.

3.1. Hypothetical Statement.

1. For the fixed effect of the i[th] level of factor A
   Ho: $\delta_i = 0$ for all i.
   VS
   $H1$: $\delta_i \neq 0$ for at least one δ_i ; i = 1, 2....
2. For the fixed effect of the j[th] level of factor B
   Ho: $\theta_j = 0$ for all j.
   VS
   $H1$: $\theta_j \neq 0$ for at least one θ_j ; j = 1, 2....
3. For the interaction
   Ho: $\delta\theta_{ij} = 0$ for all ij.
   VS
   $H1$: $\delta\theta_{ij} \neq 0$ for at least one $_{ij}$; i = 1, 2..., j= 1, 2....

The F-value shall be compared with the critical values of $F_{(\alpha)}$, where α is the desired level of significance.

3.2. Decision Rule

1. Reject Ho, the hypothesis of no difference or of no relationship between the variables if $F_{cal} > F_{(\alpha)}$,

2. Accept Ho, the hypothesis of no difference or of no relationship between the variables if $F_{cal} < F_{(\alpha)}$.

Table 3. ANOVA Table for two way ANOVA with interaction

Source of Variation	Degree of Freedom	Sum of Squares	F-Ratio
FACTOR A $(\delta)_i$	$a-1$	$\frac{\sum_{i=1}^{a} T_{i..}^2}{bn} - \frac{T_{...}^2}{abn}$	$\frac{SS_\delta}{a-1} / MS_E$
FACTOR B $(\theta)_j$	$b-1$	$\frac{\sum_{j=1}^{b} T_{.j.}^2}{an} - \frac{T_{...}^2}{abn}$	$\frac{SS_\theta}{b-1} / MS_E$
INTERACTION $(\delta\theta)_{ij}$	$(a-1)(b-1)$	$\frac{\sum_{i=1}^{a}\sum_{j=1}^{b} T_{ij.}^2}{n} - \frac{\sum_{i=1}^{a} T_{i..}^2}{bn} - \frac{\sum_{j=1}^{b} T_{.j.}^2}{an} + \frac{T_{...}^2}{rts}$	$\frac{SS_{\delta\theta}}{(a-1)(b-1)} / MS_E$
ERROR (e_{ij})	$ab(n-1)$	$SS_T - SS_\delta - SS_\theta - SS_{\delta\theta}$	
TOTAL	$abn-1$	$\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n} T_{ijk}^2 - \frac{T_{...}^2}{abn}$	

4. Numerical Analysis

4.1. Split Plot Design of an Experiment

The layout of split plot Design

$$R_1 \quad \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} t_1 & t_2 & t_3 & t_4 \\ 36 & 37 & 42 & 38 \\ 44 & 42 & 53 & 41 \\ 48 & 36 & 62 & 62 \\ 46 & 52 & 42 & 42 \end{array} \qquad R_2 \quad \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} t_1 & t_2 & t_3 & t_4 \\ 41 & 62 & 50 & 47 \\ 45 & 66 & 58 & 52 \\ 53 & 67 & 65 & 59 \\ 74 & 81 & 73 & 75 \end{array}$$

$$R_3 \quad \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} t_1 & t_2 & t_3 & t_4 \\ 55 & 46 & 51 & 49 \\ 65 & 53 & 62 & 66 \\ 65 & 65 & 68 & 69 \\ 82 & 72 & 70 & 80 \end{array} \qquad R_4 \quad \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} t_1 & t_2 & t_3 & t_4 \\ 55 & 48 & 53 & 51 \\ 66 & 50 & 56 & 60 \\ 61 & 59 & 62 & 62 \\ 84 & 70 & 68 & 76 \end{array}$$

Table 4. Estimates

Subplot	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
SP1	47.563	1.501	44.519	50.606
SP2	54.938	1.501	51.894	57.981
SP3	60.025	1.560	56.861	63.189
SP4	67.079	1.560	63.915	70.243

Table 5. Split Plot ANOVA Table

Source	Sum of Squares	DF	Mean Square	F-Ratio	Sig.
Fertilizer	3305.562	3	1101.854	10.860	.000
Main plot	52.075	3	17.358	.171	.697
Main plot Error	913,118	9	101.458		
Subplot	3095.963	3	1031.988	28.645	.000
Main plot * Subplot	426.690	9	47.410	1.316	.263
Subplot Error	1296.962	36	36.027		
Corrected Total	9622.437	63			
a. R Squared = .865 (Adjusted R Squared = .764)					

Decision 4.1.1

The difference in the maize yield by Fertilizer
◊ P- value = .000
Level of significance =0.05
Since P- value = .000 < level of significance =0.05
◊ **Conclusion:** H_o is rejected hence there is a significant mean difference in the fertilizer

Decision 4.1.2

◊ The difference in the maize yield by main-plot.
P- Value = .000
Level of significance =0.05
Since P- value = .697 > level of significance =0.05
Conclusion: H_o is accepted hence there is no significant mean difference in the main-plot.

Decision. 4.1.3

◊ The difference in the maize yield by sub plot.
P- Value = .000
Level of significance =0.05
Since P- value = .000 < level of significance =0.05
Conclusion: H_o is rejected hence there is a significant mean difference in the sub plot

Decision 4.1.4

◊ The difference in the maize yield by main-plot*sub-plot
◊ P- value = .000
Level of significance =0.05
Since P- value = .263 > level of significance =0.05
Conclusion: H_o is accepted hence there is no significant mean difference in the interaction between the main-plot*sub-plot.

Conclusion: Since the result for the Subplot is statistically significant, this calls for pairwise, comparison test to ascertain the best subplot.

Table 6. Pairwise Comparisons

(I) Subplot	(J) Subplot	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
SP1	SP2	-7.375*	2.122	.001	-11.679	-3.071
	SP3	-12.462*	2.165	.000	-16.852	-8.073
	SP4	-19.517*	2.165	.000	-23.907	-15.127
SP2	SP1	7.375*	2.122	.001	3.071	11.679
	SP3	-5.087*	2.165	.024	-9.477	-.698
	SP4	-12.142*	2.165	.000	-16.532	-7.752
SP3	SP1	12.462*	2.165	.000	8.073	16.852
	SP2	5.087*	2.165	.024	.698	9.477
	SP4	-7.054*	2.157	.002	-11.429	-2.679
SP4	SP1	19.517*	2.165	.000	15.127	23.907
	SP2	12.142*	2.165	.000	7.752	16.532
	SP3	7.054*	2.157	.002	2.679	11.429

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Findings:

◊ Using pair-wise comparison test as shown above, the result gives the mean difference of **-7.375** and P-value **= .001 for subplot 1 and subplot 2**. Since P=.001 <.05 (level of significance), it means that there is a significant mean difference between the yield of subplot 1 and subplot 2.

◊ Comparing the effect of **subplot 1 and subplot 3** the result gives the mean different of **-12.462** and **p-value = .000.** Since P=.000 < .05 (level of significance), it means that there is a significant mean difference between the yield subplot 1 and subplot 3.

◊ Comparing **subplot 1 and subplot 4**, the result gives the mean different of **-19.517** and **p-value = .000** Since P=.000 <.05 (level of significance), it means that there is a significant mean difference between the two subplots.

◊ Comparing **subplot 2 and subplot 3,** the result gives the mean difference of **-5.087 and P-value =.024** Since P=.024 <.05(level of significance), it means that there is a significant mean difference between the two subplots.

◊ Comparing **subplot 2 and subplot 4,** the result gives the mean difference of **-12.142 and P-value =.000** Since P=.000 <.05(level of significance), it means that there is a significant mean difference between the two subplots.

◊ Comparing **subplot 3 and subplot 4**, the result gives the mean difference of **-7.054 and P-value =.002** Since P=.002 <.05 (level of significance), it means that there is a significant mean difference between the two subplots.

Conclusion: From the pairwise comparison, it is shown that **subplot 4** is the best among the four types of subplots, since the mapping of **Subplot 1, Subplot 2, and Subplot 3** produces positive values

4.2. Two- way ANOVA with Interactions

4.2.1. The layout of split plot Design

Table 7. Layout of a Two- Way ANOVA With Interactions

Fertilizers	MAIZE			
	Plot 1	Plot 2	Plot 3	Plot 4
PD	36	37	42	38
	44	42	53	41
	48	36	62	62
	46	52	42	42
SM	41	62	50	47
	45	66	58	52
	53	67	65	59
	74	81	73	75
FP	55	46	51	49
	65	53	62	66
	65	65	68	69
	82	72	70	80
CS	55	48	53	51
	66	50	56	60
	61	59	62	62
	84	70	68	76

Where the organic fertilizers are poultry droppings (PD), pig manure(PM), extracts from farm product(FP) and cassava sediment(CS).

4.2.2. Testing the Underlying Assumptions

Each of the samples was independently sampled and each of the groups has the same sample size.

4.2 3. Normality Test

H_0: The population is normally distributed

vs

H_1: The population not normally distributed

The test was carried out using both Kolmogorov-Smirnov and Shapiro-Wilk statistic

Table 8. Tests of Normality

Plot		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	DF	Sig.	Statistic	DF	Sig.
Yield	Plot 1	.132	16	.200*	.952	16	.525
	Plot 2	.113	16	.200*	.970	16	.843
	Plot 3	.147	16	.200*	.955	16	.573
	Plot 4	.116	16	.200*	.961	16	.680

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Findings: The result in above Table using Shapiro-Wilk gives the probability values of **.525, .843, .573 and .680** respectively **for Plot 1, Plot 2, Plot 3 and Plot 4.** Since each of the probability values is greater than .05 (level of significance), the null hypothesis is retained. Therefore the data is normally distributed and as such satisfies the assumption of normality. The P-values for Kolmogorov-Smirnov were also greater than .05.

4.2.4. Equality of Variance Test

H_0: The variances are equal

VS

H_1: The variances are not equal

This test was carried out using Levene test as shown in the Table below.

Table 9. Test of Homogeneity of Variance

		Levene Statistic	DF 1	DF 2	Sig.
Yield	Based on Mean	1.184	3	60	.324
	Based on Median	.943	3	60	.426
	Based on Median and with adjusted df	.943	3	53.687	.427
	Based on trimmed mean	1.168	3	60	.330

The result of the test **'based on mean' gives Levene Statistic of 1.184 and probability value of .324.** Since P=.324 >. 05 (level of significance), the null hypothesis is retained meaning that the population variances are equal and as such satisfies the equality of variances assumption.

Table 10. ANOVA Computation for Two way ANOVA with interaction

Source of Variation	Sum of Squares	DF	Mean Square	F-Ratio	P-Value	F-Critical
Sample	3415.625	3	1138.542	10.50457	2E-05	2.798061
Columns	31.625	3	10.54167	0.097261	0.961171	2.798061
Interaction	994	9	110.4444	1.018997	0.438686	2.08173
Within	5202.5	48	108.3854			
Total	9643.75	63				

Note: The level of significant used is 5% significant

4.2.5. Findings and Conclusion

◊ The difference in the maize yield by fertilizer (factor)

$F_{0.05}$ (3, 48) = 2.80

F_{cal} =10.50

$F_{0.05}$ (3,48) = 2.81 < F_{cal} =10.50

Conclusion: H_o is therefore rejected and H1 accepted. Hence we conclude that there is a significant mean difference in the yield of the maize based on the type of fertilizer applied. In other words, fertilizer applied significantly affected crop yield.

◊ The difference in the maize yield by plot.

$F_{0.05}$ (3, 48) = 2.80

F_{cal} =0.10

$F_{0.05}$ (3, 48) = 2.80 > F_{cal} =0.10

Conclusion: H_o is accepted hence, there is no significant mean difference in the crop yield based on plot.

◊ The difference in the interaction between the fertilizers and crop

$F_{0.05}$ (9, 48) = 2.08

F_{cal} =1.02

$F_{0.05}$ (9, 48) = 2.08 > F_{cal} =1.02

Conclusion: H_o is accepted hence there is no significant mean difference in the interaction between fertilizer and crop. This implies that there is an interaction between the fertilizers and crops.

Table 11. LSD Pairwise Comparisons

(I) Fertilizer	(J) Fertilizer	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PD	PM	-15.31*	3.680	.000	-22.71	-7.91
	FP	-18.44*	3.680	.000	-25.84	-11.04
	CS	-16.13*	3.680	.000	-23.52	-8.73
PM	PD	15.31*	3.680	.000	7.91	22.71
	FP	-3.13	3.680	.400	-10.52	4.27
	CS	-.81	3.680	.826	-8.21	6.59
FP	PD	18.44*	3.680	.000	11.04	25.84
	PM	3.13	3.680	.400	-4.27	10.52
	CS	2.31	3.680	.533	-5.09	9.71
CS	PD	16.13*	3.680	.000	8.73	23.52
	PM	.81	3.680	.826	-6.59	8.21
	FP	-2.31	3.680	.533	-9.71	5.09

The error term is Mean Square (Error) = 108.344.
*. The mean difference is significant at the .05 level.

4.2.6. Pair wise comparison within Fertilizers

Since the result for the sample (Fertilizer) is statistically significant, this calls for pairwise comparison test to ascertain the best fertilizer.

- ◊ Using pairwise comparison test as shown above, the result gives the mean difference of -15. 31 and P-value= .000 for Poultry Dropping and Piggery Manure. Since P=.000<.05 (level of significance), it means that there is a significant mean difference between the yield of Poultry Dropping and Piggery Manure. The negative sign (-) attached to the mean difference between Poultry Dropping and Piggery Manure shows that the mean yield of Piggery Manure is higher than that of Poultry Dropping; as such Piggery Manure is better than Poultry Dropping.
- ◊ Comparing the effect of Poultry Dropping and Farm product manure on crop yield the result gives p-value = .000. Since P=.000 < .05 (level of significance), it means that there is a significant mean difference between the yield, therefore Farm Product is a better manure than the Poultry Dropping.
- ◊ Comparing the effect of Poultry dropping and Cassava sediment on crop yield the result gives p-value = .000 Since P=.000 <.05 (level of significance), it means that there is a significant mean difference between the yield. Hence cassava sediment is a better manure than the Poultry Dropping.
- ◊ Comparing the effect of Piggery Manure and Extract from Farm Product and on crop yield the result gives the mean difference of -3.13 and P-value =.400. Since P=.400>.05(level of significance), it means that there is **NO** significant mean difference between the yield.
- ◊ Comparing the effect of Piggery manure and Cassava sediment on crop yield the result gives p-value = .826. Since P=.826 >.05(level of significance), it means that there is **NO** significant mean difference between the yield.
- ◊ Comparing the effect of Extract from Farm Product (FP) and Cassava sediment (CS) on crop yield the result gives the mean difference of 2.31 and p-value .533. Since P =.533 >.05 (level of significance), it means that there is **NO** significant mean difference between the yields. The positive value of 2.31 implies that the yield of Extract from Farm Product is slightly better than that of CS though this is not significant statistically.

Hence, from the pairwise comparison it is shown that **extract from farm product** is the best among the four types of organic fertilizers applied since the mapping of Farm Product to Poultry Dropping, Piggery Manure and Cassava Sediment produces positive values.

5. Conclusions

1. From the results of the **Split Plot Design** and **Two way ANOVA with Interaction**, we see that the four types of organic fertilizer significantly affected crop yield.

2. Comparing the four types of fertilizers which are (poultry dropping, piggery manure, extract from farm product and cassava sediment) in both designs models, the results showed that the **yield from extract of farm product** has the highest means compared to other organic fertilizers, hence we can conclude that **yield from extract of farm product is the best among the four different types of organic fertilizers** for the cultivation of maize.

Organic fertilizer has effect on crop yield (maize) and extract of farm product is found to be the best type of organic fertilizer, hence, farmers should therefore adopt extracts of farm produce for maize planting.

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