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Short Communication

STATISTICAL INVESTIGATION OF THE EFFECT OF SOIL COMPOST AND ROCK PHOSPHATE ON THE GROWTH CHARACTERISTICS OF OIL PALM TREE USING FACTORIAL MODEL

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ABSTRACT

Statistical investigation of the effect of soil composts (Factor A) and rock phosphate (Factor B) on the growth characteristics of oil palm tree was carried out at 5% level of significance. Consequently, the results showed that there are significant effects of these factors on the growth characteristics of oil palm tree. There is also a significant interaction effect of soil composts and rock phosphate on the growth characteristics.

Keywords: Factorial, experiment, model, soil compost, rock phosphate, growth, oil palm tree.

INTRODUCTION

In this work, we shall investigate the effects of Soil Compost and Rock Phosphate on the growth characteristics of Oil Palm trees. The growth characteristics considered in this work are: Number of Leaves LEF), Height (HGT), Girth (GTH), Fresh Weight Leaves (FWL), Fresh Weight Root (FWR), Fresh Weight Total (FWT), Dry Weight Leaves DWL), Dry Weight Root (DWR) and Dry Weight Total (DWT) respectively. According to Pratt and Tort (1990), Hill and Wiles (1975), the investigation shall involve the use of Factorial design experiment to achieve the desired results. Hence, the factorial design experiment becomes useful in testing the effects of two or more factors, or their interaction effects on the response variables (Box *et al*., 2005; Box, 1990; Hunter, 1994).

Now, let the soil Compost and Rock Phosphate be "Factor A" and "Factor B" at ith and jth levels of experiment respectively. Accordingly Montgomery (1991) the Factorial model for the experiment is defined as

$$\text{i= 1(1)L, j = 1(1)m, k =1(1)n}$$
$$X_{ijk} = \mu + \alpha_i + \beta_j + \phi_{ij} + \in_{ijk}, i = 1(1)4;\ j = 1(1)5, k = 1(1)3 \quad (1.1)$$

where

$X_{ijk} \equiv response\,(value)\ from\ i^{th}\ level\ of\ soil\ compost\ and\ j^{th}\ level\ of\ rock\ phosphate\ at\ k^{th}\ replication$

$\mu \equiv Overall\ mean\ value$

$\alpha_i \equiv Main\ effect\ of\ soil\ compost\ at\ i^{th}\ level$

$\beta_j \equiv Main\ effect\ of\ rock\ phosphate\ at\ j^{th}\ level$

$\phi_{ij} \equiv$ *interaction effect of soil compost and rock phosphate at* $(i, j)^{th}$ *level*

$\in_{ijk} \approx N(o, \sigma^2)$ *is the random error*

Due to cost of experimentation, we make a choice of L = 4 and m =5 levels of experiment at n = 3 replications in equation(1.1). This result to 4x5 factorial design of experiment for investigating the effects of factor A, Factor B, and their interactions on the growth characteristics of Oil Palm tree respectively.

MATERIALS AND METHODS

Under the assumption that $\in_{ijk} \approx N(o, \sigma^2)$ and exploiting model (1.1), the estimates of the parameters μ, α_i, β_j and ϕ_{ij} are (Box *et al*., 2005).

$$\hat{\mu} = \frac{1}{60}\sum_{i=1}^{4}\sum_{j=1}^{5}\sum_{k=1}^{3} X_{ijk}$$

$$\hat{\alpha}_i = \frac{1}{15}\sum_{j=1}^{5}\sum_{k=1}^{3} X_{ijk} - \hat{\mu}\ ; \qquad i = 1(1)4$$

$$\hat{\beta}_j = \frac{1}{12}\sum_{i=1}^{4}\sum_{k=1}^{3} X_{ijk} - \hat{\mu}\ ; \qquad j = 1(1)5$$

$$\hat{\phi}_{ij} = \frac{1}{3}\sum_{k=1}^{3}\left(X_{ijk} - \hat{\mu} - \hat{\alpha}_i - \hat{\beta}_j\right)\ ; \qquad i = 1(1)4,\ j = 1(1)5,\ i \neq j$$

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We formulate the test hypotheses as follows:

a) H_o : $\alpha_i = 0$, for $i = 1(1)4$ (No mean effect of soil compost on the growth characteristics of oil palm tree)
Versus H_i : $\alpha_i \neq 0$, for at leasta main effectof i (There is mean effect of soil compost on the growth characteristics of oil palm tree)

b) H_o: $\beta_j = 0$, for $j = 1(1)5$ (No mean effect of rock phosphate on the growth characteristics of oil palm tree)
Versus H_i : $\beta_j \neq 0$, for at leasta main effectof j (There is mean effect of rock phosphate on the growth characteristics of oil palm tree)

c) H_o : $\phi_{ij} \neq 0$, for at least one (i, j) (There is interaction effect)

Under the null hypotheses (Cochram and Cox, 1957) in (a), (b) and (c), and for $\in_{ijk} \approx N(o, \sigma^2)$, the F-statistics for the soil compost (Factor A), rock phosphate (Factor B) and interaction (AB) are:

$$F_A = \frac{MSS_A}{MSE}, F_B = \frac{MSS_B}{MSE}, and\ F_{AB} = \frac{MSS_{AB}}{MSE} \quad (2.1)$$

respectively, where MSS_A, MSS_B, MSS_{AB} and MSE are the mean sum of squares for factor A, factor B, interaction AB and error respectively.

These statistics F_A, F_B and F_{AB} are F-distributed with degree of freedom ($v_1 = 3$, $v_2 = 40$), ($v_1 = 4$, $v_2 = 40$) and ($v_1 = 12$, $v_2 = 40$) respectively. Thus, the analysis of variance (ANOVA) table associated with the 4 x 5 factorial design is given below (Table 1):

Table 1. ANOVA table for 4 x 5 Factorial Design.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Soil compost (Factor A)	3	SS_A	$MSS_A = \frac{SS_A}{3}$	$F_A = \frac{MSS_A}{MSE}$
Rock phosphate (Factor B)	4	SS_B	$MSS_B = \frac{SS_B}{4}$	$F_B = \frac{MSS_B}{MSE}$
Interaction (AB)	12	SS_{AB}	$MSS_{AB} = \frac{SS_{AB}}{12}$	$F_{AB} = \frac{MSS_{AB}}{MSE}$
Error	40	SSE	$MSE = \frac{SSE}{40}$	

Data Collection

The data (Table 2) for this analysis were collected from Department of Statistics, Nigeria Institute for Oil Palm Research (NIFOR) at Benin City, Edo State, Nigeria. The data are on a factorial experiment conducted on the effect

Table 2. Presentation of Data.

Soil compost	Rock phosphate	REPLICATION 1								
		LEF	HGT	GTH	FWL	FWR	FWT	DWL	DWR	DWT
0	0	11	61	11	95.6	83	178.6	24.9	15.5	40.4
	50	11	61	11	96.1	49.4	145.3	29.7	13.1	42.8
	100	11	50	10.5	70.4	46.4	116.8	18.3	8.6	26.9
	150	13	58	11.5	96.7	69.9	166.6	26.7	14.3	41
	200	13	69	8	58.9	54	112.9	15.7	9.4	25.3
10	0	11	70	13	91.8	90.9	182.7	22.7	17.4	40.1
	50	12	71	12	86	47.1	133.1	27.9	13.6	41.5
	100	13	60	13	89.3	91.8	181.1	25.4	17.8	43.2
	150	13	62	13.5	115.3	97.5	212.8	32.2	18.2	50.4
	200	12	62	11.5	86.2	95.8	182	23.7	19.4	43.1
20	0	12	76	14	153.5	129.3	282.8	40.2	24.4	64.2
	50	12	73	13.5	135.2	96.6	231.8	37.7	21.6	59.3
	100	12	71	13	115.6	65.5	181.1	42.8	7.5	50.3
	150	12	61	10	104.1	97.7	201.8	29.2	19.8	49
	200	10	63	11.5	80.3	47.5	127.8	24.5	10.6	35.1
30	0	13	52	11	67.7	49.6	117.3	18.8	12.9	31.7
	50	12	57	11	62.1	46.8	108.9	18.1	9.9	28
	100	12	58	12	80.6	80.5	161.1	25.5	17.1	42.6
	150	12	65	10.5	68.3	56.5	124.8	**	**	**
	200	11	62	13	84.5	63.2	147.7	23.4	15.4	38.8

Continued…

Table 2 continued

Soil compost	Rock phosphate	REPLICATION 2								
		LEF	HGT	GTH	FWL	FWR	FWT	DWL	DWR	DWT
0	0	12	67	11.5	89.4	74.4	163.8	25.7	15.2	40.9
	50	11	56	9	75	57.2	132.2	21.9	15.5	37.4
	100	12	60	9.5	91.4	54.3	145.7	24.5	10.5	25
	150	12	69	10.5	88.3	69.5	157.8	24.9	13.5	38.4
	200	12	61	10	78.6	56.5	144.1	26.1	12.2	38.3
10	0	13	76	15	15.4	86.5	240.7	45.6	16.2	61.8
	50	13	61	14	107.1	65.5	172.6	33	16.1	49.1
	100	11	66	12	92.6	67.8	160.4	26.9	16.9	43.8
	150	13	64	12	101.1	72.6	173.7	26.4	16.3	42.7
	200	11	56	11	80.2	60.7	140.9	21.7	13.2	34.9
20	0	13	78	13	158.2	84.3	242.5	46.9	18.1	65
	50	13	78	11	113.3	51.1	164.4	38.4	12.6	51
	100	11	74	13	105.6	69.3	174.9	30.8	14.5	45.3
	150	12	55	14	96.6	57.7	154.3	26.3	13.4	39.7
	200	12	64	10	78.7	73.6	152.3	23.6	16	39.6
30	0	10	60	10	66.8	57.1	123.9	18	11.4	29.4
	50	11	61	12	81.6	96.1	177.7	21	24.9	45.9
	100	11	65	14	70.5	108	178.9	21.1	24.2	45.3
	150	11	53	14	76	105	181.3	21.3	21.2	42.5
	200	12	68	11	74.4	89	163.4	23.5	18.7	42.2

Soil compost	Rock phosphate	REPLICATION 3								
		LEF	HGT	GTH	FWL	FWR	FWT	DWL	DWR	DWT
0	0	12	58	11	77.5	36.8	114.3	27.2	8.8	30
	50	11	57	10.5	67.6	42.8	110.4	19.9	11.8	31.7
	100	12	70	12	71.7	44.8	116.5	19.7	11.9	31.6
	150	12	63	13.5	90.4	67	157.4	25.2	17.2	42.4
	200	12	61	13	82.3	66.2	148.5	24	16	40
10	0	13	63	11	97.3	45.8	143.5	25.8	11.8	.37.6
	50	11	70	13	112.6	66.8	179.4	41.1	16.4	57.5
	100	12	66	13.5	108.5	72.2	108.7	28	15.6	43.6
	150	11	61	11.5	101.7	79.6	181.3	30.9	18.5	49.4
	200	12	64	10	71	50.5	121.5	20.4	12.9	33.3
20	0	13	57	12	92.5	62.1	154.6	28.1	17.7	45.8
	50	13	80	14.5	169.6	95.5	265.1	60.3	24.9	85.2
	100	11	74	12	100.5	68.1	168.6	31.8	17.5	49.3
	150	13	64	11	79	54.6	133.6	23	13.6	36.6
	200	10	67	7	64.6	51.8	116.4	18.8	13.2	32
30	0	11	56	12	93.8	88.1	181.9	30	18.6	48.6
	50	11	55	10	69.3	79.1	148.4	22	21.1	43.1
	100	11	58	9.5	.87.4	82.9	170.3	26.8	20.9	47.7
	150	13	55	10	86.6	88.4	175	25.7	23.6	49.3
	200	12	59	9.5	88.4	141.1	229.5	27	30	57

of two factors namely soil compost (Factor A) at four levels and rock phosphate (Factor B) at five levels on the growth characteristics of oil palm tree which of course are the responses.

The growth characteristics measured are as follows: Number of leaves (LEF), Height (HGT), Girth (GTH), Fresh Weight leaves (FWL), Fresh weight root (FWR), Fresh weight total (FWT), Dry weight leaves (DWL), Dry weight root (DWR) and Dry weight total (DWT).

Analysis of Data

The analysis of data was done using statistical package SAS/STAT. The results are shown in the tables 3-13 below:

Table 3. ANOVA for lef.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Soil compost (factor A)	3	2.33	0.78	1.17
Rock phosphate (factor B)	4	4.00	1.00	1.50
Interaction (AB)	12	11.33	0.94	1.42

Table 4. ANOVA for HGT.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	858.00	286.00	10.15
Factor B: Rock phosphate	4	135.60	33.90	1.20
Interaction AB	12	730.00	60.83	2.16

Table 5. ANOVA for GTH.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	21.75	7.25	3.04
Factor B: Rock phosphate	4	20.96	5.24	2.19
Interaction AB	12	22.61	1.88	0.79

Table 6. ANOVA for FWL.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	10240.51	3413.50	12.88
Factor B: Rock phosphate	4	4276.99	1069.25	4.03
Interaction AB	12	7633.63	636.14	2.40

Table 7. ANOVA for FWR.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	4426.04	1475.35	3.63
Factor B: Rock phosphate	4	766.24	191.56	0.47
Interaction AB	12	6412.72	534.39	1.32

Table 8. ANOVA FOR FWT.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	16570.97	5523.66	4.94
Factor B: Rock sulphate	4	5463.76	1365.94	1.22
Interaction AB	12	23141.04	1928.42	1.72

Table 9. ANOVA for DWL.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	1001.10	333.70	9.65
Factor B: Rock phosphate	4	545.40	136.35	3.94
Interaction AB	12	873.17	72.76	2.10

Table 10. ANOVA for DWR.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	311.25	103.75	6.46
Factor B: Rock phosphate	4	45.31	11.33	0.71
Interaction AB	12	256.98	21.42	1.33

Table 11. ANOVA for DWT.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-value
Factor A: Soil compost	3	1598.63	532.88	8.32
Factor B: Rock phosphate	4	609.25	152.31	2.38
Interaction AB	12	1903.16	158.60	2.48

Table 12. F-value and F-table at 5% level of significance.

		LEF	HGT	GTH	FWL	FWR	FWT	DWL	DWR	DWT
Sources of variation	F table	F-value	F-value	F-value	F-value	F-value	F-value	F-value	F-value	F-value
Factor A: Soil compost	2.84	1.17	10.15	3.04	12.88	3.63	4.94	9.65	6.46	8.32
Factor B: Rock phosphate	2.61	1.50	1.20	2.19	4.03	0.47	1.22	3.94	0.71	2.38
Interaction AB	1.92	1.42	2.16	0.79	2.40	1.32	1.72	2.10	1.33	2.48

Table 13. Statistical Decision at 5% level of significance.

	DECISIONS								
	LEF	HGT	GTH	FWL	FWR	FWT	DWL	DWR	DWT
Factor A: Soil compost	Accept H_o	Reject H_o	Reject H_o	Reject H_o	Reject H_o	Reject H_o	Reject H_o	Reject H_o	Reject H_o
Factor B: Rock phosphate	Accept H_o	Accept H_o	Accept H_o	Reject H_o	Accept H_o	Accept H_o	Reject H_o	Accept H_o	Accept H_o
Interaction AB	Accept H_o	Reject H_o	Accept H_o	Reject H_o	Accept H_o	Accept H_o	Reject H_o	Accept H_o	Reject H_o

Based on the analysis, we are 95% confident that:

i. The soil compost had a significant effect on HGT, GTH, FWR, DWR, DWT, DWL. FWT and FWL
ii. The rock phosphate had a significant effect on FWL and DWL.
iii. The soil composts had no significant effect on LEF
iv. The rock phosphate interaction effect of soil compost and rock phosphate on LEF, HGT, GTH, FWR, FWT, DWR and DWT
v. There is significant interaction effect of soil compost and rock phosphate on HGT, FWL, DWL and DWT
vi. There is no significant interaction effect of soil compost and rock phosphate on LEF, GTH, FWR, FWT and DWR.

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