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Statistical Analysis of Soil Type and Organic Manure Quantity on Maize Growth and Yield: A Case Study from the Department of Crop Science, Federal University of Technology

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ABSTRACT

This study investigates the impact of different quantities of organic (poultry) manure on the height yield of maize crops in three soil types (sandy, clay, and loamy) in Owerri, Nigeria. Utilizing a randomized complete block design (RCBD), the study applies analysis of variance (ANOVA) to assess the significance of the treatments, which range from 0 to 15 tons/ha in 2.5-ton increments. Data analysis confirms that the assumptions of independence, normality, and homogeneity of variance are satisfied. Results reveal that both soil type and manure quantity significantly affect maize height, with interactions between these factors also being significant. Optimal maize height is achieved with 12.5 tons/ha of manure in sandy soil, followed by 5.0 tons/ha in loamy soil, and 15.0 tons/ha in clay soil. The study concludes that appropriate manure application enhances maize yield, and it recommends government support for farmers through education, loans, and availability of organic manure to boost maize production and contribute to Nigeria's economic growth.

Keywords: Organic Manure, Maize, Soil, ANOVA, RCBD

INTRODUCTION

Maize Maize farming in Nigeria is a crucial agricultural activity, as maize (Zea mays, L.) is one of the primary cereal crops in West Africa. It ranks as the fourth most consumed grain in Nigeria, following rice, millet, and sorghum, and contributes over 19.5% of total calorie intake globally, surpassing wheat (15.0%) and rice (16.5%) in caloric content (agricdemy, 2023).

In Nigeria, maize serves as a critical staple food and has evolved into a lucrative cash crop, particularly in the southwestern regions where small-scale farming occupies about 30% of arable land1. The country is the second-largest producer of maize in Africa, trailing only South Africa, and ranks 11th globally. Despite high production volumes, Nigeria's average yield stands at approximately 1.8 metric tons per hectare (MT/Ha), which is significantly lower than yields in South Africa (5.3 MT/Ha) and Egypt (7.7 MT/Ha) (PricewaterhouseCoopers Nigeria, 2021).

The primary obstacles to maize cultivation in Nigeria include low soil fertility, exacerbated by reduced fallow periods due to increasing population pressures. The country's tropical climate contributes to nutrient leaching due to high precipitation levels. A significant limitation for maize growth is nitrogen deficiency, as Nigeria has low organic matter levels in its soils (Opaluwa et al.,2022).

Maize has substantial nutritional needs, particularly for nitrogen (N), phosphorus (P), and potassium (K). The grain typically contains up to 2% nitrogen content, with higher concentrations present in above-ground parts of the plant. For every ton of maize harvested, approximately 20 kg of nitrogen is extracted from the soil (agricdemy, 2023).

The Nigerian government has implemented several programs to support maize farmers, such as the Central Bank of Nigeria's Anchor Borrowers Scheme and NIRSAL Microfinance Bank loans aimed at providing financial assistance and resources to farmers (PricewaterhouseCoopers Nigeria, 2021).

Overall, while maize remains a vital crop for food security and economic stability in Nigeria, addressing soil fertility issues and improving agricultural practices are essential for enhancing yields and meeting both domestic and industrial demands. Maize cultivation has ancient roots in Nigeria, dating back to pre-colonial times. Opaluwa *et al.,* (2022), Indigenous farming communities across various regions of Nigeria traditionally integrated maize into their cropping systems, alongside other staple crops like yams, millet, and sorghum (Adebayo, 2014). Archaeological evidence suggests that maize was domesticated in West Africa thousands of years ago, highlighting its long- standing importance in the region (Hunt & McGovern, 2001).

Adewale *et al.,* (2015), during the colonial era, maize cultivation underwent transformations with the introduction of commercial farming practices and the adoption of hybrid maize varieties. However, these changes also brought challenges such as soil erosion, nutrient depletion, and decreased soil fertility due to unsustainable land use practices and reliance on chemical fertilizers

Recent research has demonstrated the efficacy of organic manure in enhancing soil fertility and increasing maize yield in Nigeria. Lawal-Adebowale and Osiname (2004) write that maize requires nutrients for growth and development, and two types of fertilizers are available: organic fertilizer, which includes animal waste like cow dung and chicken droppings, and compost, which is made from animal waste like cow dung and chicken droppings, and mineral fertilizer, which includes NPK and ammonium sulphate. Traditional farming systems in Nigeria heavily rely on organic manure to maintain soil fertility and agricultural productivity.

Kamal *et al.,* (2023), a study at the Agriculture Research Farm in Peshawar-Pakistan found that combining organic and inorganic amendments can improve maize production and soil quality. The study found that the combination of organic and half- inorganic fertilizers improved soil fertility, making it a viable strategy for crop yield regulation and sustainable maize production. The study also found that the hybrid CS 220 maize variety showed superior yield and component performance compared to the Azam variety. The study suggests that efficient organic soil amendments alone or in combination with commercially available inorganic fertilizers can be used to achieve sustainable maize farming.

Shah *et al.,* (2023), conducted a study at King Saud University in Pakistan found that using organic fertilizer sources, including poultry manure and farmyard manure, along with biochar, significantly improved the growth and yield of maize hybrids under drought stress. The study found that these organic fertilizers improved soil properties and nutrient uptake, leading to increased soil porosity and decreased bulk density. The study also found that the application of organic fertilizers mitigated the adverse effects of drought by producing SOD, POD, and CAT, which are antioxidant defense systems. This suggests that organic fertilizers can be a valuable solution for improving maize hybrids' growth, yield, quality, and nutrient uptake under drought stress.

Ning *et al.,* (2022) conducted a study in North-Central China investigated the effects of chicken manure substitution for mineral nitrogen fertilizer on crop yield and soil fertility in a reduced nitrogen input regime. The study found that the highest yield was achieved under the 20% substitution ratio treatment, with 1.1% and 2.3% higher yield than chemical nitrogen alone in wheat and maize seasons, respectively. The highest nutrient recovery efficiency (REN) reached 31.2% and 26.1% at the 20%- 40% chicken manure substitution ratio in wheat season and 20%-40% in maize season, respectively. All organic substitution treatments increased soil organic matter and total nitrogen content. Implementing 20% organic substitution in wheat season and 20%-40% in maize season under the reduced nitrogen application regime is recommended.

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Sarkar (2022), conducted a study that explores the potential for sustainable organic farming in Nagaland, India, a state with over 47% of its population engaged in traditional farming. The study focuses on the benefits of state-induced organic farming methods and their effects on farmers. Nagaland has negligible use of inorganic supplements and has high potential to convert into an organic state without significant changes.

Adamu *et al.* (2023), evaluates and compares different regression algorithms to forecast the price of the most popular cryptocurrency, Bitcoin, using secondary historical Bitcoin data from Kaggle, which features an updated daily record of 24 variables over a seven-year period. The results show that one model performs better than the remaining competing models.

Adamu *et al.* (2021), applied univariate and multivariate models incorporating exogenous variables and selected the best-fitted model using the Akaike Information Criterion.

Duniya, and James (2023), conducted a study that aims to develop eco-friendly and cost-effective methods for converting agricultural plant residues into organic fertilizer for maize cultivation. The researchers developed three organic fertilizers (fertilizer A, B, and C) using a combination of residual dry plant biomass and calcium hydroxide, clay soil, and thiourea. Fertilizer C showed better nutrient release and faster decomposition of residual organic matter compared to NPK and manure. The study concluded that the treatment of agricultural plant residue determines its potential for soil fertility and amendment, but a more cost-effective approach is needed to increase nitrogen content and achieve a nutrient balance.

Harrison and Kedoneojo (2024), at Niger Delta University Teaching and Research Farm, Nigeria, examined the impact of various organic manure sources on soil chemical properties and maize growth. The study included three variants of poultry manure (broiler manure, layers poultry manure, point of lay poultry manure), swine manure (SW), and combined treatments of swine manure with each poultry manure variant. The results showed significant differences between experimental and control treatments, with notable effects on soil chemical properties. The SWPL treatment had the highest average values for pH, organic matter, calcium, magnesium, potassium, base saturation, and effective cation exchange capacity. The study recommends maximizing the use of these organic manure sources as alternatives for fertilizer application.

The historical legacy and effectiveness of organic manure in Nigerian agriculture highlight the need for policy support and investment in sustainable soil management practices. Government policies that promote organic farming provide incentives for organic manure production and facilitate access to organic inputs can help reduce maize importation dependency and enhance food security. Additionally, further research is needed to explore innovative approaches to organic manure production, application, and integration into modern agricultural systems.

In conclusion, organic manure offers a promising solution to the dual challenges of soil degradation and maize importation dependency in Nigeria. Drawing on indigenous knowledge and sustainable farming practices, organic manure can play a crucial role in restoring soil fertility, increasing maize yield, and advancing food self- sufficiency in the country. However, concerted efforts from policymakers, researchers, and farmers are essential to realize the full potential of organic manure in Nigerian agriculture.

METHODOLOGY

The analysis process is anchored on the Randomized complete block design of experiments (RCBD) and the analysis of variance (ANOVA) of the various yield of maize to the various quantities of treatments (organic manure) applied. A randomized complete block design was used because of the variability arising from a nuisance factor (soil types); with the introduction of blocking, the effect of the weeks measured is removed (i.e. this source of variability is controlled for, thus leading to greater accuracy).

Numerical values of the Randomized complete block design model parameters are estimated via the ordinary least squares (OLS) techniques, also facilitated by the use of Analysis of variance (ANOVA) table, tests of hypothesis and F-statistic at 0.05 level of significance and relevant degrees of freedom. These statistics enhance insight into the relationship or effects of the various quantities of organic (poultry) manure on the yield and growth of Maize crops. The RCBD does not only determine the main effect of contributions of each individual treatment but also identifies if there is a significant difference between the various quantities of organic (poultry) manure used in the experiment. The data for the research are unpublished secondary data extracted from the results of experiment performed in the Department of Crop Science, School of Agricultural Technology, Owerri. I, II and III are the soil types (sandy, clay and loamy) and the treatments are the various quantities of organic (poultry) manure from 0-15 tons/ha in 2.5 tons increments.

Model for the data.

The Statistical Linear Model for the Randomized complete block design (RCBD)is

given below as;

y = μ + + β + e {i = 1,2, … , a j = 1,2, … , b

$y$ij is the observed value of the ith treatment in the jth block, μ is the overall mean αi is ith treatment effect, βj = Effect in the jth block and $e$ij is Observational error associated with $y$ij where $e$ij ∼ (0, σ2).

Test for the Assumption

In order to make sure that the results from this study are not misleading or completely erroneous, the data collected for this study are subjected to tests for Normality using the Kolmogorov-Smirnov and Shapiro-Wilks test, and Homogeneity of variance using the chi-square and Levene's test respectively.

Test for the Normality

For a sample to satisfy the normality test, it must follow a normal distribution which implies that all the points will fall on the diagonal line. Hence a test is conducted using the Kolmogorov-Smirnov and Shapiro-Wilks test to test this assumption.

- Decision Rule

  Reject H_0 if the p-value is less than the level of significance

  Otherwise, we do not reject H_0; α = 0.05

Test for the Homogeneity of Variance (Levene's Test)

- Test of Hypothesis

  H_0: $\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma^2$

  H_1: $\sigma_1^2 \neq \sigma_2^2 \neq \sigma_3^2 \neq \sigma^2$

- Test Statistic

  $\chi^2_{cal} = \frac{2.3026Q}{h} \sim \chi^2_{k-1}$

  where,

  Q = (N – K)$\log_{10} S_p^2 - \sum_{i=1}^{k}(n_i - 1)\log_{10} S_1^2$

  $S_p^2 = MSE = \sum_{i=1}^{k}\left[\frac{(n_i-1)S_i^2}{N-K}\right]$

  N = $\sum_{i=1}^{k} n_i$ and

$$h = 1 + \frac{1}{3(k-1)}\left[\sum_{i=1}^{k}\frac{1}{n-1} - \frac{1}{N-K}\right]$$

$$\chi^2_{tab} = \chi^2_{k-1,\alpha}$$

- Decision Rule: Reject H_0 if $\chi^2_{cal} > \chi^2_{k-1,\alpha}$. Otherwise, we do not reject α = 0.05

Statistical Analysis of RCBD

Test of Hypothesis for both Treatment and Soil Types (Blocks)

For treatment (plot)

H_{0T}: $t_i = 0$; i = 1,2,3,4,5,6,7 that is there is no significant difference in the yield of maize at various quantities of organic (poultry) manure applied.

H_{1T}: For at least one $t_i \neq 0$; i = 1,2,3,4,5,6,7 that is significant difference in the yield of maize at various quantities of organic (poultry) manure applied.

For soil types (block)

H_{0B}: $b_j = 0$; i = 1, 2, 3 that is there is no significant difference in the yield of maize at various soil types.

H_{1B}: For at least one $b_j \neq 0$; j = 1, 2, 3 that is there is significant difference in the yield of maize at various soil types.

Level of Significance

α = 0.05

Test Statistic

$$F_{0T} = \frac{MS_{treatment}}{MS_{error}}$$

$$F_{0B} = \frac{MS_{block}}{MS_{error}}$$

Decision Rule

Reject H_{0T} if $F_{0T} > F_{\alpha,\, p-1,\, (p-1)(b-1)}$

Accept if otherwise.

Reject H_{0B} if $F_{0B} > F_{\alpha,\, b-1,\, (b-1)(p-1)}$

Accept if otherwise.

Computational Formulas

According to Montgomery (2012), the computational formulas used for this study are given below.

$$y_{i.} = \sum_{j=1}^{b} y_{ij} \qquad \bar{y}_{i.} = \frac{y_{i.}}{b}$$

$$y_{.j} = \sum_{i=1}^{p} y_{ij} \qquad \bar{y}_{.j} = \frac{y_{.j}}{p}$$

$$y_{..} = y_{.}\sum_{i=1}^{p}\sum_{j=1}^{b} y_{ij} \qquad \bar{y}_{..} = \frac{y_{..}}{N}$$

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Computing Sum of Squares

a) $SS_{Total} = \sum_{i=1}^{p}\sum_{j=1}^{b}(y_{ij} - \bar{y}_{..})^2 = \sum_{i=1}^{p}\sum_{j=1}^{b} y_{ij}^2 - \frac{y_{..}^2}{N}$

b) $SS_{Treatment} = b\sum_{i=1}^{p}(y_{i.} - \bar{y}_{..})^2 = \frac{1}{b}\sum_{i=1}^{p} y_{i.}^2 - \frac{y_{..}^2}{N}$

c) $SS_{Block} = p\sum_{j=1}^{b}(y_{.j} - \bar{y}_{..})^2 = \frac{1}{p}\sum_{j=1}^{b} y_{.j}^2 - \frac{y_{..}^2}{N}$

d) $SS_{Error} = SS_{TOTAL} - SS_{TREATMENT} - SS_{BLOCK}$

Computing Mean Sum of Squares

$MS_{treatment} = \frac{SST}{p-1}$

$MS_{block} = \frac{SSB}{b-1}$

$MS_{error} = \frac{SSE}{(p-1)(b-1)}$

DATA ANALYSIS & RESULTS

The data presented in the table below is an unpublished secondary data extracted from the result of experiment performed in the Department of Crop Science, School of Agricultural Technology, Owerri. I, II and III are the soil types (sandy, clay and loamy) and the treatments are the various quantities of organic (poultry) manure from 0-15 tons/ha in 2.5 tons increments.

The numbers inside the blocks are the Maize crop height yield in cm. The data would be used for the subsequent analysis in this study.

Table 3.1: Plant Height of Maize (Cm) at 4weeks after Planting

Plot	Treatment (ton/ha)	SOIL TYPES								
		I			II			III		
1	0	54.12	55.12	56.12	53.94	54.94	55.94	45.31	46.31	47.31
2	2.5	56	57	58	48.06	49.06	50.06	41.94	42.94	43.94
3	5	51.7	52.7	53.7	46.17	47.17	48.17	60.6	61.6	62.6
4	7.5	57.74	58.74	59.74	51.82	52.82	53.82	47.12	48.12	49.12
5	10	65.52	66.52	67.52	55.14	56.14	57.14	53.58	54.58	55.58
6	12.5	63.94	64.94	65.94	57.2	58.2	59.2	55.96	56.96	57.96
7	15	57.2	58.2	59.2	57.48	58.48	59.48	57.38	58.38	59.38

Table 3.2: Testing for Assumption Normality Table

Tests of Normality							
	SOIL TYPE	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
HEIGHT OF	Sandy	.156	21	.198	.923	21	.101

MAIZE	Clay	.138	21	.200*	.920	21	.087
	Loamy	.144	21	.200*	.926	21	.114

Conclusion: Since, p-value is greater than level of significance, we do not reject H_0 and conclude that the yield of maize (plant height cm) in the three blocks follows a normal distribution.

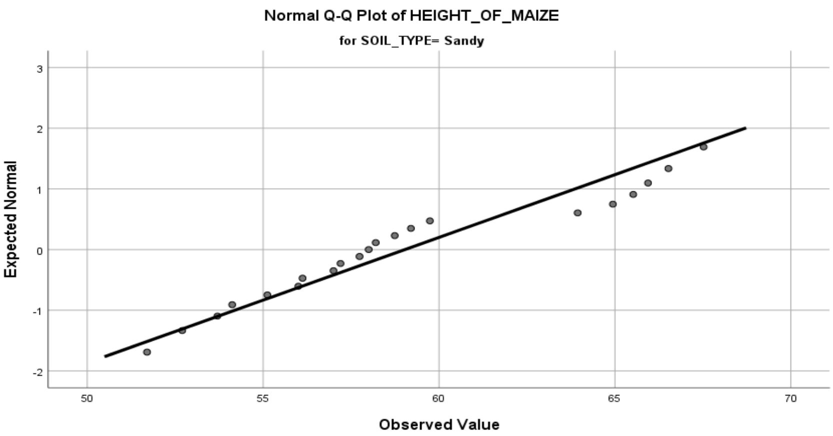

Figure 3.1 Normal Q-Q Plot of Height of Maize for Soil Type = Sandy

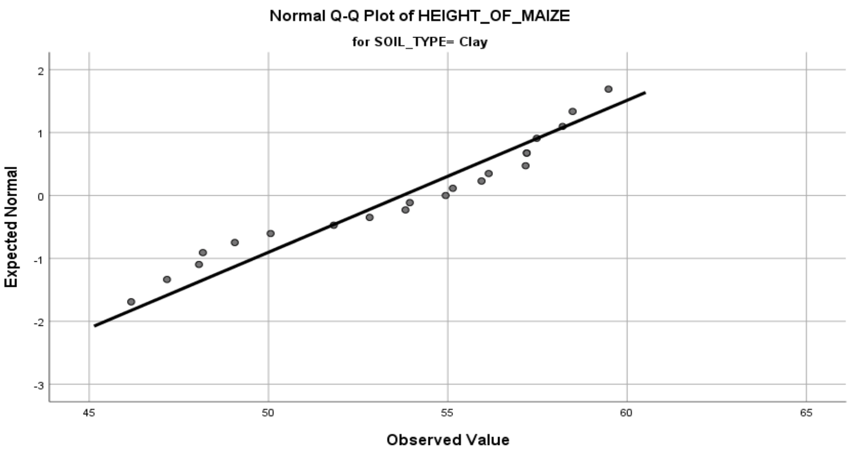

Figure 3.2 Normal Q-Q Plot of Height of Maize for Soil Type = Clay

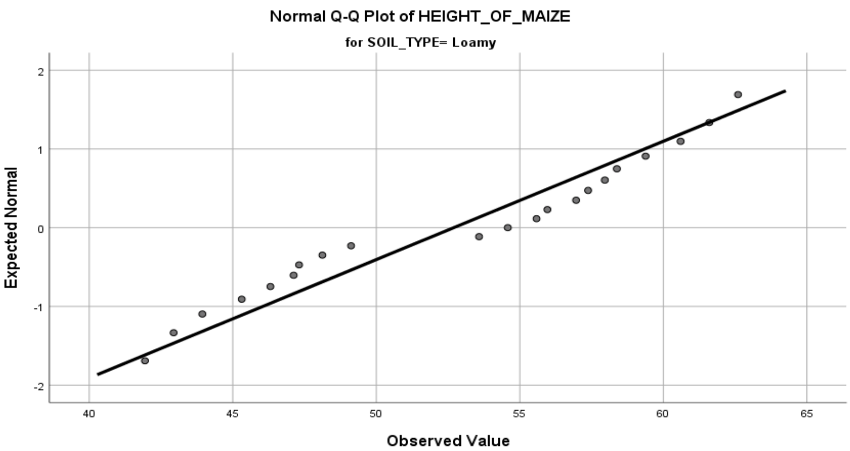

Figure 3.3 Normal Q-Q Plot of Height of Maize for Soil Type = Loamy

From the above graphs, since all the points fall on the diagonal, we conclude that the normality test has been satisfied.

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Table 3.5 Homogeneity Table

Levene's Test of Equality of Error Variances[a,b]					
		Levene Statistic	df1	df2	Sig.
HEIGHT OF MAIZE	Based on Mean	.022	20	42	1.000
	Based on Median	.048	20	42	1.000
	Based on Median and with adjusted df	.048	20	41.998	1.000
	Based on trimmed mean	.024	20	42	1.000

From the above table, since the p-value is greater than level of significance, we do not reject the null hypothesis and conclude that the error variance of the dependent variable is equal across groups.

Table 3.6: The Between-Subjects Factors of a Study that Examines the Height of Maize Plants.

		Value Label	N
SOIL TYPE	1	Sandy	21
	2	Clay	21
	3	Loamy	21
MANURE QUANTITIES	1.0	Control	9
	2.0	2.5	9
	3.0	5.0	9
	4.0	7.5	9
	5.0	10.0	9
	6.0	12.5	9
	7.0	15.0	9

This table represents the between-subjects factors of a study that examines the height of maize plants. The factors include different soil types and various quantities of manure applied.

The design involves 3 different soil types and 7 different manure quantities, with each combination of soil type and manure quantity being observed and the design is balanced as each soil type and each manure quantity has an equal number of observations (21 for each soil type and 9 for each manure quantity).

This study likely aims to analyze the effects of different soil types and varying manure quantities on the height of maize plants. The balanced number of observations across categories allows for robust statistical comparisons and interactions between the two factors.

Table 3.7 Tests of Between-Subjects Effects for the Dependent Variable "HEIGHT OF MAIZE" from an ANOVA Analysis.

Tests of Between-Subjects Effects						
Dependent Variable: HEIGHT OF MAIZE						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2139.104[a]	20	106.955	110.298	.000	.981

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Intercept	191653.421	1	191653.421	197642.620	.000	1.000
SOIL_TYPE	484.549	2	242.274	249.846	.000	.922
MANURE	829.306	6	138.218	142.537	.000	.953
SOIL_TYPE * MANURE	825.249	12	68.771	70.920	.000	.953
Error	40.727	42	.970			
Total	193833.252	63				
Corrected Total	2179.831	62				
a. R Squared = .981 (Adjusted R Squared = .972)						

From table 4.7 the model explains 98.1% of the variance in maize height (R Squared = .981, Adjusted R Squared = .972) and both soil type and manure quantity have significant effects on the height of maize.

The interaction between soil type and manure quantity is also significant, indicating that the effect of manure on maize height varies depending on the soil type. The low error variance indicates a good fit of the model to the data.

Table 3.8: Post-hoc Test for comparing the mean heights of maize grown in three different soil types: Sandy, Clay, and Loamy.

Multiple Comparisons						
Dependent Variable: HEIGHT OF MAIZE						
Tukey HSD						
(I) SOIL TYPE	(J) SOIL TYPE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sandy	Clay	5.2952*	.30389	.000	4.5569	6.0335
	Loamy	6.3329*	.30389	.000	5.5945	7.0712
Clay	Sandy	-5.2952*	.30389	.000	-6.0335	-4.5569
	Loamy	1.0376*	.30389	.004	.2993	1.7759
Loamy	Sandy	-6.3329*	.30389	.000	-7.0712	-5.5945
	Clay	-1.0376*	.30389	.004	-1.7759	-.2993
Based on observed means. The error term is Mean Square (Error) = .970.						
*. The mean difference is significant at the .05 level.						

The table presents the results of a Tukey HSD (Honestly Significant Difference) test for comparing the mean heights of maize grown in three different soil types: Sandy, Clay, and Loamy. This test is used to determine if there are significant differences between the means of the groups.

Maize grown in sandy soil is significantly taller than maize grown in both clay and loamy soils.

Maize grown in clay soil is significantly taller than maize grown in loamy soil but shorter than maize grown in sandy soil.

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All comparisons are statistically significant at the 0.05 level, as indicated by the p-values being less than 0.05.

Table 3.9: Post Hoc Test Comparing the Mean Heights of Maize Plants across Different Soil Types

HEIGHT OF MAIZE				
Tukey HSD[a,b]				
SOIL TYPE	N	Subset		
		1	2	3
Loamy	21	52.6986		
Clay	21		53.7362	
Sandy	21			59.0314
Sig.		1.000	1.000	1.000
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .970.				
a. Uses Harmonic Mean Sample Size = 21.000.				
b. Alpha = .05.				

The height of maize varies significantly across different soil types.

Maize grown in sandy soil has the highest mean height (59.0314), followed by clay soil (53.7362), and the lowest mean height is in loamy soil (52.6986).

Each soil type falls into a distinct subset, indicating significant differences in maize height between each pair of soil types.

Table 3.1.1: Post Hoc Test Comparing the Mean Heights of Maize Plants across Different Manure Quantities

Multiple Comparisons						
Dependent Variable: HEIGHT_OF_MAIZE						
Tukey HSD						
(I) MANURE QUANTITIES	(J) MANURE QUANTITIES	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	2.5	2.4567*	.46421	.000	1.0197	3.8936
	5.0	-1.7000*	.46421	.011	-3.1370	-.2630
	7.5	-1.1033	.46421	.234	-2.5403	.3336
	10.0	-6.9600*	.46421	.000	-8.3970	-5.5230
	12.5	-7.6878*	.46421	.000	-9.1248	-6.2508
	15.0	-6.2300*	.46421	.000	-7.6670	-4.7930
2.5	Control	-2.4567*	.46421	.000	-3.8936	-1.0197
	5.0	-4.1567*	.46421	.000	-5.5936	-2.7197

	7.5	-3.5600*	.46421	.000	-4.9970	-2.1230
	10.0	-9.4167*	.46421	.000	-10.8536	-7.9797
	12.5	-10.1444*	.46421	.000	-11.5814	-8.7075
	15.0	-8.6867*	.46421	.000	-10.1236	-7.2497
5.0	Control	1.7000*	.46421	.011	.2630	3.1370
	2.5	4.1567*	.46421	.000	2.7197	5.5936
	7.5	.5967	.46421	.855	-.8403	2.0336
	10.0	-5.2600*	.46421	.000	-6.6970	-3.8230
	12.5	-5.9878*	.46421	.000	-7.4248	-4.5508
	15.0	-4.5300*	.46421	.000	-5.9670	-3.0930
7.5	Control	1.1033	.46421	.234	-.3336	2.5403
	2.5	3.5600*	.46421	.000	2.1230	4.9970
	5.0	-.5967	.46421	.855	-2.0336	.8403
	10.0	-5.8567*	.46421	.000	-7.2936	-4.4197
	12.5	-6.5844*	.46421	.000	-8.0214	-5.1475
	15.0	-5.1267*	.46421	.000	-6.5636	-3.6897
10.0	Control	6.9600*	.46421	.000	5.5230	8.3970
	2.5	9.4167*	.46421	.000	7.9797	10.8536
	5.0	5.2600*	.46421	.000	3.8230	6.6970
	7.5	5.8567*	.46421	.000	4.4197	7.2936
	12.5	-.7278	.46421	.703	-2.1648	.7092
	15.0	.7300	.46421	.700	-.7070	2.1670
12.5	Control	7.6878*	.46421	.000	6.2508	9.1248
	2.5	10.1444*	.46421	.000	8.7075	11.5814
	5.0	5.9878*	.46421	.000	4.5508	7.4248
	7.5	6.5844*	.46421	.000	5.1475	8.0214
	10.0	.7278	.46421	.703	-.7092	2.1648
	15.0	1.4578*	.46421	.045	.0208	2.8948
15.0	Control	6.2300*	.46421	.000	4.7930	7.6670
	2.5	8.6867*	.46421	.000	7.2497	10.1236
	5.0	4.5300*	.46421	.000	3.0930	5.9670
	7.5	5.1267*	.46421	.000	3.6897	6.5636
	10.0	-.7300	.46421	.700	-2.1670	.7070
	12.5	-1.4578*	.46421	.045	-2.8948	-.0208

Based on observed means.

The error term is Mean Square (Error) = .970.

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

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The study reveals significant differences in maize height based on various manure quantities. Maize height increases with 2.5 tons, while decreases with 5.0, 10.0, 12.5, and 15.0 ton. The results show that 5.0 tons show significant increases but decreases with 10.0, 12.5, and 15.0 tons. The results also show significant increases with 10.0 tons but not significantly different from 12.5 and 15.0 tons. The results suggest that maize height can be affected by various manure quantities.

Therefore, the quantity of manure has a significant effect on the height of maize plants, with specific differences observed between various levels of manure application.

Table 4.12: Post Hoc Test for the Height of Maize across Different Manure Quantities.

HEIGHT_OF_MAIZE						
Tukey HSD[a,b]						
MANURE QUANTITIES	N	Subset				
		1	2	3	4	5
2.5	9	49.6667				
Control	9		52.1233			
7.5	9		53.2267	53.2267		
5.0	9			53.8233		
15.0	9				58.3533	
10.0	9				59.0833	59.0833
12.5	9					59.8111
Sig.		1.000	.234	.855	.700	.703
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = .970.						
a. Uses Harmonic Mean Sample Size = 9.000.						
b. Alpha = .05.						

This table presents the results of a Tukey HSD (Honestly Significant Difference) post hoc test for the height of maize across different manure quantities. It includes homogeneous subsets of manure quantities based on mean heights. The Tukey HSD test indicates clear differences in maize height based on manure quantities, with significant increases in height as the quantity of manure increases, particularly from 10.0 tons and above. Therefore, farmers are advised to plant their maize crop using 10 tons of manure seeing that it is very efficient and does not have much difference with 12.5 ton and will quite cheaper that 12.5 tons.

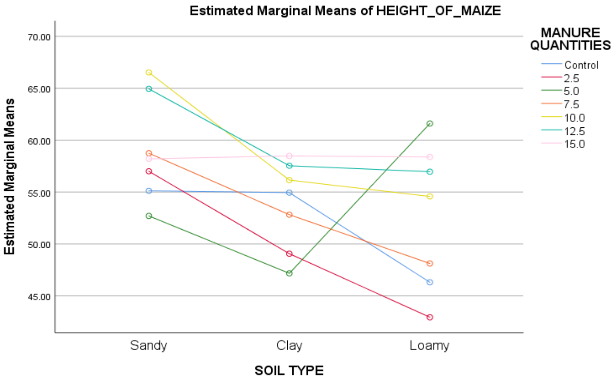

Figure 3.4 Estimated Marginal Means of HEIGHT OF MAIZE

Figure 3.4: The estimated marginal means of the height of maize for different combinations of soil types and manure quantities.

The graph illustrates how the height of maize is influenced by the combination of soil type and manure quantity. Optimal maize height is generally achieved with higher manure quantities, but the specific response varies by soil type, with some anomalies such as a decrease in height at the highest manure level (15.0 tons) in certain soils. Therefore, the best soil and best manure quantity is sandy soil with 12 tons of manure following loamy soil with 5.0 tons of manure and lastly clay soil with 15.0 tons of manure.

CONCLUSION AND RECOMMENDATIONS

Conclusion

In conclusion, based on the analysis conducted to determine if maize crop yield varied significantly when treated with different quantities of organic manure, results indicated a significant effect of the different manure quantities on maize yield. This suggests that, to optimize maize production in Nigeria across various soil types, farmers, producers, and entrepreneurs should note that the most effective soil and manure combination is sandy soil with 12 tons of manure, followed by loamy soil with 5 tons of manure, and clay soil with 15 tons of manure.

Recommendation

This research highlighted maize as an agro-economic plant with diverse uses, which, if utilized effectively, could positively impact Nigeria's economy. We recommend that the government implement policies to educate farmers, producers, and entrepreneurs about maize farming. Providing loans to farmers, producers, and entrepreneurs would further encourage maize production. Additionally, ensuring that organic manure is readily available particularly to local farmers—would support improved crop yield. The findings demonstrate that applying organic manure in the right quantities on suitable soil types is essential for maximizing production, which, in turn, would contribute to the growth of Nigeria's economy.

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