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Research Paper

Estimating Productivity of Sesame using Inorganic Fertilizer in Randomised Complete Block Experimental Design in Kontagora Local Government Area, Niger State, Nigeria.

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Abstract
The focus of this study started by highlighting the role of crop production sub-sector in the economy particularly oil crops and their contributions to the oil extraction industry and the export market in Nigeria. The study was specifically on the productivity of Sesame with the use of inorganic fertilizer in the experimental trial. Randomised complete block design (RBD) was used as a means to help local control through blocking. The experimental design consist of four replications and five treatments. This enhanced precision and accuracy by randomization through replication of experimental materials used in the design. The inorganic fertilizer and the seed were divided in the blocks according to replications as homogeneous experimental materials. Sesame was harvested and mean values in the treatments were calculated and subjected to data analysis of the variance ratio known as analysis of variance (ANOVA) or F-test statistics. The critical difference (CD) was used as a modified t-test of significance of the experimental trial. The computation of the F-test as a variance ratio of the treatment mean square (TMS) to the error mean square (EMS) was 4.147^{**} *at* $\alpha_{0.05}$ *with*$12df$*. This shows that the use of inorganic fertilizer to estimate the productivity of Sesame was significantly different. Also, the CD test showed that the t-ratio was* 7.895^{**} *at* $\alpha_{0.05}$ *with* $12df$ *indicating that the treatments differ significantly. Hence, the null hypothesis was rejected. Therefore, the response of sesame to inorganic fertilizer application was significant and satisfactory. Based on this, it was recommended that policies should be geared towards adoption and utilization of inorganic fertilizer in sesame production. Also, agricultural extension work should be intensified in disseminating the technology of inorganic fertilizer application among sesame farmers. On the whole, there should be prompt and timely release of fertilizer and other production inputs through articulated inputs delivery network system in the agro-services centers of the agricultural development projects located in the ministry of agriculture and natural resources.*

***KEY WORDS:* Sesame, Productivity, Inorganic fertilizer, RBD, ANOVA, Critical difference, t-test.**

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I. INTRODUCTION

1.1 The Place of Agriculture and Current Status of Sesame Production and Marketing Trends in Nigeria

The agriculture sector has been versatile in the process of economic growth and development in Nigeria since independence when the country attained its independence. It has been playing significant roles in providing food, income and livelihood, raw material, foreign exchange through export and serving as a basis for rural and economic development. This view was substantiated by Eyo (2008) that the Nigerian economy depends on funds generated from agricultural export expansion for the development of other sectors of the economy. Due to its important role on national building, the agricultural sector has continued to be a target of government policies overtime.

Furthermore, Jimaza and Sanni(2003) asserted that, in the context of the Nigerian economy, agriculture is tied to the various sectors and is essentially for generating broad-based growth and development. Agriculture is therefore fundamental to the sustenance of life and has become the bedrock of economic development as it still account for significant share in gross domestic product (GDP), total export and employing the bulk of total labor force. In the same vein, Ega(2008) was of the opinion that agriculture provides about 90% of the nation's total food requirements and merits priority attention from policy makers not only because of its economic significance but also because of its importance in the war against hunger, poverty and its significance in rural development.

With respect to the above, it is pertinent to say that the crop production sub-sector have been playing significant roles in rural growth and agricultural development in Nigeria. This derived its legitimacy from the premise of studying sesame as oil and export crop and its current profile in the Nigerian economy. Sesame, *Sesamumindicum* is predominantly an oil crop used for domestic purpose and exporting the marketable surplus to earn foreign exchange in the country. In this regard, most oil crops in the crop production sub-sector of the economy have been playing meaningful roles through their contribution to the gross domestic product (GDP) of the economy. Indeed, some of the oil crops such as oil palm, groundnuts and soya beans, Sesame have taken remarkable status in the domestic trade, export market and the oil extraction industry in Nigeria. Chemonics (2002), substantiated that sesame is an important crop to Nigerian agriculture, it is quite extensively cultivated, it yields in relatively poor climatic conditions and it is widely used within Nigeria's agricultural exports.However, it is given little attention and there are relatively few components involved in the trade. As a small-holder crop, it is often intercropped with others, the extent of cultivation is poorly known and there is little information on yields or productivity. For the most part, the surplus crop is commercialised, bulked up and exported with minimal processing limited to drying and cleaning.

According to Chemonics (2002), Sesame production in Nigeria probably began in the middle belt region of the country and later spread out between latitude 6^0 and 10^0N. Sesame is commonly grown and produced by smaller-holder farmers. The major producing areas in order of priority are Nasarawa, Jigawa, Benue and Niger states. Other important areas of production are found in Yobe, Kano, Kastina, Kogi, Gombe and Plateau states. Harvesting begins in the late December and continues through July of the preceding year. Each producing area has only one cropping season for the production of sesame. Several varieties of sesame are cultivated in Nigeria. Large-scale commercial production of sesame is limited in Nigeria and there are no accurate records of national production. As predominantly small-holder production, the crop is commercialised by buyers or middlemen who tour rural areas buying from farmers. The sesame is transported to larger towns bulked in store and sold to the agents of major exporters. The major buying centresare urban markets in the states where sesame is predominantly cultivated. In terms of pricing, prices increase through the season. About 60-70% of sesame produced in Nigeria is exported to major consuming countries. Without commercial scale oil extraction, only the seed is exported from Nigeria.

The Nigerian sesame export profile between 1996 – 2001 indicated that total exports have been on the increase over the quoted years ranging between 11,976 tonnes to 37,381 tonnes (EID, 2001). Relative to other vegetable oils, the trade in sesame oil is quite minor in quantity but high in value. EID (2001), statistics revealed that production has been fluctuating in various time periods between 2002 and 2015. Also, sesame production in Nigeria increased from 32,000 tonnes in 1971 to 490,000 tonnes in 2020 growing at an average annual rate of 10.51%. The total cropped area had increased to 621,413 ha in 2020with a corresponding yield of 7,885kg/Ha in the same year. Currently Nigeria is 3rd largest producer of sesame in the world and 1st in Africa. (2020, https://www.tridge.com.) (2021, https://nepc.gov.ng.nigeria-product.)

According to the NEPC (2021), Nigeria is among the top global producer and exporter of sesame. Also, NBS (2020), said the crop tops Nigerian agricultural export amid COVID-19 pandemic. The data from the (NBS) shows that it was the most exported agricultural commodity in the first quarter of 2018. Furthermore, sesame seed is the leading agricultural product export in 2020 which was valued at ₦ 55billion. It is also responsible for 4.64% of the total traded agricultural products which was valued at ₦588billion, (http:msmetoday.com, 2021).

1.2 Problem Statement

The phenomenon economics of downward trend in the Nigerian agricultural sector and the crop production sub-sector has been a matter of focus in Nigeria. This had caused great concern among researchers, agricultural administrators and policy makers in the sector. The sesame production industry as a sub-sector of the crop production sector had experienced similar fluctuation, over the years (CBN, 2011). This was glaring through its continuous fall in its level of output at various time period, which has undermined its ability to earn the desired foreign exchange through export, supply sesame seed cake as dessert,oil extraction industry and meet food requirements of the teeming population.

In fact, the sesame production industry as a crop production sector have not met the demand for the required food and raw materials needed. The raw materials and research development council (RMRDC, 2004) reported a gap in the demand and supply of this crop at various time periods. The phenomenon of fluctuation in the productivity of sesame must have been closely attributed to the characteristics of most traditional farmers. This is in terms of low productivity of resources such as labor, fertilizer, soil and climate among small-holder sesame farmers. The low level of allocation and utilization of such resources particularly soil, soil fertility level and fertilizer application might have contributed to sesame low yield in most traditional farms.

It is in this regard that productivity of sesame using inorganic fertilizer trials was demonstrated so as to validate and establish that sesame can be responsive as a versatile oil crop contributing substantially to the economy of the country. It is presumed that some of the factors attributed to its productivity are associated with the production techniques and other cultural practices used in input allocation and utilization among small-holder sesame farmers. It is in accordance with this, that sesame was choosen in this study to substantiate its productivity using inorganic fertilizer as frequently practiced and adopted by most traditional farmers producing the crop in Nigeria.

Based on this credence, the study aimed at demonstrating the use of inorganic fertilizer in estimating the productivity of sesame so as to ascertain and unveil the basis of its contribution in the process of economic growth and development. Hence, the following research question and objective were addressed by the study and subsequently an appropriate hypothesis was postulated, tested and logical inferences were made concerning the study.

1.3 Research Question

What is the level of productivity of sesame using inorganic fertilizer in the study area?

1.4 Research Objective

The specific objectives is to estimate the productivity of sesame using inorganic fertilizer in the study area.

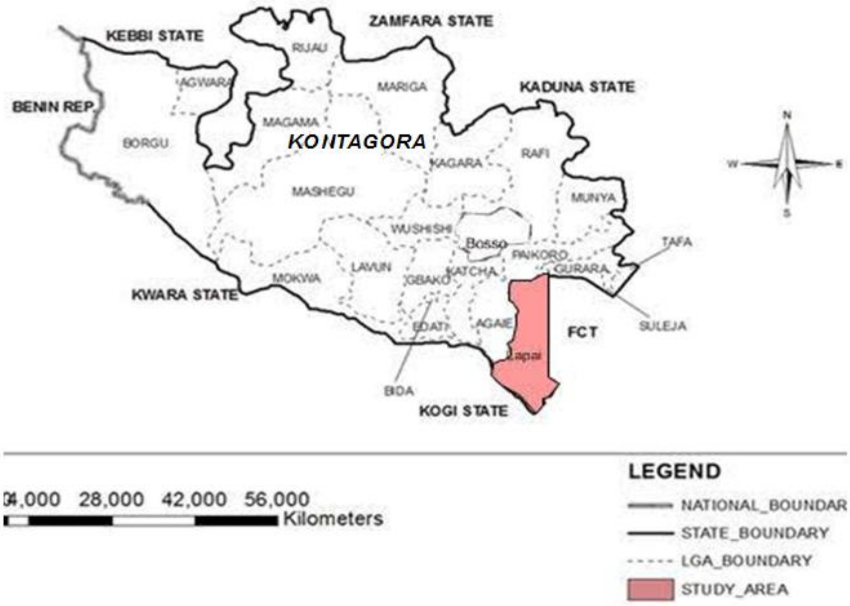
1.5 Research Hypothesis (Ho_1)

"There is no significant difference in the productivity of sesame using inorganic fertilizer in the study area"

Hypothesis is described essentially as a tentative statement or a postulate which states the expected possible relationship between variables by being cojective on the direction of research findings. Hypothesis make possible explanation of what the study is attempting to find out and validate. According to Rasaq and Ajayi, (2000) hypothesis is a good instrument for testing the validity and reliability of the research findings as it is often claimed that the most important characteristics of a good hypothesis is testability.

II. METHODOLOGY

2.1 Study Area – Kontagora LGA



Source: Google Map 2019

The field experiment was conducted at the orchard of Research Farm of the department of Agricultural Education, Federal College of Education, Kontagora. Niger State. Kontagora is located at an elevation of 335 meters above sea level and has a population of 98,754. Its coordinates are 10°24'1" N and 5°28'11" E in DMS (Degrees Minutes Seconds) or 10.4003 and 5.46972 (in decimal degrees). Its UTM position is GM 75 and its Joint Operation Graphics reference is NC 31-08.

Source: National Population Commission of Nigeria (web), NationalBureau of Statistics (web) 2019

2.2 **Site Selection, Land Preparation and Experimental Design**

Based on recommended practices for sesame production, it is adaptable to many types of soil of various texture that is well-drained. The most desirable is any soil that is fertile and loamy textured. The site that was selected was in conformity with the recommended flat and well-drained loamy soil. Hence, the experiment was conducted in the departmental demonstration farm at the lower plain of the of the school orchard. The stubbles of the left-over of the previous year were burnt minimally in order to protect the soil from destruction of some soil organisms and the essential soil mineral nutrients that are beneficial to sesame and improve its productivity.

The construction of beds were carried out on which to plant the sesame. The randomized complete block experimental design was used consisting of four replications and five treatments each measuring 1metre long and 1metre wide. This represents 1m^2 per block or replication used in the experimental trial giving rise to twenty replications as sample size or 20 data points used in data collection and analysis. Tillage operations were carried out ten days after clearing such as ploughing and preparation of beds as blocks or replications on which the seed were planted on the flat beds. This loosened the soil lumps into fine tilt and texture for proper germination and rooting of the growing seedlings. Hoes were used to further loosen the soil as the plots were sizeable, spacious as replications or blocks.

The planting date was towards mid-July since sesame is known not to tolerate heavy rainfall especially towards the maturity stage of the crop. The recommended seed rate of 2.5kg/acre was adhered to and used for planting. Drilling was done in order to sow the seed on the flat beds prepared block by block. This was helpful in carrying out other farm operations such as weeding, thinning and fertilizer application was allocated and applied randomly when the crop was about three weeks old from planting. The application of N.P.K as inorganic fertilizer derived its legitimacy from the premise of measuring productivity of Sesame in the study area. This forms the basis of the objective of this study.

Harvesting was done accordingly when the capsules were 50% yellow, mature physiologically and the moisture content of the capsules have reduced to enhance cutting the stem with sickle and properly bundled as pyramidal stakes block by block. This is to enhance measurement of the yield according to replication in the process of data collection and the mean values were calculated after harvesting. Harvesting by pulling the plant from the root was avoided in order to prevent contamination of seeds with sand, other adulterants such as weed seeds and enhance accurate measurement. The plants were tied with ropes into bundles group by group in accordance with the replications and were positioned in an erect form on tarpaulin so as to allow the capsules to be fully dried. This helps in preventing wastage of seeds and contamination by impurities thereby enhancing precision and accuracy in data collection and subsequently accurate data analysis.

2.4 Data Collection

In the randomized complete block design (RBD), the experimental materials used in the experimental trials were previously randomized and the treatments were allocated to block or replications. Subsequently, the result were collected and generated as data at harvest when the moisture content has reduced and crop was physiologically matured. The data that were collected were based on the yield per block or replication. Each harvest per block were weighed and the mean value recorded to give data points of 20. This is shown in the five treatment levels and four replicationsin the experimental trials presented in table 1. The data collected were subjected to data analysis using the model of analysis of variance (ANOVA) otherwise known F-test statistics or variance ratio and were further amenable and tractable to critical difference (CD)analysis or least significant difference(LSD)also known as modified t-test statistics.

Table 1: Sesame Yield in RBD Kg/plot

	Replication			
Treatment	I	II	II	IV
1	23	26	39	34
2	30	30	36	30
3	29	29	33	29
4	47	41	43	32
	29	21	21	32

III. DATA ANALYSIS

The data that were collected based on the result that emanated from each replication of experimental layout indicated above were subjected to analysis using the models that were described in the methodology.Indeed, the mean values were used as collected and computed from each replications, see table 2.In the analysis,F-test statistics also known as variance ratio or ANOVA and the critical difference (CD) or the least significant difference (LSD)which is a modified t-test statistics were used in order to test the null hypothesis. These inductive test statistics were used in the test of significance upon which appropriate statistical decisions were made concerning the stated null hypothesis (Ho_1) which were anchored on the result of data analysis.

Table 2: Mean Yield of Sesame

	Replication					
Treatment	I	II	II	IV	Total	Mean
1	23	26	39	34	122	30.5
2	30	30	36	30	126	31.5
3	29	29	33	29	120	30
4	47	41	43	32	163	40.5
5	29	21	21	32	103	25.7
Total		**158**	**147**	**172**	**157**	**634***

3.1 Theoretical Framework

The basic principle in most agricultural experiments involving experimental materials such as soils, fertilizers, seeds, herbicides, pesticides is that it should be as homogenous as possible. In some cases, the experimental materials are not as homogeneous as may be required. As a result, the method of local control is adopted and the experimental material is grouped into homogeneous sub-groups. The sub-group is therefore referred to as block. Since each block will consist the complete set of treatments, a block is technically referred to as replication. Therefore, the terms block and replication are used synonymously in case of complete block design.

In other words, the phenomenon of blocking helps the experimental material to be as homogenous as possible before randomly allocating the experimental materials to different experimental units. Hence, blocking and randomization enhance local control by reducing experimental error and increasing precision of the experiment.In the randomized complete block design (RBD), the experimental material is divided into "r blocks" and let there be "t treatments". Each block is then divided into "t units" and the treatments are allocated within a block at random. The resulting design practically called randomized complete block design is also known as randomized block design (RBD).

Principally, RBD has some advantages. The use of local control by grouping similar homogeneous experimental materials into groups or blocks which are randomly allocated to treatment units form the basis of merits in RBD. In this regard, sample are collected for statistical analysis which increases the precision of the experiment which is another merit of RBD. Also, blocking enhances replication which gives increased sample size in the experiment. The larger the sample size, the more accurate and efficient the result of analysis because the amount of information collected from RBD is larger and copious. RBD is quite flexible and tractable to any number of replications which can be included in it. As the number of homogenous units becomes larger, more units are available and more number of treatments can be included in the experimental design.On the other hand, increase in the number of treatment gives a corresponding increase in block size, the increase in block size makes it difficult to maintain homogeneity within blocks. The resultant effect of large block sizes is an increase in experimental error. As a result, the RBD may not be suitable and amenable for large number of treatments. Apart from this short fall, the RBD is a versatile design and it is most frequently used in agricultural experiments.

3.2 The Model

The analysis of variance (ANOVA) model for RBD is a linear relationship which is expressed as,

$$Yij = \mu + ti + rj + eij \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.$$

Where, μ = overall mean effect,

ti = the ith treatment effect,

rj = the jth replication effect, and

eij = the error term.

The total variance was then divided into three sources of variation namely; between treatments, between replications and the error term. The required sum of squares with respect to treatments, replications and error term were obtained as follows:

CF = $\frac{(GT)^2}{rt}$ −−−−−−−−−−−−−−−−−−−−−− 2 Where, CF = correction factor
GT = grand total
rt = product of number of replications and treatments.

$$Total\ SS = \sum Yj^2 - CF ----------------------- 3$$

$$Treatment\ SS = \frac{i}{r}\sum Ti^2 - CF -------------------4$$

$$Replication\ SS = \frac{i}{t}\sum Ri^2 - CF ------------------ 5$$

$$Error\ SS = Total\ SS - Replication\ SS - Treatment\ SS ------- 6$$

$$= \left(\Sigma Y_j^i - CF\right) - \left(\tfrac{1}{t}\Sigma Ri^2 - CF\right) - \left(\tfrac{1}{r}\Sigma Ti^2 - CF\right) -------------7$$

The above result was used to complete the analysis of variance (ANOVA) table. If F-test shows that there is no significant difference between replication, it is an indication that the RBD will not contribute to precision in detecting treatment effect differences. If the F-test statistics is significantly different between treatments, then we can use critical difference (CD) analytical technique to test the significance of any treatment contrast in order to make appropriate statistical decisions based on the test of significance. The critical difference (CD) is a modified t-test statistics.

3.3 The t-test statistics

The critical difference (CD) analysis also known as least significant difference (LSD) was used as a modified t-test statistics to validate the test of significance of treatment contrast and make statistical inference using the stated null hypothesis to arrive at a decision.

$$CD = t.SE(d) ------------------------ 8$$

Where, CD = critical difference
t = tabular value of t for a specified level of significance and error degrees of freedom.
SE(d) = standard error of difference.

But SE(d) = $\frac{\sqrt{2(EMS)}}{r}$ −−−−−−−−−−−−−−−−−−−−−−−−−−9

Where, EMS = error mean square
r = number of replications.

IV. RESULTS AND DISCUSSION

This result emanated from the analyzed data based on the data collected from the experimental trials. The correction factor (CF), total sum of square (TSS),replication sum of squares (RSS)and treatment sum of squares were estimated as 20097.8, 901.2, 63.40, 486.7 and 351.7 respectively.Also, the replication mean square (RMS) treatment mean square (TMS), and the error mean square (EMS) were 15.85, 121.1325 and 29.2583 with their corresponding degrees of freedom of 3,4 and 12 respectively. The total degree of freedom is 19.

Analysis of variance (ANOVA) which is also known as F-test statistics as a variance ratio or means comparison of the treatment mean square (TMS) to the error mean square (EMS) was estimated as 4.147 at $\alpha_{0.05}$ with 12df (degrees of freedom). This shows that the treatment using inorganic fertilizer to estimate the productivity of sesame in the randomized complete block (RBD) experimental design gave a result that is significantly different in the experimental trial when compared with the tabular value of the F-test.

Furthermore, the computation of the t-test test statistics was carried out using the critical difference (CD) analysis. The CD analysis is also known as the least significant difference (LSD) which is a variant of the adjusted t-test statistics to test the significance or otherwise of the experimental result of data analysis in order to arrive at an appropriate statistical decision. The tabular value of t for 0.05 at 12df is 2.179 while the calculated standard error of difference SE(D) was 3.6234. Therefore, the CD value is a product of the tabular value and calculated SE(D). Hence, the calculated CD value was 7.895 at $\alpha_{0.05}$ with 12df. The result shows that the treatment differs significantly. See table 3.

Table 3: Analysis of variance (ANOVA) table for sesame productivity

Source of variation	D	SS	MS	F-Test
Replication	3	63.40	15.85	<1
Treatment	4	486.70	121.1325	4.147**
Error	12	351.70	29.2583	

Total	**19**	**901.2**	

****P<0.05.**

Test of Hypothesis Concerning Productivity of Sesame

Test of hypothesis concerning the productivity of sesame in response to inorganic fertilizer application was carried out using the result of analysis based on the objective of the study. The null hypothesis stated is that; there is no significant difference in the productivity of sesame using inorganic fertilizer in the experimental trial. That is, $H_o: H_1 = X_i = 0$.

The result of the analysis shows that the estimated F-value of 4.147 was significantly different at $\alpha_{0.05}$ level of significance and 12df. Therefore, the null hypothesis was rejected. Also, the computation of critical difference (CD) analysis or a modified t-test statistics was used to further validate the significance of the test in the experiment. The table value of t-ratio for $\alpha_{0.05}$ at 12df is 2.179 while the calculated standard error of difference SE(D) was 3.6234. Hence, the CD value was 7.895 at 0.05 at 12df. The result indicates that the treatments differs significantly in the experimental trial. Hence, sesame responded to inorganic fertilizer application in increasing the level of productivity in the experimental test. Therefore, the null hypothesis stating that there is no significant difference in the productivity of sesame using inorganic fertilizer in the experimental trial is rejected. See table 4.

The above test is indeed a reflection of what is obtainable among most traditional small-holder sesame farmers who adopt some recommended technological packages such as fertilizer application to boost productivity of sesame. In accordance with this, there are some implications that can be deduced for production planning and investment in the sesame production industry. In most cases output levels from sesame production enterprises are relatively low which tend to discourage farmers when compared to the level of recommended output per-cropped area. In order to overcome this problem, farmers and the would-be sesame farmers need to plan their investments in sesame production by adopting improved recommended sesame production practices. Also, sufficient incentives in terms of inputs and output prices will encourage farmers to improve production while organised sesame markets are needed to absorb sesame produced by farmers in the country for local consumption and for export markets.

Table 4: Test of Hypothesis concerning productivity of sesame

Null Hypothesis	Critical Value	SE(D)	Calculated CD or LSD	decision
Yield function Yi = 0	2.179	-		
Xi = 0		3.6234	(2.179)(3.6234)	
Yi = Xi = 0		-	7.895	Reject Ho

****P<0.05**

Statistical hypothesis are quite useful when a researcher is to take statistical decision on any research hypothesis based on the stated research objective formulated. According to Rangaswanmy, (2010) when attempting to reach decision about the population, it is useful to make assumption or guesses about the population involved. When the assumption or statement about a phenomenon occurring under certain conditions is formulated as proposition it is called a scientific hypothesis. Once the hypothesis is postulated or formulated, it is expedient to make a decision on it either to accept or reject such statement of null hypothesis (HO). A statistical procedure by which a decision is made to accept or reject a statistical hypothesis is called testing of hypothesis.

V. RECOMMENDATIONS

The experimental trial in the study showed that productivity of sesame was significant with the application of inorganic fertilizer in the test. As a usual and common practice among small-holders sesame farmers, the result of the study can be recommended to farmers and the would-be sesame producers for adoption and utilization so as to improve on their level of productivities and the share or profit accruing to them in their sesame production enterprises. Based on this legitimacy, the following policy measures were proffered.

i. Government and stakeholders should formulate policy measure that is geared towards supporting the adoption and utilization of inorganic fertilizer application as a modern technological package in sesame production.

ii. The role and function of agricultural extension agents should be put in place by government and other agro-service agencies in disseminating technology associated with inorganic fertilizer application among sesame farmers.

iii. There should be prompt and timely release of fertilizer and other production inputs such as improved seed, herbicides, pesticides through articulated and organized input delivery network system by appropriate agro-service centers located in the agricultural development project of the ministry of agriculture and Natural Resources.

VI. CONCLUSION

The study started by highlighting the role of agriculture in the process of economic growth and development and the contribution of sesame as an oil crop, domestic trade, export market and the oil extraction industry in Nigeria. Inorganic fertilizer was used in the experimental trial to validate the productivity of the crop as a reflection of what is obtainable among small-holder sesame farmers. The experimental design used in the trial was randomized complete block design (RBD) from where data were collected and subsequently data analysis was carried out. The result of analysis of variance (ANOVA) or F-test and the critical difference (CD) analysis as a modified t-test statistics revealed that the response of sesame to inorganic fertilizer treatment was significant and satisfactory. This implies that sesame was productive using inorganic fertilizer treatment in the experiment. The result served as a basis for proffering some policy measures that will further help in the sustenance and improving the performance of sesame production among sesame farmers and enhance its productivity including the would-be sesame farmers in Nigeria.

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