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RESPONSE OF SESAME CROP (*SESAMUM INDICUM* L.) TO INTEGRATED NUTRIENT USE IN ANYIGBA, KOGI STATE NIGERIA.

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Abstract
This field experiment was conducted during the 2021 cropping season at the Prince Abubakar Audu University Research and Demonstration farm, Anyigba. The study investigated the comparative effect of Cow dung, Poultry manure and NPK fertilizer on the seed emergence, growth and yield of sesame. The research consisted of three main factors (Cow dung, Poultry manure and NPK fertilizer), fifteen (15) treatments in total with each factor consisting of five levels of application (0, 150, 300, 450, 600 kg/ha) respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD), with three (3) replications. Parameters measured include: Days to seedling emergence, plant height, number of leaves, number of branches, stem girth, number of capsules, fresh weight of capsules, dry weight of capsules and seed weight/plot. Growth and yield characters measured were significantly influenced by 300 kg/ha NPK fertilizer and 600 kg/ha of cow dung and 600 kg/ha poultry manure respectively. however, cow dung had no significant influence on number of capsule/plant. Highest seed yield was obtained at 600 kg/ha poultry manure and thus recommended. Alternatively, integrated use of 300kg/ha NPK + 600kg/ha PM will suffice for best performance given their complementary use.

Keywords*: Cow dung, Integrated Nutrient Use, NPK fertilizer, Poultry manure, Sesame.*

INTRODUCTION
Sesame (*sesame indicium L*) belongs to the family *Pedaliaceae*. The genus consists of about thirty-six species of which the most commonly recognized is *Sesame indicum* L popularly known as beniseed in Nigeria (Alegbejo *et al*., 2003). It is an erect, flowering annual plant which grows 50 cm to 250 cm tall or more, as determined by the soil or environmental conditions and varieties (Sharma, 2005). Sesame is usually propagated by seeds, it matures in 70 to 120 days after sowing, depending on the varieties (Indu and Savithri, 2003). Sesame originated from the tropical Africa where the greatest genetic

diversity exists but was believed to have been introduced to India at a very early date, where a secondary Centre of diversity is well developed (Alegbejo *et al*., 2003; Olaoye 2007). Its cultivation is now extended beyond the tropical and subtropical zones to temperate and sub temperate zones of the world (Ali *et al,* 2000; Boureima *et al*., 2007). Sesame utilization includes human consumption, health treatments, beautification, livestock feeding and industrial uses (Sharma, 2005; El- Habbasa *et al*., 2007).

Sesame is produced mainly in savanna agro- ecological zones of Nigeria by small holders' farmers on relatively poor soils with limited inputs, thereby resulting in low average yield. Among the traditional sesame growers in Nigeria (particularly in the north central part), fertilizer application has not been a common practice because it is considered as a minor crop and can do well even on poor soils (Haruna and Usman, 2005). However, nutrition studies in the tropics have shown that the crop perform well with the applications of organic and/or inorganic fertilizers (Olowe and Busari, 2000; Okpara *et al*, 2007) The growth and yield of Sesame when fertilizer is not applied are generally low, compared to the growth and yield when fertilizer is applied.

For instance, in Nigeria, the average yield of sesame obtained by farmers is 300 kg/ha compared to 1,960 kg/ha in Venezuela, 1,083 Kg/ha in Saudi Arabia, 517 kg/ha in Ivory Coast and 510 kg/ha in Ethiopia (Abubakar *et al*, 1998).

Manures such as cow dung and poultry manure are key fertilizers in organic and sustainable soil management. They contain many of the elements that are needed for plant growth and development. Apart from increasing soil fertility, manure serve as soil amendment by adding organic matter to the soil. Organic manure has also been reported to greatly improve water holding capacity, soil aeration, nutrient retention and microbial activity (Anonymous, 2007). Cow dung is an important source of nitrogen for crops. It helps farmers reduce inputs of commercial fertilizer, thereby increasing the profit margin of the farmers. Nutrients contained in cow dung are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Shama and Mittra, 1991) thus supporting better root, development, leading to high crop yields. NPK fertilizer application on the other hand is an important option that should be adopted in order to improve crop yields in most soils of the Northern parts of Nigeria and most parts of Africa because Nitrogen, Phosphorus and Potassium are among the limiting nutrients of the savanna soils. Adequate supply of Nitrogen is beneficial for carbohydrates and protein metabolism, promoting cell division and cell enlargement.

Today in Igala-land and by extension most part of Kogi State, little or no fertilizer have been implored in sesame production. However, Anyigba soil is generally constrained with limiting Nitrogen and therefore supplementary nutrient use can only help to improve crop yield. this being the case, integrated use of inorganic (NPK fertilizer) and/or Organic (poultry manure and cow dung) fertilizer will not only increase yield, but also reduce cost of production. The need to conduct performance evaluation on the aforementioned nutrient source to adduce a prescription on rates of application of these nutrients for optimum yield in this location, informed this research. Therefore, this

research seeks to investigate the comparative effect of organic (NPK fertilizer) and inorganic (poultry manure and cow dung) on the;

1. growth and growth attributes,
2. seed yield and yield attributes of sesame crop in Anyigba environment.

MATERIALS AND METHODS

This field study was conducted during the 2021 cropping season at the Prince Abubakar Audu University Research and Demonstration farm, Anyigba, Kogi State Nigeria. The State is situated on latitude 7° 29' N and longitude 7° 11' E on elevation of 420 m above sea-level. Anyigba which is located within the Southern Guinea Savannah Ecological Zone of Nigeria. It is characterized by an average rainfall of about 180 mm mostly distributed between the months of April and October. Mean monthly minimum and maximum temperature of about 17° C and 36.2° C respectively. The soils generally are sandy to sandy-loam. Temperature shows some variation throughout the years. Mean Monthly temperature varies between 15.1° C and 31.3° C. (Metrological Station Data, 2019). Soil sample from the experimental location was obtained using tubular auger, bulked and analyzed for its physio-chemical properties at the Soil and Environmental Management Laboratory, Prince Abubakar Audu University, Anyigba (results presented in table 1). N, P & K composition of cow dung and poultry manure used in the experiment was also analyzed and result presented in table 2.

Table 1. Physio-chemical Characteristics of the soil sample taken from the experimental site before the conduct of the experiment.

Soil characteristics	Depth (0 – 30cm)
Particle size fraction	
Sand (%)	85.0
Silt (%)	9.6
Clay (%)	4.4
Textured class	Sandy-loam
P^H (H_20)	5.3
Organic Matter (g/kg)	15.5
Total Nitrogen (g/kg)	0.87
Available P (mg/kg)	5.35
Exchangeable K (cmol/kg)	0.17
C.E.C (cmol/kg)	10.13

Table 2: N, P & K composition of cow dung and poultry manure used in the experiment

Chemical composition	Cow dung	Poultry manure
Nitrogen	1.56	1.98
Phosphorus	1.90	3.12

Potassium	1.06	1.11

Source: Soil and Environmental Management Laboratory, Faculty of Agriculture, Kogi State University, Anyigba.

Treatment and Experimental Design

The experiment consisted of a total of 15 treatments laid in a Randomized Complete Block Design (RCBD) with three replications. Treatments consisted of cow dung, poultry manure and NPK 15:15:15 fertilizer, each applied at varying rates; 0 $kgha^{-1}$, 150 $kgha^{-1}$, 300 $kgha^{-1}$, 450 $kgha^{-1}$, and 600 $kgha^{-1}$ respectively. Forty-five plots (15 x 3) were obtained in total, each measuring 3m x 4m ($12m^2$). Each plot was separated by 0.5 m discard row to minimize variation within replications. Each replication was also spaced 1.0 m apart to minimize inter replication variation. Treatments were assigned equally to every plot with a random number system to avoid biasness. Total land area used for the experiment measures 67.5m x 11.0m = $742.50m^2$ (0.0743ha). Sesame seeds (variety E-8) and NPK fertilizer were sourced from Kogi State Agricultural Development Project (ADP), Anyigba branch office. Cow dung and poultry manure was obtained from Kogi State University Livestock Teaching and Research Farm. Sowing was done on ridges of 75cm apart by means of seed drilling at rate of 5kg/ha and a depth of 1.5 cm as described by Bruno (2014). Cow dung and Poultry manure was incorporated into the soil and then left on the field to decompose into the soil for two weeks, before sowing the sesame seeds since they are slow in releasing nutrients to the soil, NPK fertilizer was applied to the plots at the time of sowing.

Cultural practices

Weed Control

Sesame grows slowly during the early stages of growth (first 3 weeks after emergence) and is not strongly competitive with weeds. Weeding shall be done manually by simple hand pulling at every point of weed appearance on every plots, while inter plot weeds and discard rows would be hoed.

Insect Pest and Disease Control

Mainly, sesame leaf damage insects, such as Heliothis caterpillars, *Helicoverpa punctigera* and *H. armigera* and green vegetable bug (*Nezara viridula*) are known to cause serious problems in Nigeria. Zero control measure has proven effective against termites and *Hilda partuelis* (Bruno 2014). Therefore, termite-free fields are effective for growing sesame. Hilda is commonly found at the edge of the field, so it would be controlled by clearing grass at the edges of the field. Aphids, thrips and other insect pests would be controlled with insecticide sprays (Imidacloprid 10% + Abamectin 1.8% WP mixture at 25 g/ha). Sesame is prone to root and stem diseases associated with waterlogging, while damping-off diseases can also occur if humidity is high. Field would be kept well drained to prevent damping-off diseases.

Data Collection and Analysis

Ten (10) plants per plot was tagged for data collection and all measurements taken were averaged. Data on the following characters was taken; germination count, plant height, number of leaves, stem girth, number of branches/plant, capsules/plant, fresh capsule weight/plant, dry capsule weight/plant and seed weight/plant.

Data collected were subjected to Analysis of Variance (ANOVA) as outlined by Steel and Torrie (1980). Separation of treatment means for significant effect was done using the fishers least significant difference (F-LSD) described by Obi (2001).

RESULTS AND DISCUSSION

Effect of Cow dung, Poultry manure and NKP Fertilizer on Growth characters of Sesame crop in Anyigba Environment.

Results obtained for application of CD, PM and NPK fertilizer on growth characters of sesame is presented in table 3.

There were significant differences in heights of plants when treated with CD, PM & NPK fertilizer. Application of 600, 450 & 300kgha^{-1} CD gave taller plants which are statistically at par to each other. Control plots and application of 150 kgha^{-1} gave shorter plants while behaving alike. Similarly, 600 & 450 kgha^{-1} PM gave taller plants in the same manner followed by application of 300 & 150 kgha^{-1} of PM. Control plots gave the shortest height of sesame.

Application of 300 kgha^{-1} of NPK fertilizer produced the tallest plants (305.3cm) followed by 450 & 150 kgha^{-1} NPK which are significantly not different from each other. However, application of 150 kgha^{-1} NPK produced shorter plants.

Application of 600 kgha^{-1} CD gave plants which higher leaf numbers, this was however not significantly different from number of leaves produced when 450 & 300 kgha^{-1} CD was applied. Similarly, leaf numbers produced when 0, 150 & 300 kgha^{-1} CD was applied are statistically the same. PM behaved the same way as CD application. However, 300 kgha^{-1} of NPK produced crops with the highest number of leaves followed by application of 150 & 450 kgha^{-1} NPK. 600 kgha^{-1} and control plots gave the least number of leaves which are statistically at par.

Application of 600 & 450 kgha^{-1} CD produced higher number of branches which are significantly not different from each other, control plots, 150 & 300 kgha^{-1} CD responded in the same manner as they gave the same number of branches. PM fertilization behaved in the same manner with application of CD. NPK influenced branch number significantly as application of 300 kgha^{-1} produced plants with the highest number of branches which is significantly different from other NPK application rates. this was followed by 150, 450 & 600 0 kgha^{-1} in that order. Control plots gave the lowest number of branches.

CD, PM and NPK Fertilizer significantly influenced ($P \leq 0.05$) the girth od sesame stems as presented in table 3. Application of 600 kgha^{-1} CD produced plants with thicker stems. However, this result was not significantly different from those obtained when 450 & 300

kgha^{-1} CD was applied. In the same manner, 450, 300 & 150 kgha^{-1} produced the same girth sizes of stems statistically. Control plots produced the thinnest stem girth.
Similarly, PM application behaved alike with CD application. 600 kgha^{-1} PM produced plants with thicker stems. This was statistically at par with those produced when 450 & 300 kgha^{-1} PM was used. Control plots also produced the thinnest stem girth.
Application of 300 kgha^{-1} NPK produced the thickest stem girth which was significantly different from other rates. 450 & 600 kgha^{-1} produced girths which are statistically the same. Also, control plots and application of 150 kgha^{-1} NPK gave the least girth sizes which are also at par to each other.

Table 3: Effect of CD, PM and NPK Fertilizer on growth characters of sesame crop in Anyigba environment.

Treatments (kgha^{-1})	**Weeks after sowing**			
	Plant height (cm)	Number of leaves/plant	Number of Branches/plant	Stem girth (cm)
CD				
0	218.85b	157.65c	110.0b	4.50c
150	238.15b	169.30bc	114.95b	4.63bc
300	252.2a	177.95abc	117.9b	4.85ab
450	259.75a	195.95ab	144.55a	4.90ab
600	273.30a	210.65a	153.7a	4.95a
F-LSD($_{0.05}$)	29.1	32.9	11.2	0.30
PM				
0	221.85c	157.75c	112.50b	4.50c
150	247.30b	179.65bc	120.80b	4.65bc
300	253.90b	188.65abc	127.90b	4.85abc
450	263.10ab	209.85ab	150.00a	4.95ab
600	279.05a	216.80a	163.30a	5.05a
F-LSD($_{0.05}$)	24.8	32.9	18.8	0.40
NPK				
0	221.85c	157.85d	111.90e	4.50c
150	268.45b	330.0b	234.10b	4.70c
300	305.30a	412.0a	289.50a	6.40a
450	273.35b	264.0c	190.40c	5.45b
600	230.55c	201.3cd	146.65d	5.35b
F-LSD($_{0.05}$)	29.0	64.0	18.2	0.25

Means with similar letter(s) in the column are not significantly different at probability level of 0.05

Table 4: Effect of CD, PM and NPK Fertilizer on yield characters of sesame crop in Anyigba environment.

	Yield Characters					
	Number of capsules/plant			Fresh capsule weight (g/plot)		
Treatments (kgha^{-1})	Fertilizers			Fertilizers		
	CD	PM	NPK	CD	PM	NPK
0	43.3	43.3b	43.3b	24.5b	24.5bc	24.5d
150	44.3	56.6a	76.6a	24.6b	25.8b	61.1b
300	46.6	58.3a	86.6a	27.2b	29.3ab	66.9a
450	48.3	60.0a	73.3a	27.8b	31.8a	45.6c
600	51.6	63.3a	48.3b	34.2a	35.0a	30.9d
LSD $_{(0.05)}$	ns	8.5	16.3	5.8	6.2	5.7
C.V (%)	27.63	17.06	28.25	25.32	24.06	25.96

Means with similar letter(s) in the column are not significantly different at probability level of 0.05

Table 4 shows the effect of CD, PM & NPK on the number of capsule/plant and fresh capsule weight of sesame crop in Anyigba environment. Cow dung application had no significant influence ($P \geq 0.05$) on capsules/plant. However, poultry manure and NPK fertilizer significantly influenced ($P \leq 0.05$) number of capsules produced per plant. Application of 600 kgha^{-1} of PM gave the highest number of capsules/plant (63.3), this was however not significantly different from those obtained when 450 kgha^{-1}, 300 kgha^{-1} and 150 kgha^{-1} of PM was applied. Control plots gave the least number of capsules (43.3).

Application of 300 kgha^{-1} of NPK gave the highest number of capsules/plant (86.6) this was however not significantly different from those obtained with 150 kgha^{-1} and 450 kgha^{-1} NPK application. Control plots and application of 600 kgha^{-1} of NPK gave the least number of capsules.

Similarly, CD, PM, & NPK significantly influenced fresh capsule weight of sesame crop in Anyigba environment (table 4).

Application of 600 kgha^{-1} of CD produced the highest weight of fresh capsule (34.2g), all other levels of application including the control pots are statistically at par.

Application of 600 kgha^{-1} PM also produced the highest capsule weight (35.0g). However, this result is not significantly different from those obtained when 300 kgha^{-1} and 450 kgha^{-1} PM was applied. Control plots and 150 kgha^{-1} PM gave the lowest fresh capsule weight (24.5g, 25.8g).

Alternatively, application 300 kgha^{-1} of NPK fertilizer produced the highest capsule weight (66.9g) which was significantly different from other application rates. this was

followed by 150 kgha^{-1} (61.1g), 450 kgha^{-1} (45.6g) in that order. However, control plots and 600 kgha^{-1} NPK application produced the least shoot weight (24.5g, 30.9g).

Table 5: Effect of CD, PM and NPK Fertilizer on yield characters of sesame crop in Anyigba environment.

	Yield characters					
	Dry weight of capsules (g/plot)			Seed Yield (g/plot)		
Treatments (kgha^{-1})	Fertilizers			Fertilizers		
	CD	PM	NPK	CD	PM	NPK
0	11.4d	11.4c	11.5c	6.5e	6.5c	6.5c
150	13.8c	14.8b	25.6b	7.1d	7.4c	13.6a
300	15.1bc	15.3ab	32.7a	7.6c	8.0bc	14.8a
450	15.4ab	16.3ab	24.1b	7.9b	9.8b	11.0b
600	16.9a	17.1a	14.3c	8.2a	16.6a	7.2c
LSD $_{(0.05)}$	1.5	2.05	5.8	0.3	0.41	2.1
C.V (%)	16.34	15.85	28.15	5.20	17.12	22.52

Means with similar letter(s) in the column are not significantly different at probability level of 0.05

Table 5 shows the effect of CD, PM & NPK on the dry capsule weight and seed yield of sesame crop in Anyigba environment. Application of 600 kgha^{-1} CD produced the highest dry weight of capsules (16.9g). this result was however not significantly different from those produced when 450 kgha^{-1} of CD was applied (15.4g). similarly, 300 kgha^{-1} and 150 kgha^{-1} of CD produced dry capsule weight that are statistically at par to each other. Control pots, gave the lowest dry capsule weight (11.4g).

Similarly, 600 kgha^{-1} PM gave the highest dry capsule weight (17.1g) which was statistically at par with those obtained when 450 kgha^{-1} and 300 kgha^{-1} PM was applied. Additionally, 150 kgha^{-1}, and 450 kgha^{-1} PM application produced weights that are statistically at par as control pots (0 kgha^{-1}) gave the least result (11.4g).

NPK fertilizer produced dry capsule weight higher than both organic fertilizers used. Application of 300 kgha^{-1} of NPK produced plants with the highest dry capsule weight (32.7g). This was followed by 150 kgha^{-1}, 450 kgha^{-1} and 600 kgha^{-1} in that order. Application of 150 kgha^{-1} and 450 kgha^{-1} gave capsule weight that are statistically at par. However, control plots and 600 kgha^{-1} gave the least yield.

Results obtained (table 5) showed that PM influenced the highest seed yield. application of 600 kgha^{-1} PM produced the highest seed yield (16.6g). this was significantly different from other PM application rates. application of 300 kgha^{-1} and 450 kgha^{-1} produced yield

that are not significantly different from each other. Similarly, seed yield obtained when 300 kgha^{-1}, 150 kgha^{-1} and 0 kgha^{-1} was applied are statistically at par.

CD applied at 600 kgha^{-1} gave the highest seed yield followed by 450 kgha^{-1}, 300 kgha^{-1}, 150 kgha^{-1} application rates in that order. control plots gave the least yield. similarly, NPK fertilizer applied at 300 kgha^{-1} gave the highest seed yield. however, this was not significantly different with those obtained with 150 kgha^{-1} NPK application. Application of 450 kgha^{-1} gave yield following 300 kgha^{-1} NPK application. 600 kgha^{-1} and control plots gave the least yield.

Significant increases recorded on both growth and yield characters of sesame crop shows that the crop performs well with the application of organic or inorganic fertilizers, this is in agreement with Olowe and Busari, (2000), Okpara *et al.,* (2007). Significant influence of organic (CD, PM) and inorganic (NPK) fertilizers on plant height, stem girth, number of branches and number of leaves has been reported Ojonugwa *et al,* (2022), Chukwu *et al.,* (2012), Agbede (2009). The influence of yield characters and yield on application of organic and inorganic characters has also been reported in many researches. Haruna & Aliyu (2012) reported that yield and economic returns of sesame were better with the applications of 5 t ha^{-1} of poultry manure, 60 kg ha^{-1} of Nitrogen. From this research, 600kg/plot of Poultry manure produced the highest seed yield. this is supported by Vaiyapuri *et al*. (2004).

All growth and yield characters measured responded best to 300kg/ha NPK fertilizer throughout the sampling periods of the experiment. However, these responses do not translate to seed yield. this is a clear indication that N released from inorganic fertilizer helps to improve organic matter decomposition and function in soil organic amendment which produced a better organic condition for highest seed yield (as evident by PM application) but NPK in its entirety only showcased this effort on growth and yield characters. This assertion is supported by Adeniyan and Ojeniyi (2003), Duhoon *et al.,* (22004), Hossain *et al.,* (2007) who asserted that lower rates of NPK could lead to incomplete organic matter decomposition resulting from enhanced soil micro-organisms as N release from component NPK fertilizer enhanced soil microbial activities thus increasing nutrient concentration of soil necessary for optimum yield. this is also supported by Jakusko and Usman (2013) who reported highest yield components in sesame from application of 300kg/ha NPK fertilizer in Northeastern Nigeria.

CONCLUSION

Organic fertilizer rates (CD & PM) and inorganic fertilizers (NPK) has proven effective in overall growth yield of sesame crop in Anyigba environment. Comparatively, growth and yield characters responded best to the application of 300kg/ha NPK which does not translate to final seed yield. alternatively, Poultry manure application at 600kg/ha gave the highest seed yield and thus recommended. For optimum growth seed yield, most literatures have recommended application of both organic and inorganic fertilizers due

to its complementary benefits as evident by this research. Therefore, application of 300kg/ha NPK + 600kg/ha PM will suffice for best performance.

AUTHOR CONTRIBUTIONS

This research was jointly conducted by all the authors mentioned in this manuscript. Authors Yusuf, M. and Akowe, I. I. designed this study, initiate the protocols and data interpretation. Author Yusuf, M. supervised and anchored the field work, obtained field data and performed preliminary data analysis. Authors Beida, A S., Iyaji, J., Abdulhakeem, S. & Alao, A. O. managed the literature searches and review to produce the initial draft. Final manuscript was read and approved by all the authors.

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REFERENCES

Abubakar, S. S., Onyibe, J. E & Tologbonshein, E. B. (1998). The role of extension, research and information dissemination in enhancing benniseed production and marketing for resources poor farmers. *Proceedings of the first workshop on Benniseed held at the National Cereal Research Institute, Baddegi, Nigeria*, March 3rd - 5th 1998. Pp 86- 89.

Adeniyan, O. N., & Ojeniyi, S. O. (2003). Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. *Moor Journal of Agricultural Research*,*4*(2), 191-197.

Agbede, O. O. (2009). *Understanding Soil and Plant Nutrition Salman.* Press & Co. Nig. Ltd. Keffi, Nigeria 260pp.

Alegbejo, M. D., Iwo, G. A., Abo, M. E & Idowu, A. A. (2003). *Sesame production Pamphlet*; A potential industrial and Export oil seed crop in Nigeria. 59-76pp

Ali, A., Kafikafi U., Yamaguchi L., Sugimoto, Y. & Inanga, S. (2000). Growth, transpiration, root - boron, cytokinins and gibberellins and nutrient compositional changes in sesame exposed to low root –zone temperature under different ratios of nitrate: Ammonium supply. *Journal of plant Nutrition* 23, 123-140.

Anonymous (2007). Effect of organic and inorganic nutrient sources on Soil Minerals Nitrogen and maize yields in Western Kenya. https://www.agnet.org

Boureima, S., Diout, M., Diop, T. A., Diatta, M., Leye, E. M., Ndiaye, F. & Seck, D. (2007). Effects of arbuscular mycorrhiza in Oculation on the growth and the development of sesame (*Sesame indicum* L.) *African Journal of Agricultural Research*, 3(3), 234 – 238.

Bruno, D. (2014). Farmer's guide for the production and post-harvest handling of sesame products in Nigeria in: *Expanding export of sesame seed and sheanut/butter through improved SPS capacity building for public and private sectors, A training Manual*. STDF Project 172 co-financed by NEPC and STDF, implemented by NEPC and supervised by ITC. Pp. 1 – 48.

Chukwu, L. I., Ano, A. O. & Asawalam, D. O. (2012). Effects of poultry manure and NPK fertilizer on soil properties and nutrient uptake of maize (*Zea mays* L.) plants growth in an Ultisol. Proceedings of the 36th Annual Conference of the Soil Science Society of Nigeria (SSSN) on 7th –11th March. University of Nigeria Nsukka.

Duhoon, S. S., Jyotishi, A., Deshmukh, M. R., & Singh, N. B. (2004, September). Optimization of sesame (*Sesamum indicum* L.) production through bio/natural inputs in: *Proceedings of the 4th International Crop Science Congress Brisbane, Australia* Vol. 26.

El-Habbasa, S. F., Abd-El-salam, M. S and Kabesh, M. O (2007). Response of two sesame varieties (Sesame indicum L.) to partial replace of chemical fertilizers by bio-organic fertilizer. *Research Journal of Agriculture and Biological Sciences,* 3(6), 563 – 571.

Haruna I. M & Usman, A. (2005) Agronomic practices that enhances increased yield and seed quality of sesame (*Sesamum indicum L.*) *A paper presented at the Agric. Transformation Day (Sesame and rice) organized by OLAM Nig. Ltd. Held at Agro Miller Ltd. Compound, Uni-Agric. Road, Makurdi,* 4th Feb; 2005.

Haruna I M. & Aliyu, L. (2012). Seed yield and economic returns of sesame (*Sesamum indicum* L.) as influenced by poultry manure, nitrogen and phosphorus fertilization at Samaru, Nigeria. *Revista Científica UDO Agrícola,* 12 (1), 152 - 156.

Hossain, M. A., Hamid, A., & Nasreen, S. (2007). Effect of nitrogen and phosphorus fertilizer on N/P uptake and yield performance of groundnut (*Arachis hypogaea* L.), *Journal of Agricultural Research (Pakistan)*.

Indu, K. P & Savithri, K. E. (2003). Effect of Bio-fertilizers vs perfected chemical fertilization for sesame grown in summer rice fallow. *Journal of Tropical Agriculture, Ibadan Nigeria. IITA Manual series*, No.7.

Jakusko, B. B., & Usman, B. D. (2013). Effects of NPK fertilizer and plant population density on productivity of sesame (Sesamum indicum L.), *Research Journal of Agricultural and Environmental Management*, *2*(5), 121-126.

Obi, I. U. (2001). *Introduction to factorial Experiments for Agricultural, Biological and Social Sciences Research.* 2nd ed. Nigeria: Optimal Int. Ltd. 45p

Ojonugwa, J. A., Musa, U.T., Yusuf, M. (2022). Influence of farm yard manure and N-levels on the growth, yield characters and yield of sesame (*Sesamum indicum* L.). *Journal of Innovative Agriculture, 9(1), 6 – 10. doi: 10.37446/jinagri/rsn/9.1.2022.6-10.*

Okpara, D. A, Maoneke, C. O and Ojikpong, T. O (2007). Effect of nitrogen and phosphorus fertilizers rates on the growth and yield of sesame (*Sesamum indicum* L.) in the southern eastern rainforest belt of Nigeria. *Nigeria Agricultural Journal* 38, 1 - 8. 45pp.

Olaoye, S. F. (2007). The Effects of Phosphorus Fertilizer Application on the Growth, seed yield and quality of sesame (*Sesamum indicum L.*) varieties. B. Tech, Ogbomoso P.47.

Olowe, V. I. O and Busari, 2000. Response of Sesame (*Sesamun indicum L*) to nitrogen and phosphorus application in southern guinea savanna of Nigeria. *Trop. Oil seeds Journal:30-37.*

Sharma, P.B. (2005). Fertilizer management in sesame (*Sesamum indicum L.*) based intercropping system in Tawab Command area. *Journal of Oil Seeds Research*, 22, 63 – 65.

Sharma, A. R. and Mittra, B. N. (1991) effect of different rates of application of organic and nitrogen fertilizer in a rice based cropping system. *Journal of agricultural Science*, 1991, 117, 313-318.

Steel, R. G. D., Torrie, J. H. (1997). *Principles and Procedures of Statistics*. McGraw Hill Book Co., NY. USA.

Vaiyapuri, V.A., Amudha, M. V., Sriramachandrasekharan & V. Imayavaramban. (2004). Effects of Sulphur levels and organic amendments on the growth and yield of sesame. *Advances in Plant Sciences* 17 (2), 681 – 685.