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Effects of Fertilizer Application on Growth, Yield and Nutritional Quality of Black Sesame (*Sesamum radiatum* Schum)

Olusola Olusegun James[1, *], Adejoro Solomon Alaba[2], Aiyelari O. Peter[2], Akinbuwa Olumakinde[3]

[1]Department of Crop Production Technology, Federal College of Agriculture, Ishiagu, Nigeria

[2]Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria

[3]Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Nigeria

Email address:

olusolaolusegun1@gmail.com (Olusola Olusegun James), makindeakinbuwa@gmail.com (Akinbuwa Olumakinde)

[*]Corresponding author

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Abstract: The experiment was conducted in Ibadan, Nigeria during 2020 and 2021 cropping season to determine the effects of fertilizer application on the growth, yield and nutritional quality of black sesame *(Sesamum radiatum* S.). The treatments were poultry manure at the rate of 4 t/ha, pig manure at the rate of 4 t/ha, NPK 20:10:10 fertilizer at the rate of 200 kg/ha, Super gro at the rate of 1 litre/ha and control (no fertilizer). The treatments were replicated three times in a randomized complete block design (RCBD). Data were collected on plant height, number of leaves from 4 – 6 weeks after planting (WAP). Leaf area, edible yield, marketable yield, total biomass and nutrient composition were determined at the termination of the experiment. The data collected were subjected to analysis of variance (ANOVA) and means were separated using Tukey at $p < 0.05$. The study showed that 4 t/ha of poultry manure and 4t/ha of pig manure significantly increased plant height and number of leaves of sesamum radiatum over other treatments. However, 200kg of NPK 20.10.10 and 4 t/ha of pig manure gave the highest in edible yield, marketable yield and total biomass at harvest. The nutrient content was investigated, the results showed that 4 t/ha of poultry manure, 4 t/ha of pig manure. 200kg of NPK 20.10.10 and 1 litre of super gro influence Black sesame, although they had differing effects on the nutrient composition. Poultry manure at the rate of 4 t/ha, pig manure at the rate of 4 t/ha, NPK 20:10:10 fertilizer at the rate of 200 kg/ha, Super gro at the rate of 1 litre/ha were recommended for production of *Sesamum radiatum.* The study proves that fertilizer application on low quality soil improved the soil physicochemical properties and also improved the nutritional quality of the crop.

Keywords: Fertilizer, *Sesamum radiatum*, Organic Fertilizer, Nutritional Quality

1. Introduction

Vegetables play an important role in the improvement of mankind's diet [1]. The most often consumed vegetables in Nigeria are *Amaranths spp* (Amaranths), *Talinum triangulare* (water leaf), *Telfaria occidentalis* (fluted pumpkin) *Corchorus olitorius* (Jews mallow), *Sesamum radiatum* (Black sesame) and *Celosia argentea* (Celosia).

Sesame (*Sesamum radiatum* Schum) locally known as Ninbolo (in Nupe), Karkashi (in Hausa), Eeku (in Yoruba) languages is a member of the Pedaliaceae family. It is an important vegetable consumed in Nigeria and many other parts of the tropics. The seed are called the black beniseed. *Sesamum radiatum* might have originated in Tropical Africa but uncertainty reigns [2]. It has long been cultivated and domesticated independently in India [2]. In many other places, *Sesamum radiatum* have been introduced and partly naturalized. It has been in the United States since the 1600s when African slave brought its seeds there [3]. Sesame is usually propagated by seeds directly on the field, through drilling and broadcasting on a well-prepared seedbed. Likewise, it can be raised in the nursery and the seedlings transplanted to a well-prepared seedbed [4]. The leaves of this

vegetable are arrange in opposite or alternate positions in the aerial part of the plant, and is grown in small quantity in rural areas [5, 6]. The fresh leaves and shoot of *sesamum radiatum* are finely cut, cooked and use for soups [7, 8]. It is one of the many neglected leafy vegetables of the tropics despite its nutritional contribution [5].

Nutritional analysis shows that most tropical green vegetables are much richer than the temperate types in terms of protein, vitamins and minerals [5]. In spite of their nutritional and medicinal benefits, the production and nutritional values of these vegetables are limited due to the low fertility of native soils in most parts of Nigeria [9].

Fertilizer application is an essential and important cultural operation for vegetable production and yield. The use of inorganic fertilizer can improve crop yield, soil pH, total nutrient content and availability, but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity [10]. One of the possible and options to reduce the use of chemical fertilizers is through the use of the readily available organic fertilizers [11]. Organic fertilizers release nutrients slowly, and steady. Likewise, it improves the soil fertility status by activating the soil microbial biomass [12, 13]. Organic agriculture practices aim to enhance biodiversity, biological cycles and soil biological activity to achieve optimal natural systems that are socially, ecologically and economically sustainable [14].

Sesamum radiatum as an underutilized species is yet to receive much research attention. The scanty information on this nutrient rich vegetable is mostly about its nutritional content. There is paucity of information on its response to soil fertility management on organic and inorganic source. As a result, there is a need to evaluate the effect of fertilizer application on the growth, yield, and nutritional quality of black sesame (Sesamum radiatum) in south west Nigeria.

2. Materials and Methods

2.1. Description of the Experimental Site

Two experiments were conducted (August to October, 2020 and December, 2020 to February, 2021) at the ADP (Agricultural development program center) in Ibadan, Southwest Nigeria. It is located on latitude 7°30'N and longitude 3°54'E, with an annual temperature 21°C to 32°C, and a mean monthly relative humidity 61 to 83% [6].

2.2. Land Preparation and Soil Sampling

The experimental site was cleared, ridged manually and made in plots (beds) 2m x 1m. Pre-planting soil sampling was carried out on the experimental field to determine the initial soil properties before treatment incorporation. Representative soil samples were collected (at the depth of 0-20 cm) at various points on the field and bulked together to determine the chemical properties of the soil before the experiment.

2.3. Sources of Materials

S. radiatum seeds were obtained from a farmer in Eruwa area of Oyo State. The seeds were cleaned and sorted to remove damaged seeds before sowing. Inorganic fertilizers were obtained from Agricultural product marketer while organic manures were obtained from local livestock farmer's farm in Ibadan.

2.4. Experimental Design and Treatment

The experiment was laid in a randomized complete block design (RCBD) with three replications and five treatments. The treatments are; T_1- chicken manure (4tons/ha); T_2- pig manure (4tons/ha); T_3- N.P.K 20:10:10 (200kg/ha); T_4- super gro (1litre/ha); and T_5- control (where no fertilizer was added).

2.5. Field Area and Spacing

Poultry manure and pig manure were applied on the plots two weeks before planting while N.P.K (20:10:10) fertilizer and liquid fertilizer (super gro) were applied at two weeks after sowing. *Sesamum radiatum* seeds were drilled at a distance of 50 cm x 20 cm and thinned to one seedling per stand at 2 weeks after planting. Hand weeding was done three (3) times to keep the field weed-free.

2.6. Data Collection

Agronomic data were collected on five randomly selected plants per plots for plant height (cm), number of leaves per plant, leaf area (cm^2), edible yield (g/m^2), marketable yield (g/m^2) and total biomass (g/m^2).

2.7. Laboratory Analysis

Leave sample collected from treatments on the field were transferred to the Soil laboratory of the Department of Crop, Soil and Pest Management, Federal University of Technology Akure for the determination of nutritional and proximate analysis. The tested vegetables were analysed for moisture content, % fat content, protein content, ash content, crude fibre, phosphorus, potassium, sodium, calcium and magnesium [15].

2.8. Data Analysis

The collected data were subjected to analysis of variance using minitab version 17 software while significant means were separated using Tukey test at 5% level of probability.

3. Results

3.1. Pre Cropping Soil Chemical Properties

Table 1. *Pre cropping Soil chemical properties of the locations.*

Nutrient values	
Parameters	**Values**
pH (H_2O)	4.52
OM%	1.32
OC	0.77
N (%)	0.08
P (mg/kg)	4.98
K (Cmol/kg)	0.16
Ca (Cmol/kg)	4.00
Na	0.32
Mg	2.00

The results of the pre-cropping soil chemical analyses showed that, the soil was acidic with pH (H_2O) value of 4.52 (Table 1). Furthermore, the organic matter contents of the soil was low (1.32 g/kg^{-1}) with low available P (4.98 ppm), exchangeable K (0.16) and Ca (4.00 cmolkg^{-1}) while the Mg contents of the soil was medium (2.00 cmolkg^{-1}) (Table 1).

3.2. Effect of Fertilizer Application on Growth, Yield and Nutritional Content of Black Sesame (Sesamum radiatum)

Figures 1 and 2 shows the effects of poultry manure, pig manure, NPK fertilizer and super gro on the height of black sesame for both 2020 and 2021 cropping season. The results showed that at 4, 5 and 6 weeks after planting (WAP) in 2020 and 2021 cropping seasons, poultry manure and pig manure were significantly different from the other treatments with the mean of 12.17 cm, 10.77 cm; 21.40 cm, 25.93 cm; 36.97 cm, 39.00 cm and 11.47 cm, 11.83 cm; 21.13 cm, 21.93 cm; 29.63 cm, 31.17 cm respectively while control (no treatment) gave the least mean in both seasons at 4, 5 and 6 WAP.

The effects of soil amendments on number of black sesame leaves are presented in Table 2. In 2020, poultry manure and pig manure had the highest number of leaves at 4 WAP (26.00 and 26.00), 5 WAP (30.00 and 30.00) and 6 WAP (36.00 and 36.00) respectively. While control (no treatment) gave the least mean of 12.00, 14.00 and 20.00 at 4, 5 and 6 WAP respectively. At maturity, NPK recorded the highest leaf area (20.63 cm^2) while control gave the least (12.81 cm^2) which were not significantly different from each other. The mean value ranges from 18.19 (leaf area) to 30.13 (no of leaves at 6 WAP).

In 2021, poultry manure and pig manure had the highest number leaves at 4 WAP (16.00 and 16.00), 5 WAP (20.00 and 20.00) and 6 WAP (24.00 and 24.00) respectively. While the control (no treatment) gave the least mean of 10.00, 14.00 and 18.00 at 4, 5 and 6 WAP respectively. At maturity, NPK recorded the highest leaf area (16.08 cm^2) while control gave the least (8.37cm^2).

The results of the effect of fertilizer application on the yield of black sesame are presented in Table 3. There were significant differences ($P < 0.05$) among the treatment for edible yield, but there was no significant differences in marketable yield and total biomass. However, N.P.K had the highest mean for marketable yield (2086.67g/m^2) and total biomass (2280g/m^2) followed by super gro with a mean of 2023.33g/m^2 (marketable yield) and 2566.67g/m^2 (total biomass) while, control treated plots had the least means of 1086.67g/m^2 (marketable yield) and 1226.67g/m^2 (total biomass) for 2020 growing season.

In 2021 growing season, there were significant differences in the treatment used on the yield of sesame. Nevertheless, there are differences in the mean of edible yield, marketable yield and total biomass yield. Pig manure had the highest means for edible yield (900g/m^2), marketable yield (1896.67g/m^2) and total biomass (2053.33g/m^2) followed by poultry manure with a mean of 786.67g/m^2 (edible yield), 1733.33g/m^2 (marketable yield) and 1886.67g/m^2 (total biomass) while control plot had the least with 436.67g/m^2 (edible yield), 763.33g/m^2 (marketable yield) and 843.33g/m^2 (total biomass) when compared to the plots treated with fertilizer application.

Table 2. *Mean performance for Effect of fertilizer application on Number of leaves of S. radiatum.*

TREATMENTS	2020				2021			
	4WAP	5WAP	6WAP	Leaf Area (cm^2) at 6WAP	4WAP	5WAP	6WAP	Leaf Area (cm^2) at 6WAP
Poultry Manure	26.00a	30.00a	36.00a	17.27a	16.00a	20.00a	24.00a	14.42a
Pig Manure	26.00a	30.00a	36.00a	20.54a	16.00a	20.00a	24.00a	14.19a
N.P.K.	20.00b	24.00b	30.00b	20.63a	14.00a	18.00b	22.00a	16.08a
Super Gro	18.67b	22.67b	28.67b	19.73a	14.00a	18.00b	22.00a	13.76a
Control	12.00c	14.00c	20.00c	12.81a	10.00b	14.00c	18.00c	8.37b
Mean	20.53	24.13	30.13	18.19	14.23	18.00	22.00	13.37
SE Mean	1.40	1.58	1.58	1.37	0.61	0.59	0.59	0.88

Means in the same column with different superscripts are significantly different using Tukey test at ($P < 0.05$) WAP- weeks after planting

Table 3. *Mean performance for the effect of fertilizer application on yield of S. radiatum for 2020 and 2021 cropping season.*

Treatments	2020			2021		
	Edible yieild (g/m^2)	Marketable yield (g/m^2)	Total biomass (g/m^2)	Edible yieild (g/m^2)	Marketable yield (g/m^2)	Total biomass (g/m^2)
Poultry Manure	586.67ab	1433.33a	1676.67a	786.67ab	1733.33a	1886.67a
Pig Manure	660.00ab	1630.00a	1843.33a	900.00a	1896.67a	2053.33a
N.P.K.	1050.00a	2086.67a	2280.00a	736.67ab	1556.67ab	1710.00ab
Super Gro	966.67ab	2023.33a	2566.67a	653.33ab	1293.33ab	1390.00ab
Control	450.00b	1086.67a	1226.67a	436.67b	763.33b	843.33b
Mean	742.7	1652.0	1919	702.7	1449.0	1577.0
SE Mean	76.30	151.0	197	60.00	138	147.0

Means in the same column with different superscripts are significantly different using Tukey test at ($P < 0.05$)

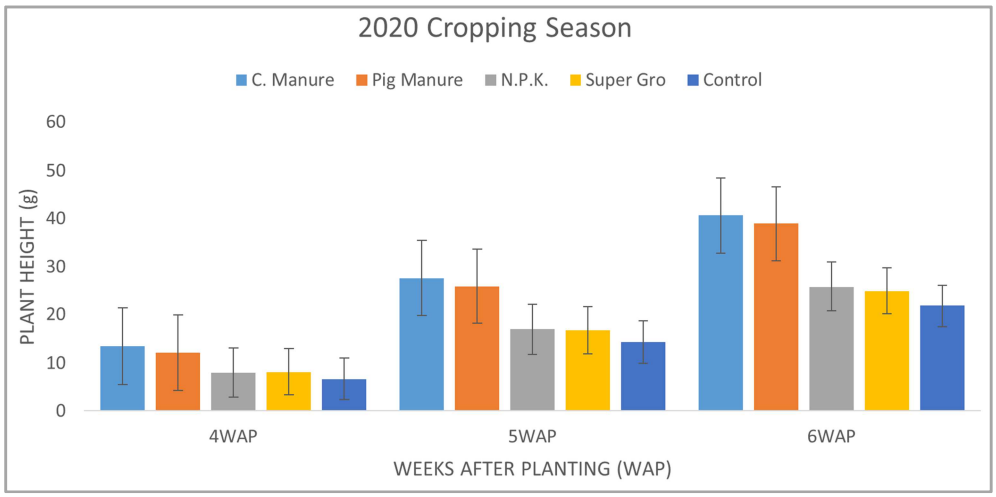

Figure 1. *Mean performance for the effect of fertilizer application on plant heights of Sesamum radiatum for 2020 cropping season.*

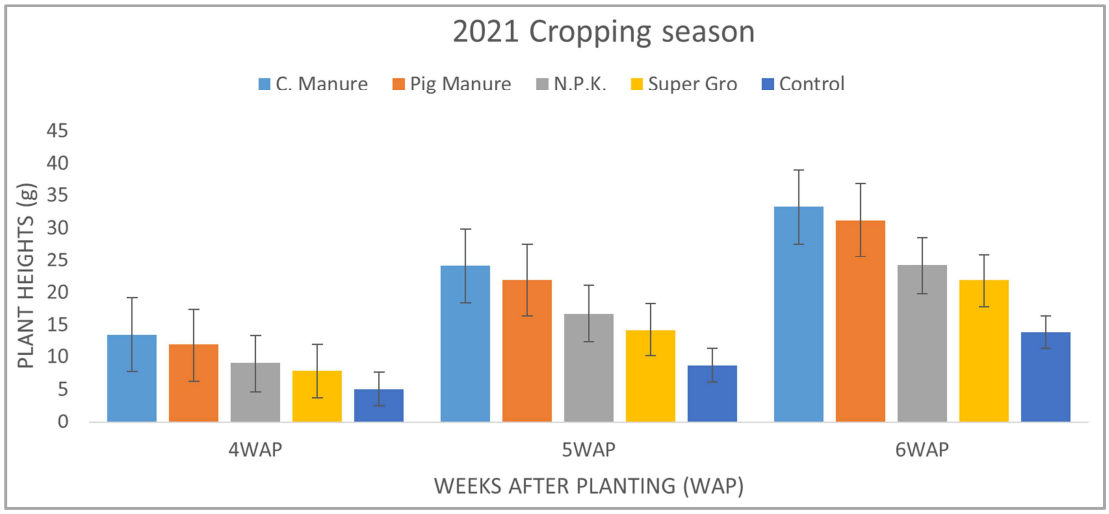

Figure 2. *Mean performance for the effect of fertilizer application on plant heights of Sesamum radiatum for 2021 cropping season.*

3.3. Nutritional Content and Proximate Analysis

The effect of fertilizer sources on proximate and nutritional content of black sesame in 2020 and 2021 are shown in Tables 4 and 5. In 2020 and 2021, all treatments increased than control in moisture content, protein, ash, fat, crude fibre, P, K Ca and Mg contents of black sesame leaves. In 2020, there was no significantly difference in moisture content, ash, protein, crude fibre, P, K, Na and Mg content. However, there was significant different among the treatments in fat content and Ca. Pig manure gave the highest fat content with a mean of 8.16%, which was significantly different from control 4.17%. Also, super gro gave the highest mean of 7.12, which was significantly different from control 4.11. Poultry manure and pig manure, were significantly different in moisture content and fat content for the treatments in 2021. Likewise, significant differences were recorded for ash content, protein content, P, K, Ca and Mg content. However, there was no significant difference in crude fibre and Na content in 2021 cropping season.

Table 4. *Mean performance for Effect of fertilizer application on nutritional composition and proximate analysis of S. radiatum for 2020 cropping season.*

Treatment	M.C	Ash	Protein	Fat	C. F	P	K	Na	Ca	Mg
Poultry manure	12.82a	19.74a	11.84a	7.14a	27.22a	16.05a	5.28a	3.06a	6.16ab	2.80a
Pig manure	14.15a	17.65a	9.63a	8.16a	25.22a	15.26a	4.30a	2.80a	4.34ab	2.86a
N.P.K	12.88a	19.61a	11.84a	7.14a	23.21a	14.63a	4.78a	3.16a	4.30ab	2.36a
Super gro	11.94a	16.22a	10.78a	7.32a	24.33a	16.89a	6.05a	4.34a	7.21a	3.14a
Control	9.85a	16.22a	9.56a	4.17b	23.21a	14.58a	3.97a	3.94a	4.11b	2.16a
Mean	12.33	17.91	10.73	6.79	24.64	15.48	4.88	3.46	5.22	2.66
SE Mean	0.56	0.69	0.45	0.40	0.91	0.61	0.28	0.21	0.41	0.14

Means in the same column with different superscripts are significantly different using Tukey test at ($P < 0.05$). MC- moisture content. C/F- crude fibre, P-Phosphorus, K-Potassium, Na-Sodium, Ca-Calcium, Mg-Magnesium

Table 5. *Mean performance for Effect of fertilizer application on nutritional composition and proximate analysis of S. radiatum for 2021 cropping season.*

Treatment	M.C	Ash	Protein	Fat	C/F	P	K	Na	Ca	Mg
Poultry manure	13.28a	12.82b	13.85a	7.84a	26.32a	14.59a	3.33a	2.24a	3.96a	2.82a
Pig manure	13.48a	12.70b	11.84b	7.84a	26.44a	10.63bc	3.03ab	2.32a	2.96b	1.86b
N.P.K	12.29ab	13.33b	10.33bc	3.45b	26.54a	111.95b	2.89ab	2.05a	3.74a	2.56a
Super gro	12.59ab	25.46a	10.12bc	3.33b	26.32a	9.32cd	3.12ab	2.32a	4.26a	2.56a
Control	10.70b	12.31b	9.56c	2.80b	25.73a	8.74d	2.70b	2.00a	2.40b	1.60b
Mean	12.47	15.32	11.14	5.05	26.27	11.05	3.01	2.19	3.46	2.28
SE Mean	0.34	1.38	0.45	0.62	0.44	0.59	0.08	0.05	0.19	0.13

Means in the same column with different superscripts are significantly different using Tukey test at ($P < 0.05$). MC- moisture content, C/F- crude fibre, P-Phosphorus, K-Potassium, Na-Sodium, Ca-Calcium, Mg-Magnesium

4. Discussion

Tropical soil nutrient and quality can be replenished through the use of fertilizers [16]. Fertilizer is a component of sustainable crop production systems. The report by Bonsu that an increase in the level of fertilizer application resulted in an increase in the growth and yield parameters of sesame [17] is in agreement with the current results. Sesame requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium (NPK) for good growth and high yield. Nitrogen, phosphorus and potassium are the three most limiting of the essential plant nutrient elements and are required in large quantities by crops especially in Nigerian soils with low inherent fertility [18]. The significant response of growth to application of poultry manure, pig manure, NPK and super gro is an indication of the role of fertilizers in plant nutrition. This study indicated that plant growth attributes such as plant height, and` number of leaves increases as a result of poultry manure application [19].

Fertilizer application on the plot would result in broader leaves, which would boost the plant's photosynthetic activity; this corroborates with the work of Auwalu and Babatunde where they reported that wider leaf area would invariably lead to greater photosynthetic activity, hence higher total marketable (vegetative) yield [5]. Organic manure is known to be capable of activating many species of micro-organisms which release phyto-hormones that stimulate nutrient absorption and plant growth [20]. Better nutrient availability and uptake throughout the growth period in poultry manure treated plot may be responsible for the higher P and crude protein value recorded in the plants harvested from the plot. The crude protein value is a reflection of the N absorbed by the plants. Application of organic fertilizer was reported to increase P availability and absorption [21]. Mishra and Ganesh reported that plant uptake of nutrients was better in organic fertilizer plots than inorganic fertilizer plots [22]. The high nutritional quality of black sesame leaves recorded in this study is in agreement with the findings of Jimam et al. who investigated the nutritional and anti-nutritional content of the plant's leaves and recorded high level of protein with a considerable level of moisture [23].

5. Conclusion

The study accessed the effect of fertilizer application on growth, yield and nutritional quality of black sesame in south west, Nigeria. The increase in growth, yield and quality of sesame recorded for all the treatments over the control suggests that fertilizer application is inevitable for a successful crop production. The significantly higher performance of organic manure treated plants over NPK on the growth, yield and quality related characters is an indication that organic manure can conveniently be used to replace NPK fertilizer when available. The study also proves that the application of fertilizer on low quality of soil improves the soil but also improved the nutritional quality of the crop.

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