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Original Article

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PERFORMANCE OF SESAME (*SESAMUM INDICUM* L.) AS INFLUENCED BY 2,4 – DICHLOROPHENOXYACETIC ACID AND NPK FERTILIZER

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ABSTRACT. The Guinea savannah zone of Nigeria is beset by increasing population and infrastructural development, thereby putting pressure on available land with rapidly declining fertility due to low organic matter content, soil erosion, high temperature and seasonal bush burning. Sesame is cultivated in this zone and the yield has remained very low, compared to yield in other parts of the world. This could be attributed to poor nutrient status and poor cultural practices used by peasant farmers. A field experiment was conducted at the Teaching and Research Farm, University of Ilorin, Nigeria, in a southern Guinea savannah zone in 2015 and repeated in 2016 cropping season to determine the effects of 2,4-Dichlorophenoxyacetic acid (2,4-D), a plant growth regulator and NPK fertilizer on the growth and yield of sesame. The experiment was laid out as a factorial arrangement, fitted into a randomized complete block design replicated thrice. The factors imposed were 2,4-D (0, 5 and 10 ppm ha^{-1}) and NPK 15:15:15 (0, 100, 200 and 300 kg ha^{-1}). Data were collected on vegetative traits (plant height, number of leaves, leaf area) and yield components (number of capsules per plant; yield per plant and per hectare). The data were subjected to analysis of variance (ANOVA) using the Genstat statistical package 17th edition and significant means were separated by using the least significant difference at 5% level of probability. The result revealed that using plant growth regulator and NPK fertilizer had significant effects (p<0.05) on plant height (151 cm) and yield per hectare (530 kg/ha). The qualitative and quantitative analysis of the seeds further reaffirmed the presence of bioactive compounds, such as saponins, tannins, flavonoids and phenolic compounds, which are important health promoting food in the seeds.

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Keywords: plant growth regulator (PGR); NPK fertilizer; growth; yield; sesame.

INTRODUCTION

Although Nigeria is among the major sesame (*Sesamum indicum* L.) exporting countries, ranking second to Sudan in production and export in Africa (FAO, 2008), with an annual earning of over US$ 878 million, its cultivation and use are not beyond subsistence level. This is due to unavailability of high yielding varieties, poor soils and poor agronomic practices (Haruna *et al.,* 2011). In addition, traditional sesame growers rely on slash and burn system of agriculture, which depends on the fallow period for fertility restoration. However, due to increase in population and infrastructural development, the follow period has been shortened. Moreover, the crop is often intercropped and its introduction is late in the season, without the addition of external inputs; this often results in low yields. There is therefore, the need to improve the growth and yield of the crop to meet the demand of consumers.

In recent times, many farmers and researchers in Nigeria have used many fertilizer types to improve the yield of sesame, but the yield still remains very low, about 450 kg/ha (Eifediyi *et al*., 2016), compared to yield in Egypt (1,323 kg/ha) and Ethiopia (825 kg/ha) (FAO, 2009). The use of plant growth regulator may be able to bridge this yield gap. Considering the low nutrient status of the savannah soils in Nigeria, there is the need for integrated use of growth regulators and inorganic fertilizer in a balanced proportion than when either is used alone for increased growth and yield of crops. Plant growth regulators (PGR) are known to affect growth, flowering and assimilate translocation in plants (Naeem *et al.*, 2004). Davies (1987) reported that PGR is involved in several processes in the development of a crop. Haque *et al.* (2005) reported the use of plant growth regulator at 80 ppm, as foliar spray had positive regulatory effect on the growth and yield attributes of sesame. Shakur (1985) observed that the yield of sesame was increased by the application of Planofix and thus increased the number of flower clusters per plant and reduced percentage of flower abortion in Bangladesh. Kapgate *et al.* (1989) reported that the application of indole acetic acid increased the plant height, number of leaves per plant, which resulted in an increase in seed yield in cotton (*Gossypium* spp.). Eifediyi and Remison (2015) reported increase in the yield of maize by the use of indole acetic acid in a southern Guinea savannah zone of Nigeria. Zahir *et al.* (1998) showed that growth and yield parameters of rice were significantly promoted in response to various auxin levels. Abro *et al.* (2004) showed that naphthalene acetic acid (NAA) had a significant effect on plant height, number of fruiting branches, number of bolls and yield in cotton (*Gossypium* spp.). Plant growth regulators had improved the production of sesame, including other plants (Mostafa *et al.,* 2009). The use of 2,4-D in high concentration is used as a herbicide, but at very low concentration promotes growth in the form of auxins. Nevertheless, the use of NPK fertilizer in combination with plant growth regulator and good agronomic practices will increase the yield on per hectare basis. Therefore, the study was carried out to find out the effect of plant growth regulator and inorganic fertilizer on the growth and yield of sesame.

MATERIALS AND METHODS

Site description

The experiment was conducted at the Teaching and Research Farm of the University of Ilorin, Ilorin, Nigeria (latitude 8°49' and longitude 4°58' East and 307 m above sea level), during the 2015 and 2016 cropping seasons in a Southern Guinea savannah zone of Nigeria. The climate of the area is tropical humid, with an average rainfall of 1186 mm, mean annual temperature of 29ºC, while the average annual relative humidity is about 85%. The soils of the study site are well drained, shallow to deep and the soil order is Alfisols, with a textural class of sandy loams belonging to the Tanke series (Ogunwale *et al*., 2002). The soil pH of the study area is slightly acidic; clay contents are low, with low moisture holding capacity and with little structural development. The soils are prone to erosion due to low vegetation cover and underlying layers of metamorphic rocks, which are often exposed outcrops of rocks in some locations. Cultivation of crops is mainly during the rainy season, with little cultivation of leafy vegetables during the dry season in areas close to streams and rivers.

Soil sampling

Top soil (0-30 cm) samples were collected in a 4×10 m^2 grid, bulked and a composite sample collected for physical and chemical characterization (*Table 1*).

Soil pH was determined in soil: water ratio 1:2.5, using glass electrode (Thomas, 1976). Total N content was determined by micro-Kjeldahl method (Bremner and Mulvaney, 1982); available phosphorus was determined following Bray No. 1 method (Kuo, 1996); organic carbon was determined according to Walkley-Black method (Nelson and Sommers, 1996); exchangeable bases, calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na), were extracted with 1N ammonium acetate. Calcium and magnesium in the extract was analyzed using atomic absorption spectrophotometer (AAS), whereas K and Na were determined by flame photometry.

Table 1 - Physical and chemical composition of the soil before and after cropping in 2015 and 2016

	Soil pH	Organic C %	Organic matter %	Total N mg kg^{-1}	Available P. mg kg^{-1}	K mg/kg	Ca $cmolkg^{-1}$	Mg $cmolkg^{-1}$
2015	5.70	0.18	0.31	0.65	1.59	0.32	4.51	1.23
2016	5.80	0.12	0.21	0.30	1.33	0.26	3.20	1.01

Experimental design and cultural practices

The experiment was laid out as a factorial arrangement, fitted into a randomized complete block design. The factors consisted of four rates of NPK fertilizer (0,100, 200 and 300 kg/ha) and three rates of plant growth regulator (2,4-D) (0, 5 and 10 parts per million (ppm)). The NPK was applied using side placement method at three weeks after sowing, while the 2,4-D was foliar applied at three weeks after sowing (WAS). The seeds (cv. Ex-Sudan) were sown using the drilling method on July 26, 2015 and July 27, 2016 and were later thinned to one plant per stand at a spacing of 30×30 cm. Preemergence herbicide (paraquat) was applied before sowing, which was complimented with one hand weeding at eight weeks after sowing.

Harvesting was manually done by hand picking the capsules from the five-tagged plants (net plot), before the capsules dehisced and then sun dried.

Data on growth and yield components

Growth parameters

The plant height of the five-tagged plants (net plot) was measured from the soil level to the terminal point of the plant, using a measuring tape at 28, 42, 56 and 70 days after sowing, whereas the number of leaves (green) of the five tagged plants (net plot) were visually assessed at 4, 6, 8, and 10 weeks after sowing. The total dry matter accumulations were assessed at 28, 42, 56 and 70 days after sowing. The plants were then oven-dried at 60^{o}C, for 24 hrs, until a constant weight was attained. The samples were later weighed by using a sensitive balance. Crop growth rate was also determined from the increase in dry matter production at 28, 42, 56 and 70 days after sowing. The leaf area per plant was determined by using the dry weight method, as described by Rhoads and Bloodworth (1964).

Yield and yield components

Data on the number of capsules per plant were assessed by counting the number of capsules per plant at harvesting of the net plot, while the yield per plant was assessed by drying the capsules of the net plot and seeds extracted and the yield per hectare were calculated by extrapolation from the yield from the net plot.

Phyto-chemical seed analyses

The phytochemical constituents analyzed were tannin, saponin, phytate, alkaloid and oxalate. The method used in determining the quantity of tannin was based on the work of Trease and Evans (1989); saponin according to Hudson and El-Difrawi (1979) as adopted by Obadoni and Ochuko (2001); phytate according to Adamu *et al.* (2007), alkaloids was according to Maga (1982) as adopted by Harborne (1998) and oxalate according to Day and Underwood (1986). These analyses were carried out using the qualitative and quantitative methods.

Data analysis

Data collected were subjected to analysis of variance (ANOVA), using the Genstat software package 17th edition and mean comparison was done using the least significant difference (LSD) at five percent level of probability, based on the work of Steele and Torrie (1980)

RESULTS

Data on the soil

Data on plant height of sesame as affected by NPK and plant growth regulator at 28, 42, 56 and 70 (DAP) days after sowing in 2015 and 2016 are presented (*Table 2*). In 2015, at

28, 42, 56 and 70 days after sowing (DAS), as the rate of fertilizer increased, a trend was observed throughout the four sampling periods of 28, 42, 56 and 70 DAS. The highest plant height was observed at the 300kg/ha rate of fertilizer application, which was significantly different (p<0.05) from the other rates. Also, using the PGR at the different rates resulted in plant height, which was significantly different (p<0.05) from the control at the four sampling periods. However, there was significant interaction at 28 and 70 DAS. In 2016, data on the plant height of sesame presented (*Table 2*). The data indicated a similar trend of the observation in 2015 was recorded.

Table 2 - Effects of plant growth regulator and NPK fertilizer on the plant height (cm) of sesame in 2015 and 2016 at 28, 42, 56 and 70 days after sowing

	2015				2016			
	Days after sowing							
PGR	**28**	**42**	**56**	**70**	**28**	**42**	**56**	**70**
0	8.48	28.32	70.77	127.08	7.68	28.18	72.59	130.30
5	9.19	29.34	73.29	131.01	8.19	30.67	73.46	134.41
10	9.53	30.74	77.47	134.20	9.42	33.47	76.78	137.24
LSD $_{0.05}$	0.151	0.91	3.01	0.55	0.220	0.860	1.84	1.68
NPK								
0	7.60	23.52	62.83	114.96	6.94	24.26	65.63	117.29
100	8.87	25.73	69.65	128.97	7.96	25.85	69.21	129.73
200	9.66	28.83	75.94	136.18	8.67	28.97	77.64	140.13
300	103.1	39.73	87.97	142.95	10.17	45.33	84.61	149.28
LSD $_{0.05}$	0.174	1.05	3.47	0.64	0.253	0.993	2.13	1.94
Interaction	0.30	Ns	Ns	1.11	0.044	1.72	1.84	Ns

Data on the number of leaves as influenced by NPK fertilizer and PGR in 2015 and 2016 are presented (*Table 3*). In 2015, using the NPK fertilizer at the 300 kg/ha produced the highest number of leaves which was significantly different (p<0.05) from the other treatments at 28 and 70 DAS, but no significant observation was recorded at 42 and 56 DAS. The use of PGR also produced a trend, which was significantly different (p<0.05) from the control at 28 and 70 days after sowing. Nevertheless, no significant difference was observed in 42 and 56 days after sowing. There was also, no significant NPK and PGR interaction throughout the four sampling periods. In 2016, there was an increase in the number of leaves with an increasing NPK fertilizer. The 300 kg/ha produced the highest number of leaves, which was significantly (p<0.05) different from the other rates at the four sampling periods of 28, 42, 56 and 70 DAS. Increasing rates of PGR also resulted in an increase in the number of leaves produced by sesame with the 10ppm rate of application producing the highest number of leaves, which was significantly different (p<0.05) from the control. However, there was only a significant (p<0.05) interaction at 28 days after sowing.

Data on the leaf area of sesame is presented in *Table 4*. In 2015, the data indicated that using NPK at 300 kg/ha produced the highest leaf area at the four sampling periods, which was significantly different (p<0.05) from the control. The plant growth regulator (PGR) also outperformed the control significantly (p<0.05) at the four sampling periods. Using the combined NPK and PGR, there was significant interaction only at 28 and 42 DAS. A similar trend of the observation in 2015 was recorded at the four sampling periods in 2016.

Table 3 - Effects of plant growth regulator and NPK fertilizer on the number of leaves of sesame in 2015 and 2016 at 28, 42, 56 and 70 days after sowing

	2015				2016			
	Days after sowing							
PGR	**28**	**42**	**56**	**70**	**28**	**42**	**56**	**70**
0	8.10	19.52	41.00	65.76	22.89	22.89	48.93	76.61
5	8.30	20.30	42.35	66.88	24.33	24.33	52.04	77.93
10	8.53	21.11	44.13	67.69	25.59	25.59	54.18	79.26
LSD $_{0.05}$	0.184	Ns	ns	0.65	0.748	0.748	1.39	1.11
NPK								
0	7.33	17.10	37.04	62.16	7.94	18.80	40.20	71.91
100	8.25	18.84	38.09	65.90	8.39	23.49	40.06	75.54
200	8.60	21.54	45.28	68.26	8.75	25.52	56.03	80.01
300	9.06	23.77	49.57	70.77	9.19	29.27	64.39	84.29
LSD $_{0.05}$	0.212	Ns	ns	0.75	0.863	0.748	1.60	1.282
Interaction	Ns	Ns	ns	Ns	ns	ns	ns	ns

Table 4 - Effects of plant growth regulator and NPK fertilizer on the leaf area (cm^2) of sesame in 2015 and 2016 at 28, 42, 56 and 70 days after sowing

	2015				2016			
	Days after sowing							
PGR	**28**	**42**	**56**	**70**	**28**	**42**	**56**	**70**
0	25.51	40.41	51.32	60.28	25.36	41.22	51.18	60.59
5	31.08	41.71	52.91	63.36	31.35	42.31	53.25	63.44
10	36.72	46.21	55.12	60.28	38.18	47.29	56.61	65.59
LSD	1.104	0.612	1.25	0.998	1.38	0.795	0.853	1.148
NPK								
0	23.59	39.49	49.48	58.25	24.83	40.83	50.43	59.06
100	31.48	41.66	51.20	61.66	31.21	42.34	52.37	62.05
200	35.09	43.90	54.82	64.54	34.67	45.56	54.66	64.93
300	34.25	46.05	56.96	65.91	35.83	45.10	57.27	66.74
LSD	1.27	0.706	1.44	1.152	1.59	0.918	0.985	1.325
Interaction	2.21	1.22	ns		ns	ns	ns	Ns

Yield and yield components

Data on the total dry matter of sesame in 2015 and 2016 is presented in *Table 5*. In 2015, increasing the rates of NPK fertilizer and the PGR resulted in an increase in the total dry matter content of sesame, but no significant difference was observed. During the 2016 cropping season, a trend was observed in both the NPK and PGR, which was significantly different (p<0.05) from the control. Nevertheless, no significant interaction was observed.

Data on the number of capsules per plant are presented (*Table 5*). In both years, a trend was observed in the application of NPK and PGR. The 300 kg/ha and the 10 ppm produced the highest number of capsules per plant, which was significantly different (p<0.05) from the control. However, a significant NPK and PGR interaction (p<0.05) was observed in 2016.

Data on the seed weight per plant and per hectare of sesame in 2015 and 2016 are presented (*Table 5*). A pattern was observed in the use of NPK and PGR. Using the NPK rate at 300kg/ha and 10 mg kg^{-1} produced the highest values which were significantly different (p<0.05) from the control in the two years of study. There was also a significant (p<0.05) NPK and PGR interaction.

Table 5 - Effects of plant growth regulator and NPK fertilizer on the total dry weight and yield components of sesame in 2015 and 2016

	2015				2016			
	Days after sowing							
PGR	Total dry matter (g)	No. of capsules/ plant	Seed wt/ plant	Seed wt/ ha (kg)	Total dry matter (g)	No. of capsules/ plant	Seed wt/ plant	Seed wt/ ha (kg)
0	0.17	82.50	3.67	367.4	0.14	88.44	3.61	360.5
5	0.18	88.78	3.95	395.5	0.15	90.56	3.88	388.3
10	0.19	90.63	4.23	423.8	0.17	94.48	4.03	405.2
LSD	ns	0.698	0.12	12.72	0.058	ns	0.051	5.14
NPK								
0	0.13	74.74	3.19	320.0	0.11	78.70	3.13	313.0
100	0.16	87.01	3.72	372.1	0.14	87.07	3.73	372.9
200	0.19	91.69	4.22	442.1	0.17	94.59	3.92	392.1
300	0.22	95.78	4.68	468.1	0.20	104.35	4.61	460.8
LSD	ns	0.806	0.12	14.68	0.006	4.627	0.059	5.93
Interaction	ns	1.396	0.25	25.43	ns	Ns	0.102	10.28

Qualitative and quantitative analysis of sesame seeds

The data on qualitative and quantitative analysis of sesame are presented in *Table 6*. The qualitative and quantitative analysis revealed the presence of tannins, phytates and saponins which has health promoting effects on man.

Table 6 - Qualitative and quantitative analysis of sesame seeds

	Qualitative	Quantitative
Tanins (g/kg)	++	3.30
Saponins (mg/kg)	+	0.56
Phytate (mol/kg)	+	0.18
Alkaloids (mg/kg)	+	0.84
Oxalate (mg/kg)	+	1.64

DISCUSSION

The control plots had moderate plant height due to plants ability to tolerate poor soils and able to perform in marginal soils.

The effect of plant regulator showed a remarkable increase in the growth and yield parameters of sesame. The tallest plants were observed with combine application of NPK fertilizer and plant growth regulator. The combined application of the treatments ensured all around nutrient availability to the crop. This report is in agreement with the findings of Bonsu (2003), who reported that an increase in the level of fertilizer application also resulted in an increase in the growth parameters of sesame. The observation was also in line with the findings of Muktar (2004), who reported that the application of gibberellins increased the plant height, number of leaves and total plant weight of some cultivars of cowpea. Zahir *et al*. (1998) also observed that growth and yield parameters of rice were significantly promoted in response to various auxin levels. Kapgate *et al.* (1989) reported that application of synthetic auxin has been found to increase the plant height, number of leaves per plant with consequent enlargement in seed yield of cotton.

The highest number of leaves was obtained at 10 WAP when 300 kg/ha of NPK fertilizer and 10 ppm of 2,4-D were applied. This report is in line with the findings of El-Nakhlawy and Shaheen (2009), who stated that vegetative production in plants increases with increased level of fertilizer. Eifediyi *et al.* (2016) also observed an increase in number of leaves of sesame when inorganic fertilizer was used in southern Guinea savanna zone in Nigeria**.** Yang *et al.* (2012) also found out that plant growth hormone increased the number of leaves of toma-toes. The maximum number of branches was obtained when 300 kg/ha of NPK fertilizer and 10 ppm of growth hormone was applied.

This report is in line with the findings of Singh and Singh (2005), who reported that the number of branches increased with increased levels of plant growth hormone in tomatoes. From the experiment, there was an increase in yield and component of sesame. Increase in NPK fertilizer and 2,4-D application led to the increase in the number of capsules per plant. This findings is in conformity with the results obtained by Olowe and Busari (2000), who found that the application of 60 kg/ha N and 13.2 kg ha^{-1} P_20_5 produced the highest number of capsule weight per plant and grain yield per hectare. Okpara *et al.* (2007) also found out that application of 75 kg/ha N, 26 kg ha^{-1} P_20_5 significantly increased the number of seeds per capsule and seed per hectare. Babeji *et al.* (2006) reported that there was a significant increase in the number of capsules per plant at 60 kg N/ha.

From the results obtained in this experiment it can be deduced that there is an increase in seed weight per plant and seed weight per hectare of sesame when 10 ppm of 2,4-D and 300 kg/ha were applied. The weight of the seed increased with increasing rate of fertilizers and lower concentration of plant hormone. This was in line with the findings of Haruna (2011), who observed that yield increase with increased level of fertilizer application. Okpara *et al.* (2007) also found out that application of 75 kg/ha N, 26 kg ha^{-1} P_20_5 significantly increased the seed weight per hectare. Mehta and Mathi (1975) also observed that number of fruits per plant of tomato increased with application of plant growth hormone.

Kaushik *et al.* (1974) reported that yield per hectare increased with the application of plant growth hormone in tomato. Ghorbani *et al.* (2008) reported that NPK has more effect on the yield of tomato plants than poultry manure. Shehu *et al.* (2010) reported that the application of NPK fertilizer at 75 kg/ha N, 45 kg P_20_5 and 22.5 kg $ha^{-1}K_20$ gave the highest seed yield of 456 kg/ha, while dry matter yield was highest (1460 kg/ha) at 112.5 kg N and 45 kg P_20_5.

Bioactive compounds that produce desirable physiologic activity, derived from plants include alkaloids, tannins and flavonoids (Hill, 1952) and can be used in drug development (Vasu *et al*., 2009). Plants containing these compounds have been used in medicine for millennia (Cragg and Newman, 2001). Sesame had earlier been reported to contain anticancer properties. The phenolic compound, such as flavonoids present in the seeds, has been found to have anti-aging and anti-carcinogenic properties. Phenolic compounds exhibit a wide range of physio-logical properties, such as anti-allergenic, anti-arthero-genic, anti-inflammatory, anti-microbial, antioxidant, anti-thrombotic, cardioprotective and vasodilatory effects (Manach *et al.*, 2005). Sesame has been regarded in the Orient as a health food for aging prevention and high energy food (Hajimahmoodi *et al*., 2008).

Ogawa *et al*. (1985) had also reported the presence of alkaloids, which have antioxidants, and strong anticancer properties (Salah *et al.,* 1985). The values of bioactive compounds present in sesame seeds further re-affirms its use in the treatment of cancer and other diseases.

Saponin has been reported to have cholesterolemic effects and thus may lessen the metabolic burden on the liver (FAO/WHO/UNU, 1991). Tannins possess antidiarrhoeal (Amabeoku, 2009) and antimicrobial activities (Corrales *et al*., 2009). The nutritional composition of sesame indicated that the tannins present in the seeds were within the acceptable limits for food. The content of saponins is very high in some plants reaching some several percent on dry weight basis (Szakiel *et al.,* 2011). Saponins are valuable compounds to humans due to their use in pharmacy, agriculture and in food but some exhibit a wide range of deleterious properties (Sun *et al*., 2009).

CONCLUSION

From the results obtained from this experiment, it can be deduced that the performance of sesame was better when 10 parts per million of 2,4-D and 300 kg/ha were applied. Although this application gave the highest yield of (530.7 kg ha^{-1}), which is below what is obtained in Saudi Arabia, but higher than previous studies in the savannah zone of Nigeria.

The results further revealed the presence of bioactive compounds in sesame seeds. These compounds have positive dietary values to mankind.

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