EFFECTS OF NITROGEN AND PHOSPHORUS FERTILIZER RATES ON THE GROWTH AND YIELD OF SESAME (*Sesamum indicum L.*) IN THE SOUTHEASTERN RAINFOREST BELT OF NIGERIA

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ABSTRACT
Field experiments were conducted at Obubra in the forest belt of Southeastern Nigeria in 2004 and 2005 cropping seasons to study the effects of nitrogen and phosphorus fertilizer rates on the growth and yield of Sesame. In each year, the experiment was laid out as a factorial in a randomized complete block design (RCBD) with three replicates. Treatments comprised four levels each of nitrogen (0, 25, 50, and 75 kg N/ha) and phosphorus (0, 30 ,60 and 90 kg P_2O_5/ha). Nitrogen application up to 75 kg N/ha significantly ($P < 0.05$) increased sesame plant height, number of leaves per plant and shoot dry matter, while the application of 50 kg N/ha increased number of capsules per plant and seed yield. On the average, the application of 60 kg P_2O_5/ha significantly ($P < 0.05$) increased the number of leaves per plant, shoot dry matter, number of capsules per plant, number of seeds per capsule and seed yield. Combined application of 50 kg N/ha and 60 kg P_2O_5/ha gave the optimum sesame average seed yield of 1,295 kg/ha and is recommended.

Key words: Nitrogen, phosphorus, growth, seed yield, sesame, Southeastern Nigeria.

INTRODUCTION
Sesame or beniseed (*Sesamum indicum* L.) is cultivated in almost all tropical and sub tropical Asian and African countries for its highly nutritious and edible seeds (Iwo *et al.*, 2002). In Nigeria, it is cultivated in the derived, northern and southern guinea, Sudan and sahel savannah zones (Alegbejo *et al.*, 2003). The seeds serve as ingredient in soup and as a source of oil (43%) (Biswas *et al.*, 2001). The oil is used mostly in medicinal preparations including solvents (Upholf, 1968). Sesame is used as a pain relieving agent in the treatment of dysentery, diarrhoea, and ulcers and as an illuminant (Voh, 1998). It is used in local preparation of weaning food (Lalude and Fashakin, 2006). The seed may be eaten alone raw, roasted, fried, or pounded and mixed with sugar. The cake after oil extraction is used as cattle feed.

Sesame nutrition has remained very controversial for a long time. While most researchers were of the view that sesame does not require any fertilization, some believed that the crop needed to be fertilized. For many years sesame yields in Nigeria remained very low, about 300 kg/ha even under good environmental condition compared with 1960kg/ha in Venezuela, 1083 kg/ha in Saudi Arabia, 517 kg/ha in Ivory Coast and 510kg/ha in Ethiopia (Abubakar, *et al.*, 1998). Among the traditional beniseed growers in Nigeria, fertilizer application has not been a common practice. Survey reports indicate that fertilizer was not generally applied to sesame even in the main growing areas (van Rheenen, 1973). In contrast, reports of nutrition studies carried out elsewhere in the tropics have shown significant yield increases due to fertilizer application. Relatively higher yields were obtained upon the application of nitrogen and phosphorus fertilizers in India (Subramanian *et al.*, 1979). Rao *et al.*, (1994) and Schilling and Cattan (1991) reported similar increases in sesame yields from the application of nitrogen, phosphorus and sulphur in Burkina Faso. Voh, (1998) also reported that sesame responded positively to nitrogen and phosphorus fertilizers but not to potassium, and that the level of response to fertilizer was greatly influenced by the soil type.

Although knowledge of some agronomic practices for sesame in Southeastern Nigeria have been reported (Ojikpong *et al.,* 2007), information on fertility requirement of the crop is limited in the region. The need to fill the gap and provide necessary information on the nutritional requirements of sesame in southeastern agro ecology of Nigeria have led to the initiation of this present study. The purpose of the present investigation, therefore, was to determine the effects of nitrogen and phosphorus fertilizer application on growth and yield of sesame in Southeastern rainforest belt of Nigeria.

MATERIALS AND METHOD

The study was conducted in 2004 and 2005 cropping seasons at the Cross River University of Technology Research farm at Obubra, under rainfed conditions. Obubra is situated at longitude 8° 16′E and latitude 5° 59′ N with an altitude of 184 m above sea level. The 2005 experiment was conducted on a site that was 350 m from that of 2004. Soil and meteorological data of Obubra are shown in Table 1.

Each year, the experiment was planted on a fresh site that had been under fallow for two years and three years for the 2004 and 2005 experiments respectively. The land used for the experiment was slashed on 21 June, ploughed on 25 June, and harrowed on 26 June, 2004. In 2005, the land was slashed on 20 June, ploughed on 24 June and harrowed on 25 June while sowing was done on 28 June for 2004 and 2005. A composite soil sample was obtained from representative field locations and used for the determination of physico-chemical properties of the soil in the two seasons.

The experiment was a factorial laid out in a randomized complete block design (RCBD) with three replicates. Nitrogen rates were at four levels (0, 25, 50 and 75 kg N/ha while phosphorus rates were also at four levels (0, 30, 60 and 90 kg P_2O_5/ha). These formed 16 treatment combinations. Each plot size measured 3 m x 3 m (9 m^2). Sowing was done at a spacing of 30 cm x 10 cm, giving a total of 333,333 plants per hectare. Prior to sowing, dry river sand was thoroughly mixed with sesame seeds (Yandev 55) to ensure even spread of seeds before a pinch containing an average of 3 to 5 seeds was planted per hole and later thinned at 3 weeks after sowing (WAS) to maintain one plant per hole. The treatments (nitrogen and phosphorous fertilizers at various combinations) were applied at the appropriate doses in the plots at 4 WAS immediately after the first weeding. A blanket application of potassium fertilizer (K_2O) at the rate of 30 kg K_2O/ha was given to all plots. The crop was protected against insect pests and aphids in 2004 and 2005 by spraying at four weekly intervals with thionex insecticide at the rate of 1 l/ha.

Data for growth parameters were taken on plant height, number of branches per plant, number of leaves per plant and shoot dry matter per plant at 7 WAS from ten representative plants per plot. At full plant maturity (120 days after sowing) data on yield and yield components were taken on number of capsules per plant, number of seeds per capsule, and seed yield (kg/ha). The data obtained were subjected to analysis of variance (ANOVA) and significant differences among treatment means separated using Fisher's least significant difference (Gomez and Gomez, 1984).

RESULTS

The soil of the experimental site was sandy loam and acidic with soil pH of 4.7 in 2004 and 5.3 in 2005. The soil was low in N but moderate in P and K. The total rainfall for the period of June through November was 1558.0 mm in 2004 and 1459.9 mm in 2005 (Table1).

The effects of nitrogen and phosphorus application on plant height, number of leaves/plant and number of branches/plant are summarized in Table 2. Plant height increased significantly with incremental application of nitrogen up to 75 kg N/ha. Sesame plants attained heights of 102 cm in 2004 and 120 cm in 2005, respectively when nitrogen was applied at 75 kg N/ha while the height of 66 cm in 2004 and 68 cm in 2005 were recorded when no nitrogen was applied. Phosphorus fertilizer application also increased plant height with corresponding increases up to 90 kg P_20_5/ha. However, plants were taller in all cases where phosphate fertilizer was applied than where there was no phosphate application in 2004. Increasing phosphate rates beyond 30 kg P_20_5 did not significantly ($P>0.05$) produce further increases in plant height. The situation in 2005 was such that phosphate application at 90 kg P_2O_5/ha rate increased plant height over 30 kg P_2O_5 rate or where no phosphate was applied while 60 kg P_2O_5/ha rate increased plant height compared to no phosphate application.

All cases of applied nitrogen significantly increased the number of leaves per plant than where no nitrogen was applied while the application of 75 kg N/ha gave higher values than application of 25 or 50 kg N/ha in 2004. In 2005, however, application of 75 kg N/ha increased the number of leaves more than the no nitrogen application or the lower nitrogen rates of 25 and 50 Kg N/ha. Phosphorus application from 30 kg P_2O_5/ha to 60 kg P_2O_5/ha resulted in significant increases in number of leaves produced, beyond which no further increment occurred in 2004. The number of branches per sesame plant was significantly increased by the application of nitrogen up to 25 kg N/ha in both years. Increasing the level of nitrogen beyond the 25 kg N/ha rate did not produce any further significant increase in the number of branches produced. Similarly, in 2005 application of phosphorus fertilizer up to 30 kg P_2O_5 /ha resulted in significant increases in number of branches while the application of 60 or 90 kg P_20_5 /ha did not increase the number of branches over where 30 kg P_20_5 was applied.

Table 1: Soil properties of the sites and monthly rainfall for the experimental periods

	2004	2005
Mechanical properties of soil		
Sand (%)	63.80	63.80
Clay (%)	12.20	10.20
Silt (%)	24.00	26.00
Texture class	Sandy loam	Sandy loam
Chemical properties of soil		
O. M (%)	2.39	1.772
N (%)P (ppm)	0.10	0.098
K (meq./100g soil)	15.68	16.97
pH (H_20)	0.34	0.36
Monthly rainfall (mm)		
June	245.80	301.30
July	304.00	269.10
August	250.60	261.90
September	321.70	301.30
October	330.40	264.90
November	105.50	56.40
Total for the period	1558.00	1459.90

Table 2: Effects of nitrogen and phosphorus on plant heights, number of leaves and number of branches per plant of sesame at 7 weeks after sowing

Fertilizer Rate	Plant Height (cm)		Number of Leaves/Plant		Number of Branches/Plant	
N (kg/ha)	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
0	65.8	67.6	27.7	36.3	4.9	5.0
25	82.6	105.8	34.5	40.2	5.6	7.1
50	97.4	112.0	37.5	37.5	5.8	6.9
75	102.2	119.7	41.1	47.3	6.5	7.3
LSD (0.05)	9.81	10.11	4.6	7.8	1.14	1.40
P (kgP_2O_5/ha)						
0	75.3	88.8	32.1	35.7	5.2	5.6
30	86.4	99.8	34.1	38.5	5.4	6.3
60	92.6	105.9	39.2	45.0	6.1	7.0
90	93.8	110.1	35.3	42.2	6.1	7.3
LSD (0.05)	9.81	10.11	4.6	NS	NS	1.4

Shoot dry matter was significantly ($P<0.05$) increased with each successive increment in applied nitrogen up to 75 kg N/ha in both years (Table 3). On the average, dry matter at 75 kg N/ha was greater than the values at 0, 25, and 50 kg N/ha by 114, 49, and 39 percent, respectively. On the other hand, incremental application of phosphorus up to 60 kg P_2O_5/ha significantly ($P<0.05$) increased the accumulation of dry matter in the shoot in 2004. In 2005, however, application of phosphorus up to 30 kg P_2O_5 /ha increased shoot dry matter and beyond this fertilizer application rate, no further increases in dry matter occurred. Interactions between nitrogen and phosphorus significantly influenced shoot dry matter in 2005. All cases of applied phosphorus and 75 kg N/ha, or 90 kg P_2O_5 /ha and 50 kg N/ha gave the highest shoot dry matter yield. Except for the 25 kg N/ha rate without phosphorus, the lowest dry matter was produced when no fertilizer was applied or when nitrogen was applied without phosphorus and vice versa.

On the average, the number of capsules per plant increased significantly with incremental application of nitrogen up to 50 kg N/ha (Table 4). Increasing nitrogen above the 50 kg N/ha rate was accompanied with significant reductions, especially in 2005. The 50 kg N/ha gave the greatest number of capsules which was, on average, higher than values at 0, 25 and 75 kg N/ha by 76, 9 and 11%, respectively. Similarly, on the average, the number of capsules increased with incremental application of phosphorus up to 60kg P_20_5 /ha. Application of 90 kg P_20_5/ha did not result in increase in number of capsules compared to the application of 60 kg P_20_5 /ha. Combined application of 50 kg N/ha and 60 kg P_20_5 /ha gave the highest number of capsules, while the lowest values occurred with no fertilizer application or in situation where phosphorus was applied at the rate of 30 kg P_20_5 /ha or 60 kg P_20_5 /ha without nitrogen in 2005.

The effect of nitrogen on number of seeds per capsule was not consistent in both years (Table 5). In 2004, application of nitrogen beyond 50 kg N/ha significantly ($P<0.05$) reduced the number of seeds per capsule compared to the no nitrogen application. Incremental application of phosphorus up to 60 kg P_20_5 /ha significantly ($P<0.05$) increased the number of seeds harvested per capsule in 2005. The situation in 2005 was such that application of 60 kg P_20_5/ha increased the number of seeds more than zero nitrogen application whereas the application of 90 kgP_20_5/ha increased the number of seeds over zero or 30kg P_20_5/ha.

The interaction between nitrogen and phosphorus did not significantly ($P>0.05$) affect the number of seeds produced per capsule.

In 2004 and 2005, seed yield increased significantly ($P<0.05$) with incremental application of nitrogen up to 50 kg N/ha (Table 6). Increasing the nitrogen fertilizer rate beyond 50 kg N/ha resulted in significant yield depression by 24% in 2005. On average,

Table 3: Effects of nitrogen and phosphorus on shoot dry matter per plant of sesame at 7 weeks after sowing

	Nitrogen levels (kg N/ha)				
Phosphorus levels (kg P_2O_5/ha)	0	25	50	75	Mean
2004					
0	9.4	11.5	9.2	15.6	11.4
30	8.3	12.4	17.8	18.2	14.2
60	12.6	16.9	19.5	25.0	18.5
90	10.7	12.2	20.3	20.3	15.9
Mean	10.3	13.3	16.7	19.8	
2005					
0	8.5	18.4	8.7	13.3	12.2
30	8.3	17.0	10.3	27.2	15.7
60	10.8	11.7	13.7	25.5	15.4
90	10.0	13.0	21.7	24.0	17.2
Mean	9.4	15.0	13.6	22.5	

		2004	2005
LSD (0.05) for nitrogen (N) means	=	2.71	3.9
LSD (0.05) Phosphorous (p) means	=	2.71	3.9
LSD (0.05) N x P means	=	NS	7.8

Table 4: Effects of nitrogen and phosphorus on number of capsules per plant of sesame at maturity

	Nitrogen levels (kg N/ha)				
Phosphorus levels (kg P_2O_5/ha)	0	25	50	75	Mean
2004					
0	42.2	63.2	60.9	63.2	57.4
30	51.0	68.6	75.4	62.8	64.5
60	55.7	72.2	80.4	76.3	71.2
90	59.2	65.7	80.2	76.8	70.5
Mean	52.0	67.4	74.2	69.8	
2005					
0	43.3	84.7	100.0	111.7	84.9
30	54.7	117.0	117.7	84.0	93.4
60	57.7	118.0	135.7	109.3	105.2
90	77.7	120.7	125.3	111.7	108.9
Mean	58.4	110.1	119.7	104.2	

		2004	2005
LSD (0.05) for nitrogen (N) means	=	4.92	10.0
LSD (0.05) Phosphorous (p) means	=	4.92	10.0
LSD (0.05) N x P means	=	NS	20.0

seed yield obtained at 50 kg N/ha (1085 kg/ha) was higher than the yields at 0, 25, and 75 kg N/ha by 112, 43, and 15%, respectively. Similar to the results obtained for nitrogen application, increasing the phosphorus rate up to 6o kg P_2O_5/ha resulted in significant increases in seed yield in both years. Applying phosphate fertilizer above the 60kg P_2O_5/ha rate, did not result in further increment in yield. Average seed yield obtained at 60kg P_2O_5/ha was higher than the yield values at 0, 30, and 90 kg P_2O_5/ha by 32, 16, and 3%, respectively. Interactions between nitrogen and phosphorus fertilizers were significant on seed yield in 2005. The higher seed yield was produced with a combination of 50 kg N/ha and 60 kg P_2O_5/ha while the lowest seed yield was obtained when no fertilizer was applied or when phosphorus was applied at 30 and 60 kg P_2O_5/ha without nitrogen fertilizer.

Table 5: Effects of nitrogen and phosphorus on number of seeds per capsule of sesame

	Nitrogen levels (kg N/ha)				
Phosphorus levels (kg P_2O_5/ha)	0	25	50	75	Mean
2004					
0	55.1	59.3	61.7	47.5	55.9
30	65.5	63.3	59.0	58.7	61.6
60	66.3	64.6	72.0	65.2	67.0
90	64.7	65.7	64.9	63.2	64.6
Mean	62.9	63.2	64.4	58.7	
2005					
0	49.9	59.2	62.6	66.9	59.7
30	56.9	66.3	64.9	64.5	63.2
60	63.0	72.2	65.3	65.9	66.6
90	67.3	68.3	68.0	68.3	68.0
Mean	59.3	66.5	65.2	66.4	

		2004	2005
LSD (0.05) for nitrogen (N) means	=	3.9	5.0
LSD (0.05) Phosphorous (P) means	=	3.9	5.0
LSD (0.05) N x P means	=	NS	NS

Table 6: Effects of nitrogen and phosphorus on seed yield (kg/ha)

	Nitrogen levels (kg N/ha)				
Phosphorus levels (kg P_20_5/ha)	0	25	50	75	Mean
2004					
0	300	660	600	720	570.0
30	407	680	668	880	658.8
60	567	690	950	902	777.3
90	590	695	800	780	716.3
Mean	466.0	681.3	754.5	820.5	
2005					
0	456	750	895	1200	825.3
30	506	820	1320	1050	924.0
60	583	900	1640	1146	1067.3
90	682895	1806	895	1069.3	
Mean	556.8	841.3	1415.3	1072.8	

		2004	2005
LSD (0.05) for nitrogen (N) means	=	89.7	131.1
LSD (0.05) Phosphorous (p) means	=	89.7	131.1
LSD (0.05) N x P means	=	NS	262.2

DISCUSSION

Fertilizer application is an important option for farmers to adopt in order to improve crop yields in most soils of southeastern Nigeria partly because of the increased intensity of land use (Ikeorgu, 1999). The findings of this study showed that for optimum vegetative performance of sesame, higher doses of nitrogen are required, while for optimum seed yield much lower doses of the nitrogen element should be used. This observation agrees with the findings of Gasques *et al* (1979), Weiss (1983) and Ugbaja (1993) on castor plant. Nitrogen fertilization increased plant height and shoot dry matter as the level was raised up to 75 kg N/ha while sesame seed yield benefited from applied nitrogen only up to 50 kg N/ha. IAR (1985) similarly showed that Yandev 55 variety responded up to 50 kg N/ha in the Northern guinea savanna while Olowe and Busari (1996) reported sesame yield increases with applied nitrogen up to 60 kgN/ha in the southern guinea savanna.

The initial soil nitrogen of 0.098% obtained in the present study was below the critical value of 0.15% N reported by Chude *et al* (2004). Increasing the nitrogen level from 50 kg N/ha to 75 kg N/ha depressed average seed yield by 13% and led to excessive vegetative growth at the expense of seed production. This agrees with the findings of Relm and Espig (1991). The higher seed yields obtained with moderate application of nitrogen were associated with an increase in number of capsules per plant and number of seeds per capsule. These yield components were the main attributes determining the effects of nitrogen fertilization. The number of seeds is established around anthesis and is partially a response to the supply of assimilates (Andrade, 1995).

Phosphorus gave substantial increase in yield both alone and in combination with nitrogen in 2005. Seed yield was increased with phosphorus application but not beyond the rate of 60 kg P_20_5/ha. Results did not show any evidence that higher phosphate fertilization could be utilized to any advantage. The significant yield increase observed with increased phosphorus rate was consistent with the reports by Rao *et al* (1994) and Schilling and Cattan (1991). The initial soil available phosphorus levels of 15.68 ppm in 2004 and 16.97 ppm in 2005 were lower than the critical value of 25 ppm reported by Ibedu *et al*, (1988) and Chude *et al*, (2004). Weiss (1983) observed that over large areas of Africa, lack of phosphate was a major factor limiting crop production, and that even where there was no serious deficiency, an annual application at planting resulted in considerable yield increases. The attainment of optimum rate of phosphorus at 60 kg P_20_5/ha is a possible indication of low availability and its subsequent utilization by the crop under the condition of the experiment.

Overall, the results from this study showed that sesame seed yield responded to fertilizer application up to 50 kg N/ha and 60 kg P_20_5/ha. In research involving sesame in the northern guinea savanna, responses of up to 60 kg N/ha and 30kg P_20_5/ha have been reported (IAR, 1996) while responses of up to 80 kg N/ha and 13 kg P/ha (30 kg P_20_5/ha) have been reported by Rao *et al* (1994) in India. The high average seed yield of 1295 kg/ha obtained at the optimum fertilizer rates of 50 kg N/ha and 60 kg P_20_5/ha indicates that the soil was low in both nitrogen and phosphorus. Similar nitrogen by phosphorus interaction was found for rice yield (De Wit, 1992); Africa yam bean yield (Okpara and Omaliko, 1995) and sunflower yield (Zubillaga *et. al*, 2002). For both rice and sunflower, the positive effect of phosphorus was attributable to its effect on the uptake of nitrogen, so that fertilization with phosphorus could be considered disguised fertilization with nitrogen. Phosphorus fertilization has been shown to be favourable to root development in the early stages of plant growth when the nitrogen supply is still at a reasonable level (De Wit, 1992). Phosphorus is known to influence the availability of nutrients such as nitrogen (Cop and Hunter, 1967). Phosphorus application also increased photosynthetic rate and radiation use efficiency (Columb *et al*. 1995 and Rodriguez *et. al*, 1998).

In conclusion, under the conditions of this study sesame crop growth was increased with increased nitrogen application up to 75 kg N/ha while seed yield was increased up to the moderate rate of 50kg N/ha. Phosphorus fertilization increased seed yield with the application of up to 60 kg P_20_5/ha.

REFERENCES

Abubakar, S. S., Onyibe, J. E., and Tologbonshe, E. B. (1998). The role of extension research and information dissemination in enhancing beniseed production, marketing of resource poor farmers. Proceedings of the First National Workshop on Beniseed held at the National Cereals Research Institute, Badeggi, Nigeria, March 3-5, 1998. pp 86-99.

Alegbejo, M.D., Iwo, G.A., Abo, M.E. and Idowu, A.A. (2003). Sesame: A potential industrial and export oilseed crop in Nigeria. Journal of Sustainable Agriculture, 23 (1): 59-76.

Andrade, F. H. (1995). Analysis of growth and yield of maize, sunflower and soybean grown at Balcarce. Argentina Field Crops Res. 41:1-12.

Biswas, T.K., Sana, N.K., Badal, R.K. and Haque, E.M. (2001). Biochemical study of some oil seeds (Brassica, Sesame and Linseed). Pakistan Journal of Biological Sciences, 4 (8): 1002-1005.

Chude, V. O., Malgwi, I. V., Amapu, I. V. and Ano, A. O. (2004). Manual on Soil Fertility Assessment. Federal Fertilizer Department/National Special Programme for Food Security, Abuja, Nigeria. 48Pp.

Colomb, B; Bouniols, A. and Delpech, C. (1995). Effect of various phosphorus availabilities on radiation – use efficiency in sunflower biomass until anthesis. Journal of Plant Nutrition 18:1649-1658.

Cope, F. and Hunter, J. G. (1967). Interaction between nitrogen and phosphorus in Agriculture. Phosphorus in agriculture Bull. Doc. N0 46.

De Wit, C. T. (1992). Resource use efficiency in agriculture. Agricultural Systems 40:125-151.

Funnah, S. M. and Metasebula, N. (1984). Effect of density on grain yield of soybeans in Swaziland. Tropical Grain Legume Bulletin 29:33-35.

Gasques, J. G. Heiffig, N. L. and Souza, E. A. (1979). Economic analysis of fertilizer trails with castor. Cientifica 7 (1):59-62.

Gomez, K. A. Gomez, A. A. (1984). Statistical Procedures for Agricultural Research, 2nd Edition, John Willey and Sons, New York, 680 pp.

IAR, (Institute of Agricultural Research) (1976-96). Cropping Scheme Meeting Reports. Legumes and Oil Seeds Research Programme, IAR, Ahmadu Bello University, Zaria. pp. 18-29.

Ibedu, M. A., Unamma, R. P. A. and Udealor, A. (1988). Soil management strategies in relation to farming systems development in south eastern agricultural zone of Nigeria. Improved Agricultural Technologies for small scale Nigeria farmers. Proceedings of the National Farming Systems Research Network Workshop held in Jos, Plateau State, Nigeria May 10-13, 1988 pp. 342-358.

Ikeorgu, J. E. G. (1999). Cover crop research activities in Southeast Nigeria. In: Cover crops for natural resource management in West Africa. Proceeding of workshop organized by IITA and CIEPCA, 26-29 Oct., 1999, Cotonou, Benin.

Iwo, G.A., Idowu, A.A. and Ochigbo, A.A. (2002). Evaluation of sesame genotypes for yield stability and selection in Nigeria. Nigerian Agricultural Journal, 33: 76-82.

Lalude, L.O. and Fashakin, J.B. (2006). Development and nutritional assessment of a weaning food from sorghum and oil-seeds. Pakistan Journal of Nutrition, 5 (3): 257-260.

Ojikpong, T. O., Okpara, D. A. and Muoneke, C. O. (2007). Influence of four varieties of sesame on maize/sesame intercropping in the south eastern rainforest belt of Nigeria. Global Journal of Pure and Applied Sciences, 13 (4). In Press.

Okpara, D. A. and Omaliko, C. P. E. (1995). Effects of staking, nitrogen and phosphorus fertilizer rates on yield and yield components of African yambean. Ghana Journal of Agricultural Science 28-29:23-28.

Olowe, V. I. O. and Busari, L D (1996). Evolving optimum rates of nitrogen and phosphorus application for sesame in southern guina savannah of Nigeria. Tropical oil seeds Journal. In: Busari L.D. and Olowe, V.I.O. (1998). Research on sesame agronomy in Nigeria. First National Workshop on beniseed. Pp. 75-85.

Rao, V. P.; Raikhelkar, S. V.; Sondge, VD (1994). Effect of irrigation and fertilization on yield and its components in Sesame (*Sesamum indicum* L.) Indian J. of Agricultural Sciences (Indian Journal of Agricultural Science, 64 (2): 93-100.

Relm, S. and Espig. G. (1991). The cultivated plants of the tropics and subtropics. Verlag Josef Magrat Scientific books/CTA pp. 109.

Rodriquez, D., Zubillaga, M. M., Ploschuck, E., Keltjens, W., Goudriaan, J. and Lavado, R. (1998). Leaf area expansion and assimilate prediction in sunflower growing under low phosphorus conditions. Plant Soil 202:133-147.

Schilling, R. and Cattan, P. (1991). Sesame cultivation in tropical Africa. Oleagineux. 46: 129-131.

Subramanian, A, Sankaran, S. and Kulandadaivehi, R. (1979). Yield response of sesame (*Sesamum indicum* L.) to nitrogen fertilizer application. Indian Agriculturist, 23: 43-48.

Thangavelu, S. (1992). Brief Review of Sesame Network. Proceedings of a Steering Committee and Workshop on Oil Crops (Ed. L. A. Navaro) Nairobi, Kenya, August 11-14, pp. 60-66.

Ugbaja, R. A. E. (1993). Optimum rates of N, P and K fertilizers for castor seed production in the derived savanna zone of southeastern Nigeria. Journal of Science and Technology 1:87-94.

Van Rheenen, H. A. (1973). Major problems of growing sesame in Nigeria. Communications of Agricultural University, Wageningen, Holland. Pp. 130.

Voh, J. P. (1998). An overview of beniseed research and production in Nigeria and prospects for increased production first national W/S on Beniseed March 3-5 1998 18-29.

Weiss, E. A. (1971). Castor, Sesame and Safflower. Leonard Hill, London. 901 Pp.

Weiss, E. A. (1983). Sesame. In: Oil seed crops. Longman. London, pp. 2833-340.

Zubillaga, M. M., Aristi, J. P. and Lavado, R. S. (2002). Effect of phosphorus and nitrogen fertilization on sunflower nitrogen uptake and yield. Journal of Agronomy and Crop Science 188: 267-274.