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ASSESSMENT OF GENETIC DIVERSITY IN NIGERIAN SESAME USING PROXIMATE ANALYSIS

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ABSTRACT
Seeds from twenty three sesame sample (*Sesamum indicum* L.) obtained from different locations in 10 states across Nigeria was accessed using evidences from proximate composition with a view to studying their genetic diversity. The plants were grown in 2008 and 2009 at the Research Garden of the Biological Sciences Department, Kogi State University (KSU), Anyigba, Nigeria to eliminate variations induced by environmental differences. Seeds of each accession were harvested and broadcast in separate perforated 5L plastic bucket filled with sandy loam soil and each bucket was later replicated five times. The experimental design adopted was the Complete Randomized Design (CRD). Each plant stand was thinned to one seedling per pot two weeks after transplanting. Seeds of each accession were composited after harvest and analyzed for the protein, oil, fibre, ash, moisture and carbohydrate contents according to the Official methods of Associations of Analytical Chemists (AOAC, 1990). Data pooled on each proximate attribute in triplicate were subjected to Analysis of Variance (ANOVA) and means with significant differences were separated using the Duncan Multiple Range Test (DMRT) statistical methods and cluster analysis. The results revealed that the entire six proximate components studied show significant variation among the different sesame genotypes which implies that genetic diversity exists among Nigerian sesame. Cluster analysis result separated the black seeded sesame from the other sesame accessions. It is therefore recommended that sesame genotypes should be selected from different geographical areas in Nigeria to maximize the genetic diversity available for the improvement of proximate composition.

KEY WORDS: genetic, diversity, proximate, *Sesamum indicum,* sandy loam.

INTRODUCTION

Sesame according to Falusi, (2007) is widely grown in Northern and Central Nigeria between latitude 7 – 14^{0}N and with an annual rainfall of about 1000 – 1500mm. In the opinion of United States Agency International Development, (2002) sesame production in Nigeria probably began in the middle belt region of the country and later spread out between latitudes 6^0 and 10^{0}N covering the derived Southern and Northern Guinea Savanna, Sudan Savanna and Sahel vegetation zone. The major beniseed producing states in Nigeria are Adamawa, Benue, Borno, Gombe, Kogi, Jigawa, Kano, Nasarawa, Katshina, Kaduna, Plateau, Yobe, Zamfara, Taraba, Kebbi, Sokoto, Cross River and Federal Capital Territory, Abuja (RMRDC, 2004).Sesame is an important oil seed crop world-wide, and it yields high quality edible and odourless oil that serve as a good source of protein and fat for humans and livestock (Adebisi *et al*., 2005). The protein content of sesame seeds ranges from 20 to 30% and the protein is high in tryptophan and methionine (IPGRI, 2004). This unique protein composition makes sesame an excellent protein supplement for soybeans, peanuts and other protein sources that lack sufficient methionine (RMRDC, 2004). According to Akinoso *et al.,* (2006) sesame seeds contain high amount of vegetable oil like soybean, cottonseed, groundnut, sunflower, rape seed and melon seeds. The oil has high nutritive value and is used in baking (El-Nakhlawy and Shaheen, (2009).Young and succulent sesame leaves are chopped into pieces and cook as vegetable soup. This preparation serves as a substitute for okra especially during scarcity of fresh okra (NAERLS, 2004). USAID, (2002) reported that dried stem may be burnt to provide fuel with the ash used for producing local soap, but such uses are entirely subordinate to seed production. Enikuomehin, (2005) gave the nutritional composition of sesame seeds as oil (50 – 52%), Protein (17 – 19%) and Carbohydrates (16 – 18%). Sonia, (2003) reported that the plasticity of individuals may influence the patterns of evolutionary diversification at the population (and ultimately species) level by precluding selective divergence in environmentally distinct site. Therefore, all organisms express some degree of responses to the environment. Although closely related species may share patterns of plasticity for certain traits, they may also differ in the amount, direction and timing of plastic response to a given environmental factor (Edmund *et al.,* 2004). However, functionally adaptive plasticity is of particular interest because it permits individual genotypes to successfully grow and reproduce in several different environments. Consequently, such plasticity can play a major role in both the distribution of organisms and their patterns of evolutionary diversification. Alege *et al.,*

(2011) reported significant genetic diversity among three species of sesame from Nigeria using morphological markers. Akinoso *et al.,* (2006) also reported that the oil content varies with genetic and environmental factors. So far, studies carried out on characterization of different sesame accessions have focused on using markers other than proximate traits. Study on the characterization of sesame using seed proximate composition is non- existing to the best of our knowledge. Abel (2007) stated that characterization of plants based on seed proximate composition could be used to classify and assess the genetic relationship among plant populations. In addition, it serves as a bench mark for the identification of potential parents for breeding programme. The aim of this study therefore is to characterize representatives of Nigerian sesame genotypes from different locations using proximate composition.

MATERIALS AND METHODS

Seed Source and Planting

Seeds of twenty three accessions of sesame which comprised of eighteen traditional and five improved accessions were obtained from 10 states in North-West, North-East, North-Central and South-West regions of Nigeria between September to November in 2007 when farmers were expected to harvest the crop. The seeds were collected, packed and sealed in paper envelops, each of which was given a collecting code. A brief description of the sesame accessions used for this study is shown in Table 1.

The field trial was conducted in 2008 and 2009 at the research garden of the Biological Sciences Department of Kogi State University (KSU), Anyigba, Nigeria located between latitude $8^0$43′ and $9^0$5′ south of the equator and between $6^0$6′ and $7^0$45′ west of the meridian. Field trial was carried out to multiply the seeds and eliminate variations induced by environmental differences. Seeds of each accession were harvested and broadcast in separate perforated 5L plastic bucket filled with sandy loam soil and each bucket was later replicated five times. The experimental design adopted was the Complete Randomized Design (CRD). Watering was carried out appropriately until seedlings were fully established. Two seedlings were transplanted into each pot and later thinned to one seedling per pot two weeks after transplanting. Seeds of each accession were composited after harvest and analyzed for the protein, oil, fibre, ash, moisture and carbohydrate contents.

TABLE 1: Brief Description of the 23 Sesame accessions used for the Study.

Accession Numbers	Accession Names	Sample Sources (States)	Geopolitical Zones	Brief Morphological Description of Samples at their Collection centre
1	*03M	Badeggi (Niger)	North Central	Stem erect, green branched, whitish pink flower with light brown seeds.
2	*E8	Badeggi (Niger)	North Central	Stem erect, green branched, whitish pink flower with light brown seeds.
3	*01M	Badeggi (Niger)	North Central	Stem erect, green branched, whitish pink flower with light brown seeds.
4	*02M	Badeggi (Niger)	North Central	Stem erect, green, branched, whitish pink flower with light brown seeds.
5	*EXSUDAN	Badeggi (Niger)	North Central	Stem erect, green, branched, whitish pink flower with light brown seeds.
6	IBA I	Ibadan (Oyo)	South West	Stem erect, green, branched, whitish pink flower with dark brown seeds.
7	IBA II	Ibadan (Oyo)	South West	Stem erect, green, branched, whitish pink flower with light brown seeds.
8	OKE I	Okene (Kogi)	North Central	Stem erect, green, branched, whitish pink flower with light brown seeds.
9	YOL I	Yola (Adamawa)	North East	Stem erect, green, branched, whitish pink flower with light brown seeds.
10	MAI I	Maiduguri (Borno)	North East	Stem erect, green, branched, whitish pink flower with dark brown seeds.
11	KAN III	Kano (Kano)	North West	Stem erect, green, branched, whitish pink flower with white seeds.
12	KAN II	Kano (Kano)	North West	Stem erect, green, branched, whitish pink flower with light brown seeds.
13	KAN I	Kano (Kano)	North West	stem erect, green, branched, whitish pink flower with light brown seeds.
14	MAK I	Makurdi (Benue)	North Central	Stem erect, green, branched, whitish pink flower with light brown seeds.
15	OUT	Otukpo (Benue)	North Central	Stem erect, green, branched, whitish pink flower with light brown seeds
16	ZAR I	Zaria (Kaduna)	North Central	Stem erect, green, branched, whitish pink with dark brown seeds
17	ANY I	Anyigba (Kogi)	North Central	Stem erect, green, branched whitish pink flower with light brown seeds
18	ANY II	Anyigba (Kogi)	North Central	Stem erect, green, branched, whitish pink flower with dark brown seeds
19	OKE II	Okene (Kogi)	North Central	Stem erect, green, branched, whitish pink flower with dark brown seeds
20	ILO I	Ilorin (Kwara)	North Central	Stem erect, purple, branched, purple flower with black seeds.
21	ILO II	Ilorin (Kwara)	North Central	Stem erect, purple, profusely branched, pink flower, black seeds
22	OFF I	Offa (Kwara)	North Central	Stem, erect, green, branched, pink flower, black seeds
23	JAL I	Jalingo (Taraba)	North East	Stem, erect, green, branched, whitish pink flower with light brown seeds

*Improved sesame genotypes.

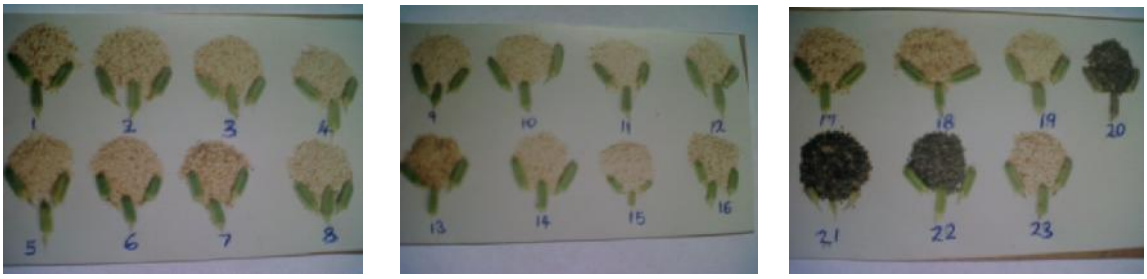
Proximate Components Studied

Approximately 30g of seed from each accession was ground in centrifuge with 0.5 sieves and analyzed in triplicate. Data were recorded for six seed quality traits, namely; crude protein, crude fat/oil, fibre, mineral ash, moisture and carbohydrate contents. Proximate analysis was carried out according to the Official methods of Associations of Analytical Chemists (AOAC, 1990).

The seed's crude protein content was determined by using 0.25g of sample and measuring the nitrogen released using Kjeldah method. Then percentage of Nitrogen obtained was multiplied by a factor 5.4. Crude fat/oil content was determined by extracting 3g of each sample with Petroleum Benzene on Sohxlet extraction unit. Fibre content in seed samples was measured as crude fibre, determined by the loss in mass upon ignition of the dried residue remaining after 1g of the sample has been digested with dilute tetraoxosulphate VI acids and potassium hydroxide. Moisture content was determined by taking 2g sample and putting it in an oven at 103^0C for seventeen hours and then, taken out of the oven, cooled in discketer and weighed after a while. Finally, the carbohydrate

content of the samples was calculated by difference carbohydrate = 100 – (Protein + Fat + Mineral + Moisture). All proximate compositions were analyzed and calculated on dry weight basis (dwb). Data pooled on each proximate attribute (in triplicate) were subjected to Analysis of Variance (ANOVA) and means with significant differences were separated using the Duncan Multiple Range Test (DMRT) statistical methods and hierarchical cluster analysis.

RESULTS



A B C

FIGURE 1 A-C: The photographs of the seeds and pods of the 23 sesame samples studied.

Table 2 shows the result of the proximate composition of the 23 sesame accessions. The least oil content was found in ILO II (24.30%) while the highest content was recorded for IBA II (58.85%). The least ash content was found in IBA II (2.32%) while ILO II had the highest ash (16.25%). The least moisture contents were found in MAI I, KAN III, KAN I and OKE II (0.25%) while the highest moisture content was found in IBA II (3.00%). The least protein content was recorded in KAN I (4.54%) while the highest protein contents was found in ANY II (25.11%). The least fibre content was found in KAN II (5.20%) while the highest fibre content was found in IBA II (49.02%). OFF I had the least carbohydrate content (4.47%) while the highest carbohydrate contents were found in KAN I (30.85%).

TABLE 2: MEANS AND DUNCAN MULTIPLE RANGE VALUES FOR MEASUREMENTS ON THE PROXIMATE CHARACTERISTICS FOR THE 23 SASAME SAMPLES.

ACCESSION NUMBER	ACCESSION NAME	OIL (%)	ASH (%)	MOISTURE (%)	PROTEIN (%)	FIBRE (%)	CARBOHYDRATE (%)
1.	03M	51.65^{cdef}	4.00^{cdef}	2.22^{gh}	17.50^{cdef}	7.75^{bcd}	16.88^{defg}
2.	E8	50.88^{cdef}	5.00^{fgh}	1.75^{fgh}	16.63^{bcd}	9.25^{cdef}	16.49^{defg}
3.	01M	52.38^{cdefg}	2.68^{bcd}	0.50^{bc}	21.38^{def}	7.50^{bcd}	15.56^{defg}
4.	02M	48.76^{cdef}	4.00^{cdef}	1.50^{fg}	14.04^{bcd}	8.21^{bcde}	23.49^{efgh}
5.	EXSUDAN	48.63^{cdef}	4.00^{cdef}	1.00^{de}	19.01^{def}	7.21^{abc}	20.15^{fgh}
6.	IBA I	34.39^{bcd}	2.78^{bcd}	0.75^{cd}	7.61^{abc}	49.02^{l}	13.45^{cdef}
7.	IBA II	58.85^{h}	2.32^{a}	3.00^{hi}	15.01^{bcd}	7.40^{abc}	13.42^{cdef}
8.	OKE I	48.77^{cdef}	4.25^{def}	1.25^{ef}	12.91^{bc}	11.52^{bcd}	21.30^{efgh}
9.	YOL I	48.38^{cdef}	2.64^{bcd}	0.50^{bc}	21.55^{def}	14.43^{def}	12.50^{cdef}
10.	MAI I	50.52^{cdef}	3.00^{bcdef}	0.25^{ab}	20.79^{def}	9.70^{efg}	15.74^{defg}
11.	KAN III	53.50^{cdefg}	5.00^{fgh}	0.25^{ab}	19.22^{def}	6.70^{abc}	15.33^{defg}
12.	KAN II	53.35^{cdefg}	5.75^{gh}	0.75^{cd}	19.02^{def}	5.20^{abc}	15.24^{defg}
13.	KAN I	42.89^{cd}	15.75^{lm}	0.25^{ab}	4.54^{ab}	5.72^{abc}	30.85^{i}
14.	MAK I	53.23^{cdefg}	5.00^{fgh}	0.50^{bc}	15.71^{bcd}	8.71^{bcde}	16.85^{defg}
15.	OTU	49.63^{cdef}	4.50^{efgh}	0.50^{bc}	15.71^{bcd}	12.32^{def}	17.34^{defgh}
16.	ZAR I	51.95^{cdef}	9.66^{jk}	1.75^{fgh}	16.67^{bcd}	6.59^{abc}	13.38^{cdef}
17	ANY I	53.02^{cdefg}	3.00^{bcdef}	1.50^{fg}	16.25^{bcd}	7.04^{abc}	19.19^{efgh}
18.	ANY II	48.98^{cdef}	5.00^{fgh}	1.00^{de}	25.11^{fg}	9.64^{cdef}	10.27^{bcd}
19.	OKE II	52.39^{cdef}	4.25^{def}	0.25^{ab}	17.55^{cdef}	17.45^{fgh}	8.11^{abc}
20.	ILO I	37.75^{bc}	10.50^{k}	2.75^{ghi}	12.74^{bc}	29.00^{ijkl}	7.26^{abc}
21.	ILO II	24.30^{a}	16.25^{m}	2.75^{ghi}	11.72^{bc}	27.01^{ijkl}	17.97^{defgh}
22.	OFF I	37.94^{bc}	9.01^{ij}	2.00^{gh}	16.04^{bcd}	30.54^{jkl}	4.47^{a}
23.	JAL I	51.75^{cdef}	4.50^{efgh}	0.75^{cd}	19.76^{cdef}	6.25^{abc}	16.99^{defg}
SIG.		S	S	S	S	S	S

The Hierarchical Cluster Analysis showed that the bulk of the genotypes clustered into two major groups (figure 2). The first cluster comprised of all the twenty brown seeded accessions from different locations all over Nigeria while

the three black seeded accessions from Kwara State occupied the 2nd cluster. In cluster I, the first sub-cluster (A) consists of four genotypes which includes accessions 11 (KAN III), 23 (JAL I), 12 (KAN II) and 13 (KAN II). The second sub-cluster (B) comprised of seven accessions with three groups under it. The first group is made up of accessions 10 (MAI I), 9 (YOL I) and 17 (ANY I) while accession 18 (ANY II) and 19 (OKE II) both occupied the same group. The last group includes accessions 8 (OKE I) and 16 (ZAR I). The third sub-cluster (C) comprised of three accessions which are improved accessions from Badeggi in Niger State. These accessions are 4(02M), 5(EXSUDAN) and 3 (01M). The fourth sub-cluster (D) included six genotypes with the two remaining improved accessions 1 (03M) and 2 (E8) occupying the same group while accessions 7 (IBA II) and 15 (OTU) occupied the 2nd group .The 3rd group comprised of accessions 6 (IBA I) and 14 (MAK I). Cluster II comprised of only one sub-cluster (sub-cluster E) which includes the three black seeded accessions from Kwara state i.e.20 (ILO I), 22 (OFF I) and 21 (ILO II) (Table 1, Figure 1 and 2).

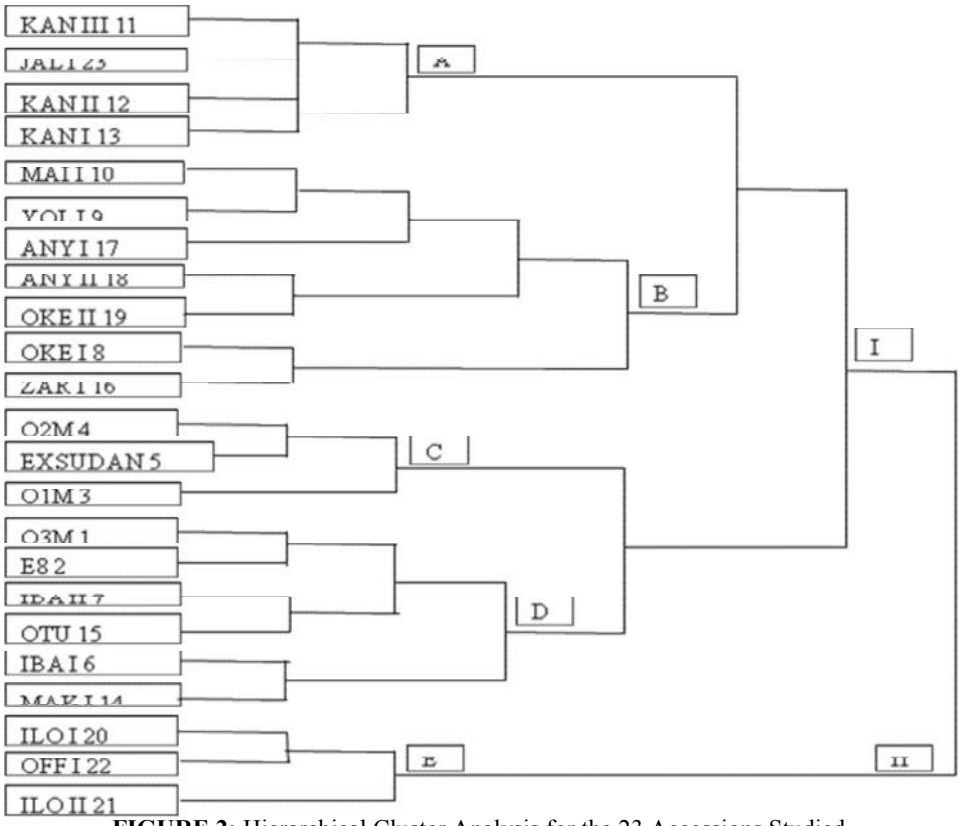


FIGURE 2: Hierarchical Cluster Analysis for the 23 Accessions Studied

DISCUSSION

The variations based on the genetic make-up of the organisms according to Alege *et al.,* (2011) are more reliable than variation induced by changes in environmental factors. The fact that the seeds of the twenty three sesame genotypes used for this study were obtained from different places points to the fact that they must have been harvested from environments with different climatic, cultural and edaphic factors. The initial level of differences among the twenty three sesame plants, therefore, may have been exaggerated by variation in the conditions of their places of cultivation. This will, no doubt, make some of these differences to be genetically important. Since this study has eliminated the environmentally induced variation by bringing the twenty three sesame plants into cultivation under the same environmental factors for two seasons, any character that now shows significant variation is most likely to have genetic impact on the plants.

All the 6 proximate characteristics studied show significant differences among the 23 sesame genotypes. These characteristics are crude oil, mineral ash, crude fibre, protein and carbohydrate (Table 2). This finding indicates that the studied sesame accessions displayed some degree of genetic diversity for seed proximate composition. According to Abel (2007), proximate analysis is widely accepted as a basis for nutritional evaluation of seeds and in addition to that, it helps to group seeds according to their seed chemical composition, similarity and relationship. That this proximate traits showed significant difference among the studied sample is an indication that there are genetic diversities and selection placed on any of these characteristics will lead to seed composition improvement in Nigerian sesame. Abel (2007) opined that since most plant breeding methods

(both traditional and modern) have the potential to alter the nutritional value of plants, they may lead to unexpected or unintended changes in the chemical composition of plants. The proximate result obtained in this study is consistent with the reports from previous researchers. For example, 51.2% oil content reported by Nweke, *et al.,* (2012) on improved sesame genotype E8 was in line with the 50.9% observed on the same genotype in this study. But there exists a little discrepancy between the nutritional composition of sesame seeds of Oil (50 – 52%), Protein (17 – 19%) and Carbohydrates (16 – 18%) reported by Enikuomehin,(2005) and the Oil (24 – 58.85%), Protein (4.54 – 25.11%) and Carbohydrates (4.47 – 30.85%) observed in this study.

4 out of the 6 proximate traits studied put accession 11 (KAN III) and 12 (KAN II) together in the same group. These attributes are crude fat/ oil, crude fibre, protein and carbohydrate contents. This finding indicates that these two accessions have similar gene control for the expression of these proximate attributes.

The clustering of all the 3 black-seeded accessions (i. e 20 (ILO I), 21 (ILO II) and 22 (OFF I) (as revealed in table 1, figure 1and 2) and the lesser crude oil, protein and carbohydrate contents of the black seeded sesame samples (i.e ILO I, ILO II and OFFI) with their relatively high mineral ash, fibre and moisture contents might be because the 3 accessions were used mainly for their leaves (vegetable leaves) and not the seeds. Therefore, selection is placed on the leaves more than the seeds at the place of collection (Ilorin and Offa in Kwara State). According to Abel (2007) the same populations of domesticated crop species from different geographical origins show selective pressure in a particular environment and less selective pressure in other environment. Also, USAID (2002) reported that cultivated sesame is highly variable due to geographical differences across different locations. This therefore leads to an enormous diversity in sesame landraces.

Cluster analysis grouped the 23 sesame accessions studied into 2 main clusters and 5 sub-clusters (Figure 2). This observation indicates the presence of genetic diversity and can therefore be used to maximize the expression of heterosis among the studied sesame. In most cases, accession with the same place of origin or adaptation zone cluster together in the same group, for example in sub-cluster A, accessions 11 (KAN III), 12 (KAN II) and 13 (KAN I) were from Kano while in sub-cluster B, accessions 17 (ANY I) and 18 (ANY II), 8 (OKE I) and 19 (OKE II) cluster together in the same group. Accessions in sub-cluster C are improved varieties from Badeggi in Niger state while the remaining 2 improved accessions occupied the same group in sub-cluster D with accessions 6 (IBA I) and 7(IBA II) grouped together in the same sub-group. Also, accessions 14 (MAI) and 15 (OTU) in sub-cluster D came from the same adaptation zone (Benue State). The 3 black-seeded samples i.e. accessions 20 (ILO I), 21 (ILO II) and 22 (OFF I) among the 23 sesame genotypes studied clustered together alone in group E. Coincidentally, the 3 genotypes were from the same adaptation zone (Kwara). All these observations imply that genetic divergence in this crop has followed geographical separation as a result of long period of cultivation as landraces in each zone. This agrees with the report of Unal and Yalcin (2008) who stated that hundreds of local sesame varieties and their ecotypes have adapted well to their specific environmental conditions. Also Pham *et al.,* (2010) stated that sesame from different continent clustered according to their geographic origins while Kim *et al.,* (2001) reported similar result on improved sesame in Korea. The possible reason for this might be because as different accessions are trying to adapt to different environmental pressures, accessions from the same adaptation zones (origin) evolved similar genes and are therefore similar phylogenetically. This further confirms the earlier report of Alege *et al.,* (2011) that Nigerian sesame is still undergoing evolution.

The cluster analysis (Figure 2) also revealed some random placing of samples within sub-clusters, for example accessions 7 (IBA II) and 15(OTU) occupied the sub-cluster (sub-cluster D) which indicates that sesame accessions failed to group strictly base on their place of origin or adaptation zones. This implies that there might be possible seed flow via market exchange or more specifically, there are gene flows among some regions. This finding supported the report of Falusi and Salako (2001) who stated that sesame collections from some States in Nigeria were replicated over states, local government and villages.

CONCLUSION AND RECOMMENDATION

The study on twenty three representatives of Nigerian sesame using evidence from proximate composition indicates that genetic variability exists among Nigerian sesame. Therefore Nigerian sesame had a common evolutionary relationship but some accessions have adapted well to their local environments through gene rearrangement due to long periods of cultivation, making them to become ecotypes. There is ample opportunity for sesame breeders to develop improved varieties if programmed selection and hybridization procedures are annexed on the sesame accessions used for this study. This study has actually enlarged sesame gene pool in Nigeria. Selecting sesame genotypes from different geographical areas will maximize the genetic diversity available for the improvement of proximate composition of Nigerian sesame.

REFERENCES

Abel, T.G. (2007) Diversity study on seed quality traits of Ethiopian mustard (*Brassica carinata* A. Braun) among seed samples selected from Oromiya regional state, Ethiopian assessed by proximate analysis. M.Sc Thesis submitted to Addis Ababa University, Addis Ababa, 67Pp.

Adebisi, M.A., Ajala, M. O., Ojo, D.K. and Salau, A.W. (2005) Influence of population density and season on seed yield and its components in Nigerian sesame genotypes, *J. of Trop. Agric*., 43 (1- 2): 13 -18.

Alege, G.O., Akinyele, B.O., Ayodele, S. M. and Ogbode, A.V. (2011) Taxonomic Importance of the Vegetative and Pod Characteristics in Nigerian Species of Sesame, *African Journal of Plant Science, 5 (3)*: 213-317.

Akinoso, R., Igbeka, J.C. and Olayanju, T.M.A. (2006) Process optimization of oil expression from Sesame seed (*Sesamum indicum* Linn). *The CIGR EJournal, 8:*1 – 7.

AOAC (1990) Official Methods of Analysis, Association of Official Analytical Chemists, 15th Edition, Washington, D.C, U.S.A. 87Pp.

Edmund, W.S., Dunn, L.C. and Dobzharisky, T. (2004) Principles of Genetics. 5th ed. Tata Mc Graw Hill editions, 459Pp.

El-Nakhlawy, F.S. and Shaheen, M.A. (2009) Response of seed yield, yield components and oil content to the sesame cultivar and nitrogen fertilizer rate diversity, *Electronic Journal of Environmental, Agricultural and Food Chemistry, 8(4):*287 – 293.

Enikuomehin, O.A. (2005) *Cercospora* leaf spot disease management in sesame (*Sesamum indicum* L.) with plant extracts. *Journal of Tropical Agriculture, 43(1 – 2):*19 – 23.

Falusi, A.O. (2007) Segregation of genes controlling seed colour in sesame (*Sesamum indicum* L.) from Nigeria, *African Journal of Biotechnology, 6(24):*2780 – 2783.

Falusi, A.O. and Salako, E.A. (2001) Assemblage of Sesame germplasm for conservation and genetic improvement in Nigeria. *Plant Genet. Resources Newsletter, 127:*25 – 38.

International Plant Genetic Resources Institute (2004) Descriptors for sesame (*Sesamum spp*) the International Plant Genetic Resources Institute, Rome, Italy: IPGRI.

Kim, D .H, Kashi, Y, Zur, G,Poleg, Y. D, Lee, S . W, Shim, K. B and Kang, C. W (2001) Genetic relationships among Sesame (*Sesamum indicum*. L) accessions using inter-simple sequence repeat (ISSR) markers, *Korean Journal of Breeding,* 33 (4): 257-269.

National Agricultural Extention and Research Liaison Services (2004) Beniseed production and utilization in Nigeria. National Agricultural Extention and Research Liaison Services, Ahmadu Bello University, Zaria.

Nweke, N.F, Ubi, E. B and Kunert, K. (2012) Application of microsatellite polymorphisms to study the diversity in seed oil content and fatty acid composition in Nigerian sesame (*Sesamum indicum* L.) accessions, *African Journal of Biotechnology*, 11(36): 8820-8830.

Pham, T.D, Nguyen, T.T, Carlsson, A.S and Bui, T.M. (2010) Morphological evaluation of sesame (*Sesamum indicum* L.) varieties from different origins. *Aus. J. of Crop Sci*., 4(7): 498-504.

Ram Materials Research and Development Council (RMDC) (2004) Survey report of ten selected agro raw materials in Nigeria, Raw Materials Research and Development Council, Abuja, Nigeria, 89Pp.

Sonia, E.S. (2003) Phenotypic plasticity in plants: a case study in ecological development. *Evolution and Development, 5(1):*25 – 33.

The United States Agency for International Development (2002) Overview of the Nigerian sesame industry. The United States Agency for International Development Nigeria, Chemonics International Inc, Washington DC: USAID.

Unal, M.K. and Yalcin, C.H. (2008) Proximate composition of Turkish sesame seeds and characterization of their oils. *GRASAS ACEITES, 59 (1):* 23 – 26.