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Phytochemical Studies and Genetic Diversity in Sesame (*Sesamum indicum* L.)

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Abstract— **Assessment of genetic diversity and correlation coefficient analysis were carried out on 23 genotypes of sesame (*Sesamum indicum* L.) obtained from different parts in 10 states across Nigeria based on the nature of their phytochemicals. The plants were grown in 2011 and 2012 at the Research Garden of the Department of Biological Sciences, Kogi State University, Anyigba, Nigeria using a Completely Randomized Design (CRD). Extracts from the seeds were screened for phenolics, saponin, alkaloid, flavonoid, tannin, phytate and oxalate. Data obtained were subjected to Analysis of Variance (ANOVA) and means separated using the Duncan Multiple Range Test (DMRT). The results revealed high genetic diversity among the 23 sesame genotypes and showed that the phenolic contents had negative correlation with tannin while flavonoid had positive correlation with saponin and alkaloid. The information provided by this research will help breeders in future breeding programmes to develop improved varieties of sesame.**

***Index Terms*— Sesame, phytochemicals, genetic diversity, correlation coefficient.**

I. Introduction

SESAME (*Sesamum indicum* L.) is an important seed crop whose oil is desirable commercially and nutritionally. This plant is highly grown in the tropical and sub tropical regions (Azeez and Morakinyo, 2009). The success of an improvement programme for a crop essentially depends on the nature and the degree of variability in the attributes of that crop (Sumathi and Muralidharan, 2010). Heritability of a trait influences the selection programme to a larger extent. Thus, gain from selection for a particular character is a function of its heritability, selection pressure and the variability existing in the base population (Parameshwarappa *et al.,* 2009). Correlation studies, according to Azeez and Morakinyo (2009), provide reliable information on the nature, extent and direction of selection. Parameshwarappa *et al.* (2009) reported that information on the association of plant characters is of great importance to breeders for selecting desirable genotypes.

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Sesame seeds are used in baking and making candy while its oil, in addition to cooking, is used in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides (Atungwu *et al.* 2003). Many nutraceuticals have been discovered from sesame. For instance, Cooney *et al.* (2001) reported that sesame oil contains pharmaceutical acid used as solvent for intra-muscular injections and has nutritive, demulcent, emollient and laxative properties. This oil, according to Morris (2002), was used during the 4th Century by the Chinese as a remedy for toothaches and gum disease. Sesame oil is known to reduce cholesterol due to its high polyunsaturated fat content. Other uses of the oil include the treatment of blurred vision, dizziness and headaches. The Indians have used sesame oil as an antibacterial mouthwash to relieve anxiety and insomnia (Khan *et al.,* 2007). Other ethno botanical importance of sesame as reported by Odugbemi (2006) includes serving as remedies for cancer, cold, colic, impotency, malaria and dysentery. Momoh *et al.* (2012) reported that in Nigeria, the leaves and roots of sesame plant are used for treating migraine, hypertension, ulcer, constipation, chicken pox and pile.

Despite the aforementioned ethno-botanical and medicinal importance of sesame, Anilakumar *et al.* (2010) stated that sesame has not received adequate attention from the research world and that research into its phytochemical composition has been limited. This study, therefore, aims to partly address this information dearth by investigating the phytochemical constituents of some Nigerian sesame accessions with a view to revealing their genetic diversity and the degrees of association among their phytochemicals.

II. Materials and Methods

A. *Seed Source and Planting*

Seeds of 23 accessions of sesame, comprising eighteen traditional and five improved accessions were obtained from 10 states in the North-West, North-East, North-Central and South-West regions of Nigeria between September to November, 2010 at harvest season. The seeds were packed and sealed in paper envelops and labeled appropriately. A brief description of each sesame accession is shown in Table 1.

The field trials were conducted in 2011 and 2012 at the research garden of the Department of Biological Sciences, 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 trials were carried out to multiply the seeds and eliminate variations induced by environmental differences. Seeds of each accession were harvested and broadcast in a separate 5L plastic bucket that was perforated at the lower end and

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filled with sandy loam soil. The set-up was then placed in the nursery and watered regularly. When seedlings were fully established, two seedlings of each genotype were transplanted into a 5L plastic bucket and replicated five times. The experimental design adopted was the Completely Randomized Design (CRD). The seedlings were later thinned to one seedling per bucket two weeks after transplanting. Seeds of each accession were composited after harvest and screened for phytochemical constituents.

B. Phytochemical Analysis

Seeds of the 23 sesame accessions were washed and air - dried. The air - dried seeds were ground using pestle and mortar. The phytochemical constituents screened for were phenolics, saponin, flavonoids, phytate, tannin, alkaloid and oxalate. The method used in determining the quantity of alkaloids was according to Maga (1982) and adopted by Harborne (1998); flavonoid according to Bohn and Kocipai-Abyazan (1994); Saponin according to Hudson and El-Difrawi (1979) and adopted by Obadoni and Ochuko (2001); tannin according to Trease and Evans (1989); oxalate according to Day and Underwood (1991); phytate according to Adamu *et al.* (2007). Data collected on each phytochemical in triplicates were subjected to Analysis of Variance (ANOVA) and means separated using the Duncan Multiple Range Test (DMRT). Simple correlation coefficients among the seven phytochemicals were estimated according to the formula suggested by Aljibouri *et al.* (1958). Genotypic and phenotypic variances, genotypic and phenotypic coefficient of variability, broad sense heritability and correlation coefficients were computed according to the method suggested by Singh and Chaudhary (1985). Genetic advance in terms of percentage of means was estimated as described by Brim *et al.* (1959).

III. RESULTS

Table 2 shows the percentage composition of the various phytochemicals investigated in each of the 23 sesame accessions. Analysis of Variance revealed high significant differences among the sesame genotypes studied for all the seven phytochemical characteristics. As shown in Table 3, the phenolics contents showed significant negative correlation with tannin while flavonoid showed positive correlations with saponin and alkaloid (at $P \geq 0.05$). Table 4 shows the estimates of genetic parameters for each of the phytochemicals in the 23 sesame accessions. The heritability estimates were high for all the phytochemical characters studied.

IV. DISCUSSION

Variation is a necessary condition for selection in breeding programmes. In plant breeding, selection is aimed at improving desirable traits. In this study, all the seven phytochemical attributes studied showed significant differences among the 23 sesame accessions (Table 2). The fact that the 23 sesame genotypes differed significantly in the seven characters is an indication that enough genetic diversity existed for their improvement. This further revealed that, although they may have originated from common ancestors, their evolution is along different trends. The original environment of each accession has actually affected the syntheses of the seven phytochemical traits studied. This agrees with the report of Yang *et al.* (2004) that ecological factors like soil type, temperature and precipitation can affect the synthesis and turn over of phyto-chemical components.

Parameshwarappa *et al.* (2009) reported that correlation coefficient analysis measures the mutual relationship between various characters and is used to determine the component characters upon which selection can be placed for improvement. In this study, the phenolic contents had negative correlation with tannin while flavonoid showed positive correlations with saponin and alkaloid (Table 3). This indicated that improvement on the phenolic contents will reduce the tannin content while improvement on the

TABLE I

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	Erect tem, green branched, whitish pink flower with light brown seeds.
2	*E8	Badeggi (Niger)	North Central	Erect stem, green branched, whitish pink flower with light brown seeds.
3	*01M	Badeggi (Niger)	North Central	Erect stem, green branched, whitish pink flower with light brown seeds.
4	*02M	Badeggi (Niger)	North Central	Erect stem, green, branched, whitish pink flower with light brown seeds.
5	*EXSUD AN	Badeggi (Niger)	North Central	Erect stem, green, branched, whitish pink flower with light brown seeds.
6	IBA I	Ibadan (Oyo)	South West	Erect stem, green, branched, whitish pink flower with dark brown seeds.
7	IBA II	Ibadan (Oyo)	South West	Erect stem, green, branched, whitish pink flower with light brown seeds.
8	OKE I	Okene (Kogi)	North Central	Erect stem, green, branched, whitish pink flower with light brown seeds.
9	YOL I	Yola (Adamawa)	North East	Erect stem, green, branched, whitish pink flower with light brown seeds.
10	MAI I	Maiduguri (Borno)	North East	Erect stem, green, branched, whitish pink flower with dark brown seeds.
11	KAN III	Kano (Kano)	North West	Erect stem, green, branched, whitish pink flower with white seeds.
12	KAN II	Kano (Kano)	North West	Erect stem, green, branched, whitish pink flower with light brown seeds.
13	KAN I	Kano (Kano)	North West	Erect stem, green, branched, whitish pink flower with light brown seeds.
14	MAK I	Makurdi (Benue)	North Central	Erect stem, green, branched, whitish pink flower with light brown seeds.
15	OUT	Otukpo (Benue)	North Central	Erect stem, green, branched, whitish pink flower with light brown seeds
16	ZAR I	Zaria (Kaduna)	North Central	Erect stem, green, branched, whitish pink with dark brown seeds
17	ANY I	Anyigba (Kogi)	North Central	Erect stem, green, branched whitish pink flower with light brown seeds
18	ANY II	Anyigba (Kogi)	North Central	Erect stem, green, branched, whitish pink flower with dark brown seeds
19	OKE II	Okene (Kogi)	North Central	Erect stem, green, branched, whitish pink flower with dark brown seeds
20	ILO I	Ilorin (Kwara)	North Central	Erect stem, purple, branched, purple flower with black seeds.
21	ILO II	Ilorin (Kwara)	North Central	Erect stem, purple, profusely branched, pink flower, black seeds
22	OFF I	Offa (Kwara)	North Central	Erect stem, green, branched, pink flower, black seeds
23	JAL I	Jalingo (Taraba)	North East	Erect stem, green, branched, whitish pink flower with light brown seeds

*Improved sesame genotypes.

TABLE II

Percentage Composition of Phytochemicals in the 23 Sesame Accessions.

	Phenolic (%)	Saponin (%)	Alkaloid (%)	Flavonoid (%)	Tannin (%)	Phytate (%)	Oxalate (%)
1	19.33^{k}	1.35^{abcde}	0.94^{d}	0.07^{cde}	0.12^{abc}	2.16^{cdef}	6.76^{c}
2	19.00^{k}	1.82^{cdef}	1.46^{g}	0.10^{gh}	0.21^{k}	2.30^{efgh}	6.78^{c}
3	25.33^{n}	1.45^{fgh}	1.75^{h}	0.09^{efgh}	0.13^{bcd}	2.76^{i}	7.56^{de}
4	19.00^{k}	1.37^{bcde}	0.98^{d}	0.13^{i}	0.17^{gh}	1.20^{a}	6.09^{a}
5	24.33^{m}	1.20^{abcd}	1.94^{i}	0.07^{cd}	0.18^{hi}	1.98^{bc}	7.71^{def}
6	$5.67b^{c}$	1.11^{abc}	0.77^{bc}	0.06^{bc}	0.39^{n}	2.41^{fgh}	9.97^{k}
7	13.33^{hi}	1.32^{abcde}	1.46^{g}	0.10^{gh}	0.20^{jk}	2.40^{fgh}	6.78^{c}
8	$7.33d^{ef}$	1.10^{abc}	0.87^{cd}	0.11^{h}	0.20^{ijk}	2.51^{gh}	7.20^{cd}
9	18.67^{k}	2.14^{h}	2.20^{k}	0.11^{h}	0.16^{fg}	1.21^{a}	8.11^{efg}
10	30.33^{o}	1.67^{efg}	0.73^{b}	0.10^{gh}	0.16^{fg}	2.27^{defg}	8.29^{gh}
11	14.33^{i}	1.68^{efg}	2.20^{k}	0.20^{j}	0.11^{ab}	2.10^{cde}	8.78^{hi}
12	8.33^{f}	0.99^{ab}	2.10^{jk}	0.07^{cd}	0.14^{de}	1.79^{b}	8.04^{efg}
13	10.67^{g}	1.41^{cde}	2.01^{ij}	0.08^{defg}	0.11^{a}	2.11^{cde}	9.06^{ij}
14	5.00^{b}	1.28^{abcde}	2.01^{ij}	0.04^{b}	0.120^{ijk}	1.96^{bc}	7.88^{efg}
15	4.00^{a}	0.96^{a}	1.80^{h}	0.09^{efg}	0.17^{gh}	2.20^{cdef}	7.67^{de}
16	23.33^{l}	1.26^{abcd}	1.24^{f}	0.08^{def}	0.15^{ef}	2.01^{bcd}	8.10^{efg}
17	7.67^{ef}	1.53^{efg}	2.41^{l}	0.15^{i}	0.21^{k}	1.08^{a}	8.97^{ij}
18	6.67^{cde}	1.82^{fgh}	3.60^{m}	0.21^{j}	0.28^{l}	2.56^{hi}	$6.69b^{c}$
19	6.33^{cd}	$1. 11^{abc}$	0.96^{d}	0.10^{gh}	0.13^{cde}	2.09^{cde}	8.30^{gh}
20	13.33^{hi}	1.85^{gh}	0.60^{a}	0.05^{bc}	0.15^{ef}	2.21^{cdef}	9.46^{j}
21	17.33^{j}	1.36^{abcde}	1.40^{g}	0.02^{a}	0.19^{hij}	2.21^{cdef}	6.20^{ab}
22	$5.67b^{c}$	1.82^{fgh}	0.60^{a}	0.09^{fgh}	0.36^{m}	1.79^{b}	8.27^{fgh}
23	12.33^{h}	0.97^{ab}	1.10^{e}	0.06^{bc}	0.15^{f}	2.01^{bcd}	6.05^{a}
SED	0.72	0.03	0.01	0.001	0.001	0.02	0.04

Mean values with different superscripts in the same column are significantly different from one another at $P<0.05$

*SED- Standard Error of Deviation.

TABLE III

Correlation Coefficient Analysis of the % Composition of Seven Phytochemicals in 23 Sesame Accessions.

Variables (%)	Phenolics (%)	Saponin (%)	Alkaloids (%)	Flavonoids (%)	Tannins (%)	Phylate (%)	Oxalate (%)
Phenolics	**1**						
Saponin	0.226	**1**					
Alkaloids	-0.169	0.176	**1**				
Flavonoids	-0.080	**0.367***	**0.505***	**1**			
Tannins	**-0.416***	0.102	-0.086	0.028	**1**		
Phylate	0.034	-0.148	-0.094	-0.089	0.082	**1**	
Oxalate	-0.218	0.128	-0.065	-0.016	0.163	-0.021	**1**

flavonoid contents will also increase the saponin and

TABLE IV

Estimates of genetic parameters for the seven phytochemicals in the 23 Sesame Accessions.

Character	Means	$\delta^2 P$	$\delta^2 g$	PCV	GCV	h^2 (%)	EGA	GAM
Phenolics	17.796	15.22	10.32	21.92	18.05	67.81	10.76	60.49
Saponin	1.415	0.32	0.28	39.98	37.40	87.50	1.02	72.08
Alkaloid	2.927	1.60	1.59	43.22	43.08	99.40	2.59	88.49
Flavonoid	0.095	0.001	0.001	33.29	33.29	98.33	0.064	64.43
Tannin	0.285	0.02	0.015	49.62	42.97	75.00	0.22	77.19
Phytate	2.057	0.54	0.52	35.72	35.06	96.30	0.46	22.41
Oxalate	7.771	3.51	3.42	24.11	23.80	97.44	3.76	48.39

Keys:
δ^2 P- Phenotypic Variance
δ^2 g- Genotypic Variance
PCV- Phenotypic Coefficient of Variation
GCV- Phenotypic Coefficient of Variation
h^2 - Heritability in the broad sense
EGA –Expected Genetic Advance
GAM- Genetic Advance over Mean

alkaloid contents. This information could be used effectively in the development of new sesame varieties.

In this study, phenolics, saponin, alkaloid, flavonoid, tannin, phytate and oxalate showed high PCV and GCV estimates (Table 4). This indicates that there is enough scope for selection based on all the phytochemical characters considered and that diverse genotypes can provide materials for breeding programme in sesame. Also, the phenotypic variances for all the seven traits were greater than the genotypic variances which indicates that the environment also played a role in the expression of phytochemical traits in sesame. Similar result was reported by Sumathi and Muralidharan (2010) on morphological characters in sesame.

High Heritability in the broad sense (h^2) and high Genetic Advance over Mean (GAM) were observed for all the phyto-chemical traits considered in this study (Table 4). Sumathi and Muralidharan (2010) reported that estimates of heritability and genetic advance in combination are more important than heritability alone. This indicates lesser influence of environment in the expression of phytochemical characters in sesame and the prevalence of additive gene action in their inheritance. This finding is in agreement with the earlier report of Azeez and Morakinyo (2009) on lipid and fatty acids profile of sesame. Thus, phenotypic or simple selection for these characters would likely be effective.

V. Conclusion

This study revealed high genetic diversity among the 23 sesame accessions studied and showed that the phenolic contents had negative correlation with tannin while flavonoid showed positive correlations with saponin and alkaloid (Table 3). This indicated that improvement on the phenolic contents will reduce the tannin content while improvement on the flavonoid contents will also increase the saponin and alkaloid contents. The information provided by this research will help breeders in future breeding programmes to develop improved varieties of sesame.

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