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VARIATION AND CORRELATION OF SEED PHYSICO-CHEMICAL PROPERTIES OF SUDANESE OKRA LINES (*ABELMOSCHUS ESCULENTUS* (*L.) MOENCH*.)

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ABSTRACT

Fifteen collections of okra accession were examined for seed physico-chemical properties. Basic seed physical parameters such as seed length, seed width, seed thickness and hundred-seed weight were examined. Chemical parameters such as crude oil%, protein %, fibre, Moisture content%, ash %, calcium mg/100g and carbohydrates were measured and analysed as per recommended methods of the Association of Official Analytical Chemists. Line HSD4899 was identified for best performance for Hundred-seed weight (g) and ash %; Line HSD5021 was identifies as the best performer for carbohydrate %; Line HSD5017 was identified for seed thickness (mm), seed width (mm) and fibre %; HSD6655 were identified for seed thickness (mm), crude oil content % and calcium mg/100g; and line HSD5024 was identified for high protein content. Seed length(mm), seed thickness (mm), seed width (mm), hundred-seed weight (g), sphericity ratio, moisture %, and ash % recorded high heritability estimates and coupled with a high genotypic coefficient of variation suggesting that these traits are under the influence of genetic control and less affected by the environment. Considerable progress can be achieved using phenotypic selection on these traits. Crude protein content has a significant but weak negative correlation with seed width and a moderate negative genotypic correlation with hundred-seed weight. Protein content recorded a significantly moderate negative genotypic correlation with hundred seed weight. The study suggests that smaller seeds tend to have more oil and protein content. Larger and heavier seeds will have higher carbohydrate content but less oil content.

Keywords: Okra, *Abelmoschus esculentus* (*L.) Moench*., seed, physicochemical

1. INTRODUCTION

Sudan produced around 322,403.39 tonnes of okra in 2021 and come forth after India, Nigeria and Mali respectively. Okra is an important vegetable in Sudan and a major component of every local recipe. It is used in the form of grinded dry flour and added to recipes to give it consistency and flavour. The preference among local farmers is for long spiny varieties that are associated in practice and usage with high mucilage. Okra originates in the Abyssinian centre of origin; a land that extends to include Ethiopia, Eritrea and Sudan. The diversity of okra in Sudan is evidenced by the wide distribution of wild and local lines in the central rain lands of Sudan; Southern Kordofan and along the Blue and White Nile, [1]. No study has examined the variability that exists for seed physicochemical traits in the Sudanese okra collection. Okra seeds have a proven report as a source of oil, protein and animal feed, [2]and [3]. These findings provide new dimensions for the okra breeding programme in Sudan. The degree of association between seed physical traits and chemical traits has not been reported in the literature. This study will help in the selection programme base on seed phenotypical traits without the need to go through laborious quantitative analysis for oil, protein and carbohydrate during the early selection process. This study aimed to examine the properties of fifteen okra accession obtained from local farmers and collected from a wide area of Sudan.

2. MATERIALS AND METHODS

Fifteen collections of okra accession were multiplied in seed multiplication block at the demonstration farm of the faculty of agriculture university of Al Zaeim Al Azhari Sudan. The accession name collection area is presented in table 1. Seeds from each accession were equally divided into three replicas and basic seed physical parameters including length, width and thickness were measured in millimetres using a micrometre to the accuracy of 0.01 mm. Sphericity was estimated using the formula described by Mohsenin [4]; The Sphericity of seeds, φ is calculated by using

- Sphericity ratio $$\Phi = \frac{(L \times W \times T)^{0.333}}{L} \quad (1)$$

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Volume: 09, Issue: 01 "January-February 2023"

Where,

L = Length of seed, mm

W = Width of seed, mm

T = Thickness of seed, mm

Table 1: Accession number, collection location and state

Sr.	Accession Number	specific location	State
1	HSD4899	Saraf elday	South Kordofan
2	HSD5023	Marawi	Northern
3	HSD1835	Kadogli	South Kordofan
4	HSD5021	Kabtot	Northern
5	HSD5017	Karmakoal Market	Northern
6	HSD4902	Abu Hasheem	South Kordofan
7	HSD6655	El Dilaima	South Kordofan
8	HSD4899	Saraf elday	South Kordofan
9	HSD5015	Kaboti	Northern
10	HSD6824	Borgidiab	Red Sea
11	HSD6947	Dolabiai	Red sea
12	HSD5024	El Gorare	Northern
13	HSD1840	Kadogli	South Kordofan
14	HSD1839	Kadogli	South Kordofan
15	HSD5025	Karma El Nuzl	Northern

Crude oil per cent, crude protein per cent; crude fibre, moisture content per cent, ash per cent, calcium mg/100g and carbohydrates were determined by the recommended methods of the association of official analytical chemists statistical analysis [5]. Data were analysed in a completely randomized design and the (ANOVA) was carried out as described by Gomez and Gomez [6]. Various genetic parameters such as genetic variance, phenotypic variance, genotypic coefficient of variation (GCV), and phenotypic coefficient of variation (PCV) were computed as per Burton [7], heritability in broad sense (h^2) as given by Burton and Vane [8]; genetic advance (GA) and genetic advance as percentage of the mean (GAM) as given by Johnson et al. [9]. Association among different characters at genotypic and phenotypic levels was carried out as described by Al-jibouri et al. [10]. The statistical significance of the genotypic and phenotypic correlation coefficient was tested using a t-test at a 5% level.

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Volume: 09, Issue: 01 "January-February 2023"

3. RESULTS AND DISCUSSION

3.1 Physical properties

Seed length recorded a range of (4.24-5.45mm), and a mean of 4.98 mm. Line HSD5021 recorded the highest best performance for seed length. Seed thickness recorded a range of (2.99-3.99 mm), and a mean of 3.65mm. Line HSD5017, HSD6655 and HSD6947 recorded the highest and best performance for seed thickness of 3.99, 3.98 and 3.95 mm respectively. The seed's width recorded a range of (3.84-5.01 mm) and an overall mean of 4.44 mm. Line HSD5017, HSD4899 and HSD6824 recorded the highest and best performance for seed width of 5.01, 5.00 and 4.94 mm respectively. The material physical parameters in terms of seed length, seed width and seed thickness are within the range recorded in similar studies by Abdel-Nabey and Abou – Tor [11] ; and Kumar et al. [12]. Hundred-seed weight recorded a range of (3.79-6.36 g) and an overall mean of 5.35 g. Line HSD4499 and HSD5025 recorded the highest and best performance of 6.36 g. The estimated value for the sphericity ratio ranged between (0.76 – 0.99) and a mean of 0.87, suggesting materials under the study tend to project towards a perfect spherical shape. Seed shape has a significant effect on the quality of the seed and other physical parameters. More spherical seed gives better handling, milling and processing quality. It has great importance as discrimination between genotypes. Measuring the different seed traits and their correlation is very helpful for designing a breeding programme for okra seed production, [13] and [14].

3.2 Chemical Properties

Crude oil content % recorded a range of (11.46 -13.79 %), and a mean of 12.53. Line HSD6655 recorded the highest and best performance for crude oil content. A similar range was recorded for the same species by Robert [15]. Protein content % recorded a range of (20.48 - 23.30 %). Line HSD5024 recorded the highest and best performance for protein content this range is similar to findings by other researchers, [16], [17] and [11]. Moisture content recorded a range between (5.11 -6.59 %). Line HSD1840 recorded higher moisture content. The range of ash in the material studied is (3.33-5.36 %). Line HSD4899 recorded the highest and best performance for ash content. Calcium is considered an important mineral additive of animal feed. Seeds rich in calcium make a good candidate for animal feed. Calcium content ranged between (658.67-4770.33 umg/100g). Line HSD6655 recorded the highest and best performance for calcium content. Carbohydrates per cent recorded a range of (25.31- 30.43 %). Line HSD5021 recorded the highest and best performance for carbohydrates. Ash content in the material studied ranged between (80.58 - 86.3 %). Line HSD5017 recorded the highest and best performance for ash %.

3.3 Genetic parameters and association

ISSN: 2455-6939

Volume: 09, Issue: 01 "January-February 2023"

Various genetic parameters are presented in Table 2. seed length (mm), seed thickness (mm), seed width (mm), 100 seed weight (g) sphericity ratio, moisture %, and ash % recorded high heritability values. The same was observed on comparing the phenotypic genotypic coefficient of variation for the above characters which suggests suggesting that these are under the influence of genetic control and less affected by the environment similar to findings by Davies [18].Considerable progress can be achieved on phenotypic selection based on the above characters. According to the criteria of classification of genetic advance estimates as a percentage of the mean (GAM) by Johnson et al. [9], we can conclude that hundred-seed weight (g), ash % and calcium mg/100g have high genetic advance while seed length (mm), seed thickness (mm), seed width (mm), sphericity ratio and moisture %, have moderate genetic advance. The rest has low genetic parameter values and much influence by the environment. This includes two important characters such as crude oil and protein content.

Table 2: Performance means of genotypes for okra seed physicochemical traits

Genotype	Seed length (mm)	Seed Thickness (mm)	Seed Width (mm)	100 seed weight (g)	Sphericity ratio	Crude Oil Content %	Protein Content %	Moisture content %	Ash %	Calcium µmg/100g	CHO %	Fiber %
HSD4899	5.02^{c}	3.63^{e}	4.38^{de}	6.36^{a}	0.86^{def}	11.91^{cd}	21.148^{bcd}	5.79^{g}	5.36^{a}	3062.00^{b}	28.42^{abcd}	82.11^{def}
HSD5023	5.06^{c}	3.77^{c}	4.02^{h}	4.44^{k}	0.84^{fg}	12.85^{abc}	22.02^{abcd}	6.15^{c}	4.76^{f}	1214.00^{bcd}	26.53^{bcd}	83.11^{cde}
HSD1835	5.23^{b}	2.99^{i}	4.01^{h}	5.05^{f}	0.76^{h}	12.80^{abc}	21.70^{abcd}	6.07^{d}	3.33^{n}	690.00^{d}	28.37^{abcd}	83.21^{cd}
HSD5021	5.45^{a}	3.58^{f}	4.27^{f}	5.63^{e}	0.85^{efg}	11.95^{cd}	20.48^{d}	5.59^{i}	4.14^{k}	2694.00^{bc}	30.43^{a}	82.13^{def}
HSD5017	4.90^{d}	3.99^{a}	5.01^{a}	4.98^{g}	0.94^{b}	12.15^{cd}	22.76^{ab}	6.00^{e}	5.01^{c}	658.67^{d}	25.31^{d}	86.3^{a}
HSD4902	4.51^{f}	3.70^{d}	4.60^{c}	4.87^{h}	0.92^{bc}	12.68^{abcd}	20.88^{cd}	6.07^{d}	4.84^{e}	2357.67^{bcd}	27.11^{abcd}	85.26^{ab}
HSD6655	5.00^{cd}	3.98^{a}	4.39^{de}	3.79^{l}	0.89^{cde}	13.79^{a}	21.80^{abcd}	6.31^{b}	4.61^{i}	4770.33^{a}	25.88^{cd}	82.8^{cde}
HSD4899	5.06^{c}	3.83^{b}	4.94^{a}	4.53^{j}	0.90^{bcd}	12.74^{abcd}	21.87^{abcd}	5.59^{i}	4.69^{g}	865.00^{cd}	28.00^{abcd}	81.54^{ef}
HSD5015	5.28^{b}	3.31^{h}	4.43^{d}	6.18^{b}	0.81^{g}	12.55^{abcd}	20.79^{cd}	5.76^{g}	4.64^{h}	1814.00^{bcd}	29.24^{abc}	81.08^{f}
HSD6824	4.21^{g}	3.65^{e}	5.00^{a}	4.63^{i}	0.99^{a}	12.50^{bcd}	22.36^{abc}	5.89^{f}	5.20^{b}	767.33^{d}	26.70^{bcd}	82.05^{def}
HSD6947	5.01^{c}	3.95^{a}	4.71^{b}	5.64^{e}	0.90^{bcd}	11.46^{d}	20.95^{cd}	5.67^{h}	4.92^{d}	990.00^{cd}	29.15^{abc}	80.58^{f}
HSD5024	4.69^{e}	3.49^{g}	3.84^{i}	5.96^{c}	0.85^{efg}	12.60^{abcd}	23.30^{a}	5.11^{l}	3.50^{m}	2307.00^{bcd}	28.45^{abcd}	81.13^{f}
HSD1840	4.90^{d}	3.70^{d}	4.58^{c}	5.83^{d}	0.90^{bcd}	12.17^{cd}	21.67^{abcd}	6.59^{a}	3.68^{l}	882.00^{cd}	27.91^{abcd}	84.23^{bc}
HSD1839	5.27^{b}	3.62^{ef}	4.34^{e}	5.98^{c}	0.83^{fg}	12.05^{cd}	21.38^{bcd}	5.55^{j}	4.45^{j}	1079.67^{cd}	29.35^{ab}	81.64^{def}
HSD5025	5.07^{c}	3.61^{ef}	4.10^{g}	6.36^{a}	0.83^{fg}	13.72^{ab}	20.69^{cd}	5.47^{k}	4.85^{e}	850.33^{cd}	27.28^{abcd}	83.95^{bc}

*Duncan's Multiple Range Test (DMRT) (α=0.05). CHO = Carbohydrate

Estimates of genotypic and phenotypic correlation coefficients between physicochemical characters were presented in Table 4. The upper diagonal represents the estimates of genotypic correlation (r_g) and the lower diagonal represents the phenotypic correlation (r_p) coefficients. The association between physicochemical traits at the genotypic level revealed that crude protein content has a significant but weak negative correlation with seed width; and a moderate negative genotypic correlation with hundred-seed weight. Likewise, protein content recorded a significantly moderate negative genotypic correlation with hundred seed weight. The traits also

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recorded a significantly strong negative association with seed length. Carbohydrate content has a strong linear relation with seed length and hundred seed weight; and a very strong negative genotypic correlation with oil content, seed thickness and seed sphericity. Sphericity has a moderately significant positive correlation with protein, ash and fibre content. The above findings touched upon three of the most important chemical composition of okra seed. They suggest that smaller seeds tend to have more oil and protein content but lesser carbohydrate content. The breeder should strike a balance between these three traits if they need to go for an ideal animal feed. It is also worth mentioning that more effort should be given to screening the Sudanese okra accession for oil as many reports recorded crude oil content as high as 20%. It shows that Okra seed oil has the potential as an ingredient in the industrial manufacture of soap, and cosmetics, [16], [17], [11] and [19].

Table 3: Estimates of mean, coefficient of variation, heritability and genetic advance in okra seed

Sr.	Trait	General mean	Coefficient of variation		Heritability	Genetic advance	Genetic Advance value % means
			GCV	PCV			
1	**Seed length(mm)**	4.98	6.283	6.373	97.21	0.635	12.762
2	**Seed thickness (mm)**	3.65	7.12	7.159	99.03	0.534	14.604
3	**Seed width (mm)**	4.44	8.26	8.306	98.89	0.752	16.92
4	**100 seed weight (g)**	5.35	14.81	14.821	99.79	1.63	30.468
5	**Sphericity ratio**	0.87	6.51	7.07	84.87	0.108	12.36
6	**Oil content %**	12.53	3.99	6.688	35.58	0.614	4.902
7	**Protein Content%**	21.59	2.92	4.961	34.56	0.762	3.532
8	**Moisture %**	5.84	6.35	6.359	99.83	0.764	13.077
9	**Ash %**	4.53	13.46	13.465	99.95	1.257	27.722
10	**Calcium µmg/100g**	1,666.80	61.12	85.907	50.62	1,493.16	89.582
11	**Carbohydrate %**	27.88	3.69	7.032	27.48	1.11	3.98
12	**Fibre %**	27.58	0.93	3.141	8.79	0.157	0.569

Table 4: Upper diagonal estimates represents genotypic correlation (r_g) and lower diagonal phenotypic correlation (r_p) represents coefficients estimates between okra seeds physicochemical traits

r_g / r_p	Seed length (mm)	Seed Thickness (mm)	Seed Width (mm)	100 seed weight (g)	Sphericity ratio	Crude Oil Content %	Protein Content %	Moisture %	Ash %	Calcium µmg/100g	Carbohydrate %	Fiber %
Seed length	1	-0.25^{NS}	-0.39**	0.30*	-0.76**	-0.08NS	-0.60**	-0.12NS	-0.26NS	0.08NS	0.78**	-0.43**
Seed thickness	-0.24^{NS}	1	0.54**	-0.38*	0.73**	-0.08NS	0.20NS	0.17NS	0.57**	0.20NS	-0.63**	0.42**
Seed width	-0.38**	0.54**	1	-0.31*	0.83**	-0.39**	0.08 NS	0.25NS	0.55**	-0.28NS	-0.40**	0.39**
100 seed weight	0.30*	-0.37*	-0.31*	1	-0.44**	-0.49**	-0.46**	-0.47**	-0.11NS	-0.20NS	0.86**	-0.50**
Sphericity	-0.70**	0.67**	0.77**	-0.40**	1	-0.23NS	0.37*	0.21NS	0.54**	-0.03NS	-0.70**	0.44**
Oil content	-0.09^{NS}	-0.04^{NS}	-0.24^{NS}	-0.30*	-0.09NS	1	0.06NS	0.15NS	-0.07NS	0.40**	-1.29**	0.62**
Protein Content	-0.38*	0.08^{NS}	0.04^{NS}	-0.27NS	0.23NS	0.11NS	1	-0.02NS	-0.27NS	-0.12NS	-1.05**	0.01NS
Moisture %	-0.12^{NS}	0.16^{NS}	0.25^{NS}	-0.47**	0.19NS	0.10NS	-0.01NS	1	-0.01NS	0.09NS	-0.66**	1.13**
Ash	-0.26^{NS}	0.57**	0.54**	-0.11NS	0.50**	-0.04NS	-0.16NS	-0.01NS	1	0.08NS	-0.47**	0.14NS
Calcium	0.06^{NS}	0.13^{NS}	-0.21^{NS}	-0.15NS	-0.03NS	0.16NS	-0.15NS	0.06NS	0.05NS	1	0.14NS	-0.13NS
Carbohydrate	0.34*	-0.35*	-0.22^{NS}	0.44**	-0.33*	-0.04NS	-0.18NS	-0.34*	-0.25NS	-0.13NS	1	-2.51**
Fiber	-0.17^{NS}	0.11^{NS}	0.11^{NS}	-0.15NS	0.17NS	0.13NS	0.14NS	0.34*	0.04NS	-0.15NS	-0.10NS	1

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