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Investigation of Quality Traits in 16 Sudanese Forage Maize (*Zea mays* L.) Genotypes

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Abstract

Sixteen forage maize (Zea mays L.) genotypes were investigated to determine their chemical compositions and mineral contents by conducting a field and a laboratory experiments. A randomized complete design with three replications was used for laying out the laboratory experiments. Quality characters included chemical composition and the minerals contents of the sixteen forage maize were measured. The results showed that there were significant differences ($P \geq 0.5$) between the forage maize genotypes for all the quality studied traits. The means of the chemical compositions showed that, the highest values of protein (10.09%,), carbohydrates (65.99%), fiber (32.48%), moisture (30.3%), Fats (1.21%), ash (2.85%) and calorie (309.43)KCal, were obtained by the genotypes Hudiba-2, TEE11, Hudiba-2, Hudiba-2, TEEI21, TZ STR 166 and TEEI 1, respectively. The means of the minerals in (mg/kg) showed that, the highest values of Ca (115.26), P (1.07), Fe (91.33), Zn (5.60), Mg (6.30), Na (3.22) and K (1.11) were obtained by the genotypes TEEI1, Hudiba-2, TZ STR 179, TZ STR 168, TZ STR 185, TEE 21 and 0804-6STR, respectively. The genotype Hudiba-2 scored the highest values of protein, fiber and relatively high value of carbohydrates. The genotype TEEI 1 scored the highest values of carbohydrates, calories and relatively high value of protein content. The considerable variability among the forage maize genotypes existed in this study for quality traits could be of a great value in any maize breeding program.

Key words: Forage maize; Genotypes; Chemical composition; Minerals contents.

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I. INTRODUCTION

Maize (*Zea mays* L.) is globally ranks third behind wheat and rice as the most important cereal crop, mainly used as staple food and animal feed in most of the developing countries (Akande and Lamidi, 2006; Olakojo *et al.*, 2007). It is an excellent source of carbohydrates, protein and good quality oil. It is more complete in nutrients than other cereals (Moraditochaee, 2012; Ali, *et al.*, 2014). Maize protein is rich in lysine and tryptophan, which provides the poor people with a way that can improve their diet. Maize protein has a high nutritive value nearly equivalent to milk (Moaveni, 2011). The average world grain maize areas were about 176.19 million hectares producing 930.13 million metric tons with average grain yield estimated at 5.78 tons per hectare (FAO, 2014).

The maize crop is characterized by its wide adaptability to the different ranges of growing conditions. Thus, it has gained adaptation and productivity in all continents through introduction and breeding programs. The genetic diversity of maize, being as an out crossing crop, is very broad for conservation and utilization in breeding programs. Maize landraces exhibit significant morphological variation and genetic polymorphism and are grown from sea level to 3800 m (Ortiz *et al*., 2010; Idris *et al.*, 2012).

Maize is a very convenient crop for forage production due to the high production of green mass per unit area, high energy content of dry matter and quality of biomass for silage making (Mandić et al. 2013).

Selection of maize is focused on maize hybrids that produce high grain yields and good quality silage combined with agronomic traits. Silage maize hybrids are certified based on fresh and dry matter yield and the proportion of the ears (Ishag, 2004). In the Sudan, grain maize is considered as a minor crop and it is normally grown as a rain- fed crop in Kordofan, Darfur and Southern states or in small irrigated areas in the Northern states (Ahmed and Elhag, 1999; Ishag, 2004), with average grain production of about 0.697 ton/ha (FAO, 2014).

In the Sudan, the Irrigated green forage production (grasses and legumes) is about 4 million tons .This production is found in Central states, Northern states, Eastern states and Khartoum state(Khair,1999). Most of forage farmers in the Sudan, especially at Khartoum state prefer to cultivate forage maize in the winter season as a substitute of forage sorghum in order to fill the gap caused by weak production of forage sorghum in this season, that is because forage maize is highly adapted to winter season of the Sudan more than forage sorghum and the productivity of it exceeded that of forage sorghum in the winter season. Few studies were conducted to measure quality traits (protein, fiber, fat, moisture, ash and carbohydrates) on leaves and stems of forage maize (Idris *et al.*, 2012). Knowledge of quality traits among different forage maize genotypes could be of a great value for animal feed, therefore the main objectives of this study is to measure quality traits in sixteen forage maize genotypes in order to select the most good quality one among them.

II.MATERIAL AND METHODS

2.1 Maize genotypes used in this study

A total of 16 forage maize (*Zea mays* L.) genotypes obtained from Agricultural Research Corporation (ARC), Wad-Madani, Sudan**,** were used in this study to determine their quality traits (chemical composition, and mineral contents). (Table, 1).

Table 1. List of the sixteen forage maize genotypes used in this study

No.	Genotype	Source
1	TEEI 1	ARC,Wad-Madani, Sudan.
2	TEEI 4	ARC,Wad-Madani, Sudan.
3	TEEI 5	ARC,Wad-Madani, Sudan.
4	TEEI 10	ARC,Wad-Madani, Sudan.
5	TEEI 11	ARC,Wad-Madani, Sudan.
6	TEEI 29	ARC,Wad-Madani, Sudan.
7	TEEI 20	ARC,Wad-Madani, Sudan.
8	TEEI 21	ARC,Wad-Madani, Sudan.
9	0804-6STR.	ARC,Wad-Madani, Sudan.
10	TZ STR 150.	ARC,Wad-Madani, Sudan.
11	TZ STR 166	ARC,Wad-Madani, Sudan.
12	TZ STR 168.	ARC,Wad-Madani, Sudan.
13	TZ STR 179	ARC,Wad-Madani, Sudan.
14	TZ STR 185.	ARC,Wad-Madani, Sudan.
15	TZ STR 184	ARC,Wad-Madani, Sudan.
16	Hudiba-2	Released Variety by ARC, Wad-Madani, Sudan.

ARC : Agricultural Research Corporation.

2.2 The Field and Laboratory Experiments:

A field experiment was carried out during the winter season of 2016 & 2017 (in the period from November 2016 to February 2017.) at the experimental farm of the College of Agricultural Studies, Sudan University of Science and Technology (sustech.edu), Shambat (.32º 32′ E. , Longitude, 15º 40′ N Latitude, and 380 meters above the sea level). The 16 forage maize genotypes were cultivated at separately plots, then and at 50% flowering these genotypes were also separately harvested and dried under sun light and prepared to be used for the measurement of their quality traits. The quality traits (chemical composition, and mineral contents) experiments were conducted at the National Food

Research Center Laboratory, Shambat, Khartoum North, Sudan. A randomized complete design (RCD) with 3 replicates was used for the laboratory experiments. The stems and the leaves of the dried 16 forage maize genotypes were manually and separately cleaned to remove dust, then the dry samples of the stems and leaves were later milled and from them the chemical composition (Approximate analysis) and the minerals contents were measured as the following procedures:

A.Chemical composition

The Chemical composition of the stems and leaves in 16 forage maize genotypes used in this study which included moisture content%, crude protein%, crude fiber%, crude fats%, ash content% and carbohydrates%, were determined by using approximate analysis according to the official method of Association of Official Analytical Chemist AOAC, (2010). The calorie values (Kcal./100gm) was calculated according IMNA, (2002).

B. The minerals content:

The mineral contents (in mg/kg) in the leaves and stems of the 16 forage maize genotypes included Calcium (Ca), Phosphor (P), Iron (Fe), Potassium (K) Magnesium (Mg), Sodium (Na) and Zinc (Zn). These minerals were determined according to the official method of Association of Official Analytical Chemist AOAC, (2010).

2.3Statistical analysis:

The statistical analysis of variance for the collected data of the chemical analysis and mineral contents for a randomized complete design was carried out according to Gomez, and Gomez (1984). The means were separated according to Duncan Multiple Range Test at 5% level of probability (Duncan, 1955).

III. RSULTS AND DISCUSSION

The statistical analysis of variance for the chemical composition and mineral contents of the 16 forage maize genotypes showed that there were significant differences ($P \geq 0.5$) between the 16 forage maize genotypes in these characters. This existing variability could be attributed to the genetic variability between them, which could be of a great potential in the improvement of Sudanese maize genotypes (through selection or hybridization) for obtaining maize genotypes characterized with high yield and good quality.Variability between maize genotypes in quality characters and other characters has been reported by many investigators, e.g Ishag, (2004); Abdalla, *et al.*, (2010); Ali *et al.*, (2014) and Idris *et al.*, (2012)

3.1 Chemical composition of the 16 maize genotype

In this study, the means of chemical compositions of the 16 forage maize genotypes were shown in (table, 2).

A.Protein Contents%

The means of protein percentage in the 16 forage maize genotypes ranged from 6.98% to10.09%, obtained by the genotypes TEEI 5 and Hudiba-2, respectively. These results reflect the high percentage of protein in these genotypes and indicate the high nutritive value of them, therefore most of these forage genotypes can be used as forages due to their high protein percentages. Similar findings were also revealed by Wolf, et al (1993) and Daboka, (2019) in their studies in different maize genotypes. Rai, 2002, reported that the relatively high concentrations of crude protein, which in forages and feeds can range from 30 to 500 g/ kg dry matter. Pavan et al, (2011) reported that dry weight and crude protein yields showed positive and significant correlation with green forage yield and had positive direct influence on their correlation with green forage yield.

B. Carbohydrates%, Fiber content% and Calorie values

The means of carbohydrates contents in the 16 maize genotypes ranged from (58.00% to 65.99%) obtained by the genotypes TEE11 and TZ STR 185, respectively. The means of the fiber contents ranged from 24.83% to32.48% obtained by the genotypes TEEI 1. and Hudiba-2, respectively. The calorie means ranged from 269.69 to 309.43 (KCal) obtained by the genotypes Hudiba-2 and TEEI 1, respectively.

The high levels of carbohydrates and fiber obtained in the studied 16 forage maize genotypes illustrate that these genotypes are highly energy animal feed, great nutritive value and of a great benefits for animals health. These results agreed with Wolf, et al(1993) who found similar findings and reported that the fiber supply the animal body with sufficient energy. In addition Koul, (1997) and Gasim, (2001) reported that, maize is considered as a great source of starch, carbohydrates and fibers making it a high-energy animal feed. Similar observations were also reported by Daboka, (2019) in his studies in forty forage maize genotypes.

C. Moisture content%, Fats content% and Ash content%:

In the 16 maize genotypes, the Fats content means ranged from 0.61% to 1.21% obtained by the genotypes TEE1 20 and TEEI 21, respectively. The moisture content means ranged from 23.5% obtained for the genotype TEEI 20 to 30.3% obtained by the genotype Hudiba-2. The Ash content% means ranged from 0.81% to 2.85% obtained by the genotypes TEE1 1 and TZ STR 166, respectively. Similar findings for Ash and Fats in different maize genotypes were reported by Redshaw *et al.*, (1986) and Vazquez de Aldana (1996) and El-Sheikh. (1998). Daboka, (2019) reported that the energy of maize is greater than sorghum and nearly equal to that of brown rice, in addition to that maize exceeded wheat, brown rice and sorghum in total fats.

3.2 Minerals contents

In this study, the means of minerals contents of the 16 maize genotypes measured in mg/kg were shown in Table, 3. The Ca ranged from 109.33 to115.26 and was obtained by the genotypes TEEI4 and TEEI1, respectively. The P ranged from 0.58 to1.07 and was obtained by the genotypes 0804-6STR and Hudiba-2, respectively. The Fe ranged from 51.33 to 91.33 and was obtained by the genotypes TEEI 21 and TZ STR 179, respectively. The Zn ranged from 2.51 to 5.60 and was obtained by the genotypes TEEI 1 and TZ STR 185, respectively. The Mg ranged from 4.00 to 6.30 and was obtained by the genotypes TEEI 4 and TZ STR 185, respectively. The Na ranged from 2.11 to 3.22 and was obtained by the genotypes TEEI 10 and TEEI 21, respectively. The K ranged from 0.58 to1.11 and was obtained by the genotypes TEEI 5 and 0804-6STR, respectively. These results illustrate the relatively high values of minerals in these forage maize genotypes and add another nutritive value in addition to values of protein and carbohydrates mentioned above. Similar findings for Ca, Mg, Fe, Cu, and K were observed in eight maize genotypes as explained by Ali *et al.*, (2014) and in forty forage genotypes as explained Daboka, (2019), these two authors also added that, maize is rich of macro-minerals specially P and trace elements specially Fe.

IV. CONCLUSION

Based on the results obtained from this study, it could be concluded that, significant and considerable variability was detected among the 16 Sudanese forage maize genotypes for chemical compositions and mineral contents, this variability would be useful in any maize breeding program aiming for improving quality traits in maize. However, the maize genotypes scored high values of quality traits could be used by Sudanese forage maize consumers and/or forage maize breeders by selection or hybridization in order to produce improved maize genotypes or hybrids characterized with high yield and good quality traits. The genotype Hudiba-2 scored the highest values of protein%, fiber %and relatively high value of carbohydrates%. The genotype TEEI 1 scored the highest values of carbohydrates, calories and relatively high value of protein content

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Table 2: The Mean Chemical composition of the 16 Maize genotypes.

No	Genotypes	Moisture %	Protein %	Fiber%	Fats%	Ash%	Carbohydrates %	Calorie value (KCal)
1	TEEI 1	25.1^{h}	7.52^{k}	24.83^{j}	$1..02^{d}$	0.81^{o}	65.99^{a}	309.43^{a}
2	TEEI 4	25.00^{i}	7.70^{j}	24.9^{j}	0.95^{e}	1.23^{l}	65.37^{b}	307.00^{ab}
3	TEEI 5	26.1^{e}	6.98^{m}	27.32^{g}	0.86^{f}	1.21^{m}	63.62^{d}	296.35^{d}
4	TEEI 10	24.9^{i}	7.16^{l}	26.26^{h}	0.76^{g}	1.51^{k}	64.29^{d}	299.95^{d}
5	TEEI 11	25.3^{fg}	8.07^{h}	26.24^{h}	1.10^{b}	0.94^{n}	63.53^{d}	302.20^{bc}
6	TEEI 29	26^{e}	9.12^{c}	26.41^{h}	0.65^{i}	1.71^{i}	63.45^{d}	296.95^{d}
7	TEEI 20	23.5^{k}	8.24^{g}	28.50^{d}	0.61^{j}	2.10^{h}	60.71^{g}	287.17^{f}
8	TEEI 21	25.4^{fg}	8.64^{f}	26.42^{h}	1.21^{a}	2.62^{c}	61.21^{f}	295.81^{d}
9	0804-6STR.	27.1^{c}	9.12^{b}	24.9	0.78^{g}	2.64^{b}	62.59^{e}	305.71^{ab}
10	TZ STR 150.	24.9^{j}	8.86^{d}	27.72^{f}	0.94^{e}	2.20^{f}	$60.^{25h}$	290.48^{ef}
11	TZ STR 166	25.5^{e}	8.74^{e}	25.97^{i}	0.87^{f}	2.85^{a}	61.56^{f}	294.8^{d}
12	TZ STR 168.	26.3^{d}	9.37^{b}	28.00^{e}	0.73^{h}	1.85^{h}	60.03^{i}	289.76^{ef}

13	TZ STR 179	28.1^{b}	7.89^{i}	31.34^{b}	0.65^{i}	1.54^{j}	58.66^{i}	273.93^{gh}
14	TZ STR 185.	25.43^{fg}	8.23^{g}	28.50^{c}	0.86^{f}	2.31^{e}	58.00^{j}	278.03^{f}
15	TZ STR 184	26.35^{d}	9.18^{c}	28.05^{d}	1.06^{c}	2.43^{d}	58.51^{i}	286.13^{f}
16	Hudiba-2	30.3^{a}	10.09^{a}	32.48^{a}	1.10^{b}	2.31^{e}	58.66^{i}	269.69^{h}
	Mean	25.9	8.3	27.5	0.88	1.90	61.3	292.6
	CV%	0.27	0.56	0.48	1.95	0.50	0.42	1.0
	F value	15.9**	984.1**	905.6**	328.5**	1336**	449.4**	46.3**

For each character (nutrient), different letters indicate means are significantly different (P <0.01).

Table 3. Means of minerals (mg/kg) of the 16 Maize genotypes

No	**Genotypes**	**Ca**	**P**	**Fe**	**Zn**	**Mg**	**Na**	**K**
1	TEEI 1	115.26^{a}	0.70 ^{g}	74.00 ^{e}	2.51 ^{k}	4.11 ^{l}	2.34 ^{i}	0.86 ^{c}
2	TEEI 4	109.33 ^{i}	0.80 ^{d}	78.00 ^{d}	2.70 ^{i}	4.00 ^{m}	2.98 ^{c}	0.62 ^{i}
3	TEEI 5	112.46^{ef}	0.75 ^{e}	57.33 ^{ij}	3.04 ^{g}	4.54 ^{i}	2.53 ^{gh}	0.58 ^{j}
4	TEEI 10	112.00 ^{f}	0.70 ^{g}	83.66 ^{c}	3.65 ^{f}	4.15 ^{l}	2.11 ^{l}	0.82 ^{d}
5	TEEI 11	110.10 ^{h}	1.01 ^{b}	59.00 ^{i}	5.21 ^{c}	4.63 ^{i}	2.20 ^{j}	0.77 ^{e}
6	TEEI 29	113.00 ^{cd}	0.82 ^{d}	61.33 ^{h}	2.85 ^{h}	6.10 ^{cd}	2.57 ^{g}	0.73 ^{e}
7	TEEI 20	112.00 ^{f}	0.73 ^{ef}	71.33 ^{f}	2.55 ^{k}	5.79 ^{e}	2.64 ^{f}	0.64 ^{h}
8	TEEI 21	114.20 ^{b}	0.65 ^{h}	51.33 ^{k}	2.62 ^{j}	6.06 ^{d}	3.22 ^{a}	0.91 ^{a}
9	0804-6STR.	110.13 ^{h}	0.58 ^{i}	71.33 f	4.45 ^{e}	5.52 ^{f}	3.14 ^{b}	1.11 ^{a}
10	TZ STR 150.	110.700 ^{g}	0.76 ^{e}	55.66 ^{jk}	3.07 ^{g}	6.13 ^{c}	2.50 ^{h}	0.69 ^{g}
11	TZ STR 166	113.50 ^{c}	1.06 ^{a}	87.66 ^{b}	3.36 ^{l}	4.20 ^{j}	2.16 ^{k}	0.68 ^{g}
12	TZ STR 168.	114.50 ^{b}	0.71 ^{fg}	77.00 ^{d}	5.60 ^{a}	4.24^{k}	2.24 ^{j}	0.73 ^{e}
13	TZ STR 179	112.66 ^{de}	0.96 ^{c}	91.33 ^{a}	5.40 ^{b}	5.02^{g}	2.65 ^{f}	0.70 ^{g}
14	TZ STR 185.	112.13 ^{ef}	0.63 ^{h}	67.66 ^{g}	5.22 ^{c}	6.30 ^{a}	2.63 ^{f}	0.81 ^{d}
15	TZ STR 184	111.96 ^{g}	0.75 ^{e}	55.00 ^{k}	5.00 ^{d}	6.23 ^{b}	2.71 ^{e}	0.74 ^{e}

16	Hudiba-2	113.00 [cd]	1.07 [a]	77.66 [d]	4.43 [e]	4.38 [j]	3.07 [c]	0.63[hi]
	Mean	112.32	0.79	69.95	3.79	5.10	2.60	0.75
	CV%	0.25	2.01	1.57	0.78	0.65	0.93	1.27
	F value	100.5**	268.3**	375.3**	4925**	2123**	635**	554.3**

For each character (nutrient), different letters indicate means are significantly different ($P \leq 0.01$).

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