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Line X Tester for Enhanced Vitamin A and E in Sorghum (*Sorghum Bicolor* (L.) Genotypes.

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Abstract: The two year trial conducted at an altitude of around 350 meters above sea level (ASL), Kebbi State is situated in the Sudan Savanna agro-ecological zone of Nigeria at latitude 130 08 N and longitude 50 15 E. The lowest and highest temperatures are 260°C and 350°C, respectively, while the relative humidity ranges from 23 to 41%. The average annual rainfall is around 752 mm (NIMET, 2017). The region is known for its lengthy dry season, which coincides with Hammattan (November to February), cold air during the hot season (March to May), and a brief wet season (Bello, 2006). The aim of this study is to create and implement sorghum varieties with elevated and stabilized amounts of vitamin A and E. Additionally, it aims to integrate beneficial characteristics into locally suited cultivators so that African farmers may utilize the seeds for commercial purposes. This is envisaged would improve the production and quality of sorghum for commercialization by increasing its market value. The study revealed that, NG/SA/Dec./07/0123 (3.50 mg) recorded highest and NG/SA/Dec./07/0097 (0.41 mg) recorded lowest. While vitamin E NG/SA/Dec./07/0097 (0.66 mg) recorded highest and NG/SA/Dec./07/0033 (0.06 mcg) recorded lowest. Therefore, based on vitamin A content, the study recommends genotype NG/SA/Dec./07/0123 and with regards to vitamin E, genotype NG/SA/Dec./07/0097 was recommended. The study observed the inverse relationship between vitamin A and vitamin E as recorded in NG/SA/Dec./07/0123 genotype (highest) but recorded as lowest for vitamin E.

Keywords: Tester; Line; genotype; Vitamin A; Vitamin E; quality; Sorghum

I. Introduction

The technique of improving crops for one or more micronutrient deficiencies is called biofortification. For healthy growth and development, energy, amino acids, vitamins, and minerals are necessary for both humans and other animals. Carbohydrates, lipids, and proteins provide energy. Different food varieties are employed as energy sources in different parts of the world. With chromosome number 2n = 20, Sorghum bicolor (L.) is a member of the Poaceae (Gramineae) family. It was identified in 1993 by the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and the Be rue Plant Germplasm Resource (IBPGR).

The northeastern region of Africa is the origin and geographic distribution of sorghum, which is found in both cultivated and wild forms (Reddy, 2004). As of 2016, the total yield per hectare of sorghum harvested in the world was 14035 Hg, or 560982660 tonnes, harvested from 399699624 hectares. In Africa, the total yield per hectare was 9040 Hg, or 21903220 tonnes, harvested within 24226758 hectares, and in Nigeria, the total yield per hectare was 1127 Hg, or 5270790 tonnes, harvested from 473630 hectares (FAO, 2016). Given that sorghum is a staple grain in areas where vitamin A insufficiency is more prevalent, it is an excellent choice for vitamin A biofortification. Since the concentration of β-carotene, the primary provitamin A carotenoid, in sorghum grain is below the desired level, therefore biofortification breeding is required.

Through the use of high-performance liquid chromatography, biology has uncovered high carotenoid accessions that were previously unknown by characterizing carotenoids in 446 accessions from the sorghum association panel and carotenoid panel. Using 345 accessions, genome-wide association studies verified that zeaxanthin epoxidase is a significant gene responsible for variation in lutein, β-carotene, and zeaxanthin itself. It was discovered that high carotenoid lines primarily stemmed from one nation and had little genetic variation.

Using genomics predictions, potential unique genetic variation for carotenoids content was found in 2,495 accessions of untested germplasm. There was proof of polygenic variation as well as oligogenic variation in carotenoids, indicating that breeding efforts can benefit from both genomic and marker-assisted selection. Essential micronutrients such as vitamins A and E are crucial for sustaining optimal health. Fat-soluble vitamin A promotes foetal development, immunological function, healthy reproduction, and eyesight. Additionally, it supports the preservation of healthy mucous membranes and skin, both of which improve vision,

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particularly in low light. Antioxidant vitamin E, which is fat-soluble, shields cells from the damaging effects of free radicals. Additionally, it strengthens the immune system and is necessary for carrying out a number of cellular processes (Ashok et al., 2013).

For optimal health, a well-balanced diet high in vitamins and minerals is necessary. Foods high in vitamin A include liver, fish, dairy products, and orange and yellow fruits and vegetables. Nuts, seeds, vegetable oils, and leafy green vegetables are good sources of vitamin E. According to Newman (2010), vitamin A micronutrient deficiency is often referred to as the "hidden hunger." Sorghum is the staple cereal grain and fodder crop grown by subsistence farmers in the hottest, driest regions of the Sahelian zone of sub-Saharan Africa and subcontinent where rainfed crop production is possible. It is not apparent until it is too late, causing irreversible harm with lifetime repercussions. Up to 500,000 children in Africa lose their sight due to vitamin A and E deficiency (VAD), which also increases their risk of illness, mortality from severe infections, and cognitive impairment (Ashok *et al.*, 2013).

Additionally, difficulties from delivery account for a large number of the approximately 600,000 deaths of women, issues that may be avoided with a higher vitamin A intake. Unfortunately, low nutritional content particularly low levels of Vitamin A really hinders the crop's potential for global acclaim and frequently delays its arrival. Therefore, the goal of the study was to increase vitamin A in sorghum. More than 300 million people in Africa, many of whom live in the drier, more susceptible agricultural areas, depend on this crop as an inexpensive staple diet. Sorghum is hard to digest when cooked, because it lacks the majority of important nutrients. If it were supplemented with essential nutrients, it may help important demographic targets who experience micronutrient deficiencies. More than 30 million children in Africa suffer from vitamin A and E deficiencies, which also contribute to 10.8 million fatalities overall and 2.55 million cases of blindness each year (Newman, 2010).

II. Material and method

Experimental Site and Experimental materials

Two year Experiment was conducted at an altitude of around 350 meters above sea level (ASL), Kebbi State is situated in the Sudan Savanna agro-ecological zone of Nigeria at latitude 130 08 N and longitude 50 15 E. With minimum and highest temperatures of 260°C and 350°C, respectively, and a relative humidity of 23–41%, the average annual rainfall is around 752 mm Anon (2018). The region is known for its lengthy dry season, which coincides with Hammattan (November to February), cold air during the hot season (March to May), and a brief wet season (Bello, 2006). The National Centre for Genetic Resource and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Nigeria, provided eight genotypes of sorghum for the experiment, along with two local checks (NG/SA/Dec./07/0139, NG/SA/Dec./07/0097, NG/SA/Dec./07/0146, NG/SA/Dec./07/0151, NG/SA/Dec./07/0086, NG/SA/Dec./07/0033, NG/SA/Dec./07/0123, NG/SA/Dec./07/0137, checks 1 and 2).

Methods used: The first experiment measured the amount of vitamin A and E in the blood; the second experiment tested the introduction of desirable or candidate genes to recurrent parents in the field; and the third experiment measured the amount of vitamin A and E in the developed progenies in different seasons and locations. A appropriate panicle (just starting to blossom) was chosen for emasculation in the field, and an opening spikelet was removed. Tied around the peduncle, the panicle is closed in a plastic or selfing bag but open at the top (Awika et al., 2004).

In the afternoon, when plant contamination from other sources is lowest, hand pollination is conducted in the field. As well as tools like trash bags (6 x 12 – 40 cm), a stapler, a knife, marking pencils, and clips, anthers can be removed with forceps, scissors, or other sharp devices (Zhao, 2008). The emasculated panicle is covered with the sack. Higher humidity can postpone anther deshiscence; covering a panicle with paper or polythene can postpone anther deshiscence by approximately thirty minutes the next morning (Awika et al., 2004). On the other hand, in warm weather, heat accumulation beneath the bag might harm the bloom. The core of the panicle produced the most pollen, which was gathered in the morning between 7 and 12 pm and then dusted on the emasculated seed parent. The self-in bag-covered panicle after pollination. The technique used, the operator's abilities, the surrounding conditions, the age of the stigma, and the quantity of pollen are all variables that affect pollination success (Ashok et al., 2010).

Table 1.General Analysis of Variance for **line x tester** Mating Design

Source of variations	Degrees of freedom (Df)	Mean Squares (MS)
Replicate (R)	r-1	
Blocks within rep (R)	Blk (r-1)	

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Genotypes (g)	(lt+c)-1	MSg
Lines/Females (l)	(l-1)	MSl
Testers/Males (t)	(t-1)	MSt
Lines X Testers	(l-1) (t-1)	MSlxt
Checks (C)	C-1	MSC
Checks vs crosses (C vs Cr)	(l-1)(t-1)(y-1)	MSC v Cr
Error (E)	(g-1) (r-1)	MSe
Total		

Source: Wright, 1921

Data Analysis

Analysis of variance was computed and statistical variations were determined as highly significant using MSTAT-c procedure version 5.1.

III. Results and discussion

One essential vitamin that is necessary for healthy development and bodily function is vitamin A. There are two forms of vitamin A, and they originate from distinct places. Provitamin A, or carotenoids, can be found in supplements, fortified meals (foods that have extra vitamins), and plant-based foods like sweet potatoes and carrots. Your body requires good fats to absorb carotenoids and transform them into retinol, the other active form of vitamin A (Graham et al., 1999). Vitamin E can be obtained as a dietary supplement, added to certain foods, and found naturally in others. The term "vitamin E" refers to a class of fat-soluble substances having unique antioxidant properties. The following tables show the average performance for vitamins A and E as determined by the study:

Table 2.Grain nutrient content during the first trial for Vitamin A and **E** enhancement for 2020 trial at teaching and research farm of Kebbi State University of Science and Technology, Aliero (KSUSTA)

Genotypes	**Vitamin A**	**Vitamin E**	**DV**
NG/SA/Dec./07/0139	2.40 mg	0.301 mg	0.01 %
NG/SA/Dec./07/0097	0.10 mg	0.08 mg	0.6 %
NG/SA/Dec./07/0146	1.01 mg	0.50 mg	0.7 %
NG/SA/Dec./07/0151	1.45 mg	0.31 mg	0. 22 %
NG/SA/Dec./07/0086	0.71 IU	0.06 IU	0.08 %
NG/SA/Dec./07/0033	2.33 mg	0.09 mcg	0.05%
NG/SA/Dec./07/0123	3.12 mg	0.07 mcg	0.01 %
NG/SA/Dec./07/0137	1.02 mg	0.91 mg	0. 25 %
CHECK 1	0.01 mg	0.02 mg	0.09%
CHECK 2	0.52 mg	0.80 IU	0.01 %

* DV= Adult daily value

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Table 3.Grain nutrient content during the second trial for Vitamin **A** and **E** enhancement for 2021 trial at teaching and research farm of Kebbi State University of Science and Technology, Aliero (KSUSTA)

Genotypes	Vitamin A	Vitamin E	DV
NG/SA/Dec./07/0139	2.70 mg	0.30 mg	0.03 %
NG/SA/Dec./07/0097	0.50 mg	0.03 mg	0.04 %
NG/SA/Dec./07/0146	1.06 mg	0.60 mg	0.60 %
NG/SA/Dec./07/0151	1.56 mg	0.33 mg	0. 05 %
NG/SA/Dec./07/0086	0.81 IU	0.02 IU	0.01 %
NG/SA/Dec./07/0033	2.60 mg	0.10 mcg	0.03%
NG/SA/Dec./07/0123	3.90 mg	0.05 mcg	0.07 %
NG/SA/Dec./07/0137	2.02 mg	0.41 mg	0. 60 %
CHECK 1	0.03 mg	0.13 mg	0.39%
CHECK 2	0.72 mg	0.90 IU	0.04%

Table 4.Grain nutrient content combined trial for Vitamin A and E enhancement for 2020 and 2021 trial at teaching and research farm of Kebbi State University of Science and Technology, Aliero (KSUSTA)

Genotypes	Vitamin A	Vitamin E	DV
NG/SA/Dec./07/0139	2.56 mg	0.42 mg	0.07 %
NG/SA/Dec./07/0097	0.41 mg	0.66 mg	0.11 %
NG/SA/Dec./07/0146	1.03 mg	0.54 mg	0.82 %
NG/SA/Dec./07/0151	1.60 mg	0.36 mg	0. 25 %
NG/SA/Dec./07/0086	0.83 IU	0.07 IU	0.06 %
NG/SA/Dec./07/0033	2.51 mg	0.06 mcg	0.02%
NG/SA/Dec./07/0123	3.50 mg	0.09 mcg	0.08 %
NG/SA/Dec./07/0137	1.84 mg	0.62 mg	0. 41 %
CHECK 1	0.02 mg	0.70 mg	0.55%
CHECK 2	0.65 mg	0.63 IU	0.03 %

* DV= Adult daily value

NG/SA/Dec./07/0123 (3.50 mg) recorded the greatest mean performance across genotypes based on Vitamins A and E (table 4). On the other hand, NG/SA/Dec./07/0097 (0.41 mg) recorded the lowest mean performance. NG/SA/Dec./07/0033 (0.06 mcg) and NG/SA/Dec./07/0097 (0.66 mg) for vitamin E showed the lowest and highest values, respectively. Thus, the study proposes genotype NG/SA/Dec./07/0123 for vitamin A content and genotype NG/SA/Dec./07/0097 for vitamin E content. The study found that there is an inverse link between vitamin A and vitamin E, with vitamin A being greatest in the NG/SA/Dec./07/0123 genotype and vitamin E being lowest.

Demonstrates how coexpression of vitamin E via ectopic expression of homogentisate geranylgeranyltransferase (HGGT) may stabilize provitamin A in sorghum and how vitamin E can improve provitamin A's stability in plants (Benson, et al., 2013). Vitamin E is an antioxidant that is soluble in fat and prevents the oxidation of fat by releasing reactive oxygen species (ROS). Researchers are looking at whether vitamin E might help prevent or postpone chronic illnesses linked to free radicals by reducing

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the production of free radicals, among other possible processes. According to Benson et al. (2013), the pericarp, germ or embryo, and endosperm are the three main anatomical components of grains

Plants' orange and red hues are caused by beta-carotene, one of the most prevalent carotenoids. When your body doesn't get enough vitamin A, it becomes deficient. Vitamin A shortage can be brought on by a diet low in the nutrient and by certain diseases. Among the symptoms are visual problems including night blindness. Supplementing with vitamin A is part of the treatment. Eating a lot of foods high in vitamin A will help avoid vitamin A deficiency (Doná et al., 2012).

IV. Conclusion

In conclusion, the study suggests genotype NG/SA/Dec./07/0123 for vitamin A content and genotype NG/SA/Dec./07/0097 for vitamin E content. The study found that there is an inverse link between vitamin A and vitamin E, with vitamin A being greatest in the NG/SA/Dec./07/0123 genotype and vitamin E being lowest.

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Competing Interests

Authors have declared that no competing interests exist.

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