GENETICS SOCIETY OF NIGERIA

43RD Annual Conference

UNIVERSITY OF LAGOS

DEPARTMENT OF CELL BIOLOGY AND GENETICS

THEME:

"GENETICS: A PANACEA FOR EMERGING CHALLENGES OF LIFE AND ENVIRONMENTAL SCIENCES"

BOOK OF PROCEEDINGS

7th – 11th October, 2019

GENETIC POTENTIALS OF LANDRACE SORGHUM GENOTYPES FOR ENHANCED MICRONUTRIENT (IRON AND ZINC) NUTRITION IN WEST AFRICA

Angarawai I. Ignatius[1a]*, Baloua Nebie[2], Mary Yeye[3], Lawali Abubakar[4], Hakeem Ajeigbe[1b] and Jonah Jerome[1c]

[1]International Crop Research Institute for Semi-Arid Tropics Kano, Nigeria (*1a*- I.Angarawai@cgiar.org, 08022115524, 1b- H.Ajeigbe@cgiar.org, 0704889836, *1c*- , 07030936908)

[2]International Crop Research Institute for Semi-Arid Tropics Bamako, Mali (B.Nebie@cgiar.org, +223 20 70 92 00)

[3]Institute for Agricultural Research, Ahmadu Bello University, Zaria (yeyemary@yahoo.com, 08032463500)

[4]Department of Crop Science, Usman Dan-Fodio University Sokoto labubakar1979@gmail.com +234 803 965 7021

*Corresponding author; I.Angarawai@cgiar.org, angarawaiijantiku@gmail.com

ABSTRACT

Micronutrient malnutrition, is one of greatest global challenges of our times with devastating consequences on health. Commonly used interventions associated with high cost and short-term benefits includes; nutrient supplementation, dietary diversification, commercial fortification, nutritional education and agricultural interventions. Biofortification of staple crops has been identified as a cost effective, sustainable means of delivery of micronutrients to the population. For effective crop biofortification program, identification of germplasms with high grain Fe and Zn concentration and understanding the genetic basis of high Fe and Zn concentration are prerequisites for manipulation of these micronutrients. Nigeria landrace sorghum germplasm, were evaluated during 2016 cropping season to assess for grain's micronutrient {Iron (Fe) and Zinc (Zn)} content. Results indicated a significant variation for Fe and Zn content among both generic Kaura (yellow seed) and Farafara (white seeded) sorghum landrace types. Variation within Kaura types for Fe ranged from 35.3 to 88.1ppm while Zn ranged from 22.2 to 69.9ppm. Farafara types varied for Fe from 35.1 to 90.7ppm while the Zn ranged from 19.5 to 63.5ppm. This variability is significant and can be exploited to introgress micronutrients in cultivars with farmers' preferred traits. To breed for combined high Fe and Zn concentration in the grain, some landrace lines were identified and could be random-mated in all possible combination to assess heritability and heterosis values for further improvement of farmer preferred varieties and development of commercial hybrid parental lines.

KEYWORDS: Sorghum, landraces, Micronutrient, Malnutrition, Biofortification

Sub-Themes: Agricultural Genetics and Biotechnology

Paper submitted to the 43[rd] Annual Conference of the Genetic Society of Nigeria, University of Lagos October, 2019.

INTRODUCTION

Micronutrient malnutrition also known as "hidden hunger", particularly among women and children, is one of the greatest global challenges of our times, which deficiency can have devastating consequences on health (Ashok, et. al., 2018; Onuegbu, et al., 2017; FAO et al., 2015; Lorenza, 2014). Such deficiencies occur when intake and absorption of vitamins and minerals are too low to sustain good health and development. Targeted strategies available to alleviate micronutrient deficiencies which include; nutrient supplementation, dietary diversification, commercial fortification, nutritional education and agricultural interventions are associated with high cost and short-term benefits (Onuegbu, et. al., 2017). The breeding of agricultural crops for higher nutrient levels (or 'biofortification') is an emerging approach that complements the existing "toolbox" of interventions. Biofortification, the process of increasing the density of vitamins and minerals of staple crops, through plant breeding, has been identified as a cost effective, feasible sustainable means of reaching and delivery of micronutrients to the rural population who may have limited access to diverse diets and other micronutrient interventions (Howarth and Amy, 2017).

Sorghum, a dietary staple of more than 500 million people in more than 30 countries of the semi-arid tropics, is one of the most familiar foods in the world (Lindsay, 2010). Results from United Sorghum Checkoff Program of International Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP) of USAID as reported by Lindsay (2010), acknowledged sorghum as an excellent source of both iron and zinc, even when calculated at 10% bioavailability for iron and moderate bioavailability for zinc. It also is rich in B-- complex vitamins, which play key roles in energy metabolism, thus a perfect combination for energy utilization. In addition, it is rich in thiamin, riboflavin, niacin, pantothenate, and vitamin B-- 6. For children ages 1-- 9 years, sorghum provides 26 to 47% of the World health Organization (WHO) Recommended Nutrient Intakes (RNI) recommendations for thiamin, 16 to 28% for riboflavin, 24 to 49% for niacin, 31 to 63% for pantothenate, and 59 to 118% for vitamin B-- 6. Thus, biofortified staple crops like sorghum, when consumed regularly, will generate measurable improvements in human health and nutrition.

For effective biofortification program, identification of germplasm with high grain Fe and Zn concentration and understanding the genetic basis of high Fe and Zn concentration is prerequisite for manipulation of these micronutrients. Ashok, et al., (2012) observed a large variability for grain Fe and Zn contents from assessment of >2200 ICRISAT sorghum core germplasm collections. Increasing our knowledge and use of existing diverse plant genetic resources especially sorghum can positively contribute to nutritional improvements. This study was carried out to identify Nigerian landrace sorghum genotypes with high grain Fe and Zn concentration for improvement of farmer preferred varieties and development of commercial hybrid parental lines.

MATERIALS AND METHODS

Four hundred and three landrace sorghum of generic Kaura (yellow seeded) and Farafara (white seeded) types comprising of 250 genotypes collected in 2014 and 153 genotypes collected in 2015 across Northern Nigeria were evaluated on two-rows plot of 5m long, spaced 0.75m and 0.3m intra-row at Minjibir and Bagauda ICRISAT's experimental stations during 2016 cropping seasons following all agronomic practices of weeding and fertilizer application. To assess their grains for micronutrient (Fe and Zn) content, panicles were harvested on standing plants directly into sampling bags at maturity to avoid contact with any contaminants. Wooden pistil and mortar were used to thresh for grain sampling. The grain samples were screened for Fe and Zn contents using Energy-dispersive X-ray fluorescence spectrometry at Flinders University of Australia in 2017.

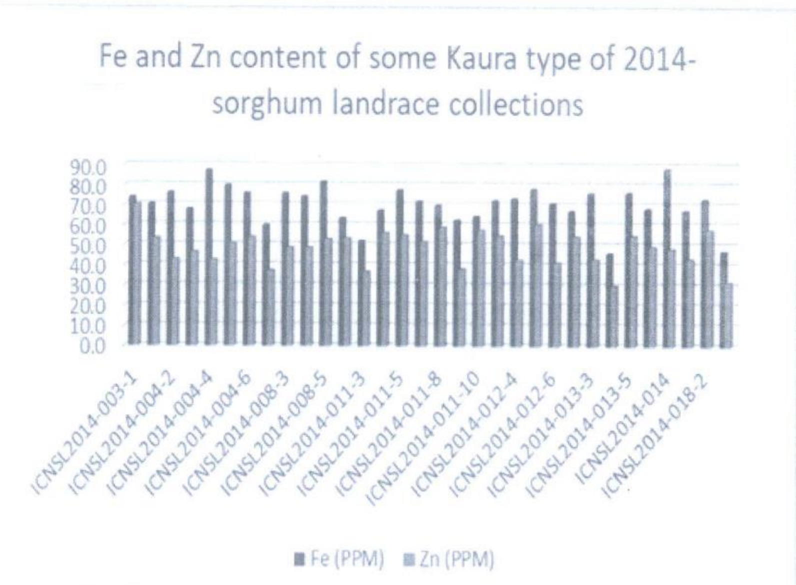
RESULTS AND DISCUSSIONS

Analysis of data for grain Iron (Fe) and Zinc (Zn) concentrations indicated a significant variation among generic *Kaura* and *Farafara* sorghum landrace collections of 2014 and 2015 (Table 1). Variation within the 2014 landrace collections for Fe concentration among the generic *Kaura* types ranged from 35.3 to 88.1ppm while Zn ranged from 22.2 to 69.9 ppm. For the generic *Kaura* genotypes ICSL2014-14 was identified to have the highest Fe concentration of 88.1ppm while ICSL2014-003-1 for high Zn concentration of 69.9ppm (Figure 1a). Similar variation was also observed within the generic *Farafara* types for Fe concentration ranging from 35.1 to 90.7 ppm while the Zn concentration ranged from 19.5 to 63.5. Among the generic *Farafara* genotype ICSL2014-002-5 was identified as the genotype with high Fe concentration of 90.7ppm, while IARSL/2014/0011 was identified to have high Zn grain concentration of 63.5ppm within 2014 collections (Figure 1b).

Within the 2015 landrace collections, grain Fe concentration varied for generic *Kaura* types from 35.3 to 64.4 ppm where CAPARLGSG2015-0158 among 2015 collections was identified to have appreciable Fe concentration of 64.4ppm (Table 1 and Figure 2a). Variation for generic *Farafara* types for Zn ranged from 22.2 to 38.7 ppm with CAPARLKSG20150292 identified as having 38.7ppm grain Zn concentrations. Grain Fe concentration among the generic *Farafara* ranged from 35.1 to 69.9ppm with CAPARLGSG20150300 among the generic *Farafara* identified to have appreciable Fe concentration of 69.9ppm (Table 1 and Figure 2b). Variability for grain Zn concentration ranged from 19.5 to 4.9 with CAPARLGSG20150043 identified to have appreciable Zn concentration of 41.9ppm (Table 1 and Figure 2b).

Result from this study concours with the work of Ashok, et. al., (2012), who assessed >2200 ICRISAT India core germplasm collections for grain micronutrients (Fe and Zn) contents and reported grain Fe concentration ranging from 26 to 60 mg kg-1 and Zn content ranged from 21 to 57 mg kg-1 among the genotypes during which promising donors lines were identified for further micronutrient improvement of farmer's preferred cultivars . In earlier studies conducted by several authors (Reddy et al. 2005; Sreeramaiah et al. 2007) indicated the superiority of landraces over controls for grain Fe and Zn contents in sorghum. Significant positive association were also observed between grain Fe and Zn contents indicating that it is feasible to develop high Fe and Zn containing cultivars with high yielding with different maturity backgrounds.

	Result for 2014 landrace collections evaluation at Minjibir				Result for 2015 landrace collections evaluation in 2016 at Bagauda			
	Kaura		*Farafara*		*Kaura*		*Farafara*	
	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
Maximum	88.1	69.9	90.7	63.5	64.4	38.7	69.0	41.9
Minimum	45.8	24.9	42.6	22.2	35.3	22.2	35.1	19.5
Mean	64.5	41.2	61.8	38.9	52.2	30.6	49.4	27.5



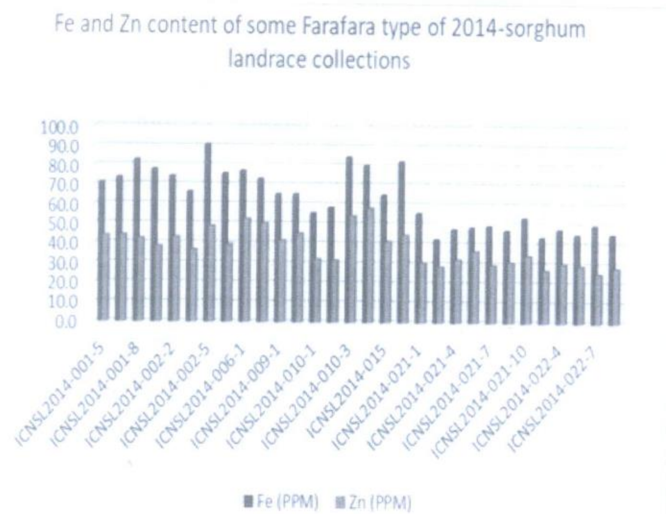
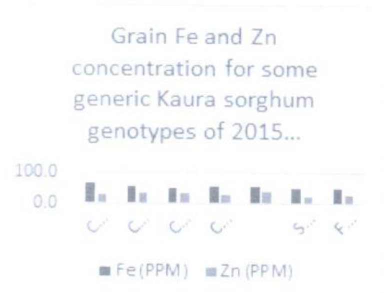


Figure 1a. Fe and Zn concentration (PPM) of 2014 landrace collections for generic Kaura types

Figure 1b. Fe and Zn concentration (PPM) of 2014 landrace collections for generic Farafaratypes



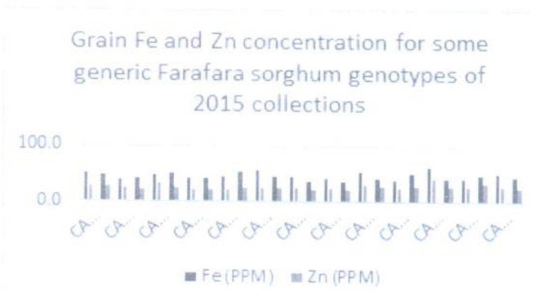


Figure 2a. Fe and Zn concentration (PPM) of 2015 landrace collections for generic *Kaura* types
Figure 2b. Fe and Zn concentration (PPM) of 2015 landrace collections for generic *Farafara* types

Summary and Conclusion

Sorghum is the most important dietary staple for more than 500 million people in more than 30 countries of the semi-arid tropics, in many countries where populations are food in secure, thus being one of the most familiar foods in the world. In order to realize the potential impact of the micronutrient-dense cultivars, the micronutrient-rich cultivars must be delivered in high-yielding backgrounds with farmers' preferred traits such as early maturity, acceptable seed color and large seed size. Considering the significant variability existing within the Nigeria landrace sorghum identified with high grain Fe and Zn concentration, manipulations for these micronutrients is possible. For effective biofortification and to breed for combined high Fe and Zn concentration in the grain, the following landraces; ICSL2014-003-1, ICSL2014-14, ICSL2014-002-5, IARSL/2014/0011, CAPARLGSG2015-0158, CAPARLGSG20150300, CAPARLGSG20150043, could be random mated in all possible combination to assess heritability and heterosis values for further improvement of farmer preferred varieties and development of commercial hybrid parental lines.

Acknowledgement

The authors acknowledge the data support obtained from HarvestPlus of the Generation Challenge Program

REFERENCES

Ashok A. Kumar, Kotla Anuradha, Rahul Phuke, Sunita Gorthy, Jayakumar Jaganathan, Anil Gaddameedi, K. Hariprasanna, H. V. Kalpande and Shivaji P. Mehtre (2018) Doubling grain Fe and Zn concentration in sorghum to combat the micronutrient malnutrition in sorghum eating populations. Book of abstracts. 1st National Genetic Congress on "Genetics for sustainable Food, health and Nutritional Security", held at ICAR-Indian Agricultural Research Institute, New Delhi India, December 14-16, 2018.

Ashok A. Kumar, Belum V. S. Reddy, B. Ramaiah K. L. Sahrawat, Wolfgang H. Pfeiffer (2012). Genetic Variability and Character Association for Grain Iron and Zinc Contents in Sorghum Germplasm Accessions and Commercial Cultivars. The European Journal of Plant Science and Biotechnology ©2012 Global Science Books.

Food and Agricultural Organizations of the United Nations 2015

Howarth E. Bouis*, Amy Saltzman (2017). Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. Global Food Security 12 (2017) 49–58

Lindsay John (2010) Sorghum: An Ancient, Healthy and Nutritious Old-World Cereal University of Nebraska - Lincoln DigitalCommons@University of Nebraska – Lincoln International Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP)

Lorenza Rossi (2014) Report on The Nutrition and Health Situation of Nigeria. Nutrition and Health Survey Using SMART Methods. UNICEF Nigeria country office.

Onuegbu N C, Ihediohanma NC, Eze CF, Okafor DC, Ojukwu M (2017). Biofortification of Local Staples in Nigeria: Prospects and Problems. J Food Biotechnol Res. Vol.1 No.1:5

Reddy BVS, Ramesh S, Longvah T (2005) Prospects of breeding for micronutrients and carotene-dense sorghums. *International Sorghum and Millets Newsletter* 46, 10-14

Sreeramaiah H, Patel K, Srinivasan K (2007) Zinc and iron contents and their bio-accessibility in cereals and pulses consumed in India. *Food Chemistry* 102 (4), 1328-1336