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GENETIC VARIABILITY FOR GRAIN MICRONUTRIENT (IRON AND ZINC) CONTENT, PLANT MORPHOLOGICAL AND OTHER PRODUCTIVITY RELATED TRAITS IN *RABI* SORGHUM [*SORGHUM BICOLOUR* (L.) MOENCH]

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ABSTRACT
Present investigation was undertaken to determine the magnitude of genetic variability for grain iron and zinc content, morphological and grain yield traits in diverse type of breeding materials. Significant variations were recorded among 134 sorghum genotypes for all the traits. A wide range of variation was observed for plant height (98.2-273 cm), Number of nodes (4.6-12.2), Number of leaves (6.3-13.4), standard leaf length (31.9-77.6cm), standard leaf breadth (4.5-9.35cm), ear head length (7.5-33.0cm), ear head breadth (4.5-8.05cm), grain yield per plant (4.0-74.1g), 100 seed weight (1.15-4.71g), five plant fodder weight (53.5-764.5g). The genetic coefficient of variation (GCV %) ranged from 10.056 (earhead breadth) to 46.23 (five plant fodder weight). The phenotypic coefficient of variation (PCV %) ranged from 12.39 (standard leaf length) to 48.97 (five plant fodder weight). Heritability in narrow sense ranged from 61.80% (earhead width) to 99.50% (test weight). High PCV and GCV estimates and high heritability coupled with high genetic advance recorded for all the traits indicated that these traits respond to selection. The genetic variability found for the traits can be exploited in developing micronutrient dense genotypes for elevating hidden hunger in future days to come.

INTRODUCTION

Sorghum [*Sorghum bicolour* (L.) Moench] is one of the fifth major important cereal crops after rice, wheat, maize and barley. It is an important staple food for more than 300 million people and feed for cattle living in Asia and Africa.

India is a major producer of sorghum and the top three largest producing states are Maharashtra, Karnataka and Madhya Pradesh. Karnataka is next to Maharashtra in terms of area and production (Anon, 2012). Its importance is ever increasing as the source of food for rural masses, food for teeming cattle population and raw material for the industries. Also with the present scarcity situation sorghum cultivation is the heart of dry land agriculture (Arunkumar, 2013b).

Most preferred post-rainy (*rabi*) sorghum varieties which are predominantly grown for food uses generally contain lower Fe and Zn content than that of rainy season sorghums (Kumar *et al.,* 2013). One in three people in the world suffer from hidden hunger, caused by a lack of minerals (Fe and Zn) and vitamins in their diets, which leads to negative health consequences (Kennedy *et al*., 2003).

In the past 40 years, agricultural research for developing countries has focused on increased cereal production. Recently, there has been a shift; agriculture must now not only produce more calories to reduce hunger, but also more nutrient-rich food to reduce hidden hunger. Biofortification provides a feasible means of reaching malnourished rural populations who may have limited access to diverse diets, supplements and commercially fortified foods. The biofortification strategy seeks to put the micronutrient-dense trait in those varieties that already have preferred agronomic and consumption traits (Bouis *et al*., 2011). One-time investment in plant breeding can yield micronutrient-rich planting materials for farmers to grow for years to come.

Improvement in yield and grain micro nutrient content of food grains for both food and nutritional security of the poor masses in dry land is urgent need for combating the micronutrient malnutrition prevailing globally. It is well established fact that the progress in improvement of a crop depends on the degree of variability in the desired character in the base material.

Therefore the present investigation was undertaken to study the extent of genetic variability, heritability and genetic advance exists for grain micronutrient content (Fe and Zn), plant morphology, yield and its attributing traits in 134 sorghum genotypes.

MATERIALS AND METHODS

The material used in this study comprised of 134 genotypes, consisting of selected accessions of mini core collection, red grain type collections, germplasm lines, advanced breeding lines and released varieties which are maintained at AICRP on

Sorghum, MARS, Dharwad. These genotypes were grown in two replications in a randomized complete block design (RCBD) at AICRP on Sorghum, MARS Dharwad, during the post-rainy season in the 2013 crop season. The experiment was laid out on medium to deep black soils in two rows of 4 m length with 45 cm × 15 cm spacing. All agronomic practices were followed to raise a healthy crop.

In each replication five random plants from each entry were selected and labelled for recording morphological observations in field. Heads of the labelled plants were bagged with kraft paper bags prior to flowering to avoid pollen contamination and to harvest pure seed for assessing the micro nutrition content. Bagged heads were harvested separately at maturity; observations on yield attributing traits were recorded pre and post threshing. Utmost care was taken while threshing to avoid metal and soil contact to assure contamination free samples for micro nutrient analysis.

Samples from two biological replicates were drawn in each genotype. Manually ground sorghum flour using mortar and pistil were analysed for grain micro nutrient content (Fe and Zn) following triacid digestion (Jackson, 1973), quantification of micronutrients were done with Atomic Absorption Spectrophotometer (AAS). Data on agronomic, yield and its component traits along with grain micro nutrient content were statistically analysed in WINDOSTAT ver8. software.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA)

The analysis of variance showed significant differences due to genotypes for twelve traits, as indicated by their mean square values (Table 1). A wide range of variation was observed for plant height (98.2-273 cm), Number of nodes (4.6-12.2), Number of leaves (6.3-13.4), standard leaf length (31.9-77.6cm), standard leaf breadth (4.5-9.35cm), earhead length (7.5-33.0cm), earhead breadth (4.5-8.05cm), grain yield per plant (4.0-74.1g), 100 seed weight (1.15-4.71g), five plant fodder weight (53.5-764.5g)(Table 1). This depicts presence of considerable genetic variation for all the traits among the134 genotypes studied. These results are in conformity with findings of Daniel and Eric (2014) who reported that significant variation for various agronomic and yield traits (days to maturity, panicle length, panicle width, harvest index, plant height, days to flowering, number of leaves, number of primary panicles, weight of grains per panicle, weight of 100 grains, economic yield, and biological yield indicated) among the sorghum genotypes. Significant differences among sorghum genotypes for economic yield, biological yield and harvest index was reported by Muhammed *et al*. (2007) Similar results were observed by Arunkumar (2013b).

Significant genotypic difference and good amount of variability for grain Zn concentration (13.2-52.45 mg/kg) and grain Fe concentration (20.6-57.89 mg/kg) was observed in the present investigation (Table 1). In line with the present study, earlier reports also have indicated wide ranges of variation for iron (3.00–11.30 mg 100 g″1) and zinc (1.10–5.02 mg 100 g″1) in sorghum genotypes (Jambunathan, 1980; Kayode *et al*. 2006). Ashok Kumar *et al*. (2009) reported large genetic variability for grain Fe and Zn concentrations in sorghum core germplasm accessions and hybrid parents and commercial hybrids. Susmita and Selvi (2014) reported significant genotypic variation for grain total iron and zinc content (21.35 mg kg-1 to 44.55 mg kg-1 and 11.33 mg kg-1 to 33.18 mg kg-1 respectively) along with other nutrient components, agronomic and yield attributing traits in sorghum. Badigannavar *et al*. (2016) have reported wide range of variability for Zn (0.76–7.58 mg 100 g″1), Fe (0.15–9.54 mg 100 g″1) and other nutritional and yield traits in released varieties and germplasm lines of post rainy sorghum. However limited variability for grain Fe and Zn concentrations in sorghum hybrid parents, advanced breeding lines and germplasm accessions was indicated in preliminary studies by Reddy *et al*. (2005).

Among the factors responsible for the wide variation in micronutrient content could be genotype, mineral concentrations and translocation rates in soil and weather conditions. Genotypes may exhibit differing abilities to absorb nutrients from the soil (Shergo *et al*., 2012). The significant difference observed for most of the traits in the present study could also be attributed to the compositions of the population, which is made of diverse genotypes included.

Genetic variability parameters

The genetic coefficient of variation (GCV %) for the twelve traits ranged from 10.06 to 46.23 for earhead breadth and five plant fodder weight respectively. The phenotypic coefficient of variation (PCV %) ranged from 12.39 to 48.97 for standard leaf length and five plant fodder weight respectively. Earhead length, Grain yield plant, 100 seed weight, five plant fodder weight, grain Zn concentration, grain Fe concentration showed both high GCV% and PCV% (Table 2). The results are in agreement with Daniel and Eric (2014) who reported high GCV% and PCV% for 100 grains weight, grain weight per

Table 1: Analysis of variance for plant morphology, grain micronutrients (Zn and Fe) contents, grain yield and its attributing traits in *rabi* sorghum

	Mean sum of squares											
Source	Plant height (cm)	No. of Nodes /plant	No. of leaves/ plant	Std. Leaf length (cm)	Std. Leaf breadth (cm)	Earhead length (cm)	Earhead breadth (cm)	Grain yield / plant (g)	100 seed weight(g)	Five plt. Fodder weight (g)	Grain Zn content (mg/kg)	Grain Fe content (mg/kg)
Replication	285.27	0.03	0.001	38.44	0.16	0.16	0.22	9.95	0.02	2281.81	1.36	17.99
Treatment	2204.04**	3.94**	4.50**	111.22**	1.69**	40.11**	1.09**	357.40**	1.23**	35871.36**	91.16**	158.23**
Error	80.91	0.19	0.23	6.79	0.16	0.93	0.26	11.83	0.003	2067.51	13.01	20.92
SEm.	6.34	0.34	0.34	1.84	0.28	0.68	0.36	2.42	0.04	32.03	2.54	3.22
C. D. @ 5%	17.79	0.86	0.96	5.15	0.79	1.9	1.01	6.8	0.11	89.94	7.14	9.05
C.V. %	4.16	4.96	4.76	4.2	5.23	5.79	7.91	9.44	1.89	16.17	12.34	12.39
Mean	216.22	8.76	10.15	62	7.58	16.62	6.42	36.45	2.9	281.24	29.24	36.92
Range	98.2-273	4.6-12.2	6.3-13.4	31.9-77.6	4.5-9.35	7.5-33.0	4.5-8.05	4.0-74.1	1.15-4.71	53.5-764.5	13.2-52.45	20.6-57.89

Table 2 : Genetic variability parameters for plant morphological, grain micronutrients (Zn and Fe) content, grain yield and its attributing traits in *rabi* sorghum

Traits	PCV (%)	GCV (%)	Heritability (%) (broad sense)	GA (Selection intensity @ 5%)	GAM (%) (Selection intensity @ 5%)
Plant height (cm)	15.63	15.07	92.9	64.7	29.92
No. of Nodes/plant	16.39	15.62	90.8	2.69	38.35
No. of leaves/plant	15.17	14.4	90.1	2.86	28.17
Std. Leaf length (cm)	12.39	11.65	88.5	14	22.59
Std. Leaf breadth (cm)	12.68	11.55	83	1.64	21.66
Earhead length (cm)	27.26	26.62	95.5	8.91	53.59
Earhead breadth (cm)	12.79	10.06	61.8	1.05	16.28
Grain yield / plant (g)	37.28	36.06	93.6	26.2	71.87
100 seed weight (g)	27.1	27.03	99.5	1.61	55.55
Five plt. Fodder weight (g)	48.97	46.23	89.1	252.8	89.88
Grain Zn content (mg/kg)	24.68	21.38	75	11.15	38.14
Grain Fe content (mg/kg)	25.64	22.44	76.6	14.94	40.48

panicle, plant height and panicle height. Susmita and Selvi (2014) also have reported that grain yield per plant, grain zinc and panicle length have got high PCV% and GCV%. Khandelwal *et al*. (2015) also reported high PCV% and GCV% for the grain yield per plant and earhead length.

Plant height, Number of nodes, Number of leaves, leaf length, leaf breadth and earhead breadth showed moderate GCV% and PCV% (Table 2). The results are in line with Khandelwal *et al*. (2015) where they have reported low PCV% and GCV% for number of leaves per plant. Susmita and Selvi (2014) reported Low GCV and PCV estimates were recorded for 100 grain weight. Similar findings were reported in the earlier studies for the above characters (Chavan *et al*., 2010; Arunkumar, 2013a; Arunkumar, 2013b).

In this study, the values of phenotypic variance exceeded genotypic variance for almost all the characters except for the trait 100 grain weight for which phenotypic variance is almost equal to genotypic variance indicating that other traits are considerably influenced by environment; similar reports were also reported by earlier workers (Susmita and Selvi (2014); Khandelwal *et al*., 2015).

Higher magnitude of GCV and PCV for most of the characters; most importantly for grain micronutrients (Fe and Zn) content, 100 grain weight and yield per plant suggests presence of sufficient genetic variability, which gives ample opportunities for the further genetic improvement toward nutritional quality with enhanced grain micronutrient concentrations along with grin yield components following suitable breeding approach post rainy sorghum.

The efficiency with which genotypic variability can be exploited by selection depends upon heritability of individual traits (Bilgin *et al*., 2010) which gives the information on the magnitude of inheritance of traits and genetic advance; it gives an indication as to how a given trait will respond to selection (Falconer and Mackey, 1996). Information on magnitude of heritability and genetic advance for the traits will be helpful in formulating suitable selection procedures for genetic improvement of the traits.

High heritability coupled with high genetic advance over mean was observed for all the traits except earhead breadth, which had moderate heritability and genetic advance over mean (Table 2.). Characters like earhead length, grain yield plant, 100 seed weight, five plant fodder weight, grain Zn concentration, grain Fe concentration, besides depicting high GCV and heritability also exhibited higher genetic advance reflecting the importance of additive gene effects in their inheritance and their expression and phenotypic selection for these characters will be effective. High heritability and high genetic advance for grain yield per plant and fodder yield have been reported by Arunkumar, (2013b). Breeding methods based on progeny testing and mass selection could be useful in improving these traits.

With this knowledge on high heritable fraction of variability for grain yield component and grain micronutrient concentration, the genotypes with elevated grain micronutrients concentrations for nutritional security coupled with high yielding ability and desired grain size can be bread in future to break yield platues as well as to elevate micronutrient malnutrition among the rurals of developing countries like India, who are not affordable either for expensive fortified foods, external supplements or diversifying their foods.

From these results, it is clear that presence of large genotypic variability among the genotypes for grain micronutrient and yield related traits is encouraging for selection of potential genotypes as parents for future breeding programme. Most of the traits exhibited low differences between their genotypic coefficient of variation and phenotypic coefficient of variation indicating least influence of environment. High heritability coupled with high genetic advance as percentage of mean was observed for Earhead length, Grain yield plant, 100 seed weight, five plant fodder weight, grain Zn concentration, grain Fe concentration. These characters need to be given greater importance while practicing selection as these traits may be likely governed by additive genes.

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