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ASSOCIATION OF GRAIN IRON AND ZINC CONTENT WITH GRAIN YIELD AND OTHER TRAITS IN PEARL MILLET (*PENNISETUM GLAUCUM* (L.) R.BR.)

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ABSTRACT

Selfed progenies (S_1s) derived from two diverse populations (PVGGP-6 and IAC-ISC-TCP1) were evaluated in two contrasting seasons at ICRISAT, Patancheru to examine the association of grain iron (Fe) & zinc (Zn) content with grain yield and component traits in pearl millet. Average grain micronutrients across both the seasons were higher in PVGGP6 (46.7 mg/kg Fe and 44.6 mg/kg Zn) than IAC-ISC-TCP-1 (37.0 mg/kg Fe and 37.2 mg/kg Zn). Significant genetic variability among the progenies was observed for Fe, Zn, grain yield and other component traits in both the populations. Significant positive correlation found between Fe and Zn content (r=0.81 to 0.82; p<0.01) in both the populations suggested the possibility of simultaneous effective genetic improvement of both micronutrients Non-significant correlation of grain Fe and Zn content with grain yield and 1000- grain weight in both the populations indicated that there would be no penalty on grain yield and seed size while breeding for grains rich in these micronutrients'

Index words: *Pennisetum glaucum*, iron, zinc, grain yield, correlations, breeding

In the last century, major emphasis of conventional breeding was to breed for high yielding varieties to meet the increased demand for food owing to the ever-growing human population. In this process, nutritional value of the grains was largely ignored. This led to the poor availability of micronutrients in most of the staple crops, which unintentionally contributed to micronutrient malnutrition among the resource-poor people of the developing world. World Health Organization (WHO, 2002) has identified grain iron (Fe) and zinc (Zn) as some of the limiting mineral micronutrients for human health. Now to recover from this crop- based nutrient deficiency, high-yielding varieties need to be developed which are rich in such important micronutrients. But grain Fe and Zn contents have been found to be negatively correlated with grain yield in some of the crops, such as maize (Banziger and Long, 2000) and sorghum (Reddy *et al.* 2005), thus making it difficult to breed simultaneously for high levels of micronutrients and grain yield. Pearl millet, being staple food for millions of poor households in the semi-arid tropics, if improved for Fe and Zn, can help improving the nutritional status of these undernourished populations. Moreover, these populations in semi-arid tropics are heavily dependant on pearl millet for meeting their nutritional deficiencies. Clear insight on genetic associations of these micronutrients with grain yield can help breeders in devising a suitable breeding strategy for enhancement of micronutrient density in pearl millet grains. So this study was conducted on pearl millet to study the relationships amongst these important nutritional components like Fe and Zn with grain yield and other agronomic traits.

MATERIAL AND METHODS

The experimental material consisted of S_1 progenies derived from two diverse populations (PVGGP6 and IAC-ISC-TCP1). Thirty S_1 progenies were derived from an improved *iniari*- based population 'PVGGP6' developed at ICRISAT-Niger is known to be rich in grain Fe and Zn. Another set of 24 progenies were derived from 'IAC-ISC-TCP1', an improved *non-iniari* population developed as a part of restorer line development programme at ICRISAT-Patancheru.

These 54 progenies derived from two different populations were grown separately in two experiments

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side-by-side in randomized complete block design (RCBD) with two replications during the summer (March-June) and rainy season (July-October) in 2007 at ICRISAT, Patancheru, India. Each progeny was grown in three rows, 2m long with 60 cm spacing between the rows in summer season, and 75 cm in rainy season, with 15 cm spacing between the plants during both the seasons. The micronutrient levels of soil measured in six samples (three each at 0-15 cm and 15-30 cm depth) at the time of planting varied from 6.9 mg/kg Fe and 2.4 mg/kg Zn for the field used during summer season to 10.75 mg/kg Fe and 3.25 mg/kg Zn for the field used during the rainy season.

Two rows of the plot were used for grain yield and other agronomic traits measurements. Data were recorded for days to 50% flower on plot basis (i.e. 50% of the plants having fully exerted stigmas on the main panicles) and 1000- grain weight (based on a sample of 200 random grains) for each plot. Plant height and panicle length were measured from five random plants from each plot. Grain yield was measured on plot basis from all the panicles harvested and dried to 12% moisture level.

Selfed grains from 6-8 plants from the remaining one row were produced for laboratory analysis of Fe and Zn content. Plants were selfed with parchment paper bags at the initiation of panicle emergence. The selfed panicles were harvested at physiological maturity, machine threshed (Wintersteiger – ID 780 ST4 – Single head thresher, Reid, Austria), and the grains cleaned of any glumes before being transferred to paper envelops with metal seals. Precautions were taken in each step to avoid any contamination of grains with dust particles and any other extraneous matter. Pearl millet samples were produced to pass through a 0.45-mesh sieve using a cyclone sample mill (Udy Corporation, Fort Collins Co., USA). The grain samples were analyzed for Fe and Zn in ICRISAT laboratory using the method described by Sahrawat *et al* (2002). The Fe and Zn in the digests were analyzed using atomic absorption spectrophotometer (Varian Techtron, Spectra AA.20, Victoria, Australia).

Grain Fe and Zn content, grain yield and other agronomic traits data were analyzed for across the two environments following a fixed model ANOVA of randomized complete block design (Gomez and Gomez, 1984) using Gen stat 10th Version computer program. The broad sense heritability was estimated as the ratio of genotypic variance to phenotypic variance. The correlation coefficients among the micronutrients, grain yield and its component traits were estimated using standard procedures.

RESULTS AND DISCUSSION

Average grain micronutrients of the progenies across both the seasons were higher in PVGGP6 (46.7 mg/kg Fe and 44.6 mg/kg Zn) than IAC-ISC-TCP-1 (37.0 mg/kg Fe and 37.2 mg/kg Zn) (Table 1). This might be due to PVGGP6 being an *iniari-* based population, as these germplasm are richer in Fe and Zn than *non-iniari* germplasm. Analysis of variance (Table 1) showed non-significant seasonal effect on Fe and Zn components in PVGGP-6 and IAC-ISC-TCP-1.In IAC-ISC-TCP-1, the Fe content varied from 34.7 mg/kg in the rainy season to 39.4 mg/kg in the summer season, while the Zn content varied from 34.2 mg/kg in the rainy season to 40.3 mg/kg in the summer season. The difference in the soil Fe and Zn contents between the two seasons were not reflected in the grain Fe and Zn contents in the season. Correlation between the two seasons for Fe ($r = 0.66$; $p<0.01$), Zn ($r = 0.67$; $p<0.01$) was highly significant, indicating high levels of consistency in the rankings of entries across the two seasons for micronutrient contents.

Analysis of variance showed highly significant differences among the progenies of both populations for all the characters. Both the populations had a wide range for Fe and Zn contents, with PVGGP6 having a wider range for both Fe (29.9-77.2 mg/kg) and Zn (30.7 – 63.0 mg / kg) than IAC-ISC-TCP1. Velu *et al* (2007) also reported large within - population genetic variability for both grain Fe and Zn content in pearl millet. Wide range in within-populations for micronutrients has also been reported for numerous other crops, for instance in maize (Banziger and Long, 2000) and sorghum (Reddy *et el.,* 2005). Wide variation was also observed for seed yield and its other component traits under study in both the populations. Thus, the availability of wide range of variation for both kind of nutritional and productive traits indicated the scope of development of Fe and Zn rich genotypes in high yielding backgrounds of pearl millet through the exploitation of within-population variability.

Table 1: Analysis of variance and measures of variability for grain Fe and Zn contents and other agronomic traits in PVGGP 6 and IAC-ISC-TCP1), 2007 summer and rainy seasons, ICRISAT, Patancheru .

Source of variation	Degrees of freedom	Mean square									
		PVGGP6					IAC-ISC-TCP1				
		Fe (mg kg^{-1})	Zn (mg kg^{-1})	Days to 50% flower	1000-grain mass (g)	Grain yield (t ha^{-1})	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Days to 50% flower	1000-grain mass (g)	Grain yield (t ha^{-1})
Season	1(1) [1]	22.3	13.7	10.8	4.1	5148.4	517.3	872.5	0.5	0.4	5159.0
Rep / Season	2(2)	25.7	87.3	19.2	2.9	153.6	154.2	97.7	1.3	3.8	174.4
Progeny	29(23)	503.0**	270.7**	3.1**	7.2**	533.8**	183.0**	150.1**	9.0**	5.9*	835.0**
Season x Progeny	29(23)	90.3*	48.1*	0.3	0.5	337.0**	19.3	6.0	1.2	0.2	412.5**
Error	58(46)	43.2	24.5	1.1	1.2	135.2	15.5	10.4	2.0	2.1	96.8
Mean		46.7	44.6	45	9.6	2.14	37	37.2	57	9.0	2.16
Range		29.9-77.2	30.7-63.0	43-47	6.6-11.8	1.36-2.93	26.8-48.3	28.2-50.9	55-61	6.5-11.22	1.36-3.02
Heritability %(bs)		65.3	64.8	42.0	60.8	9.03	71.2	79.7	51.7	62.0	43.9

*, ** Significant at 0. 05 and 0.01 probability levels, respectively.

[1]: Values in parentheses are degrees of freedom for IAC-ISC-TCP1

The magnitude of heritability was comparable for almost all the characters except for grain yield in both the populations. This implies, low environmental influence and predominant role of genetic factors on the expression of Fe and Zn due to comparable genotypic and phenotypic variance while significant effect of environment was observed on grain yield. Arulselvi *et al.* (2007) in a study on 63 pearl millet hybrids also observed higher heritability estimates for Fe and Zn. In both the populations under study, availability of substantial genetic variability for grain Fe and Zn coupled with high heritability (65-80%) indicated good prospects for selection of Fe and Zn rich pearl millet genotypes.

Significant and high positive correlation between Fe and Zn content observed in both the populations (r=0.81 to 0.82; p<0.01) (Table 2) suggested that simultaneous improvement of both of these important nutritional components is likely to be highly effective. This positive correlation between Fe and Zn was fairly consistent across the seasons (r=0.69 in the rainy season and r=0.86 in the summer season for PVGGP6 and r=0.83 in the rainy season and r=0.74 in the summer season for IAC-ISC-TCP1). Highly significant and positive correlation between Fe and Zn has been reported earlier in pearl millet (Velu *et al.*, 2007), maize (Maziya-Dixon *et al.*, 2000), wheat (Graham *et al.*, 1999) and sorghum (Reddy *et al*, 2005). It has already been

Table 2. Correlation coefficient (r) among grain Fe and Zn contents, grain yield and agronomic traits in S_1 progenies of PVGGP 6 and IAC-ISC-1 , 2007 summer and rainy seasons, ICRISAT, Patancheru .

	Correlation coefficient (r)				
Characters	Fe	Zn	Days to50% flower	1000-grain mass	Grain yield
Fe	-	0.82**	-0.20	0.20	-0.02
Zn	0.80**	-	-0.17	0.14	-0.01
Days to 50% flower	0.40*	0.26	-	0.01	0.17
1000-grain mass	0.27	0.33	-0.05	-	0.53*
Grain yield	0.16	-0.10	-0.27	0.46*	

*, ** Significant at 0. 05 and 0.01 probability levels, respectively.

Correlations for population PVGGP 6 are shown above the diagonal while correlations below the diagonal are for population IAC-ISC-TCP1.

established that Fe and Zn- rich seeds have high seedling vigor in low fertile soils coupled with resistance to diseases and plants are highly water use efficient which provides them critical advantage under semi-arid conditions (Graham and Welch, 1996). There was no correlation between seed yield and Fe and Zn contents in both the populations, indicating that simultaneous selection for Fe and Zn can be accomplished without compromising on grain yield. Moreover, non significant correlation of 1000- grain weight with Fe and Zn grain content in both the populations indicated that breeding for higher levels of micronutrients could be achieved without compromising the improvement for larger grain size, which is a farmer preferred trait in African countries (Chintu *et al*, 1994, Ipinge *et al*, 1994) and in central and southern parts of India (especially in Maharashtra).

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