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Exploring segregating populations for grain iron, zinc and productivity traits for genetic variability and trait interrelationships in finger millet (*Eleusine coracana* L. Gaertn)

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Abstract

Finger millet (*Eleusine coracana* L.), commonly known as ragi, is a climate-resilient crop recognized for its high nutritional value, particularly iron (Fe) and zinc (Zn). Improving both yield and nutritional quality requires an understanding of genetic variability and effective selection criteria in early generations. In this regard, two F_2 populations derived from the crosses GPU-28 $\times$ GE-1746 and GPU-28 $\times$ GE-6635 were evaluated at ZARS, GKVK, Bengaluru. A total of 310 and 181 F_2 plants were assessed for seven quantitative traits, along with grain Fe and Zn contents estimated using Atomic Absorption Spectroscopy. Substantial genetic variability with high heritability was observed for all traits, including micronutrients. Productive tillers per plant, number of fingers per main ear and finger length showed strong positive correlations with grain yield, identifying them as promising surrogate traits for indirect selection in early segregating generations. A positive correlation between grain Fe and Zn contents suggests that these micronutrients share similar uptake and accumulation mechanisms, thereby enabling concurrent enhancement through selection. These findings highlight valuable genetic resources for developing biofortified finger millet varieties combining improved productivity and nutritional quality.

Keywords: Atomic absorption spectroscopy, biofortified, finger millet, micronutrients

Introduction

Finger millet (*Eleusine coracana* L.) is a tetraploid with chromosome number $2n=4x=36$ belonging to the family Poaceae. Genus *Eleusine* has 11 species, out of which six are diploids ($2n=2x=18$) and five are tetraploids ($2n=4x=36$). The present cultivated species of finger millet i.e., *Eleusine coracana* subspecies *coracana* is a tetraploid and is evolved from a cross between two diploid species, *Eleusine indica* (AA) and *Eleusine floccifolia* or *Eleusine tristachya* (BB) as genome donors (Chennaveeraiah and Hiremath, 1973) [3]. It is native to Ethiopian highlands and introduced to India around 3000 years ago and thus India became the secondary centre of diversity for finger millet. (Hilu *et al.*, 1979; Singh, *et al.*, 2016) [6, 12].

Finger millet is also known as ragi, it is grown in different regions of Asia and Africa for food and fodder. In India, ragi ranks 3rd among millets and it is cultivated in an area of 1.19 m ha with a production of about 2.00 m tonnes (Sakamma *et al.*, 2018) [9]. It is exceptionally rich in calcium (344 mg/100g) which is eightfold higher than in cereals and other millets and also a high source of dietary fibre (15-20%). It comprises of a good amount of protein (7.3 g 100g⁻¹), magnesium (137 mg 100 g⁻¹), potassium (408 mg 100 g⁻¹), phosphorous (283 mg 100 g⁻¹), copper (0.47 mg 100 g⁻¹), zinc (2.3 mg 100 g⁻¹) and iron (4.6 mg 100 g⁻¹) compared to rice (Deosthale, 1970; Shobana *et al.*, 2003) [4, 11].

The study on variation in traits that are correlated with grain yield in addition to nutrient content will help in identifying and selecting the lines with superior yield and nutrient content. Also study on correlation of yield, its component traits and nutrient related traits implicates the mechanisms of mineral element uptake, its transport and accumulation in grain.

Assessing genetic variability in crop species is the first step in breeding programme to select high yielding genotypes with higher nutritional value and the yield potential of the varieties can be increased by improving the yield attributes. Hence, the present study was undertaken to assess the extent of genetic variability for grain Fe and Zn contents and grain yield in two crosses of F_2 population and to determine the correlations between the micronutrient traits and their association with grain yield.

Materials and Methods

The present investigation constituted F_2 populations derived from two crosses, GPU-28 $\times$ GE-1746 and GPU-28 $\times$ GE-6635. GPU-28 was the common female parent, which is a high yielding and highly resistant to finger and neck blast disease, it was crossed to the accessions having relatively good amount of grain Fe and Zn contents *viz.*, GE 1746 and GE 6635 respectively. The seeds of the F_1 of the two crosses were obtained from project coordinate unit (small millets), Bengaluru. A total of 310 F_2 plants from the cross GPU-28 $\times$ GE-1746 and 181 F_2 plants from GPU-28 $\times$ GE-6635 were grown during summer 2021 at the experimental fields of ZARS, GKVK, Bengaluru. Data were recorded on six quantitative traits. Each F_2 plant from both crosses was harvested separately to collect seeds. Grain Fe and Zn contents of all F_2 plants were estimated using the Atomic Absorption Spectroscopy (AAS) method.

Statistical analysis

The quantitative traits mean values of individual F_2 plants were used for computing descriptive statistics such as mean, absolute range, standardized range, GCV, PCV, heritability and GAM. The Pearson correlations (r) were calculated in F_2 populations derived from two crosses to estimate the nature of associations between plant height (cm), productive tillers plant⁻¹, finger length (cm), finger number mainear⁻¹, grain Fe content (ppm), grain Zn content (ppm) with grain yield.

Results and Discussion

The parents used in hybridization were diverse in nature with respect to traits *viz.*, days to 50 percent flowering, plant height, grain yield, grain Fe and Zn content (Fig. 1). The mean performance of cross GPU-28 $\times$ GE-6635 was

comparatively greater than the cross GPU-28 $\times$ GE-1746 for traits, such as grain yield, grain Fe and Zn content, indicating that this cross was superior compared to other cross. Higher estimates of GCV and PCV were noticed for productive tillers per plant, grain yield, grain Fe content in both crosses and grain Zn content in cross GPU-28 $\times$ GE-6635 indicates the pervasiveness of adequate variability in F_2 population of both crosses, which provides good opportunity for selection of individual plants based on these traits (Table 1). Similar findings were reported by Ulaganathan and Nirmala kumari (2014) [13], Mahanthesha *et al.* (2017) [8] for productive tillers per plant and grain yield. Ayesha *et al.* (2019) [11] for productive tillers per plant and grain yield and grain Fe content. Kumar *et al.* (2020) [7] for grain Fe and Zn content in pearl millet. Moderate estimates of GCV and PCV were noticed for plant height, fingers per main ear, finger length in both crosses and grain Zn content in cross GPU-28 $\times$ GE-1746, exhibiting the considerable amount of variability expressed for these traits. Similar results were reported earlier by Ganapathy *et al.* (2011) [5] and Shet *et al.* (2010) [10].

Moderate to high estimates of GCV and PCV along with high heritability and high GAM were observed for plant height, productive tillers per plant, number of fingers per plant, finger length, grain yield per plant and grain Fe and Zn content suggesting that, these traits are governed by additive gene action; hence selection on these traits will be effective to enhance productivity and nutritional quality of finger millet. Productive tillers per plant, number of fingers per plant and finger length were significantly correlated with grain yield per plant. This suggests that these traits can serve as surrogate traits for selecting high yielding genotypes in the early segregating generations. Associations among nutrients revealed a significant positive correlation between grain iron and zinc contents, reflecting shared mechanisms of uptake, transport and remobilization within the plant (Table 2). Similar findings were reported earlier by Upadhyaya *et al.* (2011) [14] and lower magnitude of negative association was noticed between grain yield and grain Fe and Zn content. Therefore, there is good scope for development of improved bio-fortified varieties especially targeting Fe and Zn content with appreciable quantity of grain yield.

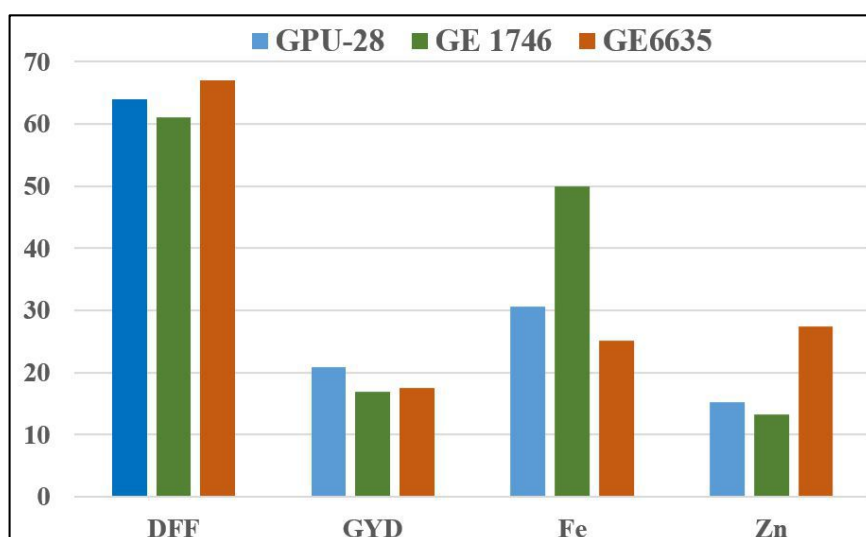


Fig 1: Mean performance of days to 50% flowering and grain yield along with grain Fe and Zn content of parents used in the crosses DFF-Days to 50 percent flowering, GYD-Grain yield per plant (g), Fe-Grain Fe content (ppm), Zn-Grain Zn content (ppm)

Table 1: Estimates of mean and variability parameters for yield and its component traits along with grain Fe and Zn content in F₂ population of two crosses of finger millet

Character	Crosses	Range		Mean $\pm$ SE _m	Standardized range	PCV (%)	GCV (%)	h ² (BS)	GAM
		Min.	Max.						
Plant height (cm)	C1	58	121	97.89 $\pm$ 0.68	0.64	12.37	10.76	75.66	19.28
	C2	54	112	83.69 $\pm$ 0.81	0.69	13.07	10.78	68.04	18.32
Productive tillers plant ⁻¹	C1	1	8	3.84 $\pm$ 0.09	1.82	43.27	29.62	46.85	41.76
	C2	1	8	3.96 $\pm$ 0.11	1.76	39.39	29.97	77.92	46.96
Finger number main ear ⁻¹	C1	4	9	6.19 $\pm$ 0.05	0.80	14.85	11.43	59.21	18.11
	C2	3	11	6.58 $\pm$ 0.08	1.21	17.06	13.62	63.79	22.41
Finger length (cm)	C1	3.5	10	5.84 $\pm$ 0.057	1.11	17.20	14.18	67.92	24.07
	C2	3.5	9	6.78 $\pm$ 0.09	0.81	18.00	15.34	72.61	26.93
Grain yield plant ⁻¹ (g)	C1	5.8	43.5	20.65 $\pm$ 0.38	1.63	32.72	25.63	61.34	41.35
	C2	4.70	38.50	22.48 $\pm$ 0.58	1.51	35.28	27.07	58.88	42.80
Grain Fe content (ppm)	C1	22.99	77.72	36.86 $\pm$ 0.43	1.48	20.64	20.12	95.01	37.87
	C2	17.46	73.78	26.94 $\pm$ 0.57	2.09	28.53	28.02	96.41	56.68
Grain Zn content (ppm)	C1	10.37	31.86	15.40 $\pm$ 0.15	1.39	17.78	17.40	95.85	26.93
	C2	9.35	32.69	16.61 $\pm$ 0.35	1.40	28.82	28.45	97.45	57.87

Table 2: Estimates of correlation coefficients for grain yield and its component traits along with grain Fe and Zn contents in F₂ population of two crosses of finger millet

Characters	Crosses	Grain yield plant ⁻¹ (g)	Grain Zn content (ppm)
Plant height (cm)	Cross 1	-0.084	-
	Cross 2	-0.116	-
Productive tillers per plant	Cross 1	0.271**	-
	Cross 2	0.398**	-
Finger length (cm)	Cross 1	0.204*	-
	Cross 2	0.109	-
Finger number main per ear	Cross 1	0.293**	-
	Cross 2	0.183*	-
Grain Zn content (ppm)	Cross 1	-0.106	-
	Cross 2	-0.096	-
Grain Fe content (ppm)	Cross 1	-0.297**	0.414**
	Cross 2	-0.134	0.212**

Conclusion

Substantial genetic variability was observed in the F₂ population of both crosses, with high heritability estimates for all traits, including grain Fe and Zn contents. Productive tillers per plant, number of fingers per main ear, and finger length exhibited strong positive correlations with grain yield per plant, suggesting their utility as indirect selection criteria for identifying high-yielding genotypes in early segregating generations. Among micronutrients, a significant positive association was recorded between grain Fe and Zn contents, indicating that considerable genotypic variability exists for these traits. This variability can be effectively exploited in breeding programs, offering a definite scope for their improvement through direct selection to enhance overall productivity.

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