Website : www.asthafoundation.in
Frontiers in Crop Improvement
Vol 9 (2) : 170-173 (July-2021) Print ISSN : 2393-8234 Online ISSN : 2454-6011
Astha Foundation, Meerut (U.P.) India

Screening of Rice Germplasm for Iron and Zinc Content in Brown and Polished Rice Using ED-XRF

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Abstract

Forty eight rice genotypes were analysed for iron and zinc content in brown and polished rice. Iron content in brown and polished rice among forty eight genotypes ranged from 6.45 ppm to 14.30 ppm and 0.8 to 4.4 ppm with mean values of 9.28 ppm and 2.12 ppm respectively. Whereas zinc content ranged from 14.7 ppm to 26.7 ppm and 6.90 to 20.6 ppm with mean values of 20.69 ppm and 12.12 in brown and polished rice respectively. Among the 48 genotypes, eleven genotypes had more than 22 ppm of zinc content in brown rice. Brown rice has more iron and zinc content than polished rice, loss of iron content was more in polished rice compare to the zinc content. Among the genotypes, landraces and traditional varieties has more iron and zinc content than improved cultivars. The present study revealed Chittimutyalu, local landrace has more iron and zinc content in both brown and polished rice and selected asrice and selected as one of the parent in development of mapping population to identify the QTLs related to iron and zinc in rice.

Key words : *Iron, zinc, rice, biofortification.*

Introduction

Rice occupies the enviable prime place among the food crops cultivated around the world. The slogan "Rice is life" is the most appropriate for India where this crop forms a livelihood for millions of rural households and describes its role in sustaining food and nutritional security. So rice being the most staple food crop in providing carbohydrates and proteins as a source of energy for billions of people in the world, however it is deficient in many essential micronutrients such as Fe and Zn. In rice the major loss of Fe and Zn is observed during milling and polishing and also the presence of anti-nutritional factor like phytic acid impeding the bioavailabilty of micronutrients.

Zinc is an essential nutrient for human health, and every human needs zinc to survive. It plays a critical role in normal functioning of body *i.e.*, cell division, immunity, and reproduction and is integrated with several enzyme systems (1). Diarrhoea, pneumonia, weight loss, growth retardation and delayed puberty in adolescents, poor appetite, delayed wound healing, etc., are due to Zinc deficiency and it is fatal if untreated (2).

Iron is the most abundant transition metal involved in various biological processes. Almost two-thirds of the body iron is found in the haemoglobin present in circulating erythrocytes, 25% is contained in a readily mobilizable iron store and the remaining 15% is bound to myoglobin in muscle tissue and in a variety of enzymes involved in the oxidative metabolism and many other cell functions (3). Abnormal iron homoeostasis can induce cellular damage through hydroxyl radical production which can cause the oxidation and modification of lipids, proteins, carbohydrates, DNA and leads to various neuro-degenerative diseases like Alzheimer's disease and Parkinson's disease (4).

Micronutrient malnutrition (Fe and Zn) is recognized as a massive and rapidly growing public health issue especially among poor people living on an unbalanced diet dominated by a single staple grain such as rice (5,6). So, it is necessary to develop the varieties containing high amounts of bioavailable Fe and Zn to improve the nutrient status of the population who depend on rice (7). Enhancing the nutrient content in rice through traditional breeding and modern technology (biofortification) is a novel agricultural approach to address the micro nutrient malnutrition problem (8). In order to improve the traits, breeder needs to identify the parents carrying the target traits. Since variability exists among the varieties, screening of rice germplasm having one or more desired micronutrients at higher concentrations is prerequisite prior proceeding to breeding.

Materials and Methods

The plant material includes forty eight rice genotypes which were collected from the germplasm available at Regional Agricultural Research Station (RARS), Maruteru, Andhra Pradesh. The experiment was conducted with 48 (45 test entries & 3 checks) genotypes during *Kharif*2015 in an Augmented Design at RARS,

Received : July-2021; Revised : July-2021; Accepted : July-2021

Table-1 : Iron and zinc content of brown and polished rice in 48 rice genotypes.

S. No.	Genotypes	Iron content in brown rice (ppm)	Iron content in polished rice (ppm)	zinc content in brown rice (ppm)	zinc content in polished rice (ppm)
1	NLR -3042	8.30	1.90	20.40	9.50
2	Burmadha	9.60	1.50	26.60	19.60
3	Azucena	8.30	4.40	23.10	15.00
4	FL478	11.00	2.80	16.85	17.20
5	Gedanzibetan	9.05	1.30	23.45	17.00
6	Isukaravalu	9.10	1.90	22.60	15.90
7	KMP 105	9.00	1.20	18.50	14.80
8	Manoharsali	7.50	2.30	21.75	15.50
9	N 22	7.30	1.20	23.30	14.30
10	Chittimutyalu	13.60	4.30	26.70	20.60
11	Godavari isukalu	10.95	3.10	24.05	17.80
12	MTU 1156	9.70	1.60	14.70	10.30
13	NDLR 8	13.40	1.80	21.80	14.30
14	Varalu	7.05	1.90	17.10	10.90
15	Warangal samba	9.25	2.20	21.70	15.70
16	IR 64	10.60	1.40	18.25	12.50
17	Mahsuri	10.35	2.80	19.45	15.00
18	RNR2354	13.50	2.50	19.00	13.30
19	Varsha	7.70	1.90	19.00	11.90
20	Srikakulamsannalu	7.20	2.10	18.15	12.00
21	Vamsadhara	7.75	3.70	23.50	15.70
22	BPT 3291	8.85	2.20	20.75	13.20
23	BPT 5204	8.30	1.80	21.10	13.30
24	MTU1061	6.45	2.40	19.10	10.75
25	MTU 1075	7.30	0.80	17.80	9.30
26	PLA1100	6.90	1.10	18.75	6.90
27	Tellahamsa	7.35	1.50	18.65	7.35
28	Improved samba mahsuri	8.45	2.10	16.65	8.45
29	Naveen	9.60	2.00	19.50	9.60
30	Luna suvarna	7.65	1.60	23.40	7.65
31	Vandana	11.75	2.00	19.60	11.75
32	Savitri	9.95	2.60	19.05	9.95
33	Annada	12.00	1.40	20.10	12.00
34	Tapaswini	11.05	1.60	20.75	11.05
35	Kaling III	12.00	1.00	20.10	12.00
36	Pooja	10.05	2.10	19.30	10.05
37	FR13A	14.30	2.00	26.55	14.30
38	Anjali	8.60	4.30	18.85	8.60
39	MTU1166	8.05	2.70	19.90	8.05
41	GSR T.M.E 80518	8.70	2.90	21.35	8.70
42	GSR H.H.Z.5.SAL10	7.70	0.80	19.55	7.70
43	NLR34449	7.20	2.50	20.85	7.20
44	BPT2615	8.35	1.80	16.75	8.35
45	NLR34242	10.60	3.10	18.00	10.60
46	MTU1010	8.90	0.90	21.4	12.7
47	MTU7029	6.50	2.00	18.35	10
48	MTU1121	8.85	2.10	20.95	13.9
	Mean	9.271	2.127	20.494	12.108
	Std. Dev.	1.989	0.864	2.765	3.250
	Std. Error	0.287	0.125	0.399	0.469
	C.V%	21.453	40.637	13.490	26.843
	Lowest	6.413	0.727	14.744	6.978
	Highest	14.473	4.527	26.744	20.328

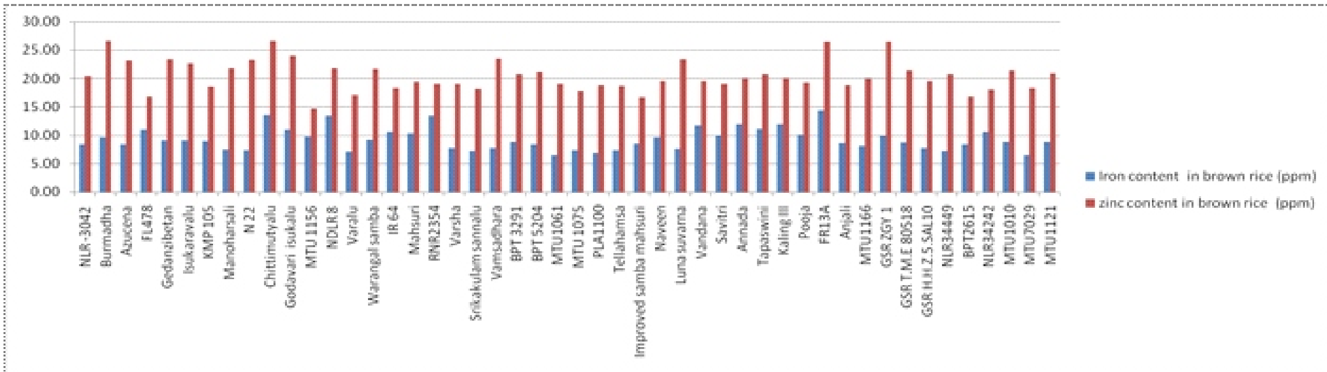

Figure-1 : Pattern of variation for iron and zinc content in brown rice among 48 rice genotypes.

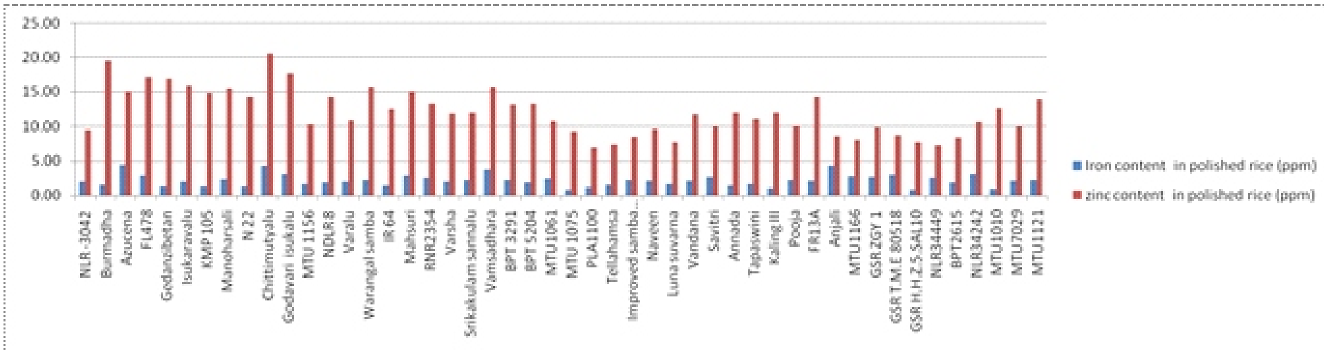

Figure-2 : Pattern of variation for iron and zinc content in polished rice among 48 ricegenotypes.

Maruteru. The seedlings were transplanted on 28th day with spacing of 20 cm between rows and 15 cm between plants. All the recommended package of practices was followed to raise a good crop.

The rice seeds samples of all the 48 genotypes were subjected to dehusking and seed separation by using palm husker. Iron and zinc contents were estimated in both brown and polished samples using EDXRF method. First iron and zinc contents were estimated in brown samples later samples were subjected to polishing using Non-ferrous miller and iron and zinc estimation.

EDXRF (OXFORD Instruments X-Supreme 8000) was performed in Indian Institute of Rice Research Station, Hyderabad. In XRF the preselected wavelength of incident X-rays expel an electron from the inner most orbit followed by the transfer of one of the electrons from the outermost orbit to the innermost orbit leading to the release of specific wavelength of X-rays. The energy of the emitted radiation is specific for a particular atom. Therefore, it is simultaneously identified and quantified by the detector. This instrument is useful in non-destructive determination of relative iron and zinc concentrations in rice samples.

Dehusked rice was cleaned for broken and debris and 5g of each sample was weighed and transferred to sample cups. The sample cups were gently shaken for uniform distribution of samples and kept for analysis. For each set of sample, it has taken 3.1 minutes which included 60s acquisition time for the separate Zn and Fe conditions as well as 66s 'dead time' during which the XRF will establish each measurement condition. Scans were conducted in sample cups assembled from 21 mm diameter and the cup combined with polypropylene inner cups was sealed at one end with 4 ìm Poly-4 XRF sample film. Concentration was expressed in microgram per gram (ìg/g).

Statistical analysis : The data collected were statistically analysed using Windows STAT Package 9.2 version and the analysis of variance showed significant differences among the genotypes of rice under study.

Results and Discussion

Forty eight rice genotypes were analysed for iron and zinc content in brown and polished rice using ED-XRF (Table-1). In brown rice the iron content ranged from 6.45 ppm to 14.30 ppm and zinc content ranged from 14.7 ppm to 26.7 ppm. The mean value of iron and zinc among the 48 genotypes in brown rice was 9.28 ppm and 20.49 ppm respectively. Among the 48 genotypes, eleven genotypes had more than 22 ppm of zinc content in brown rice. The land race FR13A had highest iron content of 14.30 ppm, followed by Chittimutyalu, 13.6 ppm in brown rice. The land race Chittimutyalu had highest zinc content, 26.7 ppm in brown rice. Whereas, iron and zinc content among the 48 genotypes in polished rice ranged from 0.8 to 4.4 ppm and 6.90 to 20.6 ppm respectively and the mean value for iron is 2.12 ppm and zinc, 12.12 ppm. Brown rice has more iron and zinc content than polished rice, loss iron content was observed after polishing. In polished rice, the Azucena (4.4 ppm) had highest iron content, and high zinc content was observed in Chittimutyalu (20.6 ppm). The Pattern of variation for iron and zinc content in brown and polished rice among 48 rice genotypes was depicted in Figure-1 and 2. Among the Maruteru varieties MTU 1075, MTU 1156, MTU 1010, MTU 1166, MTU 1121 and MTU 7029 under study, the MTU 1010 was high zinc content 21.4 ppm, high iron content 9.70 ppm in MTU 1156 in brown rice. A positive correlation (0.264) was observed between iron and zinc contents of 48 genotypes indicated the possibility of simultaneous effective selection for both the micronutrients.

Since micronutrient content of rice varies among the varieties, screening of rice germplasm is pre-requisite to identify the desired lines with high nutrient content to be used as donor parents in breeding programme to develop micro nutrient rich genotypes, to understand the basis of micro nutrient studies and to identify the QTLs. Many researchers estimated the iron and zinc content in brown rice and reported large genetic variation among the genotypes analysed. (9) analyzed 126 rice accessions for Fe and Zn concentration in brown rice using Atomic Absorption spectrophotometer. Iron concentration ranged from 6.2 ppm to 71.6 ppm and zinc from 26.2 ppm to 67.3 ppm. Seven genotypes Annada, BPT 5204, Chittimutyalu, N22, MTU 1010, MTU 7029 and IR 64 were common between them and present study. Previous studies and present study has indicated that there is no consistent value of iron and zinc for a genotype. The variation depends on different factors such as micronutrient homeostasis, sampling method, grain nature, soil properties, analytical methods, environment, genotype and genotype X environment interaction. (10) analyzed 192 accessions consisting indigenous and exotic lines for iron and zinc concentration in brown rice using ED-XRF. Results revealed that iron concentration ranged from 6.6 g/g to 16.7 g/g and zinc concentration from 7.1 g/g to 32.4 g/g and concluded that the landraces and traditional cultivars has higher iron and zinc content compared to commercial cultivars which is similar to present study.

In both brown and polished rice the landraces Chittimutyalu and FR13A had high iron and zinc content. (11) analysed the iron and zinc content in various rice genotypes, he reported that the landrace Chittimutyalu is one among the top 10 lines with high iron and zinc content and introduced into breeding program to develop high nutritional genotypes. In the present study based on the mean values of iron and zinc content, Chittimutyalu was used as one of the parent in the development of mapping population.

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