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Research Article

Variability Studies for iron and zinc content on segregating population of rice

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Abstract
More than half of the world's population, especially women and children in the developing countries suffer from micronutrient malnutrition especially deficiency in iron and zinc. Micronutrient malnutrition problems increased the interest of researchers to increase the mineral contents (Fe and Zn) in cereals to ensure adequate attainment of dietary minerals. A lot of variability does exist for micronutrients (Fe, Zn, Vitamin A, etc.) content and bioavailability in many crops including rice. The current study was conducted to assess the variability for iron and zinc content in dehusked rice grains to identify mineral-rich families. This study was conducted with the major objectives of analysis of genetic variability for grain iron and zinc content.

Key words
Rice, Iron, Zinc, variability.

Introduction

Rice, the staple food crop for more than half of the world's population, supplies adequate energy in the form of calories but it lacks other critical vitamins such as vitamin A, minerals such as iron and zinc, and other micronutrients / amino acids that are essential to human health. Today, micronutrient malnutrition is a large and growing problem in the developing world. Over three billion people currently suffer from micronutrient malnutrition (Welch and Graham, 2004). Iron deficiency may affect three billion people worldwide. It is estimated that 49 per cent of the world's population is at risk for low zinc intake. These micronutrient deficiencies are concentrated in the semi-arid tropics, particularly in South and Southeast Asia and sub-Saharan Africa (Reddy *et al.,* 2005). Attempts have been made to alleviate these deficiencies through dietary diversification, food fortification, supplementation with limited sustainable success, but these strategies do not reach most of those suffering from iron and zinc deficiency.

Plant breeding to enhance the nutrient quality of staple food crops holds promise for a low cost and sustainable approach to alleviate the problem of micronutrient malnutrition among the poorest segments of the population of developing countries. This approach has been called biofortification. Biofortification reduces malnutrition by breeding essential micronutrients into staple crops. This approach bridges the fields of human nutrition, crop science and public health to develop a set of highly sustainable nutrition interventions in a cost-effective manner. Exploiting the genetic variation in crop plants for micronutrient content is one of the most powerful tools to change the nutrient balance of a given diet on a large scale.

Material and methods

Seeds of F_3 generation of four cross combinations generated from [3]Anbil Dharmalingam, Agricultural College &Research Institute, Trichy. *viz.,* ADT 37 x IR68144-3B-2-2-3, ADT 43 x IR68144-3B-2-2-3, TRY (R) 2 x IC 255787, TRY (R) 2 x Mapillaisamba were utilized as the experimental material in the present study. Among the parents *viz*., TRY (R) 2, ADT 37 and ADT 43 are high yielding commercial varieties and IC 255787 is a high iron content line and IR68144-3B-2-2-3 is a iron donor and Mapillaisamba is a zinc donor which were used in earlier hybridization programme for introgression of high iron and zinc contributing genes. The experiment was conducted at Agricultural College and Research Institute, Madurai. The F_4 generation was raised during August to November, 2011 and F_5 generation during December 2011 to April 2012 respectively. The F_4 progenies were raised along with their parents in randomized block design with two replications. A total of five families were selected from each cross combination based on high iron and zinc content in F_3 population. For each family, 75 seedlings per replication were raised with a spacing of 20 cm between the rows and 15 cm between the plants. Each family had five rows of 15 single plants each. The recommended agronomic practices were followed throughout the crop growth period. Five single plants per family per replication were randomly selected and forwarded as single plant progeny row in F_5 generation.

The F_5 progenies were raised along with their parents in randomized block design with two replications. For each progeny row, one family with 75 seedlings per replication was raised with row to row spacing of 20 cm and 15 cm between plants. A total of 750 plants were raised with five family of each cross combination. The recommended agronomic practices were followed throughout the crop growth period. Five single plants per family per replication were randomly selected for observations.

The mean data after computing for each character subjected to standard method of analysis of variance following Panse and Sukhatme (1967), phenotypic and genotypic coefficient of variation, heritability (Broad sense) and genetic advance as per cent of mean were estimated by the formula as suggested by Burton (1952) and Johnson *et al*. (1955). The zinc and iron content were determined by using Atomic absorption spectrophotometer as suggested by Jackson (1973). All the statistical analysis was done by using GENRES statistical software GEN STAT (2004).

Results and Discussion

Grain iron content**:** Grain iron content showed wide range of variability in ADT 37 x IR68144-3B-2-2-3, and it ranged from 3.420 ppm to 5.420mm in F_4 generation while in F_5, the concentration was between 4.410 ppm and 8.000 ppm followed by ADT 43 x IR68144-3B-2-2-3. The cross ADT 37 x IR68144-3B-2-2-3 recorded high mean value for grain iron content in F_4 (4.215 ppm) and in F_5 generation (5.427 ppm), whereas low mean value for grain iron content was noticed in cross 3 (3.020 ppm to 3.119 ppm in F_4 and F_5 generations respectively). Genotypic and phenotypic variances were low in both the generations of all the crosses.

All the crosses recorded moderate genotypic and phenotypic coefficient of variation in F_4 generation except ADT 43 x IR68144-3B-2-2-3, which exhibited high genotypic and phenotypic coefficient of variation. These results were in parallel with the findings of Kalaimaghal (2011) who observed moderate GCV and PCV for iron content in the in F_2 and F_3 cross ADT37 x IR68144-3B-2-2-3. Shamak *et al.* (2011) also found moderate GCV and PCV for iron content, from a cross between BPT 5204 × HPR 14 of rice in F_4 and F_5 generation respectively. In F_5 generation, ADT 37 x IR68144-3B-2-2-3 and TRY (R) 2 x IC 255787 revealed high genotypic and phenotypic coefficient of variation and the other two crosses exhibited moderate genotypic and phenotypic coefficient of variation. The increase in the mean value in all the crosses from F_4 to F_5 indicates pressure in selection as reflected in the shift in the mean towards positive side for yield contributing and quality traits. (Table.1).

Grain zinc content**: T**he cross ADT 43 x IR68144-3B-2-2-3 showed high range of zinc content and it ranged from 0.090 ppm to1.452 ppm, 0.610 ppm to 1.830 ppm in F_4 and F_5 generations respectively. Genotypic and phenotypic variances were low in both the generations of all the crosses. The magnitude of moderate genotypic and phenotypic coefficient of variation was observed in all the crosses in both the generations except in TRY (R) 2 x Mapillaisamba, which showed low genotypic and phenotypic coefficient of variation (Table 2). Kalaimaghal (2011), in F_2 and F_3 generation reported high GCV and PCV for zinc content in the cross of TRY (R) 2 x Mapillaisamba and also by Shamak *et al*. (2011) in F_4 and F_5 generation and Purusothaman (2010) in F_1 .

High heritability with high genetic advance as percentage of mean was observed for iron content in both the generations of all the crosses. The same trend of results was observed for grain zinc content in all the crosses except TRY (R) 2 x Mapillaisamba, which showed high heritability with moderate genetic advance in both the generations. This suggests that there is high additive gene action. These results were in agreement with Shanmuga sundara pandian (2007), Purusothaman (2010) and Shamak *et al*. (2011) in F_4 and F_5 generation.

Among the four crosses, ADT 37 x IR68144-3B-2-2-3 showed wide range of variability grain iron content and it ranged from 3.420 ppm to 5.420mm in F_4 generation and in F_5 the concentration was between 4.410 ppm and 8.000 ppm . For grain zinc content TRY (R) 2 x Mapillaisamba showed wide range of variability and it ranged from 1.620ppm -1.860ppm in F_4 generation, while in F_5 , the concentration was between 1.195ppm - 2.490ppm. Moderate to high genotypic variability was observed for iron and zinc content that these traits need one or more number of generations of selfing to attain homozygosity. Based on mean, GCV & PCV, heritability and genetic advance, it was understood that the progenies of ADT 37 x IR68144-3B-2-2-3 would be more useful for improving grain iron content. Similarly TRY (R) 2 x Mapillaisamba segregants could be used for improving the grain zinc content.

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Table 1. Mean value and genetic parameters for iron content in F_4 and F_5 generations of rice crosses

Parameters	ADT 37 x IR68144-3B-2-2-3		ADT 43 x IR68144-3B-2-2-3		TRY (R) 2 x Mapillaisamba		TRY (R) 2 x IC 255787	
Generation	**P1**	**P1**	**P1**	**P2**	**P1**	**P2**	**P1**	**P2**
Range (ppm)	3.48-3.71	4.39-4.42	3.20-3.44	4.39-4.42	3.64-3.79	2.47-3.14	3.64-3.79	3.94-4.03
Generation	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$
Range (ppm)	3.42-5.42	4.41-8.00	3.32-5.77	3.96-5.03	2.42-3.57	2.42-3.47	3.00-4.35	3.30-3.90
Mean (ppm)	4.215	5.427	4.275	4.381	3.020	3.119	3.526	3.600
P.V	0.621	2.142	0.809	0.210	0.201	0.185	0.240	0.550
G.V	0.580	2.140	0.790	0.200	0.200	0.180	0.239	0.530
PCV (%)	18.696	26.968	21.040	10.460	14.845	13.790	13.894	20.601
GCV (%)	18.068	26.955	20.791	10.208	14.808	13.603	13.865	20.223
Heritability(%)	93.39	99.90	97.65	95.23	99.50	97.29	99.58	96.36
G.A. as % of mean	35.97	55.50	42.32	20.52	30.42	27.64	28.50	40.89

Table 2. Mean value and genetic parameters for zinc content in F_4 and F_5 generations of rice crosses

Parameters	ADT 37 x IR68144-3B-2-2-3		ADT 43 x IR68144-3B-2-2-3		TRY (R) 2 x Mapillaisamba		TRY (R) 2 x IC 255787	
Generation	**P1**	**P1**	**P1**	**P2**	**P1**	**P2**	**P1**	**P2**
Range (ppm)	1.77-1.93	1.05-1.22	1.72-1.84	1.05-1.22	0.83-0.86	3.50- 4.08	0.83-0.86	0.86-0.88
Generation	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$	$\mathbf{F_4}$	$\mathbf{F_5}$
Range (ppm)	0.18-1.45	0.86-1.50	0.09-1.45	0.61-1.83	1.62-1.86	1.20-2.49	0.54-1.57	1.12-1.69
Mean (ppm)	1.022	1.187	0.918	1.175	1.754	1.913	1.017	1.310
P.V	0.024	0.052	0.027	0.034	0.023	0.032	0.019	0.051
G.V	0.023	0.049	0.025	0.032	0.020	0.031	0.017	0.050
PCV (%)	15.158	19.211	17.899	15.693	8.646	9.351	13.554	17.239
GCV (%)	14.839	18.649	17.224	15.224	8.062	9.204	12.820	17.069
Heritability (%)	95.83	94.23	92.59	94.11	86.95	96.87	89.47	98.03
G.A. as % of mean	29.92	37.29	34.14	30.42	15.48	18.66	24.98	34.81