Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2891

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (5):** 888-892 (2017)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Study The Inheritance of Iron and Zinc in Segregating Population of Rice (*Oryza sativa* L.)

Maddeppa Mallimar[1*], P. Surendra[1], Babagouda Patil[2], Satish T.N.[1], Mahantesh Jogi[3] and Ramaling Hundekar[1]

[1]Department of Genetics and Plant Breeding, University of Agricultural Science College, Dharwad - 580005, Karnataka, India

[2]Department of Genetics and Plant Breeding, Agricultural College, Bapatla 522101, Acharya N G Ranga Agricultural University, Andhra Pradesh

[3]Department of Vegetable Science, College of Horticulture, UHS Campus GKVK, Benagaluru -560065, Karnataka, India

*Corresponding Author E-mail: maddeshm@gmail.com

Received: 24.04.2017 | Revised: 28.05.2017 | Accepted: 7.06.2017

ABSTRACT

Present investigation was carried out using the experimental material comprising five generations (P_1,P_2, F_1, F_2 and F_3) of two crosses derived from Swarna (high yielding mega variety) x Ranbir basmati (high Fe and Zn) and Swarna x BR2655 (high Fe and Zn). Populations of two crosses, revealed that Fe content had significant and positive dominance x dominance effect [l] followed by additive x additive effects [i]. The results of Zn contents were shown to fit the additive-additive × additive model and their effects were also significant. The similar results also found in Cross 2(Swarna x BR2655), in which iron trait showed high and negative dominance x dominance effect [l].

Key words: *Inheritance, Additive effect, Malnutrition, Anemia, XRF.*

INTRODUCTION

Rice is most widely consumed in one or other form by poorest to richest person. However, rice is a poor source of essential micronutrients such as iron (Fe) and zinc (Zn)[2]. Because of the importance of rice, FAO[5] named the year 2004 'International Year of Rice' and the theme of that year was 'Rice is life'. The average content of iron in rice grains is 1.2 mg/100 g and zinc is 0.5 mg/100 g. However, in spite of its great importance, rice on its own is not considered as a balanced diet choice, because the majority of rice is consumed in the form of polished grains, from which the bran layer and germ (the main storage sites for essential minerals such as iron (Fe) and zinc (Zn) are removed during the milling process[8]. Therefore, in developing countries, where polished rice is consumed as a staple food, anemia due to iron deficiency is the most widespread nutritional disorder[17].

Cite this article: Mallimar, M., Surendra, P., Patil, B., Satish, T.N., Jogi, M. and Hundekar, R., Study the Inheritance of Iron and Zinc in Segregating Population of Rice (*oryza sativa* L.), *Int. J. Pure App. Biosci.* **5(5):** 888-892 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2891

Malnutrition is a growing problem in the developing world mainly in South and South-East Asia and Sub-Sahara Africa[13]. Over three billion people suffer from micro nutrient malnutrition[16]. Iron deficiency may affect three billion people worldwide[11]. It is estimated that 49 per cent of the world's population is at risk for low zinc intake[3].

Grain quality is not always easy to describe, identify and quantify. Firstly it is not always easy to identify and quantify the characteristics or combination of characteristics that are responsible for human preferences which are popularly equated with grain quality. Secondly there is uncertainty in the relationship between nutritional quality and human preferences. The third complicated factor influencing grain quality research is the lack of tools or methods for measuring grain quality, as it is especially difficult to reduce to quantitative chemical and physical terms, the parameters that characterize good grain quality. Aiming at the improvement of contents of iron (Fe), zinc (Zn) in brown rice, the objective of the present study was to evaluate their genetic effects.

MATERIALS AND METHODS

The experimental material comprised two F_3 families one derived from Swarna x Ranbir basmati cross and another from Swarna X BR 2655. Cross 1 (Swarna x Ranbir basmati) comprising 214 F_3 families where in one of the parent Swarna is a popular high yielding semi dwarf variety derived from cross between Vasistha x Mahsuri having low iron and zinc content (2.93 mg 100 g^{-1} and 2.28mg 100 g^{-1} respectively).While, Ranbir basmati possess high iron and zinc content of 4 mg/100 g and 5 mg/100 g respectively and is a selection from Basmati 370. Cross 2 (Swarna X BR 2655) comprising 234 F_3 families in which the male parent BR-2655 is high in iron and zinc content (3.50 mg 100 g^{-1} and 3.02 mg 100 g^{-1} respectively) in brown rice with parentage of (BR 10 x BR 4) x (BR7 x Palghar 84-3). In both the crosses Swarna is used as female parent. These two segregating populations were used as experimental material in present study for estimating grain iron and zinc content during *kharif*, 2012 and 2013, at Agricultural Research Station (Paddy) Sirsi.

Present investigation was carried out using the experimental material comprising five generations (P_1,P_2, F_1, F_2 and F_3) of two crosses derived from Swarna (high yielding mega variety) x Ranbir basmati (high Fe and Zn) and Swarna x BR2655 (high Fe and Zn). The experiment was conducted in a randomized block design with two replications. The crosses were randomized within each replication followed by randomization of each generation within each replication. One row was allotted to each of P_1, P_2 and F_1 generation, whereas each of F_2 and F_3 generations were raised in 10 rows. Each row was three meter long with a plant to plant distance of 15 cm and row to row distance of 20 cm. The data were recorded on 10 plants per replication in parents and F_1's and 200 plants per replication in F_2's and F_3's. The iron and zinc contents of seed samples were estimated by X-ray fluorescence (XRF) spectrometry at M S Swaminathan Research Foundation, Chennai.

Observations were recorded in randomly selected five plants per family in each replication. The yield and yield components traits and grain quality characters were recorded in both the crosses (Swarna x Ranbir basmati) and (Swarna x BR-2655). The averages of the observations recorded on these five plants were considered for analysis.

From the segregating population the number of F_3 plants which performed better than mean of better parent plus two standard deviation for grain iron and zinc contents were selected as transgressive segregants. Means of the different generations were utilized for obtaining the various gene effects. The adequacy of the data for a simple additive dominance model was tested utilizing the scales 'C' and ' D' as suggested by Mather[12].

RESULTS AND DISCUSSION

Transgressive segregants for iron and zinc

Even though, the segregating population are usually assessed using their means and variability, the parameters alone will not indicate the worth of different populations for effecting the selection. It was therefore, considered necessary to compare different populations for isolation of transgressive segregants. In the present study, numbers of transgressive segregants were identified mainly for micronutrient contents in different populations on the basis of superior performance of progenies over the better parent in desirable direction for each of the component traits in F_3 generation of two crosses (Swarna x Ranbir basmati and Swarna x BR2655).The frequencies of transgressive segregants for Fe and Zn from both crosses are presented in table 1 and 2. The highest numbers of transgressive segregants were found for iron trait followed by zinc in both crosses. The genotypes which found superior for iron and zinc can be effectively used for the further breeding progamme to improve these traits.The transgressive segregants F_2-01-50, F_2-01-62, F_2-01-121, F_2-01-145 for iron content and F_2-01-111, F_2-01-162, F_2-01-204 for zinc content were identified in the Cross 1(Swarna x Ranbir basmati). In case of Cross 2 (Swarna x BR2655) The transgressive segregants F_2-02-122, F_2-02-123, F_2-02-124, F_2-02-133, F_2-02-134, F_2-02-135, F_2-02-172, F_2-02-189, F_2-02-191, F_2-02-192, F_2-02-193, F_2-02-194, F_2-02-195 for iron content and F_2-02-20, F_2-02-77 for zinc content were identified. The iron content was ranged from 7.1 to 9.9 mg/kg and zinc content was ranged from 20.6 to 35.9 mg/kg in cross one (Swarna x Ranbir basmati) and in case of cross two (Swarna x BR2655) iron content was ranged from 7.1 to 11.6 mg/kg and zinc content was ranged from 6.1 to 28.6 mg/kg.

Inheritance pattern of iron and zinc

Scaling tests

Mean data of different generations were utilized for obtaining the various gene effects. And the data was transformed into arc sine transformation whenever the data registered below 30 per cent and above 70 per cent. F_2 population recorded highest variance followed by F_3 generations. Lowest variance was evident in F_1 and other non-segregating generations, namely, P_1 and P_2.

Cross 1: (Swarna x Ranbir basmati)

Generation mean analysis, using P_1, P_2, F_1, F_2 and F_3, populations of two crosses, revealed that Fe content had significant and positive dominance x dominance effect [*l*] followed by additive x additive effects [*i*] (Table 3). Aswini[1], observed the duplicate gene interaction in the expression of total grain iron content whereas complementary gene interaction appears to be absent in the expression of zinc and other mineral element content. The results indicate the mild selection can be employed for traits like iron and copper content in segregating generation.The results of Zn contents were shown to fit the additive-additive × additive model and their effects were also significant. Additive effect for iron and zinc content in rice grain was reported by Jia-Ling *et al.*[10]. This indicated that, these traits were not much influenced by environmental factors. Hence, these traits were mostly controlled by additive and additive × additive gene interactions and expected to respond to direct selection for trait improvement. Significant opposite signs in [*h*] and [*l*] components indicated the presence of duplicate nature of epistasis.

Cross 2: Swarna x BR2655

The similar results also found in Cross 2, in which iron trait showed high and negative dominance x dominance effect [*l*] (Table 4). Based on this inheritance study, it is apparent that selection during breeding should be practiced in a later segregating generations, when the dominance effects (unfixable genes) are minimal. Similar results were earlier reported for Iron content in rice by Untung[14].

For zinc the additive x additive effect [*i*] was high and positive were prominent followed by dominance effect. This infers duplicate nature of gene interaction operating for the trait in the cross, Swarna x BR2655. Similarly, few reports indicate the predominance of additive genetic variance for both grain iron and zinc indicating the role of additive genetic effect on grain Fe and Zn in maize. (Zhang *et al.,*[18]; Gregorio[7]; Gregorio and Htut[6]) More recently detected higher magnitude of additive gene action as compared to dominance for grain iron content in rice. The [*h*] and [*l*] took opposite sign for both trait *ie* iron and zinc contents in both crosses (Swarna x Ranbir basmati, Swarna x BR2655) indicating the presence of duplicate dominant epistasis Vaithilingam[15] reported duplicate epistasis for iron and zinc in rice. Hence, selection in the early segregating generations may not give desirable recombinants. This may possibly be overcome by delaying the selection to later segregating generations when the dominance and epistasis disappear and resorting to intermating of segregants followed by recurrent selection. Delogu *et at.*[4] suggest recurrent selection as a basic breeding approach in autogamous crops. Diallel selective mating design suggested by Jenson[9] can also be adopted, which will promote more recombination.

Table 1: Transgressive segregants for iron, zinc and yield in Cross 1 (Swarna x Ranbir basmati)

Sl. No.	Character	Number of plants	F_3 Families	Iron (mg/kg)	Zinc (mg/kg)	Yield (kg/ha)
1	Iron	4	F_2-01-50	9.65	27.80	457.61
			F_2-01-62	9.69	27.40	272.25
			F_2-01-121	9.84	25.24	603.11
			F_2-01-145	9.56	29.54	403.63
2	Zinc	3	F_2-01-111	8.94	36.29	622.25
			F_2-01-162	7.74	31.21	361.29
			F_2-01-204	9.07	31.07	194.36

Table 2: Transgressive segregants for iron and zinc in Cross 2 (Swarna x BR2655)

Sl. No.	Character	Number of plants	F3 Families	Iron (mg/kg)	Zinc (mg/kg)	Yield (kg/ha)
1	Iron	13	F_2-02-122	10.35	24.23	6163.10
			F_2-02-123	11.33	27.43	6685.80
			F_2-02-124	10.23	27.53	5240.00
			F_2-02-133	10.35	27.78	3299.40
			F_2-02-134	10.65	27.78	5463.80
			F_2-02-135	10.33	23.08	2767.60
			F_2-02-172	10.23	26.03	3353.80
			F_2-02-189	10.85	28.53	5381.30
			F_2-02-191	10.55	28.53	4922.40
			F_2-02-192	10.55	27.95	2628.60
			F_2-02-193	10.25	27.95	6679.80
			F_2-02-194	10.95	21.95	5300.60
			F_2-02-195	11.43	26.95	3965.70
2	Zinc	2	F_2-02-20	9.05	29.50	4326.10
			F_2-02-77	8.25	29.40	6886.30

Table 3: Scaling test and gene action for Iron and Zinc in rice grain of Cross 1 (Swarna x Ranbir basmati)

Trait	Scale			Gene effects				Type of epistasis
	C	D	M	[d]	[h]	[i]	[I]	
Iron (mg/kg)	0.050 ± 0.036**	0.250 ± 0.026**	7.750 ± 0.003**	-0.025 ± 0.013**	-0.133 ± 0.009**	-0.208 ± 0.028**	0.267 ± 0.037**	Duplicate
Zinc (mg/kg)	0.750 ± 0.076**	1.250 ± 0.063**	28.750 ± 0.013**	-0.375 ± 0.029**	-0.833 ± 0.025**	-1.458 ± 0.071**	0.667 ± 0.100**	Duplicate

* - Significant at 5 per cent ** - Significant at 1 per cent

Table 4: Scaling test and gene action for Iron and Zinc in rice grain of Cross 2 (Swarna x BR2655)

Trait	Scale			Gene effects				Type of epistasis
	C	D	M	[d]	[h]	[i]	[I]	
Iron (mg/kg)	0.150 ± 0.015**	-0.350 ± 0.017**	7.750 ± 0.003**	0.025 ± 0.006**	0.233 ± 0.009**	0.308 ± 0.015**	-0.667 ± 0.025**	Duplicate
Zinc (mg/kg)	0.750 ± 0.076**	1.250 ± 0.063**	28.750 ± 0.013**	-0.375 ± 0.029**	-0.833 ± 0.025**	-1.458 ± 0.071**	0.667 ± 0.100**	Duplicate

* - Significant at 5 per cent ** - Significant at 1 per cent

Acknoledgement

I pay my sincere thanks to Dr. B. C. Virakthmath, Project Director, Dr. N. Shobha Rani, Principal Scientist & Head, CIS, DRR, Dr. Ravindra Babu, Principal Scientist, DRR, Hyderabad and all the Staff of Directorate of Rice Research Hyderabad for giving me experimental material, and encouragement to conduct my Masters research. I acknowledge the help of M S Swamynathan Research Foundation Chennai for Providing XRF, Dr. Vasudevan, Professor, and Head, University of Agricultural Science Raichur and staff of seed unit for providing me image analyzer.

REFERENCES

1. Aswini Samak, N. R., Shailaja Hittalmani, Shashidhar, N. and Hanumareddy Biradar. Exploratory studies on genetic variability and genetic control for protein and micronutrient content in F_4 and F_5 generation of rice. *Asian J. Plant Sci*., **10(7):** 376-379 (2011).
2. Bouis, H. E. and Welch, R. M. Biofortification a sustainable agricultural strategy for reducing micronutrient malnutrition in the global south. *Crop Sci.*, **50:** 20–32 (2010).
3. Cichy K. A., Shana, F., Kenneth, L. G. and George, L. H. Inheritance of seed zinc accumulation in navy bean. *Crop Sci.,* **45:** 864–70 (2005).
4. Delogu, G., Corenzoni, C., Marocco, A., Martiniello, P., Oduardi, M. and Stanca, A. M. A recurrent selection programme for grain yield in winter barley. *Euphytica,* **37:** 105-110 (1998).
5. FAO, 2004 International Year of Rice (IYR). Available from http//en/aboutrice. htm. Accessed on April 2 (2006).
6. Gregorio, G. B. and T. Htut. Micronutrient-dense rice : developing breeding tools at IRRI Rice Science : innovations and impact for livelihood. In : Rice science : innovations and impact for livelihood. *Proc. Inter. Rice Res. Conf.*, September 2002, Beijing, China, pp. 16-19 (2003).
7. Gregorio, G. B. Plant breeding: a new tool for fighting micronutrient malnutrition, progress in breeding for trace minerals in staple crops. *J. Nutr.,* **132:** 500-502 (2002).
8. Hoa, T. T. C. and Lan, N. T. P. Effect of milling technology on iron content in rice grains of some leading varieties in the Mekong delta. *Omonrice*, **12:** 38–44 (2004).
9. Jenson, N. E. A diallel selective mating system for cereal breeding. *Crop Sci.*, **10:** 629-35 (1970)
10. Jia-Ling, Y. and Tzer-Kuan, H. Generation mean analysis of the mineral element contents in rice. *J. Sci. Food. Agric*., **113:** 59-68 (2011).
11. Long, N. T. and Buu, B. C. Tag genes controlling grain protein content using microsatellite markers in rice (*Oryza sativa* L.). *Omon rice*., ***13*:** 67-68 (2005).
12. Mather, K. *Biometrical Genetics*. Chapman and Hall Ltd., London (1949).
13. Reddy, B. V. S., Ramesh, S. and Longvah, T. Prospects of breeding for micronutrients and carotene- dense-sorghums. *Int. Sorghum Millets Newslett.,* **46:** 10-14 (2005).
14. Untung, S. Mapping of quantitative trait loci for high iron and zinc content in polished rice (*Oryza sativa* L.) grain and some agronomic traits using simple sequence repeats markers. *Ph. D, Thesis,* Bogor Agril. Uni., Bogor (2008).
15. Vaithilingam, R. Genetic analysis of earliness and yield components in rice (*Oryza sativa* L.). *Ph. D. Thesis*, TNAU, Coimbatore (India) (1995).
16. Welch, R. M. and R. D. Graham. Breeding for micronutrients in staple food crops from a human nutrition perspective. *J. Exptl. Bot*., **55:** 353-364 (2002).
17. White, P. J. and Broadley, M. R. Biofortifying crops with essential mineral elements. *Trends Plant Sci*., **10:** 428-433 (2009).
18. Zhang, M. M., Du, Y. Q., Peng, Z. M. and He, C. X. Genetic effects of mineral elements of Fe, Zn, Mn and P in black pericarp rice grains. *Acta Genet. Sinica.,* **27:** 792-799 (2000).