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# Grain iron and zinc association studies in rice (*Oryza sativa* L.) $F_1$ progenies

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## ABSTRACT

*Rice is grown in many different environments, can be a short, medium or long grain size. It can also be waxy (sticky) or non-waxy. Iron and zinc deficiencies have been reported to be a food-related primary health problem affecting nearly two billion people worldwide. The brown and red rice genotypes have high grain iron and zinc content and attempt was made to study the association between these mineral content with grain yield. A field experiment was conducted during kharif 2010 involving forty eight hybrids developed through hand emasculation followed by pollination. These hybrids were tested to estimate phenotypic and genotypic association among grain iron, zinc, yield attributes and grain yield. It was observed that grain yield was positively correlated with number of productive tiller per plant, test weight and number of grains per panicle. A positive correlation between iron and zinc content was observed while there is no correlation between grain iron and zinc content with grain yield. Path analysis revealed the highest direct effect of test weight on grain yield followed by number of productive tillers per plant and iron content.*

**Key words:** Biofortification, correlation, grain iron, grain zinc, path analysis.

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## INTRODUCTION

Rice is a staple food for millions of people and having great importance in food and nutritional security. Rice is the second most widely consumed in the world next to wheat. From poorest to richest person in this world consume rice in one or other form. In the last two decades, new research findings generated by the nutritionists have brought to light the importance of micronutrients, vitamins and proteins in maintaining good health, adequate growth and even acceptable levels of cognitive ability apart from the problem of protein energy malnutrition. *Biofortification* [1] is a genetic approach which aims at biological and genetic enrichment of food stuffs with vital nutrients (vitamins, minerals and proteins). Ideally, once rice is biofortified with vital nutrients, the farmer can grow indefinitely without any additional input to produce nutrient packed rice grains in a sustainable way. This is also the only feasible way of reaching the malnourished population in India.

In this context breeders are now focusing on breeding for nutritional enhancement to overcome the problem of malnutrition. The range of iron and zinc concentration in brown rice is 6.3-24.4 μg/g and 13.5-28.4 μg/g respectively. There is approximately a fourfold difference in iron and zinc concentration, suggesting some genetic potential to increase the concentration of these micronutrients in rice grains [2]. A scarce scientific literature is available on the association between grain iron and zinc content with grain yield. The present research was taken up to study the association of grain iron and zinc with grain yield.

## MATERIALS AND METHODS

*Experimental design, materials and growing conditions*

The experiment was conducted at Directorate of Rice Research Farm, Hyderabad, India, during *kharif* 2010 season. The experimental material comprised of 48 rice hybrids developed through hand emasculation and pollination method from six female with eight male lines. The details of fourteen lines were mentioned in the Table 1. Seedlings at 26 days after sowing were transplanted into the main field. Each entry was planted in two rows each having ten plants with a inter row spacing of 20 cm and intra row spacing of 10 cm. The experiment was laid out in completely randomized block design with two replications. Genotypes were grown as under irrigated condition and standard crop production and crop protection practices were followed. Data on days to 50% flowering (DFF), days to maturity (DM) recorded at respective stage of crop while, plant height (PH), panicle length (PL), productive tillers per plant (PT) were recorded at harvest and number of grains per panicle (GPP), test-weight (TW), grain iron content (Fe), grain zinc content (Zn) and grain yield per plant (GY) recorded after harvest.

*Estimation of iron and zinc*

Iron and zinc content of grain samples were estimated by Atomic Absorption Spectrophotometer [3]. One gram of seed was taken and powdered it in the grinder (non metallic grinder). Powdered seed sample was digested in tri-acids ($HNO_3$+$HCl_4$+$H_2SO_4$) mixture (10:4:1) in micro-oven digester. The digested sample was cooled for 30 minutes and the volume was made up to 50 ml with double distilled water. Then a known quantity of aliquot was used for subsequent analysis. A suitable blank was run simultaneously to account for the contamination from the reagents. Zinc and Iron content were estimated in the aliquot of seed extract by using Atomic Absorption Spectrophotometer (AAS) at 213.86 nm for zinc and 248.33 nm for iron.

*Statistical analysis*

Both phenotypic and genotypic correlation coefficients were worked [4]. The direct and indirect effects of individual characters on grain yield were estimated [5] [6].

## RESULTS AND DISCUSSION

Grain yield being a complex polygenic character, direct selection based on these traits would not yield fruitful results without giving due importance to their genetic background. The association of yield and its component traits reflects the nature and degree of relationship between them. The correlation analysis helps in examining the possibility of improving yield through indirect selection of its component traits which are highly correlated.

*Association between grain yield and its component characters*

Highly significant positive correlation was observed for grain yield per plant with number of productive tillers per plant (0.660 Genotypic (G), 0.653 Phenotypic (P)) followed by tillers per plant (0.566G, 0.552P), test-weight (0.473G, 0.472P), and number of grains per panicle (0.355G, 0.356P). Grain zinc content had significant negative correlation at genotypic level (-0.312) but non-significant at phenotypic level (-0.270).

These results are in corroboration with Shashidhar *et al*., 2005, Girish *et al*., 2006, Monalisa *et al*., 2006 for number of productive tillers per plant; Sharma and Dubey, 1997, Verma and Mani 1997, Choudhury and Das 1998, Yogameenakshi *et al*., 2004, Shashidhar *et al*., 2005, Monalisa *et al*., 2006, Suman *et al*., 2006 for number of grains per panicle; Gholipoor *et al*., 1998, Habib *et al.*, 2007 for test-weight.

However grain yield with days to 50 % flowering (-0.034G, -0.018P), days to maturity (0.061G, 0.060P) plant height (-0.005G, -0.016P), panicle length (-0.094G,-0.056P), grain length (0.089G, 0.086P), grain breadth (0.275G, 0.275P), L:B ratio (-0.091G, -0.093P) and grain iron content (-0.090G, -0.047P) had non-significant correlation. The yield contributing traits like, productive tillers per plant, grains per panicle and test-weight are useful in increasing the grain yield.

*Association between mineral contents with grain yield and yield attributing traits*

There is a positive correlation (0.908G, 0.487P) between grain iron content and zinc content results are in accordance with Stangoulis *et al.*, 2007, Jeom Ho et al. 2008 and Patil 2008. Iron content had non-significant correlation with grain yield while zinc content had negative significant correlation with grain yield at genotypic level (-0.312) but non-significant correlation at phenotypic level. These results are accordance with Patil 2008, Kantti (2009). There is no correlation between grain mineral content with grain yield, hence we can take up separate breeding producer to enhancement of grain mineral content and grain yield.

*Path analysis*

The relationship between yield and yield components may be negative or positive but it is the net result of direct effect of that particular trait and indirect effects *via* other traits. Hence, it is necessary to determine the path co-efficient which partitions the observed correlation into direct and indirect effects and also reveals the cause and effect relationship between yield and their related traits.

*Direct effects of component characters on grain yield*

Among the characters studied in rice, grain length had highest positive direct effect of 0.916 towards grain yield followed by number of productive tillers per plant (0.753), number of grains per panicle (0.702) and test-weight (0.424), while L:B ratio had highest negative direct effect of -1.253 followed by grain breadth (-0.831) and other characters viz., days to 50 per cent flowering (-0.113), days to maturity (0.031), plant height (0.263), panicle length (-0.043), tillers per plant (0.069), grain iron content (-0.166) and grain zinc content (0.122) moderate to low direct effects on grain yield. Similar results were found for number of productive tillers per plant by Monalisa *et al.* (2006), Panwar *et al.* (2007) and Kole *et al.* (2008); for number of grains per panicle by Choudhury and Das (1998), Yogameenakshi *et al.* (2004) and Panwar *et al.* (2007) and for test-weight by Suman *et al.* (2006), Bhattacharyya *et al.* (2007), Habib *et al.* (2007) and Kole *et al.* (2008) towards grain yield. More number of productive tillers per plant, more number of grains per panicle has to be selected to get higher returns.

*Indirect effects of component characters on grain yield*

Among indirect effects, grain breadth had highest indirect effect *via* L:B ratio (0.847) followed by L:B ratio *via* grain length (0.721), number of tiller per plant *via* productive tiller per plant (0.709) and test-weight *via* grain length (0.604).

**Fig 1. The relationship between the proportions of grain iron and zinc in $F_1$ progenies**

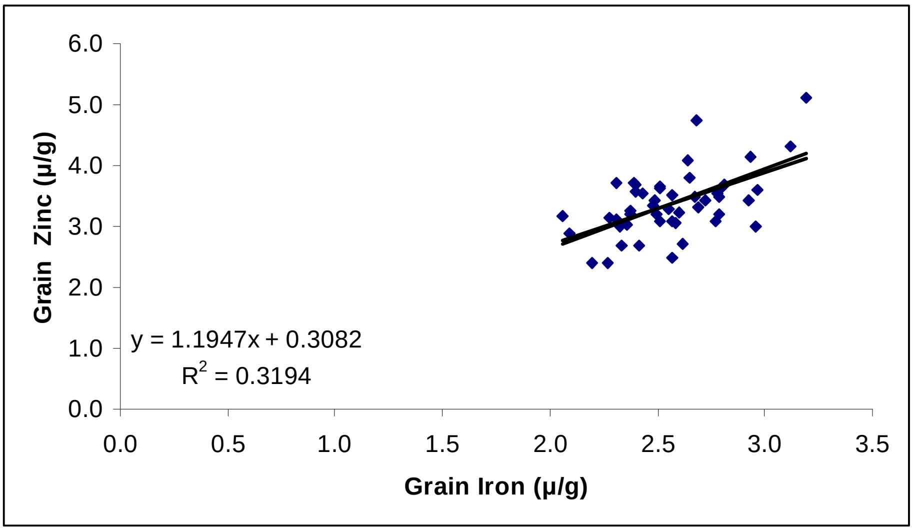
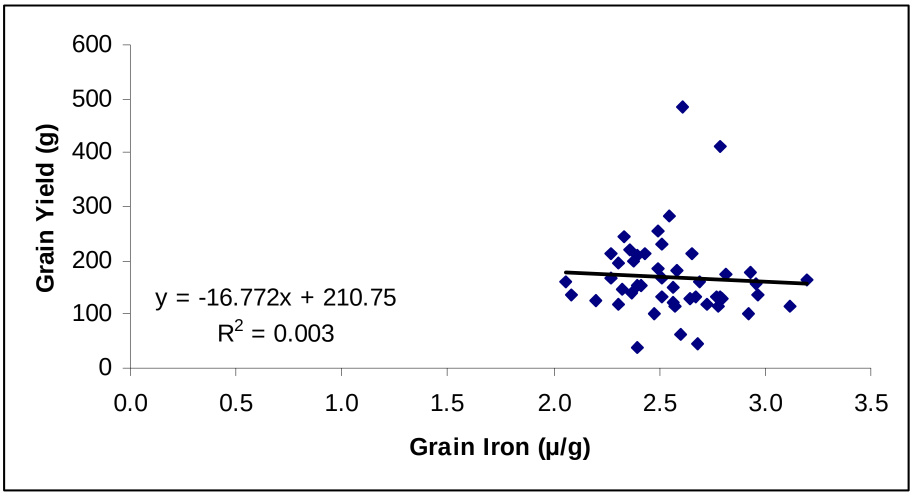



**Fig 2. The relationship between the proportions of grain iron and Grain yield in $F_1$ progenies**




Selection based on number of productive tillers per plant, test weight and number of grains per panicle would be most effective, since test-weight, number of productive tillers per plant and number of grains per panicle were had maximum direct effect as well as indirect effect on other characters *via* these traits.

There is no much direct effect of grain iron and zinc content hence, simultaneous selection has to be made to get higher yield and higher grain iron and zinc content.

In plant breeding, it is very difficult to have complete knowledge of all component traits of yield. The residual effect determines how best the casual factors account for the variability of the dependent factor, the yield in this case. Its estimate being 0.2416, the traits (Plant height, Days to 50 per cent flowering, Days to maturity, Number of tillers per plant, Number of productive tillers per plant, Panicle length, Number of filled grains per panicle, Test-weight, Grain length, Grain breadth, Length/Breadth ratio, grain iron and grain zinc) explain about 76% of the variability in the yield. The traits included in the study account fully for the variation in yield.

**Fig 3. The relationship between the proportions of grain zinc and Grain yield in $F_1$ progenies**

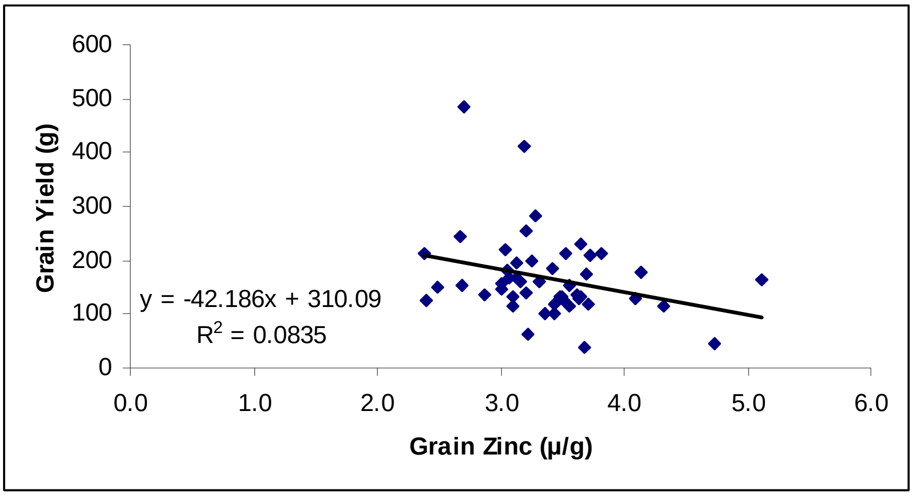



**Table 1. List of genotypes used in the study with their parentage and concentration of iron and zinc content in the grains**

| Sl. No. | Genotypes | Parentage | Iron concentration (mg/100 g of brown rice) | Zinc concentration (mg/100 g of brown rice) | Yield (t $ha^{-1}$) | Year of release |
|---|---|---|---|---|---|---|
| 1 | RP Bio-226 (Improved BPT5204) | BPT 5204*4/SS1113 | 1.07 | 2.2 | 4.63 | 2007 |
| 2 | Swarna | Vasisa /Mahsuri | 0.78 | 2.28 | 6.50 | 1979 |
| 3 | MTU1010 (Cottondora Sannalu) | Krishnaveni/IR 64 | 0.73 | 2.54 | 6.70 | 2000 |
| 4 | IR 64 | IR 5657-33-2-1/IR 2061-465-1-5-5 | 1.05 | 1.05 | 5.00 | 1985 |
| 5 | PR116 | PR108/PAU 1628//PR 108 | 0.77 | 2.38 | 7.20 | 2000 |
| 6 | Madhya Vijaya | Sona x Mahsuri | 0.73 | 2.49 | 5.50 | 1986 |
| 7 | Chittimuthyalu | Local landrace | 2.51 | 3.07 | - | - |
| 8 | Ranbir Basmati | Selection from Basmati 370 | 1.33 | 2.96 | 2.70 | 1994 |
| 9 | Madhukar | Selection from Gonda | 2.85 | 4.72 | - | 1969 |
| 10 | Jalmagna | Selection from Badhon | 1.62 | 1.94 | - | 1969 |
| 11 | Type-3 (Dehradoon basmati rice) | Selection from Deharadun Basmati | 1.41 | 3.06 | 3.00 | 1978 |
| 12 | Jalpriya | IET 4060/Jalmagna | 2.44 | 3.37 | 3.50 | 1993 |
| 13 | Suraksha | Sasyasree x MR-1523 | 1.06 | 2.53 | 5.75 | 1988 |
| 14 | BR 2655 | (BR 10 X BR 4) X (BR7 X Palghar 84-3) | 1.05 | 2.37 | 8.00 | 2001 |

**Table 2. Phenotypic and genotypic correlation coefficients among yield and yield attributes of various rice genotypes**

| | | DM | PH | PL | PT | TW | GPP | Fe | Zn | GY |
|---|---|---|---|---|---|---|---|---|---|---|
| **DFF** | P | 0.696** | 0.332* | -0.264 | -0.234 | -0.429** | 0.453** | -0.025 | 0.124 | -0.018 |
| | G | 0.847** | 0.443** | -0.378** | -0.276 | -0.497** | 0.500** | 0.11 | 0.141 | -0.034 |
| **DM** | P | | 0.14 | -0.188 | -0.192 | -0.248 | 0.406** | -0.188 | -0.139 | 0.06 |
| | G | | 0.208 | -0.296* | -0.198 | -0.331* | 0.456** | -0.488** | -0.134 | 0.061 |
| **PH** | P | | | 0.365* | -0.331* | -0.195 | 0.264 | 0.013 | 0.02 | -0.016 |
| | G | | | 0.608** | -0.354* | -0.209 | 0.284 | -0.079 | -0.055 | -0.005 |
| **PL** | P | | | | -0.196 | 0.101 | -0.016 | -0.002 | -0.072 | -0.056 |
| | G | | | | -0.307* | 0.089 | -0.005 | -0.281 | -0.302* | -0.094 |
| **PT** | P | | | | | 0.300* | -0.298* | -0.009 | -0.034 | 0.653** |
| | G | | | | | 0.33 | -0.301 | 0.03 | -0.033 | 0.660** |
| **TW** | P | | | | | | -0.244 | -0.086 | -0.183 | 0.472** |
| | G | | | | | | -0.254 | -0.235 | -0.22 | 0.473** |
| **GPP** | P | | | | | | | -0.009 | -0.176 | 0.356* |
| | G | | | | | | | -0.023 | -0.214 | 0.355* |
| **Fe** | P | | | | | | | | 0.487** | -0.047 |
| | G | | | | | | | | 0.908** | -0.09 |
| **Zn** | P | | | | | | | | | -0.27 |
| | G | | | | | | | | | -0.312* |

*P @ 0.05 = 0.458, P @ 0.01 =0.612; * and ** indicates significant at 5 %and 1 % level respectively*
*DFF-days to 50 per cent flowering DM-days to maturity; PH-plant height; PL-panicle length; PT-productive tillersTW-test-weight; GPP-grains per panicle; Fe-grain iron; Zn-grain zinc; GY-grain yield*

**Table 3. Path coefficient analysis indicating direct and indirect effects of components**

| | DFF | DM | PH | PL | PT | TW | GPP | Fe | Zn | 'r' |
|---|---|---|---|---|---|---|---|---|---|---|
| **DFF** | **-0.113** | 0.027 | 0.116 | 0.016 | -0.208 | -0.21 | 0.351 | -0.018 | 0.016 | -0.034 |
| **DM** | -0.096 | **0.031** | 0.055 | 0.013 | -0.149 | -0.14 | 0.32 | 0.081 | -0.015 | 0.061 |
| **PH** | -0.05 | 0.007 | **0.263** | -0.026 | -0.267 | -0.089 | 0.199 | 0.013 | -0.006 | -0.005 |
| **PL** | 0.043 | -0.009 | 0.16 | **-0.043** | -0.231 | 0.038 | -0.004 | 0.047 | -0.034 | -0.094 |
| **PT** | 0.031 | -0.006 | -0.093 | 0.013 | **0.753** | 0.14 | -0.211 | -0.005 | -0.004 | 0.66 |
| **TW** | 0.056 | -0.01 | -0.055 | -0.004 | 0.248 | **0.424** | -0.178 | 0.039 | -0.025 | 0.473 |
| **GPP** | -0.057 | 0.014 | 0.075 | 0 | -0.226 | -0.108 | **0.702** | 0.004 | -0.024 | 0.355 |
| **Fe** | -0.012 | -0.015 | -0.021 | 0.012 | 0.023 | -0.099 | -0.016 | **-0.166** | 0.102 | -0.09 |
| **Zn** | -0.016 | -0.004 | -0.014 | 0.013 | -0.025 | -0.093 | -0.15 | -0.151 | **0.112** | -0.312 |

*Residual effect = 0. 2416397; DFF-days to 50 per cent flowering; DM-days to maturity; PH-plant height, PL-panicle length ; PT-productive tillers; TW-test-weight; GPP-grains per panicle ; Fe-grain iron, Zn-grain zinc; GY-grain yield*

## CONCLUSION

From present studies revealed that grain yield had significant positive correlation with productive tillers per plant, test-weight and number of grains per plant. Grain Iron content and zinc content had no correlation with grain yield. Simultaneous selection / breeding can be taken up to enhance grain iron and zinc and grain yield because of no correlation. Path analysis revealed selection of more number of productive tillers per plant, more number of grains per panicle and high test-weight will be useful in increasing the grain yield.

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