

Descriptive Statistics and Heritability for Agronomic Traits and Grain Micronutrient Content in Rice (*Oryza sativa* L.)

Abstract

In the present investigation, 10 parents, their 45 crosses (half diallel) along with 2 standard checks (Rajendra Nilam and Rajendra Mahsuri-1) were evaluated during *Kharif*, 2018 in Randomized Complete Block Design with 3 replications at Rice Farm Section, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Bihar. The objective of this study was to identify promising genotypes having desirable combination of morphological characters along with high grain iron and zinc content and high grain yield potential. The results of variability parameters indicated that ample amount of genetic variability was present for all the studied traits. Most of the traits showed high heritability coupled with high genetic advance indicating fruitfulness of selection for improvement of these traits. One genotype ($P_2 \times P_7$) with high grain iron content (16.10 ppm) and high grain zinc content (26.40 ppm) along with higher yields (43.12 g/plant) was identified. Genotypes with high grain iron coupled with high grain yield ($P_7 \times P_9$, $P_8 \times P_9$, $P_5 \times P_7$ and $P_5 \times P_9$) and high grain zinc content coupled with high grain yield ($P_4 \times P_7$, $P_9 \times P_{10}$, $P_8 \times P_9$ and $P_5 \times P_7$) were also identified. These promising genotypes identified can be used further in breeding programmes to obtain superior segregants with higher grain micronutrient content and higher grain yield.

Keywords:- Rice, Diallel, GCV, PCV, Heritability, Genetic Advance, Variability parameters, Biofortification

1. Introduction:

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population contributing over 20% of the total calorie intake of humans (Seck *et al.*, 2012). To fulfil the future food demand of ever-increasing world population, it is an urgent need to take necessary steps for increasing the productivity of this crop (Ram *et al.*, 2007). Average daily intake of rice provides 20-80 per cent of dietary energy and 12-17% of dietary proteins for Asians (Chopra *et al.*, 2001). In India, rice is grown over an estimated area of about 44.50 million hectares with the production of 115.63 million tonnes with an average productivity of 3.90 tonnes per hectare (FAS/USDA, Office of Global Analysis; 2019). Micronutrient deficiencies or “hidden hunger” affect about 38% of pregnant women and 43% of preschool

children worldwide and are most prevalent in developing countries. Biofortification is a combined approach of conventional plant breeding and modern biotechnology to enrich vital nutrients (minerals, vitamins and proteins) in staple crops (Graham *et al.*, 1999; Pfeiffer and McClafferty, 2007). Among micro-elements, iron (Fe) and zinc (Zn) mineral deficiency are the most common and widespread, affecting more than half of the human population. Fe serves as an important cofactor for various enzymes performing basic functions in humans. Fe is an essential element for blood production. About 70% of the body's iron is found in the Red Blood cells as haemoglobin molecule that is involved in transfer of oxygen from the lungs to the tissues (Roohani *et al.*, 2013). Iron deficiency is one of the most prevalent micronutrient deficiencies, affecting around two billion people, globally (WHO, 2016). Zn helps in protein synthesis and regulates immune system of the human body. Zinc deficiency is a major cause of stunting among children. About 165 million children with stunted growth run a risk of compromised cognitive development and physical capability (Trijatmiko *et al.*, 2016). Zn is one of the essential micronutrients that serves as a cofactor for more than 300 enzymes involved in the metabolism of carbohydrates, lipids, proteins, and nucleic acids; hence it is important in normal growth and development of plants and animals. Some of these problems are more acute and clearly evident in developing countries where people depend on cereal based foods for their daily diet and they cannot afford to diversify their meal by adding mineral rich fruits, vegetables, and meat. To address this problem, biofortification (*i.e.*, the breeding of micronutrient fortified crops) is advantageous for people who experience difficulty in changing their dietary habits because of financial, cultural, regional, or religious restrictions. Biofortification is also advantageous for governments because it is inexpensive and sustainable compared to nutritional supplement programs.

Genetic variability is the primary need for a sound plant breeding approach for realizing higher economic yield because selection and its success would depend on the availability of wider genetic variability and extent to which traits are heritable. Together with heritability, genetic advance gives estimates of realizable gain at a specific intensity of selection which is an important tool in plant breeding. Therefore, heritability estimates along with genetic advance are more helpful in selection for yield and yield components. Therefore, the present study was carried out with an aim to evaluate rice genotypes including their cross combinations with an ultimate aim to obtain genotypes with high grain Fe and Zn content long with high grain yield.

2. Materials and Methods:

10 diverse genotypes of rice showing variability for iron and zinc (**Table 1**) were selected from Harvest Plus Trial conducted at Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. These genotypes were mated in half diallel fashion to obtain 45 direct crosses during *Kharif*, 2017. These 45 crosses along with parents and 2 standard checks (Rajendra Nilam and Rajendra Mahsuri-1) were evaluated during *Kharif*, 2018 using Randomized Complete Block Design with 3 replications. Observations for 14 traits were recorded on 5 randomly selected plants in each entry except for days to 50% flowering and days to maturity where observations were recorded on plot basis. The estimation of micronutrients (Farooq *et al.*, 2019) by XRF (X- Ray Fluorescence Spectrometry) was carried out at Harvest Plus Division, ICRISAT, Hyderabad.

Table 1. List of parental genotypes

S.N.	GENOTYPES	S.N.	GENOTYPES
1	IR68144-2B-2-2-3-1 (P1)	6	KALA JIRA JAHA (P6)
2	HATI BANDHA (P2)	7	IR91175-27-1-3-1-3 (P7)
3	TEVIRII (P3)	8	R-RIZIH-7 (P8)
4	NGOBANYO RED COVER (P4)	9	MTU 1010 (P9)
5	KHUSISOI-RI-SAREKU (P5)	10	TEINEM RUIHENG MAA (P10)

2.1 Statistical analysis:

The mean data recorded on 14 quantitative traits were subjected to estimate descriptive statistics like range, mean and coefficient of variation, heritability and genetic advance. The data was subjected to randomized block design analysis.

2.2 Estimation of Variance Components:

$$\text{Genotypic Variance } (\sigma_g^2) = \frac{\text{MSt} - \text{MSe}}{\text{No.of Replications (r)}}$$

$$\text{Environmental Variance } (\sigma_e^2) = \text{MSe}$$

$$\text{Phenotypic variance } (\sigma_p^2) = \sigma_g^2 + \sigma_e^2$$

Where,

MS_e = Mean Square Error, MS_t = Mean Square Treatment

In the present investigation three types of coefficient of variations were estimated, viz., phenotypic coefficient of variation (PCV), genotypic coefficient (GCV) and Environmental coefficient of variation (ECV). The formulae used to calculate PCV, GCV, ECV were given by Burton and De vane (1953).

$$(i) \text{ PCV (\%)} = \frac{\text{Phenotypic Standard Deviation}}{\text{Mean}} \times 100$$

$$(ii) \text{ GCV (\%)} = \frac{\text{Genotypic Standard Deviation}}{\text{Mean}} \times 100$$

$$(iii) \text{ ECV (\%)} = \frac{\text{Error Standard Deviation}}{\text{Mean}} \times 100$$

Where,

σ_p^2 = Phenotypic variance, σ_e^2 = Environmental variance, σ_g^2 = Genotypic variance, X = Mean of character

Categorization of the range of variation was done as proposed by Sivasubramanian and Madhavamenon (1973); <10% - Low, 10-20% - Moderate, >20% - High

Results:

The analysis of variance revealed that mean sum of square due to treatment was highly significant for all the characters studied, indicating the presence of ample amount of variability. The mean, range and coefficient of variance of all characters are presented in **Table 3**. The mean performance of genotype along with that of check for quality traits and grain yield is presented in **Table 4** and **Figure 1, 1(a), 2 and 2 (a)**. A wide range of variation was found for most of characters amongst genotypes. Days to 50% flowering ranged from 70.33 (P₁×P₇) to 109.00 (P₉×P₁₀). Days to physiological maturity ranged from 96.67 (P₁×P₇) to 133.00 (P₂×P₄). Plant height varied from 87.67 (P₄×P₁₀) to 185.67 (KHUSISOI-RI SAREKU). The data on flag leaf area ranged from 20.21 (P₁×P₇) to 47.26 ((P₇×P₈). The canopy temperature among parents recorded in between 22.17 (MTU-1010) to 34.48 (P₃×P₆). The data recorded for chlorophyll content ranged between 28.07 (P₁×P₃) to 51.53 (P₄×P₅). The panicle length varied in between 22.17 (P₁×P₇) to 29.67 (P₂×P₃). The number of effective tillers per plant ranged from 4 (P₃×P₆) to 17 (P₇×P₉). The values for grains per panicle recorded in between 109.33 (P₃×P₆) to 197.48 (MTU-1010). The range of test weight was recorded in between 17.51 (NGOBANYO RED COVER) to 25.05 (P₃×P₁₀). The range of harvest index was found in between 38.01 (P₂×P₈) to 59.49 (P₁×P₃). For Grain iron content the range was 8.89 (P₆×P₇) to 16.92 (P₇×P₉). The maximum and minimum grain zinc content

in grains was reported in $P_2 \times P_9$ (30.77 ppm) and $P_4 \times P_9$ (19.22 ppm), respectively. For grain yield per plant, the range was 26.75 ($P_3 \times P_6$) to 50.81 ($P_7 \times P_9$).

Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV):

Genetic variability parameters for different traits are presented in **Table 5 and Fig. 3**. High PCV and GCV was found for effective tillers per plant (32.54 & 28.27) followed by Plant height (20.77 & 20.22), moderate values of PCV and GCV was found for the traits; days to 50% flowering (12.37 & 12.03), flag leaf area (18.52 & 17.26), Chlorophyll content (14.42 & 12.80), Grains per panicle (15.60 & 14.24), grain iron content (14.15 & 13.98), grain zinc content (11.11 & 11.09) and grain yield per plant (16.37 & 13.66) while, the lowest values of PCV and GCV was found for days to physiological maturity (8.66 & 8.40), canopy temperature (9.26 & 7.09), panicle length (9.76 & 6.74) and test weight (9.55 & 5.16). In case of Harvest index PCV (10.93) and GCV (8.74) have shown moderate and low value respectively.

Heritability and Genetic Advance

High heritability was found for days to 50% flowering (94.56), days to physiological maturity (94.08), plant height (94.74), flag leaf area (86.90), chlorophyll content (78.78), effective tillers per plant (75.49), grains per panicle (83.24), harvest index (63.98) grain iron content (97.64), grain zinc content (98.18) and grain yield per plant (69.65) while, moderate heritability was found for canopy temperature (58.64) and panicle length (47.64). Only one trait; test weight (29.22) has shown low heritability.

High genetic advance as % of mean was found for days to 50% flowering (24.10), plant height (940.54), flag leaf area (33.15), chlorophyll content (23.40), effective tillers per plant (50.60), grains per panicle (26.76), grain iron content (28.46), grain zinc content (222.64) and grain yield per plant (23.48) while moderate genetic advance as % of mean was found for days to physiological maturity (16.77), harvest index (14.40) and canopy temperature (11.19). Panicle length (9.58) and test weight (5.75) showed low genetic advance as % of mean (**Table 5 & Fig. 4**).

Discussion:

Phenotypic range describes the variability for the trait of interest however the phenotypic range for individual trait cannot be used as criteria to compare the variability of several traits with respect to each other. Therefore, we can conclude that effective tillers per plant showed maximum variation with range 4.00 to 17.00 and CV value of 16.11. This was followed by grain yield per plant with range 26.75 to 50.81 and CV value of 9.02. Grain Zinc content showed minimum variation with range 19.22 to 30.77 and CV value of 1.51.

PCV for all the traits were higher than the GCV of the respective trait indicating role of environment in trait expression however, the maximum difference between PCV and GCV was found with respect to Test weight (9.55 & 5.16) indicating much influence of environment of this trait while.

Selection based on single criteria of heritability is not sufficient to predict the progress made through selection in desired direction. A more robust selection criteria for selection to be effective towards changing the trait mean in progenies of selected individual is based on coupled selection combining heritability and genetic advance as % of mean. Days to 50% flowering (94.56, 24.10), plant height (94.74, 40.54), flag leaf area (86.90, 33.15), chlorophyll plant (78.78, 23.40), effective tillers per plant (75.49, 50.60), grains per panicle (83.24, 26.76), Grain Fe content (97.64, 28.46), Zinc content (98.18, 22.64) and Grain yield per plant (69.65, 23.48) showed high heritability coupled with high genetic advance as % of mean so such traits may be selected with an objective to improve these traits.

Conclusion:

Based on the above studies five promising genotypes for high grain iron with high grain yield and high grain zinc with high grain yield were identified among the 45 hybrids (**Table 4**). The genotypes viz., $P_7 \times P_9$, $P_8 \times P_9$, $P_5 \times P_7$, $P_2 \times P_7$ and $P_5 \times P_9$ were found promising for high iron and high grain yield whereas, $P_4 \times P_7$, $P_2 \times P_7$, $P_9 \times P_{10}$, $P_8 \times P_9$ and $P_5 \times P_7$ were identified for high zinc with high grain yield. These identified genotypes may be used in future breeding programmes to achieve desired segregants for varieties with higher grain micronutrients and higher grain yields so that the selected genotypes can be tested and released.

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Table 2: Mean Sum of Squares for fourteen traits in Rice

Sl. No.	Characters	Mean sum of squares		
		Replication DF = 2	Treatments DF = 56	Error DF = 112
1	Days to fifty percent flowering (d)	32.99	337.04**	13.60
2	Days to Physiological maturity (d)	0.60	275.15**	5.65
3	Plant Height (cm)	33.34	2020.58**	36.68
4	Flag leaf area (cm ²)	9.85	124.58**	5.96
5	Canopy Temperature (°C)	5.84	17.58**	3.34
6	Chlorophyll Content (SPAD)	5.42	84.37**	6.95
7	Panicle length (cm)	1.36	12.22**	3.27
8	Effective Tiller per Plant (no)	5.84	24.65**	2.40
9	Grains per Panicle (no)	253.68	1468.85**	92.41
10	Test Weight (g)	1.42	7.21**	3.22
11	Harvest index (%)	15.88	72.61**	11.44
12	Grain Iron Content (ppm)	0.22	11.63**	0.09
13	Grain Zinc Content (ppm)	0.38	21.79**	0.13
14	Grain yield per plant (g)	19.45	90.99**	11.54

*, ** Significant at 5 and 1 per cent, respectively

Table 3: Mean, range and coefficient of variance (CV) of parents and crosses for fourteen quantitative characters in rice

S. No.	Characters	Mean	Range		CV
			Min	Max	
1	Days to 50% flowering	89.08	70.33	109.00	2.88
2	Days to maturity	112.90	96.67	133.00	2.10
3	Plant height (cm)	127.2	87.67	185.67	4.76
4	Flag leaf area (cm ²)	36.43	20.21	47.26	6.70
5	Canopy Temperature (°C)	30.70	22.16	34.48	5.95
6	Chlorophyll Content (SPAD)	39.70	28.07	51.53	6.64
7	Panicle length (cm)	25.64	22.17	29.67	7.06
8	Effective Tillers per Plant (No.)	10.0	4	17	16.11
9	Grains per Panicle (No.)	151	109.33	197.48	6.38
10	Test Weight (g)	22.34	17.51	25.05	8.04
11	Harvest index (%)	51.64	38.01	59.49	6.56
12	Grain Iron Content (ppm)	14.0	8.89	16.92	2.17
13	Grain Zinc Content (ppm)	24.2	19.22	30.77	1.51
14	Grain yield per plant (g)	37.67	26.75	50.81	9.02

258 **Table 4: Mean performance of crosses, parents and checks for Grain Iron and Zinc**
259 **with Grain yield per plant**

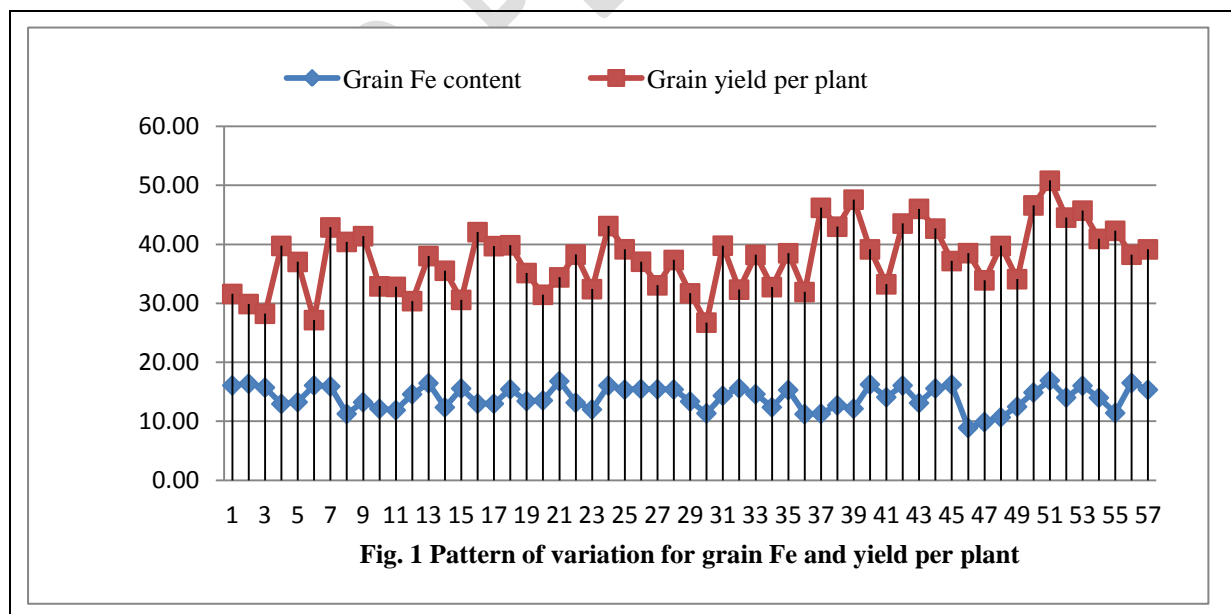
Genotypes	Fe	Zn	GYPP
P1×P2	11.9	22.2	32.80
P1×P3	14.6	27.6	30.39
P1×P4	16.5	29.8	38.03
P1×P5	12.4	25.8	35.54
P1×P6	15.6	20.8	30.60
P1×P7	13.0	21.3	42.09
P1×P8	13.0	24.7	39.72
P1×P9	15.5	28.7	39.87
P1×P10	13.4	28.9	35.15
P2×P3	13.5	25.8	31.47
P2×P4	16.8	22.8	34.42
P2×P5	13.2	20.1	38.28
P2×P6	12.0	23.6	32.42
P2×P7	16.1	26.4	43.12
P2×P8	15.4	24.3	39.18
P2×P9	15.5	30.8	37.07
P2×P10	15.4	26.0	33.07
P3×P4	15.4	20.9	37.37
P3×P5	13.4	25.5	31.70
P3×P6	11.4	25.0	26.75
P3×P7	14.4	23.2	39.79
P3×P8	15.6	20.4	32.34
P3×P9	14.6	23.5	38.23
P3×P10	12.4	24.4	32.76
P4×P5	15.3	27.3	38.51
P4×P6	11.2	20.5	31.93
P4×P7	11.3	26.8	46.21
P4×P8	12.7	20.9	43.01
P4×P9	12.2	19.2	47.60
P4×P10	16.3	23.4	39.17
P5×P6	14.1	26.1	33.24
P5×P7	16.1	23.3	43.54
P5×P8	13.1	21.9	46.03

P5×P9	15.6	22.1	42.69
P5×P10	16.2	27.7	37.19
P6×P7	8.9	27.0	38.53
P6×P8	9.9	25.2	33.92
P6×P9	10.7	26.1	39.74
P6×P10	12.5	21.7	34.11
P7×P8	14.9	21.6	46.62
P7×P9	16.9	21.7	50.81
P7×P10	14.0	20.1	44.55
P8×P9	16.1	24.5	45.73
P8×P10	14.0	23.2	40.94
P9×P10	11.4	25.1	42.31
IR68144-2B-2-2-3-1	16.1	28.1	31.61
HATI BANDHA	16.4	22.7	29.90
TEVIRII	15.7	23.5	28.25
NGOBANYO RED COVER	13.0	21.8	39.75
KHUSISOI-RI-SAREKU	13.3	25.9	37.03
KALA JIRA JAHA	16.1	24.0	27.17
IR91175-27-1-3-1-3	15.9	25.1	42.89
R-RIZIH-7	11.3	24.8	40.43
MTU 1010	13.3	21.3	41.40
TEINEM RUISHENG MAA	12.1	23.4	32.90
RAJENDRA NILUM	16.5	27.1	38.27
RAJENDRA MANSURI	15.4	26.2	39.17
Mean	14.0	24.2	37.67
C.V.	2.17	1.51	9.02
SEm±	0.17	0.21	1.961
C.D. 5%	0.49	0.59	5.50

Table 5: Estimates of genetic parameters for fourteen characters in rice

S. No.	Characters	Variance Components		Coefficient of variation (%)		Heritability (%) (broad sense)	Genetic advance as per cent of mean at 5%
		Genotypic (σ^2_g)	Phenotypic (σ^2_p)	Genotypic	Phenotypic		
1.	Days to 50% flowering	114.82	121.42	12.03	12.37	94.56	24.10
2.	Days to physio. maturity	89.83	95.49	8.40	8.66	94.08	16.77
3.	Plant height (cm)	661.29	697.98	20.22	20.77	94.74	40.54
4.	Flag leaf area (cm ²)	39.54	45.49	17.26	18.52	86.90	33.15
5.	Canopy Temperature (°C)	4.74	8.08	7.09	9.26	58.64	11.19
6.	Chlorophyll Content (SPAD)	25.80	32.75	12.80	14.42	78.78	23.40
7.	Panicle length (cm)	2.98	6.25	6.74	9.76	47.64	9.58
8.	Effective Tillers per Plant (No.)	7.41	9.82	28.27	32.54	75.49	50.60
9.	Grains per Panicle (No.)	458.81	551.22	14.24	15.60	83.24	26.76
10.	Test Weight (g)	1.33	4.55	5.16	9.55	29.22	5.75
11.	Harvest index (%)	20.38	31.83	8.74	10.93	63.98	14.40
12.	Grain Iron Content (ppm)	3.84	3.93	13.98	14.15	97.64	28.46
13.	Grain Zinc Content (ppm)	7.21	7.35	11.09	11.19	98.18	22.64
14.	Grain yield per plant (g)	26.48	38.02	13.66	16.37	69.65	23.48

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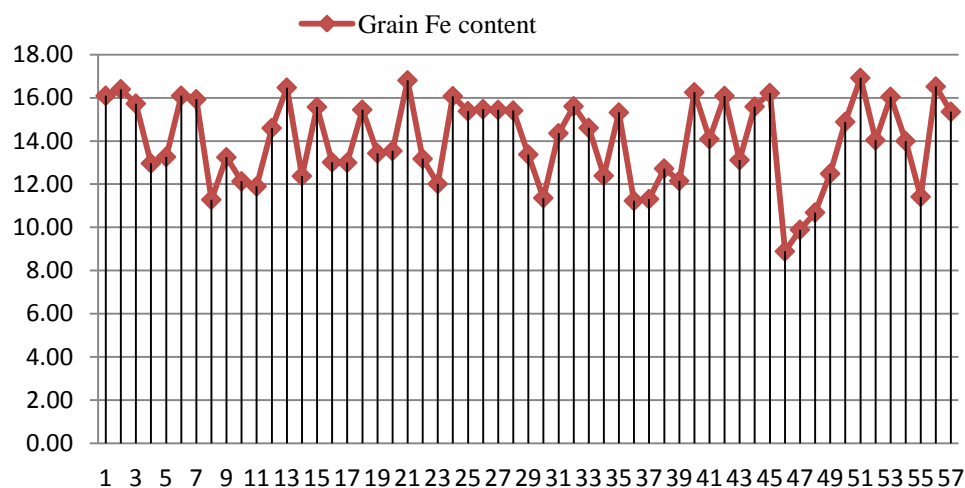


Fig. 1(a) Pattern of variation for Fe content

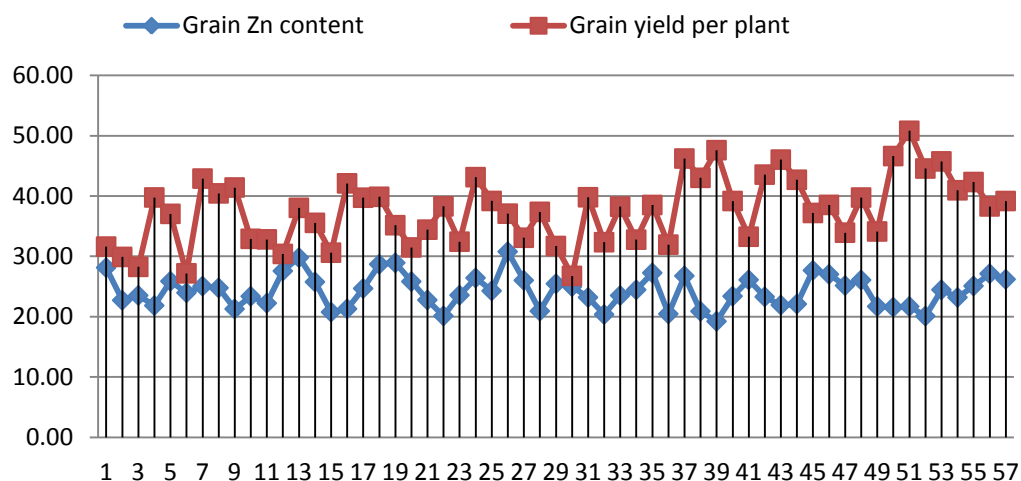


Fig. 2 Pattern of variation for grain Zinc and yield per plant

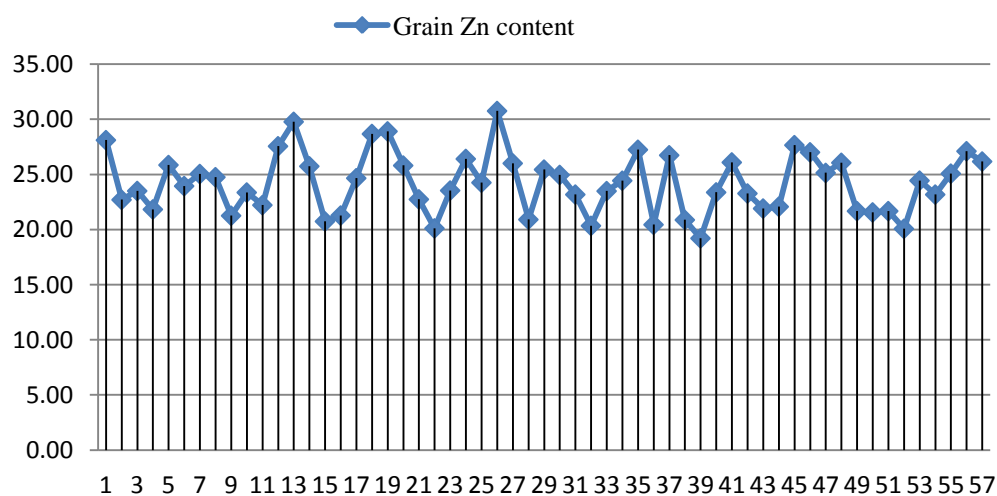


Fig. 2(a) Pattern of variation for Zinc content

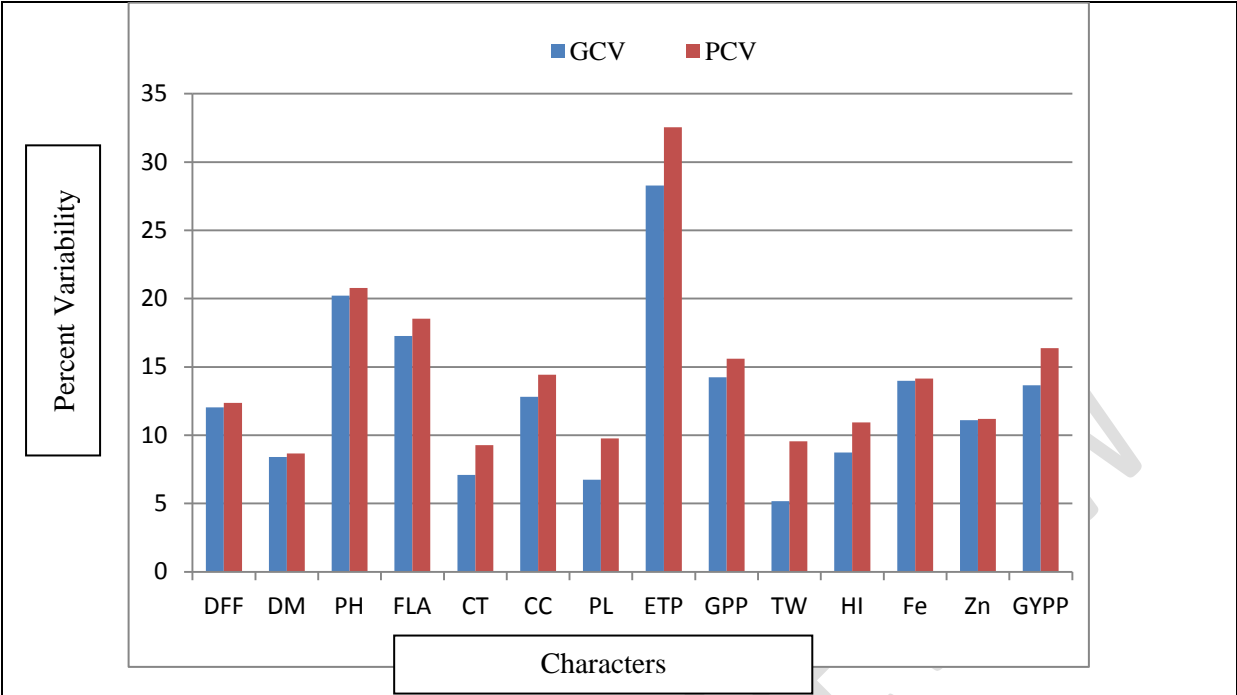


Figure 3: Phenotypic (PCV) and genotypic (GCV) coefficient of variation for various traits in parents, their crosses and standard checks of rice

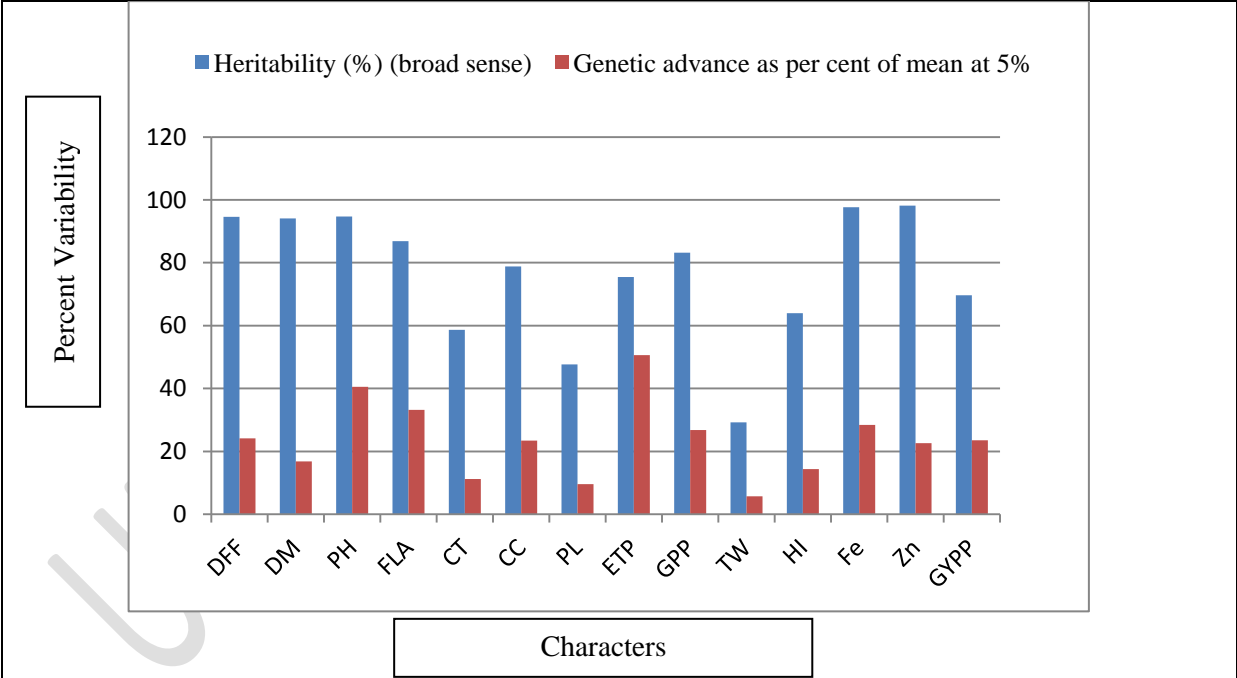


Figure 4: Heritability and genetic advance as percent of mean for various traits in parents, their crosses and standard checks of rice

268 Where, DFF-Days to 50% flowering, DM-Days to physiological maturity, PH-Plant height, FLA-Flag leaf area, CT-
269 Canopy temperature, CC-Chlorophyll content, PL-Panicle length, ETPP-Effective tillers per plant, GPP-Grains per panicle,
270 TW-Test weight, HI-Harvest index, Fe- Grain iron content, Zn-Grain zinc content, GYPP-Grain yield per plant

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