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C Jasmine
Department of Genetics and Plant Breeding, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

D Shivani
Department of Genetics and Plant Breeding, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

P Senguttuvel
Crop Improvement Section, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, India

D Saida Naik
Department of Crop Physiology, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
C Jasmine
Department of Genetics and Plant Breeding, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Genetic variability and association studies in maintainer and restorer lines of rice [*Oryza sativa* (L.)]

C Jasmine, D Shivani, P Senguttuvel and D Saida Naik

Abstract
The present investigation is carried out to study the genetic variability, heritability, correlation and path analysis of yield and yield components parameters for yield, yield attributing and nutritional characters in maintainer and restorer lines of rice. Analysis of variance revealed significant differences among all the treatments under study. High Genotypic Coefficient of Variation and Phenotypic Coefficient of Variation was observed for number of productive tillers per plant, number of spikelets per panicle, thousand grain weight, grain yield per plant, grain iron and zinc concentration. A small difference between GCV and PCV for all the characters studied indicates less influence of environment on these characters. Except days to flowering and panicle length all the characters have high heritability coupled with high genetic advance as per cent of mean indicating that these traits were controlled by additive type of gene action.
Character association studies revealed that, there was a significant positive correlation between Fe and Zn content, indicating the possibility of simultaneous improvement of both mineral elements. The characters grain yield per plant showed significant positive association with thousand grain weight indicating yield can be improved through improvement of this trait. The results of path analysis revealed that the traits thousand grain weight, number of spikelets per panicle, number of productive tillers per plant, and grain iron concentration had a high positive direct effect which could be considered as good selection criteria for yield improvement.

Keywords: Variability, Heritability, correlation, path coefficient

Introduction

Rice (*Oryza sativa* L.) is a mega-food crop grown in over a hundred countries, with a total cultivated area of about 158 million hectares and an annual harvest of over 700 million tonnes (470 million tonnes of milled rice), serving over 3.5 billion people and accounting for 20% of total daily calorie intake. (Seck *et al.*, 2012) [20]. Global rice demand is projected to grow from 496 million tonnes in 2020 to 555 million tonnes in 2035, according to Food and Agricultural Policy Research estimates. Zinc (Zn) and iron (Fe) are two important nutrients for sustaining life in all living species. Approximately 90% of Fe and 40% of Zn are lost after polishing. Iron and zinc deficiency affects up to 80 percent and 35% of the world's population (WHO).

The future agricultural revolution increases the grain production but decreases the availability of micronutrient content (Miller *et al.* 2013) [12]. Therefore, the knowledge of variability for grain yield, yield attributes and quality characters in these rice genotypes is essential for the successful yield and nutritional quality improvement through breeding. Further, since grain yield depends on various component characters, the knowledge of correlation among yield, yield components and quality traits, in addition to identification of direct and indirect effects of the yield and quality traits on grain yield would help in effective yield improvement. The present investigation was undertaken in this context to elucidate information on variability, heritability, genetic advance, character associations and path coefficients in the rice genotypes to identify effective selection criteria for grain yield and quality improvement of coloured rice genotypes.

Materials and Methods

The experiment was conducted at Research Farm, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, India, during *Rabi*, 2021. The experimental material comprised of 54 restorer lines and 10 maintainer lines (Table.1) laid out in Randomized Block Design with 2 replications. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop.

Five representative plants for each population were randomly selected to record observations on the quantitative characters under study. Data on days to 50% flowering (DFF) recorded at flowering stage while, plant height (PH), panicle length (PL), number of productive tillers per plant (NPT) were recorded at harvest and number of spikelets per panicle (SPP), test-weight (TW), grain iron content (Fe), grain zinc content (Zn) and grain yield per plant (GY) were recorded after harvest. Grain Iron and Zinc content were estimated by following recommended standard procedure i.e., X – Ray fluorescence Spectrometry (XRF) (EDXRF, model- X-supreme 8000).

Statistical analysis: Analysis of variance was calculated for each of the characters separately using a randomized block design (Panse and Sukhatme, 1985) [14]. Broad sense heritability (h^2) was calculated as per the procedure suggested by Lush (1940) and genetic advance as per cent of mean (GAM) was estimated based on the formula proposed by Johnson *et al.* (1955) [9]. Correlation coefficients were calculated at genotypic and phenotypic level using the formulae suggested by Falconer (1964) [5]. Seed yield was used as the dependent variable, and path coefficient analysis suggested by Wright (1921) [27] and Dewey and Lu (1959) [3] was used to estimate the direct and indirect effects at the genotypic and phenotypic levels.

Table 1: List of 64 parental lines used in the study

S. No	Name of the genotype	Breeding material
1.	CrMS-32B	Maintainer line
2.	DRR-10B	Maintainer line
3.	DRR-6B	Maintainer line
4.	DRR-3B	Maintainer line
5.	APMS-6B	Maintainer line
6.	IR688897B	Maintainer line
7.	IR58025B	Maintainer line
8.	IR79156B	Maintainer line
9.	IR80555B	Maintainer line
10.	IR6888B	Maintainer line
11.	HSRV-2	Restorer line
12.	HSRV-7	Restorer line
13.	HSRV-8	Restorer line
14.	HSRV-15	Restorer line
15.	HSRV-17	Restorer line
16.	HSRV-21	Restorer line
17.	GP-4	Restorer line
18.	GP-5	Restorer line
19.	GP-6	Restorer line
20.	GP-7	Restorer line
21.	GP-9	Restorer line
22.	GP-17	Restorer line
23.	GP-19	Restorer line
24.	GP-20	Restorer line
25.	GP-21	Restorer line
26.	GP-22	Restorer line
27.	GP-23	Restorer line
28.	GP-24	Restorer line
29.	GP-25	Restorer line
30.	GP-26	Restorer line
31.	GP-27	Restorer line
32.	GP-28	Restorer line
33.	GP-32	Restorer line
34.	GP-36	Restorer line
35.	GP-38	Restorer line
36.	GP-41	Restorer line
37.	GP-42	Restorer line
38.	GP-47	Restorer line
39.	GP-48	Restorer line
40.	ATR-363	Restorer line
41.	ATR-477	Restorer line
42.	SVTCP-64	Restorer line
43.	SVTCP-65	Restorer line
44.	SVTCP-66	Restorer line
45.	SVTCP-67	Restorer line
46.	SVTCP-69	Restorer line
47.	SVTCP-73	Restorer line
48.	SVTCP-74	Restorer line
49.	SVTCP-76	Restorer line
50.	SVTCP-90	Restorer line
51.	SVTCP-91	Restorer line
52.	SVTCP-93	Restorer line

53.	SVTCP-95	Restorer line
54.	SVTCP-96	Restorer line
55.	SVTCP-102	Restorer line
56.	SVTCP-106	Restorer line
57.	SVTCP-111	Restorer line
58.	SVTCP-110	Restorer line
59.	SVTCP-114	Restorer line
60.	SVTCP-116	Restorer line
61.	SVTCP-117	Restorer line
62.	SVTCP-123	Restorer line
63.	SVTCP-130	Restorer line
64.	SVTCP-132	Restorer line

Results and Discussion

The success of any crop improvement programme depends on the magnitude of genetic variability and the extent to which the desirable trait is heritable. The estimate of variability of yield and yield contributing characters and their heritable components in the material is more important in any crop breeding programme. The presence of genetic variability in breeding material has been emphasized by Falconer (1981) [6], so as to exercise critical selection pressure. The information on the nature and magnitude of variation in segregating population of a cross where selection is actually practiced will be more meaningful and it is of immediate practical utility. Moreover correlation studies provide information about the relative contribution of various component traits on grain yield per plant and help in effective identification and selection of superior plants.

Since yield is polygenically controlled and highly influenced by environment, selection based on yield alone is not effective. Therefore, improvement in yield can be brought about by effecting indirect selection through yield attributes whose heritability is high and show strong association with yield. Selection for specific character is known to result in correlated response in certain other characters. Generally, plant breeders make selection for one or two attributes at a time. Then it becomes important to know the effect on other characters. Improvement on grain yield per plant, the most important target character in many cereal crops, it can be achieved by direct selection through other easily observable characters. But, this needs a good understanding of association of different traits with grain yield per plant and their possible associations among themselves.

The data on mean performance along with different variability parameters for all the characters indicated the existence of variability in the population (Table 2). The character number of spikelets per panicle, grain yield per plant and thousand grain weight showed high range of variation. The presence of such wide range of variation indicated the existence of large genetic variation among the individuals. Small difference between PCV and GCV (Figure1) was recorded for all the traits studied in the present investigation, indicating the little influence of environment.

The results also revealed that the characters number of productive tillers per plant, number of spikelets per panicle, thousand grain weight, grain yield and grain iron concentration has high GCV and PCV. This showed that these characters are major contributors to the total variability. Moderate PCV and GCV was observed for plant height and grain zinc concentration indicating selective breeding could be done for these character. High heritability along with GA was observed for all these traits indicates the pre-dominant role of additive gene action in the inheritance of the traits and hence, the effectiveness of direct selection for these traits (Table & Figure 2). The results are in accordance with the reports of Sudeepthi *et al.* (2020) [25] for number of productive tillers per plant; Htwe *et al.* (2019) for number of spikelets per panicle; Sudeepthi *et al.* (2020) [25] for thousand grain weight, Singh *et al.* (2020) [24] for grain yield, Prasannakumari *et al.* (2020) [16] for grain iron concentration; Siddi (2020) [22] for plant height; and Maganti *et al*. (2019) [11] for both grain iron and zinc concentrations.

Low GCV and PCV was observed for days to fifty percent flowering which showed that the variability for these characters was meagre. The days to 50% flowering and panicle length had high heritability with moderate genetic advance. The results are in accordance with Yuvaraja *et al.* (2019) [28] for days to fifty percent flowering and Htwe *et al.* (2019), for panicle length.

The results on character associations between yield, yield components and quality characters are presented in Table 4. A perusal of these results revealed positive and significant association of grain yield with test weight indicating scope for simultaneous improvement of these traits. The results are in agreement with the reports of Umarani *et al.* (2019); Parimala *et al.* (2020) [26, 15] for test weight.

Positive and significant associations were also noticed for days to fifty percent flowering with number of productive tillers per plant (Sarker *et al.* 2014) [19] and grain zinc concentration (Singh *et al*. 2018) [23], plant height with panicle length (Umarani *et al.* 2019) [26] and number of spikelets per panicle (Sarker *et al.* 2014) [19], number of productive tillers per plant with thousand grain weight (Prasannakumari *et al.* 2020) [16], panicle length with number of spikelets per panicle (Singh *et al.* 2020) [24]. Grain iron concentration has a significant positive correlation (r=0.248) with grain zinc concentration as shown in fig 3, implying the possibility of concurrent selection of both the micronutrients. (Raza *et al.* 2019; Singh *et al.* 2020) [18, 24].

Negative and significant associations were in contrast observed for plant height with grain iron concentration (Gangashetty *et al.* 2013) [7], panicle length with grain iron and concentration (Dore *et al.* 2018; Shivani *et al.* 2018) [21, 4], number of spikelets per panicle with test weight (Rahman *et al.* 2014) [17] and Grain iron concentration (Pandey *et al.* 2018) [13]. A perusal of these results indicated the need for balanced selection while effecting simultaneous improvement for these traits.

Selections based on the results of correlation coefficient analysis may not often produce the desired result and hence the study of path coefficient analysis for the estimates of degree of relationship is necessary. Path coefficient analysis allows the separation of the correlation coefficients into direct as well as indirect effects. The results on path analysis of yield components and quality characters on grain yield per plant are presented in Table 5 and Fig. 4. Thousand grain weight had the greatest positive direct effect on grain yield (Parimala *et al.* 2020) [15], followed by number of spikelets per panicle (Prasanna kumari *et al.* 2020) [16], number of productive tillers per plant (Singh *et al.* 2020) [24], and grain iron concentration (Singh *et al.* 2018) [23], indicating that selection for these characters was likely to result in a direct increase in grain yield per plant. The trait thousand grain weight had also recorded high positive and significant association with grain yield per plant, indicating the effectiveness of direct selection for this trait in improvement of grain yield per plant.

However, moderate to negligible or negative direct effects on single plant yield were noticed for days to 50% flowering (Babu *et al.* 2012) [2], plant height (Islam *et al.* 2019) [8], panicle length (Babaeian and Bagheri 2018) [1] and grain zinc concentration (Singh *et al.* 2020) [24]. Further, non-significant association of the above traits was also noticed with grain yield per plant in general, indicating the need for use of restricted simultaneous selection model for nullifying the undesirable indirect effects in order to make use of the high positive direct effects observed for the traits on grain yield per plant.

In current research, the residual effect is 0.909 showing that the characters involved in present study contributed only 10% of variability influencing to the dependent variable i.e., single plant yield. The higher residual value of in the study indicates that apart from the traits considered, there could be several other morphometric traits which could have a significant influence in expression of yield.

Table 2: Mean performance of 64 rice parents for grain yield, its components and quality traits

S. No	Genotype	Days to 50% Flowering	Plant height (cm)	productive tillers/ Plant	Panicle Length (cm)	No of spikelets/ Panicle	1000 grain weight (g)	Grain yield/ Plant (g)	Grain iron concentration (ppm)	Grain zinc concentration (ppm)
1	CrMS-32B	114	81.46	11	24.615	168.5	18.4	24.265	8.5	20.05
2	DRR-10B	109	77.25	11.5	21.595	143.5	16.35	20.9	8.45	20.7
3	DRR-6B	100.5	61.975	11	21.285	114.5	19.905	13.74	9.5	19.6
4	DRR-3B	103	77.575	10	21.265	100	22.995	22.555	9.65	20.75
5	APMS-6B	115	86.87	12.5	21.83	223	16.025	24.28	6.6	16.3
6	IR688897B	97	78.21	12	24.74	135.5	21.025	25.8	7.945	17.25
7	IR58025B	110	80.08	11.5	22.65	137	18.33	19.285	7.17	13.75
8	IR79156B	106.5	84.045	15.5	19.7	112	18.3	22.46	7.67	12.57
9	IR80555B	107.5	74.425	17.5	15.295	132.5	18.5	21.61	9.33	25.1
10	IR6888B	92.5	75.295	12.5	23.505	110	18.45	18.705	7.945	16.855
11	HSRV-2	112.5	80.13	9.5	21.78	113	20.15	20.695	7.525	14.74
12	HSRV-7	108.5	93.93	9	22.76	117	21.195	21.155	7.57	17.37
13	HSRV-8	104	91.165	10.5	25.595	132	23.675	18.78	7.16	15.57
14	HSRV-15	105.5	104.075	11	26.475	156.5	21.75	20.55	6.575	16.74
15	HSRV-17	105	111.455	9.5	26.98	124	20.95	10.04	7.65	15.2
16	HSRV 21	106.5	87.46	15.5	24.645	153	18.37	13	6.8	14.48
17	GP-4	119	100.53	10.5	28.31	261.5	19.14	16.5	5.63	19.05
18	GP-5	113	101.41	11.5	26.995	250	16.6	20.33	5.32	16.05
19	GP-6	119.5	99.81	10.5	25.785	209	17.76	23.12	5.75	17.15
20	GP-7	103	84.185	11.5	25.06	142.5	23.005	13	7.1	15.15
21	GP-9	117	93.5	14.5	23.7	277	14.755	12.3	7.725	16.95
22	GP-17	113	83.62	11.5	24.56	159.5	19.535	11.43	7	15.5
23	GP-19	111.5	91.79	11.5	22.765	197	15.8125	16.19	6.25	16.15
24	GP-20	113	89.675	9.5	21.9	154	18.765	18.065	7.275	16.45
25	GP-21	119	85.93	12	22.24	222	18.4	15.495	4.27	15.3
26	GP-22	108	80.62	11.5	19.33	134.5	20.48	17.57	8.47	18.1
27	GP-23	122	88.21	11.5	23.645	181	19.42	22.52	7.35	15.4
28	GP-24	107.5	86.075	11	24.795	177.5	18.785	22.25	7	14.45
29	GP-25	106.5	89.5	12.5	22.865	191	20.28	29.935	9.15	16.35
30	GP-26	113.5	98.375	10.5	25.005	173.5	22.895	30.715	8.275	16.55
31	GP-27	114.5	84.775	12.5	23.505	190.5	20.45	34.69	8.265	16.3
32	GP-28	108	89.915	10	21.32	151	18.755	25.71	8.46	18.25
33	GP-32	116	99.09	12.5	24.15	120.5	25.39	17.93	7.155	16.3
34	GP-36	117	101.94	13.5	26.015	170.5	25.015	16.6	9.275	22.12
35	GP-38	121	94.49	13.5	20.96	373.5	11.605	18.07	8.35	22.8
36	GP-41	105	88.165	13	24.915	171.5	18.27	25.25	8.45	18.375
37	GP-42	119	113.4	22.5	28.825	171	22.62	20.815	7.775	13.955
38	GP-47	97.5	80.46	9.5	22.915	103	20.155	18.09	6.6	15.3
39	GP-48	103	88.85	10.5	20.015	122	19.375	18.15	15.825	12.15
40	ATR-363	99	117	6.5	25.65	142	18.475	16.365	7.05	18.105
41	ATR-477	104.5	112	8.5	23.15	194	17.885	13.038	9.55	21.1
42	SVTCP-64	104.5	97.015	11	28.115	353	15.375	24.015	6.3	14.55
43	SVTCP-65	101	100.575	9.5	26.5	348.5	8.655	20.94	7.6	15.3
44	SVTCP-66	107.5	95.09	12	23.005	162.5	17.35	23.98	9.7	17.65
45	SVTCP-67	111.5	90.64	9.5	22.95	202.5	17.35	19.045	10.15	18.6
46	SVTCP-69	102.5	109.935	9	28.395	202.5	19.755	18.0985	7.25	12.05

47	SVTCP-73	95	81.73	12.5	20.295	101	17.97	23.295	7.45	13.1
48	SVTCP-74	104.5	99.205	9.5	25.825	192	20.665	16.595	7.45	14.05
49	SVTCP-76	96	94.835	12.5	23.725	184.5	17.895	20.98	7.05	14.2
50	SVTCP-90	95	101.005	12.5	27.905	143.5	21.585	21.62	6.95	11.25
51	SVTCP-91	66.5	95.905	10.5	26.03	229	17.12	17.165	7.8	11.225
52	SVTCP-93	100.5	94.095	9.5	24.75	177	18.845	22.83	7.4	13.12
53	SVTCP-95	67	91.19	9.5	29.185	232.5	16.5	22.86	5.85	14.25
54	SVTCP-96	104.5	88.74	10.5	25.97	356.5	5.405	12.87	6.1	16.25
55	SVTCP-102	91	86.33	8	22.1	225.5	8.45	13.475	8.05	18.6
56	SVTCP-106	107	85.21	10.5	22.96	197	12.5	13.96	8.1	10.25
57	SVTCP-111	106.5	97.11	11	25.01	187.5	14.95	13.11	8.6	19.05
58	SVTCP-110	113.5	99.06	10	23.995	210.5	12.605	16.455	8.35	17.8
59	SVTCP-114	107.5	95.24	8	23.905	303	8.355	14.905	7.48	14.2
60	SVTCP-116	96	83.145	12.5	24.98	147	16.76	16.755	7.25	13.1
61	SVTCP-117	107	83.545	13.5	22.14	144	14.62	23.145	8.65	21.6
62	SVTCP-123	107	124.775	10	27.09	249.5	18.01	19.24	6.7	11.58
63	SVTCP-130	103.5	100.95	12.5	24.395	202	12.435	25.225	6.45	13.3
64	SVTCP-132	100.5	100.44	12.5	23.91	133.5	22.3	23.495	8.45	15.83
	Max. value	122.00	124.77	22.500	29.1850	373.50	25.39	34.69	15.825	25.10
	Avg. mean	105.97	91.94	11.39	24.00	182.75	18.02	19.6251	7.73	16.27
	Min. value	66.50	61.97	6.50	15.29	100.00	5.4050	10.040	4.270	10.250
	Range	55.50	62.8	16.00	13.895	273.50	19.99	24.65	11.55	14.85
	C.D. (p=5%)	6.3005	2.9750	1.3761	1.8006	8.3330	0.9265	2.3153	1.089	0.3871

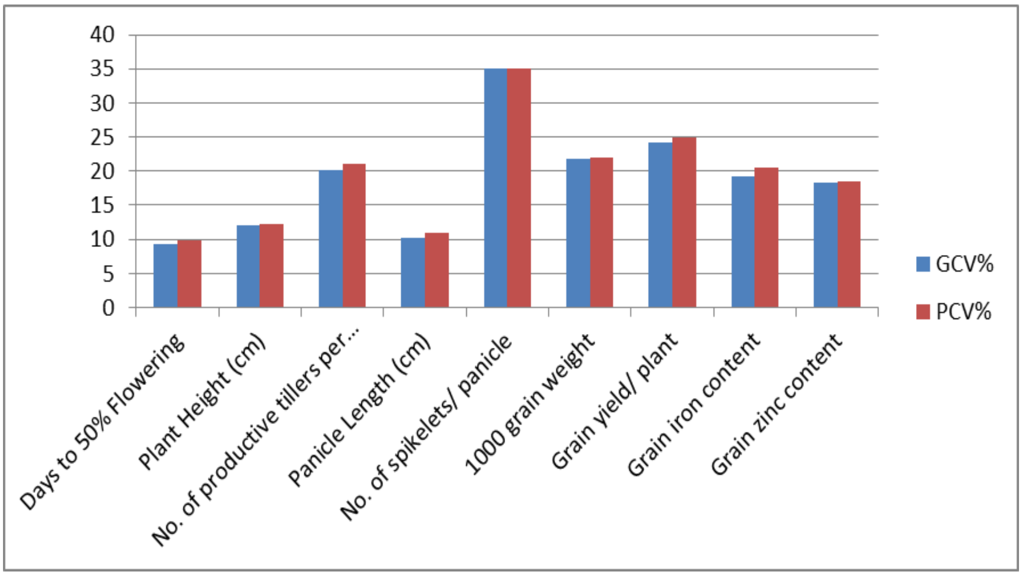

Fig 1: Histogram of phenotypic co-efficient of variation (PCV) and genotypic co- efficient of variation (GCV) for grain yield and its component characters in rice

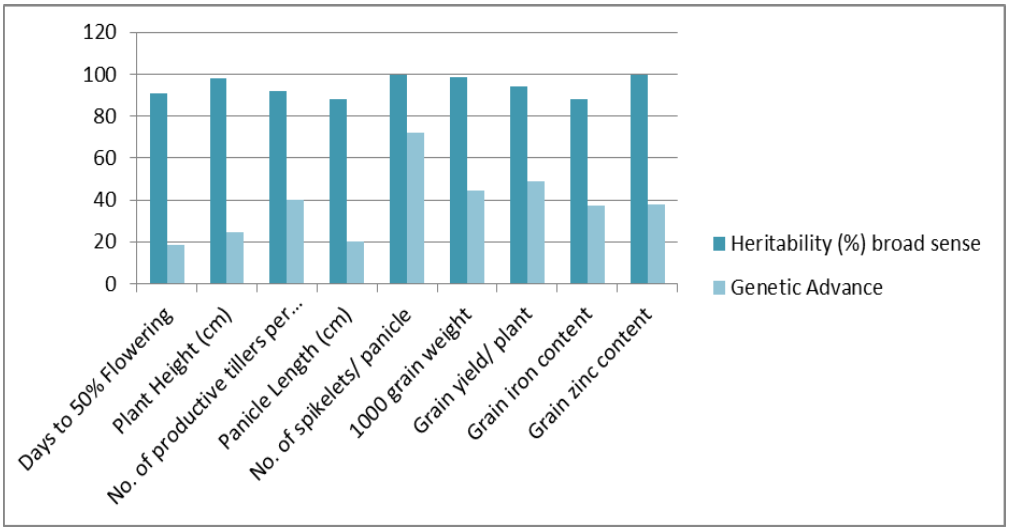

Fig 2: Histogram of heritability in broad sense (h2) and genetic advance for grain yield and its component characters in rice

Table 3: Estimates of mean, range and genetic parameters for yield and yield attributing traits in parental lines of rice

Characters	Mean	Range	Coefficient of variability		Heritability (%) broad sense		Genetic Advance as percent of mean (at 5%)
			Min.	Max.	GCV%	PCV%	
Days to 50% Flowering	105.97	66.50	122.00	9.316	9.779	90.7	18.280
Plant Height (cm)	91.94	61.97	124.77	12.097	12.205	98.2	24.700
No. of productive tillers per plant	11.39	6.50	22.500	20.208	21.093	91.8	39.882
Panicle Length (cm)	24.00	15.29	29.1850	10.302	10.965	88.3	19.940
No. of spikelets/ panicle	182.75	100.00	373.50	34.983	35.057	99.6	71.912
1000 grain weight	18.02	5.4050	25.39	21.753	21.904	98.6	44.501
Grain yield/ plant	19.6251	10.040	34.69	24.279	24.986	94.4	48.598
Grain iron content(ppm)	7.73	4.270	15.825	19.204	20.460	88.1	37.134
Grain zinc content(ppm)	16.27	10.250	25.10	18.403	18.441	99.6	37.831

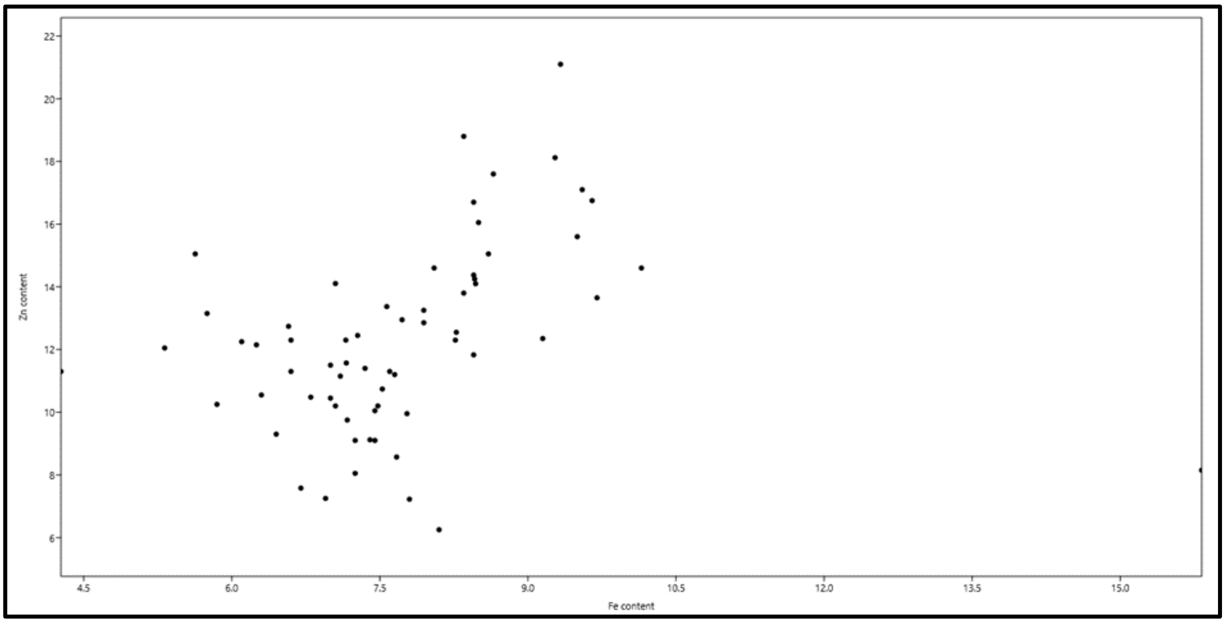

Fig 3: Positive correlation between iron and zinc in 64 rice genotypes

Table 4: Phenotypic (P) and Genotypic (G) correlation coefficient analysis of yield and yield contributing characters in rice

Character		Days to 50% flowering	Plant height (cm)	No of productive tillers/plant	Panicle length (cm)	No of filled grains per panicle	1000 grain weight (g)	Grain iron concentration (ppm)	Grain zinc concentratio n (ppm)	Grain yield per plant(g)
Days to 50% flowering	G	1.0000	0.081	0.253*	-0.166	0.101	0.102	-0.022	0.321**	0.02998
	P	1.0000	0.0798	0.2437 **	-0.1641	0.0987	0.1011	-0.0221	0.3123 ***	0.0383
Plant Height(cm)	G		1.0000	-0.131	0.623**	0.335**	0.022	-0.183	-0.216	-0.09815
	P		1.0000	-0.1286	0.5981 ***	0.3325 ***	0.0229	-0.1752 *	-0.2152 *	-0.0954
Number of productive tillers / plant	G			1.0000	-0.133	-0.113	0.193	0.034	0.082	0.17430
	P			1.0000	-0.1211	-0.1115	0.1902 *	0.0335	0.0804	0.1735
Panicle Length(cm)	G				1.0000	0.355**	0.054	-0.449**	-0.378**	-0.07203
	P				1.0000	0.3436 ***	0.0544	- 0.4436 ***	-0.3646 ***	-0.0736
Number of spikelets /panicle	G					1.0000	-0.688**	-0.291*	-0.015	-0.10475
	P					1.0000	-0.6845 ***	-0.2822 **	-0.0151	-0.1036
1000 Grain Weight (g)	G						1.0000	0.118	0.005	0.2560*
	P						1.0000	0.1130	0.0049	0.246*
Grain iron concentration (ppm)	G							1.0000	0.249*	0.07194
	P							1.0000	0.2408 **	0.0710
Grain zinc concentration (ppm)	G								1.0000	0.01673
	P								1.0000	0.0166

P-represents phenotypic correlation coefficient; **G-** represents genotypic correlation coefficient, *5% level of significance, **1% level of significance

Table 5: Phenotypic (P) and Genotypic (G) Path coefficient analysis of yield and yield contributing characters in rice

Character		Days to 50% flowering	Plant height (cm)	No of productive tillers/plant	Panicle length(cm)	No of Spikelets per panicle	1000 grain weight (g)	Grain iron concentration (ppm)	Grain zinc concentration (ppm)	Grain yield per plant(g)
Days to 50% flowering	G	-0.0850	-0.0070	-0.0223	0.0142	-0.0089	-0.0087	0.0018	-0.0280	0.0210
	P	-0.0506	-0.0040	-0.0123	0.0083	-0.0050	-0.0051	0.0011	-0.0158	0.0383
Plant Height(cm)	G	-0.0089	-0.1083	0.0145	-0.0704	-0.0365	-0.0024	0.0208	0.0235	-0.1011
	P	-0.0087	-0.1086	0.0140	-0.0650	-0.0361	-0.0025	0.0190	0.0234	-0.0954

Number of productive tillers / plant	G	0.0304	-0.0154	0.1157	-0.0170	-0.0133	0.0226	0.0039	0.0097	0.1751
	P	0.0282	-0.0149	0.1156	-0.0140	-0.0129	0.0220	0.0039	0.0093	0.1735
Panicle Length(cm)	G	0.0237	-0.0922	0.0209	-0.1420	-0.0521	-0.0077	0.0647	0.0558	-0.0703
	P	0.0195	-0.0711	0.0144	-0.1188	-0.0408	-0.0065	0.0527	0.0433	-0.0736
Number of spikelets /panicle	G	0.0334	0.1082	-0.0369	0.1178	0.3208	-0.2220	-0.0968	-0.0049	-0.1060
	P	0.0267	0.0901	-0.0302	0.0931	0.2709	-0.1854	-0.0764	-0.0041	-0.1036
1000 Grain Weight (g)	G	0.0451	0.0097	0.0864	0.0239	-0.3055	0.4416	0.0544	0.0024	0.2278
	P	0.0398	0.0090	0.0749	0.0214	-0.2695	0.3937	0.0445	0.0019	0.2203
Grain iron concentration (ppm)	G	-0.0008	-0.0072	0.0013	-0.0171	-0.0113	0.0046	0.0374	0.0096	0.0730
	P	-0.0008	-0.0067	0.0013	-0.0170	-0.0108	0.0043	0.0384	0.0093	0.0710
Grain zinc concentration (ppm)	G	-0.0169	0.0112	-0.0043	0.0202	0.0008	-0.0003	-0.0132	-0.0513	0.0168
	P	-0.0158	0.0109	-0.0041	0.0185	0.0008	-0.0002	-0.0122	-0.0507	0.0166

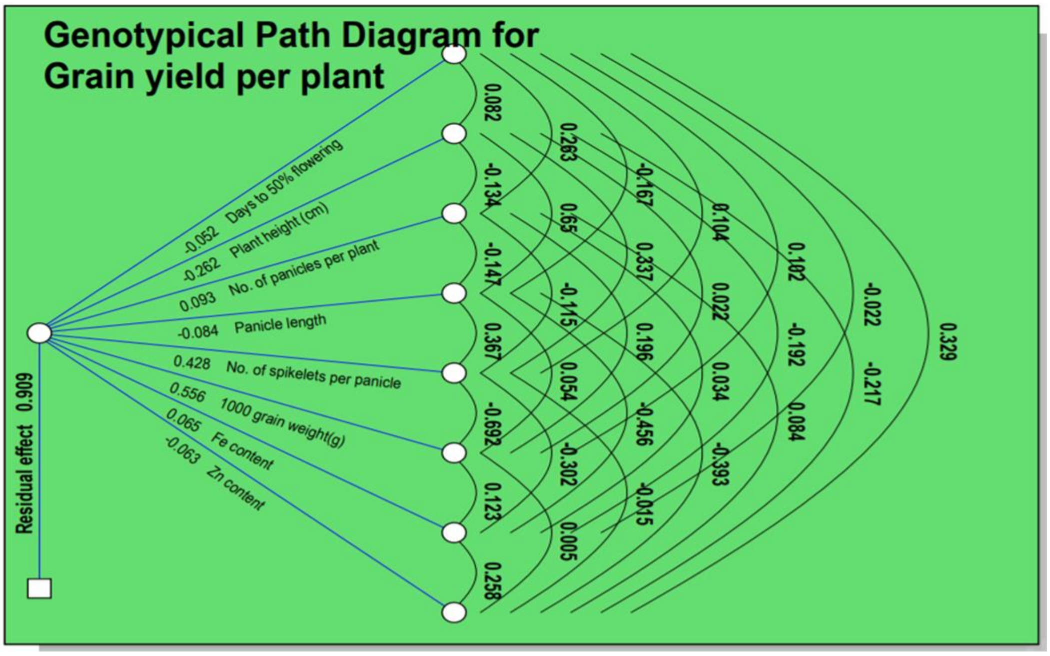

Fig 4: Genotypic path diagram for Grain yield per plant

Conclusion

Even though, higher values of PCV were recorded than GCV, the difference was very narrow for almost all the characters studied indicating the least influence of the environment. However, the characters, the number of spikelets per panicle, grain yield per plant and thousand grain weight showed a wide range of variation. High heritability with high Genetic advance was exhibited by plant height, number of productive tillers per plant, number of spikelets per panicle, thousand grain weight, yield per plant, grain iron and zinc concentration among all the genotypes. Due to a significant and positive association with yield, thousand grain weight, is considered as a major character while selecting the genotypes for yield improvement. Direct positive association towards grain yield was contributed by the traits 100 seed weight, number of spikelets per panicle, the number of productive tillers per plant and grain iron concentration indicating the importance of these traits as selection criteria for enhancing the yield potential and nutritional quality.

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