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Research Note

Genetic Diversity of Brown Rice for Iron and Zinc Content

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Abstract
Biofirtification is one of the sustainable approaches for improving the F2 and Zn content and their bioavailability in rice grain. Screening germplasm for Fe and Zn content is the initial step of biofortificaton. Sixty accessions of rice genotypes for Fe and Zn concentration. Iron concentration ranged from 3.38 ppm to 36.99 ppm and zinc from 3.32 ppm to 42.49 ppm. Genotypes having high Fe and Zn content are selected for further breeding programme.

Keywords
Rice, Vitamins, Bio fortification, Genotypes, Germplasm, Iron and Zinc.

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. Development of varieties containing higher amounts of Fe and Zn would improve nutrition in regions where population depend on rice as a staple food. Food fortification has been recommended as one of the preferred approaches for preventing and eradicating iron and zinc deficiency (Mehansho, 2006). Scientists have coined the term “biofortified” for genotypes that deliver increased levels of essential minerals or vitamins. Bio-fortification, when applied to staple crops, such as rice, is a sustainable approach, provided that access to the technology in the form of seeds is unrestricted. Breeding programs aimed at producing varieties with high iron and zinc concentrations also seek to combine the higher mineral content along with other food characteristics attractive to farmers or consumers. Studies by Harvest Plus and others have shown considerable losses of iron and zinc during the polishing of rice. For this reason, Harvest Plus breeding work is focused on increasing mineral levels in white rice. Initial germplasm screening and field evaluations for iron and zinc have included breeding lines from Korea, Bangladesh, Indonesia, India, and the Philippines. Commercial varieties of rice normally contain 2 mg/kg iron. Thirty lines of rice with more than 5 mg/kg grain iron were initially selected from germplasm banks and evaluated in multi-location trials in the wet and dry seasons in the Philippines to determine agronomic and nutritional performance, assess genotype by environment interactions for iron and zinc, and to identify parent materials and candidates for fast-track breeding (Anuradha *et al.,* 2012).

The experimental material of 60 rice genotypes comprising of local land races, improved cultivars and local popular hybrids. The experiment was conducted in randomized block design with three replications during *kharif* 2011 under rainfed situation at Agriculture Research Station (ARS), Siruguppa, UAS Raichur. Twenty five days old seedlings were transplanted with a spacing of 20 cm and 10 cm between rows and between plants, respectively. In each replication, genotypes were planted in a 3m X 2m length with single seedling per hill. All recommended agronomic practices were followed to ensure a normal healthy crop. Observations on different characters were recorded on five randomly selected plants from the two central rows of each plot at different growth stages as per Standard Evaluation System for rice by IRRI 1996.

Analysis of grain Fe and Zn content**:** The rice samples were air dried to 12-14 per cent moisture content. Hand hulling was carried out by Palm dehusker which was made up of rubber material. During hand hulling, thelemma and palea were removed to prepare the fine power using pestle and mortar. Half a gram of powdered samples was taken in a 100 ml conical flask. Twelve ml of triple acid mixture (9:2:1 Nitric: Sulphuric: Perchloric acid) was added to the sample and kept for cold digestion over night. The digested samples were kept on a hot plate till the solution turned colourless. Then the extract was diluted to 50 ml and fed to the Atomic Absorption Spectrophotometer (GBC Avanta ver.2.02) available at the Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Raichur, Karnataka, India. The readings were expressed as ppm. Statistical analysis was done by using indostat and SPSS softwares. Mahalanobis. (1936) D2 statistic analysis was used for assessing the genetic divergence among the genotypes based on morphological traits and grain Fe and Zn content. Clustering was carried out using Tocher's method as described by Rao. (1952). The intra and inter cluster distance was calculated by the formula given by Singh and Chaudhary. (1977).

Plant breeding programs in bio-fortification of staple food crops such as rice and wheat require screening of germplasm, varieties and elite lines having Fe and Zn-dense grains to be used as donor parents Stangoulis. (2010). An increase in concentration of Fe and Zn in grain is a high-priority research area. Exploitation of large genetic variation for Fe and Zn existing in cereal germplasm is an important approach to minimize the extent of Fe and Zn deficiencies in developing world. Maximum micronutrients are frequently present in some landraces and genetically distant wild varieties Brar *et al.* (2011).

According to the mean performance (Table 1) a wide range of variation was found for most of characters. Through this study an attempt was made to assess the mean performance and extent of variability in rice germplasm which depicts the mean performance of 60 genotypes for quantitative characters along with the standard error of difference and critical difference.

Among the genotypes screened for Fe & Zn concentration, the highest values were obtained in the set of rice genotypes. Among rice genotypes ADT-43, HMT and Parimala sanna were found to be high for both iron and zinc (36.99 and 42.27), (14.52 and 30.45) and (12.90 and 27.43) respectively. It was interesting to note that all the genotypes had high zinc content than iron. Our results are consistent with study by Banerjee *et al*. (2010) and Anuradha *et al.* (2012) who estimated Fe and Zn concentration in 46 rice accessions including 3 wild genotypes *O. nivara, O. latifolia* and *O. officinalis.* They showed that wild accessions had high iron and zinc. Anandan *et al.* (2011) reported that the content of Fe and Zn in traditional genotypes were significantly higher than that of improved cultivars. Anuradha *et al.* (2012) reported that the wild species are a good source of high Fe and high Zn.

The phenotypic coefficient of variation was maximum for grain Zn content (48.23) followed by number of litters (35.89) (Table 2). The genotypic coefficient of variation was the highest for grain Zn content (62.00), followed by No. of Tillers/plant (35.73) and panicle weight (25.56) (Table 2) Shanmuga Sundara Pandian (2007) and Gregario *et al* (2000) have reported high variability for Fe and Zn in rice. Narrow differences between PCV and GCV suggested that negligible influence of environmental factors which was recorded in all the characters except panicle weight and Zn content. It was observed that plant height, number of panicles per plant, number of grains per panicle, panicle weight, grain yield, straw yield, biological yield and grain Zn content showed high heritability coupled with high genetic advance as percent of mean (Table 2) implying that these traits were not much influenced by environmental factors. This is in accordance with results of Shanmuga Sundara Pandian (2007). These result shows that there was a significant genetic diversity or variation in the existing rice germplasm besides indicated that the high Fe lines also had high Zn but the high Zn lines did not have high Fe (Swamy *et al.*, 2011).

The analysis of variance revealed significant differences among the genotypes for all the characters. Based on D^2 values, all the genotypes could be grouped into six clusters (Table 3). The genotypes within each cluster were closer to each other than the genotypes in different clusters. Maximum number of genotypes (41) were included in cluster I followed by 7 in cluster III and IV, 3 in cluster II and each in cluster V & VI. Genotypes from same geographic location fell into different clusters indicating that clustering of populations did not follow their geographic or location distribution.

Average intra and inter-cluster distances have been shown in (Table 4). Maximum intra-cluster distance was observed in cluster IV (37.56) followed by cluster III (35.05) indicating genetic diversity among the genotypes belonging to these clusters. The minimum intra-cluster distance was observed in clusters V and VI. The developing good segregants by crossing the genotypes of the same cluster showing low values for intra-cluster distance are very low. Therefore, the crosses should be made between the genotypes of clusters separated by large inter-cluster distances (Sandhyakishore *et al*., 2007; Chandra *et al*., 2007). Highest inter-cluster distance was observed between clusters II and VI (130.21) suggesting wide diversity between these clusters. Therefore, genotypes belonging to these clusters may be used in hybridization programme for the improvement of rice. The least inter-cluster distance was observed between clusters I and IV (43.36) followed by clusters I and V (43.53) indicating

close relationship between the genotypes of these clusters and hence, may not be emphasized upon to be used in hybridization programme. Crosses involving parents belonging to the most divergent clusters would be expected to manifest maximum heterosis and wide variability of genetic architecture (Sarkar *et al*, 2006).
The diversity was also supported by the appreciable amount of variation among the cluster means for different characters (Table 5). Cluster I showed the maximum cluster means for number of panicles/plant, number of grains/panicle, harvest index and Zn content; cluster II recorded the maximum values for plant height and number of tillers. Cluster III showed maximum values for panicle weight, panicle length, leaf width, flag leaf width, grain yield, and biological yield. Maximum values for 1000 grain weight flag leaf width and Zn content were recorded by cluster IV and cluster VI showed higher mean values for days to 50% flowering, leaf length, flag leaf length straw yield and Fe content. The results were agreed with the findings of Banumathy *et al.,* 2010. Thus, these genotypes hold great promise as parents for obtaining promising elite lines through hybridization and to create further variability for these characters.

Variations in Fe and Zn values in different samples of the same accession can also arise due to presence or absence of embryo in grains, time of harvest or different digestion or analytical methods. This variation in iron and zinc values was also due to homeostasis regulating their translocation, absorption, and transport within the plant system (Welch *et al.,* 1997). Another factor contributing to difference in iron and zinc values was the phloem sap loading and unloading rates within the reproductive organs as measured by Welch. (1986). Thus there was a range of Fe and Zn concentration and no fixed values quite akin to the trait yield. Secondly, soil properties also influence the grain Fe and Zn concentration. The pH, organic matter content and Fe/Zn levels of native soil showed significant effects on grain Fe and Zn contents (Chandel *et al.,* 2010). The grain yield and zinc content in the rice grain was subjected for Z test where Chinna ponni, NMS-2, Burma black and nice emergency were showed positive value. and MUT 1010, MRP5041 and K 108 were showed negative value. Similarly for grain yield and iron content the results showed that, Chinna ponni, MUT 1010 were showed positive value and MRP5041 were showed negative value.

For plant and yield characters, Mysore mallige, Mugada sugandhi, Mysore sanna, Madras sanna, Raja bhoga, Karigajavali, GGV 05-02, Supreme sona and 27P04 recorded good performance to harvest index, grain yield, biological yield, number of seeds and plant height hence we can use these genotypes for further breeding work for yield and yield attributing characters. The maximum iron content was observed in ADT-43 followed by Meese batta, HMT, Parimala sanna and Sarjan. Maximum zinc content was observed in Gangavati sanna and also observed in ADT-43, so we can select the genotypes having high Fe and Zn content which will solve the malnutrition problem The genotypes of cluster III (Mysore sanna, Mysore mallige, Parimala sanna, Gouri sanna, gandha sale, Raj kamal and Siri 1253) indicated more diverse mean values for panicle weight, panicle length, leaf width, flag leaf width grain yield and biological yield. ADT-43, HMT, Parimala sanna, Burma black and Gangavati sanna had high iron and zinc contents. Thus, these genotypes may be used in future hybridization programme to achieve desired segregants for early rice varieties with higher yield.

References

Anandan, A., Rajiv, G., Eswaran, R. and Prakash, M., 2011. Genotypic variation and relationships between quality traits and trace elements in traditional and improved rice (oryza sativa l.) genotypes. *J. Food Sci.*, **76** (4): 122–130.

Anonymus., 1996. Standard evaluation system for rice. 4th Edition. Published by INGER Genetic Resources, International Rice Research Institute, Philippines

Anuradha, K., Surekha, A., Anil, K. B., Prasad Babu, A, Mallikarjuna Swamy, B. P., Longvah, T., Sarla, N., 2012. Evaluating rice germplasm for iron and zinc concentration in brown rice and seed dimensions., *J. Phytology*, **4**(1):19-25

Banerjee, S., Sharma, D. J., Verulkar, S. B. and Chandel, G., 2010. Use of in silico and semi quantitative RT-PCR approaches to develop nutrient rich rice (*Oryza sativa* L.). *Indian J. Biotechno.*, **9** (2): 203-212.

Banumathy, S., Manimaran, R.,Sheeba, A., Manivannan, A., Ramya, B., Kumar, D. and Ramasubramanian, G. V., 2010. Genetic diversity analysis of rice germplasm lines for yield attributing traits. *Electron. J. Plant Breed.,* **1**(4), 500-504.

Brar, B., Jain, S., Singh, R. and Jain, R. K., 2011. Genetic diversity for iron and zinc contents in a collection of 220 rice (*Oryza sativa* L.) genotypes. *Indian J. Genet.,* **71**(1): 67-73.

Chandel, G., Banerjee, S., See, S., Meena, R., Sharma D. J. and Verulkar, S. B., 2010. Effects of different nitrogen fertilizer levels and native soil properties on rice grain Fe, Zn and protein contents. *Rice Sci.*, **17**(3): 213−227.

Chandra, B. S., Reddy, T. D. and Ansari, N. A., 2007. Genetic divergence in rice *(Oryza sativa L.). Research on Crops.* **8**(3): 600-603.

Gregario, G. B, Senadhira, D., Htut, H. and Graham, R. D. 2000. Breeding for trace mineral density in rice. *Food Nutr. Bull***., 21:** 382-386.

Mahalanobis, P. C., 1936. On the generalized distance in statistics. *Proc. Nat. Instt. Sci. India***., 2:** 49-55.

Mehansho, H., 2006. Iron fortification technology development: new approaches. *J. Nutr* **136**: 1059–1063

Rao, C. R., 1952. Advanced statistical methods in biometric research. John Wiley Sons, New York, 390.

Sandhyakishore, N., Babu, V. R., Ansari, N. A. and RaviChandran., 2007. Genetic divergence analysis using yield and quality traits in rice *(Oryza sativa L.) Crop Improv*., **34** (1): 12-15.

Sarkar, K. K., Chandra, D., Anirban, M. and Biswas, A. K., 2006. Genetic divergence for yield and its contributing traits in some rice genotypes (*Oryza sativa* L.) grown in Zn-deficient soil. *J. Crop and-Weed*. **2** (2): 14-16.

Shanmuga Sundara Pandian, G., 2007. Studies on diversity and Genotype × Environment interaction for micronutrient content in rice (*Oryza sativa* L.). *M.Sc. (Ag.). Thesis*, Tamil Nadu Agricultural University, Coimbatore, India.

Singh, R. K. and Chaudhary, B. D., 1977. Biometrical Methods in Quantitative Genetic Analysis.

Stangoulis, J., 2010. Technical aspects of zinc and iron analysis in biofortification of the staple food crops, wheat and rice. World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010, Brisbane, Australia

Swamy, B. P. M., Kaladhar, K., Anuradha, K., Batchu, A. K., Longvah, T., Viraktamath, B. C. and Sarla, N., 2011. Enhancing iron and zinc concentration in rice grains using wild species. ADNAT Convention and International Symposium on Genomics and Biodiversity", CCMB, Hyderabad (23 – 25th Feb 2011) (P- 71).

Welch, R. M. 1986. Effects of nutrient deficiencies on seed production and quality. *Adv. Plant Nut*, **2**:205-247.

Welch, R. M., Combs, G. F. and Duxbury, J. M., 1997. Toward a "greener" revolution issues in Science and Technology, **14**: 50-58.

Table 1. Mean performance of 60 genotypes for Plant, yield and nutrient characters.

S.No	Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
1	Mugada sugandh	93	105	11	10	154.33	25.34	14.8	5148.15	2837.04	7985.2	64.46	11.49	4.86
2	Sanna nellu	157.4	103	10	10	125.9	27.79	20.3	4774.07	5665.19	10439.3	45.74	6.72	18.37
3	Kariga javali	140.2	101	13	11	123.33	27.26	21.3	4911.11	5592.59	10503.7	46.77	7.22	11.74
4	Chinna ponni	86	103	12	8	133.78	24.85	18.9	2707.41	3644.44	6351.9	42.63	7.09	10.9
5	NMS-2	125.73	101	10	10	182.33	24.55	15.8	4570.37	4859.26	9429.6	48.43	7.98	4.43
6	Coimbatore sanna	135.33	104	11	11	124	21.88	27.5	5792.59	9625.93	15418.5	37.56	4.82	13.56
7	Mysore sanna	124	112	16	15	186.22	23.05	32.9	6925.93	6662.96	13588.9	50.95	5.53	4.45
8	Madras sanna	121.67	101	15	15	177.11	22.92	36	7214.81	5992.59	13207.4	54.62	4.49	3.32
9	Gham sale	138.2	98	11	10	135.22	23.96	20.8	4948.15	4855.56	9803.7	50.43	7.85	25.36
10	Bangar sanna	137.67	105	13	12	141.44	24.65	25.2	5548.15	6055.56	11603.7	47.81	9.84	7.95
11	Surgeon	104.93	117	10	10	103.67	22.75	24.2	5000	6485.19	11485.2	43.5	12.56	7.92
12	Tuyi malli	115.73	104	13	11	135.56	26.09	26.8	5792.59	6888.89	12681.5	45.67	4.9	10.44
13	Kichidi samba	137.07	104	12	11	159.56	26.5	25.1	5562.96	6125.93	11688.9	47.59	5.64	8.67
14	Mysore mallige	78	113	18	16	110.56	22.88	36	7311.11	4474.07	11785.2	62.02	5.3	5.44
15	Kappu basumati	140	103	10	10	189.89	28.84	21.3	4977.78	6192.59	11170.4	44.56	4.71	9.57
16	HMT	80.4	105	14	14	118.78	19.89	26.3	6140.74	5692.59	11833.3	51.9	14.52	30.45
17	Parimala sanna	135.2	113	11	10	115.72	27.01	20.3	4748.15	7007.41	11755.6	40.4	12.9	27.43
18	Jeerige sanna	122.93	105	10	10	121.56	24.23	21.3	4933.33	5974.07	10907.4	45.23	6.2	12.29
19	Delhli sanna	100.4	98	15	14	144.56	26.19	38.3	6040.74	4755.56	10796.3	55.97	3.97	15.53
20	Uggi bhatta	119.73	105	13	10	139.33	22.4	39	4607.41	5514.81	10122.2	45.51	7.32	28
21	Kyasakki	114.27	98	13	10	119.33	23.17	20.3	4618.52	5422.22	10040.7	45.98	7.09	11.51
22	Kagi sale	130.47	103	11	9	162.67	23.32	21.3	4655.56	4592.59	9248.1	50.33	15.83	17.15
23	Gouri sanna	102.47	113	10	10	174.33	24.06	23.7	5188.89	7844.44	13033.3	39.8	10.18	11.35
24	Ratna choodi	115.53	100	15	14	137.11	22.22	28	6207.41	6325.93	12533.3	49.53	4.83	4.79
25	Raja bhoga	141.87	100	16	14	111.78	23.92	27.3	5970.37	6096.3	12066.7	49.42	7.19	26.39
26	Kari jiddu	113.07	105	11	9	121	20.92	24.2	4629.63	4770.37	9400	49.24	5.04	12.6
27	Meese bhatta	87.13	103	10	10	49	15.75	13.9	4555.56	5622.22	10177.8	44.76	20.91	15.62
28	ADT 43	59.8	101	9	8	126.11	18.61	14.4	2277.78	2781.48	5059.3	45.03	36.99	42.27
29	Gandha sale	123.33	118	9	9	135.11	23.64	17.9	3770.37	4511.11	8281.5	45.53	6.14	21.93
30	Navaara	103.53	105	10	8	75.44	19.96	17.2	3685.19	5703.7	9388.9	39.22	11.04	15.73
31	Selum sanna	99.73	107	11	11	167.56	21.22	24.8	5566.67	5888.89	11455.6	48.5	7.22	12.45
32	Ambe mohar	113.33	100	10	9	95.44	19.98	21.2	3881.48	4355.56	8237	47.1	10.27	10.23
33	Raj kamal	118.13	113	10	9	118.89	23.97	18.6	3811.11	4177.78	7988.9	47.72	7.82	12.63
34	Burma black	107.47	113	10	8	98	20.6	16.6	3588.89	5174.07	8763	40.96	6.88	10.49
35	Raj mudi	119.73	104	13	12	154	22.95	28.7	5614.81	6970.37	12585.2	44.63	4.38	10.18
36	KH- 4(varanasi)	75.07	105	11	10	194.44	20.87	26.7	5025.93	5814.81	10840.7	46.34	6.08	9.88
37	IET 19251	70.13	102	12	9	172.44	20.56	18.8	4089.26	5925.93	10215.2	41.98	8.82	33.76
38	NES 07-03-1	67.8	103	13	9	178.78	18.9	16.5	3695.56	5185.19	9080.7	42.85	9.18	27.82
39	GGV 05-02	79.4	105	20	19	177.89	22.26	37.1	7755.56	6007.41	13696.3	58.22	4.9	14.16
40	Badri	79.53	103	16	15	168.56	23.82	29.3	6310.37	6481.48	12991.9	50.07	5.05	9.39

Table 1. Contd..

S.No	Accession	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
41	Ratan sagar	112.2	101	18	15	171	21.64	18.4	6566.67	6111.11	12877.8	52.59	4.8	17.85
42	Gangavati sanna	75.07	101	16	14	191.56	19.01	22.5	6007.04	7222.22	13429.3	46.35	10.36	42.49
43	Yaramallala	74.93	105	12	10	186.44	20.81	20.3	4928.15	5925.93	11054.1	46.32	6.36	29.7
44	GGV 05-01	83.8	104	17	17	167.56	22.59	30.3	7224.44	6796.3	15387.4	49.03	3.72	12.42
45	GV SAT	84.87	104	18	18	137.11	21.39	28.7	7399.26	9666.67	15932.6	48.42	5.77	12.65
46	Gidda emergency	78.67	104	9	9	143.44	20.86	17.9	3681.11	7814.81	11829.3	31.18	6.27	12.87
47	MTU 1010	100.67	100	21	21	156.78	21.58	28.3	8092.59	9551.3	17843.9	46.46	10.37	30.49
48	Nice emergency	68.53	100	10	10	174.33	20.2	18	3708.22	4010.44	8364.4	53.01	6.24	8.26
49	BPT 5204	61.93	103	15	14	180.33	18.32	24.8	5925.19	7000	12791.9	48.12	12.24	8.36
50	27P04	76.87	105	18	17	198.44	19.65	22	7114.81	5185.19	12500	58.54	6.27	12.12
51	K 108	87.87	105	22	21	166.67	22.09	34.3	8149.63	6522.44	14872.1	56.13	4.87	19.53
52	Super sona	75.33	105	15	13	173.22	17.67	19.9	5753.33	5185.19	11138.5	53.44	3.39	20.7
53	MRP 5041	95.67	102	25	24	176.56	22.23	40.5	7467.67	4430	23103.7	57.36	11.27	24.46
54	MRP 5042	78.27	106	22	22	193.11	21.69	38.6	4876.67	3670	16044.4	56.73	4.52	6.38
55	Supreme sona	72.8	106	21	20	181.78	19.4	39.6	10644.44	7322.22	18200	58.44	4.76	9.59
56	Gangavati sona	64.33	103	22	21	187.22	18.09	33.4	8400	5952	19414.8	43.24	6.52	12.19
57	Siri 1253	93.47	118	23	23	201.33	22.62	40.2	9120.33	5950	25200	50.63	5.77	4.97
58	Mohima	99.6	104	24	24	186.22	17.6	40.5	5950	4616.67	23111.1	57.3	6.66	13.05
59	Ankur pooja	71.13	102	23	22	172.33	21.85	38.6	5740	3793.33	16251.9	55.41	8.17	15.05
60	Gangotri	64.33	103	22	21	183.11	18.78	34.3	5454.67	7273.33	15847	54.1	7.88	22.50
	Mean	100.6	104	14	13	151.49	22.26	25.8	5579.31	5809.22	12380.6	48.7	8.05	15.44
	S.E.	1.19	0.07	1.14	0.71	2.93	0.57	0.13	219.16	196.35	631.65	1.97	1.23	2.65
	C.D. 5%	3.33	0.19	3.19	2	8.21	1.6	0.36	613.78	549.89	1768.96	5.53	3.33	4.32

*, ** Significant at 5% and 1% level respectively

X 1 **Plant height (cm)**
X 2 **Days to 50% flowering**
X 3 **Number of tillers/plant**
X 4 **Number of panicles/plant**
X 5 **Number of grains/panicle**
X 6 **Panicle length (cm)**
X 7 **Panicle weight (g)**
X 8 **Grain yield (kg/ha)**
X 9 **Straw yield (kg/ha)**
X 10 **Biological yield (kg/ha)**
X 11 **Harvest Index (%)**
X 12 **Iron (ppm)**
X 13 **Zinc (ppm)**

Table 2. Estimation of Mean, range and genetic parameters for plant and yield attributing characters of rice genotypes

S.N	Characters	Mean	Min	Max	VG	VP	GCV	PCV	h² (bs)	GA	GAM
	Plant height(cm)	100.6	59.8	157.4	633.68	637.97	25.05	25.14	99.30	51.71	51.40
	Days to 50% flowering	104	98	118	22.6	22.74	4.57	4.59	99.80	9.82	9.41
	No. of Tillers/plant	14	9	25	12.71	14.06	35.73	35.89	90.30	9.69	38.19
	No. of panicles/plant	13	8	24	22.35	22.55	19.49	20.5	99.10	6.98	73.28
	No. of grains/panicle	151.49	49	201.33	1109.44	1114.11	21.98	22.03	99.60	68.46	45.19
	Panicle length(cm)	22.26	15.75	28.84	7.86	8.41	12.55	12.98	93.40	5.58	24.99
	panicle weight(g)	25.8	13.9	40.5	60.05	62.63	25.56	30	95.90	15.63	60.51
	Grain yield(kg/ha)	5579.31	2277.78	10644.44	2423644.5	2567745.4	23.91	26.85	94.40	3115.73	55.84
	Straw yield (kg/ha)	5809.23	2781.48	9666.67	2012402.8	2128066.8	24.42	25.11	94.60	2841.77	48.92
	Biological yield(kg/ha)	12380.62	5059.3	25200	14523920	15722876	23.44	26.33	92.40	7546.48	60.95
	Harvest index	48.7	31.18	64.46	36.44	42.89	13.19	14.99	85.00	11.49	23.92
	Iron (ppm)	15.4	3.32	42.49	125.53	135.86	14.55	13.98	92.38	22.18	27.69
	Zinc (ppm)	8.02	3.38	36.99	153.19	248.01	62.00	48.23	78.94	63.13	61.70

VG	**Phenotypic variance**	**h^2**	**Heritability (%)**
VP	**Genotypic variance**	**GA**	**Genetic advance**
PCV	**Phenotypic coefficient of variation (%)**	**GAM**	**Genetic advance as % of Mean**
GCV	**Genotypic coefficient of variation (%)**		

Table 3: Clustering of rice genotypes.

Cluster No	Genotypes	No. of Genotypes
I	IET 19251, NES 07-03-1, BPT 5204, Yaramallala, GGV 05-01, GV SAT, Gidda emergency, Gangavati sanna, Gangavati sona, GGV 05-02, 27P04, K 108, Mugada sugandh, MRP 5042, KH- 4(Varanasi), Selum sanna, Raj mudi, Badri , Ratan sagar, Tuyi malli, Kichidi samba, Bangar sanna , Kagi sale, Chinna ponni Uggi bhatta, Madras sanna, Kappu basumati, NMS-2, MRP 5041, Ankur pooja, Nice emergency, Mohima, MTU 1010, HMT, Super sona , Gangotri , ADT 43, Coimbatore sanna, Kariga javali, Jeerige sanna and Ratna choodi	41
II	Gham sale, Kyasakki and Ambe mohar	3
III	Mysore sanna , Gouri sanna, Raj kamal, Mysore mallige, Parimala sanna, Gandha sale and Siri 1253	7
IV	Meese bhatta, Navaara, Kari jiddu, Sanna nellu, Raja bhoga, Delhli sanna and Supreme sona	7
V	Burma black	1
VI	Surgeon	1

Table 4. Intra (diagonal) and Inter cluster average distances (D^{2}) in Rice genotypes.

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Cluster I	**29.29**	43.53	70.25	43.36	70.16	102.69
Cluster II		**27.64**	94.69	55.91	95.24	130.21
Cluster III			**35.05**	79.75	46.47	66.30
Cluster IV				**37.56**	64.30	94.09
Cluster V					**0.00**	37.15
Cluster VI						**0.00**

Table 5. Mean values of six clusters for Morphological characters of Rice genotypes.

	X 1	X 7	X 3	X 2	X 5	X 6	X 4	X 8	X 9	X 10	X 11	X 12	X 13
Cluster I	95.20	102.89	18.24	13.91	163.08	21.93	26.25	5,647.45	5,895.06	12,741.58	49.12	7.93	16.08
Cluster II	121.89	98.33	19.98	9.66	116.66	22.87	20.78	4,482.78	4,877.67	9,360.44	47.84	7.83	14.56
Cluster III	110.71	114.00	18.74	13.04	148.88	24.09	27.08	5,839.29	5,804.00	13,090.57	48.14	7.91	13.09
Cluster IV	110.86	102.57	18.68	12.23	115.64	22.75	25.84	5,757.10	5,705.19	11,495.57	48.98	8.52	16.26
Cluster V	107.33	112.67	11.00	7.93	98.00	20.60	16.60	3,589.00	5,174.00	8,763.00	40.93	6.88	10.49
Cluster VI	105.00	117.67	16.60	9.90	103.67	23.70	24.20	5,000.00	6,485.00	11,485.33	43.53	12.56	7.92

X 1 **Plant height (cm)**
X 2 **Days to 50% flowering**
X 3 **Number of tillers/plant**
X 4 **Number of panicles/plant**
X 5 **Number of grains/panicle**
X 6 **Panicle length (cm)**
X 7 **Panicle weight (g)**
X 8 **Grain yield (kg/ha)**
X 9 **Straw yield (kg/ha)**
X 10 **Biological yield (kg/ha)**
X 11 **Harvest Index (%)**
X 12 **Iron (ppm)**
X 13 **Zinc (ppm)**