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Research Article

Assessment of genetic diversity based on morphological, grain Fe and Zn content in rice

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Abstract
Variability and diversity was assessed among 78 rice genotypes for various morphological traits including grain Fe and Zn content. Grain Fe and Zn content exhibited high genotypic and phenotypic coefficient of variation coupled with high heritability and genetic advance as per cent of mean. In general, the overall composition of the clustering pattern showed that genotypes collected from the same geographic origin were included in same cluster. It was observed that Zinc content contributed maximum towards divergence followed by number of grains per panicle, grain length and grain breadth. The present study revealed that the clusters XV (T550), XIV (T366) and I (ADT 36, ADT 37, ADT 38, ADT 39, ADT 43, ADT 44, ADT 45, ADT 46, ADT 47, ADT 48, Local Aduthurai and T401) possessing the high mean values for most of the desirable traits could be crossed with clusters V (CO 47 and W.Ponni), VIII (GIZA 178 and T272) and XII (IR 68144-3B-2-2-3-3B-2-2-3) for simultaneous improvement of yield, grain Fe content and grain Zn content. Highest inter cluster distance was noticed between cluster XVI (T289) and cluster XV (T550) followed by cluster VIII (Giza 178 and T272) and cluster XVI (T289) indicating wide genetic diversity among these clusters. Intercrossing of these genotypes may create wide segregation in the segregating populations and promising progenies can be selected for yield improvement.

Key Words: Rice, genotypes, Fe and Zn, Diversity

Introduction

Rice is the most predominant staple food especially in South and South East Asia. Green Revolution in rice has substantially increased the rice production globally. Though the rice requirement has been satisfied appreciably quantity wise, enhancement of nutritive value of rice has not been given much importance. In most of the South and South East Asia rice is consumed in bulk as a staple food. Mostly polished grains are used for consumption which contain only traces of Fe, Zn and Vit A which is far below the WHO recommendation and hence Fe and Zn deficiencies have become more prevalent. The prevalence of iron deficiency is estimated to be about 30 per cent of the world population (WHO, 1992) and hence Fe deficiency is the most widespread nutrient deficiency worldwide especially among women and children (Lucca *et al.*, 2002). Biofortification of rice for high Fe and Zn in grains would be helpful to overcome the problems arise due to deficiencies of these two important minerals. Though biofortification could be done by supplementary capsule/pills or food by enriching the food grains with high Fe and Zn at post harvest stages, these methods are costly and had shown only a limited impact on target population. Hence breeding rice varieties with inbuilt high Fe and Zn would be a sustainable way. However, before initiating the breeding work on biofortification of rice grains with high Fe and Zn, it is important to know the genetic variability, heritability, genetic advance and genetic diversity existing in the available germplasm to plan for effective breeding (Allard, 1960). Hence the present investigation was taken up to study the genetic variability, heritability, genetic advance and genetic diversity based on morphological traits, grain Fe and Zn content in 78 rice genotypes.

Material and methods

Field Experiments**:** The study was conducted with a total number of 78 genotypes comprising of 31 land races, 4 Indian Accessions (NBPGR), 9 exotic cultivars and 34 adapted varieties which were raised in the experiment fields of -Anbil Dharmalingam Agricultural College and Research Institute, Trichy during 2010 . The seedlings were planted in Randomized Block Design (RBD) with two replications with spacing of 20 x 10 cm. In each replication, genotypes were planted in a single row (3m length) with single seedling per hill. All the recommended crop management practices were adopted and various biometrical observations were recorded on five randomly selected plants. The tagged individual plants were harvested separately. Observations on 12 plant traits viz., plant height, leaf length, leaf breadth, days to fifty percent flowering , productive tillers , panicle length, number of filled grains per panicle, hundred grain weight, single plant yield , grain length , grain breadth , grain length / breadth ratio (L/B) were recorded at different growth stages as per Standard Evaluation System for rice by IRRI

(Anon ,1996) - in addition to the estimation of Fe and Zn in grains .

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 the lemma and palea were removed and thereafter polished by using sand paper (No.100) 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. 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, Tamil Nadu Agricultural University, Coimbatore. The readings were expressed as ppm.

Statistical analysis : The Phenotypic and Genotypic Coefficient of Variation (PCV and GCV), heritability at broad sense and genetic advance were calculated and scales were given following the methods suggested by Burton (1952) for PCV and GCV, Lush (1940) for heritability and Johnson *et al.* (1955) for genetic advance. Mahalanobis (1936) D^2 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). The ranking given to each cluster mean on the basis of performance across all the characters and cluster possessing least score was given rank first and the highest score as last.

Results and discussion

The results of descriptive statistics analysis indicated the existence of appreciable variability among the genotypes for the different characters studied. Among the genotypes evaluated for grain Fe content in the polished rice, the genotypes, Kosuva Kathazhai, IC350429, T420 and IR68144-3B-2-2-3-3B-2-2-3 had the highest values of 7.50, 7.17, 5.39 and 5.27 ppm respectively (Table 1). Virk *et al* -(2006)and 2007) have reported upto 7.4 ppm of Fe in polished rice. For grain Zn content, the genotypes Mapillai Samba, T272 and TKM9 had the highest mean values of 4.18, 2.84 and 1.70 ppm respectively.

The phenotypic coefficient of variation was maximum for grain Fe content (59.54) followed by Zn content (45.30) and number of productive litters (41.52) (Table 2). The genotypic co efficient of variation was the highest for grain Fe content (59.46), followed by Zn content (45.09) and leaf breadth (36.45). –Senedhira *et al* (1998), Gregario *et al* (2000) and - Shanmuga Sundara Pandian (2007) 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 number of productive tillers, number of grains per panicle, and single plant yield. It was observed that grain Fe content, Zn content, leaf breadth, plant height, leaf length and single plant yield 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).

Based on the results of D^2 analysis, (Table 3) the 78 genotypes were grouped into 16 clusters in which, cluster VI was the largest with 25 genotypes followed by cluster IX with 15 genotypes- Cluster I had 12 genotypes and cluster II had five genotypes while clusters III, IV,V, VII,VIII, X ,XI, XII and XIII were of equal size, comprising two genotypes each. The clusters XIV,XV and XVI were solitary. Inter cluster distance was higher than intra cluster distance indicating wider genetic diversity among different clusters (Table 4). The maximum intra cluster distance recorded in cluster I (15362.64) which was significantly different from cluster III (2370.70) and cluster IV (2394.62). The inter cluster distance was higher for all clusters. Highest inter cluster distance was noticed between cluster XVI and cluster XV (68641.14) followed by cluster VIII and cluster XVI (43975.53) indicating wide genetic diversity among these clusters. The contribution of each character towards divergence is presented in Table 5. It was observed that Grain length - contributed maximum - (15.95) towards divergence followed by - single plant yield (15.50) and grain breadth ((10.56) The remaining characters contributed very minimum towards divergence.

The ten varieties and two local land races originated from Aduthurai (Tamil Nadu Rice Research Institute, India) were grouped in the single cluster, cluster I. It is worth mentioning that the cluster VI comprised all the varieties developed from RRS, Ambasamudram and Tirurkuppam. The cluster X comprised two genotypes IC255787, IC350465 which are the accessions collected from NBPGR. In general, the overall composition of the clustering pattern showed that genotypes collected from the same geographic origin were included in same cluster. Contrary reports have been made by Seetharaman *et al.* (2009). The present study revealed that high genetic similarity (i.e. presence of parallelism) among the genotypes of common geographic origin and low similarity among the genotypes of diverse geographic origin as reported by Sundaram *et al.,* (2007). The genotypes ADT43, ADT44 and ADT45 which had IR50 as their common parent and the genotypes ADT36 and ADT39 which had IR20 as their common parent, ADT46 and ADT47 had ADT38 as one of their parents were included in cluster I. In cluster VI, ASD16, ASD17 and ASD18 which had ADT31 as their common parent, TKM10 and TKM11 had C22 as their common parent and TKM9 and ASD17 had IR8 as common parent were present. Similar results were obtained by Malik Ashiq Rabbani *et al.* (2008).

It was interesting to note that the high grain Fe containing genotypes IR68144-3B-2-2-3-3B-2-2-3, IC350429 were grouped into same cluster viz., cluster XII. Likewise the high grain Zn containing genotypes Mapillai samba and TKM9 were present together in cluster VI. Malik Ashiq Rabbani et al (2008) have also reported similar results in aromatic rice where the rice quality traits differentiated cultivars into broad categories.

The cluster I was characterized by its semi dwarf plant type, high leaf breadth, highest number of grains per panicle and lowest grain Fe content. The cluster V was distinguished by high single plant yield, lowest value for grain breadth. The cluster VII had the shortest panicle, lowest value for single plant yield and hundred grain weight. The cluster VIII was distinguished by flowering duration and highest value for grain Zn content. The cluster X had lowest value for leaf length and grain Zn content. The cluster XI had highest value for leaf length. The cluster XII was characterized for less number of productive tillers and high grain Fe content. The cluster XIV had lowest value for leaf breadth, grain length and L/B ratio and lengthiest panicle. The cluster XV had lowest value for days to fifty percent flowering, number of grains per panicle and highest value for hundred grain weight, grain length and L/B ratio. The cluster XVI had highest value for plant height, number of productive tillers and grain breadth. Similar results were observed Banumathy *et al.,* (2010).

The present study revealed that the clusters XV (T550), XIV (T366) and I (ADT 36, ADT 37, ADT 38, ADT 39, ADT 43, ADT 44, ADT 45, ADT 46, ADT 47, ADT 48, Local Aduthurai and T401) possessing the high mean values for most of the desirable traits could be crossed with clusters V (CO 47 and W.Ponni), VIII (GIZA 178 and T272) and XII (IR 68144-3B-2-2-3-3B-2-2-3) for simultaneous improvement of yield, grain Fe content and grain Zn content. Highest inter cluster distance was noticed between cluster XVI (T289) and cluster XV (T550) followed by cluster VIII (Giza 178 and T272) and cluster XVI (T289) indicating wide genetic diversity among these clusters. Intercrossing of these genotypes may create wide segregation in the segregating populations and promising progenies can be selected for yield improvement.

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Table 1. Mean performance of genotypes for different traits

Genotypes	PHT (cm)	LL (cm)	LB (cm)	PL (cm)	NPT	DFF	SPY (g)	HGW (g)	NGP	GL (cm)	GB (cm)	L/B	Fe (ppm)	Zn (ppm)
ADT36	93.60	41.10	4.40	24.30	18	85	8.97	2.06	76	6.42	2.20	2.92	2.10	1.11
ADT37	101.60	35.00	1.50	20.20	11	76	14.50	2.30	90	4.91	2.70	1.82	1.55	1.20
ADT38	107.60	36.30	1.50	27.50	36	95	11.06	2.10	79	6.50	2.00	3.25	1.02	1.10
ADT39	100.60	35.40	1.90	21.80	17	97	14.98	1.78	84	6.75	2.00	3.38	1.10	0.94
ADT43	77.30	30.20	1.40	21.20	13	80	14.14	1.60	83	5.60	1.90	2.95	1.26	1.30
ADT44	119.90	39.30	1.80	25.80	21	120	18.95	2.30	80	5.80	2.40	2.42	1.32	1.07
ADT45	87.60	24.90	1.40	20.60	22	88	16.94	1.80	99	5.97	1.80	3.31	1.00	1.06
ADT46	111.50	37.10	1.80	28.70	26	94	18.12	2.50	80	6.55	2.20	2.98	0.62	0.78
ADT47	92.00	35.60	4.10	22.30	20	93	19.30	1.40	109	5.05	2.00	2.53	1.57	1.38
ADT48	74.70	22.10	1.20	21.06	36	82	19.78	2.20	110	6.46	2.00	3.23	1.66	1.02
Kosuva Kathazhai	130.30	37.50	1.40	23.90	27	84	20.20	2.82	84	5.37	2.20	2.44	7.50	1.04
Madhukar	127.30	31.60	1.70	23.00	18	87	8.28	2.66	70	6.05	2.20	2.75	2.44	1.07
Local Aduthurai	153.60	45.00	1.70	26.50	17	85	14.11	1.90	66	4.62	2.00	2.31	1.08	1.50
Purpil Puttu	142.00	47.40	1.80	21.60	14	94	8.94	2.49	50	5.78	2.60	2.22	0.89	1.43
Taichung Native1	102.50	24.80	1.60	22.40	12	94	10.53	2.38	62	4.83	2.60	1.86	0.31	0.89
Kar Nel	165.60	46.20	1.50	26.60	22	92	9.77	2.20	52	5.92	2.40	2.47	0.42	0.95
Mapillai Samba	92.30	18.10	1.10	14.00	14	52	6.99	2.21	41	5.63	2.40	2.35	0.82	4.18
Mattaikar	153.30	41.60	1.40	21.60	11	78	18.52	2.50	78	6.24	2.40	2.60	0.63	0.91
TKK1	171.00	41.80	1.50	26.60	12	94	16.35	2.30	69	5.83	2.40	2.43	0.75	1.18
ASD1	143.00	36.00	1.10	22.50	16	70	9.03	1.95	53	5.78	2.00	2.89	0.38	1.03
ASD7	130.30	31.60	1.10	22.00	25	72	10.73	2.18	63	5.46	1.80	3.04	0.32	1.11
ASD16	113.60	56.00	1.50	25.70	29	84	9.07	2.40	77	5.58	2.60	2.14	0.51	1.55
ASD17	99.00	37.80	1.30	24.30	15	86	10.06	2.20	66	5.70	1.90	3.00	0.47	0.94
ASD18	106.40	37.20	1.80	24.70	23	77	8.48	2.30	88	5.97	1.80	3.32	0.30	1.04
ASD20	93.90	37.20	1.40	24.20	25	87	13.56	2.20	92	6.26	1.80	3.48	2.49	1.57
TKM5	130.30	37.70	1.00	21.50	27	83	6.03	2.05	70	6.08	2.20	2.76	0.87	1.17
TKM6	130.00	42.70	1.10	22.90	29	89	7.27	1.79	55	6.00	2.00	3.00	0.26	1.09
TKM8	153.30	57.80	1.70	23.50	14	93	8.03	1.96	79	5.52	2.00	2.76	0.11	1.16
TKM9	92.10	29.50	1.40	18.90	23	78	10.05	2.10	61	5.40	2.40	2.25	0.45	1.70
TKM10	160.30	46.20	1.90	24.00	19	94	13.66	2.30	79	5.00	2.40	2.08	2.76	1.15
TKM11	147.30	40.60	1.90	25.60	33	94	13.52	2.10	86	6.45	2.00	3.23	2.79	0.96
TRY1	116.30	33.70	1.90	22.10	22	102	18.84	2.50	92	6.20	2.40	2.58	2.51	0.80
TRY2	98.00	28.40	1.90	23.90	16	88	18.26	2.30	92	7.20	2.40	3.00	2.56	0.81
CO43	132.00	34.80	1.80	20.70	24	101	20.12	2.20	108	6.00	2.40	2.50	2.62	0.86
CO47	121.60	34.20	1.60	22.30	37	96	18.54	2.00	78	5.60	1.80	3.11	2.65	1.02
CO48	105.60	36.30	1.50	22.60	29	98	19.80	2.48	83	5.94	2.20	2.70	2.73	0.82
CO49	91.00	32.40	1.70	25.10	29	100	18.74	1.84	89	5.80	2.00	2.90	3.20	0.97
MDU5	77.30	29.40	1.30	22.60	46	90	22.17	2.30	71	6.80	2.20	3.09	3.20	1.25
IR36	144.10	48.30	1.70	22.90	39	86	16.88	2.10	63	5.06	1.80	2.81	3.13	1.12
IR64	157.60	33.20	2.00	26.20	31	78	18.57	2.30	72	6.80	2.40	2.83	3.19	1.35
I.W.Ponni	120.30	34.60	1.60	23.70	26	107	19.29	1.70	78	5.55	1.80	3.08	2.97	1.23
BPT5204	90.30	27.20	4.70	21.10	40	82	21.40	1.85	89	5.40	1.60	3.38	2.79	1.44
CR1009	104.00	33.20	1.60	24.80	20	114	25.24	1.72	93	5.00	2.60	1.92	3.16	1.08
Paiyur1	102.10	33.70	1.50	25.40	16	98	12.74	1.54	71	5.40	2.00	2.70	3.09	1.31
CUIABANA	178.60	37.70	1.30	22.50	33	85	4.51	1.68	43	5.60	1.90	2.95	2.68	0.87
IDSA77	120.00	28.50	1.40	20.40	10	92	5.97	1.75	54	6.20	2.10	2.95	2.97	0.79
CR547-1-2-3	134.00	24.80	1.70	18.50	21	98	6.39	2.11	59	6.40	2.60	2.46	2.38	0.62
DULAR (Acc32561)	115.00	28.00	1.20	21.30	12	86	6.51	1.86	39	5.40	1.80	3.00	3.06	0.83
GIZA178	128.00	41.60	1.50	21.60	15	96	13.35	2.23	58	6.00	2.10	2.86	2.84	0.66
T6	186.00	41.50	1.50	26.50	33	97	16.95	2.15	52	5.70	2.00	2.85	3.87	0.73
T71	191.60	41.40	1.90	25.20	19	92	18.43	1.97	68	5.90	1.90	3.11	3.34	0.89
T75	182.00	49.60	1.70	29.00	32	85	15.91	2.38	55	6.20	2.20	2.82	3.29	0.95
T132	211.00	58.90	1.90	29.00	27	102	11.72	1.88	58	5.40	2.20	2.45	3.29	1.04
T137	177.00	43.20	2.10	25.40	20	76	13.22	2.41	60	5.40	1.80	3.00	2.80	1.09
T175	158.60	57.60	1.70	26.30	29	100	17.25	1.88	65	5.40	2.20	2.45	2.67	0.88
T184	145.30	31.00	1.70	25.00	23	94	15.48	1.74	61	6.00	2.00	3.00	2.53	1.32
T235	182.30	51.40	1.70	28.20	23	79	18.84	2.16	61	5.60	2.70	2.07	3.12	1.05
T261	173.60	52.70	1.70	28.80	17	92	10.25	2.14	41	5.60	2.00	2.80	2.38	0.82
T271	179.00	51.30	1.90	26.00	12	92	11.29	1.90	64	5.40	2.00	2.70	3.55	0.85
T272	113.30	33.50	1.20	23.70	17	108	13.51	2.30	69	6.11	2.40	2.55	2.99	2.84
T287	203.30	41.10	1.80	27.40	15	102	10.83	2.33	49	5.59	2.40	2.33	2.47	1.33
T289	208.00	35.40	2.00	24.80	33	97	13.42	1.97	70	5.92	2.80	2.11	3.08	1.05
T296	197.60	55.70	1.50	28.00	23	100	12.43	1.76	59	6.13	2.10	2.92	2.77	1.09
T306	173.00	47.80	1.40	23.80	20	88	15.74	2.24	42	5.90	2.50	2.36	3.63	0.83
T336	182.60	55.80	1.30	25.00	22	82	11.59	2.25	55	5.12	2.10	2.44	3.51	1.06
T356	186.30	57.70	1.20	25.10	20	89	12.87	1.75	49	5.54	2.20	2.52	2.76	0.86
T366	184.60	35.30	1.20	27.90	17	94	9.97	2.02	39	4.06	2.00	2.03	4.21	0.95
T401	183.00	51.40	1.70	28.20	17	79	12.51	2.05	66	4.75	2.00	2.38	2.66	1.02
T420	177.30	42.00	1.70	23.30	17	95	15.68	2.71	54	5.06	2.20	2.30	5.39	1.01

T426	173.70	45.20	1.80	25.50	19	91	14.40	1.96	71	5.14	2.60	1.98	3.13	0.96
T550	174.30	54.40	1.80	27.10	15	73	10.89	2.82	37	6.32	2.00	3.16	2.95	0.80
T557	200.60	50.20	1.60	28.60	16	96	10.49	1.78	59	5.43	2.00	2.71	2.99	0.89
T693	186.60	47.00	1.70	24.70	20	102	10.97	2.14	53	5.49	2.40	2.36	3.31	1.03
IR68144-3B-2-2-3-3B-2-2-3	78.50	27.00	1.10	21.50	14	77	12.87	1.52	58	5.43	2.10	2.59	5.27	1.02
IC255787	136.30	27.60	1.30	23.70	32	77	14.78	2.37	53	5.70	2.20	2.59	4.51	0.54
IC350429	145.00	47.00	1.40	27.50	13	100	17.66	2.27	78	5.32	2.50	2.13	7.17	0.32
IC208793	185.00	53.60	1.30	31.00	20	98	14.25	2.38	61	5.13	2.30	2.23	4.57	0.30
IC350465	125.00	25.00	1.50	21.00	24	82	16.59	2.63	58	6.26	2.00	3.13	3.25	0.26
Mean	138.97	39.39	1.67	24.16	21	90	13.82	2.12	68	5.73	2.17	2.68	2.47	1.08
S.Ed	2.43	0.712	0.03	0.40	6.55	1.51	1.82	0.03	8.37	0.07	0.03	0.03	0.07	0.04
CD 5 %	4.83	1.418	0.06	0.81	13.05	3.00	3.62	0.07	16.67	0.15	0.07	0.07	0.15	0.09

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

PHT= Plant Height, LL= Leaf Length, LB= Leaf Breadth, PL= Panicle Length, NPT= Number of Productive Tillers, DFF= Days to Fifty percent Flowering, SPY= Single Plant Yield, HGW= Hundred Grain Weight, NGP= Number of Grains per Panicle, GL= Grain Length, GB= Grain Breadth, L/B= Grain Length Breadth ratio, Fe= Iron content, Zn= Zinc content.

Table 2. Estimates of Variability, Heritability and Genetic advance

Character	PV	GV	PCV (%)	GCV (%)	Heritability (%)	GA	GA as % of mean
PHT (cm)	1420.89	1414.89	27.12	27.07	99.58	77.33	55.64
LL (cm)	95.30	94.79	24.78	24.72	99.47	20.00	50.78
LB (cm)	0.37	0.37	36.50	36.45	99.75	1.25	74.99
PL (cm)	8.52	8.35	12.08	11.96	98.05	5.90	24.41
NPT	83.05	40.11	41.52	28.85	48.28	9.08	41.29
DFF	112.97	110.68	11.82	11.70	97.98	21.45	23.86
HGW (g)	0.09	0.09	14.33	14.23	98.66	0.62	29.12
NGP	323.33	253.24	26.31	23.29	78.32	28.87	42.46
GL (cm)	0.31	0.30	9.67	9.57	98.05	1.12	19.53
GB (cm)	0.07	0.07	12.39	12.27	98.17	0.54	25.05
L/B	0.16	0.16	15.06	15.00	99.25	0.83	30.79
Fe (ppm)	2.17	2.16	59.54	59.46	99.72	3.02	122.32
Zn(ppm)	0.24	0.24	45.30	45.09	99.07	1.00	92.45
SPY (g)	21.62	18.30	33.64	30.95	84.64	8.11	58.66

PHT= Plant Height, LL= Leaf Length, LB= Leaf Breadth, PL= Panicle Length, NPT= Number of Productive Tillers, DFF= Days to Fifty percent Flowering, SPY= Single Plant Yield, HGW= Hundred Grain Weight, NGP= Number of Grains per Panicle, GL= Grain Length, GB= Grain Breadth, L/B= Grain Length Breadth ratio, Fe= Iron content, Zn= Zinc content.

Table 3. Composition of D^2 clusters for 78 rice genotypes

Clusters	Number of genotypes	Name of genotypes
I	12	ADT36, ADT37, ADT38, ADT39, ADT43, ADT44, ADT45, ADT46, ADT47, ADT48, Local Aduthurai, T401
II	5	Kosuva Kathazhai, Madhukar, Purple Puttu, T296, T356
III	2	IR36, T175
IV	2	T271, T557
V	2	CO47, I.W.Ponni
VI	25	TN1, Karnel, Mapillai Samba, Mattaikar, TKK1, ASD1, ASD7, ASD16, ASD17, ASD18, ASD20, TKM5, TKM6, TKM8, TKM9, TKM10, TKM11, TRY1, TRY2, CO43, CO48, CO49, MDU5, IR64, Paiyur1
VII	2	IDSA77, DULAR (Acc32561)
VIII	2	GIZA178, T272
IX	15	BPT5204, CR1009, CUIABANA, CR547-1-2-3, T6, T71, T75, T132, T137, T184, T235, T261, T287, T306, T693
X	2	IC255787, IC350465
XI	2	T336, IC208793
XII	2	IR68144-3B-2-2-3-3B-2-2-3, IC350429
XIII	2	T420, T426
XIV	1	T366
XV	1	T550
XVI	1	T289

Table 5. Percentage contribution of each character towards genetic divergence in 78 genotypes of rice

Source	Times Ranked 1st	Contribution %
PHT (cm)	0	0.00
LL (cm)	211	7.03
LB (cm)	150	5.00
PL (cm)	191	6.36
NPT	154	5.13
DFF	167	5.56
HGW (g)	119	3.96
NGP	193	6.43
GL (cm)	479	15.95
GB (cm)	311	10.36
L/B	274	9.12
Fe (ppm)	160	5.50
Zn(ppm)	138	4.60
SPY (g)	616	15.50

PHT= Plant Height, LL= Leaf Length, LB= Leaf Breadth, PL= Panicle Length, NPT= Number of Productive Tillers, DFF= Days to Fifty percent Flowering, SPY= Single Plant Yield, HGW= Hundred Grain Weight, NGP= Number of Grains per Panicle, GL= Grain Length, GB= Grain Breadth, L/B= Grain Length Breadth ratio, Fe= Iron content, Zn= Zinc content.

Table 4. Average intra and inter D^2 values for 78 genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	15362.64	17365.13	17386.05	12781.49	12585.45	14541.34	16692.51	13798.21	18486.14	16218.68	14091.72	18383.98	16504.55	28920.26	24557.15	39136.91
II		15253.33	11022.12	10769.67	12000.82	14137.89	11825.49	10296.17	14663.68	13297.97	10543.52	15378.93	11743.11	27118.29	19053.68	34113.43
III			2370.70	11880.81	7089.65	14166.11	14064.17	9420.01	12609.61	14255.87	9362.20	17506.97	12180.96	31379.27	17434.45	36705.98
IV				2394.62	9216.78	12135.90	8555.84	9992.45	11002.69	13491.95	5748.87	11354.22	8690.25	16931.49	18501.36	28804.29
V					2515.96	11517.39	9833.85	5535.57	12000.39	9616.57	10262.39	15138.69	11589.27	26520.06	19555.07	37047.27
VI						13121.23	13007.41	10748.73	15781.38	12592.91	12094.22	16914.48	13827.94	27216.73	20332.90	35881.64
VII							3197.84	5659.62	12301.59	10268.60	11617.83	10503.74	11804.82	19037.48	16343.87	35663.40
VIII								3507.96	13560.92	10621.84	9372.54	11839.08	10797.74	26346.83	13668.58	43975.72
IX									13646.97	12290.15	12357.31	17585.71	11900.74	22065.12	21754.99	28780.45
X										5927.34	11744.04	14545.94	10892.67	21741.45	16166.91	30490.10
XI											7429.03	10769.29	8562.88	17285.84	13323.12	37046.62
XII												8381.64	13753.48	23148.72	22355.26	39975.33
XIII													13208.82	18248.92	21438.03	26087.81
XIV														0.00	33771.93	38116.82
XV															0.00	68641.14
XVI																0.00

Table 6. Mean performance of clusters and character contribution with respect to different characters

Character	PHT (cm)	LL (cm)	LB (cm)	PL (cm)	NPT	DFF	SPY (g)	HGW (g)	NGP	GL (cm)	GB (cm)	L/B	Fe (ppm)	Zn (ppm)
Cluster														
I	**107.70**	35.85	**2.03**	23.84	26.25	88.96	15.49	1.99	**92.39**	5.77	2.09	2.83	**1.40**	1.12
II	155.49	45.66	1.51	24.12	24.18	90.09	12.94	2.28	59.06	5.75	2.24	2.57	3.26	1.10
III	150.13	52.50	1.69	24.40	39.69	92.22	17.07	1.98	59.53	5.16	1.98	2.63	2.89	1.00
IV	186.90	49.99	1.73	26.89	15.27	92.58	11.64	1.82	60.57	5.37	1.97	2.70	3.22	0.87
V	119.14	33.89	1.58	22.66	31.51	100.01	**19.91**	1.82	78.77	5.52	**1.7 7**	3.10	2.77	1.13
VI	121.85	36.77	1.51	23.05	25.25	86.38	13.10	2.17	71.80	5.89	2.19	2.73	1.50	1.23
VII	115.75	27.83	1.28	**20.54**	14.29	87.68	**5.74**	**1.78**	38.92	5.72	1.92	2.98	2.97	0.81
VIII	119.77	37.28	1.34	22.48	17.37	**101.22**	13.93	2.25	63.02	6.05	2.23	2.71	2.90	**1.75**
IX	167.10	41.69	1.88	25.19	27.16	91.95	14.71	2.05	54.45	5.65	2.18	2.66	2.99	1.01
X	128.38	**25.84**	1.38	21.96	28.99	78.10	16.79	2.46	57.45	5.99	2.07	2.86	3.81	**0.40**
XI	181.05	**53.88**	1.28	27.60	19.23	88.69	14.93	2.28	56.66	5.12	2.17	2.34	3.98	0.68
XII	111.22	36.83	1.25	24.42	**13.97**	88.19	14.03	1.89	68.20	5.39	2.30	2.36	**6.36**	0.67
XIII	174.64	43.37	1.74	24.27	17.41	92.56	16.54	2.33	58.59	5.08	2.39	2.14	4.25	0.99
XIV	187.37	35.83	**1.22**	**28.32**	15.23	95.41	9.97	2.05	39.59	**4.06**	2.03	**2.03**	4.28	0.95
XV	172.56	53.86	1.78	26.83	14.85	**72.27**	10.89	**2.79**	**25.74**	**6.34**	1.98	**3.16**	2.92	0.80
XVI	**204.88**	34.87	1.97	24.43	**40.39**	95.55	14.42	1.94	73.88	5.91	**2.76**	2.11	3.04	1.05

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