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Phenotypic Assessment of Natural Diversity in Low-Land Rice Germplasm as Affected by Iron Toxicity

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Authors' contributions

This work was carried out in collaboration among all authors. Author ICM conceived and designed the study. Authors DS, ICM and S. Panda collected all the data and performed the statistical analyses. Authors DB and S. Panda provided the germplasm and required logistics. Author DS wrote the first draft of the manuscript and authors ICM and S. Pradhan corrected the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Iron toxicity that seriously affect rice yield is a critical concern for the crop improvement programs in rice. Morphological analysis of germplasm is essential for the success of varietal crop improvement programs. The objective of this investigation is to estimate the phenotypic diversification of one hundred and fifty germplasm to identify the tolerant genotypes under iron toxic situation for exploitation of inherited variability from the accessible germplasm. Experiment has been carried out under lowland field condition to determine the reaction of rice germplasm under hotspots for iron toxicity. Significant differences among the genotypes have been observed. A significant difference is present among all the traits like days to 50% flowering, Plant height, panicle length, grain/panicle, grain weight, yield, leaf bronzing index (LBI) and tillers number. The phylogenetic analysis was also

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carried out to find out a core population for further study like association mapping with trait of interest. The genotypes like Mahsuri, Kusuma, Ganjamgedi, Pratikhya, Swarna, Dhusura have been found to be tolerant genotypes under iron toxic condition.

Keywords: Iron toxicity; genetic diversity; tolerant; morphological.

1. INTRODUCTION

Rice is a staple food for half of the world's population mostly in Asia. Rice is vulnerable to many biotic and abiotic stresses like insect-pest, fungus, viruses, drought, flood, submergence, high/low temperature, salinity, iron (Fe) toxicity [1]. These factors result 30-60% yield loss globally in each year [2]. Iron toxicity is a serious nutrient disorder in lowland areas. Yield depletion by iron toxicity is about 16-78% [3] and moreover decrease in nutrition quality [4]. Symptoms related to iron toxicity in rice are bronzing (Leaf discolorations), black coating on roots, limited tillering, damaged root system, leaf tip necrosis [5]. Development of resistant cultivars of rice is a major breeding activity to overcome the problems associated with iron toxicity, which requires selection of a potential donor for introgression of the trait of interest in to the suitable background of rice genotypes. The improvement of rice yield is a continuous process to keep pace with population growth, for which collections of germplasm, systematic screening for desired traits and subsequent incorporation of the relevant genes into existing cultivars is very essential for sustained high productivity. The germplasm including land races provide a rich source for many agronomically important characters. Characterization of germplasm is essential to provide information on the traits of accessions assuring the maximum utilization of the germplasm collection to the final users. Characterization involves the recording and compilation of data on the important characteristics which distinguish accessions within a species, enables an easy and quick discrimination among phenotypes. It allows simple grouping of accessions, development of core collections, identification of gaps and retrieval of valuable germplasm for breeding programmes, resulting in better insight about the composition of the collection and its genetic diversity. It also facilitates a check on the trueness-to-type of homogeneous samples, allowing detection of misidentifications or duplicates and indicating possible errors made during other genebank operations. Successful crop improvement depends on genetic variability that arises from genetic diversity [6]. Lack of genetic diversity may limit breeding progress and gain from selection [7]. Assessment of genetic diversity is, therefore, extremely vital in rice breeding from choice, conservation of a distinct native type of rice and correct utilization [8]. This study aimed to characterize mostly low land rice accessions which can facilitate to identify the variability for the iron toxicity, a major problem in lowland rice cultivation, and selection of potential donors for future rice breeding in case of iron toxicity.

2. MATERIALS AND METHODS

A set of 150 rice germplasms consisting of landraces (129), and released varieties (21) pertaining to low land rice cultivation were used for the present study. The experiment was conducted for three seasons in a replicated trial at RRTTS (Regional research for transfer of technology Station) OUAT, Bhubaneswar situated in 20°15`N latitude and 85°52`E longitude. Seeds were sown in nursery bed and transplanted after 21 days in a plot which is hotspot of iron toxicity with a sub-plot size of 2.7 m X 0.6 m maintaining a spatial arrangement of 15 cm apart and 20 cm among rows. All the required agronomic practices for lowland rice cultivation was followed with a fertilizer dose of NPK as manure at the rate of 80:40:40 Kg/ha respectively. Standing water was maintained in the field to provide a saturated anaerobic condition. The initial soil Fe-content was measured to be 242 ppm. Three manual weeding processes were carried out in the course of the investigation. Harvesting was done at rice grains maturity on all elementary plots. For 150 rice germplasms data collection has been done considering those parameters: days for 50% flowering, Plant height, panicle length, Number of grains/panicle, grain weight, yield q/ha, leaf bronzing score, and numbers of tillers/hill. These observations were recorded by taking reference from Standard Evaluation System of Rice. The data were entered with the Excel spreadsheet version 2013. The suitable statistical treatment like analysis of variance (ANOVA), correlation tests (Pearsons) were done and phylogenic analysis was performed by converting morphological traits in to binary codes.

3. RESULTS AND DISSCUSION

Genetic divergence is extremely important and key for crop advancement. Existence of additional variability in the main population increases possibility of more enhancement (2). Phenotypic assessment can contribute additional information on the structure and spatial distribution of diversification. The phenotypic analysis of rice germplasms is studied using quantitative agro-morphological parameters. This investigation finds out the existence of considerable variation in the midst of various parameters of rice germplasm under iron toxicity condition.

3.1 Phenotypic Diversity

A set of 150 germplasms including landraces and released high yielding cultivars were investigated for different morphological characteristics with particular reference to leaf bronzing index due to iron toxicity in soil in the natural environment at the research station of Regional Research and Technology Transfer Station, OUAT, Bhubaneswar in Kharif season in successive three years in a replicated trial with two replications. Noticeable trait dissimilarities were observed among all the studied genotypes. Significant results were noted via analysis of variance (ANOVA) for all chosen parameters.

Table 1. Morphological performance of rice genotypes under iron toxicity condition

Treatments	DF	PH	PL	GN	GW	Yield	LBI	Tillers
1. Sankaribako	105.73	106.23	21.11	77.81	25.16	11.40	4.67	6.65
2. Kalakrushna	100.75	122.55	25.06	144.57	14.06	13.58	3.83	6.37
3. Assamchudi	100.05	112.50	22.90	102.80	21.70	11.09	4.67	5.16
4. Gelei	97.70	103.93	22.10	120.05	16.04	15.40	3.50	7.20
5. Kalamara	99.08	122.57	21.80	79.43	14.63	3.78	2.33	4.61
6. Nini	96.60	112.84	24.51	97.96	21.09	9.68	3.67	6.68
7. Gurumukhi	104.75	113.08	21.27	86.53	24.55	16.74	4.00	5.57
8. Jubaraj	105.00	109.76	24.13	84.35	18.99	12.51	5.17	6.15
9. Champa	105.33	113.46	20.81	124.10	22.76	24.22	2.67	6.42
10. Veleri	110.25	114.12	24.75	87.85	21.90	17.05	4.00	5.72
11. Dhinkisiali	107.58	114.57	21.45	94.09	18.16	12.34	2.33	7.51
12. Dhabalabhuta	106.17	121.49	21.78	86.17	20.44	23.22	3.00	6.58
13. Bayabhanda	108.25	120.19	23.29	85.87	18.85	17.17	3.17	6.96
14. Lata mahu	102.83	112.13	20.46	89.79	18.94	20.47	3.67	6.29
15. Hatipanjara	105.50	119.90	22.77	87.92	19.04	22.38	3.00	8.80
16. Mugei	103.34	114.84	21.67	76.71	19.94	12.13	3.67	5.17
17. Sagiri	102.00	123.36	22.33	125.97	24.24	15.70	5.00	4.99
18. Kakiri	102.67	111.71	22.31	102.22	23.30	18.27	4.83	5.79
19. Madia	101.75	118.58	24.47	106.22	21.39	19.86	5.67	5.71
20. Dhusura	102.50	113.72	25.70	82.58	23.09	21.18	1.83	6.54
21. Bangali	100.83	115.25	22.84	99.77	21.96	24.11	3.67	5.32
22. Banda	107.22	132.03	25.79	108.51	20.26	13.85	3.00	4.77
23. Jalpaya	103.42	116.77	23.25	99.39	17.12	19.56	3.67	5.77
24. Chudi	107.08	116.41	26.29	127.39	21.17	22.97	4.33	5.85
25. Nilarpati	104.83	118.09	22.34	103.19	26.53	24.65	3.50	5.13
26. Gelei	106.42	116.62	20.82	134.07	16.55	25.43	4.33	5.96
27. Ratanmali	105.25	108.15	25.04	123.58	16.52	19.17	2.50	6.77
28. Umarcudi	103.42	110.79	26.21	125.99	18.25	17.14	4.50	6.14
29. Jaiphula	103.58	115.14	21.40	140.80	13.09	18.44	5.50	6.32
30. Karpurakranti	104.17	115.67	22.69	104.81	12.21	16.64	4.00	6.51
31. Ramakrushnabilash	102.67	113.93	23.44	135.25	12.98	25.72	3.33	7.45
32. Bagudi	104.67	115.05	24.20	140.50	21.61	31.82	4.33	5.93
33. Sunapani	110.58	107.74	25.90	123.62	21.24	45.03	3.17	6.89
34. Anu	100.50	112.43	22.64	148.89	12.79	18.21	3.17	6.53
35. Mayurkantha	100.67	123.85	22.44	101.52	22.54	26.14	3.33	5.48
36. Champeisiali	107.50	120.13	23.89	95.17	21.41	15.66	4.33	6.14
37. Nalijagannath	106.42	119.40	19.88	120.45	21.07	46.92	4.67	5.60
38. Mhasuri	111.25	113.47	26.62	143.37	17.74	42.32	3.00	7.75
39. Ranisaheba	104.17	110.94	23.07	129.63	19.09	25.14	2.50	6.79
40. Punjabniswarna	104.92	116.09	26.30	93.20	20.03	17.38	2.67	5.24

Treatments	DF	PH	PL	GN	GW	Yield	LBI	Tillers
41. Kusuma	102.17	117.18	23.22	119.48	25.48	23.38	1.67	5.19
42. Kenrdajhali	103.17	110.09	23.84	122.56	18.04	12.89	2.67	6.18
43. Jaiphula	100.17	114.43	24.79	98.49	13.79	10.12	2.50	6.48
44. Jabaphula	104.62	109.70	24.50	116.91	21.98	10.83	3.50	5.72
45. Khandasagar	101.33	107.52	22.67	74.25	18.05	11.96	5.83	5.37
46. Pipalbasa	102.67	123.15	24.90	67.66	23.37	11.19	5.00	6.03
47. Budidhan	105.08	115.07	27.24	120.65	15.65	13.91	5.33	6.29
48. Karpuragundi	107.67	112.50	22.65	126.80	13.05	17.83	5.33	5.79
49. Basapatri	100.67	111.94	21.61	100.36	16.59	14.31	4.67	6.48
50. Bagadachinamala	104.00	110.47	22.63	98.51	16.08	23.90	4.00	6.54
51. Kalaheera	105.33	115.63	23.71	118.39	17.14	33.23	4.33	6.56
52. Rasapanjari	106.42	102.81	23.38	126.93	22.01	23.27	4.17	4.81
53. Biridibankoj	109.67	119.02	23.27	108.16	24.65	24.95	3.00	6.37
54. Jagbalia	113.25	110.01	21.85	141.56	38.40	27.05	3.67	6.36
55. Dholamadhoi	109.75	111.53	25.75	107.71	23.56	33.95	3.50	5.97
56. Kaniara	104.50	103.11	20.68	100.63	17.89	20.45	3.17	5.56
57. Bishnupriya	106.75	109.07	21.54	121.40	17.90	21.26	5.67	6.06
58. Madhabi	108.17	109.81	22.07	126.24	22.79	22.53	4.00	5.12
59. Jungajhata	104.83	112.58	25.64	106.07	23.59	21.68	4.00	6.75
60. Rangasiuli	107.00	117.02	25.34	123.16	18.93	21.06	3.33	6.19
61. Sankarachini	107.00	112.88	24.41	99.59	22.54	20.52	2.33	6.23
62. Saluagaja	104.50	114.30	22.72	140.72	18.04	20.35	5.83	7.36
63. Mayurachulia	106.92	107.52	21.71	168.47	13.15	21.67	4.50	5.46
64. Basudha	107.17	105.23	21.06	147.91	15.83	23.18	3.17	7.67
65. Tikimahsuri	107.17	98.37	25.50	127.09	12.60	14.98	3.00	7.01
66. Tulasibasa	104.77	118.09	25.44	112.87	17.72	19.78	3.33	5.48
67. Asinasita	103.17	112.61	23.47	106.23	11.77	20.95	3.50	7.04
68. Bhangar	105.33	94.14	22.04	123.54	12.68	21.24	3.83	6.67
69. Kalajeera	107.17	117.42	22.49	151.79	12.16	19.71	3.17	6.84
70. Gobindabhog	105.17	117.59	23.46	163.49	14.20	22.52	4.67	6.04
71. Basudha	104.50	91.71	21.42	137.73	14.21	20.84	5.50	5.07
72. Agnisar	104.83	112.47	21.37	108.37	20.61	18.56	4.83	4.58
73. Malata	106.17	112.00	21.31	110.79	16.80	20.73	4.50	5.59
74. Kabir	107.00	100.71	21.47	118.32	19.62	14.36	2.17	6.31
75. Nadal ghanta	104.50	117.87	23.13	118.31	21.06	23.59	3.00	6.88
76. Latachaunri	103.00	109.88	23.48	145.96	21.29	17.99	2.67	5.83
77. Nalikalma	103.67	104.79	25.66	144.17	20.95	21.96	4.50	6.39
78. Sarubhajana	102.17	126.05	21.77	124.91	21.13	15.07	3.33	6.22
79. Luna	104.33	121.68	24.78	101.09	23.01	51.58	2.67	6.10
80. Abiram	101.00	118.98	23.24	109.05	21.30	20.91	5.33	4.86
81. Sebati	99.83	81.64	22.48	91.70	18.15	21.88	5.67	6.99
82. Ahiram	104.50	121.49	23.76	105.92	22.52	16.55	4.83	6.08
83. Bhutmundi	107.83	119.73	22.51	96.29	23.55	20.10	2.67	5.55
84. Makarkanda	107.83	116.56	22.14	98.64	23.86	20.63	3.17	6.92
85. Jata	104.17	115.93	24.67	100.89	21.03	18.07	3.67	6.02
86. Khajurikandi	101.92	118.89	21.70	119.05	17.51	15.74	2.67	6.29
87. Tulasimali	102.67	114.92	24.07	104.42	19.99	20.16	3.33	6.19
88. Nalibaunsagaja	103.25	118.99	21.35	102.85	25.18	19.88	3.33	6.83
89. Malabati	105.17	112.57	22.73	112.85	23.35	30.56	3.67	6.20
90. Pateni	108.58	120.43	23.86	130.06	18.77	26.49	2.33	6.12
91. Nikipakhia	106.00	102.62	24.26	108.60	15.14	22.71	2.33	5.71
92. Malliphujajhuli	103.92	104.23	24.76	105.52	15.76	16.78	3.67	7.57
93. Jhilli	103.83	110.75	24.04	126.24	17.81	24.38	3.50	6.41
94. Bharati	104.33	103.41	20.86	123.99	15.88	21.37	3.50	7.08
95. Hunder	103.67	112.78	21.91	123.50	17.26	20.25	3.00	4.65
96. Sapri	103.83	122.20	24.88	99.22	19.86	26.32	3.33	6.35
97. Dholabankoi	106.50	114.72	23.10	98.82	20.58	24.38	3.50	6.08

Treatments	DF	PH	PL	GN	GW	Yield	LBI	Tillers
98. Korkaili	86.17	106.09	22.13	126.84	21.50	29.34	2.67	5.08
99. Kalamulia	114.50	112.94	22.03	103.63	21.75	22.84	4.00	6.17
100. Kusumkunda	110.75	111.34	21.41	101.98	23.57	25.44	2.00	6.37
101. Sarswati	110.83	129.97	22.54	111.17	25.17	26.89	2.67	6.50
102. Budhamanda	111.67	112.07	22.67	114.01	26.14	23.67	2.67	6.90
103. Khajara	112.42	120.95	24.11	121.78	30.90	22.19	2.83	6.91
104. Matia khoja	108.50	121.12	24.81	111.09	19.21	20.27	3.67	6.22
105. Haribhohg	108.50	120.50	22.97	93.57	21.53	31.22	3.83	6.12
106. Labangalata	111.92	101.94	22.12	166.67	18.27	32.85	3.33	6.78
107. Dimapur	111.08	107.93	23.69	157.70	25.78	27.87	3.33	5.82
108. Padmakesari	109.75	100.64	23.38	124.38	19.50	27.01	3.50	6.66
109. Mahipal	110.50	103.32	24.43	153.21	20.47	29.53	4.17	7.77
110. Dhanashree	111.50	100.19	23.66	133.37	17.25	26.43	3.00	7.34
111. Khndiratnachudi	108.58	122.25	24.56	103.92	20.81	24.40	4.50	6.71
112. Ruksal	113.50	132.89	23.25	133.44	22.73	23.30	4.00	5.44
113. Harisankar	111.50	98.17	22.89	129.94	19.34	26.19	5.33	5.90
114. Jagannath	112.75	96.99	21.48	154.35	17.90	27.25	3.67	6.65
115. Mahalaxmi	114.58	91.42	21.85	187.00	18.05	30.16	5.67	7.37
116. Manika	112.17	93.42	23.91	152.48	17.03	28.76	4.50	5.79
117. Urbashi	111.50	119.62	25.02	123.76	19.03	28.17	3.67	5.86
118. Rambha	115.58	109.45	25.43	135.25	21.36	37.81	4.33	6.00
119. Salivahar	121.83	99.77	21.69	123.52	15.57	35.41	3.83	6.52
120. Mhasuri	122.00	97.36	22.23	158.70	18.56	40.82	1.67	8.42
121. Savitri	122.58	104.75	21.26	138.62	20.59	50.47	3.00	8.64
122. Mahanandi	121.50	98.11	20.79	151.48	21.84	43.84	4.17	7.70
123. Ramachandi	124.83	91.74	22.28	100.79	20.81	39.80	3.33	7.53
124. Indrayati	119.00	92.12	22.12	124.78	23.34	34.01	4.33	6.57
125. Prachi	119.00	98.66	23.72	124.97	21.73	37.25	2.67	6.30
126. Jagabandhu	118.83	99.03	22.49	131.00	19.94	35.53	2.83	5.95
127. Uphar	116.08	98.60	22.29	140.80	20.59	34.14	2.50	7.51
128. Mrunalini	112.33	99.49	26.45	100.53	21.07	40.60	4.67	6.54
129. Tanmayee	114.17	99.25	22.08	129.25	17.73	44.43	4.33	6.20
130. Ashutosh	117.25	99.93	22.38	133.62	19.41	46.96	4.00	6.45
131. Hasanta	112.67	98.31	22.29	129.88	21.06	35.63	3.33	7.32
132. Santepheap	108.50	92.82	24.76	182.80	21.92	45.03	4.17	7.91
133. OR237-23	110.17	107.80	20.43	134.31	21.74	25.73	2.83	6.05
134. GanjamGedi	108.00	112.57	20.76	153.21	19.06	19.92	1.83	7.04
135. Seulapana	109.75	99.42	21.05	112.01	21.47	24.47	3.67	6.99
136. Kandalipenda	103.42	110.95	21.47	101.66	20.37	22.71	3.33	6.90
137. Kukudimanji	103.33	104.98	20.38	104.18	26.09	21.25	4.83	6.38
138. Habira	102.67	115.04	22.48	118.32	23.52	25.22	4.00	6.44
139. Kantha kamal	102.17	120.01	23.74	111.77	22.74	18.92	4.00	5.68
140. Bankoi	103.33	122.09	22.93	116.22	17.91	25.30	5.17	5.66
141. Laxmi	105.42	89.58	21.61	128.77	17.23	37.18	3.00	6.29
142. Pratikhya	110.42	93.43	22.43	147.42	18.71	47.03	1.50	7.47
143. Ranidhan	111.08	102.88	21.56	153.12	17.18	45.52	2.67	7.37
144. Swarna	107.92	96.38	24.93	134.85	18.71	44.42	2.17	6.54
145. Manaswini	104.58	96.93	24.33	141.34	21.73	34.49	3.00	6.24
146. MTU1010	109.83	100.14	24.78	101.85	15.99	36.20	3.83	6.48
147. Tejaswini	108.50	104.99	22.93	114.73	18.15	31.18	3.33	6.91
148. IR 64	102.83	91.25	24.01	89.66	18.55	27.89	4.83	8.27
149. Hiranmayee	101.58	96.39	25.38	123.21	21.12	36.86	3.17	6.35
150. Lalat	109.08	93.74	23.46	134.74	16.98	41.79	2.33	8.20
CV%	6.200	13.203	9.516	23.657	24.669	47.257	47.671	20.373
CD	5.299	20.313	3.039	32.828	5.817	12.483	2.10	1.900

Where: DF-Days to flowering; PH- plant height in cm; PL- Panicle length in cm; GN-Grain number per panicle; GW-1000 grain weight in gram; Yield- yield in Q/ha; Tillers- number tillers per hill

All the test genotypes were found to have significant differences with respect to various parameters taken for the present study. All the morphological traits studied here viz., Numbers of days to 50% flowering after sowing, plant height, panicle length, number of grains per panicle, 1000 grain weight (seed index), yield in Q/ha, leaf bronzing score, number of tillers per hill showed diversification. All morphological characters were scored in replications of each rice genotype. Leaf bronzing score was taken for determination of reaction level of each genotype viz., resistant, moderate, susceptible. The outcomes obtained during morphological analysis are depicted in Table 1.

Genotypes are significantly varied with different parameters under iron toxicity condition. Genotype Korkaili showed minimum days for 50% flowering occurrencei.e.86.17 days while genotype Ramachandi took maximum days for 50% flowering i.e 124.83 days. Maximum plant height observed in the genotype Ruksali.e132.89 cm while minimum plant height noticed in the genotype Sebati i.e. 81.64cm. Panicle length is also significantly affected by genotype and Fe-toxicity interaction. Panicle length of genotype Nalijagannath is 19.88 cm which is lowest among other genotypes and genotype Budidhan showed the maximum panicle length that i.e 27.24 cm. Grain number also significantly varied among the genotypes. Genotype Pipalbasa produced lowest number grain per panicle i.e. 67.66 while genotype Mahalaxmi has the highest grain number among the other i.e. 187. The genotype Asinasita has the lowest grain weight i.e. 11.77 gm and the genotype Jagabalia has the highest grain weight compare to other genotypes i.e. 38.40 gm. Yield of the genotype Kalamara is 3.78q/ha which is lowest among other 150 genotypes whereas the genotype Luna has shown the highest yield i.e 51.58 q/ha. Number of tillers significantly varied among the genotypes. In case of tiller number, the genotype which has the highest tiller among all genotype Hatipanjara i.e. 8.80 and lowest tiller number noticed in the genotype Agnisar i.e. 4.58. Leaf bronzing score of different genotypes depends on the reaction condition of all the genotypes in the hotspot where the genotypes Karpuragundi, Khandasagar, Agnisar, IR-64, Sebati showed the high susceptibility in iron toxic condition with a scale of around 5.00whereas genotype Pratikhya, Kusuma, Ganjamgedi, Mahsuri showed the highest tolerant capacity against iron toxicity in the scale of 1.50, 1.67, 1.83 and 1.67 respectively.

The phenotypic performance of tolerant and/or susceptible rice genotypes may vary from one location to another and according to the type of soil. In the present study, tolerant variety Mahsuri has a low LBI with higher grain yield, also some other genotypes like Pratikhya, Ganjamgedi, Kusuma are found to be tolerant with reduction in yield and susceptible variety like Jubaraj has higher LBI with reduction in grain yield. Same result also noted in Sikirou et al. [8,4] experiment that susceptible rice genotypes IR64 and Bouake 189 showed higher LBI with a GY reduction, whereas tolerant cultivars Suakoko 8 and WITA 4 showed a lower LBI and a GY reduction. Whereas some genotypes like IR-64, Sebati, Mahalaxmi are susceptible yet grain yield is more compared to tolerant genotypes. It depends on the yield attributing characters like panicle number, tiller number, grain weight and also different soil types which may explain this type of contrasting reports.

3.2 Character Association

The degree of correlation among the morphological parameters is significant for plant breeding. The analysis of correlations assists breeders in the time of preference and extends a more proper understanding of the various constituents of the yield. The rate of leaf bronzing is evaluated to be a straightforward marker of the iron toxicity severity [9,10,11]. The Pearson's correlation coefficient exhibited a strong correlation (r=0.566) between the yield and flowering also between the yield and grains/ panicle(r=0.404). There is also positive correlation present between tillers and yield (r=0.381), on the other hand positive correlation present among tillers and flowering(r=0.365), flowering and grains/panicle(r=0.341), as well as in tillers and grains/panicle(r=0.249), grain weight and height(r=0.194), Grain weight and flowering (r=0.144) and yield and grain weight(r=0.111). The negative correlation present between the leaf bronzing indexes with all the morphological characteristics except grains per panicle. Leaf bronzing index (LBI) was found to be negatively correlated with flowering, plant height, Panicle number, grain weight, yield and tillers. The higher genetic variability and reliable correlation of LBI are significantly connected with grain yield reduction, recommending that LBI is a practical approach for deciding tolerant genotypes under Fe-toxicity [12]. The level of correlation may be affected due to factors, such as the extremity of Fe concentration, the period of Fe stress, kind of soil conditions, and sort of genotype used in the investigation. The present collection of germplasm depicts a valuable diversity among all the genotypes. However, the large and diverse collection of genetic resource which is actually key to a successful crop improvement programme poses difficulty in management. Therefore, for selection of a core collection from such a diverse set of germplasm, the classificatory analyses like phylogenic and principal component analyses were conducted that separated the entire collection into two major groups at 30 phenon level with more than 4 subgroups at higher phenons. The representative genotypes from all these groups and sub-groups would constitute a core collection which would facilitate quick and correct evaluation at molecular level in the subsequent improvement programme.

Table 2. Character association as revealed from 150 diverse rice genotypes evaluated under Fe-toxicity

	DF	LBI	PH	PL	GN	GW	YIELD	TN
DF	1.000							
LBI	-0.057	1.000						
PH	-0.345***	-0.044	1.000					
PN	-0.082	-0.057	0.144	1.000				
GN	0.341***	0.026	-0.357***	-0.065	1.000			
GW	0.144**	-0.078	0.194*	-0.013	-0.187	1.000		
YIELD	0.566***	-0.093	-0.462	-0.020	0.404***	0.111	1.000	
TN	0.365***	-0.171*	-0.379	-0.022	0.249	-0.141	0.381***	1.000

, ** and * significant at 0.05, 0.01 and 0.001probability level respectively, DF: days for 50% flowering, LBI: leaf bronzing index, PH: plant height, GN: grain number, GW: grain weight, TN: tiller number*

Fig. 1. Rice genotypes susceptible Fe-toxicity

Fig. 2. Rice genotypes tolerant to Fe-toxicity

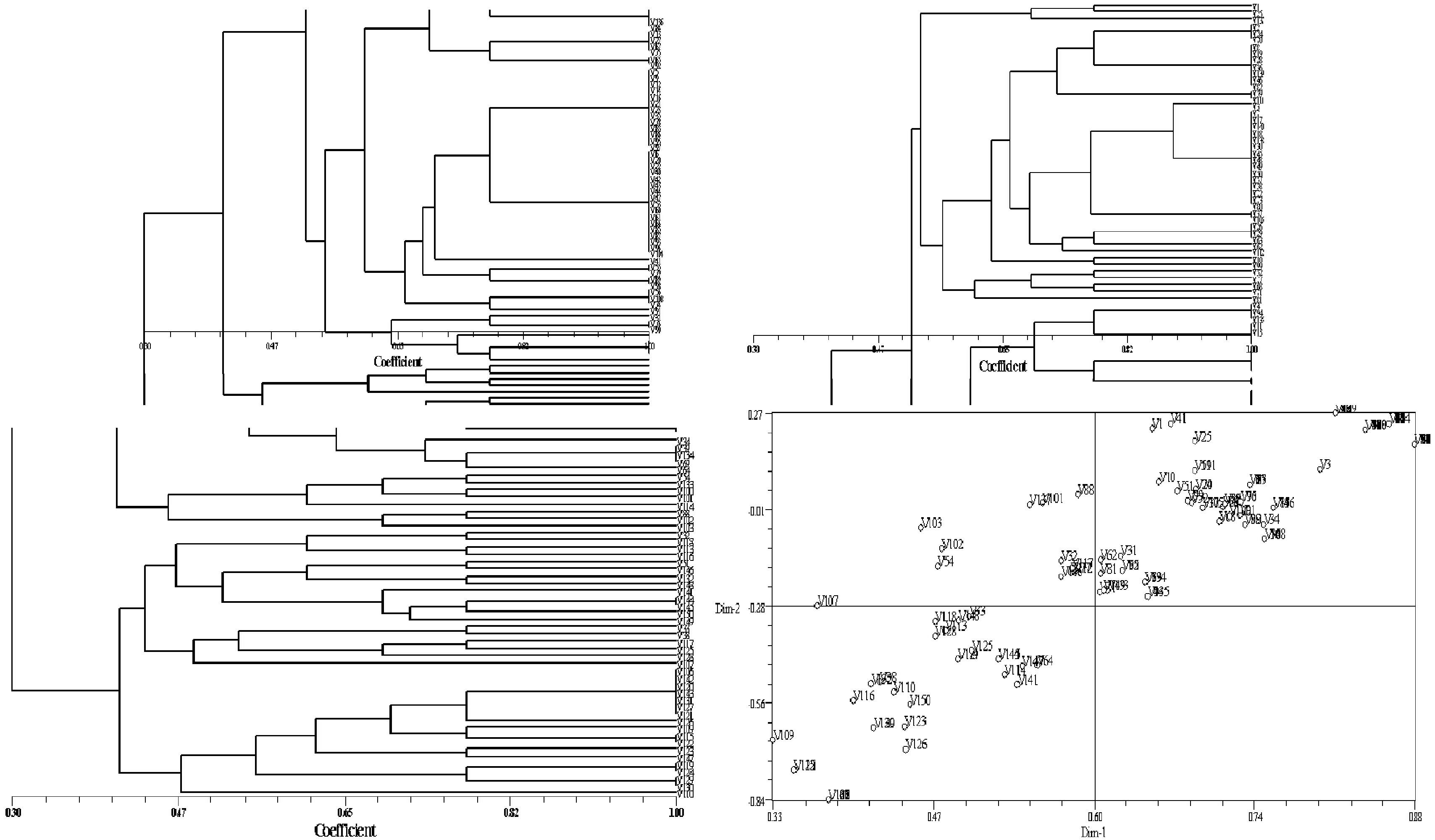

Fig. 3. Phylogenic analysis and PCA based on phenotypic traits

4. CONCLUSION

A set of 150 rice genotypes were evaluated in their natural habitat of low-land rice cultivation ecosystem prone to iron toxicity. All these genotypes differ significantly from each other with respect to 8 quantitative descriptors. The genotypes like Mahsuri, Kusuma, Ganjamgedi, Pratikhya, Swarna, Dhusura have been found to be tolerant genotypes under iron toxic condition which can be used as potential donors for introgression of the trait for tolerance to Fe-toxicity in to the background of other high yielding genotypes. The phylogenic analysis conducted helps to find out a core population for subsequent molecular study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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