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Article

Phenotypic diversity analysis of iron rich rice landraces

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Abstract: Anemia in human being due to iron deficiency would be solved with the intake of iron rich rice *(Oryza sativa L.)* grain developed by biofortification. Phenotypical study of obsolete rice germplasms containing high iron content is important. Phenotypic characters like flowering and maturity time; plant height; tillers hill^{-1}; grains panicle^{-1}; seed weight and grain yield plant^{-1} were studied for 39 rice genotypes in this research. In this research, Malagoti showed early maturity (126 day), Dhar Shail showed highest filled grain panicle^{-1} (303), Marish Shail showed highest grain yield plant^{-1} (86.66g), and Karengal showed lowest filled grain panicle^{-1} (59.67) and lowest grain yield plant^{-1} (17.20g). Number of filled grains panicle^{-1} showed high heritability. All the yield contributing traits except panicle length and unfilled grains panicle^{-1} were significantly and positively correlated with grain yield plant^{-1} at both phenotypic and genotypic level. The highest direct effects (0.486 and 9.75) on grain yield plant^{-1} were found for plant height and days to maturity at phenotypic and genotypic level with residual effect 0.461 and 0.496 respectively. Finally, the obsolete genotypes with highest grain yield (Marish Shail) and early maturity (Malagoti) performance would be used as breeding materials to improve iron rich rice varieties.

Keywords: anemia; cereal crop; heritability; micronutrient

1. Introduction

Iron deficiency is the leading human nutritional disorder in the world. In Bangladesh 49% of pregnant woman and 53% of preschool children are anemic due to iron deficiency (Hossain and Hussain, 2004). The severe form of iron deficiency affects about 3.5 billion people worldwide (Kracht, 1999; Ahman *et al.*, 2000). In infant and young children, it impairs immunity, reduces the physical growth and cognitive development; at school age it affects school performance and reduces activity levels; at adulthood, it reduces work capacity and decrease resistance to fatigue. In pregnant women, iron deficiency anemia is associated with an increased risk of pre-mature delivery, retarded growth of the fetus, low birth weight and increased risk that the new born baby die soon after birth. Anemia is the main cause of death during childbirth (Chrispeel and Sadava, 1994). Plant foods contain almost all of the mineral and organic nutrients regarded as essential for human nutrition, but often these are not present in sufficient amounts.

Rice landraces available in Bangladesh are comprised of the unique source for gene of high adaptability with valuable nutrient contents but are poor yielders (Jahan *et al*., 2013). Therefore, it is an indispensable demand for varietal improvement with nutrients in such situation. Rice is one of the most important cereal crops in Bangladesh and it is the main staple food for the people. About two-thirds of total calorie supply and about one-half of the total protein intakes of an average person in the country are supplied by cereals (Hossain, 2002).

Among the large population of this country, a large portion suffered in malnutrition and one of the important ways to mitigate this problem by growing nutritional quality improved rice cultivars. In Bangladesh, 11528.51 thousand hectares of land produces 33540.32 thousand metric tons of rice (BBS, 2012).
Bangladesh earns about 18.7% of her GDP from agriculture (Economic Review, 2013). Improving mineral nutrition through plant biotechnology may be a more sustainable strategy to combat nutrient deficiencies in human populations. The ferritin protein takes up Fe, stores it in a non-toxic form, and releases it when needed for metabolic functions, as iron stored in ferritin rice is bioavailable. The removal of the outer layers of the rice seed by commercial milling dramatically reduces the level of iron in the grains because most of the iron is accumulated in the aleurone layer. The rice glutelins compose up to 70-80% of the total seed protein and represent the major storage protein of rice (Junling Luo *et al.*, 2008). Correlation coefficient determines the simple relations among the traits. It does not determine always decisive result about determination of plant selection criteria (Cakmakci *et al*., 1998). Path coefficient analysis as to correlation coefficient gives more detailed information on the relations, so it is commonly used by plant breeders to determine yield and yield contributing characters (Board *et al*., 1997; Williams *et al*. 1990). The landraces with gene (s) for highest grain yield, high iron content and resistant capacity could be used as principal source of biofortification. Therefore, the present study was conducted to estimate the nature and magnitude of genetic divergence for iron content, yield performance and the characters contributing to that genetic diversity of selected rice landraces of Bangladesh. From this study, the genotypes with good performance would be used in developing nutritionally improved rice cultivar with high resistance ability against different biotic and abiotic stresses through the effective breeding techniques.

2. Materials and Methods

2.1. Experimental site, duration and materials

This study was conducted at the research laboratory of Department of Agricultural Chemistry, Bangladesh Agricultural University; and experimental field and laboratory of Biotechnology and Soil Science Division of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during July 2013 to February 2014. There are 39 rice genotypes (Table 1) were used in this study.

2.2. Growing of seedling, transplanting and harvesting

Approximately 10-15 seeds of each variety were taken randomly and dried in oven at 54°C for 48 hrs followed by germination on the wet blotting paper in petridishes. The seedlings were grown in small plastic pots. Thirty days older 2-3 seedlings per hill were transplanted to the main field of Biotechnology Division of BINA. Harvesting was done depending upon the maturity of different genotypes. Different genotypes attain their maturity at different times. The date of harvesting was confined when 90% of the grain attained golden yellow color.

2.3. Experimental design and data collection

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The plot size was 4 m x 2.5 m, row to row and plant to plant distances were 20 cm and 15 cm, respectively. Morphological data viz. days to 50% flowering, days to maturity, plant height, total tillers and effective tillers hill^{-1}, filled and unfilled grains panicle^{-1}, 1000 seed weight (g) and grain yield plant^{-1} (g) were taken for genotype carefully.

3. Results and Discussion

In morphological aspect, the analysis of variance (ANOVA) revealed highly significant genotypic effects for all the morphological characters *viz.*, days to 50% flowering, days to maturity, plant height, panicle length, total tillers plant^{-1}, effective tillers plant^{-1}, filled grain panicle^{-1}, unfilled grain panicle^{-1}, 1000-grain weight and grain yield plant^{-1} among the 39 rice genotypes (Table 2).

3.1. Phenotypic diversity

In case of mean performance of 39 rice genotypes, Marish Shail had the highest yield (86.66 g) while Karengal had the lowest yield plant^{-1} (17.20 g) potentiality. Mean performance of the genotypes was 41.15g for grain yield plant^{-1} (Table 3). After considering all the characters, varieties with lower days to 50% flowering and days to maturity, medium plant height, maximum effective tillers plant^{-1}, highest panicle length, maximum filled grain panicle^{-1} and highest grain yield performance would be selected for varietal biofortification for grain and nutritional quality improvement.

Table 1. List of experimental rice genotypes and their source of collection.

SL. No.	Genotypes	Source of collection	SL. No.	Genotypes	Source of collection
1	Sadagotal	BINA Gene Bank	21	Bajra Muri	BINA Gene Bank
2	Rupessor	BINA Gene Bank	22	Patnai Balam	BINA Gene Bank
3	Marish Shail	BINA Gene Bank	23	Rani Shalot	BINA Gene Bank
4	Malagoti	BINA Gene Bank	24	Khejur Chori	BINA Gene Bank
5	Kumra Ghor	BINA Gene Bank	25	Golapi	BINA Gene Bank
6	Hati Bajor	BINA Gene Bank	26	Kalmilata	BINA Gene Bank
7	Chap Shail	BINA Gene Bank	27	Tilek Kuchi	BINA Gene Bank
8	Ghocca	BINA Gene Bank	28	Raja Shail	BINA Gene Bank
9	Asam Binni	BINA Gene Bank	29	Kathi Goccha	BINA Gene Bank
10	Gengeng Binni	BINA Gene Bank	30	karengal	BINA Gene Bank
11	Jolkumri	BINA Gene Bank	31	Bashful Balam	BINA Gene Bank
12	Shaheb Kachi	BINA Gene Bank	32	Mowbinni	BINA Gene Bank
13	Chini Shail	BINA Gene Bank	33	Lalanamia	BINA Gene Bank
14	Bhute Shalot	BINA Gene Bank	34	Nunnia	BINA Gene Bank
15	Bogi	BINA Gene Bank	35	Khuchra	BINA Gene Bank
16	Volanath	BINA Gene Bank	36	Kalomota	BINA Gene Bank
17	Ghigoj	BINA Gene Bank	37	Mondessor	BINA Gene Bank
18	Ponkhiraj	BINA Gene Bank	38	Mohime	BINA Gene Bank
19	Hogla	BINA Gene Bank	39	Nona Kochi	BINA Gene Bank
20	Dhar Shail	BINA Gene Bank			

Table 2. Analysis of variance based on phenotypic diversity among 39 iron rich rice genotypes.

Characters	d.f	DF	DM	PHT(cm)	TTH^{-1}	ETH^{-1}	PL(cm)	FGP^{-1}	$UFGP^{-1}$	1000 SW(g)	GYP^{-1}(g)
Genotype	38	609.983	578.960	539.243	32.040	28.049	11.815	7355.72	544.288	104.543	714.887
Replication	2	6.163	4.777	31.75	30.576	17.444	3.180	10.534	116.312	0.860	189.442
Error	76	1.012	1.254	2.626	0.892	0.510	1.008	2.474	151.068	0.266	7.054
Level of Significance		**	**	**	**	**	**	**	**	**	**

** indicates significant at 0.01 probability level

(Here, d.f= Degree of freedom, DF= Days to 50% flowering, DM= Days to maturity, PHT= Plant height (cm), TTH^{-1}= Total tillers $hill^{-1}$, ETH^{-1}= Effective tillers $hill^{-1}$, PL= Panicle length (cm), FGP^{-1}= Filled grain $panicle^{-1}$, $UFGP^{-1}$= Unfilled grain $panicle^{-1}$, 1000 SW= Weight of 1000 seeds (gm) and GYP^{-1}= Grain yield $plant^{-1}$).

Table 3. Phenotypic diversity among 39 selected indigenous rice genotypes.

SL. No.	Genotypes	DF	DM	PHT (cm)	TTH^{-1}	ETH^{-1}	PL (cm)	FGP^{-1}	UFGP^{-1}	1000 SW (g)	GYP^{-1} (g)
1	Malagoti	86.33^{K}	126.60^{K}	137.33^{R}	12.67^{E-I}	8.33^{N-Q}	22.33^{Jk}	225.00^{C}	14.00^{CD}	22.82^{P-S}	42.79^{K-N}
2	Marish Shail	92.33^{IJ}	136.33^{J}	172.67^{B}	20.67^{A}	18.33^{A}	23.00^{I-K}	176.67^{E}	15.0^{BCD}	26.77^{H-J}	86.66^{A}
3	Sada Gotal	106.33^{EF}	143.33^{E-G}	159.33^{F-J}	09.33^{K-N}	7.33^{PQ}	26.33^{B-G}	109.0^{MN}	7.67^{D}	33.01^{D}	26.35^{R-V}
4	Kathi Goccha	91.67^{J}	138.67^{H-J}	159.67^{F-I}	12.33^{F-J}	9.33^{M-P}	23.33^{H-K}	140.67^{GH}	11.67^{D}	27.69^{GH}	36.33^{M-P}
5	Bashful Balam	94.00^{IJ}	140.33^{G-I}	151.33^{L-N}	20.67^{A}	18.00^{A}	22.33^{JK}	120.00^{J}	8.33^{D}	22.58^{Q-S}	48.78^{G-K}
6	Raja Shail	92.33^{IJ}	126.67^{K}	142.67^{PQ}	11.33^{G-L}	10.33^{J-N}	26.00^{C-H}	140.33^{GH}	46.67^{A-C}	24.65^{L-N}	35.69^{N-Q}
7	Volanath	98.33^{H}	137.00^{J}	168.67^{B-D}	08.33^{MN}	8.00^{O-Q}	23.67^{G-K}	110.67^{LM}	8.00^{D}	26.17^{I-K}	23.14^{T-W}
8	Chap Shail	94.33^{IJ}	141.67^{F-H}	156.33^{H-K}	13.33^{E-H}	11.67^{G-L}	25.33^{E-I}	102.33^{OP}	13.00^{CD}	32.44^{D}	32.30^{O-S}
9	Ghocca	101.67^{G}	138.67^{H-J}	148.67^{NO}	11.67^{F-K}	10.00^{K-O}	23.00^{I-K}	100.33^{PQ}	14.00^{CD}	25.66^{J-L}	25.77^{S-V}
10	Ghigoj	106.67^{EF}	143.00^{E-G}	157.33^{G-K}	14.33^{D-F}	13.67^{C-G}	21.67^{K}	116.67^{JK}	58.67^{A}	27.90^{GH}	44.49^{I-L}
11	Golapi	94.33^{IJ}	138.33^{IJ}	143.33^{PQ}	13.33^{E-H}	12.33^{E-J}	23.00^{I-K}	257.67^{B}	20.00^{B-D}	21.68^{RS}	68.93^{B}
12	GengengBinni	92.00^{IJ}	126.67^{K}	148.33^{NO}	11.33^{G-L}	10.67^{J-M}	28.33^{A-D}	178.33^{E}	10.00^{D}	22.54^{Q-S}	42.84^{K-N}
13	Hati Bajore	108.00^{DE}	143.67^{EF}	146.33^{OP}	10.00^{J-M}	9.33^{M-P}	27.00^{B-E}	119.67^{J}	10.33^{D}	36.96^{B}	41.41^{K-N}
14	Kuchra	105.00^{F}	143.00^{E-G}	153.33^{K-M}	20.33^{AB}	18.33^{A}	24.00^{F-K}	81.67^{UV}	7.67^{D}	34.71^{C}	52.00^{E-H}
15	Mohime	107.0^{D-F}	143.00^{E-G}	185.67^{A}	15.00^{DE}	14.00^{C-F}	25.67^{D-I}	128.67^{I}	23.67^{B-D}	32.91^{D}	59.24^{C-E}
16	Tilek Kuchi	107.0^{D-F}	142.67^{E-G}	154.33^{KL}	16.33^{CD}	14.00^{C-F}	24.00^{F-K}	137.67^{H}	9.00^{D}	33.60^{CD}	64.70^{BC}
17	Rani Shalot	108.00^{DE}	142.67^{E-G}	160.33^{F-H}	16.33^{CD}	15.33^{CD}	25.33^{E-I}	96.33^{QR}	14.00^{CD}	38.35^{B}	55.20^{D-G}
18	Kumra Ghor	106.67^{EF}	143.00^{E-G}	171.67^{BC}	18.67^{A-C}	17.67^{AB}	29.00^{AB}	115.00^{KL}	13.00^{CD}	30.84^{E}	60.26^{CD}
19	Dhar Shail	94.33^{IJ}	135.67^{J}	162.67^{EF}	11.67^{F-K}	10.33^{J-N}	24.00^{F-K}	303.00^{A}	30.33^{A-D}	14.15^{U}	42.89^{J-N}
20	Khejur Chori	107.6^{D-F}	142.67^{E-G}	161.33^{E-G}	11.33^{G-L}	9.33^{M-P}	26.67^{B-F}	126.00^{I}	25.00^{A-D}	32.93^{D}	37.33^{L-O}
21	Shaheb Kachi	107.3^{D-F}	142.33^{FG}	149.67^{M-O}	08.67^{L-N}	6.67^{Q}	31.00^{A}	119.67^{J}	7.33^{D}	40.00^{A}	33.47^{O-R}
22	Kalmilata	87.33^{K}	135.67^{J}	168.33^{CD}	17.67^{BC}	15.67^{BC}	24.33^{E-K}	126.67^{I}	14.67^{B-D}	25.07^{K-N}	47.64^{H-K}
23	Lalanamia	107.33^{D-F}	143.00^{E-G}	125.67^{T}	7.00^{N}	6.67^{Q}	25.00^{E-J}	159.67^{F}	35.00^{A-D}	25.65^{J-L}	28.71^{Q-T}
24	Rupessor	94.67^{I}	136.00^{J}	140.33^{QR}	14.33^{D-F}	13.33^{D-H}	24.33^{E-K}	157.67^{F}	59.00^{A}	27.32^{G-I}	57.26^{C-F}
25	Asam Binni	87.67^{K}	126.67^{K}	155.33^{J-L}	11.67^{F-K}	11.00^{I-M}	24.67^{E-J}	156.67^{F}	15.00^{B-D}	26.84^{H-J}	46.28^{H-K}
26	Nunnia	92.33^{IJ}	142.67^{E-G}	153.33^{K-M}	14.00^{D-F}	12.00^{F-K}	25.00^{E-J}	83.67^{UV}	49.00^{AB}	17.55^{T}	17.700^{W}
27	Ponkhiraj	86.67^{K}	135.67^{J}	132.33^{S}	17.67^{BC}	15.33^{CD}	25.33^{E-I}	92.00^{RS}	5.00^{D}	24.38^{L-O}	33.64^{O-R}
28	Mow Binni	92.33^{IJ}	126.67^{K}	156.00^{I-K}	12.33^{F-J}	12.33^{E-J}	24.00^{F-K}	174.33^{E}	23.67^{B-D}	23.79^{N-Q}	51.14^{F-I}
29	Bogi	91.67^{J}	127.00^{K}	155.67^{I-K}	11.00^{H-L}	10.33^{J-N}	25.00^{E-J}	198.00^{D}	22.67^{B-D}	25.54^{J-M}	52.35^{E-H}
30	Hogla	124.00^{B}	168.33^{C}	156.33^{H-K}	13.33^{E-H}	12.33^{E-J}	28.33^{A-D}	80.20^{V}	22.33^{B-D}	27.75^{GH}	27.44^{R-U}
31	Bhute Shalot	132.00^{A}	170.33^{A-C}	142.00^{Q}	15.00^{DE}	14.33^{C-E}	28.67^{A-C}	93.67^{R}	32.67^{A-D}	28.05^{GH}	37.64^{L-O}
32	BazraMuri	132.00^{AI}	168.67^{BC}	171.67^{BC}	12.67^{E-I}	11.67^{G-L}	25.67^{D-I}	105.0^{NO}	17.00^{B-D}	21.44^{S}	26.24^{R-V}
33	Karengal	129.67^{A}	170.33^{A-C}	132.47^{S}	13.67^{D-G}	11.93^{G-K}	24.00^{F-K}	59.67^{W}	22.00^{B-D}	24.17^{M-P}	17.20^{W}
34	Kalo Mota	130.33^{A}	170.33^{A-C}	142.47^{PQ}	10.33^{I-M}	9.67^{L-O}	24.67^{E-J}	84.67^{TU}	23.00^{B-D}	24.80^{K-N}	20.32^{U-W}
35	Mondeshor	132.00^{A}	172.33^{A}	139.13^{QR}	11.67^{F-K}	11.33^{H-M}	26.00^{C-H}	113.0^{K-M}	23.00^{B-D}	29.70^{EF}	38.05^{L-O}
36	Nona Kochi	130.67^{A}	171.67^{AB}	148.07^{NO}	12.00^{F-J}	11.67^{G-L}	25.67^{D-I}	88.33ST	14.33^{CD}	28.37^{FG}	29.21^{P-T}
37	Chinisail	109.67^{D}	145.67^{E}	125.40^{T}	13.67^{D-G}	13.33^{D-H}	25.00^{E-J}	124.67^{I}	25.67^{A-D}	11.86^{V}	19.74^{VW}
38	Jolkumri	101.00^{GH}	136.33^{J}	139.27^{QR}	12.33^{F-J}	12.00^{F-K}	26.33^{B-G}	156.67^{F}	13.00^{CD}	23.07^{O-R}	43.40^{J-M}
39	Patnai Balam	115.00^{C}	155.33^{D}	165.33^{DE}	13.33^{E-H}	12.73^{E-I}	26.33^{B-G}	143.33^{G}	19.00^{B-D}	27.57^{G-I}	50.34^{F-J}
	CV (%)	0.967	0.774	1.062	7.089	5.953	3.976	1.173	59.666	1.903	6.408
	Maximum	132.00	172.33	185.67	20.67	18.33	31.00	303.00	59.00	40.00	86.66
	Minimum	86.33	126.60	125.40	7.00	6.67	21.67	59.67	5.00	11.86	17.20
	Mean	104.56	144.07	152.31	13.37	12.07	25.21	133.42	20.60	27.02	41.15
	LSD $_{(0.05)}$	1.632	1.815	2.634	1.546	1.165	1.625	2.559	19.993	0.836	4.316
	Level of sig.	**	**	**	**	**	**	**	**	**	**

Here, Genotypes with the different letter(s) are significantly different.

Table 4. Genetic parameters of different yield and yield contributing characters of 39 rice genotypes.

SL. No.	Characters	σ^2p	σ^2g	PCV (%)	GCV (%)	h^2_b (%)	GA	GA (%)
1	DF	204.004	202.991	13.661	13.626	99.503	29.276	28.000
2	DM	193.823	192.572	9.663	99.632	99.354	28.494	19.778
3	PHT (cm)	181.501	178.873	8.845	8.780	98.552	27.350	17.957
4	TTH^{-1}	11.281	10.384	25.125	24.105	92.048	63.687	476.414
5	ETH^{-1}	9.693	9.176	25.798	25.101	94.666	60.714	503.099
6	PL (cm)	4.608	3.604	8.513	7.529	78.212	34.585	137.166
7	FGP^{-1}	2453.556	2451.085	37.127	37.108	99.899	101.935	76.404
8	$UFGP^{-1}$	282.136	131.074	81.545	55.582	46.459	16.075	78.042
9	1000 SW(g)	35.024	34.759	21.955	21.872	99.243	12.099	44.886
10	GYP^{-1}(g)	242.996	235.943	37.581	37.031	97.097	31.179	75.168

(Here, σ^2p= Phenotypic variance, σ^2g= Genotypic variance, PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, h^2_b= Heritability in broad sense, GA= Genetic advance, GA%= Genetic advance in percent of mean)

Table 5. Coefficients of phenotypic and genotypic correlation among different yieldcomponents.

Characters	Corr.	DM	PHT (cm)	TTH^{-1}	ETH^{-1}	PL (cm)	FGP^{-1}	$UFGP^{-1}$	1000 SW (g)	GYP^{-1} (g)
DF	r_p	0.944**	-0.101	-0.149	-0.047	0.327*	-0.514**	0.027	0.184	-0.371*
	r_g	0.947**	-0.102	-0.157	-0.054	0.364*	-0.516**	0.050	0.184	-0.381*
DM	r_p		-0.100	-0.031	0.037	0.238*	-0.552**	0.022	0.096	-0.395*
	r_g		-0.099	-0.033	0.038	0.272*	-0.554**	0.039	0.095	-0.402*
PHT (cm)	r_p			0.243*	0.244*	0.028	0.030	-0.137	0.278*	0.404**
	r_g			0.252*	0.249*	0.018	0.030	-0.203	0.280*	0.409**
TTH^{-1}	r_p				0.937**	-0.231*	-0.142	-0.101	0.015	0.554**
	r_g				0.973**	-0.261*	-0.149	-0.127	0.018	0.568**
ETH^{-1}	r_p					-0.137	-0.169	-0.040	-0.008	0.576**
	r_g					-0.192	-0.175	-0.039	-0.005	0.565**
PL (cm)	r_p						-0.229*	-0.120	0.343*	-0.138
	r_g						-0.272*	-0.179	0.387*	-0.192
FGP^{-1}	r_p							0.072	-0.381*	0.465**
	r_g							0.104	-0.383*	0.471**
$UFGP^{-1}$	r_p								-0.239*	-0.073
	r_g								-0.347*	-0.090
1000 SW(g)	r_p									0.242*
	r_g									0.245*

(Here, * and ** indicate significant at 0.05 & 0.01 level of probability, respectively. $r_{p=}$ Phenotypic correlation and r_g= Genotypic correlation)

Table 6. Partitioning of phenotypic correlations into direct and indirect effects of morphological characters of 39 rice genotypes by path coefficient analysis.

Characters	DE	DF	DM	PHT (cm)	TTH^{-1}	ETH^{-1}	PL (cm)	FGP^{-1}	$UFGP^{-1}$	1000 SW (g)	Corr. with Yield $plant^{-1}$	RE
DF	0.387	------	-0.359	-4.859	-5.510	1.640	-3.237	0.064	-1.926	4.649	-0.371*	
DM	-0.382	0.364	------	-0.180	-0.037	9.841	-3.923	-3.006	0.353	5.165	-0.395*	
PHT	0.486	-3.874	0.141	------	-0.147	-7.872	-2.354	-3.757	-1.926	-3.616	0.404*	
TTH^{-1}	0.367	-5.811	3.818	-0.194	------	-0.131	-9.220	2.630	8.987	-2.583	0.554**	
ETH^{-1}	-0.328	-1.937	1.145	0.116	0.147	------	-5.395	1.753	0.109	-1.033	0.576**	0.461
PL	-9.809	0.128	-1.527	0.117	0.345	-0.180	------	-7.264	0.148	-3.099	-0.138	
FGP^{-1}	-0.125	-0.198	-0.092	1.458	-7.714	4.592	-5.689	------	8.987	1.808	0.465**	
$UFGP^{-1}$	-0.642	1.162	0.210	1.458	-5.143	5.576	2.256	1.753	------	0.121	-0.073	
1000 SW(g)	0.258	6.973	-7.635	-6.802	-0.037	1.312	1.177	-8.766	-0.302	------	0.242*	

Here, DE=Direct effects, RE=Residual effect

Table 7. Partitioning of genotypic correlations into direct and indirect effects of morphological characters of 39 rice genotypes by path coefficient analysis.

Characters	DE	DF	DM	PHT (cm)	TTH^{-1}	ETH^{-1}	PL (cm)	FGP^{-1}	$UFGP^{-1}$	1000 SW (g)	Corr. with Yield $plant^{-1}$	RE
DF	-0.179	------	9.263	-1.492	7.557	-5.463	1.448	-0.334	-4.910	3.765	-0.381*	
DM	9.751	0.170	------	-1.492	1.417	4.370	1.086	-0.353	-3.929	2.092	-0.402*	
PHT	0.149	1.788	-9.751	------	-0.118	0.273	8.046	1.927	1.964	5.857	0.409**	
TTH^{-1}	-0.472	2.861	-2.925	3.731	------	1.060	-1.046	-9.635	1.277	4.183	0.568**	
ETH^{-1}	1.092	8.940	3.900	3.731	-0.458	------	-7.644	-0.115	3.929	-2.092	0.565**	0.496
PL	4.023	-6.437	2.632	2.985	0.123	-0.208	------	-0.173	1.768	8.157	-0.192	
FGP^{-1}	0.642	9.297	-5.363	4.477	7.085	-0.197	-1.086	------	-9.821	-0.079	0.471**	
$UFGP^{-1}$	-9.822	-8.940	3.900	-2.984	6.140	-4.370	-7.241	6.424	------	-7.321	-0.090	
1000 SW(g)	0.209	-0.032	9.751	4.178	-9.447	-1.093	1.569	-0.244	3.437	------	0.245*	

Here, DE=Direct effects, RE=Residual effect

Table 8. Number, percent and name of genotypes in different clusters.

Cluster No.	Genotypes	Percent (%)	Name of the rice genotypes
I	14	35.90	Malagoti, Golapi, Dhar Shail, Gengeng Binni, Jolkumri, Asam Binni, Mow Binni, Bogi, Raja Shail, Nunnia, Chinisail, Lalanamia, Ghigoj, Rupessor.
II	10	25.64	Marish Shail, Bashful Balam, Kalmilata, Ponkhiraj, Kuchra, Tilek Kuchi, Rani Shalot, Mohime, Patnai Balam, Kumra Ghor.
III	8	20.51	Sada Gotal, Hati Bajore, Khejur Chori, Shaheb Kachi, Kathi Goccha, Ghocca, Chap Shail, Volanath.
IV	7	17.95	Hogla, Bhute Shalot, Bazra Muri, Karengal, Kalo Mota, Mondeshor, Nona Kochi.

Table 9. Cluster mean for ten yield and yield contributing characters of 39 rice genotypes.

Characters	Cluster I	Cluster II	Cluster III	Cluster IV
Days to 50% flowering	95.90 (L)	100.90 (L)	101.92 (L)	130.10 (H)
Days to maturity	134.35 (L)	141.77 (L)	141.00 (L)	170.28 (H)
Plant height (cm)	145.90 (L)	161.53 (H)	156.25 (I)	147.45 (L)
Number of tillers $hill^{-1}$	12.21 (L)	17.67 (H)	10.62 (L)	12.67 (I)
No. of Effective tillers $hill^{-1}$	11.19 (L)	15.94 (H)	8.96 (L)	11.85 (I)
Panicle length (cm)	24.62 (L)	24.93 (L)	25.79 (H)	26.14 (H)
No. of Filled grains $panicle^{-1}$	173.74 (H)	121.80 (I)	116.04 (L)	89.22 (L)
Unfilled grains $panicle^{-1}$	30.19 (H)	12.93 (L)	12.13 (L)	22.05 (I)
1000 Seed weight (g)	22.53 (L)	29.68 (H)	31.86 (H)	26.33 (I)
Grain yield $plant^{-1}$ (g)	42.44 (I)	55.85 (H)	32.01 (L)	28.01 (L)

H= High value, I= Intermediate value, L= Low value

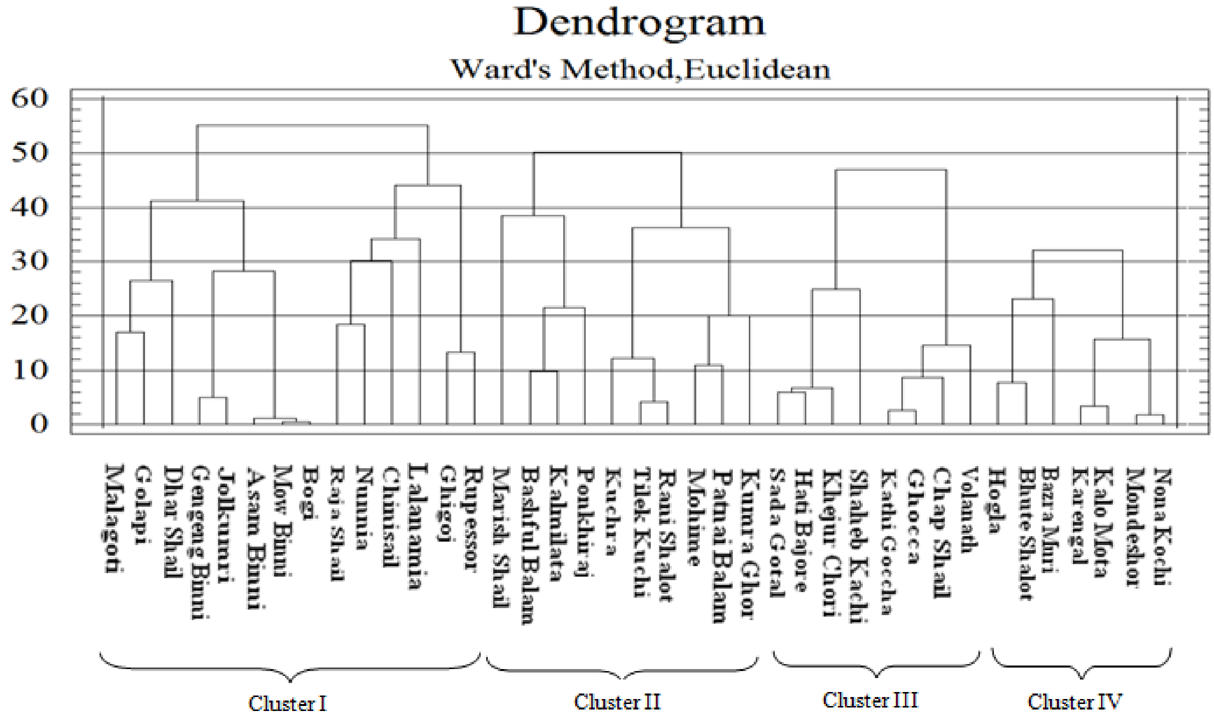

Figure 1. Dendrogram based on summarized data on differentiation among 39 rice landraces according to Ward's method.

3.2. Genetic parameters different yield and yield contributing characters

Genotypic variances, phenotypic variances, PCV, GCV, heritability, genetic advance and genetic advance in percentage for all the quantitative characters are presented in Table 4. High heritability was found for total tillers hill^{-1}.

3.3. Correlation coefficient among yield and yield contributing characters in rice genotypes

Among the 21 significant associations, 13 associations were positively and 8 associations were negatively significant. All characters except panicle length (cm) and 1000 grain weight (g) showed significant positive correlation with grain yield plant^{-1} (Table 5).

3.4. Path co-efficient analysis

The characters having direct positive effect on yield plant $^{-1}$ indicating that these are the main contributors to yield of the plant. Path analysis results among all the characters at phenotypic and genotypic level are presented in Table 6 and Table 7. In path analysis, the residual effects at phenotypic and genotypic level were 0.461 and 0.496 respectively indicating that, the ten characters contributed 53.9% and 50.45% of variability in yield plant^{-1} at phenotypic and genotypic level respectively.

3.5. Clustering of the selected 39 rice genotypes based on their phenotypic performances

Using Euclidean distance following Ward's method, the 39 rice genotypes were grouped into four distinct clusters (Table 8). Cluster I, II, III, and IV consist of 14, 10, 8 and 7 genotypes respectively. In case of days to maturity, genotypes in cluster I, II, III showed low values and cluster IV showed high value. Genotypes in cluster I and III showed lower number of effective tillers hill^{-1}, cluster IV showed intermediate value and cluster II showed high value. For panicle length (cm), genotypes in cluster I and II showed low values, cluster III and IV showed high values. In terms of yield plant^{-1} (g), genotypes in cluster I showed intermediate value; cluster II showed high values; and cluster III and IV showed low values. Cluster mean for ten yield and yield contributing characters of 39 rice genotypes were mentioned in Table 9.

3.6. Dendrogram and clustering of 39 genotypes

Dendrogram (Figure 1) was prepared based on Ward's method consisting of grouping of 39 rice genotypes into four distinct clusters *viz.* Cluster I, II, III and IV (Table 8).

4. Conclusions

For the biofortification purpose, screening of obsolete rice germplasms containing high iron content is essential. In this study 39 rice genotypes were analyzed for yield contributing phenotypic characters. From this research, the local landrace Malagoti (early flowering & maturity), Chini Shail (low height), Marish Shail (maximum tiller, effective tiller & grain yield), Shaheb Kachi (highest panicle length & 1000 seed weight) and Dhar Shail (maximum filled grain panicle^{-1}) can be used as breeding materials for varietal development with good phenotypic and genotypic performance.

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Conflict of interest

None to declare.

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