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Evaluation of Newly Bred Zinc and Iron Enriched Rice Genotypes for Cultivation under Aerobic Condition using Genetic Parameters: Implication on Drought Management

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Abstract

This research focused on the evaluation of twelve newly bred rice genotypes with diverse morphological traits under aerobic cultivation to develop strategies for water conservation while maintaining grain productivity and quality. The experiment was conducted during the summer season of 2016, employing a Randomized Complete Block Design (RCBD) with wetland cultivation as a control. For analysis, various vegetative and reproductive traits namely, Plant height, Number of Tillers, Shoot Weight, Days to 50% flowering, Days to Maturity, Number of Productive Tillers, Panicle Length, Grain Weight, Length of the seed, Breadth of the seed, Ratio of Length and Breadth of the Seed, and Test weight of 100 seeds were recorded. Data on analysis of variance revealed the significant difference for days to flowering, maturity, plant height, panicle length, test weight, and grain yield under aerobic and wetland cultivation methods during the summer season, 2016, suggesting these traits are under high genetic control. Genetic parameters such as percentage of GCV, PCV, Heritability, and GAM were estimated across 13 parameters comprising vegetative and reproductive characters. The findings suggest a considerable amount of genetic variability for most traits, providing a foundation for the potential implementation of an effective selection procedure in breeding new rice varieties within the selected genotypes.

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Introduction

Rice (*Oryza sativa* L.), is a crop for assuring nutrition and food security as a chief source of energy and stable food for half of the global population, majorly for Asian countries.[1] Asia is the most significant contributor to global rice production, accounting for around 90% of the total output. Rice is indeed a versatile crop with a high degree of adaptability to cultivate in dry and wetland conditions in a wide range of latitudes and under various soil, climatic, and hydrological conditions.[2] The global average yield of irrigated rice is 5 t ha−1 and the variations in yield averages are based on factors like location and season in addition to the genetic contribution of various genotypes3. The yield of rice grain varies from 7–8 t ha−1 and 5 -6 t ha-1 and during dry and respectively.[4] As the population continues to grow, there is an increase in the demand for rice, particularly in Asia and Africa.[5] As the global population continues to grow in Asia, the need for increased rice production becomes crucial to ensure food security in addition to meeting the dietary needs of billions of people.[6]

To meet ever-increasing demand, it is important to scale up rice production either by increasing yield per unit area or expanding areas under cultivation.[7] The intensive requirement of water for the cultivation of rice is a growing concern for many rice-growing countries. Although a number of Agro-practices are suggested to minimize the water requirement for cultivation, the development of newer and drought-hardy genotypes coupled with an evaluation under minimal water is one of the viable strategies proposed. More recently, the concept of cultivating rice under aerobic conditions is gaining larger attention as this method requires minimal water similar to that of other dryland crops. The aerobic method involves planting or seeding directly on the soil without prior establishment of a nursery.[8] The development of rice varieties with superior grain yield under low input including limited water usage is of paramount importance in the current scenario of agriculture.[9] In addition, productivity is one of the major objectives of rice breeding programs.[10]

Identification of rice cultivars with improved agronomic traits is essential in rice breeding.[11] Genetic variation is the basis of plant breeding and provides a great array of genotypes as a source of genetic stock.[12] To assess the performance of a genotype, reliable estimates for heritability are essentially required and this would provide the knowledge to predict the nature of the succeeding generation, to make an appropriate selection, and to assess the magnitude of genetic improvement through selection.[13,14] This study was conducted to evaluate the performance of 12 genotypes of rice cultivars under two extreme cultivation methods (wetland and dry land) in the summer season of India. Analysis of variations followed by estimation of genetic variability using genetic parameters such as genetic coefficient variation (GCV), phenotypic coefficient variation (PCV), heritability at broad sense (h^2), mean percent of genetic advance (GAM) with respect to yield and its attributing traits were analyzed. The implication of the present study to develop breeding strategies for generating new hybrids for an aerobic method of cultivation as one of the strategies to minimize the water requirement for the cultivation of rice is discussed.

Materials and Methods

Selection of Genotypes

Seven elite rice lines, characterized with high iron and zinc along with the two checks and three parents were selected.[15,16] The selected genotypes were generated by advancing the F2 generation through F8 by following the principles of single-seed descent followed by rapid generation from parents of Azucena and Moromutant (AM 1, AM 27, AM 65, AM 72, AM 94B, AM 143 B), Buddha X IR 64 (ARB 6) locally named as Anagha or ARB – 6. The national yield check IR 64 and micronutrient check Chittimuthyalu was also included in the experiment (Table 1)

Experimental Area and Design

This study was carried out in the experimental field of Aerobic Rice Research Laboratory, Department of Plant Biotechnology, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra. Bangalore. The experimental plot is located at the latitude of 12^{o} 58’ North longitude, 77^{o} 35’ East and altitude of 930 meters above mean sea level (MSL). Randomized Complete Block Design (RCBD) was laid-out with three replications in aerobic water regimes with a similar set of replications for wetland cultivation (a control) during summer season (Figure 1).

Table 1: List of selected genotypes of rice used in this study.

Sl. No.	Variety Name	Pedigree
1.	AM 1	Azucena X Moromutant
2.	AM 27	Azucena X Moromutant
3.	AM 65	Azucena X Moromutant
4.	AM 72	Azucena X Moromutant
5.	AM 94B	Azucena X Moromutant
6.	AM 143B	Azucena X Moromutant
7.	ARB 6	Budda X IR 64
8.	IR 64	Parent (IRRI developed *indica* variety)
9.	Chittimuthyalu	Check (Rice variety from Andra Pradesh)
10.	Azucena	Parent (Japonica variety)
11.	Moroberekan	Parent (Japonica variety)
12.	Budda	Parent (Local Germ Plasm from Karnataka)

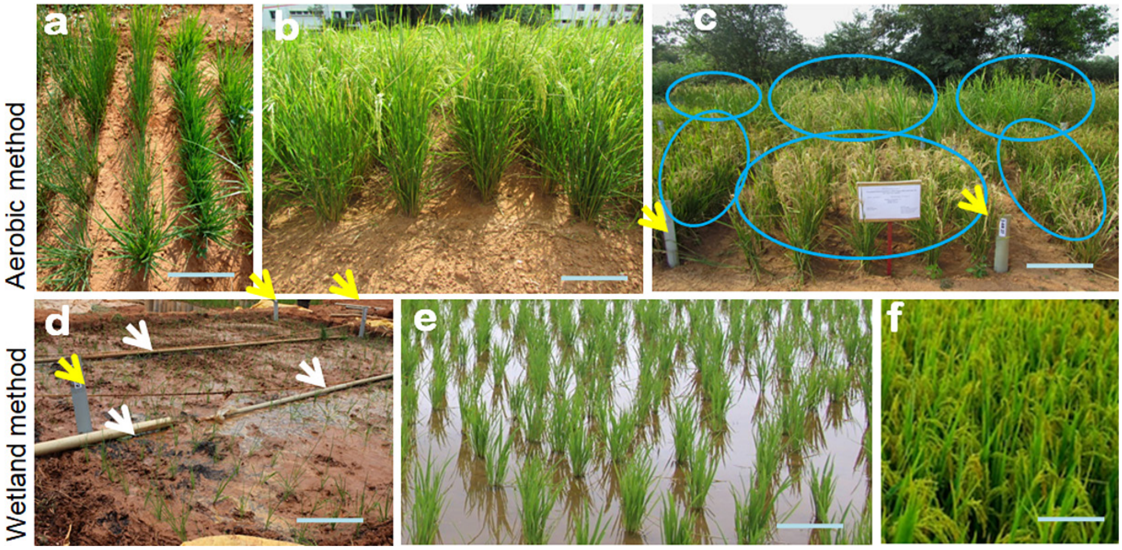

Fig. 1: Experimental genotype of rice in the field; a. Plants in the vegetative stage; b. Genotypes under aerobic cultivation method during 50% flowering stage; c. Replicated blocks showing grain maturity; d. Field preparation of wetland; e. Plants at the vegetative stage in the wetland; f. Plants at wetland at grain maturity stage

Preparation of Aerobic Condition

Aerobic rice cultivation involves growing rice in non-flooded or well-drained conditions with minimal water usage for irrigation. This method is contrasting with the traditional method, where the rice plant is submerged for three fourth of the period under cultivation, needing a huge quantum of water. In the aerobic method of rice cultivation, fields are not flooded throughout the cropping season and water is applied over the soil surface at regular intervals, similar to that of other dryland field crops.[8] To construct a temporary structure to stimulate wetland or water-puddled conditions, a tank measuring 11m x 9m x 1m (length x width x height) was covered with waterproof tarpaulin and filled with soil the same of the aerobic plot. The tank was lined with PVC pipes to avoid the escape of water from the experimental tank.

Nutrition and Plant Protection Measures

The experimental plot was maintained based on the recommended package.[17] Nitrogen was supplemented in the form of Urea at the basal dosage of 50% during sowing, 25% after 30 days after sowing (DAS) and 25% after 60 DAS for High Nitrogen Condition. Phosphorous (P) as single super phosphate (16% P2O5) was applied during basal dosage for High Phosphorous conditions. Potassium (K) was applied in the form of a Murate of Potash (60% K2O) in a Split of 50% during sowing and the rest 50% at 30 DAS. Measures were taken to control pest and disease by drenching soil with Chlorpyrifos (0.3 milliliters per liter of water) to control root grub. A spray of Tricyclazole (0.6 grams per liter of water) was applied to avoid the emergence of blast disease.

Data Collection

Five plants were randomly selected from the center of replicated plots of each genotype. Observations on vegetative (plant height, number of tillers, shoot weight) and reproductive (days to 50% flowering, number of productive tillers, panicle length, grain weight, length of the seed, breadth of the seed, weight of the 100 seeds) parameters was carried out for statistical analysis for the proposed genetic parameters. The data was compiled using the mean value of the three replicates of phenotypic observation of each genotype. The data was subjected to Statistical Package for Agricultural Research (SPAR2.0).[18]

Analysis of Variance

Analysis of variance for various traits recorded in aerobic and wetland conditions during the summer season was performed based on the standard methods.[19,20] The significance of the experiment was arrived at by comparing the data with the standard values.[21] The Standard Error of the Mean (SEM)[22] and the Critical Difference (CD)[23] were used to compare the mean of individual data.

Genetic Variance and Correlation Analysis

Genetic Variance (GV) and Phenotypic Variance (PV) were calculated based on the established method.[24,25] The genetic parameters for yield and its attributing traits were determined and genotypic and phenotypic coefficient variation was computed for analysis.[26] The percent of phenotypic coefficient variance (PCV) and genotypic coefficient variance (GCV) was calculated.[27] The genetic advance was determined and the percent of mean of genetic advances was calculated.[28] The Heritability (broad sense) was estimated for all the traits using the ratio of genotypic variance and phenotypic variance. The heritability percent was determined.[29] The correlation analysis which shows the degree of association between the traits was determined by computing the phenotypic data set.[30]

Results

Analysis of Variance (ANOVA)

The analysis of variance for 13 quantitative characters under the aerobic cultivation method during summer showed a high degree of significance among the evaluated genotypes of rice for days to flowering (265.78), days to maturity (195.27), plant height (1338.94), grain weight (57.03) and panicle length (29.93). All 13 characters are highly significant among all the 12 genotypes. A similar observation was made with respect to the wetland method of cultivation, indicating that genotypic influences are dominating over the agronomic characters rather than the influences of the two methods of cultivation employed in this study. Therefore, the above quantitative characters are applicable for the selection and hybridization of significant traits on tested genotypes. Details of the results are presented in Table 2. a and 2. b.

Variability, Genetic Advance, and Heritability

Reproductive traits such as days to fifty percent flowering (DFF) and days to maturity (DM) were found to have low GCV and PCV values (> 10 %). Most of the parameters associated with quantitative traits of rice grain such as panicle length (PL), Length of the seed (SL), breadth of the seed (SB), length/breadth ratio of the seed (LB ratio), test weight (TW) was found to have moderate GCV and PCV (10-20%). High GCV and PCV (<20 %) were recorded for traits namely, plant height (PH), number of tillers (NT), number of productive tillers (NPT), shoot weight (SW), grain weight (GW) and biomass (BM). High heritability at broad sense (<60%) is observed in the traits such as days to 50% flowering (DFF), days to Maturity (DM), plant height (PH), number of tillers (NT), number of productive tillers (NPT), panicle length (PL), shoot weight (SW), grain weight (GW), biomass (BM), length of the seed (SL), breadth of the seed (SB), Ratio of Length and

Breadth of the Seed (LB ratio), test weight of 100 seeds (TW) Low Genetic percent cent mean (10-20%) in days to maturity under aerobic condition during summer. advances as percent mean (>10%) were observed in traits namely, days to maturity (DFF) in wetland conditions during summer, and moderate Genetic advance as.

Table 2. a. Analysis of variance (mean sum of squares) for yield and its attributing traits under aerobic conditions during summer

Source of variation	d.f	DFF	DM	PH	NT	NPT	PL	SW	GW	BM	SL	SB	LB Ratio	TW
Genotype	11	265.78**	195.17**	1338.94**	78.68**	79.98**	29.93**	163.66**	57.03**	278.14**	3.09**	0.26**	0.70**	0.54**
Error	22	5.95	14.53	22.17	4.98	4.89	4.90	20.36	5.29	29.79	0.10	0.02	0.04	0.01
CD @ 5%	4.13	6.45	7.97	3.78	3.74	3.75	7.64	3.90	9.24	0.55	0.24	0.34	0.20	
CD @ 1%	5.61	8.77	10.84	5.13	5.09	5.09	10.38	5.29	12.56	0.74	0.33	0.47	0.27	
CV	2.39	2.77	5.30	14.14	14.27	11.22	17.30	14.65	13.07	3.62	5.24	6.16	4.53	

Table 2. b. Analysis of variance (mean sum of squares) for yield and its attributing traits under wetland conditions during summer

Source of variation	d.f	DFF	DM	PH	NT	NPT	PL	SW	GW	BM	SL	SB	LB Ratio	TW
Genotype	11	209.79**	86.80**	1199.10**	15.38**	16.04**	26.84**	69.54**	33.32**	182.73**	2.97**	0.25**	0.58**	0.54**
Error	22	6.28	0.86	73.57	0.81	0.90	1.51	4.32	2.72	8.38	0.04	0.01	0.01	0.01
CD @ 5%	4.24	1.57	14.52	1.52	1.61	2.08	3.52	2.79	4.90	0.34	0.13	0.19	0.20	
CD @ 1%	5.77	2.13	19.74	2.07	2.18	2.83	4.78	3.80	6.66	0.46	0.17	0.26	0.27	
CV	2.44	0.67	9.52	10.02	11.62	7.24	14.92	21.87	13.48	2.28	2.75	3.54	4.65	

** Significant at 1%, DFF: Days to 50% flowering; DM: Days to Maturity; PH: Plant height; NT: Number of Tillers; NPT: Number of Productive Tillers, PL: Panicle Length, SW: Shoot Weight, GW: Grain Weight, BM: Bio Mass, SL: Length of the seed, SB: Breadth of the seed, LB Ratio: Ratio of Length and Breadth of the Seed, TW: Test weight of 100 seeds

Correlation Studies

Correlation analysis describes the association and nature of the relationship between the two variable traits. This assists in evaluating the likelihood of increasing the yield through indirect selection of its highly connected attributing attributes. As a tool for indirect selection, it is crucial in plant breeding. The plant breeder may benefit from knowing how the development of one character can cause parallel changes in other characters through the study of the correlation between various characters. The study of the correlation between different characters may help the plant breeder to know how the improvement of one character will bring simultaneous changes in other characters.[31]

Table 3. (a): Estimation of genetic parameters for yield and its attributing traits in different genotypes under aerobic & wetland conditions during summer

Traits in varied water regimes	DFF		DM		PH		NT		NPT		PL		SW	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Mean±SE	102.23 ±1.41	102.5 ±1.45	137.5 6±2.21	137.59 ±0.54	88.89 ±2.72	90.08 ±4.96	15.79 ±1.29	8.97± 0.52	15.5± 1.28	8.17± 0.55	19.72 ±1.28	17±0 .72	26.08 ±2.61	13.94 ±1.2
Min. Range	91.00	91.33	126.00	129.67	53.67	49.83	5.60	5.73	5.27	5.27	14.21	11.50	15.29	5.31
Max. Range	117.00	114.67	150.33	148.33	119.13	121.33	21.28	12.83	21.61	12.83	24.56	21.89	41.60	22.30
GCV %	9.10	8.04	5.64	3.89	23.57	21.50	31.39	24.57	32.28	27.50	14.65	17.09	26.50	33.45
PCV %	9.41	8.40	6.28	3.95	24.16	23.52	34.42	26.54	35.29	29.85	18.45	18.56	31.65	36.62
h2 Broadsense	93.57	91.53	80.56	97.10	95.19	83.60	83.15	85.76	83.67	84.87	63.03	84.80	70.12	83.43
GAM (%)	18.14	15.84	10.43	7.90	47.37	40.50	58.97	46.88	60.82	52.19	23.96	32.42	45.71	62.94

Table 3. (b)

Traits in varied water regimes	GW		BM		SL		SB		LB Ratio		TW	
	1	2	1	2	1	2	1	2	1	2	1	2
Mean±SE	15.7 ±1.33	7.55 ±0.96	41.78 ±3.16	21.48 ±1.68	8.95 ±0.19	8.69 ±0.12	2.74± 0.09	2.72± 0.05	3.31± 0.12	3.23± 0.07	2.61± 0.07	2.56± 0.07
Min. Range	7.68	2.05	24.73	7.35	6.98	6.21	2.38	2.29	2.38	2.38	1.47	1.48
Max. Range	23.67	12.87	54.97	33.97	11.05	9.93	3.28	3.24	4.08	3.71	3.04	3.16
GCV %	26.45	42.30	21.78	35.49	11.15	11.38	10.21	10.59	14.12	13.46	15.98	16.35
PCV %	30.24	47.61	25.40	37.96	11.72	11.60	11.47	10.94	15.40	13.92	16.60	17.00
H2 Broadsense	76.52	78.94	73.54	87.40	90.49	96.13	79.18	93.70	84.05	93.53	92.59	92.53
GAM (%)	47.67	77.42	38.47	68.35	21.84	22.98	18.71	21.11	26.66	26.81	31.67	32.39

SE: Standard Error; Min. Range: Minimum Range; Max Range: Maximum Range; GCV %: Genetic Coefficient Variation percent; PCV %: Phenotypic Coefficient Variation percent; h2 Broad sense: Heritability at Broad sense; GAM %: Genetic advance mean percent 1: Aerobic condition; 2: Wetland condition; DFF: Days to 50% flowering; DM: Days to Maturity; PH: Plant height; NT: Number of Tillers; NPT: Number of Productive Tillers, PL: Panicle Length, SW: Shoot Weight, GW: Grain Weight, BM: Bio Mass, SL: Length of the seed, SB: Breadth of the seed, LB Ratio: Ratio of Length and Breadth of the Seed, TW: Test weight of 100 seeds

The highest positive correlation was observed for the number of tillers with the number of productive tillers (1.00), Days to 50% flowering with Days to Maturity (0.92), Biomass with shoot weight (0.90), and Plant height with panicle length (0.90) under aerobic condition and Biomass with shoot weight (0.97) and with grain weight (0.94), number of tillers with the number of productive tillers (0.97), Days to 50% flowering with Days to Maturity (0.75) under wetland land condition. Detailed data on aerobic and wetland conditions for the summer season is presented in Table 4. a. and 4. b. respectively.

Table 4. a. Estimation of Phenotypic correlation for yield and its attributing traits under aerobic conditions during the Summer

	DFF	DM	PH	NT	NPT	PL	SW	GW	BM	SL	SB	LB Ratio	TW
DFF	1												
DM	0.92*	1											
PH	0.02	0.12	1										
NT	-0.10	-0.13	-0.63*	1									
NPT	-0.07	-0.11	-0.62*	1.00**	1								
PL	0.03	0.04	0.90**	-0.75**	-0.75**	1							
SW	-0.17	-0.04	0.83**	-0.59*	-0.60*	0.76*	1						
GW	-0.73**	-0.62*	0.10	-0.20	-0.23	0.29	0.30	1					
BM	-0.46	-0.31	0.68*	-0.54*	-0.57*	0.71*	0.90**	0.68	1				
SL	-0.38	-0.34	0.46	-0.35	-0.36	0.56	0.64*	0.72	0.82	1			
SB	0.35	0.44	0.23	-0.19	-0.16	0.23	0.12	-0.17	0.02	-0.01	1		
LB Ratio	-0.51	-0.55*	0.22	-0.12	-0.15	0.29	0.41	0.64*	0.60	0.77*	-0.64*	1	
TW	-0.19	-0.16	0.47	-0.41	-0.40	0.61*	0.52	0.44	0.60	0.65	0.65	0.09	1

Table 4. b. Estimation of Phenotypic correlation for yield and its attributing traits under wetland conditions during the Summer

	DFF	DM	PH	NT	NPT	PL	SW	GW	BM	SL	SB	LB Ratio	TW
DFF	1												
DM	0.75*	1											
PH	-0.04	-0.21	1										
NT	0.09	0.54	-0.44	1									
NPT	0.21	0.67*	-0.35	0.97**	1								
PL	-0.45	-0.57	0.75**	-0.65*	-0.64*	1							
SW	-0.25	-0.53	0.74**	-0.63*	-0.65*	0.85**	1						
GW	-0.35	-0.42	0.57	-0.42	-0.47	0.82**	0.83**	1					
BM	-0.30	-0.51	0.70*	-0.57*	-0.60	0.87**	0.97**	0.94**	1				
SL	-0.59	-0.75**	0.60	-0.62*	-0.68*	0.82**	0.83*	0.80*	0.85*	1			
SB	0.31	0.13	0.31	-0.06	-0.05	0.09	0.27	0.36	0.32	0.17	1		
LB Ratio	-0.73**	-0.73**	0.31	-0.48	-0.53	0.62*	0.50	0.40	0.48	0.72*	-0.55	1	
TW	-0.24	-0.46	0.45	-0.43	-0.49	0.52	0.61	0.69	0.67	0.76*	0.72*	0.13	1

It showed a significant negative correlation with Grain weight and Days to 50% flowering (-0.73); Grain weight and Days to Maturity (-0.62) and Panicle length with both the number of tillers and number of productive tillers (- 0.75) under aerobic condition and Panicle length with both Number of tillers (-0.64) and number of productive tillers (- 0.64). Similar results were reported in previous studies.[32,33,34]

Discussion

Genetic improvement of rice is a continual process across the world due to the increase in demand for rice grain to meet the ever-increasing population. Although molecular breeding become a viable tool for genetic improvement, conventional breeding combined with trait-associated selection with various genetic parameters is very fundamental in the rice breeding program. India is one of the major rice producers and the considerable number of rice varieties were exploited for commercial cultivation. In this study, seven of the genotypes are known to have high amount of Zinc and Iron.[31] Therefore, evaluation of these genotypes for their performance with respect to several agronomic traits are important. In this study, the analysis of variance showed a very high significant difference among the genotypes evaluated across most of the traits as reported by a number of researchers.[11,35,36,37] This indicates that rice genotypes are highly variable for several agronomic traits, facilitating scope for genetic improvement through various breeding strategies. The detailed results on genetic parameters are presented (Table 3)

High degree of genetic variability (genotypic and phenotypic) was found with most of the traits from low to high. Higher genotypic variability (GCV) and phenotypic variability (PCV) were recorded for most important agronomic traits namely, plant height (PH), number of tillers (NT), number of productive tillers (NPT), shoot weight (SW), grain weight (GW) and biomass (BM). GCV and PCV at more than 20% is considered as high, whereas values less than 10% are considered to be low and values between 10% and 20% being considered to be moderate38. According to this, most the traits have high to intermediate GCV and PCV for all the genotypes of rice evaluated in this study. Therefore, these traits could be used as the most probable genetic indicators during the process of selection and hybridization of elite genotypes in genetic improvement of rice varieties as suggested.[39]

The observed results on genetic variation clearly show that the PCV values are slightly higher than GCV values but the difference was not larger. For example, PCV & GCV values for DFF, DM, PH and NT, and NPT were respectively low under the wetland method of cultivation during summer. However, for certain of the traits such as GW and NT, the difference between PCV and GCV values is slightly higher with the dominance of PCV over GCV. Therefore, a higher difference between PVC and GVC could be an indication of environmental influence on phenotypic expression as previously reported in rice.[40] However, the difference between genotypic and phenotypic coefficient of variation is very little for all studied traits. This result indicated that the influence of environment on the expression of most of the traits is very small and the present findings are supported by a number of previous works.[41,11,35,42]

Broad sense heritability is classified as low (>60%), medium (30% to 60%) and high (>60%) based on the published report.[28] All the traits included in the present study were found to have higher heritability among the selected genotypes of rice. It was reported that direct selection cannot be followed if the broad sense heritability is either lower or medium. However, a combination of broad sense heritability with other strongly inheritable genetic parameters can be taken during genetic evaluation.[28]

Genetic advance as percent of mean (GAM) is classified as low (10%) moderate (10%-20%) and high (>20%) [18]. In this study, GAM is ranging from low (18.14 for DFF under wetland condition) to high (77.42 for GW under Aerobic condition) across the various traits. However, only a few traits are found to have higher GAM. For example, 60.82 for NPT under wetland condition, 62.94 for SW under aerobic condition, 68.35 for BM for aerobic condition and 77.42 for GW in aerobic condition. These traits are found to have GAM% more than 60% and can be used as genetically useful marker for utilization in rice breeding program of selected rice genotypes. Higher values of GAM for the above traits are appears to be governed by non-additive gene action. Therefore, these traits are highly useful selection procedure for breeding newer varieties of rice[42,43,44]

In this study, we have demonstrated the successful cultivation of different genotypes of rice under minimal water usage in aerobic cultivation method and the amount of genetic variability among the selected genotypes of rice were determined. This study also opens up a new dimension of research on water use efficiency under drought prone areas for cultivation rice. As the selected genotypes are enriched with Zinc and Iron through the continuous breeding programme, cultivation of these genotypes after systematic evaluation is expected to benefit in several ways, including the alleviation of malnutrition.

Conclusion

Our study clearly indicated the existence of adequate genetic variability in all the selected genotypes. This variation could be effectively utilized through the development of viable and appropriate breeding strategies for the improvement of rice varieties. The higher estimates of heritability and genetic advance were the significant results of our study, indicating the predominance and frequent occurrence of additive gene action, providing an opportunity for direct selection based on the observed traits. The phenotypic correlation analysis showed most of the traits evaluated are essential for the selection of high-yielding genotypes as they share a wide range of genetic variability in the selected genotypes of rice. As the selected varieties are found to have high levels of Zinc and Iron, the present study forms the basis for breeding newer genotypes of rice with improved nutritional values.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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