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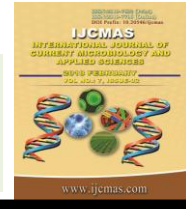

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Evaluation of Elite Accessions of Rice for Morphological and Nutritional Traits

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A B S T R A C T

The fourteen genotypes selected were grown during *Kharif*-2014 at in order to evaluate the performance of fourteen **e**lite accessions of rice for yield and its component traits. The present experiment was laid under randomized complete block design with three replications at field under aerobic rice/biotechnology rice research laboratory, Department of Plant Biotechnology, University of Agricultural Sciences, GKVK campus, Bangalore, India during *Kharif*-2014. Analysis of variance for all morphological traits shown that mean sum of squares due to genotypes was highly significant for all characters. Among all genotypes grain yield per plant as well as panicle length was found to be maximum for AM-1 variety. Also high iron content of brown rice was found in BR-2655 while Moroberekkan variety showed minimum polishing loss of iron. Meanwhile Moroberekkan variety had maximum zinc content for both brown and white rice which proves it's suitability as bio fortified consumption grain.

Introduction

Rice (*Oryza sativa* L.) is a "Global Grain" cultivated widely across the world feeding millions of mankind. It is grown over 160 million hectares and providing 20 per cent daily calories for half of the world's population. More than 3.5 billion people are depending upon rice as a staple food and one fifth of the world population depend on rice cultivation for their livelihoods. Asia produces and consumes about 90 per cent of the world's rice (www.sustainablerice.org). It has been reported that rice significantly lack some of the micronutrients such as Fe, Zn, Ca, Mg, Cu, I and Se etc., which are important for human beings for their proper growth and development (Banerjee and chandel, 2011) especially after polishing. Taking weight percentage into account, in rice 43 per cent of the total Zn, 65 per cent of the total Fe, and 85 per cent, 92 per cent of the total K, Ca and Mn were removed by the milling process if the hull and bran tissues (embryo + aleurone layer) were thoroughly removed from the endosperm fraction during polishing (Lu *et al.*, 2013). Thus, a rice - based diet is the primary cause of micronutrient malnutrition throughout much of the developing world. Iron, zinc, and vitamin A deficiencies are common in rice consuming regions. These deficiencies account for decreased work productivity, reduced mental capacity, stunting, blindness, increased child mortality, and elevated morbidity and mortality in general (Baishya *et al.*, 2015).Considering the above factors, this study has been undertaken with the aim of comparison of quantification of Iron and Zinc in the brown, white, and cooked rice in elite accessions along with their mean performance with agronomic traits.

Materials and Methods

Studies of morphological traits

The present experiment was conducted at aerobic rice laboratory, Department of Plant Biotechnology, University of Agricultural Sciences, GKVK campus, Bangalore, India during *Kharif*-2014in order to evaluate the performance of fourteen genotypes of rice for various yield and its component traits. The genotypes were sown in rows spacedat30 cm apart with intra-row spacing of 15cmwith three replications each.

The recommended dose of fertilizer *i.e.* nitrogen 100 Kg, phosphorus 50 Kg and potassium 50 Kg along with 5 tone of FYM per hectare was applied. N was applied in the form of urea at basal, 30 and 60 DAS @ 50 %, 25 % and 25 % respectively. P was provided through single super phosphate (16 % P_2O_5) and K as Murite of potash (60 % K_2O). Irrigation was done once in five days. All necessary measures were taken to control pest and disease infestation. Study of physico-chemical properties of soil at the experimental site showed the presence of0.74 ppm Zn (estimated using DTPA, diethylene triaminepenta acetic acid extractable method), a pH of 6.1 and 7.4 g kg^{-1} of organic carbon. The study on analysis of variance and mean performance of genotypes was carried out for morphological traits *viz.*, plant height, total number of tillers, number of productive tillers, panicle length, percentage spikelet fertility, days to first flowering, hundred grain weight, days to 50 % flowering, days to maturity and shoot dry weight.

Estimation Zn and Fe content in brown, white and cooked rice

The dehusked 5 g samples (brown rice) of the fourteen genotypes in three replications were subjected to X-rays and the content was recorded in mg/kg using florescence (XRF) (OXFORD Instruments X-Supreme 8000, Nicholas *et al.,* 2012) at ICRISAT, Hyderabad, Andhra Pradesh. Measurement conditions were followed as recommended by the manufacture for analysis of Zn and Fe in a cellulose matrix. Analysis time for each sample was 186 s, which included 60 s acquisition time for the separate Zn and Fe conditions as well as 66 s ‘dead time’ during which the XRF establishes each measurement condition.

Scans was conducted in sample cups assembled from 21 mm diameter all cups combined with polypropylene inner cups sealed at one end with 4 µm Poly-4 XRF sample film. Calibration of instrument was done using known ICP-OES values of high, low zinc and iron containing genotypes (Gande *et al.,* 2014).

Zn and Fe content were estimated from the white rice which was collected individually from each genotypes using 10 g brown rice sample and polished by nonferrous miller (Mini Lab Rice Polisher Model K-710, Krishi International) DRR, Hyderabad. Machine was cleaned with brush internally and externally after every turn of polishing. XRF readings were taken for all the white rice samples at ICRISAT, Hyderabad. Zn and Fe content in cooked rice (mg kg-1) Zn and Fe content was estimated from the cooked rice samples of all genotypes by XRF method in MSSRF, Chennai.

Observations of cooking parameters

Cooking parameters which were studied for the all genotypes are kernel length before cooking (mm), kernel length after cooking (mm), water uptake before cooking (ml), water uptake after cooking (ml) and volume expansion and elongation ratio. For measuring the kernel length before and after cooking, average of 10 grains was taken. Water uptake for all genotypes before cooking was measured by adding 5 g of samples in 15 ml distilled water for 10 minutes. Water uptake after cooking was measured by dipping the cooked samples in 50 ml distilled water for 10 minutes. Elongation ratio for the grain was calculated as the ratio of kernel length after cooking and cooking, respectively. Volume expansion was calculated as increase in the volume after cooking (X-50) and before cooking (Y-15).

Results and Discussion

Analysis of variance

The phenotypic variation manifested by the genotype has two components namely genotypic and environmental. Analysis of variance of 23 among 23 characters revealed high significant difference among the means of all the genotypes (Table 1) thus indicating considerable scope for selection even for micronutrient distribution in rice grain. This difference can be attributed to variations present in the genotypes as well as the environmental factors.

Mean performance of genotypes for different morphological traits:

The mean values of different growth and yield parameters with respect to genotypes are presented in table 4. Among the selected genotypes, BR-2655 showed minimum plant height at maturity (52.33 cm), whereas maximum plant height was observed in AM-65(103.73 cm), with an average of 80.07cm. Total number of tillers varied from 6.36 (Moroberekkan) to 15.33 (Karthika) with an average of 10.91. Number of productive tillers was observed maximum in genotype karthika (12.56) and minimum in Moroberekkan (4.20) with an average of 8.43.

The genotype AM-1possessed maximum panicle length of 21.90 cm, whereas minimum panicle length was observed in BR-2655 (16.07) with the average value of 18.78cm. Percentage spikelet fertility varied from 61.12 (AM-65) to 69.71 (AM-1) with an average of 64.60.Among the selected genotypes, days to first flowering were minimum in Black rice (72days) and maximum in Karthika (122.33 days). Among the selected genotypes, range of variation for days to fifty percent flowering was from 95 (Black rice) to 137 (Karthika) with an average of 111 days. Maturity was attained within minimum number of121.67days in genotype AM-1, whereas Karthika took maximum (148.67 days) time to attain maturity. An average value of 132.02 days was recorded for days to maturity.

Hundred grain weight ranged from 1.20 gram (Radhunipagal) to 2.58 gram (Moroberekkan) with an average values of 1.95gram.Maximum grain yield per plant was obtained in TKM-9(30.53 g), whereas it was observed to be minimum in AM-72(4.02 g), with overall mean of 13.73 g.

The magnitude of phenotypic variability is reflected by range and deviation from the mean values. High range was noticed for days to 50 % flowering, total number of tillers, number of productive tillers, plant height, panicle length, days to maturity, shoot dry weight, grain yield per plant. Similar results were obtained by Hemareddy (1993), Dhananjaya *et al.*, (1998), Venkataramana and Hittalmani (1999), and Nagabhushana (2002).

Table.1 Analysis of variance for morphological characters

Source of variation	df	Mean Sum of Squares DFF	DFPF	NT	NPT	PH	PL
Genotype	13	790.10**	564.10**	16.56**	15.21**	997.43**	9.33**
Error	26	42.55	41.96	1.81	1.01	35.17	2.03
CD at 5 %		10.95	10.87	2.04	1.69	9.95	2.39
CD at 1 %		14.80	14.70	2.75	2.28	13.45	3.23
CV		6.87	5.84	11.12	11.92	7.41	7.58

Source of variation	df	PSF	DM	SDW	HGW	GY/P
Genotype	13	21.49**	212.13**	58.74**	0.43**	207.87**
Error	26	4.42	16.08	15.02	0.07	2.47
CD at 5 %		3.53	6.73	6.50	0.44	2.64
CD at 1 %		4.77	9.10	8.79	0.60	3.56
CV		3.26	3.04	12.10	13.51	11.45

** Significant at 1 %

PH=Plant height
NT=Total number of tillers
NPT=Number of productive tillers
PL=Panicle length
SDW=Shoot dry Weight
HGW=Hundred grain weight
DFF=Days to first flowering
DFPF=Days for 50 % flowering
DM=Days to maturity
PSF =Percentage spikelet fertility

Table.2 Average Zinc and Iron contents (mg kg^{-1}) in different parts of rice grain

Genotypes	BROWN RICE		WHITE RICE		COOKED RICE	
	ZINC	IRON	ZINC	IRON	ZINC	IRON
AM 27	27.05	11.70	22.20	5.85	21.65	22.10
AM 65	35.05	14.35	31.55	4.00	26.90	12.75
AM-72	33.60	12.65	32.65	4.85	29.45	14.75
AM-158	34.70	14.60	28.55	5.30	24.05	19.15
Black Rice	23.35	12.20	24.20	7.50	20.80	20.30
BI-33	23.55	14.65	23.10	14.05	22.65	10.55
AM-143	24.20	10.90	23.95	5.30	20.50	20.15
AM-1	24.05	15.40	23.75	3.75	21.45	15.90
RadhuniPagol	27.80	17.50	21.65	11.65	18.55	31.10
BR-2655	25.80	21.70	23.20	5.80	18.80	23.95
Karthika	43.00	13.40	34.20	6.15	33.20	24.45
Subhdra	25.00	17.55	18.70	2.20	15.45	6.85
Moroberekkan	38.80	14.90	37.45	13.85	33.5	10.5
TKM-9	23.85	11.00	22.10	4.75	19.35	16.90

Table.3 Analysis of variance for cooking characters in elite rice accessions

Source of variation	df	KLBC	KLAC	WUBC	WUAC	ER	VE
Genotype	13	0.04**	0.03**	1.96**	17.28**	2.22**	1.31**
Error	26	0.00	0.00	0.05	0.47	0.06	0.07
CD at 5 %		0.02	0.03	0.39	1.15	0.43	0.46
CD at 1 %		0.03	0.04	0.53	1.56	0.58	0.61
CV		6.38	2.10	6.32	5.23	6.52	7.47

KLBC=kernel length before cooking
WUBC= water uptake before cooking
KLAC= Kernel length after cooking
WUAC=water uptake after cooking

Table.4 Mean performance of different genotypes for yield and its components

Genotype	Plant height	NT	NPT	SDW	Grain yld. Per plant	PL	HGW	DFF	DFPF	DM	PSF	BRF	WRF	BRZ	WRZ
AM-27	73.20	12.67	9.67	27.16	21.11	21.65	2.37	99.00	107.67	132.67	67.72	11.70	5.85	27.05	22.20
AM-65	103.63	9.45	6.50	38.07	10.26	19.15	2.06	107.67	124.33	138.00	64.46	14.35	4.00	35.05	31.55
AM-72	64.86	13.47	9.00	31.42	3.69	18.39	1.93	107.33	118.33	134.00	65.68	12.65	4.85	33.60	32.65
AM-158	68.40	13.93	8.13	29.64	11.84	18.54	1.91	82.00	103.67	127.33	63.20	14.60	5.30	34.70	28.55
black rice	98.80	13.73	8.40	31.10	15.35	19.92	2.18	72.00	95.00	123.33	68.77	12.20	7.50	23.35	24.20
BI-33	97.50	12.07	7.80	31.05	14.66	19.79	1.61	84.00	102.00	125.33	68.47	14.65	14.05	23.55	23.10
AM-143	61.57	13.35	7.56	24.87	13.30	17.26	1.74	84.67	99.00	126.67	70.56	10.90	5.30	24.20	23.95
AM-1	101.47	13.53	8.67	39.23	30.01	21.90	2.30	74.00	95.67	121.67	69.71	15.40	3.75	24.05	23.75
RadhuniPagal	89.20	16.18	9.73	44.23	5.35	17.23	1.20	105.00	120.00	137.33	69.85	17.50	11.65	27.80	21.65
BR-2655	52.33	13.71	8.40	33.72	4.34	21.47	1.54	115.33	127.67	143.33	67.60	21.70	5.80	25.80	23.20
Karthika	76.67	20.77	16.23	32.26	12.78	16.07	1.59	122.33	137.00	148.67	59.48	13.40	6.15	43.00	34.20
Subhdra	64.07	17.53	10.57	25.16	17.94	17.33	2.26	78.67	96.00	123.33	70.62	17.55	2.20	25.00	18.70
Moroberekkan	103.73	6.36	3.86	40.30	6.36	20.39	2.58	108.00	122.67	140.00	64.82	14.90	13.85	38.80	37.45
TKM-9	65.27	14.60	9.50	28.27	22.02	18.17	2.05	89.33	105.00	126.67	67.12	11.00	4.75	23.85	22.10
Mean	**79.31**	**13.67**	**8.86**	**32.61**	**13.50**	**19.09**	**1.95**	**94.95**	**111.00**	**132.02**	**67.00**	**14.46**	**6.79**	**29.27**	**26.23**
S.D	**17.93**	**2.86**	**2.46**	**5.79**	**7.48**	**1.83**	**0.38**	**16.23**	**13.71**	**8.41**	**3.18**	**2.96**	**3.71**	**6.50**	**5.61**
C.V	**22.61**	**20.92**	**27.75**	**17.77**	**55.39**	**9.60**	**19.53**	**17.09**	**12.35**	**6.37**	**4.74**	**20.48**	**54.75**	**22.19**	**21.40**

PH=Plant height
NT=Total number of tillers
NPT=Number of productive tillers
PL=Panicle length
SDW=Shoot dry Weight
BRF= Fe content in brown rice
BRZ= Zn content in white rice

HGW=Hundred grain weight
DFF=Days to first flowering
DFPF=Days for 50 % flowering
DM=Days to maturity
PSF =Percentage spikelet fertility
WRF= Fe content in White rice
WRZ=Zn content in white rice

Fig.1 Iron and zinc content in brown and white rice

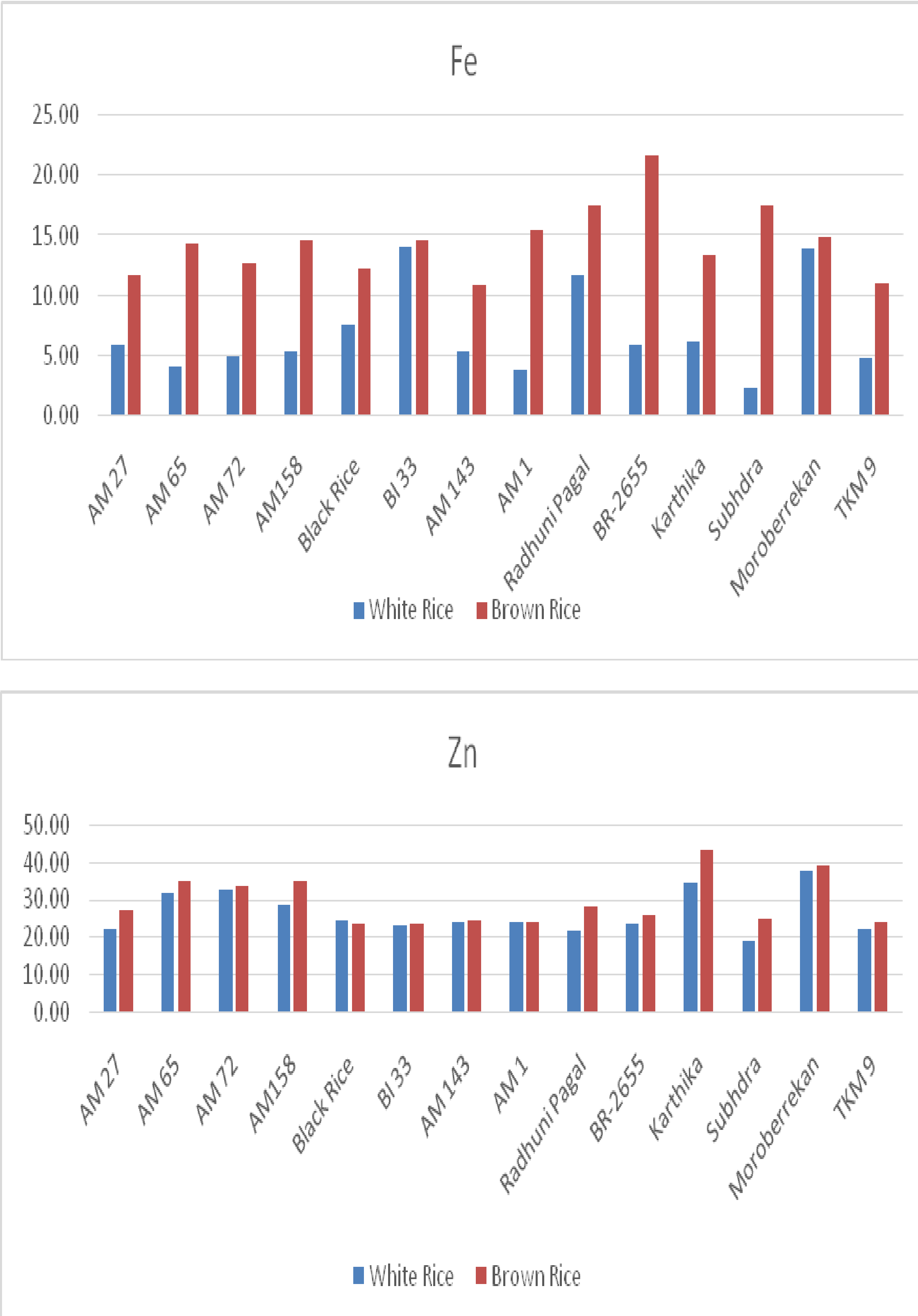
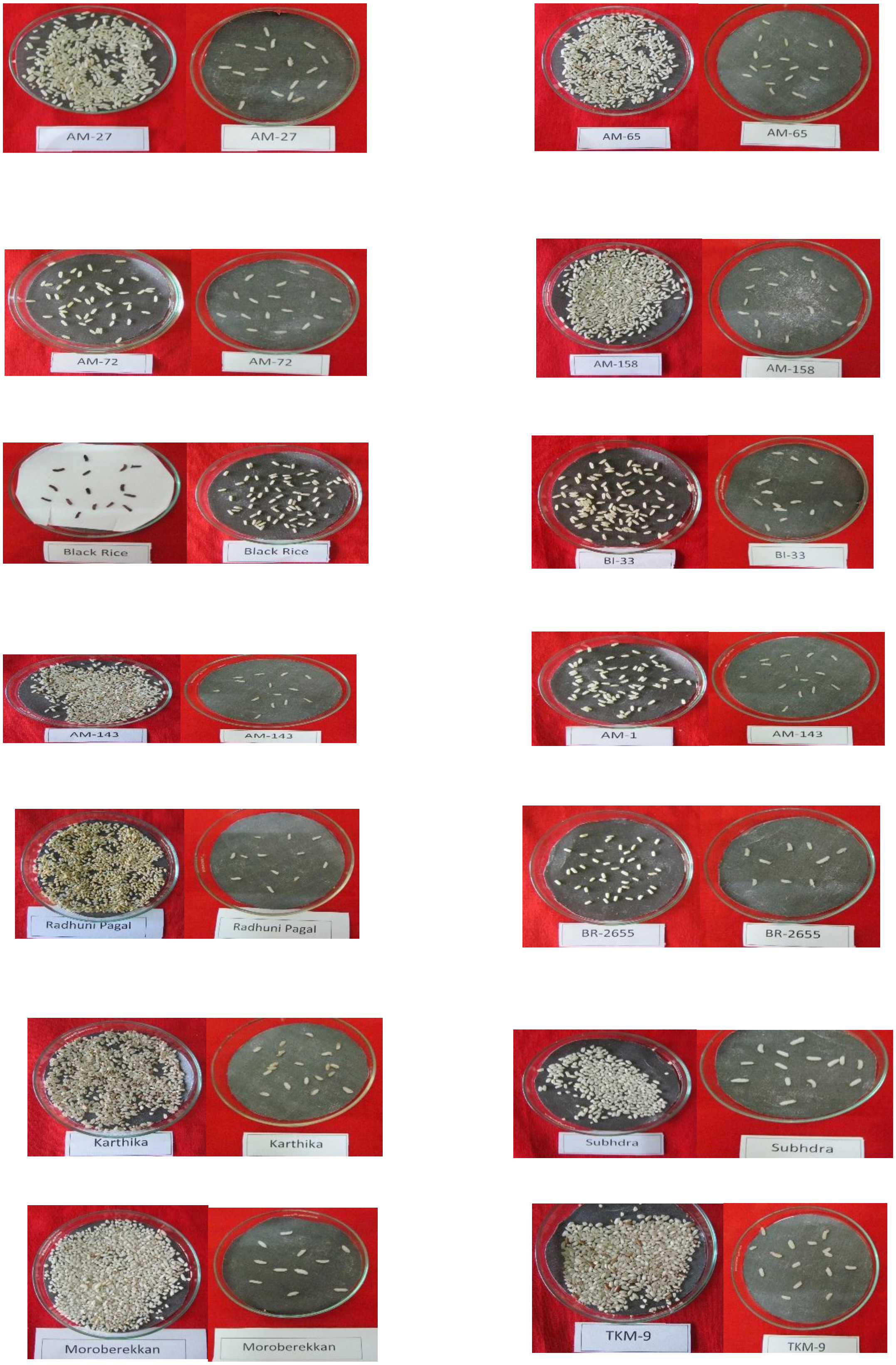


Fig.2 Volume expansion of white rice for different varieties after cooking



Evaluation of genotypes for Zinc and Iron content in different parts of rice grain

Zinc and Iron content in brown, white and cooked rice

Zinc and Iron content in different parts of rice grain i.e., brown rice (after removing husk), white rice (obtained after polishing of brown rice) and cooked rice (obtained after cooking of white rice) of elite genotypes was estimated using XRF at ICRISAT, Hyderabad and MSSRF, Chennai (Table 2).

Highest grain Zinc content in brown rice was observed in Karthika (43.00 mg kg^{-1}), lowest in Black rice (23.35 mg kg^{-1}). Highest zinc content in white rice was observed in Moroberekkan (37.45 mg kg^{-1}) and lowest in Subhdra (18.70 mg kg^{-1}). Highest zinc content in cooked rice was observed in Moroberekkan (33.50 mg kg^{-1}) and lowest in Subhdra (15.45 mg kg^{-1}).

Highest iron content in brown rice was observed in BR-2655 (21.70 mg kg^{-1}), lowest in AM-143 (10.90 mg kg^{-1}). Highest iron content in White rice was found in BI-33 (14.05 mg kg^{-1}) and lowest in Subhdra (2.20 mg kg^{-1}). Highest iron content in cooked rice was recorded in Radhunipagal (31.10 mg kg^{-1}) and lowest in Subhdra (6.85 mg kg^{-1}) ((Figure 1).

The range in the means of Zn and Fe content in brown rice, Zn content in brown rice, Zn and Fe content in white rice is higher except for Fe content in brown rice, but there were no reports on these traits earlier. Tiwari *et al.*, (2009) reported grain zinc content in wheat mapping population, ranged from 19.9 to 64.2 mg/kg. Similarly, Grain zinc content ranged from 0.4 to 104 mg/kg in rice germplasm accessions (Anuradha *et al.,* 2012) and Bekele *et al.,* (2013) reported 16.1 to 88.6 mg/kg for the RIL population in rice.

Evaluation of elite genotypes for cooking characters

The mean sum of squares due to various sources of variation for different characters of fourteen genotypes is represented in table 3. Highly significant differences among the genotypes were observed for all the characters indicating variability for the cooking associated traits. Volume expansion of white rice for different varieties after cooking is shown in figure 2.

For cooking characters significant differences among genotypes were observed. For water uptake before and after cooking Ahmed and Khalid (1985) reported the significant differences among genotypes. For elongation ratio Singh *et al.,* (2000) reported the variations and results in present study are in accordance to that.

Analysis of variance revealed significant mean sum of squares for all the characters studied indicating the presence of variability among the genotypes. Thus, it could be concluded that there exists a lot of genetic variation among the genotypes and improvement could be brought through simple selection. On the basis of mean performance of genotypes for different characters, the varieties namely, Moroberekkan, BR-2655 and AM-1 showed best performance in terms of grain yield as well as their iron and zinc content. Thus, the above mentioned varieties can be recommended to be grown in order to solve the problem of hidden hunger i.e. malnutrition in the region.

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