ISSN 2250-3153

Evaluation of Popular Rice (*Oryza sativa* L.) Hybrids for Quantitative, Qualitative and Nutritional Aspects

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Abstract-Genotypic differences in grain quality including protein, micronutrient concentrations and few of the yield attributing parameters of twenty one popular rice hybrids were assessed. The data revealed huge variations in grain quality among the hybrids. All hybrids tested have statistically similar milling percentage (70.1- 72.9 per cent). Head rice recovery of PA 6444 being the highest (70.9 per cent) at par with 15 hybrids was significantly higher than Sahyadri-4, Indirasona, HSD-1 and CORH-3. Most of the grain types of the hybrids were classified as long slender types. Highest water uptake was exhibited with Pusa RH-10 and PSD-3. Protein content varied by 4.05 per cent among the hybrids ranging from 5.74 per cent in PSD 3 (lowest) to 9.79 per cent in DRRH-2 (highest). Mean micronutrient iron concentration of hybrids (68.4 ppm) was found to be 1.83 times that of zinc (37.3 ppm). Two hybrids with both high iron and zinc concentration (DRRH-2 with 125.8 ppm and 43.8 ppm; and Sahyadri-4 with 104.8 and 43.0 ppm) were identified.

Index Terms - Hybrid Rice, Nutrition, Quality and Yield

I. INTRODUCTION

Rice accounting for supply of twenty nine per cent of total calories is the principal food crop of India and breeding for higher yield is the prime focus of research. Rice is known as the grain of life and is synonymous with food for Asians as it supplies majority of starch, protein and micronutrient requirements [1], [2], [3]. The average percentage of protein in rice grains is 8 per cent, iron is 1.2 mg 100 g^{-1} and zinc is 0.5 mg 100 g^{-1}. The amino acid profile shows that it is rich in glutamic acid and aspartic acid, highest quality cereal protein being rich in lysine (3.8 per cent), the first limiting amino acid. Recent studies have unraveled a number of unknown properties of rice, some of which have been reported in ancient Indian Ayurvedic literature. Positive qualities of high digestibility of starch, high biological value of amino acids, high content of essential fatty acids, selenium and anti-hypertension effect have been confirmed scientifically. Rice, therefore, is described as “Functional Food” [4].

The projected demand for rice can only be met by maintaining steady increase in production over the years. Several breeding strategies are being employed in increasing the yield potential of rice and those among the available strategies; hybrid rice offers an immediate opportunity to break the yield plateau set by the semi-dwarf rice varieties after the first green revolution. In the recent years, much emphasis is given for the cultivation of hybrid varieties. Hybrid rice technology has proved to be one of the most feasible and readily adoptable approaches to break the yield barrier, as they yield about 15-20 per cent more than the best of the improved or high yielding varieties. Being convinced of the potential of hybrid rice technology in enhancing the production, India adopted this technique and has released nearly more than forty-three hybrids for commercial cultivation. Hybrid technology has been widely acclaimed and accepted. The extent of hybrid vigor for yield increase was the major concern when hybrid rice was first developed.

Attaining food self sufficiency in quantitative terms has been the aim of many countries of the world till late 20th century and accordingly the crop improvement programmes have been oriented in this direction that have successfully achieved this task. Many Asian countries are approaching self-sufficiency in rice production and are now looking for ways to improve the quality of their rice for either national consumption or as a revenue generating export. To achieve this goal and to compete in the international market, grain must be of high quality and conform to international standards. In recent decades, as living conditions are being steadily improved, human demand for high quality rice is continuously on increase, which entailed in incorporation of preferred grain quality features as the most important objective next to yield enhancement [5].

Grain quality in rice is very difficult to define with precision as preferences for quality vary from country to country. Grain quality has always been an important consideration in rice variety selection and development. Based on the survey of 11 major rice growing countries Juliano and Duff (1991) [6] concluded that grain quality is second only to yield as the major breeding objective. In the future, grain quality will be even more important as once the very poor , many of whom depend largely on rice for their staple food become better off and begin to demand higher quality rice [5].

Malnutrition has been a serious problem in the developing world mostly in South and South East Asia and Sub Saharan Africa [7]. Over three billion people suffer from micronutrient malnutrition [8]. In most of these countries, rice is the staple food. In order to enhance the micronutrient concentration in the grain, suitable breeding programmes should be followed. However, rice scientists have long recognized its micronutrient deficiencies, which are the basis of numerous human health problems worldwide. Mineral nutrient deficiencies have egregious societal costs including learning disabilities among children, increased morbidity and mortality rates, lower worker productivity and added high health care costs, all of which diminish human potential, felicity and national economic development [9], [10]. In recent years, attention has turned towards strategies for improving human vitamin and mineral nutrition, especially iron, zinc, selenium and iodine [11], [12].

Rice is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are much more important than for any other food crop [13]. As a pivotal crop in cereals, rice provides the staple food for more than fifty percent of the world's people. However, as rice is consumed in the milled form, the physical attributes of the intact endosperm are of foremost importance in determining consumer preference. Therefore, the percentage of head grain, grain dimensions, weight, chalkiness, translucency of the grains, cooking and eating quality should be considered during the development of hybrid varieties. Most of the qualitative traits are genetically controlled. The inheritance of grain quality is more complicated than that of other agronomic traits in cereals due to epistasis, maternal, cytoplasmic effects, and the triploid nature of endosperm [14].

Since 1992, researchers at International Rice Research Institute have been evaluating the genetic variability of iron and zinc content in rice grain [15], [16]. There were obvious differences in iron and zinc contents among the genotypes tested, suggesting a genetic potential to increase content of these micronutrients in rice grain [17]. [18] Zeng *et al.* reported that mineral element contents of 653 Yunnan rice accessions were closely related to most quality traits, including significant correlations between amylose content and potassium, gel consistency and iron or zinc content, and gelatinization temperature and manganese content. [19] Zang *et al.* found that indirect selection of grain characteristics may be one of the breeding methods to select for iron, zinc and manganese content in black pericarp indicia rice. Thus, it is important to improve the understanding of relationships between mineral nutrients and rice quality and select rice genotypes appropriate for breeding programme. Although, rice is not a major source of mineral in the diet, any increase in its mineral concentration could significantly help to reduce iron and zinc deficiency because of the high levels of rice consumption in Asia [16]. The estimation of iron and zinc concentration is normally achieved through Inductively Coupled Plasma Optical Emission Spectrophotometry or Atomic Absorption Spectroscopy [20]. [21] Jiang *et al.* reported that around 75 per cent of total grain zinc was present in the endosperm of brown rice, while [22] Takahashi *et al.* revealed that zinc is most abundant in the embryo and in the aleurone layer using X- ray fluorescence imaging.

Grain quality characters are reported to play important role in genetic divergence too [23]. Besides grain quality characters, agro-morphological characters like plant height, weight of panicle, 1000-grain weight, panicle length also contribute towards genetic divergence [24]. In the light of the above scenario, the present investigation is carried out with the objective of studying several quantitative, qualitative and nutritional parameters among popular rice hybrids of India.

II. MATERIALS AND METHODS

The present investigation is carried out at Directorate of Rice Research Farm, ICRISAT, Patancheru, Hyderabad, Andhra Pradesh, India, situated at 17.5°N latitude, 78.27°E longitude and at an altitude of 545 m above mean sea level. Twenty one popular rice hybrids released (Table 1) in India were analyzed in a Randomized Block Design with three replications in three blocks. Each block consisted of twenty one genotypes randomized and replicated within each block. Twenty seven days old seedlings raised in nursery were transplanted at 20 cm x 15 cm. The experimental sandy clay loam soil with pH 8.7 contained 0.9 per cent organic carbon, 11.8 kg ha^{-1} of available P, 295 kg ha^{-1} of available N and 439 kg ha^{-1} of available K at the time of sowing. The crop was given a dosage of 100-26.4-33.3 kg N-P-K ha^{-1} through urea (N), single superphosphate (P) and murate of potash (K). Entire P and K were applied as basal while N was applied in three equal splits (basal *i.e*. at transplanting, and top dressing at 25 and 50 days after transplanting). Two manual weedings were done prior to top dressing of nitrogen. Need based irrigations were given to supplement rainfall so as to maintain 2-3 cm standing water all through the crop till physiological maturity. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop.

Five representative plants for each hybrid in each replication were randomly selected to record observations on the quantitative characters under study. Days to 50 per cent flowering were computed on plot basis. Data was recorded on physico-chemical quality characters from the bulk samples. The samples have been analyzed for different quality traits which include kernel length (mm), kernel breadth (mm), length/breadth ratio, volume expansion ratio and amylose content (per cent) as per the standard procedures for each trait. Ten de-husked whole kernels were measured using a seed analyser and based on the kernel length and L/B ratio, grains were classified into long slender (LS), medium slender (MS), long bold (LB) and short bold (SB).

The milling characteristics were computed following the method given by Ghosh *et al*. in 1971 [25]. Dehusking was carried out in 'Satake' laboratory huller (type THU 35 A) and the dehusked brown rice was passed through Satake Grain Testing Mill (Type-TM 05) for 1 minute 30 seconds to obtain uniformly 5-6 per cent polish. Total polished kernels were weighed and the milling percentage was calculated (Weight of the polished kernel / Weight of the paddy x 100). The milled samples were passed through rice grader to separate whole kernels from the broken ones. Small proportions of whole kernels which passed along with the broken grains were separated by hand**.** Full rice and three fourth kernels were considered and weighed and head rice recovery in percentage was calculated (Weight of whole polished grain / Weight of paddy x 100).

As per the standard procedures, water uptake in ml [26], alkaline spreading value [27], amylose content [28] and gel consistency in mm [29] was estimated. Iron and zinc content (ppm) of seed samples was estimated by Atomic Absorption Spectrophotometer as suggested by Lindsay and Novell (1978) [30]. Total nitrogen in rice flour was estimated by Micro-

Kjeldahl method and the protein content was derived by multiplying total nitrogen content with 5.95 [3].

III. RESULTS AND DISCUSSION

a) Quantitative Parameters

The mean performance of quantitative characters of the popularly grown rice hybrids is presented in Table 2. Based on the mean performance it was observed that CORH-3 was found to be an early maturing hybrid (78 days), while Sahyadri-1 was a late maturing hybrid (108 days). The mean days to 50% flowering was observed to be around 96.7 days among the hybrids. Early maturing varieties tend to produce less head rice than late maturing varieties. Highest plant height was exhibited by CRHR-7 (116.89 cm) while lowest by Sahyadri-2 (83.66 cm). Mean plant height possessed by the hybrids was observed to be 97.3 cm. The length of the panicle was highest for CRHR-7 (29.56 cm) while it was lowest for PA 6129 (23.78 cm) with a mean value of 26.11 cm among the hybrids. Number of productive tillers per plant was observed to be more in DRRH-2 (11.7) and lowest (6.7) in CRHR-7. The mean value of productive tillers per plant was observed to be around 9.28.

Number of filled grains per panicle were lowest (67.2) in Sahyadri-4, whereas highest (159.3) in PA 6444. Mean number of filled grains per panicle possessed by the hybrids was observed to be 114 in count. Varieties that fill uniformly have higher grain density and less chalkiness. Number of chaffy grains per panicle were lowest in GK5003 (5.98), and were highest in Sahyadri-3(30.3) with a mean value of 20.2. Suruchi exhibited the lowest 1000-grain weight (19.1g), while HSD-1 recorded the highest values (28.4 g). The mean 1000-grain weight was observed to be around 24.1g among the hybrids. Mean grain yield per plant was observed to be around 22.98 t ha^{-1}. Highest mean grain yield per plant (24.35 g) was exhibited by Pusa RH-10, while lowest (20.99 g) in CRHR-7. Highest grain yield (t ha^{-1}) was produced by Pusa RH-10 (8.04) and the least by CRHR-7 (6.93).

b) Qualitative Parameters

The mean performance of qualitative characters of few of the selected hybrids grown popularly is presented in Table 3. Among the grain quality characters, the milling quality of rice may be defined as the ability of rice grain to stand milling and polishing without undue breakage so as to yield the greatest amount of total recovery and the highest proportion of head rice to brokens. The milling recovery was more in PA 6444 (73.5 per cent) and low in CORH-3 (70.1 per cent) with a general mean of 71.89 per cent among the hybrids. Head rice recovery is an inherited trait, although environmental factors such as temperature and humidity during ripening and post harvest stages are known to influence grain breakage during milling. Grain size and shape, hardness, presence or absence of abdominal white, moisture content, harvest precision, storage conditions, processing and type of mills employed have direct bearing on head rice recovery [31]. In general, varieties with long grains and those having white centers give lower head rice yields. The maximum mean value for head rice recovery percentage was observed in PA 6444 (70.9 per cent) and low value in CORH-3 (54.9 per cent). Mean head rice recovery per cent possessed by the hybrids was observed to be around 66.16 per cent. Breeders have to pay special attention for improving this trait, as rice out turn is the most important index for fixation of procurement price of paddy [32]. The kernel length was found to be highest in Pusa RH-10 (7.91 mm) and lowest in Suruchi (5.43 mm) with a general mean value of 6.45 cm. The kernel breadth was highest for HSD-1(2.18 mm) and lowest for Pusa RH-10 (1.90 mm) with a mean of 2.08 cm. High expansion breadth wise is not a desirable quality attribute in high quality rice required to command premium in the market. Short and medium type grains which are more round, thick and hard than long grains produce higher head rice yields. The L/B ratio varied from 4.16 (Pusa RH -10) to 2.52 (Sahyadri-2) with the general mean of 3.11. A low value observed by Hossain *et al*. (2009) [13] indicates poor cooking quality.

The volume expansion ratio was highest in DRRH-2 (5.60) and lowest for HSD-1 (4.10). Mean volume expansion ratio possessed by the hybrids was observed to be around 4.62. The water uptake was highest for Pusa RH-10 (380 ml) while it was lowest for GK5003 (280 ml). The mean water uptake was observed to be around 309.52 ml among the hybrids. The extent of water absorbed by rice during cooking is considered an economic quality as it gives an estimate of the volume increase during cooking. Water uptake shows a positive significant influence on grain elongation [33]. Characters like alkali spreading value ranged from medium to high values with a general mean of 5.68. The alkali spreading value was found to be highest for Sahyadri-2 (7.01) while it was lowest for HSD-1(4.32). Rice grains with high amylose content possess high volume expansion, cook dry and flaky, are less tender and become harder upon cooling [34], while those with low amylose content cook moist and are sticky. The percentage of amylose content was found to be highest for CRHR 7 (25.66 per cent) while it was lowest for Sahyadri-3 (18.95 per cent). Mean amylose content per cent among the hybrids was observed to be around 22.13 per cent. Gel consistency measures the tendency of the cooked rice to harden on cooling. Rice grains with low gel consistency tend to be less sticky on cooking and are associated with harder cooked rices. This is particularly evident in high amylose rice. Grains with high gel consistency exhibit a higher degree of tenderness on cooking which is one of the most preferred characteristics among the grain quality parameters. Gel consistency (mm) was observed with a maximum value of 75 (KRH-2) to a minimum value of 37 (Suruchi) with a general mean of 55.38 mm.

c) Nutritional Parameters

The mean performance of nutritional characters of popular rice hybrids is presented in Table 4. Increasing the protein content of rice without losing the yield potential would increase the protein intake of people in Asia. Increasing the glutelin fraction mainly results in the enhancement of protein content. Donors with 16% protein are available in germplasm but studies have shown that inheritance of protein content is complex with low protein content being dominant. Heritability values are low in the early generation and a large proportion of the total variability in protein content is attributable to environment [32]. High amounts of protein content was found to be observed in the hybrids of DRRH-2 (9.79 per cent) and Sahyadri-2 (9.45 per cent) while lowest value was obtained for PSD-3 (5.74 per cent). The mean protein content among the hybrids was found to be 7.95 per cent. Plant breeders have had only limited success in improving the nutritional quality of seed proteins, primarily because genes encoding the seed storage proteins with high levels of essential amino acids do not normally exist in any given species. Modifying the genes that encode seed proteins by genetic engineering may therefore be an ideal solution to the problem of nutritional quality. High contents of iron (12.58 mg $100g^{-1}$) and zinc (4.38 mg $100g^{-1}$) were observed in DRRH-2 while lowest amount of iron was obtained in PHB-71(2.89 mg $100g^{-1}$). The lowest content of zinc was observed in Sahyadri-3 (3.07 mg $100g^{-1}$). The mean iron content was recorded to be around 6.84 mg $100g^{-1}$ and zinc content at 3.73 mg $100g^{-1}$ among the hybrids.

IV. CONCLUSION

The potential for improving quality through genetics is quite high. There should be no conflict between breeding for better appearance, milling and cooking qualities and breeding for yield. In the short term, the additional selection characters may slow breeding. However, most grain quality characters are apparently highly heritable and can be selected for at early generations. This study will guide the utilization of popular rice hybrids in plant improvement programmes and provides a basis for further studies into how the nutritional and grain quality parameters could be enhanced.

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Table 1. Details of twenty one popular rice hybrids of India

S.No.	Name	Nominating Agency
1.	DRRH – 2	Directorate of Rice Research, Hyderabad
2.	PA 6129	Bayer Bio-Science
3.	Sahyadri – 2	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
4.	Sahyadri –4	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
5.	Pusa RH -10	Indian Agricultural Research Institute, New Delhi
6.	Indirasona	Indira Gandhi Krishi Vishwa Vidyalaya, Raipur
7.	GK 5003	Ganga Kaveri Seeds
8.	PSD-3	G. B. Pant University of Agriculture and Technology, Pantnagar
9.	Sahyadri – 3	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
10.	PA 6201	Bayer Bio-Science
11.	HSD-1(HKRH-1)	Chaudhary Charan Singh Haryana Agricultural University, Karnal
12.	PA 6444	Bayer Bio-Science
13.	Suruchi (MPH 5401)	Mahyco Seeds, Hyderabad
14.	JKRH- 2000	JK Agri. Genetics
15.	US - 312	US Agri Seeds
16.	CORH- 3	Tamil Nadu Agricultural University, Coimbatore
17.	KRH-2	University of Agricultural Sciences, Mandya
18.	Sahyadri -1	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
19.	PHB – 71	Pioneer Overseas Corporation
20.	CRHR - 5	Central Rice Research Institute, Cuttack
21.	CRHR - 7	Central Rice Research Institute, Cuttack

ISSN 2250-3153

Table 2: Mean performance of popular rice hybrids for various quantitative characters

Character	Days to 50 per cent flowering	Plant height (cm)	Panicle length (cm)	No. of productive tillers/plant	No. of filled grains/ panicle	No. of chaffy grains/panicle	1000-grain weight (g)	Grain yield(t/ha)
1. DRRH-2	82.9	85.0	25.22	11.67	134.0	24.4	23.89	7.92
2. PA 6129	80.3	92.2	23.78	9.44	120.2	12.9	23.59	7.45
3. Sahyadri-2	82.3	83.7	25.33	9.67	84.4	18.4	23.38	7.74
4. Sahyadri-4	89.8	89.5	26.11	9.67	67.2	15.5	24.90	7.69
5. Pusa RH-10	89.7	91.1	26.78	10.33	92.9	12.3	25.78	8.04
6. Indirasona	102.0	106.8	26.33	9.67	94.6	24.4	25.62	7.56
7. GK 5003	100.2	97.4	26.33	8.67	124.8	6.0	20.74	7.85
8. PSD-3	103.4	96.8	24.89	8.33	96.9	7.3	26.69	7.47
9. Sahyadri-3	96.0	92.7	27.78	9.00	80.5	30.3	26.32	7.63
10. PA 6201	95.1	100.8	25.89	9.33	113.9	25.0	21.84	7.59
11. HSD-1	102.4	92.6	27.11	9.22	121.2	25.6	28.35	7.37
12. PA 6444	103.2	103.3	26.33	8.44	159.3	30.2	23.75	7.29
13. Suruchi	102.2	98.7	25.56	7.44	92.2	20.0	19.14	7.25
14. JKRH-2000	100.4	86.5	25.78	10.67	136.2	27.8	23.25	7.66
15. US 312	102.9	101.6	27.22	10.00	133.4	9.1	21.39	7.70
16. CORH-3	77.4	98.0	24.67	8.11	85.9	11.8	22.31	7.64
17. KRH-2	100.7	98.9	25.89	11.33	123.9	30.0	22.89	7.90
18. Sahyadri-1	107.8	95.4	24.89	10.22	89.6	11.5	25.94	7.89
19. PHB-71	106.9	99.4	25.67	8.66	140.8	20.4	25.75	7.39
20. CRHR-5	103.4	115.3	27.11	8.33	152.5	21.7	24.27	7.15
21. CRHR-7	101.7	116.9	29.56	6.67	150.3	38.8	26.40	6.93
Mean	**96.7**	**97.3**	**26.11**	**9.28**	**114.0**	**20.2**	**24.10**	**22.98**
C. V.	1.84	5.68	3.00	13.04	5.37	9.74	2.32	4.40
S.E.	1.03	3.19	0.45	0.70	3.53	1.13	0.32	0.58
C.D. 5per cent	2.93	9.12	1.29	1.99	10.10	3.24	0.92	1.67

Table 3: Mean performance of popular rice hybrids for various qualitative characters

Character	Milling per cent	Head rice recovery per cent	Kernel Length (mm)	Kernel Breadth (mm)	L/B Ratio	Volume expansion ratio	Water uptake (ml)	Alkali spreading value	Amylose content (per cent)	Gel consistency (mm)
1. DRRH-2 (LS)	72.2	65.4	7.05	2.01	3.50	5.60	285.0	4.47	20.93	47.00
2. PA 6129 (LB)	72.3	67.5	6.00	2.21	2.72	4.70	320.0	6.94	20.43	49.00
3. Sahyadri-2 (SB)	70.2	64.9	5.47	2.17	2.52	4.10	315.0	7.01	22.34	50.00
4. Sahyadri-4 (LS)	71.6	**63.3**	7.01	2.09	3.36	4.10	325.0	7.00	23.48	41.00
5. Pusa RH-10 (LS)	72.4	68.4	7.91	1.90	4.16	4.60	380.0	6.07	20.05	51.00
6. Indirasona (LS)	70.4	**61.5**	6.85	2.01	3.41	4.40	295.0	5.06	24.54	71.00
7. GK 5003 (MS)	72.0	63.6	5.90	2.03	2.91	5.00	280.0	4.69	21.28	56.00
8. PSD-3 (LS)	72.4	67.9	7.04	2.07	3.41	4.10	345.0	7.00	20.82	60.00
9. Sahyadri-3 (LS)	72.2	65.2	7.41	2.07	3.58	4.40	290.0	5.61	18.95	63.00
10. PA 6201 (LS)	73.2	69.9	6.05	2.08	2.91	5.60	315.0	4.58	23.16	65.00
11. HSD-1 (LB)	71.9	**60.7**	6.45	2.18	2.95	4.10	305.0	4.32	21.42	54.00
12. PA 6444 (LB)	73.5	70.9	6.26	2.17	2.89	4.20	305.0	5.17	21.25	60.00
13. Suruchi (MS)	71.2	70.6	5.43	2.03	2.68	4.50	285.0	5.98	23.22	37.00
14. JKRH-2000 (SB)	72.8	69.9	6.29	2.11	2.99	4.20	310.0	5.44	22.86	60.00
15. US 312 (MS)	70.4	68.3	5.61	2.06	2.73	5.60	315.0	4.68	21.68	52.00
16. CORH-3 (LS)	70.1	**56.9**	6.37	2.05	3.10	4.60	310.0	5.86	24.83	44.00
17. KRH-2 (LB)	72.2	65.6	6.21	2.14	2.90	4.20	290.0	4.08	20.87	75.00
18. Sahyadri-1 (LS)	73.3	67.3	6.69	2.14	3.12	5.20	320.0	5.83	22.24	53.00
19. PHB-71 (LS)	72.6	68.0	6.44	2.00	3.21	4.60	300.0	5.66	22.45	51.00
20. CRHR-5 (LS)	71.7	67.5	6.57	2.07	3.19	5.00	310.0	5.90	22.34	60.00
21. CRHR-7 (LS)	72.0	68.0	6.55	2.08	3.16	4.20	300.0	6.92	25.66	64.00
Mean	**71.9**	**66.2**	**6.45**	**2.08**	**3.11**	**4.62**	**309.5**	**5.68**	**22.13**	**55.38**
C. V.	7.13	6.82	1.84	1.64	2.44	2.22	1.66	2.26	2.03	3.69
S.E.	2.96	2.60	0.07	0.02	0.04	0.06	2.96	0.07	0.26	1.18
C.D. 5%	-	7.45	0.20	0.06	0.12	0.17	8.45	0.21	0.74	3.37

Table 4: Mean performance of popular rice hybrids for various nutritional characters

Character	Protein content (per cent)	Iron (mg/100g)	Zinc (mg/100 g)
1. DRRH-2	9.79	12.58	4.38
2. PA 6129	8.86	8.95	4.26
3. Sahyadri-2	9.45	7.91	3.87
4. Sahyadri-4	8.80	10.48	4.30
5. Pusa RH-10	8.26	4.52	3.75
6. Indirasona	7.64	7.85	3.87
7. GK 5003	7.39	8.15	3.84
8. PSD-3	5.74	7.29	3.99
9. Sahyadri-3	7.67	4.13	3.07
10. PA 6201	7.86	7.76	4.59
11. HSD-1	7.84	6.76	3.17
12. PA 6444	7.15	6.11	3.72
13. Suruchi	7.93	6.87	3.35
14. JKRH-2000	7.42	7.15	3.55
15. US 312	7.47	6.62	3.76
16. CORH-3	8.10	7.37	3.53
17. KRH-2	6.49	4.39	3.43
18. Sahyadri-1	7.74	5.90	3.33
19. PHB-71	8.48	2.89	3.81
20. CRHR-5	8.59	2.96	3.15
21. CRHR-7	8.30	6.93	3.62
Mean	**7.95**	**6.84**	**3.73**
C. V.	12.92	28.62	4.42
S.E.	0.59	1.13	0.10