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Assessment of genetic variability for quantitative and physiological traits in some aromatic rice varieties under rain-fed ecosystem to sustain economic livelihood of farmers

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Abstract
The present investigation was undertaken to evaluate twelve aromatic rice genotypes including four check varieties namely Pratikshya, Hasanta, MTU-1010 and Sovini. The trial was performed in randomized block design with three replications. Studies were conducted on different yield attributing traits and physiological parameters to assess the availability and extent of genetic variability and the physiological and genetic basis of yield variations in the given population. Significant variation was seen among the test genotypes for all the traits except panicle number as was evident from the analysis of variance. Moderate to high degree of heritability estimates were observed for majority of the traits under study except for panicle number and leaf area index. The characters like grain yield per plant, plot yield and different other growth parameters exhibited high genotypic coefficient of variation coupled with high heritability and high genetic advance. Majority of the traits showed significant and positive associations between yield and yield components like grain yield per plant followed by harvest-index as most important traits which need due consideration at the time of selection. Thus, presence of several contrasting types of inter-relationships would simultaneously lead to improvement in others due to correlated responses. Path analysis studies suggested that selection would be quite efficient in improving yield and yield components in context of germplasm evaluated. The cultures like Geetanjali, Pratikshya, Khudrat, Ketakijoha, MTU-1010, Hasanta, CR-910, CR-907, Pooranbhog, were found to be promising.

Keywords: rice, aromatic, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance

Introduction

India is an agrarian economy with rice being the predominant source of dietary energy for majority of the population. About 61% of Indian farmers rely on rain-fed agriculture and rain-fed areas account for about 40% of rice production in the country. The eastern Indian states like Assam, Bihar, Odisha, West Bengal, Madhya Pradesh and Uttar Pradesh account for about 63.3% of the total rice cropped area in the country and yet produce only 48% of the total rice production in the nation. The lower average rice yields of eastern India may be attributed to the fact that about 80% of the area under rice in the eastern Indian states is rainfed and exposed to major abiotic stresses like drought, low soil fertility, flooding and water stagnation (Singh & Singh, 2000). Though rice accounts for about 30-50 percent of agricultural income for majority of farm households; farmers in rain-fed areas earn only 20-30 per cent from farm related activities. 84% of rural poor are inhabitants of high density tribal pockets of rainfed areas where high yielding technologies are seldom followed. Due to this, inspite of high minimum support price and surplus rice production in most of the years, the farmers fail to recover the cost of production in the existing market infrastructure leading to distress sale of rice due to poor market facilities. Aromatic or scented rice comprise a group of rice varieties which emit aroma on cooking with excellent cooking qualities and hold a prime position in Indian society. Besides the domestic market, the Basmati class of rice which are world renowned for their pleasant aroma, extra long superfine grain, extreme grain elongation and soft texture of cooked rice, also fetch premium price in the international markets. India became a major exporter of aromatic rice undeviatingly exporting 0.5 - 0.6 million tonnes of Basmati rice and 1.5 - 2.5 million tonnes of non-Basmati rice contributing Rs. 3000 - 4000 crores to the Indian economy. With the growing demand for quality aromatic rice in the international markets, improvement of basmati types became imperative and it was one of the highly emphasized area of research till date. Though, the improvement of the aromatic Basmati lines was given high regard, the enhancement of indigenous small and medium grained aromatic rice with small and round grains, white colour and fluffiness without much elongation on cooking and retaining a pleasant fragrance for a longer duration than the Basmati types were somewhat neglected due to lacking export value. Due to the non – retention of aroma in the traditional basmati cultivars, their areas of cultivation are limited especially in relatively warmer parts of Odisha and the adjoining Eastern-Indian states. However, the indigenously grown scented rice varieties of the state possess a very strong aroma under the prevailing warmer climate during grain maturity period in kharif season. It has been estimated that about one percent of the total area under rice cultivation i.e., 40-50 thousand hectares is put under aromatic rice cultivation with a production level of 30-35,000 tons of scented rice annually in the state. A survey conducted in the rural as well as urban markets revealed that the indigenous small and round grain aromatic rice varieties fetch a price range of Rs.60-65 per kg (about twice the price of normal non-aromatic rice). Unfortunately, systematic efforts haven't been taken so far, for the collection, characterization, evaluation and genetic improvement of this much-valued short grained scented rice of Odisha which can help all categories of farmers to earn greater returns and also the consumers to get quality scented rice at a reasonable cost. Also, it's higher yield may help in shaping our deformed economy during COVID – 19 disaster scenario and supporting small and marginal farmer's in getting higher returns from small chunks of cultivated lands. However, yield is a complex character influenced by a number of components traits most of which are under polygenic control. Thus, the identification and characterization of important components with respect to their relation with yield and other traits are useful tools for selection of high yielding varieties.

Materials And Methods

A total of 12 rice genotypes including 4 check varieties namely Pratikshya, Lalat, MTU-1010 and Sovini were collected from Central Rice Research Institute, Cuttack and OUAT, Bhubaneswar. The test genotypes were analyzed in randomized block design (RBD) with three replications as 8 row plots of 3.75 m length with a row to row distance of 20 cm and plant to plant distance of 15cm in lowland areas under rainfed ecosystem at the Crop Improvement Unit, GIETU, Gunupur during Kharif, 2019. Recommended crop management practices along with need based crop protection measures were followed to raise a normal, healthy plant stand. A total of twelve metric traits, i.e, plant height (PH) , days to 50% flowering (DF) , panicle length (PL) , panicle number (PN), flag leaf angle (FLA), Flag Leaf Area (FLAr), fertile grain number (FGN), fertility percentage (F%), 100 grain weight (100-GW), harvest index(HI), grain yield per plant (GYP) and plot yield (PY); and four physiological traits like Leaf Area ratio (LAR), Leaf Area Index (LAI), leaf area duration (LAD) and post flowering photosynthetic contribution to grain yield (PPCG) were measured during this study. Ten metric traits were recorded on five competitive plants selected randomly from the middle rows of each plot, whereas, the characters like plot yield and days to 50% flowering were recorded on whole plot basis. The data recorded were subjected to statistical analysis at 5% level of significance based on the sample mean of the various characters under observation. The analysis of variance was carried out separately for each trait following the procedures of randomized block design analysis (Panse and Shukhatme, 1954). On the basis of analysis of variance, the different variability parameters like mean, range, standard error of mean (SEm), standard error of difference (SEd), critical difference (CD), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h2 bs) and genetic advance (GA) were assessed. The genotypic and phenotypic correlations coefficients between character pairs were computed according to Robinson *et al.* (1951) [19], Johnson *et al.* (1955) and Al-Jibouri *et al.* (1958) [2].

Results And Discussion

The analysis of variance (Table 1) revealed significant variation among the test genotypes for all the traits except panicle number. The moderate to high magnitude of genetic variance for majority of traits except for days to flowering, plant height, panicle length, panicle number, fertility percentage, leaf area index, indicates that sufficient variation exists in the material studied. A perusal of the relative magnitude of variation amongst the varieties has been presented in Table 2.

Table 1: Analysis of variance (ANOVA) for various characters (Mean sum of squares)

Sl. No.	Characters	Source of Variation (df)		
		Replication (2)	Genotype (11)	Error (22)
1	Days to 50% flowering	2.09*	168.45**	0.42
2	Plant height (cm)	81.99**	208.75**	8.41
3	Panicle length (cm)	1.50	7.30**	0.64
4	Panicle number	0.72	2.84	1.79
5	Flag leaf angle (0^0),	4.05	106.23**	13.03
6	Flag Leaf Area (cm^2)	12.92	55.04**	9.25
7	No. of fertile grains / panicle	1378.89*	1697.96**	270.25
8	Fertility percentage	189.08*	294.98**	51.81
9	100- grain weight (g)	0.02	0.55**	0.02
10	Harvest index	47.87*	133.59**	14.13
11	Leaf Area ratio (cm^2/g)	1.25	380.90**	13.41
12	Leaf Area Index at 50% flowering	1.69	1.38	0.78
13	Leaf area duration (week)	6.18	14.28**	2.61
14	Post – flowering photosynthetic contribution to grain yield (%)	12.04	468.90**	15.14
15	Grain yield / plant (g)	36.01**	25.34**	6.16
16	Plot yield (q/ha)	119.13**	157.58**	4.93

*and ** Significant at 5% and 1% level of probability respectively.

Figures in parentheses indicate degrees of freedom (df) for corresponding sources of variation

Table 2: Mean, Range, and Coefficient of variation, Genotypic and phenotypic coefficient of variation, Heritability and Genetic advance estimates of various characters

Sl. No.	Characters	Mean	Range	CV (%)	GCV (%)	PCV (%)	h^2 (%)	GA (10%)	GA as percentage of mean
1	Days to 50% flowering	101.08	82.00-113.00	0.64	7.40	7.41	99.75	13.16	13.01
2	Plant height (cm)	95.12	79.44-110.00	3.05	8.59	8.77	95.97	14.09	14.81
3	Panicle length (cm)	23.29	20.32-27.87	3.44	6.40	6.70	91.19	2.50	10.75
4	Panicle number	8.70	8.00-13.42	15.37	6.83	11.20	37.17	0.64	7.32
5	Flag leaf angle (0^0),	25.75	12.88-30.91	14.02	21.65	23.11	87.73	9.19	35.69
6	Flag Leaf Area (cm^2)	19.92	15.20 – 28.43	15.27	19.61	21.50	83.18	6.27	31.48
7	No. of fertile grains / panicle	111.58	108.33-198.67	14.73	19.55	21.32	84.08	35.21	31.55
8	Fertility percentage	71.85	57.09-91.22	10.02	12.53	13.80	82.44	14.39	20.02
9	100- grain weight (g)	2.32	1.41-2.86	5.65	18.24	18.53	96.90	0.73	31.61
10	Harvest index	40.49	25.78-52.68	9.29	15.59	16.48	89.42	10.50	25.94
11	Leaf Area ratio (cm^2/g)	54.61	40.43-80.16	6.71	20.27	20.63	96.48	19.13	35.03
12	Leaf Area Index at 50% flowering	3.69	2.98-4.72	23.91	12.10	18.36	43.46	0.52	14.04
13	Leaf area duration (week)	9.71	7.56-11.98	16.62	20.30	22.45	81.74	3.14	32.31
14	Post – flowering photosynthetic contribution to grain yield (%)	60.27	36.03-76.33	6.46	20.41	20.74	96.77	21.29	35.33
15	Grain yield / plant (g)	12.07	6.87-17.06	20.55	20.94	24.07	75.70	3.87	32.07
16	Plot yield (q/ha)	43.37	26.42-52.06	5.12	16.45	16.71	96.87	12.36	28.49

The analysis of variance and range of variations concerning all the characters under study (Table 1 and 2) made it clear that adequate genetic variability exists in the material, thus providing massive scope for selection of genotype, which could possibly be exploited in the future breeding program for realization of higher and stabilized yields in rice. It is hardly surprising that enormous amount of variability is present for almost all the characters under study , as the materials under study ranged from mid-early to late maturity duration varieties, maintained wider range of genetic diversity in terms of plant type, maturity duration, grain characteristics, yielding ability and were proved capable of inducing variability for various traits. The comprehensive data on mean, range, CV, genotypic and phenotypic coefficient of variation for yield and its component traits along with physiological characters under study of twelve elected rice genotypes are presented (Table 2). The genotypic and phenotypic coefficient of variation in different traits maintained correspondence for most of the characters except for leaf area index, panicle number and grain yield per plant. Majority of the traits showed smaller difference between PCV and GCV indicating little influence of the environment, therefore selection on the basis of phenotypic value for most of the traits is expected to be effective. In general, phenotypic coefficient of variation was higher than the genotypic co-efficient of variation suggesting the influence of environmental factors. Particularly in leaf area index, panicle number and grain yield per plant the difference between the two estimates was fairly wide enough indicating the greater influence of environment on expression of these traits.

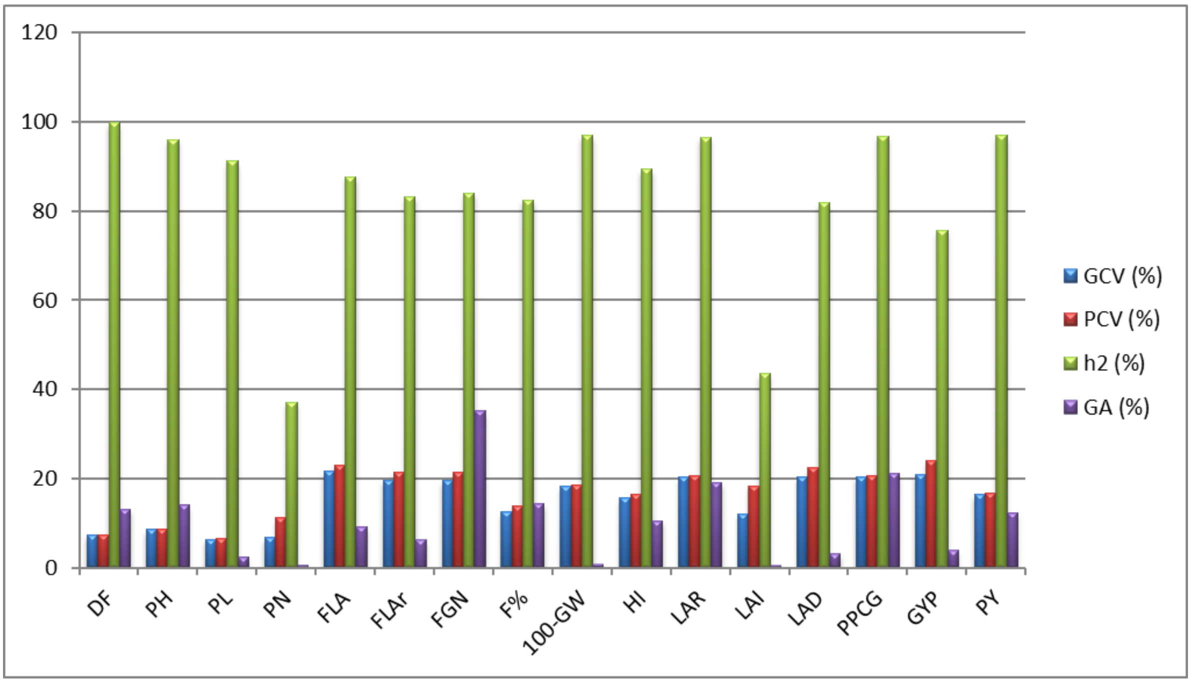

Fig 1: Cumulative representation of different genetic parameters GCV, PCV, Heritability and GA for 16 characters in rice

Both GCV and PCV were observed to be high (more than 15%) for traits like flag leaf angle, flag leaf area, number of fertile grains per panicle, 100-grain weight, harvest index, leaf area ratio, leaf area duration, postflowering photosynthetic contribution to grain yield, grain yield per plant and plot yield, suggesting that these traits are under the influence of genetic control. Hence these traits can be relied upon and simple selection can be practiced for further improvement. A review of literature from published reports on genetic variability indicates very inconsistent and contrasting results by Tuwar *et al.* (2013) [28], Singh *et al.* (2013) [24], Ganapati *et al.* (2014), Anis *et al.* (2016) [3], Mishu *et al.* (2016) [16], Rukmini *et al.* (2017) [20] and Goswami (2018) [9]. However, in majority of cases these estimates were found to be low for panicle length, panicle number, plant height, days to 50% flowering; moderate to high for fertile grains/panicle, 100-grain weight and harvest index. Moderate to high degree of approximate heritability values were observed for all the traits except for panicle number and leaf area index. Traits like flag leaf angle, flag leaf area, number of fertile grains per panicle, fertility percentage, 100-grain weight, harvest index, leaf area ratio, leaf weight ratio, leaf area duration, post-flowering photosynthetic contribution to grain yield, grain yield per plant and plot yield exhibited higher values of genetic advance. Moderate levels of genetic advance were recorded for days to 50% flowering, plant height, leaf area index. Lower values of genetic advance were recorded for panicle length and panicle number. Considering the importance of GCV value simultaneously with heritability and genetic advance in increasing the reliability and response of selection, efforts were made to indicate both heritability and genetic advance values along with GCV for various traits during the present investigation (Figure 1). The characters like flag leaf angle, flag leaf area, number of fertile grains per panicle, 100-grain weight, harvest index, leaf area ratio, leaf area duration, post-flowering photosynthetic contribution to grain yield, grain yield per plant and plot yield exhibited high GCV coupled with high heritability and high genetic advance indicates the preponderance of additive gene and hence selection based on phenotypic performance for these traits would be effective (Augustina *et al.* 2013; Sandhya *et al.* 2014; Savitha and Usha Kumari, 2015; Mishu *et al.* 2016; Islam *et al.* 2016, Srujana *et al.* 2017; and Ali *et al.* 2018) [4, 22, 16, 11, 26, 1] . The traits like flag leaf angle, flag leaf area, number of fertile grains per panicle, fertility percentage, 100-grain weight, harvest index, leaf area ratio, leaf area duration, post-flowering photosynthetic contribution to grain yield, grain yield per plant and plot yield exhibited high heritability coupled with high genetic advance indicates the preponderance of additive gene effect and hence selection based on phenotypic performance for these traits would be effective (Augustina *et al*., 2013, Sandhya *et al*. 2014; Mishu *et al*. 2016; Islam *et al*. 2016) [4, 22, 16, 11]. Days to 50% flowering, plant height, panicle length exhibited high heritability value and moderate to low genetic gain suggested that the inheritance of such traits might be under the control of both additive and non-additive gene effects. Therefore, selection of genotypes on the basis of phenotypic performance of the above traits may not be productive (Dhanwani *et al*. 2013; Haque *et al*. 2014; Sarwar *et al*. 2015; Kumar *et al*. 2015; Sala and Shanti, 2016; and Sumanth *et al*. 2017) [7, 10, 23, 14, 21, 27].

It was interesting to note that panicle number and leaf area index exhibited low heritability with low genetic gain suggested that inheritance of such traits might be under the control of non-additive gene effects. Therefore, selection of genotypes on the basis of phenotypic performance of the above traits may not be effective (Mulugeta *et al*., 2012) [17]

Mean Performance of Different Genotypes for Various Traits

The mean performance of different genotypes in regards to various characters including plot yield has been presented in Table 3. It was interesting to note that the yield of some of the aromatic lines under test was found to be comparable with the yield of the check varieties. The increase or decrease in plot yield was not associated with the corresponding increase or decrease of related traits under study. This discrepancy might have resulted due to undetected sampling errors during recording of observations. Although maximum care has been taken for recording data from a large number of samples for estimating the mean, yet the experimental bias in favor of single plants cannot be ruled out. As during the present investigation, the per se performance of the varieties is more meaningful, therefore, major emphasis was given to plot yield than other yield components estimated on per plant basis to identify the most promising cultures for their future use.

Out of twelve cultures evaluated during the present investigation, as many as nine cultures showing yield level of more than 45q/ha could be sorted out to be promising. The yield performance of these promising entries along with other metric traits is presented for ease of better comprehension (Table.4).

Table 3: Mean performance of different genotypes with respect to characters under study

Sl. No.	Variety	DF	PH (cm)	PL (cm)	PN	FLA (0^0)	FLAr (cm^2)	FGN	F%
1.	CR 907	107.33	89.37	20.39	8.00	27.54	20.24	132.89	89.91
2.	CR 909	104.00	96.53	24.79	8.33	29.24	15.28	125.33	84.58
3.	CR 910	109.00	92.63	23.43	8.67	28.69	20.05	138.89	68.02
4.	Lalbasna	102.33	91.80	20.76	9.00	30.59	22.12	108.89	60.79
5.	Lalsuper	95.33	92.03	22.90	10.33	17.99	22.20	126.00	63.40
6.	Khudrat	104.00	98.47	27.02	9.33	25.79	18.24	118.22	91.22
7.	Pooranbhog	102.67	93.07	24.57	9.33	23.42	15.77	198.00	81.94
8.	Ketakijoha (Aromatic check)	82.00	104.60	27.80	13.00	18.52	12.20	126.44	74.30
9.	Geetanjali (Aromatic check)	82.00	79.77	21.83	13.33	27.54	20.24	119.44	89.24
10.	MTU 1010 (Yield check)	106.67	90.70	23.67	8.33	24.97	23.90	151.11	69.46
11.	Pratikshya (Yield check)	105.33	99.11	23.18	9.77	12.88	18.18	131.67	61.70
12.	Hasanta (Yield check)	113.00	109.80	22.90	11.00	30.74	28.22	193.11	74.30

Table 3: Mean performance of different genotypes with respect to characters under study

Sl. No.	Variety	100-GW (g)	HI	LAI	LAR	LAD	PPCG	GYP	Plot Yield (q/ha)
1.	CR 907	2.07	45.83	3.73	51.92	8.33	76.33	13.59	45.88 (8)
2.	CR 909	2.48	34.52	3.78	44.76	10.31	58.26	10.16	44.48
3.	CR 910	2.27	44.49	2.67	66.45	8.12	36.53	9.05	46.00 (7)
4.	Lalbasna	2.09	25.78	3.99	49.87	9.69	74.68	10.66	26.42
5.	Lalsuper	1.96	43.85	4.72	47.02	11.43	59.28	6.87	29.98
6.	Khudrat	2.63	48.10	3.10	80.16	9.07	47.94	16.96	50.83 (3)
7.	Pooranbhog	1.41	40.91	3.89	42.18	10.07	72.31	9.78	45.20 (9)
8.	Ketakijoha (Aromatic check)	1.96	43.85	3.42	55.04	10.75	70.66	13.20	48.07 (4)
9.	Geetanjali (Aromatic check)	2.66	51.50	4.63	59.25	11.09	65.60	16.96	51.86 (1)
10.	MTU 1010 (Yield check)	2.43	43.21	3.10	80.16	9.07	47.94	15.47	47.67 (5)
11.	Pratikshya (Yield check)	2.13	45.83	4.03	49.81	9.51	61.25	17.06	51.71 (2)
12.	Hasanta (Yield check)	2.53	40.49	3.17	52.79	7.70	59.99	9.75	46.52 (6)

Table 4: Promising cultures in rice

Sl. No.	Variety	DF	PH (cm)	PN	FGN	F (%)	100 – GW (g)	PY (q/ha)
1.	Geetanjali	82.00	79.77	13.33	119.44	89.24	2.66	51.86
2.	Pratikshya	107.33	99.11	9.77	131.67	61.70	2.13	51.71
3.	Khudrat	104.00	98.47	9.33	118.22	91.22	2.63	50.83
4.	Ketakijoha	82.00	104.60	13.00	126.44	74.30	1.96	48.07
5.	MTU-1010	106.67	90.70	8.33	151.11	69.46	2.43	47.67
6.	Hasanta	113.00	109.80	11.00	193.11	74.30	2.53	46.52
7.	CR 910	109.00	92.63	8.67	138.89	68.02	2.27	46.00
8.	CR 907	107.33	89.37	8.00	132.89	89.91	2.07	45.88
9.	Pooranbhog	102.67	93.07	9.33	198.00	81.94	1.41	45.20

The most promising cultures identified during the present investigation were Geetanjali, Pratikshya, Khudrat, Ketakijoha, MTU-1010, Hasanta, CR-910, CR 907, Pooranbhog exhibiting a plot yield of more than 45q/ha. Out of these, Geetanjali, Khudrat, Ketakijoha, CR-910, CR-907 and Pooranbhog were aromatic varieties. The superior performance of Geetanjali, was due to higher tiller number, harvest index, LAI, grain yield per plant. Similarly, the high yield in Khudrat was due to superior expression of panicle number, fertility percentage, 100-grain weight, harvest index, LAR, LAD and grain yield per plant. The high yield in Pratikshya may be accredited to higher panicle number, number of fertile grains per panicle, harvest index, LAI, PPCG and grain yield per plant. The high yield in Ketakijoha was due to longer panicle length, higher panicle number, fertile grain number, harvest index, LAI, LAR, LAD, PPCG and grain yield per plant. The superior yield performance of MTU-1010 was due to longer panicle, greater flag leaf area, fertile grain number, 100 - grain weight, LAR, LAD and grain yield per plant. The superior yield performance of Hasanta was related to longer panicle length, higher tiller number, greater flag leaf angle, greater flag leaf area, higher fertile grain number, fertility percentage, 100-grain weight, harvest index, PPCG. Similarly, the high yield performance of CR-910, may be explained due to longer panicle length, higher flag leaf angle, flag leaf area, 100-grain weight. The high yield in case of CR-907 was related to high flag leaf angle, fertility percentage, harvest index, LAR, PPCG and grain yield per plant. The superior yield performance in case of Pooranbhog could be explained by longer panicle length, greater flag leaf angle, higher fertile grain number, fertility percentage, PPCG and grain yield per plant.

Conclusion

It was interesting to note that the high yield performance of promising aromatic cultures was accountable for the superior expression of various traits under study and no definite trend of relationship between the yield and other traits has been established. However, it is of vital importance to identify various quantitative and physiological traits associated with the promising genotypes, which could be exploited for realization of higher yield and greater character stability in rice. The trial, in general, revealed that higher yield, in the promising genotypes can be attributed to longer panicle length, higher panicle number, higher grain number with improved spikelet fertility, higher 100-grain weight, higher harvest index, LAI, LAD, post flowering contribution to grain yield and grain yield per plant. These characters may serve as the basis of selection for prediction and realization of higher yield, greater stability and better adaptation in rice. The complex breeding behavior and the role of environment in expression of characters like aroma and head recovery have made it difficult to combine all the desirable quality traits in a single genotype in desired norm and direction. Therefore, there is a need for basic research on breeding behaviour of quality traits including aroma that would help in making breeding strategy more precise to develop varieties that would be promising and would enhance farmer's income.

References

1. Ali EN, Rajeswari S, Saraswathi R, Jeyaprakash P. Genetic variability and character association for earliness, yield and its contributing traits in F2 population of rice (*Oryza sativa* L.), Electronic Journal of Plant Breeding. 2018;9(3):1163-1169.
2. Al-Jibouri HA, Miller PA, Robinson HF. Genotypic and environmental variances and covariances in a upland cotton cross of inter specific origin, Agronomy Journal. 1958;50:633-636.
3. Anis Gala, Sabagh Ayman EL, Ghareb Abdelfatah, Rewainy Ibrahim EL. Evaluation of promising lines in rice (*Oryza sativa* L.) to agronomic and genetic performance under Egyptian conditions, International Journal of Agronomy and Agricultural Research (IJAAR)

2016;8(3):52-57.
4. Augustina UA, Iwunor OP, Ijeoma OR. Heritability and character correlation among some rice genotypes for yield and yield components, Journal of Plant Breeding and Genetics 2013;1(2):73-84.
5. Babu VR, Badri J, Yadav PA, Bhadana VP, Priyanka C, Subba Rao LV et al. Genealogical atlas of high yielding rice varieties released in India, ICAR-IIRR, Hyderabad, Technical Book No. 86/2015, 2015, 198.
6. Das SR, Roy JK, Kar M, Das S. Aromatic rice of Orissa. In: Treaties on scented rice of Orissa. Kalyani Publishers. Edited by R. K. Singh and U. S. Singh, 2003, 365-375.
7. Dhanwani RK, Sarawgi AK, Solanki A, Tiwari JK. Genetic variability analysis for various yield attributing and quality traits in rice (*Oryza sativa* L.), The Bioscan. 2013;8(4):1403-1407.
8. Ganapati RK, Rasul MG, Mian MAK, Sarkar U. Genetic variability and character association of T-aman rice (*Oryza sativa* L), International Journal of Plant Biology & Research. 2015;2(2):1013.
9. Goswami A. Studies on genetic variability for yield and yield traits in rice (*Oryza sativa* L.), International Journal of Plant Sciences 2018;13(1):188-191.
10. Haque S, Pradhan SK, Anandan A, Singh ON. Morphometric diversity studies in rice genotypes for yield and yield attributing characters under drought, The International Journal of Science & Technoledge 2014;2(8):139-142.
11. Islam MA, Raffi SA, Hossain MA, Hasan AK. Analysis of genetic variability, heritability and genetic advance for yield and yield associated traits in some promising advanced lines of rice, Progressive Agriculture 2016;26:26-31.
12. Johnson HW, Robinson HP, Comstock ER. Estimates of genetic and environmental variability in soybeans, Agronomy Journal 2016;47:314-318.
13. Joshi RK, Behera L. Identification and differentiation of indigenous non Basmati aromatic rice genotypes of India using microsatellite markers. African Journal of Biotechnology 2006;6(4):348-354.
14. Kumar V, Kumar N, Suresh BG. Systematic evaluation of exotic rice germplasm for yield component characters and its grain yield, International Journal of Research Studies in Biosciences 2015;3(3):53-56.
15. Mackill DJ, Ismail AM, Singh US, Labios RV, Paris TR. Development and rapid adoption of submergence-tolerant (Sub1) rice varieties, Advances in Agronomy 2012;115:303-356.
16. Mishu Most. Fatema Kaosar, Rahman Md. Waliur, Azad Mohammad Abul Kalam, Biswas Bhabendra Kumar, et al. Study on Genetic Variability and Character Association of Aromatic Rice (*Oryza sativa* L.) Cultivars, International Journal of Plant & Soil Science 2016;9(1):1-8.
17. Mulugeta SA, Sentayeh, Kassahun B. Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice, Pl. Sci 2012;7:13-22.
18. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi 1954;(2):381.
19. Robinson HF, Comstock RE, Harvey PH. Genotypic and phenotypic correlations in corn and their implications in selection, Agronomy Journal 1951;43:282-287.
20. Rukmini DK, Chandra BS, Lingaiah N, Hari Y, Venkanna V. Analysis of variability, correlation and path coefficient studies for yield and quality traits in rice (*Oryza sativa* L.), Agri. Sci. Digest 2017;37(1):1-9.
21. Sala M, Shanthi P. Variability, heritability and genetic advance studies in F2 population of rice (*Oryza sativa* L.), International Journal of Forestry and Crop Improvement. 2016;7(1):57-60. ~ 920 ~ International Journal of Chemical Studies http://www.chemijournal.com
22. Sandhya, Lavanya GR, Babu GS, Kumar R, Rai SK, Devi B. Study of genetic variability and D2 analysis in elite rice genotypes, International Journal of Food, Agriculture and Veterinary Sciences 2014;4(2):12-16.
23. Sarwar G, Hossain MS, Harun-ur-rashid M, Parveen S. Assessment ofgenetic variability for agro-morphological important traits in aman rice, (*Oryza sativa* L.), International Journal of Applied Sciences and Biotechnology 2015;3(1):73-79.
24. Singh CM, Suresh G, Kumar B, Mehandi S. Analysis of Quantitative Variation and Selection criteria for yield improvement in exotic germplasm of upland rice (*Oryza sativa* L.), The Bioscan 2013;8(2):485-492.
25. Singh VP, Singh RK. editors. Rainfed Rice: A Sourcebook of Best Practices and Strategies in Eastern India. International Rice Research Institute 2000, 292.
26. Srujana G, Suresh BG, Lavanya GR, Ram BJ, Sumanth V. Studies on genetic variability, heritability and genetic advance for yield and quality components in rice (*Oryza sativa* L.), Journal of Pharmacognosy and Phytochemistry 2017;6(4):564-566.
27. Sumanth V, Suresh BG, Ram BJ, Srujana G. Estimation of genetic variability, heritability and genetic advance for grain yield components in rice (*Oryza sativa* L.), Journal of Pharmacognosy and Phytochemistry 2017;6(4):1437-1439.
28. Tuwar AK, Singh SK, Sharma A, Bhati PK. Appraisal of genetic variability for yield and its component characters in rice (*Oryza sativa* L.), Bio life 2013;1(3):84-89.