

Full Length research Paper

# Study of genetic divergence of Indigenous Aromatic Rice (*Oryza Sativa* L.): Potentials and consequences of on-farm management in traditional farming

Kailash Chandra Samal<sup>1</sup>, Gyana Ranjan Rout<sup>1\*</sup>, Satya Ranjan Das<sup>2</sup>

<sup>1</sup> Dept. of Agricultural Biotechnology, College of Agriculture,  
<sup>2</sup> Rice Research Station, Dept. of Plant Breeding and Genetics,  
Orissa University of Agriculture and Technology,  
Bhubaneswar -751003 Odisha, India.

Accepted January 7, 2014

The genus *Oryza* has 21 species of which *Oryza sativa* and *Oryza glaberrima* are the only cultivated species derived respectively from their perennial wild progenitors *Oryza rufipogon* and *Oryza longistaminata*. The diversification of *O. sativa* does not confined to these three sub-species only but develops into many more varietal groups through selection under diverse agroclimatic conditions, cultural practices and quality preferences. The present study implies that the divergences of 78 genotypes of aromatic rice including International check varieties, traditional Basumati and evolved Basumati on the basis of morphological, biochemical and genetical variations. The plant height among the genotypes ranged from 85.91cm to 159.67 cm whereas the panicles/plant ranged from 6.06 to 16.22 with the mean value of 9.56. The grain length is highest in all evolved Basmati genotypes followed by indigenous aromatic rice. The lowest grain length was found in 'Jala', 'Magura', 'Ratnasundari' and highest in 'Kusumabhog' and 'Gatia'. The lowest grain breadth was recorded in eight genotypes. The alkali spreading value (ASV) varied from 2.0 (IR-64) to 6.17 (Jalaka) indicating very wide variability. The present investigation also highlighted the inter and intra-population diversity among 78 rice genotypes with a view to assess the potentials and consequences of on-farm management of rice landraces in traditional farming.

**Key words:** Aromatic rice, physicochemical characters, cooking qualities, genetic divergence, germplasm conservation.

## INTRODUCTION

India is known as one of the mega centers of biodiversity and Jeypore tract in the Odisha state, India is considered as a centre of origin of rice. This area is home for a rich diversity of landraces. The genus *Oryza* has 21 species of which *Oryza sativa* (Asian cultivar) and *Oryza glaberrima* (African cultivar) are the only cultivated species derived respectively from their perennial wild progenitors *O. rufipogon* and *O. longistaminata* (Vaughan *et al.*, 2003). Further, the Asian cultivar *O. sativa* has undergone differentiation into three distinct eco-geographical subspecies, viz., indica, japonica (temperate

japonica) and javanica (tropical japonica) (Singh *et al.*, 2000a; Vaughan *et al.*, 2003). The diversification of *O. sativa* does not confine to these three sub-species only as subsequent studies reveal further differentiation of the cultivar species into many more varietal groups largely as a result of human selection over centuries suiting diverse agroclimatic conditions, cultural practices and varied quality preferences. On the basis of isozyme analysis that Asian cultivar to have differentiated into six varietal groups viz., Indica, Aus, Ashina, Rayada, Aromatic and Japonica (Glaszmann, 1987). Jeypore Tract, Odisha, India is considered to be a centre of origin of Aus ecotype of rice. The tract comprises of the Southern parts of Odisha and its adjoining areas Chhattisgarh and Jharkhand state inhabited by many tribal groups belonging to Proto-Australoid ethnic stock who speak

\*Corresponding author. E-mail:- [grout@rediffmail.com](mailto:grout@rediffmail.com)

austric languages. The Aus rice (small and medium grained aromatic rice) of the Jeypore tract constitutes small but a special group of rice, considered as of the best quality. Majority of the indigenous aromatic rice cultivars are small and medium grained (Singh *et al.* 2000a,b; Kovach *et al.*, 2009; Li *et al.*, 2010; Ray *et al.*, 2013). Since the time of civilization, thousands of locally adapted aromatic rice genotypes have been evolved as a consequence of natural and human selection. These landraces are the genetic reservoirs of useful genes.

With growing demand for aromatic rice in international market, high emphasis was placed till now on improvement of basmati types. The improvement of indigenous small and medium grained aromatic rice, which possesses outstanding quality like aroma, kernel elongation after cooking and taste were somewhat neglected as they lacked export value. Almost every country has its own set of aromatic rice that performs well in native areas. With respect to aroma, elongation on cooking and taste, short grained aromatic rice is known to be superior to Basmati types. Little attention has been paid for their characterization and conservation. As such, there is very little information available on physical and chemical parameters of rice grains of traditional non-basmati indigenous aromatic rice. The large scale spread of modern, high yielding rice varieties has replaced the traditional varieties especially in the irrigated rice ecosystem leading to reduced genetic base and thus increased genetic vulnerability (Das and Rout, 2006). Therefore, emphasis is now given for collection and conservation of these unique resources. Further, management of the indigenous aromatic rice genetic resources by way of characterization and documentation helps in protection of these unique bio-resources in accordance with the provision laid out in the (1992) meet on Conservation of Biological Diversity (CVT). In the present investigation, an effort was made to collect, characterize and preserve the aromatic rice germplasm so as to find out the fact for its wider adoption and commercialization in their adoptable ecosystem. The present investigation is to study the agro-morphological, cooking quality and biochemical characteristics of 78 rice genotypes of Eastern India and inter- and intra-population diversity with special reference to on-farm management.

## **MATERIALS AND METHODS**

### **Exploration and collection of aromatic rice genotypes**

Field survey was conducted to find out the aromatic rice varieties/landraces in different part of Eastern India during the year 2010-13. During the period of survey, local farmers were enquired primarily about native aromatic landraces. Based on this information, fine grid survey was conducted and fresh seed stocks for each cultivar were collected from fields, farmer's store, local

market and threshing floors. Along with this, farmer's opinions about peculiarities and shortcomings of the cultivars were also recorded. In addition, Basmati rice types, international check varieties and high yielding varieties were procured from Central Rice Research Institute, Cuttack, Odisha as well as National seed Corporation, New Delhi. The collected rice germplasm are conserved in Rice Research Station of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India. The field experiment was conducted in 2010 - 2012 wet seasons at the experimental farm of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India. One month old seedlings of seventy-eight rice genotypes were transplanted in Randomized Block Design with three replications and spacing (15 x 20cm) was maintained. The standard cultural practices were followed.

### **Characterization of germplasm**

Days to flowering have been recorded as soon as 50% of the panicles appeared. Number of tillers were recorded when grain has set and the total number of fertile panicles emerged by each plant. The plant height was measured from ground level to the top of the node (just below the panicle). Panicles were harvested at maturity and individually placed in an envelope. All panicles were taken out of the envelopes and air-dried at room temperature for one week. After that fertility of panicle, 1000 grain-weight and grain yield/plant were estimated. The grain and kernels characters measured through a slide calipers as per the DUS guideline (PPV and FRA, 2008). Ten measured (length and width) rice grains were taken into 20 ml glass test tube and soaked for 30 minutes in 5 ml of tap water. After soaking, the test tubes were put into the boil water for cooking. When the grains cooked properly test tubes were taken out from boiled water and water inside the test tubes removed. After that cooked grain were kept on a glass plate for few minutes to evaporate extra moisture and then measured the length and width of the cooked grain.

### **Alkali Spreading test**

Ten milled rice were taken in petriplate and 10 ml of potassium hydroxide (19.54 g of potassium hydroxide dissolve in one liter) was added to the sample. Samples were kept undisturbed for 24 hours in an incubator at 27-30°C (Juliano and Villareal, 1993). The degree of spreading is measured using a seven-point scale as follows: grain not affected (1); grain swollen (2); grain swollen, collar incomplete and narrow (3); grain swollen, collar complete and wide (4); grain split or segmented, collar complete and wide (5); grain dispersed, merging with collar (6) and grain completely dispersed and inter-

mingled (7). Alkali spreading value corresponds to gelatinization temperature as follows: 1 - 2 high (74.5 – 80 °C), 3- high intermediate, 4 & 5- intermediate (70 - 74°C), and 6 - 7, low (<70°C).

### Amylose content

100 mg of rice flour was placed in 100 ml volumetric flasks and added 1 mL of 95% (v/v) ethanol. Then, 9 mL of NaOH (40 g NaOH dissolved in one liter) was added and boiled in a water bath for 10 min at 70 °C. Samples were diluted to 100 mL distilled water. Later, 5 mL of sample suspension was added to 50 mL of distilled water in a 100 ml of flask and 1 mL of acetic acid (57.75 ml diluted in one liter water) was added to acidify the sample along with 1.5 mL of iodine solution (0.2%). Distill water was added to make the volume of 100 ml and the suspension was mixed well and kept for 20 min. As a control, NaOH solution was used for the calibration of spectrophotometer and samples were measured at 620 nm. Standard samples with known values of amylose content were used to draw the standard curve. The amylose content of different varieties was calculated in comparison with standard graph (Perez and Juliano, 1978; A.O.A.C., 1990).

### DATA ANALYSIS

Data were analyzed using SAS. 9.2 (2008) software and Microsoft Excel. The Pearson's correlation coefficients (r) analysis was conducted to find the relationship of different attributes. The analysis of variance (ANOVA) and estimation of correlation between characters was carried out separately for each of the characters. The significance of the treatment effect was judged with the help of 'F' test. The difference between significant treatments means were tested against C.D at 5%.

### RESULTS

The source of cultivation and category of rice genotypes was indicated in Table 1. Different yield attributing traits and physiological growth parameters were examined to assess the availability and extent of genetic variability, nature and magnitude of character association. The analysis of variance indicated that the significant differences among the genotypes tested in respect of all the characters studied indicating existence of considerable genetic variation among the genotypes. Estimation of mean, range, standard deviation, standard error and coefficient of variation (CV) of various agromorphological characteristics of 78 genotypes were analyzed (Table 2). The result indicates that the plant height among the genotypes ranged from 85.91 cm to 159.67 cm whereas the panicles/plant ranged from 5.56 to 14.22 with the mean value of 8.29. Similar variation

was also observed in respect of panicle length, grains/panicle, days to 50% flowering and yields in q/ha. The coefficient of variation (CV) was highest in case of grain yield (27.60%) followed by panicle number (22.02%), fertile grains (18.74%), plant height (12.83%) fertility percent (8.22%) whereas CV was lowest (4.61%) in case of days to 50% flowering indicating extent of variation present in different characters and the scope of improvement in these traits through appropriate selections methods. The standard error of mean in respect of different characters indicates the extent of uncontrolled variation found in the sample.

The physical character like grain shape, size and appearance are very important components and determine the consumers' acceptability. The grain length (GL) was highest in all evolved Basmati genotypes ranged from 4.90 ('Ratnasundari') to 12.41 (Taraori Basmati). The grain width (GW) was ranged from 1.80 ('Magura', 'Kalajauvan', 'Basumati', 'Basnasapuri') to 3.50 ('Kusumabhog' and 'Gatia'). The highest grain length-breadth ratio was observed in all Basumati genotypes viz. 'Geetanjali' (3.95), 'Karpurabasa' (4.54), 'Basmati-370' (4.77), 'Karnal local' (5.05), 'Taraori Basmati' (5.77), 'Pusa Basmati' (5.86). The lowest grain length-breadth ratio was observed in varieties viz. 'Kusumabhog'(1.69), 'Dholabankoi' (1.88), 'Bhasumati' (1.88), 'Mugajai' (1.90), 'Tulasiphoola' (1.97) and 'Gatia' (1.97) (Table 3).

On the basis of average length and breadth of the kernel, these were classified into different shape and size. The highest kernel length (KL) was found in 'Taraori Basmati' (8.85 mm) and lowest in the genotypes like 'Nuakalajeera', 'Kalajeera' and 'Kalajauvan' (3.10 mm). The higher kernel breadth (KB) was found in 'Gatia' (3.20) and lower in 'Nuakalajeera', 'Pusa Basmati-1', 'Karnal local', 'Jalaka', 'Jala', 'Magura', 'Nuadhusura', 'Jaiphulla', 'Basumati Bhog', 'Gangaballi', 'Chatianaki-1', 'Kalajauvan'. Higher Kernel length after cooking (KLAC>13 mm) was observed in 'Kalanamak' (13.06 mm), 'Basmati 370' (13.2 mm), 'Karnal local' (13.87 mm), 'Geetanjali' (15.45 mm), 'Taraori Basmati' (15.95 mm), 'Pusa Basmati 1' (16.45 mm). The highest Kernel elongation ratio (KER) was observed in 'Bhasumati', 'Geetanjali', 'Pimpudibasa-1', 'Pusa Basmati 1', 'Kalanamak' and 'Karnal local' (2.15). The alkali spreading value (ASV) varied from 2.0 ('IR64') to 'Karnal local' (7.00). The maximum starch content was observed in 'Pusa Basmati 1' (74.46) and minimum in 'Basnasapuri' (61.70). The amylose content varied from 15.45% ('Neelabati') to 25.25% ('Geetanjali' and 'Ganjeikalli') (Table 3). The result indicates that 'Basmati 370', 'Geetanjali', 'Pusa Basmati 1', 'Taraori Basmati', 'Karnal local', 'Dubraj', 'Kalajeera-1', 'Kalikati', 'Karpurabasa', 'Geetanjali', 'Krishnabhoga', 'Kalanamak', 'Neelabati', 'Kaminibhog-1', 'Kaminibhog-2', 'Pimpudibasa', 'Nuadhusura', 'Nuakalajeera', 'Chatianaki', 'Chatianaki-1', 'Jaiphulla', 'Sujata', 'Swarna', 'Pratikshya', 'IR36', 'IR 64' and 'IR 8' were found to be the promising genotypes with

**Table 1.** Different category of aromatic indigenous rice genotypes collected from different farmers field of Eastern Part of India.

Sr. no.	Genotype name	Source of collection / Pedigree	C*	Sr. no.	Genotype name	Source of collection /pedigree	C*
1	Acharmati	Puri	IA	40	Kusumabhog	Puri	IA
2	Baukunja	Cuttack	IA	41	Kukudajata	Koraput	IA
3	Baranamgomati	Cuttack	IA	42	Krishnabhoga	Koraput	IA
4	Basnasapuri	Puri	IA	43	Karpurakranti	Koraput	IA
5	Basnaparijat	Kandhamal	IA	44	Kalajeera-1	Denkanal	IA
6	Basumati	Kandhamal	IA	45	Lajakulibadan	Denkanal	IA
7	Basumati	Puri	IA	46	Mahulakuchi	Kalahandi	IA
8	Basumatidhan	Koraput	IA	47	Manasi-1	Ganjam	IA
9	Badsahbhog	Koraput	IA	48	Magura	Kalahandi	IA
10	Bishnubhog	Koraput	IA	49	Nuakalajeera	Puri	IA
11	Basumati Bhog	Koraput	IA	50	Nelidhan	Cuttack	IA
12	Chatianaki	Cuttack	IA	51	Neelabati	Balasore	IA
13	Chatianaki-1	Cuttack	IA	52	Nuadhusura	Cuttack	IA
14	Chinikamini	Kandhamal	IA	53	Nanu	Cuttack	IA
15	Dhobaluchi	Kandhamal	IA	54	Pimpudibasa	Keonjhar	IA
16	Dulhabhog	Keonjhar	IA	55	Pimpudibasa-1	keonjhar	IA
17	Dholabankoi	Cuttack	IA	56	Ratnasundari	Kalahandi	IA
18	Dhanaprasad	Koraput	IA	57	Sujata	Puri	IA
19	Dubraj	Koraput	IA	58	Srimula	Cuttack	IA
20	Dulhabhog-1	Puri	IA	59	Thakurbhog	Puri	IA
21	Danger Basumati	Koraput	IA	60	Tulasiphoola	Puri	IA
22	Gangaballi	Kandhamal	IA	61	Thakursuna	Cuttack	IA
23	Ganjam local-1	Ganjam	IA	62	Sheetabhog	Cuttack	IA
24	Ganjam local-2	Ganjam	IA	63	Gopalabhoga	Puri	IA
25	Ganjeikalli	Cuttack	IA	64	Tulasiphulla	Puri	IA
26	Gatia	Ganjam	IA	65	Bhasumati (P)	Puri	IA
27	Heerakani	Ganjam	IA	66	Saragadhulli	Puri	IA
28	Jala	Keonjhar	IA	67	Mugajai	Balangir	IA
29	Jalaka	Kandhamal	IA	68	Kalanamak	Feridabad,UP	IA
30	Jaiphulla	Koraput	IA	69	Basmati 370	Selection	TB
31	Kalajeera	Koraput	IA	70	Taraori Basmati	Selection from Basmati370	TB
32	Kalajauvan	Puri	IA	71	Karnal local	Selection	TB
33	Khosakani	Cuttack	IA	72	Pusa Basmati 1	Pusa150/Karnal Local	EB
34	Kaminibhog-1	Bolangir	IA	73	Geetanjali	Selection from Basmati370	EB
35	Kaminibhog-2	Bolangir	IA	74	IR8	Peta/Dee-geo-woo-gen	ICV
36	Kalikati	Kalahandi	IA	75	IR36	Multiple cross involving nine parents	ICV
37	Kalikati-1	Kalahandi	IA	76	IR64	IR. 5857-33-2-1/IR.2061-465-1-5-5	ICV
38	Kanakachampa	Bolangir	IA	77	Swarna	VasistaxMahsuri	HYV
39	Karpurabasa	Koraput	IA	78	Pratikshya	Swarna/IR 64	HYV

C\* - category of rice, IA- Indigenous non-basmati aromatic rice from Odisha, TB - Traditional Basmati, EB - Evolved Basmati, HYV - High Yielding Varieties, ICV - International Check Varieties,

**Table 2.** Agro-morphological characteristics of 78 genotypes of aromatic rice.

Sl. No.	Genotypes	Accession	Days to 50% flowering	Plant Height (cm)	Panicle length (cm)	No of panicles/plant	Fertile grains /panicle	Fertile grain (%)	Yield (q/ha)
1	Achanmati	AR-1	100.85	108.80	24.61	7.92	174.90	88.81	23.95
2	Baukunja	AR-2	99.09	119.55	25.45	7.65	92.60	84.79	24.89
3	Baranamgomati	AR-3	104.22	148.51	25.66	7.71	97.35	88.99	23.44
4	Basnasapuri	AR-4	104.16	145.90	25.21	8.69	158.72	80.30	23.44
5	Basnaparijat	AR-5	104.34	118.21	24.35	8.80	147.03	92.40	24.07
6	Basumati	AR-6	100.27	120.87	25.45	7.31	109.85	74.63	25.72
7	Basumati	AR-7	100.10	103.44	24.46	7.99	98.45	66.73	25.34
8	Basumatidhan	AR-8	91.26	122.49	22.89	6.20	116.13	88.88	30.86
9	Badsahbhog	AR-9	104.31	136.82	25.59	8.38	159.16	91.22	24.52
10	Bishnubhog	AR-10	100.44	130.19	22.92	7.34	195.02	96.63	24.16
11	Basumati Bhog	AR-11	102.51	105.10	24.53	8.57	83.00	65.36	24.73
12	Chatianaki	AR-12	98.40	147.97	30.20	6.48	126.19	72.00	24.45
13	Chatianaki-1	AR-13	99.19	141.18	29.09	7.42	123.08	72.04	19.04
14	Chinikamini	AR-14	100.97	126.56	28.29	7.93	119.99	81.38	22.36
15	Dhobaluchi	AR-15	91.44	104.01	19.32	6.61	123.53	84.58	24.46
16	Dulhabhog	AR-16	98.88	124.42	24.26	7.18	152.37	86.89	17.48
17	Dholabankoi	AR-17	102.92	127.37	27.43	7.50	159.07	86.84	25.07
18	Dhanaprasad	AR-18	101.01	159.67	25.99	7.82	123.41	73.18	21.39
19	Dubraj	AR-19	97.03	116.59	26.09	5.79	161.46	92.45	26.16
20	Dulhabhog-1	AR-20	100.93	126.17	23.73	6.93	141.32	85.89	20.78
21	D. Basumati	AR-21	101.96	126.25	23.79	6.84	135.46	83.17	19.13
22	Gangaballi	AR-22	97.44	126.39	25.59	8.38	139.90	88.74	22.22
23	Ganjam local-1	AR-23	98.37	123.37	24.43	7.16	137.12	87.45	21.59
24	Ganjam local-2	AR-24	105.33	130.91	24.63	7.27	128.94	87.49	21.54
25	Ganjeikalli	AR-25	104.92	112.27	23.32	5.70	191.80	89.45	24.48
26	Gatia	AR-26	107.11	137.11	23.90	7.59	135.15	82.35	18.57
27	Heerakani	AR-27	98.89	118.13	25.21	8.52	175.84	88.81	24.48
28	Jala	AR-28	103.14	115.80	25.49	8.99	136.83	76.63	19.20
29	Jalaka	AR-29	104.27	107.54	24.83	6.09	112.11	90.36	19.23
30	Jaiphulla	AR-30	102.58	105.19	21.20	5.68	107.49	84.16	18.71
31	Kalajeera	AR-31	104.56	130.25	26.24	10.42	123.19	90.81	26.62
32	Kalajauvan	AR-32	101.46	141.25	30.28	7.17	143.47	91.54	19.77
33	Khosakani	AR-33	104.32	128.27	25.92	6.96	174.87	88.05	28.12
34	Kaminibhog-1	AR-34	105.84	132.09	26.54	10.14	154.44	90.16	27.80
35	Kaminibhog-2	AR-35	103.91	129.91	25.76	7.01	145.84	88.74	19.59
36	Kalikati	AR-36	101.41	134.01	25.15	8.64	164.19	87.14	29.42
37	Kalikati-1	AR-37	102.72	149.09	28.42	8.16	153.88	69.67	26.59
38	Kanakachampa	AR-38	98.95	136.36	25.09	7.33	146.76	76.95	24.42
39	Karpurabasa	AR-39	103.41	137.88	26.70	7.29	133.96	81.28	18.62
40	Kusumabhog	AR-40	103.38	132.56	25.24	5.66	129.24	85.93	18.57

Table 2. Cont.

41	Kukudajata	AR-41	103.50	137.02	24.37	7.57	140.43	80.54	24.36
42	Krishnabhoga	AR-42	101.88	111.58	24.60	8.45	110.34	73.27	23.48
43	Karpurakranti	AR-43	102.82	131.76	24.97	9.87	107.84	84.67	27.40
44	Kalajeera-1	AR-44	100.07	125.99	25.58	6.94	125.85	86.52	20.58
45	Lajakulibadan	AR-45	103.21	136.89	25.45	7.87	150.22	81.18	18.60
46	Mahulakuchi	AR-46	97.40	122.59	24.03	6.73	134.68	83.64	18.51
47	Manasi	AR-47	101.50	115.78	24.73	7.80	117.35	88.45	24.29
48	Magura	AR-48	108.17	112.49	22.88	7.17	112.70	83.80	17.65
49	Nuakalajeera	AR-49	105.91	136.73	27.33	8.09	159.94	97.92	27.32
50	Nelidhan	AR-50	105.85	141.17	24.59	11.97	174.09	93.49	23.45
51	Neelabati	AR-51	108.49	110.66	25.92	8.83	160.59	86.41	24.41
52	Nuadhusura	AR-52	104.75	126.28	25.97	10.01	110.70	76.01	25.12
53	Nanu	AR-53	103.53	134.08	24.48	8.28	165.54	86.99	25.47
54	Pimpudibasa	AR-54	100.32	125.49	26.98	10.60	160.91	86.77	28.81
55	Pimpudibasa-1	AR-55	103.84	112.82	23.97	10.58	128.48	91.37	26.55
56	Ratnasundari	AR-56	104.89	118.18	25.83	9.87	165.45	92.64	19.20
57	Sujata	AR-57	96.64	115.47	25.65	8.36	140.68	87.56	24.37
58	Srimula	AR-58	105.54	126.09	25.43	7.96	131.62	77.11	17.06
59	Thakurbhog	AR-59	106.97	127.81	29.08	8.52	145.79	90.03	18.04
60	Tulasiphoola	AR-60	98.69	111.25	25.44	6.86	178.22	83.61	25.68
61	Thakursuna	AR-61	103.66	108.45	25.84	5.56	185.89	84.97	17.65
62	Sheetabhog	AR-62	103.09	121.13	24.05	7.02	145.46	84.74	23.95
63	Gopalabhoga	AR-63	102.23	122.44	25.22	7.36	125.59	78.04	24.99
64	Tulasiphulla	AR-64	98.51	111.19	23.79	7.68	108.05	80.05	22.61
65	Bhasumati (P)	AR-65	100.36	104.24	24.59	7.66	102.95	66.13	23.95
66	Saragadhulli	AR-66	103.23	129.58	24.84	8.51	165.87	82.77	20.72
67	Mugajai	AR-67	106.73	139.18	23.80	7.90	136.92	84.18	20.62
68	Kalanamak	AR-68	101.14	142.18	24.81	8.02	135.42	79.84	18.04
69	Basmati 370	AR-69	115.60	140.46	23.58	7.93	112.25	85.23	25.50
70	T. Basmati	AR-70	112.48	138.55	26.26	8.54	145.83	79.87	28.78
71	Karnal local	AR-71	109.65	134.23	23.90	10.12	154.98	80.19	27.40
72	Pusa Basmati 1	AR-72	108.81	92.97	27.00	10.31	154.15	90.12	32.45
73	Geetanjali	AR-73	102.30	116.80	26.42	10.46	145.18	90.12	30.25
74	IR8	AR-74	100.78	87.44	26.75	12.01	165.20	91.45	45.40
75	IR36	AR-75	91.65	89.00	27.12	12.93	194.16	92.07	46.80
76	IR64	AR-76	88.75	87.28	26.82	13.87	198.05	90.45	47.50
77	Swarna	AR-77	118.80	87.70	25.45	12.74	178.92	90.57	47.98
78	Pratikshya	AR-78	106.06	85.91	25.46	14.22	201.40	87.92	48.20
	Mean		102.49	123.17	25.34	8.29	142.45	84.53	24.85
	Max		118.80	159.67	30.28	14.22	201.40	97.92	48.20

**Table 2.** Cont.

Min	88.75	85.91	19.32	5.56	83.00	65.36	17.06
Sd	4.72	15.80	1.74	1.82	26.70	6.94	6.86
CV (%)	4.61	12.83	6.86	22.02	18.74	8.22	27.60
Se	0.53	1.79	0.20	0.21	3.02	0.79	0.78

**Table 3.** Physical characteristics and cooking qualities of aromatic indigenous rice genotypes.

S. N.	Genotypes	Accession	1000G W	GL	GB	G-L/B	KL	KB	K-L/B	KLAC	KE R	AS V	STAR CH (%)	AMY%
1	Acharmati	AR-1	17.00	7.15	2.98	2.40	5.08	1.98	2.57	8.78	1.73	4.67	70.12	22.12
2	Baukunja	AR-2	15.30	6.78	2.84	2.39	5.12	2.14	2.39	7.94	1.55	5.33	69.58	21.45
3	Baranamgomati	AR-3	19.80	7.10	3.40	2.09	5.10	2.10	2.43	8.62	1.69	5.67	71.20	20.48
4	Basnasapuri	AR-4	11.00	5.80	1.80	3.22	4.80	1.90	2.53	7.63	1.59	5.50	61.70	18.45
5	Basnaparijat	AR-5	11.10	6.10	2.10	2.90	4.80	1.90	2.53	6.19	1.29	4.33	69.20	19.25
6	Basumati	AR-6	11.80	5.60	1.80	3.11	4.50	2.10	2.14	8.01	1.78	4.50	68.50	18.47
7	Basumati	AR-7	16.90	6.16	2.16	2.85	4.66	2.00	2.33	8.06	1.73	4.67	71.45	20.14
8	Basumatidhan	AR-8	12.80	6.10	2.10	2.90	4.10	2.20	1.86	6.64	1.62	4.33	71.30	20.78
9	Badsahbhog	AR-9	11.50	6.66	2.33	2.86	4.33	2.00	2.17	6.84	1.58	4.67	72.25	21.78
10	Bishnubhog	AR-10	13.30	7.00	2.83	2.47	4.83	2.00	2.42	7.05	1.46	5.13	69.25	20.78
11	Basumati Bhog	AR-11	17.20	6.80	1.90	3.58	4.10	1.50	2.73	6.64	1.62	4.67	72.80	18.45
12	Chatianaki	AR-12	12.80	6.66	2.50	2.66	4.83	2.33	2.07	8.69	1.80	4.13	69.10	17.48
13	Chatianaki-1	AR-13	12.50	6.30	2.80	2.25	4.90	1.50	3.27	8.87	1.81	4.17	70.12	17.89
14	Chinikamini	AR-14	12.30	6.00	3.00	2.00	4.00	2.50	1.60	7.84	1.96	4.67	70.28	18.45
15	Dhobaluchi	AR-15	23.40	5.90	2.90	2.03	3.90	2.50	1.56	6.20	1.59	4.17	68.30	19.98
16	Dulhabhog	AR-16	18.40	5.10	1.90	2.68	4.20	1.90	2.21	7.52	1.79	4.17	68.90	20.45
17	Dholabankoi	AR-17	12.40	6.20	3.30	1.88	4.50	2.30	1.96	7.29	1.62	4.67	69.40	21.45
18	Dhanaprasad	AR-18	14.50	7.66	2.16	3.55	6.00	2.00	3.00	7.74	1.29	5.00	68.45	18.96
19	Dubraj	AR-19	15.60	8.20	2.30	3.57	6.10	2.00	3.05	11.96	1.96	3.67	72.60	16.48
20	Dulhabhog-1	AR-20	18.90	6.00	2.50	2.40	4.33	2.16	2.00	8.18	1.89	3.13	70.29	18.45
21	D. Basumati	AR-21	15.60	5.90	2.10	2.81	4.50	1.80	2.50	7.61	1.69	5.67	68.30	17.45
22	Gangaballi	AR-22	11.60	5.90	1.90	3.11	4.20	1.50	2.80	6.01	1.43	6.00	69.30	21.45
23	Ganjam local-1	AR-23	11.80	6.10	2.90	2.10	4.20	2.30	1.83	7.27	1.73	3.67	71.70	18.74
24	Ganjam local-2	AR-24	13.90	5.90	1.90	3.11	4.10	1.60	2.56	7.13	1.74	4.13	70.70	22.45
25	Ganjeikalli	AR-25	15.50	6.90	3.30	2.09	4.20	3.10	1.35	6.26	1.49	6.00	72.90	25.25
26	Gatia	AR-26	18.00	6.90	3.50	1.97	4.10	3.20	1.28	6.27	1.53	5.67	69.40	24.5

**Table 3.** Cont.

27	Heerakani	AR-27	11.00	5.90	2.50	2.36	4.50	2.20	2.05	7.11	1.58	5.13	68.20	23.78
28	Jala	AR-28	11.60	4.90	2.00	2.45	3.90	1.50	2.60	5.93	1.52	5.67	66.50	22.4
29	Jalaka	AR-29	14.20	5.10	1.90	2.68	4.10	1.40	2.93	6.52	1.59	6.17	66.37	21.78
30	Jaiphulla	AR-30	19.20	5.90	1.90	3.11	4.10	1.50	2.73	7.42	1.81	3.13	72.60	17.75
31	Kalajeera	AR-31	14.40	5.20	2.10	2.48	3.10	1.70	1.82	5.27	1.70	3.67	68.50	16.28
32	Kalajauvan	AR-32	13.50	5.10	1.80	2.83	3.10	1.60	1.94	4.90	1.58	5.33	71.40	20.46
33	Khosakani	AR-33	13.90	7.10	3.10	2.29	5.10	2.50	2.04	7.75	1.52	5.67	72.60	21.98
34	Kaminibhog-1	AR-34	12.20	6.10	2.90	2.10	5.10	2.50	2.04	9.28	1.82	5.35	72.80	17.48
35	Kaminibhog-2	AR-35	11.90	6.90	2.50	2.76	6.10	2.00	3.05	10.61	1.74	4.67	72.20	17.24
36	Kalikati	AR-36	10.90	8.10	3.20	2.53	6.10	2.50	2.44	10.98	1.80	5.13	69.60	20.45
37	Kalikati-1	AR-37	11.20	6.20	2.80	2.21	5.50	2.50	2.20	9.79	1.78	5.00	68.90	21.14
38	Kanakachampa	AR-38	12.10	7.10	2.90	2.45	4.10	2.50	1.64	6.93	1.69	5.67	70.26	21.54
39	Karpurabasa	AR-39	12.30	9.80	2.16	4.54	7.00	2.00	3.50	11.13	1.59	5.83	72.45	20.45
40	Kusumabhog	AR-40	17.40	5.90	3.50	1.69	4.20	2.50	1.68	6.72	1.60	5.67	68.75	21.56
41	Kukudajata	AR-41	12.40	6.00	3.00	2.00	4.66	2.33	2.00	7.13	1.53	6.13	70.54	20.45
42	Krishnabhoga	AR-42	13.40	6.90	3.10	2.23	5.10	2.20	2.32	10.00	1.96	5.13	69.70	17.45
43	Karpurakranti	AR-43	13.60	6.90	2.30	3.00	4.20	2.30	1.83	7.35	1.75	5.67	69.30	21.45
44	Kalajeera-1	AR-44	13.90	7.00	3.00	2.33	5.00	2.00	2.50	9.00	1.80	4.67	73.25	16.25
45	Lajakulibadan	AR-45	12.50	6.00	3.00	2.00	4.33	2.16	2.00	7.01	1.62	4.78	69.58	20.45
46	Mahulakuchi	AR-46	12.10	6.66	2.50	2.66	4.66	2.00	2.33	7.83	1.68	6.13	69.47	21.86
47	Manasi-1	AR-47	13.20	7.10	2.40	2.96	4.10	2.00	2.05	6.52	1.59	5.67	70.00	20.45
48	Magura	AR-48	17.60	4.90	1.80	2.72	4.10	1.50	2.73	6.23	1.52	5.50	68.45	24.56
49	Nuakalajeera	AR-49	11.00	5.10	2.20	2.32	3.10	1.20	2.58	5.24	1.69	4.13	71.30	16.48
50	Nelidhan	AR-50	12.30	6.33	2.50	2.53	4.60	2.00	2.30	8.23	1.79	4.67	68.95	18.65
51	Neelabati	AR-51	14.00	7.33	3.00	2.44	5.16	2.66	1.94	9.44	1.83	3.67	73.45	15.45
52	Nuadhusura	AR-52	15.90	5.80	1.90	3.05	4.10	1.50	2.73	8.12	1.98	4.67	71.40	16.98
53	Nanu	AR-53	11.00	6.23	2.45	2.54	4.57	2.45	1.87	6.95	1.52	3.67	69.45	24.56
54	Pimpudibasa	AR-54	13.30	5.10	2.20	2.32	4.89	2.18	2.24	9.78	2.00	4.50	70.25	15.89
55	Pimpudibasa-1	AR-55	14.10	6.78	2.58	2.63	4.42	2.14	2.07	9.24	2.09	4.67	68.12	15.78
56	Ratnasundari	AR-56	13.40	4.90	2.10	2.33	3.50	1.80	1.94	5.95	1.70	4.67	71.50	19.78
57	Sujata	AR-57	14.10	8.20	2.10	3.90	5.90	1.80	3.28	9.56	1.62	3.50	72.70	19.45
58	Srimula	AR-58	11.10	7.45	2.85	2.61	5.78	2.45	2.36	8.84	1.53	4.67	69.40	24.12
59	Thakurbhog	AR-59	12.90	6.10	2.80	2.18	5.20	2.50	2.08	9.00	1.73	2.67	68.70	23.46
60	Tulasiphoola	AR-60	12.40	6.10	3.10	1.97	4.20	2.30	1.83	7.35	1.75	4.13	73.45	16.01
61	Thakursuna	AR-61	11.50	6.66	2.50	2.66	4.66	2.33	2.00	7.92	1.70	5.67	69.85	21.58



Table 3. Cont.

62	Sheetabhog	AR-62	10.70	6.20	2.30	2.70	5.50	1.90	2.89	8.36	1.52	5.67	68.30	18.65
63	Gopalabhoga	AR-63	11.50	6.20	3.10	2.00	4.20	2.50	1.68	7.27	1.73	4.68	71.50	22.36
64	Tulasiphulla	AR-64	13.70	6.30	2.50	2.52	4.10	2.30	1.78	7.71	1.88	4.68	69.70	16.24
65	Bhasumati (P)	AR-65	16.90	6.40	3.40	1.88	4.50	2.50	1.80	9.23	2.05	4.33	71.10	15.86
66	Saragadhulli	AR-66	11.80	5.90	2.90	2.03	3.90	2.30	1.70	6.08	1.56	5.67	72.60	19.65
67	Mugajai	AR-67	11.60	5.90	3.10	1.90	4.10	2.30	1.78	6.23	1.52	5.33	71.40	23.56
68	Kalanamak	AR-68	20.50	8.00	2.66	3.01	6.16	2.16	2.85	13.06	2.12	3.54	74.25	15.64
69	Basmati 370	AR-69	20.12	9.58	2.01	4.77	6.94	1.95	3.56	13.2	1.90	3.00	71.26	17.85
70	T. Basmati	AR-70	20.45	12.41	2.15	5.77	8.85	1.92	4.61	15.95	1.80	3.00	72.45	15.85
71	Kamal local	AR-71	18.15	10.86	2.15	5.05	6.45	1.35	4.78	13.87	2.15	3.12	70.25	17.98
72	Pusa Basmati 1	AR-72	18.90	10.78	1.84	5.86	7.80	1.28	6.09	16.45	2.11	2.86	74.46	17.54
73	Geetanjali	AR-73	19.45	9.12	2.31	3.95	7.47	2.39	3.13	15.45	2.07	5.00	72.14	25.25
74	IR8	AR-74	30.30	8.12	2.61	3.11	6.54	2.05	3.19	10.98	1.68	2.10	70.12	19.78
75	IR36	AR-75	22.30	9.64	2.48	3.89	6.84	1.84	3.72	11.65	1.70	2.00	69.45	22.45
76	IR64	AR-76	26.30	9.72	2.48	3.92	6.74	1.81	3.72	11.37	1.69	2.00	68.95	22.4
77	Swarna	AR-77	30.12	5.45	2.15	2.53	3.95	1.98	1.99	6.12	1.55	2.00	73.24	21.45
78	Pratikshya	AR-78	31.25	7.12	2.78	2.56	6.12	2.14	2.86	8.14	1.33	2.00	72.54	19.45
	Mean		15.13	6.76	2.52	2.77	4.90	2.08	2.45	8.40	1.71	4.54	70.39	19.86
	Max		31.25	12.41	3.50	5.86	8.85	3.20	6.09	16.45	2.15	6.17	74.46	25.25
	Min		10.70	4.90	1.80	1.69	3.10	1.20	1.28	4.90	1.29	2.00	61.70	15.45
	Sd		4.55	1.45	0.48	0.83	1.10	0.39	0.78	2.41	0.19	1.09	2.03	2.59
	CV%		30.04	21.48	18.9	29.87	22.5	18.6	31.98	28.71	11.0	24.0	2.89	13.07
	Se		0.51	0.16	0.05	0.09	0.12	0.04	0.09	0.27	0.02	0.12	0.23	0.29

N.B. GL = Grain length; GB = Grain breadth; G-L/B = Grain length/breadth ratio; 100GW = 1000 Seed. Weight; KL = Kernel length; KB = Kernel breadth; K-L/B = Kernel length/breadth, KLAC = Kernel length after cooking; KER = Kernel elongation ratio; ASV = Alkali spreading value; Amy % = Amylose percentage.

regard to good quality and optimum yield potential (Table 4).

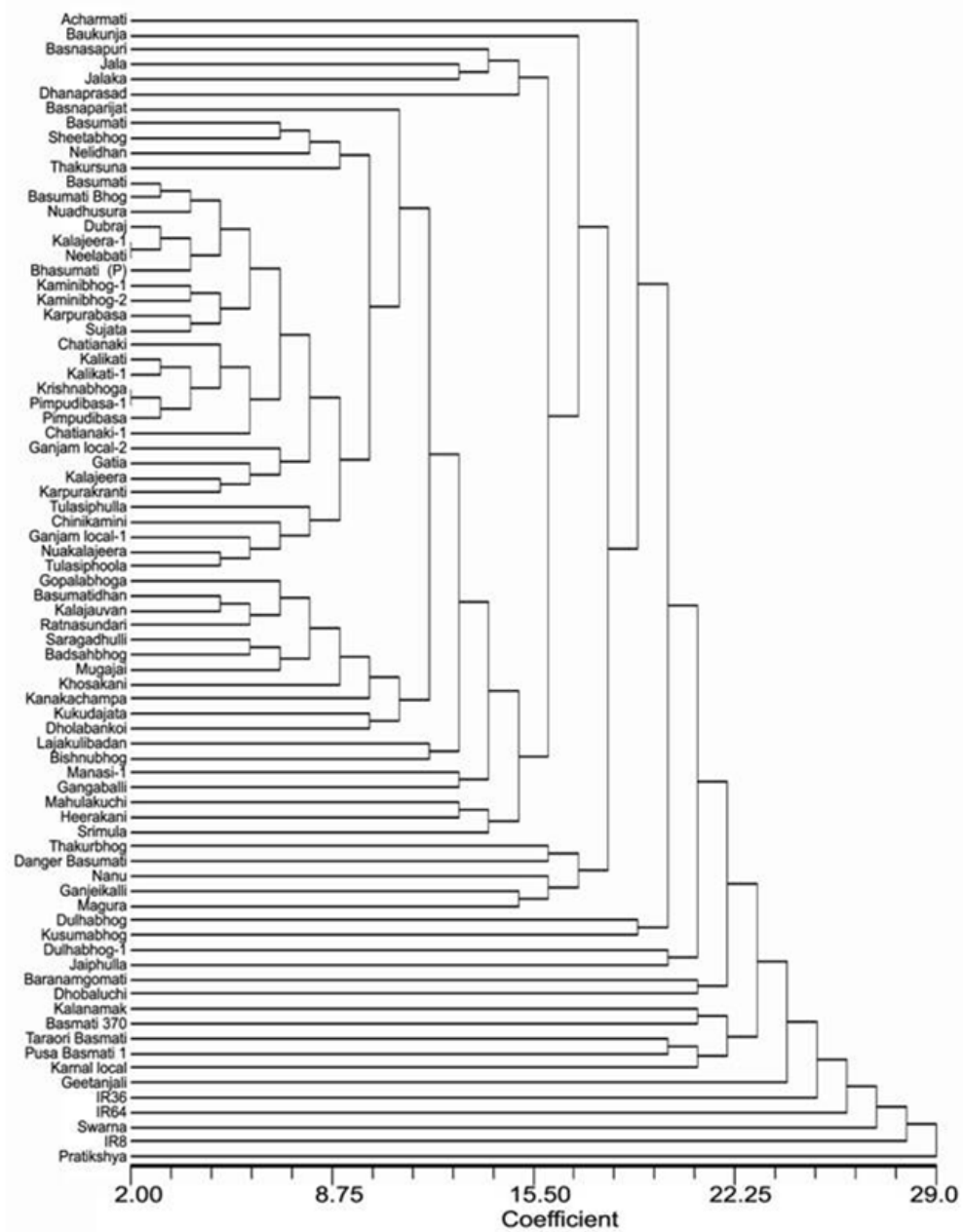
On the basis of cluster analyses, it was observed that the variety like 'Basmati-370' 'Kalanamak', 'Taraori Basumati' and 'Pusa Basumati-1' were making one cluster (Figure 1). All these varieties are evolved 'Basumati' categories. All the International check varieties like 'IR 36', 'IR 64', 'Swarna', 'IR 8' and 'Pratikshya' were also in same clusters with regard to morphological, kernel elongation ratio, alkali spreading value and amylose percentage characteristics. Similarly, the rice genotypes such as

'Kaminibhog-1' & 'Kaminibhog-2' were in one cluster and collected from same villages of Odisha. On the basis of agro-morphological traits analysis, it was indicated that the variety 'Acharmati' had 21% similarity with other 60 aromatic rice genotypes (Figure 1).

Pearson's correlation coefficient was computed among 12 quantitative traits and 7 agro-morphological traits among 78 varieties of aromatic rice/landraces was placed in Table 5a-b. Plant height was highly significant and positively correlated with most of traits such as days to flowering, number of grains per panicle, yield of plant and

**Table 4.** Agronomic attributes of the variety collected from different farmer's fields.

Characters	Value	Name of genotypes/landraces
Grain yield (%)	> 26.0q/ha	Basumatidhan, Dubraj, Geetanjali, IR36, IR64, IR8, Kalajeera, Kalikati, Kalikati-1, Kaminibhog-1, Karnal local, Karpurakranti, Khosakani, Nuakalajeera, Pimpudibasa, Pimpudibasa-1, Pratikshya, Pusa Basmati 1, Swarna, Taraori Basmati,
Fertility percentage	> 90.0 %	Badsabhog, Basnaparijat, Bishnubhog, Dubraj, Geetanjali, IR36, IR64, IR8, Jalaka, Kalajauvan, Kalajeera, Kaminibhog-1, Nelidhan, Nuakalajeera, Pimpudibasa-1, Pusa Basmati 1, Ratnasundari, Swarna, Thakurbhog
Panicle number / plant	> 10	Geetanjali, IR36, IR64, IR8, Kalajeera, Kaminibhog-1, Karnal local, Nelidhan, Nuadhusura, Pimpudibasa, Pimpudibasa-1, Pratikshya, Pusa Basmati 1, Swarna
Panicle length	> 26.0 cm	Chatianaki, Chatianaki-1, Chinikamini, Dholabankoi, Dubraj, Geetanjali, IR36, IR64, IR8, Kalajauvan, Kalajeera, Kalikati-1, Kaminibhog-1, Karpurabasa, Nuakalajeera, Pimpudibasa, Pusa Basmati 1, Taraori Basmati, Thakurbhog,
Number of grains/panicle	> 160	Achanmati, Bishnubhog, Dubraj, Ganjeikalli, Heerakani, IR36, IR64, IR8, Kalikati, Khosakani, Nanu, Neelabati, Nelidhan, Pimpudibasa, Pratikshya, Ratnasundari, Saragadhulli, Swarna, Thakursuna, Tulasiphoola,
1000 grain weight.	> 20.0 g	Basmati 370, Dhobaluchi, IR36, IR64, IR8, Kalanamak, Pratikshya, Swarna, Taraori Basmati,
Grain length (GL)	> 7 mm	Acharmati, Baranamgomati, Basmati 370, Bishnubhog, Dhanaprasad, Dubraj, Geetanjali, IR36, IR64, IR8, Kalajeera-1, Kalanamak, Kalikati, Kanakachampa, Karnal local, Karpurabasa, Khosakani, Manasi-1, Neelabati, Pratikshya, Pusa Basmati 1, Srimula, Sujata, Taraori Basmati
Grain breadth (GB)	< 2 mm	Basnasapuri, Basumati, Basumati Bhog, Dulhabhog, Gangaballi, Ganjam local-2, Jaiphulla, Jalaka, Kalajauvan, Magura, Nuadhusura, Pusa Basmati 1
Grain length/breadth (G-L/B)	> 3.5 mm	Dhanaprasad, Basmati 370, Basumati Bhog, Dubraj, Geetanjali, IR36, IR64, Karnal local, Karpurabasa, Pusa Basmati 1, Sujata, Taraori Basmati
Kernel length (KL)	> 6 mm	Basmati 370, Dhanaprasad, Dubraj, Geetanjali, IR36, IR64, IR8, Kalanamak, Kalikati, Kaminibhog-2, Karnal local, Karpurabasa, Pratikshya, Pusa Basmati 1, Taraori Basmati
Kernel breadth (KB)	< 1.8 mm	Basumati Bhog, Chatianaki-1, Danger Basumati, Gangaballi, Ganjam local-2, Jaiphulla, Jala, Jalaka, Kalajauvan, Kalajeera, Karnal local, Magura, Nuadhusura, Nuakalajeera, Pusa Basmati 1, Ratnasundari, Sujata
Kernel length/breadth (K-L/B)	> 3mm	Dhanaprasad, Basmati 370, Chatianaki-1, Dubraj, Geetanjali, IR36, IR64, IR8, Kaminibhog-2, Karnal local, Karpurabasa, Pusa Basmati 1, Sujata, Taraori Basmati,
Kernel length after cooking (KLAC)	> 9mm	Basmati 370, Bhasumati (P), Dubraj, Geetanjali, IR36, IR64, IR8, Kalajeera-1, Kalanamak, Kalikati, Kalikati-1, Kaminibhog-1, Kaminibhog-2, Karnal local, Karpurabasa, Krishnabhoga, Neelabati, Pimpudibasa, Pimpudibasa-1, Pusa Basmati 1, Sujata, Taraori Basmati, Thakurbhog,
Kernel elongation ratio (KER)	> 1.80	, Basmati 370, Bhasumati (P), Chatianaki, Chatianaki-1, Chinikamini, Dubraj, Dulhabhog-1, Geetanjali, Jaiphulla, Kalajeera-1, Kalanamak, Kalikati, Kaminibhog-1, Karnal local, Krishnabhoga, Neelabati, Nuadhusura, Pimpudibasa, Pimpudibasa-1, Pusa Basmati 1, Taraori Basmati, Tulasiphulla
Alkali spreading value (ASV)	3 -4.25	Basmati 370, Chatianaki, Dubraj, Dulhabhog-1, Ganjam local-1, Ganjam local-2, Jaiphulla, Kalajeera, Kalanamak, Nanu, Neelabati, Nuakalajeera, Sujata, Taraori Basmati, Tulasiphoola,
Amylose percentage (AMY %)	< 18%	Taraori Basmati, Basmati 370, Bhasumati (P), Chatianaki, Chatianaki-1, Danger Basumati, Dubraj, Jaiphulla, Kalajeera, Kalajeera-1, Kalanamak, Kaminibhog-1, Kaminibhog-2, Karnal local, Krishnabhoga, Neelabati, Nuadhusura, Nuakalajeera, Pimpudibasa, Pimpudibasa-1, Pusa Basmati 1, Tulasiphoola, Tulasiphulla



**Fig.1. Similarity Coefficient cluster analysis by using agromorphological characteristics of 78 rice genotypes/landrace of Eastern India**

panicle length. Yield of plant had highly significant and positively correlated with plant height and number of panicles and also significant with days to flowering. Amylose has a greater effect on the processing properties and eating quality. Amylose is directly correlated to hardness, whiteness and dullness of cooked

rice and volume expansion and water absorption during cooking. Varieties with low amylose content have a soft and sticky cooked texture while those with high amylose content have flaky and hard texture. The amylose content is negative correlated with slenderness (kernel length). Kernel elongation ratio has also positive correlation with

**Table 5a.** Correlation of different physical and cooking quality characteristics of aromatic indigenous rice genotypes.

	1000GW	GL	GB	G-L/B	KL	KB	K-L/B	KLAC	KER	ASV	STARCH	AMY%
GL	0.354	1.000	0.005	0.785	0.889	-0.027	0.735	0.844	0.266	-0.113	0.314	-0.043
GB	-0.046	0.005	1.000	-0.599	-0.042	0.743	-0.448	-0.051	-0.009	-0.060	0.151	-0.016
G-L/B	0.296	0.785	-0.599	1.000	0.718	-0.481	0.870	0.697	0.224	-0.035	0.172	-0.033
KL	0.356	0.889	-0.042	0.718	1.000	-0.028	0.768	0.912	0.228	-0.126	0.222	-0.035
KB	-0.098	-0.027	0.743	-0.481	-0.028	1.000	-0.610	-0.057	-0.050	-0.065	0.073	0.112
K-L/B	0.333	0.735	-0.448	0.870	0.768	-0.610	1.000	0.749	0.253	-0.026	0.154	-0.086
KLAC	0.317	0.844	-0.051	0.697	0.912	-0.057	0.749	1.000	0.600	-0.102	0.291	-0.072
KER	0.065	0.266	-0.009	0.224	0.228	-0.050	0.253	0.600	1.000	-0.031	0.240	-0.117
ASV	-0.225	-0.113	-0.060	-0.035	-0.126	-0.065	-0.026	-0.102	-0.031	1.000	-0.184	-0.053
STARCH	0.223	0.314	0.151	0.172	0.222	0.073	0.154	0.291	0.240	-0.184	1.000	-0.055
AMY%	-0.103	-0.043	-0.016	-0.033	-0.035	0.112	-0.086	-0.072	-0.117	-0.053	-0.055	1.000

GL = Grain length; GB = Grain breadth; G-L/B = Grain length/breadth ratio; 1000GW = 1000 Seed. Weight; KL = Kernel length; KB = Kernel Breadth ;K-L/B = Kernel length/breadth; KLAC = Kennel length after cooking; KER = Kernel elongation ratio; ASV = Alkali spreading value; Amy % = Amylose percentage.

**Table 5b.** Correlation of different agronomic characteristics of aromatic indigenous rice genotypes.

Characters	Days to flowering	50%	Plant Height (cm)	Panicle length (cm)	No panicles/plant	of Fertile grains per panicle	Fertile grain (%)	Yield (q/ha)
Plant Height (cm)	0.166		1.000	0.207	-0.373	-0.193	-0.162	0.551
Panicle length (cm)	0.031		0.207	1.000	0.230	0.169	-0.028	0.157
No of panicles/plant	0.135		-0.373	0.230	1.000	0.375	0.221	0.754
Fertile grains per panicle	0.021		-0.193	0.169	0.375	1.000	0.524	0.432
Fertile grain (%)	0.053		-0.162	-0.028	0.221	0.524	1.000	0.247
Yield (q/ha)	-0.051		-0.551	0.157	0.754	0.432	0.247	1.000

amylose content. Alkali spreading value, which is an indirect measure of gelatinization temperature, showed a negative association with amylose and starch content.

## DISCUSSION

Genetic assessment of germplasm is an important step for crop improvement program (Garris *et al.*, 2005; Choudhury *et al.*, 2013). Genetic diversity has been utilized and preserved partially during the process of domestication and cultivation; not even 15 percent of potential genetic diversity has been utilized in case of crop plants (FAO, 2002). Large number of valuable allelic having great economic importance is still unutilized. Genetic improvement of rice can be done through introgression of valuable genes/genomic regions from wild progenitors/ landraces/traditional varieties which are

presently grown in Eastern parts of India, one of the major domestication centers of rice. Some landraces and traditional varieties had been under cultivation by farmers since few decades, usually on the basis of practices inherited from their forefathers and easy availability of seeds. During the survey, the data indicate that the traditional varieties/landraces are preferred by the farmers due to their good taste, impressive cooking qualities and suitability for cultivation in particular agro-climatic regions. The genotypes like 'Kalajeera', 'Kaminibhog-1', 'Kaminibhog-2', 'Bishnubhog', 'Tulasiphulla', 'Krishnabhoga' and 'Karpurakranti' are well known to farmers because of their tolerance to drought prone environments and aroma. Surveys for aromatic rice varieties revealed that the some of the indigenous varieties/landraces had late maturity hence they require prolonged and consistent water supply. Many aromatic rice varieties/landraces were grown in hilly regions having

lower temperature, typical soil conditions and moisture with high aroma. In particular, the three districts of Odisha (Koraput, Bolangir and Kalahandi) were taken as the niche areas for aromatic rice cultivation.

In the present study showed that the traditional Basmati and a short grain aromatic rice varieties were collected and cultivated in the farmers field along with International check varieties by using both chemical fertilizers (Urea, Nitrogen, potassium and phosphorous) as well as traditional manures (Cow-dung, Vermicompost) for production and productivity. The aroma of aromatic rice became reduced when chemical fertilizers used in farmers field. Suwanarit *et al.* (1996) reported that the aroma and other physico-chemical characters were adversely affected by the application of nitrogen. On the morphological analysis, it was observed that the variety like 'Basmati-370', 'Kalanamak', 'Taraori Basumati' and 'Pusa Basumati-1' were making one cluster. The length and breadth of grains, grain length/breadth ratio, kernel length after cooking and kernel elongation ratio were very close with each other as compare with other traditional 'Basumati'. All the International check varieties like 'IR 36', 'IR 64', 'Swarna', 'IR 8' and 'Pratikshya' were in same clusters with regard to morphological, kernel elongation ratio, alkali spreading value and amylose percentage characteristics. The higher alkali spreading value (ASV) was ranged from 2 to 7.0. The starch content varied from 61.70 to 74.46. Vanaja and Babu (2003) reported that the quality and quantity of starch and gelatinization temperature strongly influence the cooking quality. The gelatinization temperature affects the water uptake, volume expansion ratio and linear kernel elongation (Vanaja and Babu, 2003). Juliano (1993) indicated that the amylose content is the major factor for eating quality. It determines the hardness or stickiness of cooked rice, cohesiveness, tenderness, colour of cooked rice. It is an indicator of volume expansion and water absorption during cooking as reported by Deyner *et al.*, (2001). Hien *et al.* (2007) reported that the morphological traits were useful for preliminary evaluation and used as general approach for assessing genetic diversity among aromatic rice cultivars. Considering the extent of variation in panicle length, fertile grains per panicle, grain morphology and yield performance in the present study can be used for assessment of diversity.

Cluster analysis of rice based on agro-morphological characteristics was reported by many researchers (Ghalain, 2006; Hien *et al.*, 2007; Naik *et al.*, 2006; Mathure *et al.*, 2010, 2011; Sarawgi *et al.*, 2012). Sarawgi and Bhisne (2007) reported that the separation of 'Kalanamak', 'Pimpudibasa' from Basmati types, while 'Basmati-370' further separated from 'Taraori Basumati' and 'Pusa Basumati-1' on the basis of agro-morphological and quality characters. The present study showed that the varieties like 'Kalanamak' and 'Basumati-370' are in same cluster on the basis of agronomical and quality characteristics. 'Taraori Basumati', 'Pusa Basumati-1'

and 'Karnal local' were in same clusters on the basis of agronomical characteristics. Pearson's correlation coefficients analysis showed a significant positive association of kernel length with length/breadth ratio, grain length, kernel elongation ratio and negative association with kernel breadth, alkali spreading value and amylose percentage. The kernel l/b ratio was found positively associated with grain length and kernel length. Among the agronomic traits, plant height exhibited significant positive correlation with length of panicle and negative correlation with number of panicles/plant, fertile grains per panicle and fertile grains percentage. Positive association of grain yield with productive tillers/plant was also studied by (Meenakshi *et al.*, 1999). The kernel length/breadth ratio was found to be positively associated with grain length/breadth and negatively associated with kernel and grain breadth. Kibria *et al.* (2008) reported that there were negative correlation between aroma and grains per panicle as well as grain yield. However, the present result indicate that grain yield has positive correlation with panicle length, number of panicles/plant, fertile grain per panicle, percentage of fertile grain and negative correlation with plant height. Total grain per panicle also exhibited a positive effect and correlation coefficient with grain yield per plant. Similar observation was reported by Kim *et al.*, (1999). Further, Golam *et al.* (2011) reported that the number of fertile tillers, grains/panicle, and fertile grain per panicle has the positive contribution to grain yield. They also reported that the yield contributing characters have used as potential breeding materials (Chakrabarty *et al.*, 2012).

In conclusion, the present study indicates that Eastern Part of India particularly Odisha and Chhattisgarh represents the massive diversity of aromatic rice germplasm including landraces. Morphophysical, biochemical and cooking characteristics were evaluated for 78 aromatic rice genotypes/landraces including International Check Varieties, traditional Basumati and evolved Basumati grown in the different agroclimatic regions of Odisha. Among the varieties, traditionally aromatic and evolved Basumati varieties of rice showed good morpho-physical and biochemical characteristics. The properties like kernel length after cooking was maximum in the genotypes like 'Dubaraj', 'Kalikati 1' & 2, 'Krishnabhog', 'Kalanamak', 'Torja Basumati', 'Basumati', 'Pusa Basumati 1', 'Geetanjali' as compare with International Check Varieties. The maximum amylose percentage value (~ 25%) was observed in the aromatic rice varieties like 'Geetanjali', 'Magura' and 'Ganjeikalli'. The study revealed that some of the aromatic rice varieties were with high grain quality, panicle length, fertile grains per panicle, number of panicles per plant, fertile grain percentage and yield performance were good source of valuable germplasm for breeding. The indigenous aromatic rice genotypes like 'Bishnubhog', 'Nuakalajeera' and 'Pimpudibasa-1', 'Thakurbhog', 'Kaminibhog-1', 'Kalajauvan', 'Kalajerra', 'Jalaka', 'Dubraj', 'Basnaparijat', 'Badsahbhog' showed high fertile grain

with high abiotic stress tolerance suitable for aromatic rice breeding.

## ACKNOWLEDGMENTS

The authors wish to acknowledge the Department of Agriculture, Govt. of Odisha for providing the financial assistance under Rastriya Krishi Vikash Yojana and Department of Agril. Biotechnology, College of Agriculture, Bhubaneswar, OUAT, India for providing the laboratory and field facility.

## REFERENCES

- A.O.A.C. (1990). Official Methods of Analysis. The Association of Official Analytical Chemists, 15<sup>th</sup> Edition, Arlington, West Virginia, Washington DC, USA, p. 1400.
- Chakrabarty SK, Joshi Monika A, Singh Y, Maity A, Vashisht V, Dadlani M (2012). Characterization and evaluation of variability in farmers' varieties of rice from West Bengal. *Ind. J. Genetics and Plant Breeding*, 72(2): 136-142.
- Choudhury B, Khan ML, Dayanandan S (2013). Genetic structure and diversity of indigenous rice (*Oryza sativa*) varieties in the Eastern Himalayan region of Northeast India. *Springer plus*, 2: 228-238.
- Das SR, Rout S (2006). Proc. of National Semi. on Biodiversity Conservation and Sustainable Development, OUAT, Bhubaneswar 9-10, March 2006, pp. 53-66.
- Deyner K, Johnson P, Zeeman S, Smith AM (2001). The control of amylase synthesis. *J. Plant physiol.* 158: 479-487.
- FAO (2002). A report on: Crops and drops – making the best use of water for agriculture. Food and Agriculture Organization of the United Nations. Rome.
- Garris A, Tai T, Coburn J, Kresovich S, McCouch SR (2005). Genetic structure and diversity in *Oryza sativa* L. *Genetics*. 2005; 169: 1631–1638.
- Ghalain SS (2006). Genetic divergence in rice (*Oryza sativa* L.) genotypes grown in Kamaun Himalaya. *Indian J. Genet.*, 66: 37–38.
- Glaszmann JC (1987). Isozymes and classification of Asian rice varieties. *Theor. Appl. Genet.*, 74: 21–30.
- Golam F, Hui Yin Y, Masitah A, Afnierna N, Majid NA, Khalid N, Osman M (2011). Analysis of aroma and yield components of aromatic rice in Malaysian tropical environment. *Austral. J. Crop Sci.* 5: 1318-1325.
- Hien NL, Sarhadi WA, Hirata Y, Oikawa Y (2007). Genetic diversity of morphological responses and the relationships among Asia aromatic rice (*Oryza sativa* L.) cultivars. *Tropics*, 16: 343–355.
- Juliano BO, Villareal CP (1993). Grain quality evaluation of world rices. International Rice Research Institute, Manila, Philippines.
- Kibria K, Islam MM, Begum SN (2008). Screening of aromatic rice lines by phenotypic and molecular markers. *Bangladesh J. Bot.*, 37: 141–147.
- Kim JS, Oh SY, Kim SK (1999). Characteristics of concentration and load of nitrogen and phosphorous in paddy field areas. *J. of KEES*. 41: 47-56.
- Kovach MJ, Calingacion MN, Fitzgerald MA, McCouch SR (2009). The origin and evolution of fragrance in rice (*Oryza sativa* L.) Proc. National Academy of Sciences of the United States of America. 106: 14444–14449.
- Li X, Yan W, Agrama H, Hu B, Jia L, Jia M, Jackson A, Moldenhauer K, McClung A, Wu D (2010). Genotypic and phenotypic characterization of genetic differentiation and diversity in the USDA rice mini-core collection. *Genetica*. 138: 1221–1230.
- Mathure S, Shaikh A, Renuka N, Wakte K, Jawali N, Thengane R, Nadaf A (2011). Characterisation of aromatic rice (*Oryza sativa* L.) germplasm and correlation between their agronomic and quality traits. *Euphytica*, 179: 237–246.
- Mathure S, Jawali N, Nadaf A (2010). Diversity analysis in selected non-basmati scented rice collection (*Oryza sativa* L.). *Rice Sci.* 17: 35–42.
- Meenakshi T, Amirthadevarathinam A, Backiyarani S (1999). Correlation and path analysis of yield and some physiological characters in rainfed rice. *Oryza*, 36: 154-156.
- Naik D, Sao A, Sarawgi AK, Singh P (2006). Genetic divergence studies in some indigenous scented rice (*Oryza sativa* L.) accessions of Central India. *Asian J. Plant Sci.* 5: 197–200.
- Perez CM, Juliano BO (1978). Modification of the simplified amylose test for milled rice. *Starch-Starke*, 30: 424-426.
- PPV, FRA (2008). Guidelines for the conduct of tests for Distinctness, Uniformity, Stability of rice (*Oryza sativa*), Protection of Plant Varieties and Farmers' Right Authority, Ministry of Agriculture, Govt. of India, New Delhi, India.17.
- Ray A, Deb D, Ray R, Chattopadhyay B (2013). Phenotypic characters of rice landraces reveal independent lineages of short-grain aromatic *indica* rice. *AoB Plants*, 5: plt032. (doi: 10.1093/aobpla/plt032)
- Sarawgi AK, Bisne R (2007). Studies on genetic divergence of aromatic rice germplasm for agromorphological and quality characters. *Oryza*, 44: 74-76.
- Sarawgi AK, Parikh M, Sharma B (2012). Morphological and Quality Characterization of Dubraj Group from Aromatic Rice Germplasm of Chhattisgarh and Madhya Pradesh. *Vegetos- Int. J. Plant Res.* 25: 387- 394.
- Singh RK, Gautam PL, Saxena S, Singh S (2000a). Scented rice germplasm: conservation, evaluation and utilization. In: Singh RK, Singh US, Khush CS (eds) *Aromatic rices*. Kalyani publisher, New Delhi, pp. 107–133.
- Singh RK, Singh US, Khush GS, Rohilla R, Singh JP, Singh

- G, Shekhar KS (2000b). Small and medium grained aromatic rices of India. In: RK Singh, US Singh, CS Khush (eds) Aromatic rices. Kalyani Publishers, New Delhi, pp. 155–177.
- Suwanarit A, Kreetapirom S, Buranakarn S, Varanyanond W, Tungtrakul P, Somboonpong S, Rattapat S, Ratanasupa S, Romyen P, Wattanapryapkul S, Naklang K, Rotjanakusal S, Pornurisnit P (1996). Effect of nitrogen fertilizer on grain qualities of Khao Dawk Mali-105. *Kasetsart J. Nat. Sci.*, 30: 458–474.
- Vanaja T, Babu LC (2003). Association between physico-chemical characters and cooking qualities in high yielding rice varieties of diverse origin. *IRRN*, 28: 28–29.
- Vaughan DA, Morishima H, Kadowaki K (2003). Diversity in the *Oryza* genus. *Current Opinion Plant Mol. Biol.*, 6: 139–146.