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Screening of indigenous aromatic rice cultivars for yield and aroma under moisture stress condition in western undulating zone of Odisha

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Abstract
Performance of forty genotypes comprising nineteen land races, one local check variety (Acharmati) and six high yielding varieties, twelve popular aromatic rice cultivars and two advanced breeding lines were evaluated to determine character association, variability and diversity for grain yield, yield components and aroma level under irrigated and non-irrigated conditions at RRTTS, Bhawanipatna, Odisha. High values of phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), high heritability (h^{2}) and genetic advance (GA) were recorded for aroma level, grains per panicle and thousand grain weight. Significant positive correlation for panicles per plant (r =.603) and negative correlation for aroma level (r = -.370) was observed with yield. All the genotypes were grouped into 11 clusters. Most of the indigenous aromatic rice cultivars were found in Cluster I and others distributed in cluster IV, cluster V, cluster VII and cluster XI. Cluster II consisted of basmati types and cluster III comprised HYV. Aromatic Test (sensory test) using 1.7% KOH solution was done for rapid evaluation of aroma level of the genotypes. The present study revealed that the indigenous aromatic rice cultivars like Gangaballi, Khosakani, Neelabati, with high aroma level, Dubraj and Dhanaprasad with faint aroma were superior genotypes of their respective clusters under both irrigated and non-irrigated conditions. Crossing between superior genotypes of diverse cluster pairs may provide desirable transgressive segregants for developing high yielding varieties of aromatic rice and can be used as potential breeding materials for improvement of aromatic land races.

Keywords: land races, indigenous aromatic rice, yield, yield attributes

Introduction
Jeypor**e** tract of Odisha is considered as the secondary centre of origin of rice and is the home for innumerable land races of rice. The land races of aromatic rice are tall, late maturing, photosensitive with short and medium grains and low yielding capacity but possess outstanding qualities like aroma, fluffiness and taste. Land races are relatively genetically more diverse than the developed varieties of a crop (Villa *et al*., 2005) [24] Thus, landraces are a natural source of genetic diversity in any crop. Availability of genetic diversity is the basic requirement of any crop improvement programme (Manonmani and Fazlullah Khan, 2003) [13]. Genetically diverse genotypes are required for selecting parents having wider variability for different characters (Nayak *et al.*, 2004) [15]. Genetic diversity can be estimated by the D^2 analysis, metroglyph and principle component analysis using morphological traits (Manonmani and Fazlullah Khan, 2003) [13]. Through genetic divergence analysis the genetic distance among the genotypes is quantified and the progeny of the crosses between the parents with maximum genetic divergence can be utilised for genetic improvement of the genotypes (Arunachalam, 1981) [1].
Morphological and bio chemical characters of these genotypes are to be improved for gain in yield (Golam *et al.*, 2004) [6]. In the present study, an attempt was made to screen out the superior genotypes from the available collection of aromatic land races for their further genetic improvement.

Materials and Methods
Plant material and experimental detail
Performance of forty genotypes comprising nineteen land races, one local check variety (Acharmati) and six high yielding varieties which were collected and maintained at the Regional Research & Technology Transfer Station (RRTTS), Bhawanipatna in Kalahandi district which is geographically very near to Jeypore and is one of the three districts of Odisha state considered as the niche area for short and medium grained aromatic rice cultivars, twelve popular aromatic rice cultivars and two advanced breeding lines collected from

National Rice Research Institute, Cuttack, Odisha were tested in this investigation. The field experiment was conducted during wet seasons of 2015 and 2016 in Randomized Block Design with two replications under irrigated (normal) and non irrigated (moisture stress) condition, at the experimental farms of RRTTS, Bhawanipatna. Twenty five days old seedlings were transplanted in 6 m^2 plots with spacing of 20 cm x 15 cm using single seedling per hill. Standard cultural practices were followed. Eight morpho-physiological parameters were studied and aroma level of each genotype was evaluated. Data on 8 quantitative traits viz. days to 50% flowering, days to maturity, plant height, number of panicles per plant, panicle length, number of filled grains per panicle, thousand grain weight and grain yield were recorded from each entry from the randomly selected plants.

Estimation of mean, range, standard deviation, standard error and coefficient of variation of various agronomic characters of 40 genotypes were analyzed using RBD design (Panse and Sukhatme, 1985) [16]. Phenotypic and Genotypic coefficients of variation were worked out according to Burton,1952. The significance of the treatment effect was judged with the help of 'F' test, C.D. at 5%. Correlation coefficient, path coefficient at genotypic and phenotypic levels were computed following Singh and Chaudhury (1985) [23]. Heritability (in broad sense) of different characters was estimated by the formula suggested by Hanson *et al*. (1956) [9] and the expected genetic advance (GA) from selection among genotypes for different characters was calculated following Johnson *et al*., (1995) [11]. D^2 values were calculated by using the formula of Mahalanobis (1936) [12]. On the basis of the magnitude of D^2 values the genotypes were grouped into different clusters according to Tocher's method following Roa (1952)

Aroma test (sensory test)

Aroma level of each genotype was estimated by Aroma Test (sensory test) using 1.7% potassium hydroxide (KOH). Leaf aroma test was done by taking 0.2 g of leaf from each genotype. Leaves were cut into small pieces soaked in 10 ml of 1.7 % KOH solution in covered glass petri-plates and left for 10 minutes. Each petri-plate containing the sample was then opened one by one and scored on 1-4 scale with 1,2,3 and 4 corresponding to absence of aroma, slight, moderate and strong aroma, respectively, by smelling. Grain aroma test was also done by soaking forty grains of each genotype in 10 ml of 1.7% KOH solution for one hour in covered petri- plates and the samples were scored by the same method as Leaf Aromatic Test (Golam *et al*. 2011) [7]. Two panels (ten members each) of faculty and staff of RRTTS, Bhawanipatna, and College of Agriculture, Bhawanipatna were invited to score the aroma in each genotype

Results and Discussion

Analysis of variance revealed the existence of significant difference (5% level) in all the characters among the genotypes

Genetic parameters

Highest coefficient of variation was observed in aroma level (13.14%), number of panicles per plant (9.26%) followed by number of filled grains per panicle (7.4%) and panicle length (6.02%). Larger genotypic variation (more than 15%) were observed in aroma level, number of grains per panicle, thousand grain weight, grain yield and plant height which are likely to be less influenced by environmental fluctuations and thus can be considered as indices of selection. The estimates of genotypic coefficient of variance (GCV) for all the characters were smaller than the corresponding phenotypic coefficient of variance (PCV), indicating some amount of influence of environment in the expression of characters (Table 1). However, relatively small differences (closeness) between GCV and PCV for these characters indicated that these were mostly governed by genetic factors with minor environmental influence. All the characters showed high heritability (more than 80%). High heritability coupled with high genetic advance was observed for aroma level, number of grains per panicle, thousand grain weight and grain yield indicating that these characters were predominantly governed by additive gene action. High heritability and moderate to low genetic advance for rest of the characters suggested the predominant role of non- additive gene action in their inheritance. The finding in the present study was in close agreement with reports of Das *et al*. (2001) [4]. Considering the above mentioned findings, it could be stated that variation among the genotypes is due to genetic diversity owing to long period of cultivation by the people in the geographically isolated area.

The mean of the values of different characters, compared under irrigated and non-irrigated conditions (Table 1.), revealed that days to 50% flowering was delayed (irrigated 109 days and non-irrigated 110 days) whereas days to physiological maturity (irrigated 141.5 days and non-irrigated 139.7 days) was earlier in non-irrigated condition. This indicated shortening of flowering and grain filling period under water stress conditions. Plant height (irrigated 122.74 cm and non-irrigated 119.49cm), panicle length (irrigated 26.02 cm and non-irrigated 23.71 cm), number of panicles per plant (irrigated 7.34 and non-irrigated 6.17), number of filled grains per plant (irrigated 208.9 and non-irrigated 191.5), thousand grain weight (irrigated 15.85 and non-irrigated 15.20) and grain yield (irrigated 29.63 q/ha and non-irrigated 2.57 q/ha) was high in irrigated condition. A clear reduction in the values of yield and yield attributing characters was observed in non-irrigated condition. Similar results were reported by Islam *et al*. (1994a) [10]. Rahman *et al*. (2002) [18] stated that water stress during different growth stages in plants slowed down carbohydrate synthesis, decreased translocation of assimilates to the grains and thus lowered the number of panicles per plant, grains per panicle, grain weight and ultimately reduced the grain yield. It was observed that aroma level (irrigated 2.54 and non-irrigated 2.57) was high in non-irrigated condition. It is in confirmation with the findings of Bradbury *et al*. (2008) who reported that, level of 2-acetyl-pyrrolin (2AP) the primary compound responsible for aroma in aromatic rice is higher in plants exposed to water stress condition.

Correlation coefficient

The phenotypic correlation coefficients for different grain yield components and aroma level, presented in Table 2 and Fig.1 indicated that the traits days to 50% flowering (.256), days to maturity (.197) number of panicles per plant (.603) number of grains per panicle (.059) were found to have direct effect on yield (Ashok *et al*., 2016 and Bornare *et al*., 2014) [2]. Plant height (-.304), panicle length (-.569) and thousand grain weight (.06) were negatively correlated to yield (Golam *et al*., 2011) [7]. Aroma level (-.370) showed significant negative correlation with yield (Nadaf *et al*., 2014 and Fitzgerald *et al*., 2010) [14, 5].

Genetic divergence

The knowledge of genetic diversity is important when genetically diverse parents are to be studied for a wide array of recombinants. The 40 genotypes were grouped into 11 clusters by using D^2 values (Table 3). Cluster I contained maximum number of genotypes (15) all being indigenous aromatic cultivars with mean values of 149 days for physiological maturity,139 cm for plant height, 265 for filled grains per panicle, 11.74grams for thousand grain weight, 3.18 for aroma level (moderate) and 27.19 q/ha for yield (Table 5). Cluster II, the second largest cluster had 6 genotypes (basmati types) with mean values of 124 days for physiological maturity,110 cm for plant height, 103 for filled grains per panicle, 24.61grams for thousand grain weight, 2.45 for aroma level (slight to moderate) and 26.44 q/ha for yield. The indigenous aromatic rice group was observed to be taller (139 cm to 110 cm in basmati type), of late duration (149 days to 124 days in basmati type) and is short to medium grained (on an average 265 grains per panicle and 11.74 grams thousand grain weight compared to 103 grains per panicle and 24.61grams in basmati types). It was also observed that the indigenous aromatic rice has high aroma level (3.18 compared to 2.45) and yield higher than the basmati types (27.19 q/ha compared to 26.44 q/ha) in this agro climatic condition. Cluster mean for number of panicles per plant (8.63) and aroma level (3.35) was highest for cluster VII indicating existence of potential genotypes in this cluster to be considered at the time of selection. The findings from the cluster mean of 11 clusters for nine characters can be utilised for selection of superior genotypes for different characters like, grain yield per plant the best aromatic genotypes could be CR Dhan 907 from cluster III, Neelabati, Ketakijoha from cluster VII, Dubraj and Dhanaprasad from cluster V followed by Khosakani and Kalakrushna from cluster IV. Similarly for aroma Neelabati, Ketakijoha from cluster VII, Gangaballi, Jaiphulla, Pimpudibasa from cluster I. As regards to long grain size, Geetanjali and Pusa1121 from cluster II having maximum thousand grain weight (24.61g) could be promising genotypes for this zone.

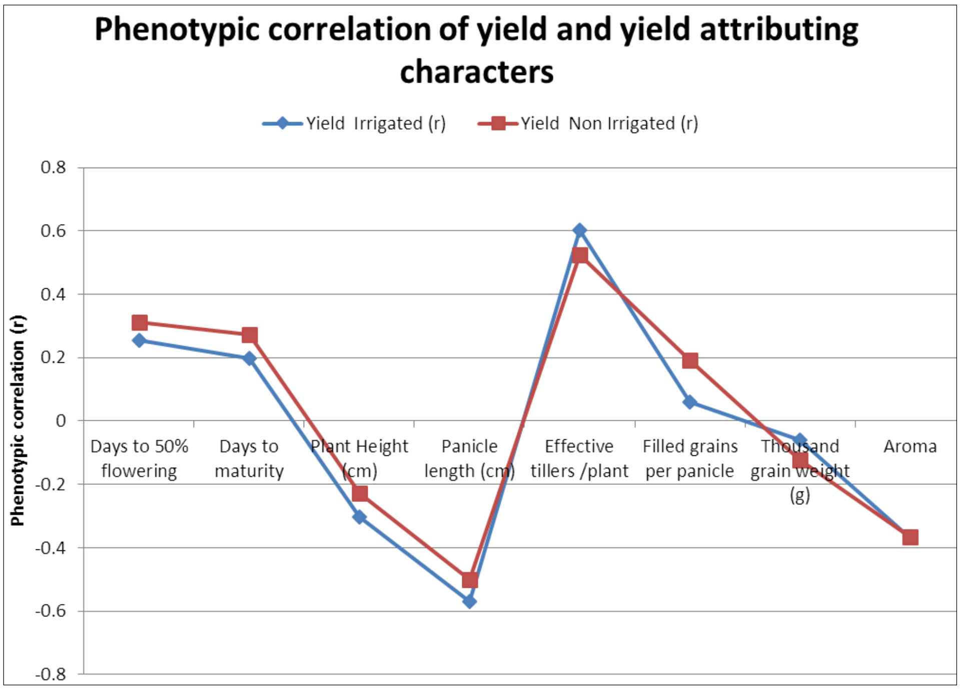

Fig 1: Phenotypic correlation of yield with yield attributing characters

Table 1: Varietal characters of genotypes grown under irrigated and non-irrigated condition

Environment	*Parameter	Days to 50% flowering	Days to physiological maturity	Plant height (cm)	Panicle length (cm)	No. of panicles / plant	No. of filled grains /panicle	1000-grain weight (g)	Grain yield (q/ha)	Aroma level
Irrigated	GM	109	141.5	122.74	26.02	7.34	208.9	15.85	29.63	2.54
	PCV	8.96	8.01	15.8	9.83	15.6	33.09	31.02	19.19	36.92
	GCV	8.94	8.0	15.73	8.86	14.1	32.67	30.95	18.97	35.73
	CV	0.86	0.65	2.01	6.02	9.26	7.4	3.01	4.1	13.14
	CD	1.32	1.3	3.47	2.21	0.96	21.78	0.67	3.71	0.47
	h^2 (%)	99.54	99.67	99.19	81.24	82.27	97.50	99.53	93.66	97.72
	GA	15.7	14.06	27.58	14.06	22.5	56.78	54.34	33	60.86
Non irrigated	GM	110	139.7	119.49	23.71	6.17	191.5	15.2	23.85	2.57
	PCV	9.11	7.83	15.05	9.31	11.5	33.28	32.73	19.51	38.65
	GCV	9.09	7.81	14.88	8.09	10.1	32.73	32.69	19.09	38.5
	CV	0.63	0.68	3.14	6.52	7.65	8.54	2.38	5.71	4.88
	CD	0.98	1.33	5.29	2.18	0.67	23.04	0.51	3.92	0.48
	h^2 (%)	99.76	99.63	97.82	75.49	77.74	96.71	99.74	99.20	95.73
	GA	16	13.72	25.91	12.37	15.7	56.65	57.45	32.9	32.87

GM- Grand Mean, PCV- Phenotypic Coefficient of Variance, GCV- Genotypic Coefficient of Variance, CV- Coefficient of Variance, CD- Critical Difference, h^2 – Heritability in broad sense, GA- Genetic Advance

Cluster analysis

The maximum inter cluster distance was observed in between clusters VII and X (3338.32) followed by clusters I and X (3196.15) confirming wide genetic diversity between aromatic rice (cluster VII and I) and non aromatic rice (cluster X) genotypes (Table 4). Minimum inter cluster distance was observed in between I and IV (262.46) consisting of indigenous aromatic rice genotypes. The maximum intra-cluster distance was observed for cluster VII (244.49) followed by cluster IV (185.51) and cluster V (173.66). The selection of diverse genotype for above cluster would produce a broad spectrum of variability for morphological and quality traits studied. The hybrids developed from the selected genotypes of these diverse clusters may produce desired transgressive segregants. This would be rewarding in indigenous aromatic rice breeding programme (Sarawgi and Shrivastava, 1996 [20], Sarawgi and Rastogi, 2000 [21], Ray *et al*., 2002 and Nayak *et al*, 2004) [15]. The above grouping indicates existence of wide genetic divergence among the collected genotypes. Such high degree of divergence was also reported in local collection by Gupta *et al*. (1999) [8], Sarawgi and Rastogi (2000) [21] and Nayak *et al*. (2004) [15]

Table 2: Correlation of yield and yield contributing characters

Characters	Days to 50% flowering	Days to physiological maturity	Plant height (cm)	Panicle length (cm)	No. of panicles / plant	No. of filled grains /panicle	1000-grain weight (g)	Aroma level	Grain yield (q/ha)
Days to physiological maturity	0.930	1.00	0.567	-0.058	0.144	0.792	-0.841	0.305	0.197
Plant height (cm)	0.526	0.567	1.00	0.364	-0.285	0.608	-0.579	0.561	-0.304
Panicle length (cm)	-0.034	-0.058	0.364	1.00	-0.297	0.039	0.048	0.396	-0.569
No. of panicles / plant	0.197	0.144	-0.285	-0.297	1.00	0.012	-0.115	-0.221	0.603
No. of filled grains /panicle	0.750	0.792	0.608	0.039	0.012	1.00	-0.809	0.321	0.059
1000- grain weight (g)	-0.843	-0.841	-0.579	0.048	-0.115	-0.809	1.00	-0.362	-0.060
Aroma level	0.298	0.305	0.561	0.396	-0.221	0.321	-0.362	1.00	-0.370
Yield (q/ha)	0.256	0.197	-0.304	-0.569	0.603	0.059	-0.060	-0.370	1.00

Table 3: Genotypes included in different clusters

Cluster No.	No. of genotypes included in each cluster	Name of genotype
I	15	Gangaballi, Jaiphulla, Nua Dhusura, Nanu, Thakursuna, Heerakani, Nua kalajeera, Dhusura, Kalajeera, Pimpudibasa, Badshabhog, Lajkulibadan, Jabaphulla, Mahakamati, Nuachinikamini
II	6	Geetanjali, PUSA 1121, CR 3699-16-4, Lalat, Basmati 370, Taroari Basmati
III	4	CR Dhan-907, Pooja, Swarna, Pratikshya
IV	3	Khosakani, Kalakrushna, Acharmati
V	3	Dubraj, Dhanaprasad, Sujata
VI	3	Tejaswini, Poornabhog, CR2713-179
VII	2	Ketakijoha, Neelabati
VIII	1	Kalanamak
IX	1	Pusa Basmati-1
X	1	MTU-1010
XI	1	Maharaji

Table 4: Average intra- cluster (diagonal) and inter- cluster D^2 values among 11 clusters formed with forty genotypes of rice

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	144.61	2310.75	874.71	262.46	364.39	1087.30	348.34	300.96	1775.76	3196.15	715.78
II		147.74	1352.51	1751.18	1714.07	523.91	2439.75	1369.41	255.67	277.31	638.36
III			149.84	829.07	381.49	364.49	500.77	718.87	1115.23	1917.16	531.9
IV				185.51	387.89	828.1	528.72	299.15	1437.22	2451.18	473.35
V					173.66	645.89	318.65	322.78	1383.71	2572.39	386.47
VI						135.55	993.2	576.05	349.22	846.33	293.76
VII							244.49	613.45	1976.38	3338.32	879.61
VIII								0.0	829.65	2061.37	319.89
IX									0.0	412.72	563.28
X										0.0	1278.91
XI											0.0

Table 5: Cluster mean of eleven clusters (D^2 based) for different characters

Sl. No.	Character	Cluster										
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1.	Days to 50% flowering	115.69	93.37	112.04	111.96	112.30	101.82	118.71	105.51	92.44	89	106.17
2.	Days to physiological maturity	149.19	124.07	142.88	143.15	150.84	132.58	150.90	144.16	125.68	112.25	141.36
3.	Plant height (cm)	138.51	110.16	93.04	147.20	121.84	100.16	116.74	129.88	100.82	98.06	129.15
4.	Panicle length (cm)	27.23	27.63	23.32	21.61	23.33	25.20	25.05	26.24	27.67	24.26	25.65
5.	No. of panicles / plant	7.14	6.84	8.49	7.06	7.63	8.05	8.63	6.42	5.89	6.83	6.88
6.	No. of filled grains /panicle	264.51	103.04	189.89	241.46	239.06	171.86	194.27	224.44	127.36	119.66	191.64
7.	1000-grain weight (g)	11.74	24.61	16.47	14.16	15.75	18.02	11.51	13.57	19.17	23.59	21.10
8.	Aroma level	3.18	2.45	1.44	2.66	1.76	2.07	3.35	1.80	2.10	1.47	2.05
9.	Yield (q/ha)	27.19	26.44	38.00	33.73	34.24	32.09	35.25	21.24	17.96	28.39	28.35

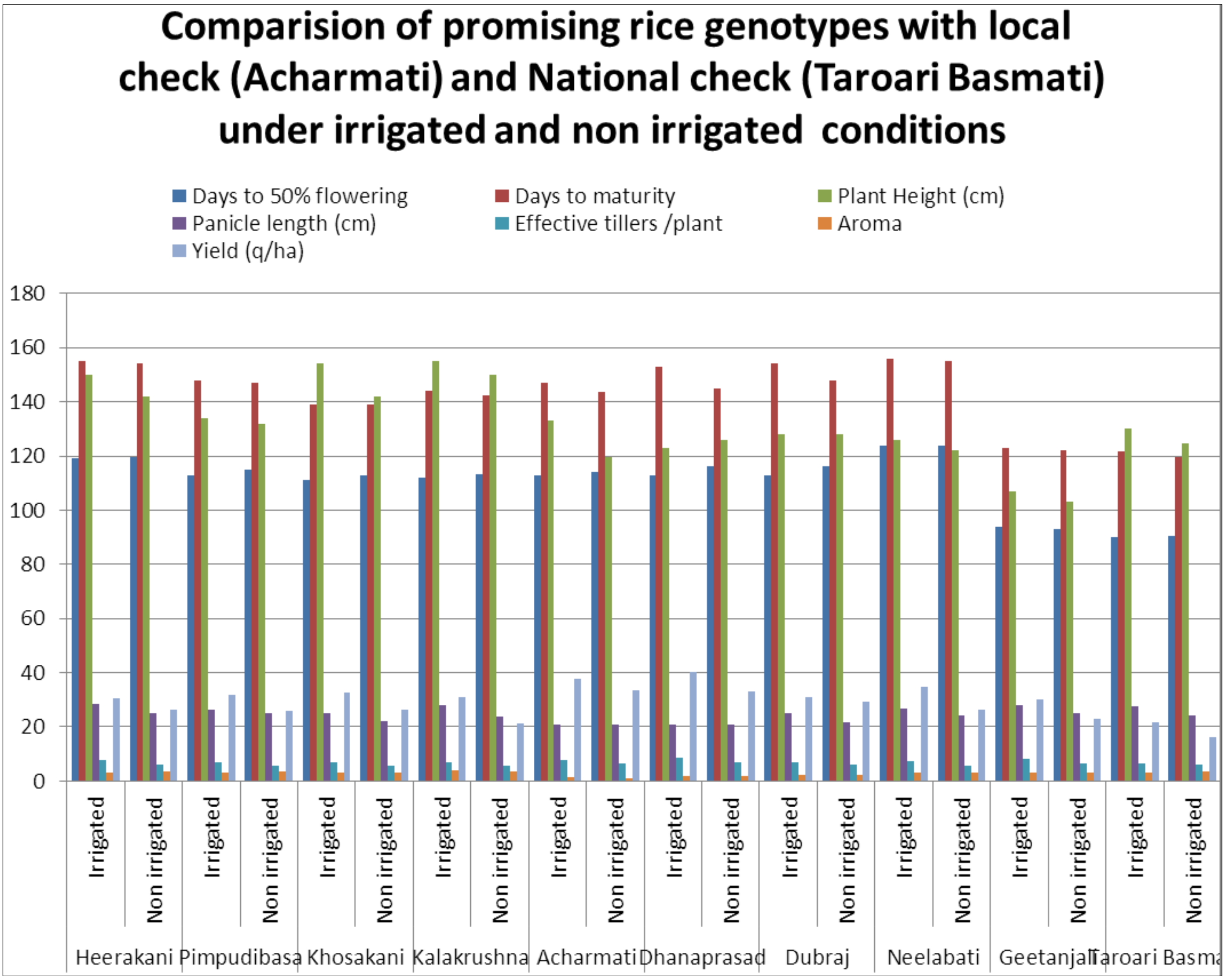

Fig 2: Comparision of promising rice genotypes with local check (Acharmati) and National check (Taroari Basmati) under irrigated and non irrigated conditions

Conclusion

In the present study high values of genetic diversity was observed among the genotypes which fulfils the basic criteria of taking up a breeding programme with these genotypes. It was also observed that thebasmati type rice genotypes which were studied in this investigation could not perform better than any of the land races in terms of yield mainly due to environmental unsuitability as the characters of these cultivars are best expressed only in their native area with high influence of environment on expression of their characters (Shobha Rani and Krishnaiah 2001) [22]. Few indigenous cultivars like Dhanaprasad, Dubraj, Acharmati, Khosakani, Heerakani, Pimpudibas and Neelabati were found to be tolerant to moisture stress conditions (Fig 2.) giving more yield under non irrigated condition when compared with basmati types

The indigenous aromatic land races which possess excellent grain quality and can be a great source of increased farm income for the farmers are not exploited fully due to many reasons one of these being their low productivity. The superior genotypes identified from the above study can be utilised as breeding material for genetic improvement of the short and medium grained aromatic rice, an unexplored wealth of India.

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