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Indigenous aromatic rice genotypes (*Oryza sativa* L.) of Wayanad district in Kerala: Performance in varied environmental conditions

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Abstract
The most popular traditional aromatic rice genotypes in Kerala are *Gandhakasala* and *Jeerakasala* grown in the foothills of Wayanad district. On the basis of the grain characteristics, eight Gandhakasala genotypes and one Jeerakasala genotype were selected from the 35 samples collected from various parts of Wayanad district. At Wayanad, aromatic rice genotypes showed more favorable characteristics than at Palakkad. The aromatic rice genotypes JT 9, GT 3, GT 8 and JT 9 performed better based on the high grain and straw yield, intermediate amylose content and moderate aroma in Wayanad district. Among the genotypes GT 3 expressed the better taste, aroma and appearance for cooked rice, and could be recommended for general cultivation in Wayanad.

Keywords: Aromatic rice, gandhakasala, jeerakasala, indigenous rice, varied environment

1. Introduction
Wayanad district in Kerala is the homeland and ranks first in the cultivation of traditional aromatic rice. *Gandhakasala* and *Jeerakasala* are the most popular among them and cultivated in an approximate area of 327 ha and 22 ha respectively (GOK, 2021) [2]. *Gandhakasala* rice and *Jeerakasala* rice are registered as Geographical Indications from Wayanad district in Kerala. The cultivation of aromatic rice in Wayanad is highly influenced by the favourable environmental conditions like high altitude and the low temperature prevailing there. However, the decline in the area of cultivation of these genotypes is resulting in the reduction of their genetic diversity. Despite the market potential of these rice genotypes, only limited research has been conducted to understand the performance and adaptability of these genotypes in different agro-climatic regions of Kerala. Hence a study was undertaken to characterize and evaluate the aromatic rice cultivars in varied environmental conditions of the state.

2. Materials and Methods
An initial survey was conducted in Wayanad district to collect the seed samples of *Gandhakasala* and *Jeerakasala* genotypes. From this survey, seed samples of 35 *Gandhakasala* and two *Jeerakasala* genotypes were collected. The grains that were uniformly short, white kernelled, golden lemma and palea and straw coloured apiculus were selected as *Gandhakasala* types (GT 1 – GT 8) and grains which were slightly elongated with partial awns, white kernelled, and golden lemma and palea were selected as *Jeerakasala* type (JT 9) for the study and compared with non aromatic local check variety for each location (Aiswarya at Wayanad, Deepti at Idukki and Uma at Palakkad). Field experiments related to the investigation were conducted at Regional Agricultural Research Station (RARS), Ambalavayal, Wayanad district, farmer's field at Pampadumpara, Idukki district representing high altitude areas and farmer's field at Kuzhalmannam block in Palakkad district representing normal altitude area during *Kharif* season using organic way of cultivation. The genotypes were grown in a Randomized Complete Block Design (RCBD) at each location with three replications. Following the Standard Evaluation System of Rice (IRRI, 1996) [5], morphological observations were made at different stages of plant growth from 10 randomly selected plants in each replication and the mean was worked out. The grains collected were analyzed for biochemical and cooking qualities.

3. Results and Discussions

3.1 Loss of Genetic Purity

A high level of variability was apparent in various grain characteristics, particularly the apiculus colour in the seed samples collected. It was having pigmented apiculus (Fig. 1), suggesting the possibility of natural outcrossing of these unique genotypes with other non-aromatic genotypes cultivated in Wayanad district. This in turn led to the loss of varietal purity of this unique aromatic germplasm resulting in low aroma and different grain characters. Therefore, it is imperative that aromatic genotypes of this region should be collected, conserved and improved and raised to varietal status.

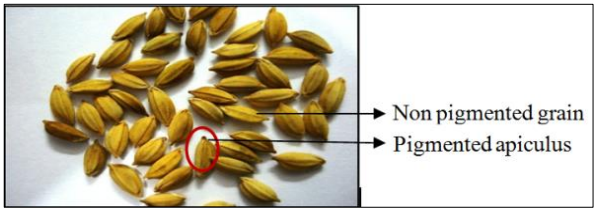

Fig 1: Sample containing admixtures of pigmented apiculus grains

3.2 Morphological Characterization

The aromatic genotypes were characterized by the presence of well exserted panicles, yellow stigma, straw coloured apiculus, fertile spikelets, golden coloured lemma and palea, moderately difficult panicle threshability and white seed coat. *Jeerakasala* genotype was straw coloured, short and partly awned whereas *Gandhakasala* genotypes were awnless (Fig. 2). At three locations, aromatic genotypes showed lower seedling height (26.70 cm, 32.65 cm and 18.51 cm) than check varieties, which indicated a lower ability to compete with weed flora during the early growth stages. The long droopy leaves in aromatic genotypes would have caused mutual shading, which would have reduced the photosynthetic efficiency. *Jeerakasala* types produced more productive tillers per hill in all three locations than *Gandhakasala* types and check varieties (Table1). In aromatic genotypes, the total duration was nearly 30 days less at Palakkad than high altitude areas due to the higher temperature prevailing at Palakkad. In tune to days to 50 per cent flowering, total duration of aromatic types was more at high altitude areas (Table 2). *Jeerakasala* type recorded significantly higher grain yield and 1000 grain weight than *Gandhakasala* types at Wayanad and Palakkad. The grain yield for JT 9 (2735.22 kg/ha) was comparable with Aiswarya (3055.55 kg/ha). The mean value of 1000 grain weight for aromatic genotypes at Wayanad district was 14.49 g whereas at Palakkad it was 12.37 g. In all locations, the mean straw yield was greater for aromatic genotypes than for check varieties. At both locations, grain length was significantly lower for aromatic genotypes than check varieties. The *Jeerakasala* type recorded the highest grain length at Wayanad (7.36 mm) and Palakkad (7.24 mm) districts. In Wayanad and Palakkad, the mean grain width was 2.03 mm and 1.85 mm, respectively. Among aromatic genotypes, *Jeerakasala* recorded the lowest grain width. The highest mean straw yield for aromatic genotypes was found in Idukki district (8095.08 kg/ha) followed by Palakkad district (4764.75 kg/ha) and Wayanad district (3987.99 kg/ha). Aromatic rice genotypes grown at Idukki had higher straw yield due to excessive vegetative growth expressed as high culm number and culm length. At both locations, the aromatic genotypes showed lower milling recovery than the check varieties, indicating the requirement for specifically designed machines to mill aromatic genotypes. GT 4 recorded the highest milling recovery per cent (71.09) among the aromatic types at Wayanad and Palakkad.

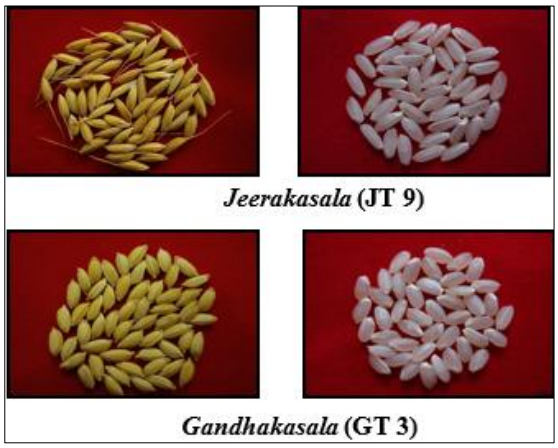

Fig 2: Grains and kernels of aromatic genotypes

3.3 Cooking and Biochemical Characterization: The quality and preference of aromatic rice are determined by the appearance, size, shape, aroma, nutritional value, and cooking characteristics of the kernels (Bhonsle and Sellappan, 2010) [1]. Lengthwise expansion without increase in girth is considered most desirable trait in high quality rice (Golam and Prodhan, 2013) [3]. At Wayanad, *Gandhakasala* types recorded high kernel elongation ratio and low volume expansion ratio (preferred grain characteristics for aromatic rice) compared to *Jeerakasala* type and check variety. Aroma is one of the most valuable traits in grain quality of specialty rice and it helps to fetch a premium price in the market. The aroma is best formed when cooler climate coincides with flowering and maturity in aromatic rice. (Jewel, Z. A. *et.al*, 2011) [6]. At Wayanad, most of the aromatic genotypes except GT 5 expressed moderate aroma. Whereas, at Palakkad the genotypes expressed slight aroma only, reducing its marketability. Around the world, rice varieties with intermediate amylose content (25-28%) are preferred since cooked rice with intermediate levels of amylose becomes moist, tender, non sticky and does not harden after cooking (Hossaina, *et al*. 2009) [4]. At Wayanad, aromatic genotypes recorded low to intermediate amylose content. GT 3, GT 8 and JT 9 had intermediate amylose content which can add to consumer preference. At Palakkad, all aromatic genotypes except GT 2 had low amylose content which lead to the stickiness of cooked rice (Table 3). Based on the organoleptic test conducted on GT 3, GT 8 and JT 9 it was found that GT have a better taste, aroma and appearance for cooked rice.

Table 1: Mean performance of morphological characters of aromatic genotypes

Genotypes	Seedling height (cm)			Plant height (cm)			Number of productive Tillers		
	Wayanad	Palakkad	Idukki	Wayanad	Palakkad	Idukki	Wayanad	Palakkad	Idukki
GT 1	27.15^{bc}	37.70^{a}	19.05^{b}	101.56^{a}	86.85^{e}	118.25^{ab}	6.46^{d}	7.79^{de}	12.10^{b}
GT 2	26.46^{bc}	29.67^{d}	18.09^{b}	97.183^{a}	102.59^{abc}	120.35^{a}	8.05^{b}	9.23^{b}	14.03^{a}
GT 3	27.17^{bc}	32.77^{c}	19.60^{ab}	87.233^{b}	89.92^{de}	113.64^{abcd}	7.00^{cd}	7.07^{f}	10.67^{bc}
GT 4	27.03^{bc}	32.75^{c}	18.70^{b}	99.747^{a}	97.37^{cd}	116.36^{abc}	6.55^{d}	7.55^{def}	12.27^{b}
GT 5	26.18^{bc}	29.83^{d}	18.33^{b}	95.273^{a}	111.39^{a}	103.88^{ef}	7.43^{bc}	8.17^{cd}	12.07^{b}
GT 6	25.18^{c}	34.04^{bc}	17.00^{b}	98.300^{a}	109.59^{ab}	108.42^{cde}	6.77^{cd}	8.75^{bc}	11.57^{b}
GT 7	26.09^{c}	34.07^{bc}	17.73^{b}	95.967^{a}	94.28^{cde}	106.21^{de}	6.34^{d}	8.60^{bc}	9.24^{cd}
GT 8	25.73^{c}	26.75^{e}	19.80^{ab}	84.227^{b}	100.83^{bc}	110.28^{bcde}	6.93^{cd}	9.00^{b}	8.73^{d}
JT 9	29.31^{ab}	36.28^{ab}	18.27^{b}	88.243^{b}	86.86^{e}	90.14^{g}	9.27^{a}	9.93^{a}	14.30^{a}
Check	30.80^{a}	33.05^{c}	22.53^{a}	48.05^{c}	51.81^{f}	96.20^{fg}	7.95^{b}	7.33^{ef}	9.21^{cd}

Table 2: Mean performance of morphological characters of aromatic genotype

Genotypes	Panicle length (cm)			Total duration (days)			Spikelet sterility (%)		
	Wayanad	Palakkad	Idukki	Wayanad	Palakkad	Idukki	Wayanad	Palakkad	Idukki
GT 1	26.63^{a}	30.80^{a}	25.14^{a}	180.0^{b}	144.00^{abc}	188.67^{a}	11.12^{b}	12.32^{b}	100^{a}
GT 2	24.27^{ab}	33.91^{a}	25.07^{a}	180.0^{b}	144.00^{abc}	188.67^{a}	11.31^{b}	12.01^{b}	100^{a}
GT 3	27.10^{a}	34.18^{a}	25.14^{a}	180.33^{b}	145.00^{ab}	188.67^{a}	11.23^{b}	12.89^{b}	100^{a}
GT 4	26.20^{a}	31.20^{a}	23.48^{a}	179.67^{b}	143.67^{bc}	188.67^{a}	12.10^{b}	12.45^{b}	100^{a}
GT 5	24.00^{ab}	32.67^{a}	23.29^{a}	180.00^{b}	144.00^{abc}	189.00^{a}	11.39^{b}	12.21^{b}	100^{a}
GT 6	22.13^{b}	31.61^{a}	24.75^{a}	179.67^{b}	143.67^{bc}	188.67^{a}	11.04^{b}	12.56^{b}	100^{a}
GT 7	24.70^{ab}	31.25^{a}	24.12^{a}	179.33^{b}	144.33^{abc}	189.00^{a}	12.19^{b}	12.67^{b}	100^{a}
GT 8	24.66^{ab}	26.48^{b}	25.03^{a}	179.00^{b}	143.00^{c}	188.67^{a}	12.45^{b}	12.62^{b}	100^{a}
JT 9	25.87^{a}	32.14^{a}	23.78^{a}	182.67^{a}	145.67^{a}	188.33^{a}	11.22^{b}	12.89^{b}	100^{a}
Check	16.38^{c}	19.83^{c}	22.20^{a}	131.00^{c}	120.00^{d}	161.00^{b}	2.35^{a}	1.12^{a}	100^{a}

Table 3: Mean performance of grain yield and grain characters of aromatic genotypes

Genotypes	Grain yield (kg/ha)		1000 grain weight (gm)		Amylose content (%)		Aroma	
	Wayanad	Palakkad	Wayanad	Palakkad	Wayanad	Palakkad	Wayanad	Palakkad
GT 1	1576.89^{bc}	1488.34^{cd}	15.18^{c}	12.60^{de}	19.04^{g}	18.42^{f}	Moderate	Slight
GT 2	1077.09^{e}	1652.12^{c}	13.83^{d}	9.77^{h}	26.36^{a}	24.58^{a}	Moderate	Slight
GT 3	1642.50^{b}	1281.15^{de}	15.55^{c}	14.10^{c}	20.28^{d}	18.93^{e}	Moderate	Slight
GT 4	1308.89^{bcde}	1097.81^{e}	12.96^{ef}	10.82^{fg}	17.82^{j}	17.15^{g}	Moderate	Slight
GT 5	1122.77^{de}	1258.93^{de}	13.62^{de}	12.97^{d}	19.11^{f}	18.36^{f}	Slight	Slight
GT 6	1366.45^{bcde}	1104.81^{e}	13.60^{de}	12.20^{e}	18.61^{h}	17.03^{g}	Moderate	Slight
GT 7	1220.00^{cde}	1294.48^{de}	13.47^{de}	10.45^{gh}	17.92^{i}	17.12^{g}	Moderate	Slight
GT 8	1490.56^{bcd}	1294.48^{de}	12.74^{f}	11.40^{f}	20.16^{e}	19.14^{d}	Moderate	Slight
JT 9	2735.22^{a}	2133.37^{b}	19.50^{b}	17.00^{b}	21.56^{c}	19.96^{c}	Moderate	Slight
Check	3055.55^{a}	5055.44^{a}	25.81^{a}	25.67^{a}	21.66^{b}	23.14^{b}	Moderate	Slight

3.4 Spikelet Sterility

At Pampadumpara in Idukki district, unusually high spikelet sterility was observed for all the genotypes. This is a pioneer report of such high level of spikelet sterility in rice, nearing to 100 per cent in Kerala. This type of spikelet sterility was also observed in nearby plots/farmer's fields of the experimental area, leading to total crop loss. The high spikelet sterility was due to the low air and water temperature (extremely low temperature of 13.5^{0}C to 15^{0}C was experienced continuously for four days) during panicle development stages especially during microspore formation stage which had affected pollen grain development. Reduction in pollen grains, poor pollen germination, and reduced anther dehiscence all correlate strongly with low temperature induced spikelet sterility (Matsui *et al.*, 2001; Prasad *et al.*, 2006; Zeng *et al.*, 2017) [8, 9, 7]. Observation of spikelets at harvest revealed dry intact stigma and undeveloped ovary (Fig 3) which indicated the failure of pollination in these spikelets.

Fig 3: Sterile spikelet with undeveloped ovary at Pampadumpara

4. Conclusions

The study indicated that the environmental conditions in Wayanad are highly conducive for the cultivation of aromatic genotypes. These unique aromatic genotypes from Wayanad district in Kerala have to be conserved as they are losing their genetic purity due to the natural outcrossing. *Gandhakasala* types GT 3 and GT 8 and *Jeerakasala* type JT9 showed better grain and straw yield, intermediate amylose content, and

moderate aroma, which were the preferred and favoured qualities in specialty rice. Among these, GT3 was found to have better flavour, taste and appearance for cooked rice and it could be recommended for cultivation in Wayanad.

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