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DUS Characterisation of Advanced Recombinant Lines of Kalanamak Rice (*Oryza sativa* L.) Using Morphological Descriptors and Quality Parameters

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Authors' contributions

This work was carried out in collaboration among all the authors. Authors Banshidhar and ID designed and executed the experiment and performed the statistical analysis. Author MKS provided technical support in interpretation of results and prepared the original draft of the manuscript. Author PJ proof read the manuscript and prepared the final draft. All authors read and approved the final draft of the manuscript.

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ABSTRACT

The present investigation was undertaken with the objective of DUS characterisation of advanced recombinant lines of *Kalanamak* rice for 47 visually assessed characters and 15 quantitative characters. Trials were conducted for two seasons during Kharif 2016 and 2017 at Norman E. Borlaug Crop Research Centre (NEBCRC), G. B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar, Uttarakhand in a Randomized Complete Block Design (RCBD) in three replications with the spacing of 20 cm × 15 cm and the recommended cultural practices were followed. For this data were recorded for sixty-two DUS descriptors following the guidelines of the International Union for the Protection of New Varieties of Plants (UPOV) and the Protection of Plant Varieties and Farmer's Rights Authority (PPV & FRA). In the present study, 27 visually assessed characteristics are found to be monomorphic, 18 are dimorphic and 2 are polymorphic. KARL10 with higher yield, intermediate amylose content, early 50% flowering and early maturity is reported to be best genotypes in respect of desired characteristics and could be used as a potential source for deriving improved lines through selection.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the three most important food crops grown in world. It is an annual monocot that belongs to poaceae family under genus Oryza. Being the staple food grain of more than 50% of the world's population it meets 21% of dietary energy and 15% of global protein requirement. More than 3.5 billion people i.e. almost half of the total world's population is dependent on rice to meet their daily requirements [1]. In India rice is cultivated over an area of 43.38 million hectares producing 104.32 million tons of grains with average productivity of 2404 kg /ha (2016-2017, Annual report DAC&FW). In many rice growing regions of India farmers are cultivating some unique land races, having special characteristics especially for high yield and disease resistance, which are valuable in commerce as well as for breeding programmes. Kalanamak is one such fine quality aromatic rice cultivated in India. It derives its name from black husk of kernel (Kala) and ability for successful adaption in usar soils characterised by higher salt concentration and high pH and/or having a distinct salty taste (Namak). A large number of such varieties are grown with different names in different parts of the country. Many of these varieties may be eligible for registration as donor, under the NBPGR, if fully characterized and meet the requirements of registration. The registration of a newly bred variety or genotype shall only be entertained if it fulfills to the criteria of novelty, distinctiveness, uniformity and stability [2]. India has recently enacted Distinctiveness, Uniformity and Stability (DUS) characterization for rice. For this data is recorded for sixty-two DUS descriptors (fourteen quantitative and forty-eight qualitative characters) as laid down in the guidelines of the International Union for the Protection of New Varieties of Plants (UPOV) and the Protection of Plant Varieties and Farmer's Rights Authority (PPV & FRA). The distinctiveness, uniformity and stability (DUS) tests of new varieties of rice are currently conducted according National Test Guidelines for DUS test in rice which was developed by Indian Institute of Rice Research, Rajendranagar, Hyderabad (Rani et al., 2004). In India about 700 varieties of rice having certain diagnostic traits are released and notified. These traits are followed for the purpose of seed certification procedures and are much useful in correct identification of a variety [3]. Comprehensive and legal characterisation for these traits is also useful in distinguishing one cultivar from the other, and thus provide a concrete base to protect the rights of the breeders/breeding institutions against unfair trade practices. Thus it is the need of hour to characterise all varieties of common knowledge and to prepare and maintain a comprehensive data base for reference and comparison. Therefore, this work was undertaken for DUS characterization of advanced recombinant lines of *Kalanamak* rice for 46 visually assessed characteristics and 15 measurable characteristics.

2. MATERIALS AND METHODS

The field experiments were conducted in a Randomized Block Design (RBD) with three replications during the *Kharif* seasons of 2016 and 2017 at Norman Ernest Borlaug Crop Research Centre(NEBCRC), Govind Ballabh Pant University of Agriculture & Technology(GBPUAT) Pantnagar, Uttarakhand. In the first year (Kharif 2016) data for quantitative as well as quantitative character were recorded for DUS characterization. In the second year (Kharif 2017) similar experiment were carried out at Tarai Bhawan, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand.

2.1 Observation, Scoring and Assessment

The observations were made on thirty plants or plant parts 10 plants per replication following the guidelines of PPV & FRA, 2001. Four types of assessments viz. Visual assessment by observation of individual plant or parts of plants (VS), Visual assessment by a single observation of a group of plants or parts of plants (VG), measurement of a number of individual plants or parts of plants (MS) and measurement by a single observation of a group of plants or parts of plants (MG) was followed for the scoring.

2.2 Procedure for Estimation of Measurable Characteristics

Leaf length and leaf width of penultimate leaf was measured on thirty plants (10 plants for each replication) at booting stage using wooden scale and recorded in data book. Stem thickness was measured on thirty plants (10 plants for each replication) at milk development stage using thread and wooden scale. The thread was ringed around the stem at mid-height and the length of thread was measured on scale to get the thickness of stem. Data for stem length was recorded in same way as that for leaf length

described above at milk development stage. Data for the panicle length of main axis was recorded in same way as that for leaf length described above at milk development stage. Panicle number per plant was counted on thirty plants (10 plants for each replication) at dough development stage. 1000 fully developed and matured kernels were counted and measured using electronic balance at hard caryopsis stage. For measuring grain length 10 grains were placed on graph paper joining end to end. The start and end point of pattern was marked and measured using a wooden scale at hard caryopsis stage. For measuring grain width 10 grains were placed on graph paper joining side by side. The start and end point of pattern was marked and measured using a wooden scale at hard caryopsis stage. Data for decorticated grain length and decorticated grain width was measured in same way as that for grain length and width. The presence or absence of amylose in the kernels was measured by single observation of a group of grains at hard caryopsis stage. The procedure defined by Juliano [4] was used to determine the content of amylose in endosperm. Gelatinization temperature (GT) was determined indirectly as the alkali spreading value (ASV) of hulled kernels, as per modified procedure of Little et al. [5]. Six whole grains, were dipped in Petri-dishes containing 1.7% KOH so that no two grains were in direct contact with each other. The plates were then incubated at room temperature for 24 hr. The alkali spreading value was scored visually by the appearance of the grains and the degree of grain disintegration on a 1-7 linear scale. Since ASV is inversely related to Gelatinization temperature, a lower ASV corresponds to a higher GT, conversely, a higher ASV indicates a lower GT. Gelatinization temperature classified as given below [5]. About 15 ml of distilled water was added to 5 g of rice sample in a test tube (200 mm × 35 mm) and soaked for 10 minutes. The sample was cooked in the water bath for 15 minutes. Cooked rice was transferred into a petri-plates. After cooling it was kept in the refrigerator for 20 min. Then these petri-plates were opened and the contents were smelled. The samples possessing the scent, as one could easily feel, produced a sharp and readily recognizable aroma.

2.3 Procedure for Estimation of Visually Assessed Characteristics

Coleoptile color was assessed visually for single plant 10 days after seed germination. Basal leaf sheath color was assessed visually for single plant at booting stage. Leaf sheath anthocyanin coloration and intensity of anthocyanin coloration were assessed visually for group of plants at booting stage. Intensity of green color, anthocyanin coloration, distribution of anthocyanin coloration was assessed visually for group of plants at booting stage. Pubescence of blade surface, presence of auricle, anthocyanin coloration of auricle, presence of leaf collar, anthocyanin coloration of leaf collar, presence of ligule, color of ligule and shape of ligule were assessed visually for single plant at booting stage. Flag leaf attitude of blade (early observation) was assessed visually for group of plants at beginning of anthesis period. Flag leaf attitude of blade (late observation) was assessed visually for group of plants at ripening stage. Leaf senescence was assessed visually for group of plants at hard caryopsis stage. Culm attitude was assessed visually for single plant at booting stage. Stem anthocyanin coloration of nodes, intensity of anthocyanin coloration of nodes and anthocyanin coloration of internodes were assessed visually for single plant at milk development stage. Density of pubescence of lemma was assessed visually for single plant at beginning of anthesis to dough development stage. Color of stigma was assessed visually for single plant at half way anthesis. Color of tip of lemma was assessed visually for single plant at dough development stage. Anthocyanin coloration of keel, anthocyanin coloration of area below apex and anthocyanin coloration of apex was assessed visually for single plant at half way anthesis. Lemma and palea color was assessed visually for group of plants at dough development stage. Sterile lemma color was assessed visually for single plant at hard caryopsis stage. Curvature of main axis, presence of secondary branches, secondary branching intensity, attitude of branches and panicle exertion were assessed visually for group of plants at ripening stage. Presence of awn, color of awn, length of longest awn, distribution of awn was assessed visually for single plant at ripening stage. Decorticated grain color was assessed visually for group of plants at hard caryopsis stage. Grain: Phenol reaction of lemma. Grains are soaked in 1.5 per cent aqueous solution for 24 hours, drained and air-dried. Hull color is then recorded unstained and stained [6]. Time of heading is recorded at half of inflorescence stage when panicle appear in at least 50% plants by visual assessment for a group of plant. The time for maturity is recorded

by visual assessment for group of plants at ripening stage.

3. RESULTS AND DISCUSSION

3.1 DUS Characterisation of Rice

The test guideline for rice (UPOV/TG/16/8, 2004) is used for distinctness, uniformity and stability (DUS) tests of new varieties of *rice*. Novelty, Distinctiveness, Uniformity and Stability of a variety is defined according to Article 7 of the 1961/1972 and 1978 Acts and Article 12 of the 1991 Act of the UPOV Convention. In the present study, data were recorded on 12 genotypes (11 advanced recombinant lines of Kalanamak rice and PSD 17) for 62 morphological traits as per the DUS test guidelines. Observations were recorded on 60 morphological characteristics which included 46 visually assessed characteristics and 14 measurable characteristics. The remaining 2 characteristics *viz.,* culm: attitude (for floating rice) and polished grain: expression of white core, were not applicable to the investigated material. The characters studied in this investigation were scored under visually assessed characteristics and measurable characteristics.

3.2 Visually Assessed Characteristics

The morphological data scored on 46 visually assessed characteristics are presented in Table 1. These characters were assessed either by visual observation on individual plants or a group of plants. Visually assessed characters play key role in establishing distinctiveness of a variety from other known variety in public domain. Distinctiveness of a variety is determined through clear and distinct differences between test variety and reference variety for one or more characteristics following the test guidelines. In the present study, 27 visually assessed characteristics were found to be monomorphic, 18 were dimorphic and 2 were polymorphic. Monomorphic characters include coleoptile color, anthocyanin coloration of leaf, distribution of anthocyanin coloration on leaf, anthocyanin coloration of leaf sheath, intensity of anthocyanin coloration of leaf sheath, presence of auricles, anthocyanin coloration of auricles, presence of collar, anthocyanin coloration of collar, presence of ligule, color of ligule, flag leaf: attitude of blade (early observation), anthocyanin coloration of nodes, intensity of anthocyanin coloration of nodes, anthocyanin coloration of internodes, culm attitude, male sterility, anthocyanin coloration of apex of lemma, distribution of awn, presence of secondary branching in panicle, attitude of branches in panicle, panicle exertion, phenol color reaction of lemma, decorticated grain color, presence of amylose in endosperm, gelatinization temperature and decorticated grain aroma. Dimorphic characters includes basal leaf sheath color, pubescence of blade surface, shape of ligule, flag leaf attitude of blade (late observation), culm attitude, anthocyanin coloration of keel, anthocyanin coloration of area below apex, color of stigma, curvature of main axis of panicle, color of tip of lemma, density of pubescence of lemma, presence of awns, color of awns, distribution of awn, panicle secondary branching, leaf senescence, sterile lemma color and decorticated grain shape. Polymorphic characteristics includes leaf intensity of green color, lemma and palea color and length of longest awn. The different states of expression were found to be sufficient to assess distinctiveness and no statistical method was used for the interpretation of the visually assessed characteristics. These characters are visually scored following the DUS guidelines, for two consecutive years during kharif 2016 and 2017. The expression of characters under different states depending upon provided notes at different stage of observation were similar in both the year which are presented in the Table 1.

3.3 Measurable Characteristics

Mean performances over the years of the 15 measurable characteristics along with their states of expression are presented in Table 2. Data on five characteristics *viz.,* leaf: length of blade, leaf: width of blade, stem thickness, stem length: excluding panicle and panicle number per plant were recorded on ten plants per replication while for rest of the 9 characteristics *viz.,* time of heading (50% plants with panicles), panicle: length of main axis, time of maturity, grain: weight of 1000 fully developed grains, grain: length, grain: width, decorticated grain: length, decorticated grain: width and endosperm: content of amylose were measured by a single observation per replication. KARL-1 has minimum mean value for leaf width (0.73 cm), stem length (110.00 cm) and maturity time (170.83 days) while maximum mean value for panicle length (28.33 cm), thus this line can be

Table 1. Morphological characterization of visually assessed characteristics over the year 2016-2017

Sl. no.	Genotype	Leaf characteristics															
		Coleoptile Color	Basal leaf Sheath (LS) color	Intensity of green color	AC	AD	AC of LS	Intensity of AC in LS	Pubescence on blade	Auricles	AC of auricles	Collar	AC of collar	Ligule	Shape of ligule	Color of ligule	Senescence
1	KARL 1	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
2	KARL 2	Cl	LP	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
3	KARL 3	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
4	KARL 4	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
5	KARL 5	Cl	PL	MG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
6	KARL 6	Cl	LP	MG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
7	KARL 7	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
8	KARL 8	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
9	KARL 9	Cl	PL	DG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
10	KARL 10	Cl	LP	MG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
11	KARL 11	Cl	LP	MG	A	A	A	A	W	P	Cl	P	A	P	Sp	W	M
12	PSD 17	Cl	PL	L	A	A	A	A	A	P	Cl	P	A	P		W	E

Cl: Colorless, PL : Purple lines; LP : Light purple, DG: Dark green, MG: Medium green,L:light green, A: Absent; AC : Anthocyanin coloration ; AD: Anthocyanin distribution; W : Weak; P : Present, Sp: Split, T: Truncated, W: White, M : Medium, E : Early

Sl. no.	Genotype	Flag leaf attitude of blade			Lemma				Spikelet				Stem			
		Early observation	Late observation	Male sterility	AC of keel	AC of area below apex	AC of apex	Sterile lemma Color	Lemma and palea color	Color of stigma	Density of pubescence of lemma	Color tip of lemma	Culm attitude	AC of nodes	Intensity of AC of nodes	AC of internodes
1	KARL 1	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
2	KARL 2	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
3	KARL 3	E	E	A	S	S	S	Pr	Pr	LP	W	B	E	A	A	A
4	KARL 4	E	E	A	S	S	S	Pr	Pr	LP	W	B	E	A	A	A
5	KARL 5	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
6	KARL 6	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
7	KARL 7	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
8	KARL 8	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
9	KARL 9	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
10	KARL 10	E	E	A	S	S	S	Pr	PF	LP	W	B	E	A	A	A
11	KARL 11	E	E	A	S	S	S	Pr	Pr	LP	W	B	E	A	A	A
12	PSD 17	E	SE	A	A	A	S	G	GF	W	A	Y	E	A	A	A

E: Erect, SE: Semi erect, S: Strong, B: Black, Y: Yellowish, Pr:Purple, G: Gold, PF : Purple furrow, GF: Gold furrow

Sl. no.	Genotype	Panicle									Grain	Decorticated grain			Endosperm	
		Curvature of main axis	Awns	Color of awns	Length of longest awn	Distribution of awns	Presence of secondary branching	Secondary branching	Attitude of branches	Exertion	Phenol reaction of lemma	Shape	Color	Aroma	Presence of amylose	GT
1	KARL 1	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
2	KARL 2	St	P	Pr	SH	WL	P	C	E-SE	WE	P	MS	LB	P	P	HM
3	KARL 3	St	P	Pr	M	WL	P	C	E-SE	WE	P	MS	LB	P	P	HM
4	KARL 4	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
5	KARL 5	St	P	Pr	M	WL	P	C	E-SE	WE	P	MS	LB	P	P	HM
6	KARL 6	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
7	KARL 7	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
8	KARL 8	St	P	Pr	SH	WL	P	C	E-SE	WE	P	MS	LB	P	P	HM
9	KARL 9	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
10	KARL 10	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
11	KARL 11	St	A	A	A	A	P	C	E-SE	WE	P	MS	LB	P	P	HM
12	PSD 17	SSt	A	A	A	A	P	S	E-SE	WE	P	LS	LB	P	P	M

St: Straight, SSt: semi straight, SH: Short, M: Medium, WL: Whole length, C: Clustered, E-SE: Erect to semi erect WE: Well; Exerted, MS: Medium slender, LS: Long slender, LB: Light brown, GT: Gelatinization temperature, HM: High medium

Table 2. Data scored on measurable characteristics (Mean value) over the year

Genotype	Characters														
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
KARL 1	34.50	0.73	146.00	2.83	110.00	28.33	12.83	170.83	11.91	7.20	1.90	4.20	1.65	20.73	760.00
KARL 2	30.67	1.12	148.00	2.73	130.83	27.33	11.67	176.67	17.33	8.30	1.95	5.00	1.65	21.33	536.67
KARL 3	30.00	1.15	140.33	2.03	131.50	24.33	10.50	175.00	18.45	8.00	2.15	4.40	1.90	20.13	566.83
KARL 4	26.50	0.97	141.33	2.37	130.33	23.67	10.67	175.83	10.06	7.50	2.15	4.45	2.10	20.67	469.50
KARL 5	27.00	1.25	140.00	2.17	134.83	21.67	9.50	175.67	13.06	7.80	2.45	5.30	2.00	22.13	789.17
KARL 6	39.17	1.37	148.67	2.37	134.17	24.67	9.00	177.50	11.53	8.20	2.15	4.65	1.80	21.33	505.00
KARL 7	28.00	0.75	145.67	2.17	129.67	21.67	11.50	178.33	12.38	7.20	2.10	4.35	1.70	19.73	932.00
KARL 8	21.50	1.10	144.00	1.57	114.67	20.67	11.67	179.67	13.87	7.30	1.85	4.35	1.55	19.47	1338.00
KARL 9	25.33	1.17	138.67	2.97	110.00	24.67	17.17	174.17	14.06	6.90	2.00	4.20	1.60	20.73	1212.50
KARL 10	23.17	1.07	139.33	2.43	139.67	24.33	14.83	172.83	15.02	6.80	1.95	3.95	1.65	21.67	1160.83
KARL 11	28.33	0.85	144.33	2.07	136.67	26.67	12.25	178.00	16.74	7.30	1.80	4.60	1.70	20.27	803.33
PSD 17	30.17	0.45	96.67	2.17	110.67	21.67	13.67	138.17	22.74	12.25	2.25	9.70	1.90	20.47	2296.67

C1:Length of leaf blade (cm), C2: Width of leaf blade(cm), C3: Time of 50% heading (days), C4:Stem thickness (cm), C5: Stem length: excluding panicle (cm), C6 :Length of panicle main axis (cm), C7: Panicle number per plant, C8:Time of maturity (days),C9:Weight of 1000 fully developed grains (g), C10 :Grain length (mm), C11: Grain width (mm), C12: Decorticated grain length (mm), C13: Decorticated grain width (mm), C14: Content of amylose in endosperm(%), C15:Yield (g/6m2)

used for selecting early maturing genotypes with high yield. KARL-2 has maximum mean value for grain length (8.30 mm). KARL-3 has maximum mean value for test weight (18.45 g). KARL-4 has maximum mean value for decorticated grain width (2.10 mm) while minimum mean value for test weight (10.06 g) and yield (469.50 g/m^2). KARL-5 has maximum mean value for grain width (2.45 mm), decorticated grain length (5.30 mm) and amylose content (22.13%), thus this line can be used for selecting longer grain length with intermediate amylose content as small sized grain with low amylose content is a major constraint in commercialization of *Kalanamak* rice, as Indian favour longer grains with intermediate amylose content. KARL-6 has maximum mean value for leaf blade length (39.17 cm), blade width (1.37 cm) and 50% heading (148.67 days) while minimum mean value for panicle number per plant (9.0). KARL-7 has intermediate values for all traits. KARL-8 has maximum mean value for maturity time (179.67 days) and yield (1338.00 g/m^2) while minimum mean value for blade length (21.50 cm), stem thickness (1.57 cm), panicle length (20.67 cm), decorticated grain width (1.55 mm) and amylose content (19.47%). KARL-9 has minimum mean value for 50% heading (138.67) and stem length (110.00 cm) while maximum mean value for panicle number per plant (17.17) and stem thickness (2.97 cm), thus this line can be used for selecting genotypes with lodging resistance trait as lodging is a major problem in *Kalanamak* rice. KARL- 10 has maximum mean value for stem length (139.67 cm) while minimum mean value for grain length (6.80 mm) and decorticated grain length (3.95 mm). KARL-11 has minimum mean value for grain width (1.80 mm).

3.4 Salient Findings

- *Kalanamak* is a small grained rice. However, KARL2, KARL3 and KARL6 showed relatively longer grain length (8.0-8.2 mm) over the year.
- KARL8, KARL9, and KARL10 showed significant higher yield (1150-1340 g/6m^2) than that for other KARL genotypes.
- *Kalanamak* rice has low amylose content. However, in India people prefer intermediate amylose content rice. In the present investigation KARL2, KARL5, KARL6 and KARL 10 showed intermediate amylose content (21-22%).
- Out of 11, five genotypes namely KARL3, KARL4, KARL5, KARL9 and KARL10 showed early 50% flowering (138-141 days) over the year. Similarly, these genotypes along with KARL1 showed early maturity time (170-176 days). An interesting trend was observed for KARL1 with respect to mid-late 50% flowering but earliest maturity time (170 days).
- Another important constraint in widespread cultivation of Kalanamak rice is lodging problem which could be overcome by selecting genotypes with short and thick stem. KARL1, KARL2 and KARL9 showed thicker stem (2.7-3.0 cm) while KARL1, KARL8, and KARL9 showed short stem height (110-114 cm) over the years. Thus, these genotypes are good source for selecting non-lodging genotypes.

4. CONCLUSION

Kalanamak rice is a strong scented aromatic rice variety which could outshined even premium quality basmati rice in most of the quality characters. However, small grain size, long maturity duration and lower amylose content are some major constraints to its wide spread cultivation. In the present investigation with 11 advanced recombinant lines, some genotypes were reported to show significant response towards the desired level for these three agronomically important traits. Selection in these genotypes will be quite returning for deriving early maturity genotypes, which would be a major improvement for large scale adoption of this long duration genotype. The reported results from DUS characterisation will be quite helpful for students, breeders, farmers and others who are in academic and research activities as a good source of information in selecting improved genotypes for various breeding programmes viz. resistance breeding, breeding for early maturity, breeding for intermediate amylose content, breeding for lodging resistance etc.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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