Research Article

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Morphological diversity of Sri Lankan traditional rice varieties "*Pachchaperumal*" and "*Suduru samba*"

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Abstract: Sri Lankan traditional rice varieties consist of more than one accession mostly which, exhibit a wide variation in morphological characters, flowering time and yield. The objective of this study was to evaluate the diversity based on days to flowering (DF) and 12 morphological characters of two Sri Lankan traditional rice varieties *Pachchaperumal and Suduru samba* comprising of 13 and 7 accessions respectively. DF of *Pachchaperumal* and *Suduru samba* varied from 60 – 72 and 79 – 99 days respectively. Vegetative morphological characters and yield components also varied among *Pachchaperumal and Suduru samba* accessions while pericarp colour, grain width, and length were distinct characters between the two varieties. According to the hierarchical cluster analysis, 2 major clusters were identified at the rescale distance of 25 separating accessions of *Pachchaperumal* and *Suduru samba* except for accession 3136 of *Pachchaperumal*, which was located in *Sudura samba* cluster. Seven clusters were derived at rescaled distance of 5 where accessions of similar quantitative and qualitative morphological characters were clustered together. There were negative correlations between DF and selected yield components in contrast to positive correlations between DF and selected vegetative growth parameters. Our results may be useful in the determination of identity of accessions belonging to the same variety, which could be further supported by molecular analysis.

Keywords: flowering time, morphology, *Pachchaperumal*, Sri Lankan rice, *Suduru samba*, yield

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1 Introduction

Sri Lanka is self-sufficient in rice production with approximately 3.6 million metric tons of rice per year (FAO 2014). Unfavourable climatic and environmental conditions and reduction of land use could adversely affect the rice production in the near future (Bambaradeniya and Amerasinghe 2004). Therefore, it is necessary to increase the production of rice by enhancing its genetic diversity through breeding new varieties. These new varieties should be able to face future challenges of climate change (Yoshida 1983).

There are around 500 varieties in the Sri Lankan traditional rice collection while most of the varieties contain more than one accession from diverse 46 agro-ecological sub regions of Sri Lanka. Genetic diversity of Sri Lankan traditional rice may be depicted in variation of days to flowering (DF), plant architecture, yield and photoperiodic response (Irangani and Shiratake 2013). Several environmental factors affect the DF, plant architecture, vigour and yield of rice plant; photoperiod and temperature are the main factors among them. About 755 accessions belonging to different varieties of Sri Lankan rice have been characterized (Team of NRC research project 12-129, 2014, 2015a and 2015b). A mini core collection was developed for flowering time variation (Rathnathunga et al. 2016a).

Sri Lankan traditional rice cultivation was discouraged due to the introduction of new improved rice varieties in early 1960s in the country. Before 1940s there were around 150 Sri Lankan traditional varieties of four age groups: varieties of 5-6 months (*Podi wee, Molagu samba, Kohu ma wee, Kurulu thuda*); varieties of 4-4.5 months (*Devareddari*), varieties of 3.5 months (*Vellai illankalayan, Mada al, Sulai, Pachchaperumal, Dahanala, Murunga, Pokkali*); and varieties of 3 months (*Sudu heenati, Kalu heenati*), which were very popular among farmers (Rajapakse et al. 2000). In 1940s the Department of Agriculture identified pure lines and released them for cultivation. A hybridization program was carried out and H series varieties (old improved

varieties) were released. Later the new improved varieties replaced the traditional rice. Improved varieties were exploited from the farmer fields (Rajapakse et al. 2000; Wang et al. 2012). Current Sri Lankan traditional rice cultivation is around 0.1% of the total cultivated land area, which extends about 1000 ha annually (Wang et al. 2012). Sri Lankan Government is attempting the re-introduction of traditional rice to farmer fields as a component in organic agriculture, mainly due to its nutritive and *ayurvedic* value and resistance to insects, diseases and adverse climatic conditions (Berger 2009; Dharmasena 2010; Fisher and Lucy 2012; Vanlanka Community Foundation 2014).

In 1960's Sri Lankan traditional rice germplasm was deposited in the IRRI gene bank. Later, a replica of the whole collection was brought back to Sri Lanka. However, passport data was not completely available at the Plant Genetic Resource Centre (PGRC). Assigning the variety name for accessions from different geographical locations of Sri Lanka was based on farmers' information. Therefore, duplicated accessions may exist within a variety, and accessions not belonging to a given variety may be included in certain varieties (Personal communication with Mr. A.S.U. Liyanage from PGRC).

Pachchaperumal is a red rice variety, which was considered as divine rice in traditional *Sinhalese* culture. *Suduru samba* is a white rice variety of very small, palatable grain considered to be comparatively resistant to brown plant hoppers and thrips. *Pachchaperumal is* known to be a good diet for patients that suffer from diabetes and cardiovascular diseases, and *Suduru samba* is considered to be an aphrodisiac in traditional Sri Lankan medicine. (Kottearachchi et al. 2010; Dhasa Maha Yodhayo 2011; Progress Programme 2011 and 2012; Rice 2016; Varietal Improvement 2016). *Pachchaperumal and Suduru samba* are considered as photoperiod insensitive short aged (3 – 3.5 months) varieties in farmer fields (Yoshida 1983). The objective of this study was to characterize two Sri Lankan traditional rice varieties *Pachchaperumal and Suduru samba* comprising of 13 and 7 accessions respectively. Each accession was characterized based on the number of days to flowering (DF), 12 morphological characters in order to determine their varietal identity, and relationships between DF and morphological characters: Characterization of *Pachchaperumal and Suduru samba* accessions may be useful for the genetic diversity among accessions on morphological variation and to determine the effect of DF variation within variety.

2 Materials and methods

2.1 Rice Accessions

Twenty accessions of two Sri Lankan traditional rice varieties as thirteen of *Pachchaperumal* (Accession numbers: 8827, 9049, 3136, 3752, 3408, 5549, 5550, 5548, 5547, 5546, 6834, 5383, 3946) and seven of *Suduru samba* (Accession numbers: 4362, 5402, 2202, 3333, 3572, 3594, 3671) were selected.

2.2 Field experiment

Pachchaperumal and *Suduru samba* accessions were grown at Rice Research and Development Institute, at Batalagoda, in Sri Lanka (located in agro-ecological zone, IL1 of latitude 7° 29' 12" N and longitude 80° 21' 53" E with a height of 137 m above mean sea level). Average temperature during the cropping season was around 32 °C and the soil type was dark brown earth (DBE). A plot of three rows with 9 plants was considered as one replicate of the experiment: The spacing was 20 cm x 20 cm within and between rows and 40 cm between plots in a Complete Randomized Design (CRD). There were 4 replicates. The experiment was carried out in late short day season (*Maha*), from December 2012 to long day season till July 2013. Fertilizer application, pest and disease management and weed control were done according to the recommendation by Department of Agriculture, Sri Lanka (Rice 2016). The basal dressing of urea, TSP and MOP (of 50, 62.5 and 50 kg/ ha) was applied during the land preparation. Top dressings of 61.75, 123.5 and 123.5 kg/ ha of urea were applied at 2 weeks, 5 weeks and 7 weeks of planting, respectively. Manual weeding was done at regular intervals. The experimental field was irrigated in order to maintain a standing water level.

2.3 Evaluation of morphological traits

Quantitative morphological characters measured from each replicate for each accession are days to flowering (DF) and at maturity: plant height (PH), culm length (CL), culm number (CN), culm diameter (CD), panicle length (PL) grain length (GL), grain width (GW), leaf number (LN), leaf length (LL), leaf width (LW), shoot weight (SW) and panicle weight (PW). Panicle type, awn presence, lemma and palea colour, seed shape, and pericarp colour were evaluated as qualitative morphological characters. LeT of flag leaf was measured in degrees of Celcius

using Leaf Temperature meter (Specturm technologies. Inc., Australia) and the difference between LeT and environmental temperature (LeTD) was calculated by subtracting LeT from the prevailing temperature in the field. With respective to each quantitative character in a given accession, average value of replicates was considered for analysis. Measurement techniques were performed according to modified descriptors of rice published by the Team of NRC research project 12-129 (2014; 2015a; 2015b).

2.4 Statistical analysis

Data was analyzed using the Principal Component Analysis (PCA) with a correlation matrix through SPSS software (version 20, IBM, USA) to define the patterns of variation between all explanatory variables. Twenty accessions of *Pachchaperumal* and *Suduru samba* were clustered using Hierarchical Cluster Analysis through SPSS software. The measure of dissimilarity was based on Euclidean distance. Clustering method was Ward's linkage. The number of clusters was determined at the rescaled distance of 25 and 5. A correlation analysis was carried out to evaluate the significant relationship between quantitative morphological traits during the PCA.

3 Results

3.1 DF and morphological variation among accessions of Sri Lankan traditional rice varieties Pachchaperumal and Suduru samba

DF and quantitative morphological vegetative characters and yield components varied among *Pachchaperumal and Suduru samba* accessions, while accessions of each variety could be distinguishable based on DF, plant architecture and grain size. DF varied from 60 – 72 and 79 – 99 days and 64.8 days and 89.1 days in average in *Pachchaperumal and Suduru samba* varieties respectively. Grains of *Pachachperumal* were longer (0.7 to 1.1 cm) in contrast to the grains of *Suduru samba* (0.5 to 0.6 cm). Average values of LL, PH, CN and GL were 46.4 and 61.6 cm, 131.7 and 155.5 cm, 14.1 and 24.7, and 0.8 and 0.5 cm respectively (Table 1).

3.2 Genetic diversity of Pachchaperumal and Suduru samba accessions through Principal Component Analysis and Cluster Analysis

First three Principal Components (PC) explained 75% of total observed variation. DF, LL, PH, CL, CN, GL, GW and SW were included in PC1. CD, PL and PW were included in PC2 while LN and LW were included in PC3. The PC1, PC2 and PC3 explained 40.8%, 20.8% and 13.4% of variance respectively (Table 2). According to the hierarchical cluster analysis, 2 major clusters were identified at the rescale distance of 25, which were further separated in to 7 clusters at rescaled distance of 5 indicating similar DF groups in most clusters (Figure 1).

3.3 Variation of qualitative morphological characters among Pachchaperumal and Suduru samba accessions

All *Pachchaperumal* accessions produced the light brown to red pericarps, while *Suduru samba* produced off-white pericarps except for accession 4362, which produced red pericap. The qualitative morphological

Table 1: Descriptive statistical explanation of the variation of quantitative characters among the accessions of *Pachchaperumal* and *Suduru samba*

		Variety *Pachchaperumal*			Variety *Suduru samba*		
Character	**Unit**	**Range**	**Average**	**Standard deviation**	**Range**	**Average**	**Standard deviation**
DF	days	60 - 72	64.8	3.8	79 – 99	89.1	8.5
LN	number	25.3 - 127	67.3	31.8	25.7 – 107	57.8	28.9
LL	cm	41.5 - 54.9	46.4	3.7	52.3 - 71.6	61.6	7.2
LW	cm	9 - 13	10.8	1.1	6.2 - 12.6	9.8	1.9
PH	cm	116.5 - 151.5	131.7	10.6	141.5 - 164.3	155.3	8.0
CL	cm	87 - 129.5	108.7	11.0	120.7 - 149.7	130.5	9.7
CN	number	9 - 27	14.1	4.9	13.7 - 37.3	24.7	8.6
CD	cm	0.32 - 0.65	0.4	0.1	0.35 - 0.8	0.6	0.2
GL	cm	0.7 - 1.1	0.8	0.1	0.5 - 0.6	0.5	0.0
GW	cm	0.3 - 0.35	0.3	0.0	0.2 - 0.3	0.2	0.0
PL	cm	11.75 - 19.75	15.6	2.4	12.4 - 28.4	21.7	5.7
SW	g	65.63 - 138.18	97.2	24.2	108.83 – 177	139.9	22.2
PW	g	11.83 - 47.08	24.4	8.9	4.2 - 32.98	19.5	10.3

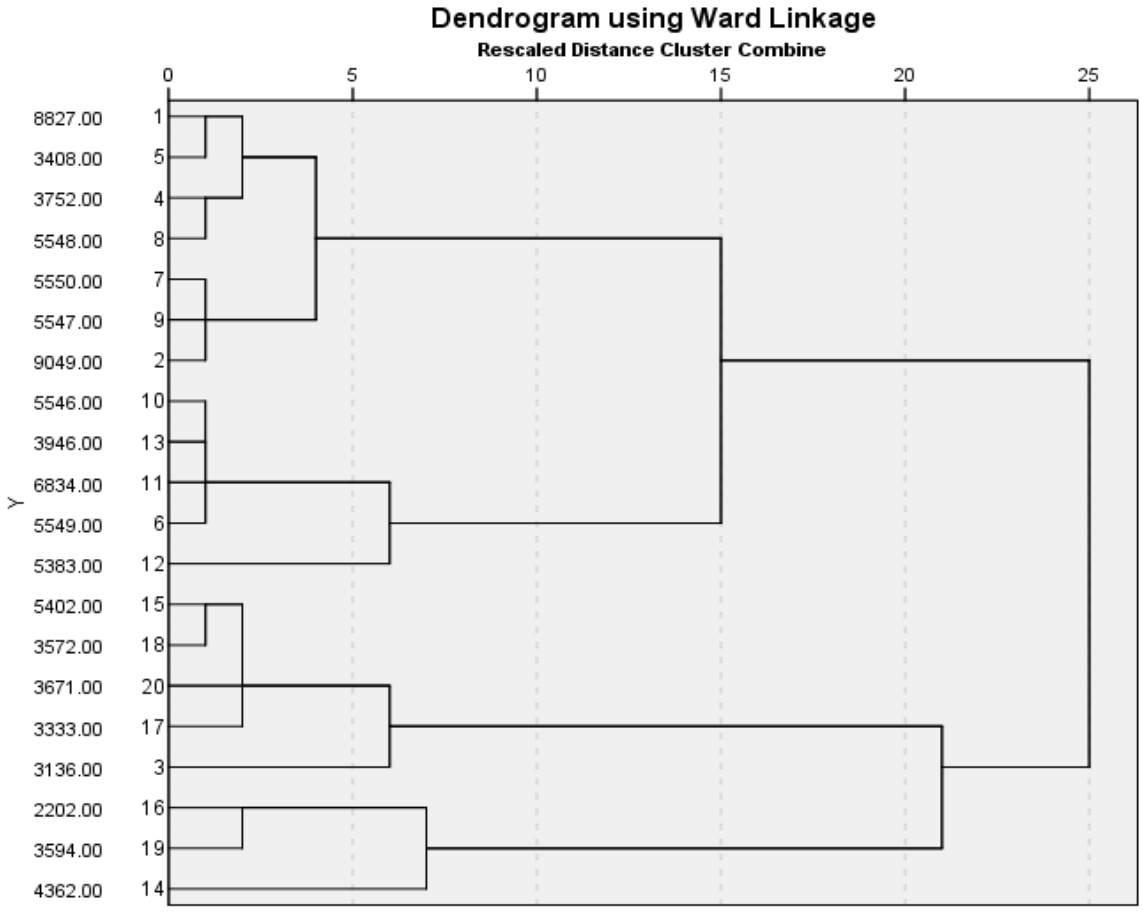

Figure 1: Dendogram of *Pachchaperumal* and *Suduru samba* accessions derived through Ward's linkage method of Cluster Analysis based on days to flowering and 12 morphological characters

Table 2: First three PCs on variation among accessions of Sri Lankan traditional rice varieties *Pachchaperumal and Suduru samba*

PC	PC 1	PC 2	PC 3
Contribution to variation	40.8 %	20.8%	13.4 %
Composition of characters	DF (0.866) LeTD (0.670) LL (0.763) PH (0.764) CL (0.702) CN (0.806) GL (-0.638) GW (-0.925) SW (0.841)	CD (0.740) PL (0.785) PW (-0.829)	LeT (0.651) LN (0.739) LW (0.540)

background of accessions of each cluster indicated significantly similar lemma and palea colour, and similar pericarp colour variation within 4, 6 and 7 clusters of *Suduru samba* accessions and cluster 1, 3 and 5 of *Pachchaperumal* accessions (Table 4). Awns were absent in both *Pachchaperumal and Suduru samba* accessions.

3.4 Relationship between days to flowering, vegetative growth and yield components

There were significantly positive correlations between DF and quantitative morphological characters of LL, PH, CL, CN, CD, PL and SW and, negative correlations between GL and GW (Table 5).

Table 3: Variation of quantitative morphological characters of *Pachchaperumal* and *Suduru samba* within clusters which were derived through Ward's linkage method

Cluster number	Variety and accession number	DF	LeT	LeTD	LN	LL	LW	PH	CL	CN	CD	GL	GW	PL	SW	PW
1	*Pachchaperumal* 8827	69	26.67	3.4	79	50.2	11.6	151.5	121.8	10.5	0.55	0.8	0.3	16.43	69.23	25.1
	Pachchaperumal 3408	60	26.33	3.8	108	47.8	11	141.8	119.6	14.3	0.65	0.8	0.3	19.3	115.5	18.48
	Pachchaperumal 3752	71	27	3.1	49	54.9	12.2	123.5	110.5	9	0.35	0.8	0.3	16.63	87.35	11.83
	Pachchaperumal 5548	64	26	4.1	86.3	46.1	10	125	102.3	11.3	0.43	0.8	0.3	15.18	65.63	16.43
	Pachchaperumal 5550	62	26.33	3.8	127	44.5	10.4	128.6	104	14.8	0.35	0.8	0.3	12.7	73.5	24.53
	Pachchaperumal 5547	64	26	4.1	108	45.4	13	128	111	13.5	0.45	1.1	0.3	17.2	129.8	29.93
	Pachchaperumal 9049	72	26.67	3.4	51.5	47	11.4	149.5	129.5	17.3	0.4	0.8	0.3	13.5	112.53	29.93
2	*Pachchaperumal* 5546	66	26	4.1	49.3	41.5	9.2	127.5	110.5	9.8	0.55	0.7	0.3	16	71.13	17.68
	Pachchaperumal 3946	64	25.33	4.8	60.5	46.4	10.8	116.5	103.5	10.3	0.32	0.8	0.3	16.25	82.85	16.95
	Pachchaperumal 6834	62	24.33	5.8	48.8	49.4	10.6	135	111	10.8	0.4	0.8	0.3	14.75	111.1	24.43
	Pachchaperumal 5549	66	26.33	3.8	54	41.8	11.2	121.3	104	18.5	0.4	0.8	0.3	13.5	110.83	25.03
3	*Pachchaperumal* 5383	61	23.67	6.4	25.3	43	9	128	87	16.3	0.43	0.8	0.35	19.75	95.35	29.18
4	*Suduru samba* 5402	79	23.67	8.4	34.8	54	9.4	154.5	133.8	18	0.6	0.5	0.2	17.5	126.23	32.98
	Suduru samba 3572	99	23.33	8.8	55	71.6	10.2	159	130.5	28.3	0.45	0.6	0.2	19.75	129.8	22.53
	Suduru samba 3671	93	23	9.1	84	61.3	6.2	150.5	121.1	25.8	0.5	0.6	0.2	22.75	177	29.98
	Suduru samba 3333	97	25.67	6.4	58.5	59.7	10	141.5	128.5	17.5	0.35	0.5	0.2	12.4	145.9	21.35
5	*Pachchaperumal* 3136	62	26.33	3.8	28.5	45.6	10	136.5	97.8	27	0.38	0.8	0.3	11.75	138.18	47.08
6	*Suduru samba* 2202	81	24	8.1	39.7	52.3	9.2	164.3	149.7	32	0.7	0.5	0.2	28	135.33	4.2
	Suduru samba 3594	94	23	9.1	107	69.6	10.8	163.8	129.1	37.3	0.8	0.5	0.2	22.75	156.25	12.4
7	*Suduru samba* 4362	81	22.67	9.4	25.7	62.5	12.6	153.7	120.7	13.7	0.7	0.5	0.3	28.4	108.83	12.9

Table 4: Variation of qualitative morphological characters of *Pachchaperumal* and *Suduru samba* within clusters which were derived through Ward's link age method

Cluster number	Variety and accession number	Panicle type	Awn presence	Lemma and palea colour	Seed shape	Pericarp colour
1	*Pachchaperumal* 8827	Compact	Absent	Brownish black furrows on straw background		Light brown seed coat with white strip
	Pachchaperumal 3408	Compact	Absent	Reddish brown spots in gold background	Spindle	Light brown seed coat with white strip
	Pachchaperumal 3752	Compact	Absent	Brownish black furrows on straw background		Red
	Pachchaperumal 5548	Compact	Absent	Brownish black furrows on gold background	Spindle	Brown
	Pachchaperumal 5550	Compact	Absent	Reddish brown spots in gold background		Red
	Pachchaperumal 5547	Compact	Absent	Purple spots on straw background	Very spindle	Light brown
	Pachchaperumal 9049	Compact	Absent	Brownish black furrows on straw background		Light brown seed coat with white strip
2	*Pachchaperumal* 5546	Compact	Absent	Straw	Half spindle	Red with black apiculus
	Pachchaperumal 3946	Compact	Absent	Reddish brown spots in gold background	Spindle	Brown seed coat with strip
	Pachchaperumal 6834	Intermediate	Absent	Reddish brown spots in gold background		Brown seed coat with white strip and black apiculus
	Pachchaperumal 5549	Intermediate	Absent	Reddish brown spots in gold background	Spindle	Brown
3	*Pachchaperumal* 5383	Compact	Absent	Straw		Red
4	*Suduru samba* 5402	Intermediate	Absent	Gold or gold furrows on straw background	Spindle	Off-white
	Suduru samba 3572	Compact	Absent	Gold or gold furrows on straw background	Spindle	Off-white
	Suduru samba 3671	Compact	Absent	Purple spots on straw background	Half spindle	Off-white
	Suduru samba 3333	Compact	Absent	Purple spots on straw background	Spindle	Off-white
5	*Pachchaperumal* 3136	Compact	Absent	Reddish brown spots in gold background	Spindle	Brown seed coat with white strip and black apiculus
6	*Suduru samba* 2202	Intermediate	Absent	Purple spots on straw background	Spindle	Off-white
	Suduru samba 3594	Compact	Absent	Gold or gold furrows on straw background	Spindle	Off-white
7	*Suduru samba* 4362	Compact	Absent	Straw	Semi round	Red

Table 5: Correlation among the quantitative characters within accessions of *Pachchaperumal* and *Suduru samba*

	Character	DF	LN	LL	LW	PH	CL	CN	CD	GL	GW	PL	SW	PW
Correlation	DF	1.000												
	LN	- 0.052	1.000											
	LL	0.899*	0.012	1.000										
	LW	- 0.287	0.110	- 0.081	1.000									
	PH	0.699*	- 0.066	0.711*	- 0.176	1.000								
	CL	0.682*	- 0.010	0.592*	- 0.067	0.833*	1.000							
	CN	0.619*	0.008	0.560*	- 0.372	0.676*	0.474*	1.000						
	CD	0.332*	0.072	0.418*	- 0.028	0.710*	0.566*	0.451*	1.000					
	GL	- 0.768*	0.312	- 0.686*	0.406*	- 0.694*	- 0.642*	- 0.531*	- 0.536*	1.000				
	GW	- 0.873*	- 0.050	- 0.737*	0.431*	- 0.701*	- 0.779*	- 0.689*	- 0.382*	0.747*	1.000			
	PL	0.421*	- 0.128	0.515*	- 0.119	0.598*	0.474*	0.407*	0.765*	- 0.521*	- 0.350*	1.000		
	SW	0.655*	- 0.020	0.573*	- 0.341*	0.570*	0.474*	0.751*	0.299	- 0.432*	- 0.701*	0.330*	1.000	
	PW	- 0.226	- 0.113	- 0.282	- 0.176	- 0.138	- 0.371*	0.011	- 0.416*	0.350*	0.175	- 0.540*	0.200	1.000

* > 0.3 - significant correlation (+) positive, (-) negative

4 Discussion

4.1 Variation among accessions of Sri Lankan traditional rice varieties Pachchaperumal and Suduru samba

Sri Lankan traditional rice is known to be photoperiod sensitive where highly short-day sensitive varieties such as *Ma wee* are grown only during short -day season (*Maha*) (Chandraratne, 1964; Irangani and Shiratake, 2013; Team of NRC 12-129, 2015b). We have observed a wide flowering time variation among traditional rice *Sulai* (57-179 days), *Sudu wee* (62 to 200 days+) and *Hondarawala* (57 to 200 days+) accessions during late short day season in Sri Lanka in contrast to *Pachchaperumal* (60 – 72 days) and *Suduru samba* (79 – 99 days) (Rathnathunga et al. 2015; Rathnathunga et al. 2016b; Rathnathunga et al. 2016c). The two varieties could be distinguishable due to variation in quantitative characters of DF, vegetative growth parameters and grain size, and qualitative character of pericarp colour. *Suduru samba* produced the typical small grains, which receive a higher price in the market. The LL, LW, PH, CL, CN, CD, GL, GW, PL, SW and PW varied differently among *Pachchaperumal and Suduru samba* accessions, which differentiated *Pachchaperumal and Suduru samba* varieties into 2 different clusters at the rescale distance of 25 according to the hierarchical cluster analysis (Figure 1). Our results confirm the fact that the *Pachchaperumal and Suduru samba* varieties are of different genetic composition, which can be explained by the means of the phenotypic variation. According to Yano et al. (2001), phenotypic variation resulted due to different genetic composition.

Grain length and width of all accessions of *Suduru samba* were lesser making a small seed shape while in all *Pachchaperumal* accessions, seed shape was larger (Table 3). Lower range of DF, LL, CL and SW were among *Pachchaperumal* accessions in contrast to *Suduru samba* accessions, which indicated a relatively lower plant growth in *Pachchaperumal* variety.

4.2 Genetic diversity of Pachchaperumal and Suduru samba accessions through Principal Component Analysis and Cluster Analysis

Comparatively similar PCs were identified in studies of *Sulai*, *Sudu wee* and *Hondarawala* varieties, which suggested the fact that same character standards applied in all genetic diversity studies of Sir Lankan rice (Rathnathunga et al. 2015; Rathnathunga et al. 2016b; Rathnathunga et al. 2016c) (Table 2). *Pachchaperumal* accessions of 8827, 3408, 3752, 5548, 5550, 5547 and 9047 of cluster one, 5546, 3946, 6834 and 5549 of cluster two, accession of 5383 of cluster three were grouped into

one major cluster at rescale distance 25 indicating the genetic similarity of *Pachchaperumal* accessions. Only accession of 3136 of *Pachchaperumal* clustered with *Suduru samba* accessions, which showed the highest SW of 138.18 g and the highest PW of 47.08 g among *Pachchaperumal* accessions. The accessions from two varieties were different in plant structure, which may indicate the divergent genetic background in each variety. Accessions of 5402, 3572, 3671 and 3333 of *Suduru samba* were included in the cluster four, accessions of 2202 and 3594 of *Suduru samba* accessions in cluster six and 4362 of *Suduru samba* in cluster seven suggesting the genetic similarity between all *Suduru samba* accessions. Variation of DF and other quantitative characters was evident between accessions among different clusters. There are studies on differentiation of traditional rice and improved rice using morphological parameters and comparatively a higher variation was observed in traditional rice for morphological traits under multivariate analysis of variance, suggesting that morphological differentiation of *Pachchaperumal and Suduru samba* varieties could be precise (Suriyagoda et al. 2011; Wijayawardhana et al. 2015). An initial identification of the phenotypically distinguishable Sri Lankan traditional rice varieties could be important to assess the molecular genetic background and its diversity for future breeding approaches (Wijayawardhana et al. 2015).

4.3 Variation of qualitative morphological characters among Pachchaperumal and Suduru samba accessions

Chandrarathna (1964) explained the gene interactions involved in pericarp colour as very important to determine the genetic variation of similar accessions of a variety. He further explained the facts affecting the variation of lemma and palea colour, and pericarp colour. Gene interactions are suggested for pericarp colour variation in selected Sri Lankan traditional rice (unpublished). Genetic basis for morphologically similar accessions of *Pachchaperumal* and *Suduru samba* with different DF would provide more precise information on pleiotropic effect of flowering time on vegetative growth and yield (Table 4). Pericarp colour of all *Pachchaperumal* accessions was light brown to red with comparatively large seed shape while the pericarp colour of *Suduru samba* accessions with comparatively small seed shape were off-white in colour except for the accession 4362. However the two groups derived from the cluster analysis much precisely defined the phenotypic diversity of the varieties, which emphasizes their diverse genetic construction (Table 3 and Table 4). This naturally occurring allelic variation could be a new resource for the functional analysis of plant genes, which made up of complex phenotypic traits. (Yano 2001)

4.4 Relationship between days to flowering, vegetative growth and yield components

DF and selected quantitative morphological characters of vegetative growth and yield components of *Pachchaperumal* and *Suduru samba* accessions were correlated. Delayed flowering time increased the vegetative growth and reduced the grain size (Table 5). Similar observations were reported for *Sulai, Sudu wee* and *Hondarawala* varieties, where there were positive relationships between DF and vegetative growth characteristics, while negative relationships existed between DF and yield components (Rathnathunga et al. 2013; Rathnathunga et al. 2015; Rathnathunga et al. 2016b; Rathnathunga et al. 2016c). In contrast, relationship between DF and yield components of photoperiod responsive 43 *Ma wee* accessions of Sri Lankan traditional rice was positive under inductive short day season (Pushpakumari et al. 2017). Above results suggest that a common relationship model between the DF and vegetative growth and DF and yield components among Sri Lankan traditional rice varieties may not exist, emphasizing the need for molecular analysis (Yano, 2001).

5 Conclusions

According to the dendogram derived through the hierarchical cluster analysis based on morphological characters and flowering time, 2 major clusters were formed at the rescale distance of 25 separating accessions of *Suduru samba* variety from those of *Pachchaperumal* variety. DF of *Pachchaperumal* and *Suduru samba* varied from 60 – 72 and 79 – 99 days respectively. Grains of *Pachchaperumal* variety (of 0.7 to 1.1 cm in length) could be distinguishable from those of *Suduru samba* (of 0.5 to 0.6 cm) due to long length. All *Pachchaperumal* accessions produced the light brown to red pericarps, while *Suduru samba* produced off-white pericarps. There were negative correlations between DF and selected yield components in contrast to positive correlations between DF and selected vegetative growth parameters. A molecular analysis of variable accessions will be necessary to reveal the genetic

diversity and genetic pathways of flowering, vegetative growth and yield in Sri Lankan traditional rice.

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