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Research Article

Evaluating the variability parameters among rice (*Oryza sativa*. L) landraces and varieties from Tamil Nadu

Aishwarya Duraiswamy[1]. K. Sherina Jebakani[1], J. Lydia Pramitha[1*], S. Ramchander[1], N. Devasena[1], D. Wilson[1], P. Dinesh Kumar[2] and P. Ramesh Kumar[3]

[1]Genetics and Plant Breeding, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore, India
[2]Agricultural Statistics, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore, India
[3]Crop Physiology and Bio chemistry, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore, India
***E-Mail:** lydiapramitha@karunya.edu

Abstract
Rice is one of the major food crops which is being most explored for continuous improvement to feed the growing population. In view of this, forty-three rice landraces and varieties from Tamil Nadu were subjected to variability and principal component analyses with fifteen quantitative traits and eight qualitative traits. For the variability parameters a higher PCV, GCV with high heritability and genetic advance was observed for all the traits. This indicated the presence of additive gene action and effective selection could be carried out for all traits in future breeding programs. Subsequently, from the principal component analysis five reliable PC's with eigen values greater than one was attained. PC1 explained a total variability of 28.53% followed by PC2 which exhibited 16.99% of the variability. The major positive contributions towards the variability across PC's were established by days to 50% flowering, plant height, flag leaf length, culm length, days to maturity, leaf width, panicle length, number of tillers, number of productive tillers, seedling height and grain width. Among all, Sornamasuri and JGL were found to be desirable for yield attributing traits from the PCA biplots and these genotypes could be evaluated for their similar performance in other breeding programs for utilization. Further among all qualitative traits, grain colour and leaf blade colour were observed to be variable among the landraces and they could be utilised as key morphological markers for identifying true to type varieties in future.

Keywords: Rice landraces, PCV, GCV, h^2, GA and PCA

INTRODUCTION

Rice is the major staple food consumed across countries for regular calorie intake (Ram *et al*., 2016). Among all, the world's largest producer of rice is China, followed by India which produces 3590 kg per ha (Surendran *et al*., 2021). To feed the world's population in 2050, which is expected to grow from nearly 7.60 billion to more than 9.80 billion, the global agricultural production should be 70% over the next 30 years (Carvajal-Yepes *et al*., 2019). Although several breeding programs have been initiated, the landraces of rice are yet to be explored for their novel traits. Landraces provide an important genetic resource for executing breeding programs for nutritional quality and inherent traits in rice (Chakravorty *et al*., 2013). Further, these landraces are also known to be higher in fibre as well as in micronutrients. This reinstates the importance of genetic characterization and variability analysis of land races for future use in hybridization programs. In this study, the major objective was to characterize and analyse the variability of rice landraces for yield attributing traits. Records of the recent researches have shown that landraces possess more nutritional value than the released varieties (Zhang *et al*., 2022). Hence, these novel landraces could contribute to the development of new varieties by identifying donors with elite qualitative and quantitative traits. In view of this, a study was conducted to characterize rice landraces from Tamil Nadu for grain yield and quality traits. Further, to analyse the variability, observations were subjected to variability and PCA analysis.

The variability of a base population presents the overall effectiveness of the selection for a trait improvement. Higher variability among the rice genotypes for plant height, number of filled grains per panicle, 1000 seed weight and single panicle yield with a preponderance of additive gene action by heritability and genetic advance exhibits the needs for characterising the germplasm for trait-based breeding program (Rashid *et al.,* 2017). Recent reports for traits like panicle length, grain length, grain yield, kernel length and days to flowering for non-additive gene action indicated by a higher heritability and moderate genetic advance proposes the importance of these basic studies among diverse collections for effective selection and hybridization (Asante *et al.,*2019).

Another well-known multivariate statistical technique for data analysis is Principal Component Analysis (PCA) and this is used to determine possible components to explain the overall variability (Mishra *et al*., 2017). Presently, variability among landraces contributed by PC1 and PC2 for a study was 29.95% and 20.26% respectively. Five PCs were reliable out of 13 and the overall variability in landraces was observed to be exerted by thousand-grain weight, grain yield, filled grain percentage, grain width, total grain per panicle, flag leaf breadth, kernel width and grain length (Dhakal *et al*., 2020). Recently, among landraces the traits namely, grain length, 1000 grain weight, grain yield, panicle weight and spikelet fertility percentage were also found to be the major characters that positively contributed towards PC1 and PC2. This further emphasized the importance of characterization of landraces (Burman *et al*., 2021). In a view of this, the current study was conducted to identify the variable traits for future use in breeding programmes with rice landraces collected from different agroclimatic regions of Tamil Nadu.

MATERIALS AND METHODS

A set of 43 genotypes comprising 32 landraces and 11 varieties were evaluated during *kharif* 2022 at Karunya Institute of Technology and Sciences (KITS), Coimbatore (**Table 1**). The accessions were raised in a randomized block design with three replications with spacing of 20 x 20 cm. Observations were recorded on 15 quantitative traits *viz*, days to fifty percent flowering (DFF), seedling height (SH), plant height (HT), number of tillers (NT), number of productive tillers (PT), number of seed per panicle (NSP), flag leaf length (FLL), flag leaf width (FLW), culm length (CL), panicle length (PL), grain length (GL), grain width (GW), days to maturity (DTM), 1000 grain weight (SGW), single plant yield (SPY). Observations were also recorded for eight qualitative traits namely, grain colour (GC), awn presence (AP), panicle type (PT), leaf angle (LA), leaf blade colour (LBC), leaf blade pubescence, ligule colour (LC) and collar colour (CC). The statistical analysis for Principal component Analysis (PCA) was carried out using STAR version 2.0.1 developed by IRRI and the Genetic variability parameters were further analysed in the “variability packages” of R version 4.2.2.

RESULTS AND DISCUSSION

The study revealed a higher genetic variability for all traits. The analysis of variance indicated that there was a wide range of variation among the germplasm for all the observed traits (**Table 2**). Among the 15 quantitative traits, 1000 grain weight, grain width and flag leaf length were observed to exhibit high PCV and GCV with a lower ECV. Thus, it presented a lower influence of environment for these traits. Among the rest of the traits, days to 50% flowering, seedling height, plant height, number of seeds per panicle, panicle height, culm length, grain length, flag leaf width, days to maturity and single plant yield exhibited a moderate GCV and PCV with low ECV. Among all, the number of productive tillers and the number of tillers were found to be influenced by environment due to its higher ECV (**Table 3**). Hence, a higher variability was observed for all the yield attributing traits and among them few traits were also found to be influenced by the environment. Similar variability among the rice germplasm for these traits were also reported by Kamana *et al*. (2019).

Regarding heritability and genetic advance, all the traits established a high heritability cum genetic advance except for number of productive tillers. For the number of productive tillers, a moderate PCV and GCV were observed with a lower heritability and high genetic advance. This reveals the presence of additive gene action for all these traits and selection could be rewarding for all of them (Lingaiah, 2018). Similar findings for additive gene action in single plant yield and other yield attributing traits were reported by Dhanwani *et al*. (2013) and Yadav *et al*. (2017). Therefore, these traits could be further evaluated and improved in other breeding programs in near future.

These 15 quantitative traits were further subjected to a principal component analysis (PCA) for analysing the individual trait contribution towards the overall variability. With eigen values greater than 1.0, the first five components explained 75.01% of the total variation. PC1 contributed for 28.53% of the total variation and PC2 exhibited a variation of 16.99% respectively. Subsequently PC3, showed a variation of 11.18% followed by that PC4 and PC5 exhibited an overall variation of 8.44% and

Table 1. List of Rice Genotypes

S. No.	Genotype	Place of collection
1	ADT 45	Madurai local
2	Amman Ponni	TNAU, AC & RI, Madurai.
3	Aanai komban	TNAU, AC & RI, Madurai.
4	Arumpatham Kuruvai	TNAU, AC & RI, Madurai.
5	ASD -16	TNAU, Coimbatore
6	CO55	TNAU, Coimbatore
7	Chinnar	TNAU, AC & RI, Madurai.
8	CO51	TNAU, Coimbatore
9	CO52	TNAU, Coimbatore
10	CO53	TNAU, Coimbatore
11	CO54	TNAU, Coimbatore
12	TPS 3	TNAU, Coimbatore
13	TPS 5	TNAU, Coimbatore
14	CR1009 SUB 1	State seed farm, Kanniyakumari
15	JGl	Madurai local
16	Kalasar nel	Kanniyakumari local
17	Karudan Samba	Kanniyakumari local
18	Karum Kuruvai	TNAU, AC & RI, Madurai.
19	Karupu Kavuni	TNAU, AC & RI, Madurai.
20	Kattuyanam	TNAU, AC & RI, Madurai.
21	Keerai Samba	Kanniyakumari local
22	Kerala Samba	Kanniyakumari local
23	Kichadi samba	TNAU, AC & RI, Madurai.
24	Kollan Samba	Kanniyakumari local
25	Kothamalli samba	TNAU, AC & RI, Madurai.
26	Kottaram Samba	Kottaram local
27	Kullaiyadi Samba	TNAU, AC & RI, Madurai.
28	Kullakar	TNAU, AC & RI, Madurai.
29	Kullipadichan	TNAU, AC & RI, Madurai.
30	Kuttakar	TNAU, AC & RI, Madurai.
31	Mappilai Samba	TNAU, AC & RI, Madurai.
32	Milagu samba	TNAU, AC & RI, Madurai.
33	Norungan	TNAU, AC & RI, Madurai.
34	Poongar	TNAU, AC & RI, Madurai.
35	Raja Samba	Kottaram local
36	Rathashalli	TNAU, AC & RI, Madurai.
37	Seeraga Samba	TNAU, AC & RI, Madurai.
38	Sithiraikar	TNAU, AC & RI, Madurai.
39	Sivapu Kavuni	TNAU, AC & RI, Madurai.
40	Sornamasuri	TNAU, AC & RI, Madurai.
41	Thanga Samba	Kanniyakumari local
42	Thuyamalli	TNAU, AC & RI, Madurai.
43	Vellakar	TNAU, AC & RI, Madurai.

Table 2. ANOVA for 15 quantitative traits of rice

Character	Mean sum of squares		
	Genotype	Replication	Error
Degrees of freedom	**2**	**42**	**84**
Days to 50% Flowering	1000.32***	2.57	24.09
Seedling Height	213.94***	13.49	18.25
Plant Height	1478.51***	3.60	50.52
No of Tiller	43.94***	0.340	4.93
No of Productive Tiller	35.03***	17.25	6.58
No of Seed Per Panicle	994.5***	33.89	31.81
Flag Leaf Length	213.28***	3.11	11.27
Flag Leaf Width	0.04***	0.00	0.00
Culm length	703.31***	12.74	26.96
Panicle Length	38.79***	0.55	3.24
Grain Length	6.40***	0.94	0.37
Grain Width	1.12***	0.02	0.03
Days to Maturity	915.68***	27.73	42.82
1000 Grain weight	153.66***	1.67	3.41
Single Plant Yield	81.50***	4.65	9.23

Table 3. Estimation of genetic parameters of 43 rice genotypes based on yield contributing traits

Characters	Mean	Range		PCV%	GCV%	ECV%	h^2 (%)	GAM (%)
		Min	Max					
Days to 50% Flowering	97.87	67.00	152.0	19.10	18.43	5.01	93.11	36.63
Seedling Height	42.39	24.00	76.00	21.55	19.05	10.07	78.14	34.68
Plant Height	112.35	76.00	178.0	20.42	19.41	6.32	90.40	38.03
No of Tiller	19.18	10.39	30.14	22.06	18.79	11.57	72.51	32.96
No of Productive Tiller	17.54	9.00	26.00	22.85	17.55	14.63	59.00	27.77
No of Seed Per Panicle	125.88	83.00	159.0	14.91	14.23	4.48	90.98	27.96
Flag Leaf Length	38.66	22.45	65.10	22.93	21.22	8.68	85.66	40.46
Flag Leaf Width	1.10	0.83	1.43	10.81	10.30	3.28	90.91	20.24
Culm length	84.72	59.00	134.0	18.75	17.72	6.12	89.32	34.50
Panicle Length	19.36	7.66	26.61	20.06	17.78	9.30	78.52	32.45
Grain Length	7.14	2.00	9.77	21.59	19.83	8.53	84.38	37.53
Grain Width	2.67	1.17	3.75	23.56	22.64	6.52	92.33	44.81
Days to Maturity	130.41	99.00	183.0	14.00	13.07	5.01	87.17	25.15
1000 Grain weight	27.49	15.06	45.81	26.60	25.74	6.72	93.61	51.30
Single Plant Yield	27.15	13.00	40.31	21.26	18.07	3.19	72.29	31.66

7.14% respectively (**Table 4**). The variable characteristics associated with PC1 were days to 50% flowering, plant height, flag leaf length, culm length and days to maturity (**Table 5**). Further, the traits leaf width and panicle length were the major positive contributors of overall variation in PC2. From PC3 and PC4, the traits namely number of tillers and number of productive tillers were found to contribute to the overall variability and for PC5, it was exerted by the seedling height and grain width. Hence, it was observed that these traits exhibited a higher variation among genotypes and thus, selection for these traits would be effective for future breeding programs. Similar contribution for these traits towards variability through PCA was also reported by Soe *et al*. (2019).

The PCA biplot revealed a positive correlation of yield with grain length, seedling height, grain width, flag leaf width, single plant yield, number of seeds per panicle, thousand

Table 4. Eigen values, Percentage of variation and Cumulative percentage for principal components

Principal Components	Eigen values	Percentage variation	Cumulative Percentage
PC1	4.84	28.53	28.53
PC2	2.88	16.99	45.52
PC3	1.90	11.18	56.70
PC4	1.43	8.44	65.14
PC5	1.21	7.14	72.29
PC6	1.01	5.96	78.25
PC7	0.81	4.81	83.06
PC8	0.64	3.81	86.87
PC9	0.34	2.05	94.87
PC10	0.28	1.68	96.55
PC11	0.25	1.49	98.03
PC12	0.17	1.05	98.08
PC13	0.08	0.49	99.58
PC14	0.06	0.36	99.93
PC15	0.01	0.07	100.0

Table 5. Eigen value, factor scores and contribution of the first five principal component axes to variation in rice landraces/varieties

Parameter	PC1	PC2	PC3	PC4	PC5
DFF	**0.36**	-0.05	0.17	-0.32	0.07
SH	-0.16	-0.13	-0.17	0.20	**0.37**
HT	**0.33**	0.00	-0.33	0.08	0.17
NT	0.21	-0.04	**0.33**	**0.49**	0.13
PT	0.23	-0.06	**0.30**	**0.52**	0.05
NSP	-0.01	-0.29	0.03	0.07	-0.53
FLL	**0.30**	-0.35	-0.13	-0.12	0.00
FLW	-0.09	-0.42	-0.16	-0.03	-0.00
CL	**0.36**	-0.05	-0.31	0.08	0.07
PL	0.15	0.09	-0.47	0.23	-0.27
GL	-0.28	-0.27	0.07	-0.11	0.24
GW	-0.17	-0.31	-0.00	-0.06	**0.39**
DTM	**0.35**	-0.07	0.17	-0.33	0.09
1000GW	0.08	-0.17	0.16	-0.23	-0.36
SPY	-0.03	-0.41	0.28	0.19	-0.16

grain weight, leaf length, flag leaf length, days to maturity, number of tillers, number of productive tillers and days to 50% flowering (**Fig. 1**). These characteristics could be regarded as the finest performers and since they are related to yield, they could be considered as the major selection indicators in future breeding programs. From the PCA biplot, the genotypes *viz*., Karundan samba and Karum kuruvai were identified as ideal for thousand seed grain weight and leaf length. Also, the grain length and grain width of the genotypes *viz.,* Raja samba, Kottaram samba, TPS 5, Sornamasuri, Chinnar and Keerai samba were found to be higher on the plot near the axis of the grain related traits. These could be evaluated in other breeding trials for their similar performance for grain characteristics. Among all, Kerala samba had a single plant yield that was higher than all other genotypes. Also, JGL and Kothamalli samba were observed to be best performing genotypes for number of seeds per panicle in the biplot. Inclusively, Poongar had the earliest days for maturity and could be used in developing early maturing cultivars. Among all, the genotypes such as Kerala samba, JGL, Kothamalli samba, CO 55, Sornamasuri, Chinnar, Keerai samba, CR1009 SUB-1 and Karundan samba were identified as superior genotypes from the biplot for future hybridization and selection for yield attributing traits (**Fig. 2**).

Variability among collected landraces of rice also existed among the recorded qualitative traits and this could be

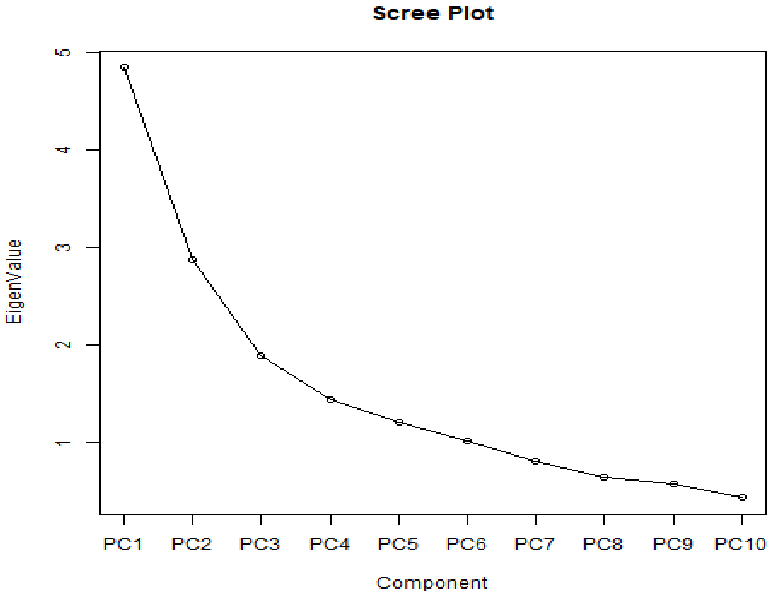

Fig. 1. Scree plot diagram using principal components and their Eigen value

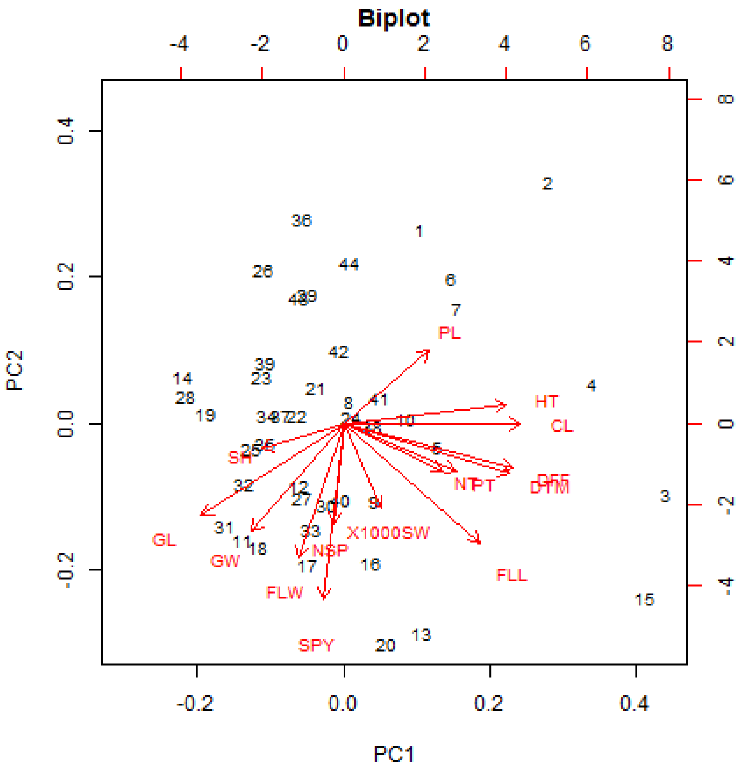

Fig. 2. Biplot diagram of PC1 and PC2

Table 6. Qualitative traits recorded in the rice genotypes

S.No	Genotype	GC	A	PT	LA	LBC	LBP	LC	CC
1	Kullakar	Red	0	C	D	G	I	W	G
2	Seeraga Samba	White	0	C	E	LG	G	W	G
3	Annai Komban	Dark Brown	0	C	E	DG	I	P	G
4	Norungan	Light orange	0	C	D	G	I	W	G
5	Kulipadichan	Dark Red	0	C	H	DG	I	W	G
6	Sivapu Kavuni	Red	0	I	E	PM	I	P	G
7	Sithiraikar	Light Brown	0	I	E	G	I	W	G
8	Karum Kuruvai	Light Brown	0	C	E	DG	G	W	P
9	Milagu Samba	Whitish Brown	0	O	D	G	I	W	P
10	Chinnar	Whitish Brown	1	I	E	P	I	P	G
11	Sornamasuri	Black	1	C	E	G	I	W	P
12	Karuppu Kavuni	Red	0	I	E	P	I	P	G
13	Arumpatham Kuruvai	Dark Red	0	I	E	G	I	A	G
14	Mapillai Samba	White	0	C	D	PB	I	P	P
15	Kothamalli Samba	White	0	I	E	DG	I	P	G
16	Kichadi Samba	White	0	C	E	G	I	P	G
17	CR1009 SUB 1	White	0	C	E	G	G	A	LG
18	TPS – 5	White	0	C	E	G	I	W	G
19	ASD – 16	White	0	C	E	G	P	W	G
20	TPS - 3	Whitish Brown	1	C	E	LG	P	W	G
21	CO54	Whitish Brown	0	I	E	LG	P	W	G
22	CO53	Whitish Brown	0	C	E	LG	G	W	G
23	CO51	Light Brown	0	C	E	G	G	W	G
24	CO52	Light Brown	0	C	E	G	P	W	G
25	CO 55	White	0	C	E	G	P	W	G
26	Kalaser	White	0	I	E	G	P	W	G
27	Keerai Samba	White	0	C	E	G	P	W	G
28	Kollan Samba	Brown	0	C	E	LG	P	W	G
29	Thanga Samba	Reddish Brown	0	I	E	DG	P	W	G
30	Kerala Samba	Brown	0	I	E	DG	P	PL	G
31	Raja Samba	White	0	I	E	DG	P	PL	G
32	Kottaram Samba	White	0	C	E	DG	P	W	G
33	JGL	White	0	O	E	DG	P	W	G
34	ADT (R) 45	Light Brown	0	O	E	DG	G	W	G
35	Poongar	White	1	C	E	LG	P	W	G
36	Amman ponni	White	0	C	E	LG	P	W	G
37	Kuttakar	White	0	C	E	G	I	W	G
38	Vellakar	Red	0	C	E	DG	P	W	G
39	Karundan Samba	White	0	C	E	LG	P	W	G
40	Kullaiyadi Samba	Red	0	I	E	DG	P	W	G
41	Kattuyanam	White	0	I	E	DG	P	PL	G
42	Thuyamalli	White	0	C	H	G	G	W	G
43	Rathashalli	Red	0	C	E	DG	G	W	G

GC - Grain Colour, A – Awing [0 – absent, 1- short and partly awned], PT- Panicle Type [C- compact, I - Intermediate, O - Open], LA - Leaf Angle [E - Erect, H- Horizontal, D- Drooping], LBC - Leaf Blade Colour [LG - Light Green, G - Green, DG - Dark Green, PM -Purple Margin, PB - Purple Blotch, P - Purple], LBP - Leaf Blade Pubescence [G - Glabrous, I - Intermediate, P - Pubescent], LC – Ligule Colour [A -Absent, W -White, PL - Purple Line, P - Purple], CC - Collar Colour [LG - Light Green, G - Green, P – purple].

useful for further characterization and identification of novel true to type rice accessions in future programs (Wangpan *et al*., 2018). Within the qualitative traits, a significant difference was observed among the 43 rice genotypes. Among all the qualitative traits, the colour of the grains were observed to exhibit a higher variability. Out of the forty-three genotypes, six genotypes namely Kullakar, Sivapu kavani, Karuppu kavani, Vellakar, Kullaiyadi samba and Rathashalli were observed to be red. However, two genotypes *viz*, Kuliadichan and Arumpatham kuruvai were observed to be dark red. Further, five genotypes namely TPS 3, CO 54, CO 53, Chinnar and Milagu samba exhibited a whitish brown coloured seed. Among the 43 genotypes, there were awns observed only in three genotypes *viz*., Sornamasuri, TPS 3, Poongar and Chinnar. Regarding the panicle type, 27 out of the 43 exhibited compact panicle, 13 genotypes were observed to have intermediate type of panicle and three of them had an open type (**Table 6**). Similar observations for the qualitative variability were observed by Aditya *et al*. (2021). Considering the leaf angle, 37 were observed to be erect, four were drooping and two were horizontal. Among all, the leaf blade colour was observed to be green for 17 genotypes, dark green for 15 and light green for eight.

Beyond this, the anthocyanin pigmentation in leaf was also specifically variable among these landraces. Sivapu kavuni was observed to have a purple margin and Mapillai samba had a purple blotch. However purple colour leaves were observed in Karuppu kavani and Chinnar. Similar reports in another study conducted by Chakrabarty *et al.* (2012) for the anthocyanin variations emphasized the colour variations distributed in auricles, collar, ligule and leaf blade of the landraces.

Regarding hairiness, high pubescence was observed for nineteen genotypes and sixteen of them were intermediate for pubescence. Among all, eight were observed as glabrous. Further, ligule colour was observed to be white for thirty-one genotypes and purple in three genotypes *viz*., Kerala samba, Raja samba and Kattuyanam. Whereas, a complete purple coloured ligule was found in seven genotypes *viz*, Aanai komban, Sivapu kavuni, Chinnar, Karuppu kavani, Mappilai samba, Kothamalli samba, Kichadi samba. However, there were no ligules observed in the rest of genotypes namely Arupatham kuruvai and CR1009 SUB-1. Beyond this, there were variations for collar colour observed among the genotypes. Thirty-eight green collar genotypes and four purple genotypes for collar colour were observed. Only Kichadi samba among all was found to exhibit a light green collar colour (**Table 6**). These qualitative traits could be used as effective indicators to further evaluate and purify the available landraces collected from different regions in future.

To conclude, among all the quantitative traits, flag leaf length, plant height, number of tillers and grain width were highly variable. Hence, effective selection could be carried out for these traits from this population for improvement in other breeding programs. Also, among all the qualitative traits, grain colour and leaf blade colour were highly variable among landraces and they could be useful in characterization and identification of genotypes and varieties in future. The desirable genotypes for improving yield attributing traits from the PCA biplots were Sornamasuri and JGL. These genotypes could be further evaluated for identifying potential donors for novel traits for use in rice breeding programs (**Fig. 2**).

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