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Research Article

Genetic variability in rice (*Oryza sativa* L.) landraces for seedling vigour traits

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Abstract
A study was carried out in 73 rice landraces along with two varieties to study the genetic variability and association of the traits related to early seedling vigour. Morphological traits such as seedling height, leaf sheath length and leaf blade length were measured in seedlings on 15 and 25 days after sowing. Analysis of variance indicated the presence of genetic variability for seedling vigour related traits in rice landraces. High GCV, PCV and high heritability coupled with high genetic advance as per cent of mean were observed indicating selection may be effective for improvement of these traits. Estimates of genotypic correlation were higher than that of phenotypic correlation indicating strong genetic association among the traits studied. Landraces *viz*., *Senkar, Palkachaka, Murugankar, Kaatuponni, Kochin Samba, Poongar, Thillainayagam* and *Kuliyadichan* exhibited significantly higher seedling height on both 15 and 25 DAS. These landraces may harbour favourable alleles for early seedling vigour. Hence, they can be utilized for improving early seedling vigour after validating its stable expression across varied environments.

Keywords
Landraces, variability, early seedling vigour.

INTRODUCTION

Rice (*Oryza sativa* L.) is the main food source for more than one-third of the world's population. About 90 % of the world's rice is grown in Asia (Pathak *et al*., 2011). Through the centuries of cultivation and selection, thousands of rice cultivars have been evolved, which are well adapted to the local environments. Further, only a small fraction of available landraces has been used in breeding. Traditional native landraces are widely grown under rainfed lowland conditions by farmers in India. Due to the unpredictable rainfall patterns, direct-seeded rice has become regular practice under the rainfed situation.In the tropics, the rice cropping system is shifting from transplanting to direct sowing because it is less labor intensive (Erguiza *et al*., 1990). Direct seeding is associated with a higher risk of yield loss than transplanting due to competition with weeds (Rao *et al*., 2007). Poor crop establishment is one of the major constraints in the direct-seeded rice systems and particularly in adverse growing environments such as drought (Du & Tuong, 2002; Kumar *et al*., 2009). Improving crop early vigour is an effective strategy for good crop establishment (Balasubramanian & Hill, 2002; Namuco *et al*., 2009; Zhang *et al*., 2005). Most of the landraces are less productive, but they possess weed-smothering ability by early vigour and excellent growth adaptation features to direct-seeded conditions.

Early vigour is a combination of the ability of the seed to germinate uniformly and emerge after planting (i.e. seed vigour) and the ability of the young plant to grow and develop after emergence (i.e. seedling vigour). Early seedling vigour (ESV) determines rapid, uniform emergence and the development of seedlings under a wide range of field conditions. Seedling vigour is one of the major determinants for successful crop establishment (Zhang *et al*., 2005). Germination rate and early seedling growth are the major seedling-vigour related traits. Rapid shoot and root growth were observed to be closely associated with seedling-vigour (Williams and Peterson 1973; Sasahara *et al*., 1986). The current study was initiated with the main aim of identifying rice landraces with superior early seedling vigour related traits which belongs to *Oryza sativa* L. ssp. *indica*.

MATERIALS AND METHODS

The present experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy, Tamil Nadu during Late *samba* season of September 2019 to February 2020 to study the seedling-vigour related traits in rice landraces. The experimental material involved 73 rice landraces along with two rice varieties *viz.*, TRY 2 and TRY 3. The experiment was laid out in a randomized block design with three replications. Seeds of each of the genotype were sown on raised nursery beds. Five seedlings in the middle of rows were randomly selected and labelled with a marker pen. Anandan *et al.* (2016) determined that the early observations were taken on 14th and 28th DAS were reliable estimators to study ESV. Seedling height (cm), leaf sheath length (cm) and leaf blade length (cm) were measured in the selected seedlings on 15 DAS. The same set of traits was observed on twenty-five days after sowing in the same plant. The rate of increase in growth variable at time't' is called an Absolute growth rate (AGR). It was measured by the differential coefficient of 'h' with respect to time't'. The absolute growth rate was calculated by using the following formula (Radford, 1967):

$$\textbf{AGR (plant height)} = \frac{h_2 - h_1}{t_2 - t_1}$$

Where h_1 and h_2 are the plant height at times t_1 and t_2 respectively.

Analysis of variance was estimated as per the procedure proposed by Panse and Sukhatme (1967). Heritability was calculated based on the formula given by Lush (1940) and genetic advance by Johnson *et al.* (1955). The range of heritability was categorized as low (0- 30), medium (31-60) and high (> 60) as suggested by Johnson *et al.* (1955). The genetic advance was estimated based on the formula given by Johnson *et al.* (1955) and the traits were classified as having high (>20 %), moderate (10- 20%) or low (<10%) genetic advance. All the statistical analysis was carried out using TNAUSTAT software.

RESULTS AND DISCUSSION

Analysis of variance revealed that the mean sum of squares due to genotypes were highly significant for all the characters under study (**Table 1**). It indicates that the rice landraces studied were highly variable for the traits under study. The estimates of mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in a broad sense (h^2) and genetic advance as per cent of mean (GAM) were calculated and presented in **Table 2.** PCV and GCV in conjunction with heritability and genetic advance as per cent mean for the traits help in deciding the breeding program to be adapted to crop improvement.High PCV value was observed for the leaf sheath length (33.56%) followed by leaf blade length (21.07%) and seedling height (20.77%) on 15 DAS. Similarly, on 25 DAS high PCV was recorded by leaf sheath length (25.30%) followed by leaf blade length (22.68%) and seedling height (21.84%). High GCV was recorded by leaf sheath length on both 15 DAS and 25 DAS (28.85% and 21.37%) and moderate GCV was recorded by leaf blade length (17.87% and 18.58%) and seedling height (18.23% and 18.49%) on 15 and 25 DAS. High PCV and GCV values indicate that these traits are suitable for direct selection.

Table 1. ANOVA for morphological traits in rice in 73 landraces

Source of variations	Degrees of freedom	Mean sum of squares					
		15 DAS			25 DAS		
		Leaf sheath length	Leaf blade length	Seedling height	Leaf sheath length	Leaf blade length	Seedling height
Treatment	74	2.8863**	10.1020**	18.1773**	4.2856**	31.7265**	53.5563**

**Significance at 1% level, respectively

Table 2. Variability parameters for morphological traits in rice in 73 landraces

S. No.	Trait	Mean	Range		PCV (%)	GCV (%)	h^2 (%)	GA (%)
			Minimum	Maximum				
15 DAS								
1	Leaf sheath length (cm)	3.21	1.18	6.30	33.56	28.85	73.89	51.08
2	Leaf blade length (cm)	9.65	4.88	16.08	21.07	17.87	71.92	31.22
3	Seedling height (cm)	12.87	6.38	19.38	20.77	18.23	77.02	32.97
25 DAS								
4	Leaf sheath length (cm)	5.25	1.78	8.00	25.30	21.37	71.36	37.20
5	Leaf blade length (cm)	16.22	7.58	24.89	22.68	18.58	67.14	31.37
6	Seedling height (cm)	21.47	9.36	31.75	21.84	18.49	71.71	32.26

Heritability and genetic advance are important selection parameters. Cairns *et al*. (2009) have reported moderate to high heritability of traits governing early vigour which indicates early vigour is a heritable trait. Highest heritability was recorded by seedling height (77.02% and 71.71%) followed by leaf sheath length (73.89% and 71.36%) and leaf blade length (71.92% and 67.14%) on 15 and 25 DAS. This is supported by the study of Redona *et al*. (1996) who observed high heritability (80%) for seedling height. Heritability estimates were more than 60% for all the characters studied which indicate that these characters were less influenced by environmental conditions and phenotypic selection would be effective for these characters.

Genetic advance as per cent of mean was more than 20% for all the characters under study. High genetic advance as per cent of mean was recorded by leaf sheath length followed by seedling height and leaf blade length on both 15 DAS and 25 DAS. Genetic advance as per cent of the mean of leaf sheath length was higher on 15 DAS (51.08%) when compared to 25 DAS (37.20%). High heritability accompanied with high genetic advance indicates the preponderance of additive gene action in its inheritance and for such traits, selection may be effective in crop improvement.For all the traits studied, the genotypic correlation was higher than phenotypic correlation signifying low environmental influence in the inheritance of traits and relative stability of the genotypes (**Table 3 & Table 4**). In the rice landraces, all the seedling vigor related traits are significantly and positively correlated with each other. The very high association was observed between seedling height and leaf blade length on both 15 DAS and 25 DAS. The genotypic correlation coefficient between leaf sheath length and leaf blade length on 25 DAS (0.8015) showed a greater difference when compared with 15 DAS (0.5216).

Table 3. Correlation analysis of morphological traits related to seedling vigor in 73 rice landraces 15 Days after sowing

Trait	Leaf sheath length	Leaf blade length	Seedling height
Leaf sheath length	1.0000	0.5216**	0.7788**
Leaf blade length	0.4205**	1.0000	0.9414**
Seedling height	0.7235**	0.9306**	1.0000

**Significance at 1% level, respectively (lower diagonal represents Phenotypic correlation and upper diagonal represents Genotypic correlation)

Table 4. Correlation analysis of morphological traits related to seedling vigor in 73 rice landraces 25 Days after sowing

Trait	Leaf sheath length	Leaf blade length	Seedling height
Leaf sheath length	1.0000	0.8015**	0.8910**
Leaf blade length	0.6844**	1.0000	0.9856**
Seedling height	0.8202**	0.9784**	1.0000

**Significance at the 1% level, respectively (lower diagonal represents Phenotypic correlation and upper diagonal represents Genotypic correlation)

Rice leaf sheath is derived from the lower part of cells of leaf primordia which wraps up the nodes and internodes of the stem around the leaf base and protects axillary buds as well as strengthening the mechanical support (Liu *et al*., 2011). Leaf-sheath length on 15 DAS expressed a wide range of variation among the rice landraces from 1.18 cm to 6.31 cm with a mean value of 3.21 cm. Landraces *Kuliyadichan, Karungkuruvai, Karuthakar, Kochin Samba, Navara, Ottadam, Thillainayagam, Palkachaka, Kaatuponni, Rajamudi, Kodai* and *Mattaikar* recorded highly significant leaf sheath length on 15 DAS (Table 5). Yano *et al*. (2012) demonstrated that the gene *OsGA20ox1* increases plant height and leaf sheath length at the initial growth stage of rice. Hence, these landraces may harbour the corresponding alleles which contribute to leaf sheath length. The highest leaf sheath length was observed in *Kuliyadichan* (6.31 cm) followed by *Karungkuruvai* (5.42 cm) and *Karuthakar* (5.29 cm). The lowest leaf sheath length was recorded by *Swarna kichadi* (1.18 cm).

Leaf-blade length ranged from 4.89 cm to 16.09 cm on 15 DAS with a mean value of 9.65 cm. *Poongar* recorded highest leaf blade length of 16.09 cm followed by *Vasaramundan* (13.85 cm) and *Murugankar* (13.37 cm). *Thulasi vaasam* had the lowest leaf blade length of 4.89 cm on 15 DAS. *Senkar, Murugankar, Poongar, Vasaramundan, Kaatuponni, Kochin Samba, Palkachaka, Poovan Samba* and *Kallimadayan* recorded highly significant leaf blade length 15 DAS.

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Table 5. Mean performance and Absolute Growth Rate (AGR) among 73 rice landraces

S. No.	Name	15 DAS LS (cm)	15 DAS LB (cm)	15 DAS SH (cm)	25 DAS LS (cm)	25 DAS LB (cm)	25 DAS SH (cm)	AGR (cm/day)
1	Senkar	2.65	13.02*	15.67*	6.86*	24.89*	31.75*	1.61
2	Murugankar	3.85	13.37*	17.23*	6.01	22.66*	28.67*	1.14
3	Vellaichithiraikar	3.35	9.99	13.34	6.70*	24.23*	30.93*	1.76
4	Palkachaka	4.71*	11.63*	16.34*	8.00*	23.21*	31.21*	1.49
5	Sornakuruvai	4.04	10.67	14.71	6.61*	20.50*	27.11*	1.24
6	Rasacadam	2.61	6.81	9.42	4.70	16.70	21.40	1.20
7	Malayalathan samba	2.81	9.67	12.48	3.79	17.94	21.73	0.93
8	Kattikar	4.09	10.15	14.23	5.81	19.09	24.91	1.07
9	Shenmolagi	2.79	9.39	12.18	5.06	18.32	23.38	1.12
10	Kaatuponni	4.42*	11.96*	16.38*	6.34	22.01*	28.35*	1.20
11	Kalarkar	3.91	9.81	13.72	4.71	18.05	22.76	0.90
12	Seevana samba	3.49	9.96	13.45	5.05	17.00	22.05	0.86
13	Mattakuruvai	2.30	9.12	11.42	5.41	15.96	21.37	0.99
14	Karuthakar	5.29*	10.39	15.67*	5.90	17.63	23.53	0.78
15	Thooyamalli	1.34	5.27	6.61	3.87	13.15	17.03	1.04
16	Jeeragasamba	2.28	6.30	8.58	2.95	12.85	15.81	0.72
17	Mattaikar	4.10*	9.14	13.24	4.55	15.28	19.83	0.66
18	Katta samba	3.11	10.14	13.25	5.31	16.29	21.60	0.83
19	Sirumani	2.73	7.77	10.51	5.08	15.55	20.63	1.01
20	Vadivel	3.45	8.76	12.21	4.73	12.93	17.67	0.55
21	Norungan	2.29	11.27	13.55	5.47	16.00	21.47	0.79
22	Ponmani samba	2.97	11.07	14.05	4.97	16.11	21.08	0.70
23	Thattan samba	3.07	10.68	13.75	4.73	18.47	23.20	0.95
24	Kaliyan samba	2.81	8.97	11.78	4.67	17.39	22.06	1.03
25	Kallimadayan	3.57	11.51*	15.09*	5.31	17.15	22.45	0.74
26	Panamara samba	3.33	8.76	12.09	5.55	12.19	17.73	0.56
27	Thillainayagam	4.76*	10.56	15.32*	6.83*	19.00	25.83*	1.05
28	Kodai	4.11*	10.06	14.17	6.57*	15.97	22.53	0.84
29	Kavuni sigapu	2.97	9.59	12.57	5.73	16.23	21.97	0.94
30	Poovan samba	3.10	11.63*	14.73	6.85*	20.75*	27.60*	1.29
31	Vaalan	2.22	10.79	13.01	5.90	16.10	22.00	0.90
32	Perungar	2.45	8.98	11.43	5.57	15.80	21.37	0.99
33	Iravai pandi	2.45	9.40	11.85	5.53	14.87	20.40	0.85
34	Vasaramundan	3.69	13.85*	17.54*	6.60*	15.73	22.33	0.48
35	Kallundai	3.07	9.69	12.75	6.53*	15.85	22.38	0.96
36	Karunguruvai	5.42*	9.73	15.15*	6.13	15.80	21.93	0.68
37	Poombalai	2.83	10.25	13.09	5.40	17.07	22.47	0.94
38	Ottadam	4.89*	9.86	14.75	7.17*	17.27	24.43	0.97
39	Kottara samba	3.10	7.36	10.46	5.53	13.64	19.17	0.87
40	Poongar	3.30	16.09*	19.39*	7.15*	19.03	26.18*	0.68
41	Kaatu samba	2.20	8.62	10.82	3.33	11.05	14.38	0.36
42	Kulivedichan	6.31*	10.69	17.00*	6.56*	19.03	25.59*	0.86
43	Karupu kavuni	3.99	9.21	13.20	4.25	15.55	19.79	0.66
44	Ilupaipoo samba	2.17	9.47	11.63	3.22	13.51	16.73	0.51
45	Singinikar	2.93	11.37	14.30	5.99	19.93*	25.92*	1.16
46	Anna samba	3.57	9.20	12.77	5.93	16.85	22.77	1.00
47	Kaatuyanam	3.55	10.74	14.29	5.25	16.50	21.75	0.75
48	Milagu samba	2.83	8.80	11.63	4.03	11.91	15.95	0.43
49	Thengaipoo samba	2.47	8.93	11.40	5.87	14.00	19.87	0.85
50	Kichadi samba	1.93	7.37	9.30	4.70	13.90	18.60	0.93
51	Sambamosanam	3.43	9.80	13.23	5.77	16.57	22.33	0.91
52	Swarna mughi	3.70	9.10	12.80	5.30	14.17	19.47	0.67
53	Navaraan	5.01*	10.19	15.20*	6.17	16.23	22.40	0.72
54	Rajamudi	4.37*	10.90	15.27*	6.70*	18.60	25.30	1.00
55	Kochin samba	5.03*	11.70*	16.73*	7.13*	19.43	26.57*	0.98
56	Karudan samba	3.33	9.47	12.80	6.13	15.37	21.50	0.87
57	Rajamannar	2.13	9.13	11.27	4.47	13.50	17.97	0.67
58	Kothamalli samba	2.90	10.10	13.00	4.67	12.87	17.53	0.45
59	Thulasi vaasam	1.50	4.89	6.39	4.03	11.70	15.73	0.93
60	Neelam samba	2.93	9.77	12.70	6.00	18.73	24.73	1.20
61	Ramakali	3.80	9.15	12.95	5.68	16.29	21.97	0.94
62	Kaalanamak	3.67	8.43	12.10	4.91	15.50	20.41	0.83
63	Salem samba	3.03	7.33	10.37	4.04	12.68	16.72	0.64
64	Vaalsigapu	3.60	10.18	13.78	5.84	17.01	22.85	0.91
65	Paalkudavazhai	2.77	9.67	12.43	4.63	14.44	19.07	0.66
66	Pisini	2.80	10.39	13.19	4.73	16.61	21.33	0.81
67	Rathasali	3.27	8.50	11.77	4.17	14.52	18.69	0.69
68	Kaatuvaanibam	2.77	8.57	11.33	5.25	18.29	23.53	1.22
69	Vaadan samba	3.10	9.13	12.23	4.45	17.61	22.07	0.98
70	Koombalai	2.60	10.17	12.77	4.49	16.35	20.83	0.81
71	Swarna kichadi	1.18	5.59	6.77	1.78	7.58	9.36	0.26
72	Mysore malli	1.31	5.76	7.07	2.14	7.87	10.01	0.29
73	Katarni	2.52	10.57	13.09	4.23	15.77	20.00	0.69
74	TRY 2	2.38	8.77	11.15	3.23	10.59	13.82	0.27
75	TRY 3	2.38	9.18	11.56	3.70	11.63	15.33	0.38
	Grand mean	3.2159	9.6566	12.8724	5.2504	16.2243	21.4747	
	C.d. (5%)	0.8824	1.7259	2.0518	1.1380	3.3756	3.9919	

*Significance at 5% level. LS= Leaf sheath length; LB=Leaf blade length; SH=Seedling height.

Zhao *et al*. (2006) reported that visual vigour rating or early plant height can be used as an indirect selection criterion together with the weed-free yield for weed competitiveness. On 15 DAS about 14 landraces *viz., Poongar, Vasaramundan, Murugankar, Kuliyadichan, Kochin Samba, Kaatuponni, Palkachaka, Senkar, Karuthakar, Thillainayagam, Rajamudi, Navara, Karunguruvai* and *Kallimadayan* exhibited significantly increased seedling height. Peterson (1978) observed that delayed emergence of rice seedlings from water surface greatly increase seedling mortality thereby causing significant reductions in yield. As these landraces had rapid emergence, they have a low seedling mortality. Seedling height on 15-day old seedling was highest in *Poongar* (19.39 cm) followed by *Vasaramundan* (17.54 cm) and *Murugankar* (17.23 cm). The lowest seedling height was observed in *Thulasi vaasam* (6.39 cm). On 15 DAS a mean value of 12.87 cm was recorded by seedling height with a range of 6.39 cm to 19.39 cm.

In 25 day old seedlings, *Palkachaka* had the highest sheath length of 8.0 cm followed by *Ottadam* (7.17 cm) and *Poongar* (7.15 cm). *Swarna kichadi* had the lowest sheath length of 1.78 cm. A mean value of 5.25 cm was observed for the leaf sheath length on 25 DAS with a range of 1.78 cm to 8 cm. A significant value for sheath length was exhibited by *Palkachaka, Ottadam, Poongar, Kochin Samba, Senkar, Poovan Samba, Thillainayagam, Murugankar, Rajamudi, Sornakuruvai, Vasaramundan, Kodai, Kuliyadichan* and *Kallundai.* The importance of leaf sheath elongation and seedling elongation for submergence tolerance was reported earlier by Ramakrishnayya *et al*. (1990) and Sarkar *et al*. (1996).The range of leaf blade length on 25 DAS varied between 7.58 cm to 24.89 cm with a mean value as 16.22. The longest leaf blade was observed in *Senkar* (24.89 cm) followed by *Vellaichithiraikar* (24.23 cm) and *Palkachaka* (23.21 cm). The shortest leaf blade was observed in *Swarna kichadi* (7.58 cm). *Senkar, Vellaichithiraikar, Palkachaka, Murugankar, Kaatuponni, Poovan Samba, Sornakuruvai* and *Singinikar* recorded significantly higher leaf blade length on 25 DAS.

Dingkuhn *et al*. (1991) suggested that rice varieties suitable for the direct seeded system must possess early seedling vigour and enhanced foliar growth to combat weeds. Early establishment and rapid ground cover at vegetative stage reduces soil evaporation, accelerate root access to soil water and nitrogen, and improves weed competition (Finch *et al*. 2010; Zhao *et al*. 2006). Twelve landraces *Senkar, Palkachaka, Vellaichithiraikar, Murugankar, Kaatuponni, Poovan Samba, Sornakuruvai, Kochin Samba, Poongar, Singinikar, Thillainayagam* and *Kuliyadichan* recorded significant seedling height on 25 DAS with greater potential to compete with weeds. The highest seedling height of 31.75 cm was recorded by *Senkar* followed by *Palkachaka* (31.21 cm) and *Vellaichithiraikar* (30.93 cm). The seedling height on 25 DAS showed a mean value of 21.47 cm.

Among the 14 rice landraces which showed significantly highest seedling height on 15 DAS only 8 landraces *viz*., *Senkar, Palkachaka, Murugankar, Kaatuponni, Kochin Samba, Poongar, Thillainayagam* and *Kuliyadichan* exhibited significantly highest seedling height on 25 DAS as they had a higher absolute growth rate. While the other 6 landraces had lower absolute growth rate and did not show significantly higher seedling height on 25 DAS.

Four landraces *Vellaichithiraikar, Poovan Samba, Sornakuruvai* and *Singinikar*, which did not exhibit significantly highest seedling height on 15 DAS recorded significantly highest seedling height on 25 DAS as they had a higher absolute growth rate. Eight landraces exhibited higher seedling height on both 15 and 25 DAS. When per cent increase over the mean of leaf sheath and leaf blade was compared from 15 to 25 DAS, *Senkar* and *Poongar* had high leaf sheath growth while *Palkachaka, Murugankar, Kaatuponni, Kochin Samba, Thillainayagam* and *Kuliyadichan* had high leaf blade growth.

Development of high-yielding varieties with enhanced seedling vigour is essential to improve rice stand establishment and increase weed competition ability under direct seeding. The identified landraces with rapid early rice growth may reduce water loss through evapotranspiration by early canopy closure. Genotypes identified from this study harbouring favourable alleles for early seedling vigour can be utilized for improving early seedling vigour after validating its stable expression across varied environments.

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