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Research Article

Characterization of rice (*Oryza sativa*) germplasm accessions for seedling vigor and its related traits

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Abstract
Rice is the most important cereal that serves as the carbohydrate resource for more than one-third of the world population. To keep pace with the population growth, the productivity level should be further increased. Among the various approaches available for breaking the yield ceiling, seedling vigor plays a very significant role since, it has a direct bearing on yield and other growth parameters. High seedling vigor paves way for raising the crop by direct seeding under water stressed situations as it suppresses weeds growth due to earlier establishment and speedy growth. The present study involves characterization of 210 rice germplasm accessions with wide genetic and geographic origin for seedling vigor and its related traits under controlled environmental condition. About 32 germplasm accessions were identified as highly vigorous based on seedling vigor indices.

Keywords
Seedling vigor, direct seeding, germplasm accession.

Introduction

Rice (*Oryza sativa)* is the most important dietary component for the world population and it is the staple food in Asian, Pacific, Latin American, Caribbean, North African and sub-Saharan countries (Chauhan, 2013**).** In India, it is grown in varied agro-climatic conditions and the productivity level of rice is lower (2494 kg/ha) in comparison to that of many countries such as China (6710 kg/ha) and Vietnam (5573 kg /ha). This lower productivity level may be due to shortage of water, land, labour and other resources to produce higher yields in addition to the stresses created by changing climate scenario (Singh *et al*., 2013).

Given these limitations, direct seeding is considered to be a viable option to maintain and increase the productivity level of rice under water stressed situations. However, in direct seeding the major threat is crop establishment for which weeds becomes major obstacle. The early growth and establishment of seedlings leads to higher biomass that suppresses the weed competition and increases the yield under direct seeded condition (Zhao *et al*., 2006). Since, rice is considered to be a well-diverse and has evolved into a tremendously broad base for genetic diversity as reflected by number of landraces existing today (Sujay, 2007), this study aims to identify the germplasm accessions with high seedling vigor through selection from a broad genetic resources of rice.

Materials and Methods

A set of 210 rice (*Oryza sativa* L.) germplasm accessions was obtained from Ramiah Gene Bank, Department of Plant Genetic Resources, CPBG, TNAU, Coimbatore. The germplasm accessions include 105 land races, 30 improved varieties and 75 breeding lines with wide genetic and geographic origins. The screening of rice germplasm for seedling vigor and its related traits was carried out under controlled condition in the glasshouse available at Centre for Plant Breeding and Genetics (CPBG), TNAU, Coimbatore, during September – October, 2017 (Fig. 1). The screening for seedling vigor was carried out using seedling box method (Fig. 1). 25 seeds from each genotype were sown in a galvanized iron tray of size 110 cm x 60 cm with the spacing of 5 cm x 5 cm in two replications. The observations on germination percentage and other seedling parameters such as shoot length (cm), root length (cm), total seedling length (cm), seedling fresh weight (g), seedling dry weight (g), number of leaves, number of nodes, internodal length (cm), vigor index I and vigor index II were recorded on 20 days after sowing. The scoring for seedling/vegetative vigor was also taken

on seedlings based on standard evaluation system for rice recommended by IRRI (2005) (Table 1). The seed germination per cent was calculated using the formula mentioned below,

Seed germination per cent = (Number of seeds germinated/ Total number of seeds sown) x 100
Vigor indices of the seedlings obtained from the germination test were calculated using the following formulae (Abdul-Baki and Anderson, 1973).
Vigor index - I: Seed germination per cent x seedling length (cm)
Vigor Index -II: Seed germination per cent x seedling dry weight (g)
The basic statistics *viz*., mean, range, minimum, maximum, standard deviation, standard error, coefficient of variation, degree of skewness and kurtosis were estimated for each traits under study with the help of Minitab 10.0 software. The correlation coefficient was calculated for all seedling vigor and its related traits using Pearson's correlation coefficient.

Based on the mean performances of the germplasm for vigor index - I and vigor index - II, a simple linear regression analysis was done to identify highly vigorous germplasm accessions.

Results and Discussion

The descriptive statistics for the 11 quantitative traits studied are presented in Table 2. The average germination percentage of all germplasm accessions was 89.56 per cent. Among the 210 germplasm accessions studied, TPS 1 recorded longest seedling length of 56.8 cm whereas C*hinthamani* recorded the lowest length of 8.55 cm. The longest and shortest root length were observed in CB 14740 (33.27 cm) and *Matali* (5.4 cm), respectively. The cultivar CO 37 (0.75g) had the highest seedling fresh weight, while the landrace *Gandakasala* (0.09 g) had the least value for the same trait. Seedling dry weight was the highest in CB 14681 (0.15 g) whereas *I. W. Ponni* recorded the lowest of 0.02 g. The number of nodes recorded among the accessions was in the range of two to four with the average of three nodes per seedling. The longest and shortest internodal length was observed in *Thattan Samba* (14.2 cm) and *Chandaikar* (0.40 cm), respectively. The breeding line CB 14740 (8025.47) recorded the highest vigor index –I and the cultivar CO 39 (14.20) recorded the highest vigor index – II. In the germplasm accessions taken, 16, 47, 104, 34 and 9 number of genotypes came under the seedling / vegetative vigor scale of 1,3,5,7 and 9 respectively.

The correlation coefficient calculated for all seedling vigor and its related traits was given in Table 3. A significant and positive correlation existed between vigor index I and vigor index II (0.687). The internodal length exhibited significant and positive correlation with seedling shoot length (0.220). Since, all the traits including germination percentage, seedling shoot length, root length, fresh weight, dry weight, number of leaves, number of nodes, total seedling length except internodal length were significantly correlated with seed vigor indices, seedling vigor index – I and seedling vigor index – II could be considered as a criteria for selecting vigorous germplasm accessions. The results were found to be in accordance with the studies on seed and seedling vigor traits including relative stage of seedling development (Namuco *et al.*, 2009) relative seedling growth rate measured as dry weight accumulation, seedling survival (Farooq *et al.*, 2006) and seed response to stress (Rajjou *et al.*, 2012).

The scatter diagram and trend line was drawn using the mean values of vigor index I and vigor index - II. The vigor index - I of 4750.38 and vigor index II of 5.39 were used to draw the coordinates to make four quadrants as shown in the Fig. 2. The germplasm accessions with high seedling vigor for both indices were selected from quadrant IV (Table 4).

Among the eleven seedling traits studied, vigor index – I and vigor index - II had significant and positive correlation with germination percentage, seedling shoot length, root length, fresh weight, dry weight, number of leaves, number of nodes, total seedling length except internodal length. Thirty two germplasm accessions (Table 4) from the 210 germplasm accessions studied were found to be highly vigorous and these could be used as a source for further improvement of seedling vigor trait.

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Table 1. Scoring for seedling/vegetative vigorbased on descriptors of Standard Evaluation System (SES) for rice by IRRI (2005)

SCALE	DESCRIPTION
1	Extra vigorous (very fast growing; plants at 5-6 leaf stage have 2 or more tillers in majority of population)
3	Vigorous (fast growing; plants at 4-5 leaf stage have 1-2 tillers in majority of population)
5	Normal (plant at 4-leaf stage)
7	Weak (plants somewhat stunted; 3-4 leaves; thin population; no tiller formation)
9	Very weak (stunted growth; yellowing of leaves)

Table 2. Statistical parameters for seedling vigor and its related traits in rice germplasm accessions

Statistical parameters	Vg	G (%)	SL (cm)	RL (cm)	TL (cm)	FW (g)	DW (g)	NOL	NON	INL (cm)	SVI	SVII
Mean	4.74	89.56	34.96	17.65	52.60	0.31	0.06	4.00	3.00	2.69	4750.38	5.39
Standard Error	0.13	0.80	0.43	0.47	0.75	0.01	0.00	0.05	0.05	0.10	86.71	0.18
Standard Deviation	1.84	11.62	6.25	6.81	10.85	0.12	0.03	0.69	0.69	1.50	1256.56	2.57
Kurtosis	0.12	3.53	2.35	-0.09	0.81	1.95	0.64	-0.38	-0.38	16.17	-0.16	0.59
Skewness	0.00	-1.47	-0.32	0.72	0.19	1.12	0.87	-0.18	-0.18	2.73	-0.22	0.94
Range	8.00	68.00	48.25	33.77	66.75	0.66	0.13	3.00	3.00	13.80	6639.87	13.16
Minimum	1.00	32.00	8.55	5.40	23.95	0.09	0.01	2.00	1.00	0.40	1385.60	1.04
Maximum	9.00	100.0	56.80	39.17	90.70	0.75	0.15	5.00	4.00	14.20	8025.47	14.20
Coefficient of variation	38.86	12.98	17.89	38.60	20.63	38.32	42.33	17.29	23.06	55.80	26.45	47.65

Abbreviations used

Vg - Seedling / Vegetative vigor
G - Germination
SL – Seedling shoot length
RL – Seedling root length
FW – Seedling fresh weight
DW – Seedling dry weight
NOL – Number of leaves
NON – Number of nodes
SVI – Vigor Index I
SVII – Vigor Index II
TL – Total seedling length
INL – Internodal length

Table 3. Correlation between seedling vigor and its related traits

	G	SL	RL	TL	FW	DW	NOL	NON	INL	SVI	SVII
G	1										
SL	0.220**	1									
RL	0.295**	0.379**	1								
TL	0.312**	0.814**	0.846**	1							
FW	0.292**	0.481**	0.508**	0.596**	1						
DW	0.241**	0.392**	0.607**	0.606**	0.683**	1					
NOL	0.321**	0.419**	0.545**	0.583**	0.468**	0.479**	1				
NON	0.321**	0.419**	0.545**	0.583**	0.468**	0.479**	1.000**	1			
INL	0.05	0.220**	-0.049	0.096	0.014	-0.05	-0.078	-0.078	1		
SVI	0.687**	0.711**	0.780**	0.899**	0.596**	0.581**	0.594**	0.594**	0.088	1	
SVII	0.454**	0.388**	0.622**	0.614**	0.694**	0.965**	0.514**	0.514**	-0.041	0.687**	1

**represent Correlation is significant at the 0.01 level (2-tailed)
*represent Correlation is significant at the 0.05 level (2-tailed)

Table 4. Mean performance of rice germplasm accessions with high seedling vigor

S.No	GENOTYPE	Vg	G (%)	SL (cm)	RL (cm)	TL (cm)	FW (g)	DW (g)	NOL	NON	INL (cm)	SVI	SVII
1	CB 13506	3	100	39.37	28.13	67.5	0.29	0.1	4	3	2.6	6750	10.2
2	CB 14528	5	100	32.5	26.17	58.67	0.71	0.1	4	3	3.6	5866.67	9.8
3	CB 14681	3	92	44.63	31.13	75.77	0.75	0.15	5	4	2.9	6970.53	13.34
4	CB 14740	3	92	53.97	33.27	87.23	0.64	0.1	5	4	2.4	8025.47	9.48
5	CB 1904	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
6	CL 13	5	92	25.03	27.53	52.57	0.46	0.13	4	3	4.9	4836.13	11.96
7	CO 33	5	100	29.57	26.83	56.4	0.43	0.08	5	4	2.1	5640	8
8	CO 37	1	100	39.07	25.6	64.67	0.75	0.12	5	4	2	6466.67	12.2
9	CO 39	1	100	35.1	20.8	55.9	0.52	0.14	5	4	1.4	5590	14.2
10	Indian Sando	5	100	42.73	26.07	68.8	0.38	0.11	4	3	2.8	6880	11
11	IR 11A106	5	100	35.4	32.97	68.37	0.33	0.08	5	4	1.6	6836.67	8
12	IR 11A318	5	100	37.9	22.9	60.8	0.26	0.08	5	4	1.4	6080	7.8
13	IR 11N169	5	92	37.83	17.5	55.33	0.36	0.1	5	4	2.4	5090.67	9.2
14	IR 20	1	100	35.93	17.3	53.23	0.55	0.11	5	4	3.1	5323.33	10.7
15	IR 28	3	100	34.87	22.47	57.33	0.55	0.11	5	4	1.7	5733.33	10.6
16	IR 50	1	96	50.73	27.13	77.87	0.69	0.11	5	4	1.9	7475.2	10.56
17	IR10A136	5	100	34.63	21.07	55.7	0.47	0.09	5	4	2.4	5570	8.6
18	IR11A546	3	92	38.1	29.5	67.6	0.49	0.13	5	4	2.6	6219.2	11.96
19	IR11N 191	3	100	34.9	28.9	63.8	0.46	0.1	5	4	3.4	6380	10.2
20	*Irunaazhi*	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
21	Jaya	3	92	34.67	25.67	60.33	0.6	0.09	5	4	3.8	5550.67	8.65
22	PMK 1	5	92	38.53	26.07	64.6	0.36	0.09	4	3	3.8	5943.2	8.28
23	PMK 2	1	96	50.73	27.13	77.87	0.69	0.11	5	4	1.9	7475.2	10.56
24	RP 5898-38-7-2-1-1	1	100	38.53	33.53	72.07	0.5	0.1	5	4	3.1	7206.67	10
25	RP 5947-38-5-2-1-1-1	1	100	44.93	27.33	72.27	0.48	0.12	4	3	2.8	7226.67	12
26	Sourya	5	92	42.83	32.47	75.3	0.28	0.09	4	3	3.9	6927.6	8.1
27	*Tellasannavadulu*	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
28	TKM 4	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
29	TRY 2	5	100	33.67	25.6	59.27	0.34	0.08	4	3	1.8	5926.67	8.3
30	TRY 3	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
31	Uma	3	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
32	*Urunikaima*	1	100	33.8	18.9	52.7	0.41	0.1	4	3	2	5270	10
33	**ADT 43 (Check)**	5	92	29.67	15.23	44.9	0.16	0.08	4	3	3.7	4130.8	7.54

Abbreviations used:

Vg - Seedling / Vegetative vigor
G - Germination
SL – Seedling shoot length
RL – Seedling root length
FW – Seedling fresh weight
DW – Seedling dry weight
NOL – Number of leaves
NON – Number of nodes
SVI – Vigor Index I
SVII – Vigor Index II
TL – Total seedling length
INL – Internodal length

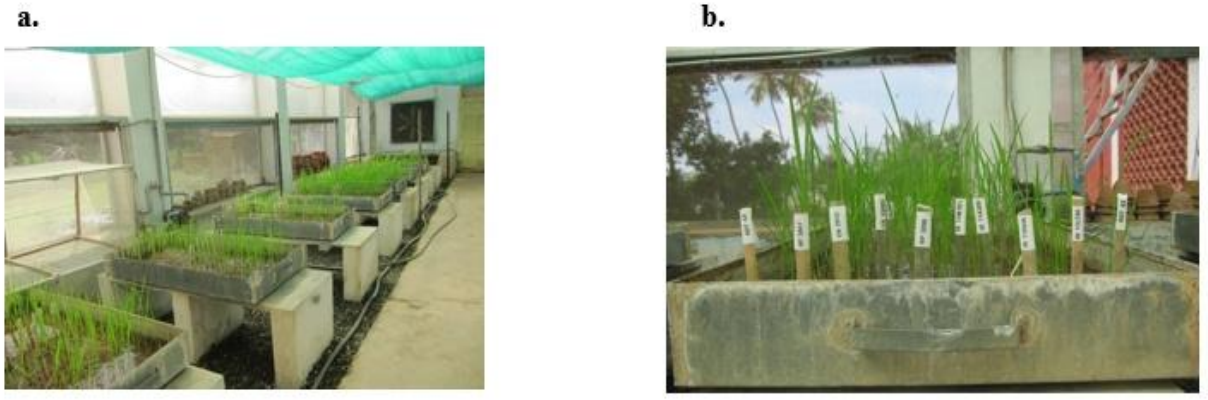

Fig. 1. Seedling box experiment
a. Arrangement of seedling boxes in the glasshouse, b. Close-up view of seedling box

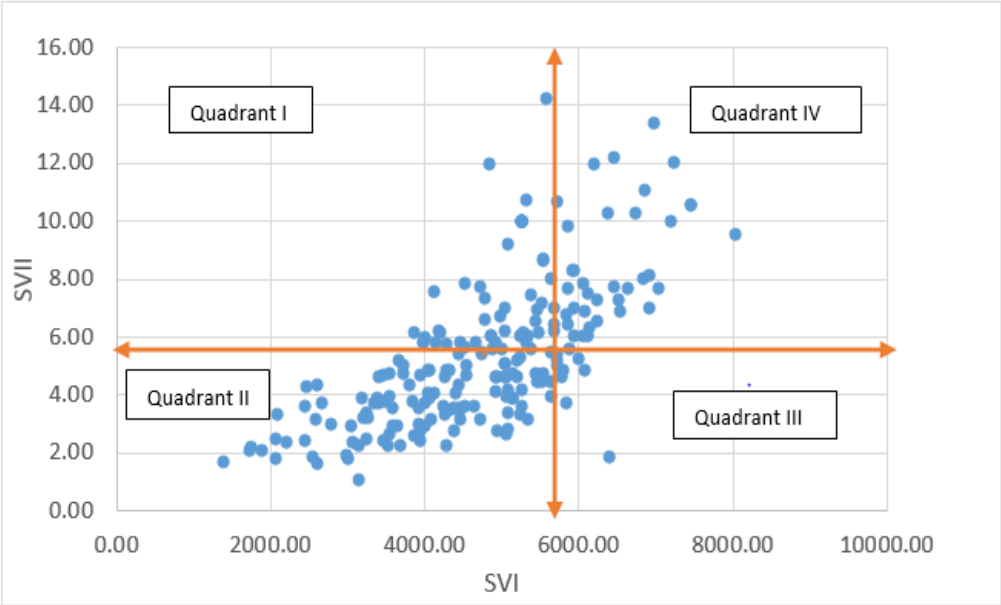

Fig. 2. Identification of highly vigorous germplasm accessions.

QUADRANT I – Germplasm accessions with high vigor index II
QUADRANT II - Germplasm accessions with poor vigor index I and vigor index II
QUADRANT III - Germplasm accessions with high vigor index I
QUADRANT IV- Germplasm accessions with high vigor index I and vigor index II