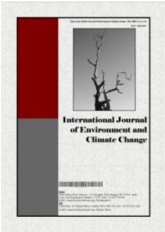

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Studies on Variability, Correlation and Path Analysis for Seedling Vigour Traits in Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author PS, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors CDR, LVSR, AK designed the study. Authors PS and CDR managed the analysis of the study. Author PS and LVSR managed the literature searches and field and lab data collection.All authors read and approved the final manuscript.

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ABSTRACT

The research work was undertaken in *Kharif,* 2019 at Department of Seed Science and Technology, College of Agriculture, PJTS Agriculture University, to identify lines with good vigour and high yield. Analysis of variance revealed existence of significant differences among the genotypes. Dry weight of seedling followed by seedling vigour index-II had showed high PCV and GCV. Germination (%) -first count, length of shoot, length of root, dry weight of seedling, seedling vigour index-I, seedling vigour index-II and field emergence exhibited high heritability along with high genetic advance as per cent of mean. Length of seedling, seedling vigour index-II and germination (%) -first count exhibited the high positive direct effect on per plant grain yield. Among all the traits Seedling vigour index-II and dry weight of seedling has shown high variability, correlation and cause effect analysis. Therefore, these traits have to be given importance during selection process for identification of high vigour rice lines.

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Keywords: Rice; vigour; variability; correlation; path analysis.

1. INTRODUCTION

Rice is one of the most important food crops in the world providing staple food for nearly half of the global population. Rice crop is exposed to many unfavourable conditions like drought, salinity, extreme temperatures and many biotic stresses. To overcome all these adverse effects high quality seed has to be used [1]. Seed vigour is an important characteristic of seed quality, reflecting potential seed germination, seedling growth, seed longevity, and tolerance to adversity [2-5]. Strong vigour seeds can boost seed germination speed and uniformity, as well as the ultimate percentage of germination, resulting in flawless field emergence, crop performance, and even high yield under various [6]. Cultivars with strong seed vigour are desirable for farmers to get optimum stand establishment [7]. Keeping in view the importance of seedling vigour present study was undertaken.

2. MATERIALS AND METHODS

Present study was undertaken with 30 rice genotypes collected from Rice Research Center, Agricultural Research Institute, PJTSAU, to estimate the variability, heritability and genetic advance of rice genotypes for seedling vigour traits. Completely Randomized Design and Randomized Block Design, was adopted to conduct the experiment. Seedling vigour analysis was carried out at Department of Seed Science and Technology, College of Agriculture, PJTS Agriculture University. The data was collected on characters *viz* germination (%)-First count, germination (%)-Final count, length of seedling (cm), length of root (cm), length of shoot (cm), dry weight of seedling (mg), Seedling vigour index-I, Seedling vigour index-II, Field emergence and grain yield per plant (g).

Methodology: Germination test was conducted on pure seed fraction using 100 seeds in two replicates following between paper (BP) method at 25^{0}C temperature (ISTA, 2004). The germinated seeds were evaluated into normal, abnormal seedlings and dead seeds on 14th day. The germination per cent was calculated based on the number of normal seedlings produced.

Germination percentage -First count: Seeds germinated at 5th day of germination in the standard germination test were counted and expressed as percentage.

Germination percentage -Final count: Seeds germinated at 14th day of germination in the standard germination test were counted and expressed as percentage. The germination per cent was calculated based on the number of normal seedlings produced in the germination test.

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total No. of seeds kept for germination}} \text{ x } 100$$

Root length(cm): Root length was measured from the cotyledonary node to tip of the primary node. Ten normal seedlings selected at random from each of the replication from germination test were carefully removed on the 14th day and used for measuring root length.

Shoot length (cm): Shoot length was measured as distance from coleoptile node to shoot tip. Ten normal seedlings from each replication were selected randomly on 14th day of germination and used for measuring shoot length.

Seedling length (cm): Seedling length was measured from the root tip to shoot tip for ten normal seedlings and the mean seedling length was expressed in centimeters.

Seedling dry weight (mg): Seedling dry weight was estimated in four replications, following the standard method. Ten normal seedlings used for root and shoot length measurements were picked up from each replication and after removing cotyledons they were put in butter paper bags and kept in hot air oven at 80^{0}C for 24 hours. The dry weight of the seedlings was recorded and expressed in mg 10 seedlings^{-1}

Seedling Vigour Index (SV): The seedling vigour indices were calculated using the following formula suggested by Abdul-Baki and Anderson (1973).

Vigour index-I: Seed germination per cent x seedling length (cm)
Vigour Index-II: Seed germination per cent x seedling dry weight (g)

Field emergence: The genotypes that emerged first (7th day) were considered as high vigour genotypes. Field emergence (%) was calculated by dividing the final number of seedlings emerged to the total (20 seeds) number of seeds sown.

Table 1. List of genotypes with parentage

S. no	Rice genotypes	Parentage
1.	RNR -28393	RGL 11414 X WGL 3962
2.	RNR -28376	Bhadrakali X VIR 79216-141-1-3-3
3.	RNR -28355	BPT 5204 X CSR-23
4.	RNR - 29086	BPT 5204 X (BPT 5204/NLR145) /BLNR1
5.	RNR - 29090	Tellahamsa X (BPT 5204/NLR145)/BLNR6
6.	RNR - 29092	BPT 5204 X NBR-16
7.	RNR - 29183	CN 1757-5-3-7 MLD-18 X RNR15048
8.	RNR - 29194	CN 1757-5-3-7 MLD-18 X RNR15048
9.	RNR - 29094	BPT 5204/BM7(BBM-1)//BPT 5204 X BM71(BBM2)
10.	RNR - 29397	Bhadrakali X IR 79597-56-1-2-1
11.	JGL -1798	BPT 5204 / Kavya
12.	JS - 1	Local cultivar
13.	GK - 1	Local cultivar
14.	RNR -21278	RNR 2465 X NLR 3449
15.	JGL-3828	Sambamahsuri / Agani
16.	KNM -118	MTU 1010 X JGL13595
17.	JGL-11727	JGL 420 / MTU 1001
18.	JGL-3844	Sambamahsuri/ARC 5984//Kavya
19.	JGL-17004	WGL 14377/JGL 3855
20.	JGL-11118	IET 8585/JGL1798
21.	JGL-11470	JGL 418/Gedongbetan
22.	JGL-3855	BPT 5204/ARC 5984//Kavya
23.	KNM -733	MTU 1010 X JGL-11470
24.	RNR -15435	RNR 17818 X Vasumathi
25.	JGL-18047	MTU 1010 X JGL 13595
26.	RNR - 15459	RNR 17818 X Chittimuthyalu
27.	RNR - 11718	MTU 1010 X NLR 34449
28.	RNR - 2354	Early Samba X RNR 19994
29.	RNR - 15048	MTU 1010 X JGL 3855
30.	HMT SONA	Local cultivar

2.1 Statistical Analysis

Standard procedure given by Panse and Sukhatme, 1978 was used for analysis of variance done for each character. Johnson et al. [8] proposed estimation of genotypic and phenotypic correlation coefficients and the range of genetic advance as per cent of mean based on classes high (20 and above), medium (10 - 20) and low (0 - 10). Categorization of the range of variation was effected as proposed by Sivasubramanian and Madhavamenon [9].

Category	Range of variation
Low	less than 10 %
Moderate	10-20 %
High	more than 20 %

GCV and PCV values were classed as high (20 and beyond), medium (10-20) and low (0-10) as given by Sivasubramanian and Menon [9]. Allard [10] suggested that heritability in broad sense was estimated as the ratio of genotypic variance to the total variance and expressed as percent. Johnson et al. [8] estimates of heritability were classified as high (61-100), moderate (30-60) and low (0-29). Falconer's formulas were used to calculate correlation coefficients at the genotypic and phenotypic levels (1964). INDOSTAT software was used to conduct all statistical analyses.

As suggested by Johnson et al. [8] (h^2) estimates were categorized as:

Category	Range of heritability
Low	0-30%
Medium	30-60%
High	> 60%

The range of genetic advance as percent of mean was classified as suggested by Johnson et al. [8].

Category	Range of GAM
Low	less than 10 %
Moderate	10-20 %
High	more than 20 %

3. RESULTS AND DISCUSSION

3.1 Genetic Parameters

Significant variation was observed among the genotypes for all the traits under study presented in Table 1. Table 2 indicates the results pertaining to genetic variability parameters *viz*., mean, genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), broad sense heritability (h^2) and genetic advance as per cent of mean (GAM) for seedling vigour traits. For all the traits the values of PCV were higher than the GCV values indicating that these characters may be influenced by the environment. High PCV and GCV values were observed for dry weight of seedling followed by seedling vigour index-II. High PCV and moderate GCV value was observed for length of root. Whereas moderate values were registered for length of seedling, length of shoot, seedling vigour index-I, field emergence and germination (%) first count, similar results by Pavan et al. [11]. Low for germination (%) final count, similar results were accordance with findings of Rishabh et al. [12].

High heritability coupled with high genetic advance as per cent of mean observed for germination (%) -first count, length of seedling, length of shoot, length of root, dry weight of seedling, seedling vigour index -I, seedling vigour index-II , field emergence and grain yield per plant indicated that these traits were controlled by additive type of gene action. Similar findings were given by Pavan et al. [11], Nusrat et al. (2018) for length of shoot and Rishabh et al. [12] for dry weight of seedling, Pavan et al. (2016) for seedling vigour index-II. For selection of traits for improving yield along with PCV and GCV values, heritability and genetic advance has to be considered to get reliable results.

The high estimates of heritability coupled with moderate genetic advance as per cent of mean were observed for germination (%)-final count.

Character association studies revealed that grain yield per plant showed significant and positive association seedling vigour index-II. However, it had negative and significant correlation with field emergence. Correlation analysis gives nature and degree of relationship only, path analysis can be used to study direct and indirect cause and effect relationship. Table 3. contains the data.

Path coefficient analysis revealed that length of seedling, seedling vigour index-II and germination (%) -first count exhibited higher positive direct effect on grain yield per plant indicating that the selection for these characters was likely to bring about an overall improvement in grain yield per plant directly. Similar findings were observed by Nusrat et al. (2018) for length of seedling, Rajendragouda et al. [13] for seedling vigour index-II and Saxena and Suman [14] for positive direct effect of germination (%)-first count. As a result, it is advised that these traits be prioritised in the selection process in order to isolate better lines with higher production potential in rice. The Table 4 contains the data.

Table 2. Analysis of variance for vigour and yield traits in rice

Sl. No	Characters	Mean sum of squares		
		Replications (d.f. = 1)	**Treatments (d.f. = 29)**	**Error (d.f.= 29)**
1	**Germination (%) -First count**	1.35	275.17**	4.04
2	**Germination (%) -Final count**	1.35	95.57**	9.04
3	**Length of seedling (cm)**	1.11	31.10**	3.27
4	**Length of root (cm)**	0.19	9.46**	0.54
5	**Length of shoot (cm)**	4.04	16.46**	3.19
6	**Dry weight of seedling (mg)**	0.001	0.003**	0.0001
7	**Seedling vigour index -I**	13127.60	350230.6**	37172.46
8	**Seedling vigour index-II**	2.36	21.40**	0.62
9	**Field emergence**	240.0	484.83**	67.58
10	**Grain yield per plant (g)**	0.32	25.21**	0.52

*** Significant at 1 level of probability*

Table 3. Genetic variability parameters for seedling vigour and yield in rice

S.No	Characters	Mean	Range		Phenotypic Variance	Genotypic Variance	PCV (%)	GCV (%)	Heritability in broad sense (h^2) (%)	Genetic advance as percent of mean
			Min	Max						
1	Germination (%)-First count	93.42	32.50	99.00	139.61	43.26	12.65	12.46	97.10	25.30
2	Germination (%)-Final count	91.98	62.00	99.50	52.30	0.17	7.86	7.15	82.70	13.40
3	Length of seedling (cm)	25.78	16.25	32.40	17.19	13.91	16.08	14.47	80.90	26.81
4	Length of shoot (cm)	11.38	8.45	17.90	5.00	4.46	19.65	18.56	89.20	36.10
5	Length of root (cm)	14.40	7.15	18.95	9.83	6.64	21.77	17.89	67.50	30.27
6	Dry weight of seedling (mg)	0.11	0.06	0.20	0.001	0.001	34.52	32.51	88.70	63.07
7	Seedling vigour index-I	2376.06	1276.5	3079.6	193701.5	156529.1	18.52	16.65	80.80	30.84
8	Seedling vigour index-II	10.22	4.92	16.44	11.01	10.39	32.49	31.56	94.40	63.15
9	Field emergence	87.00	35.00	100.00	276.21	208.62	19.10	16.60	75.50	29.73
10	Grain yield per plant (g)	19.12	10.45	26.75	12.87	12.35	18.7	18.38	96.00	37.09

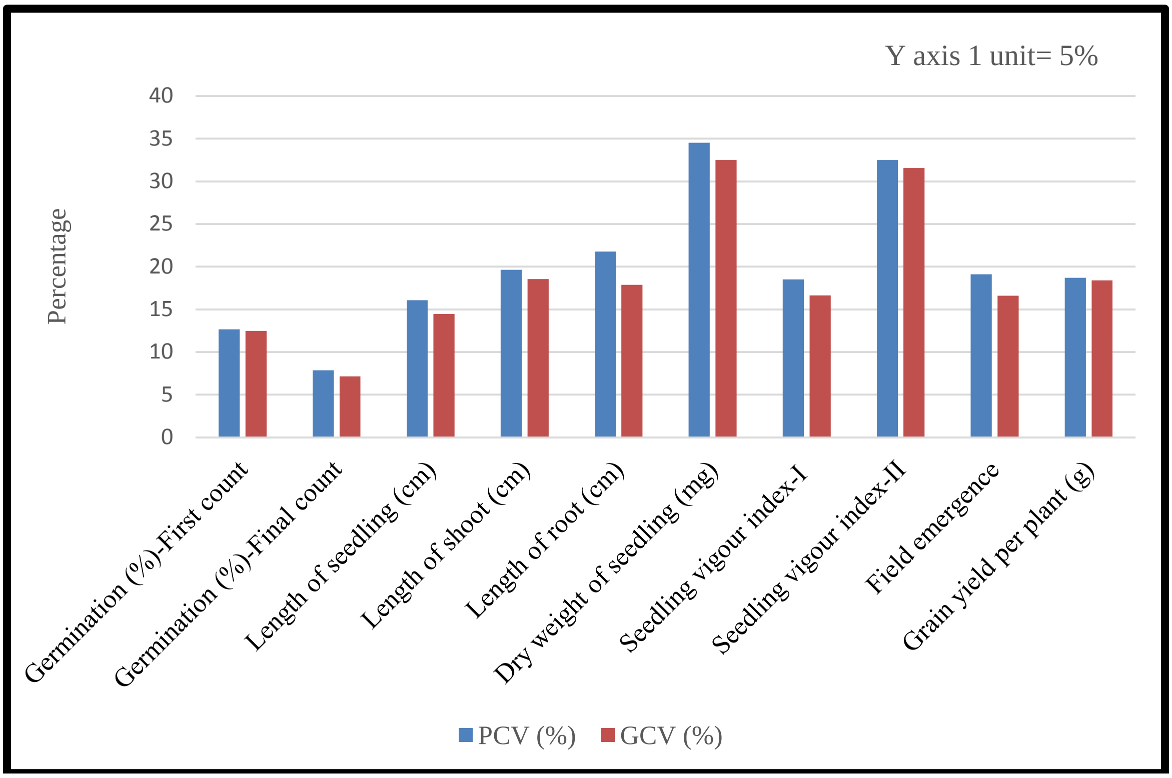

Fig. 1. Graphical representation of PCV and GCV

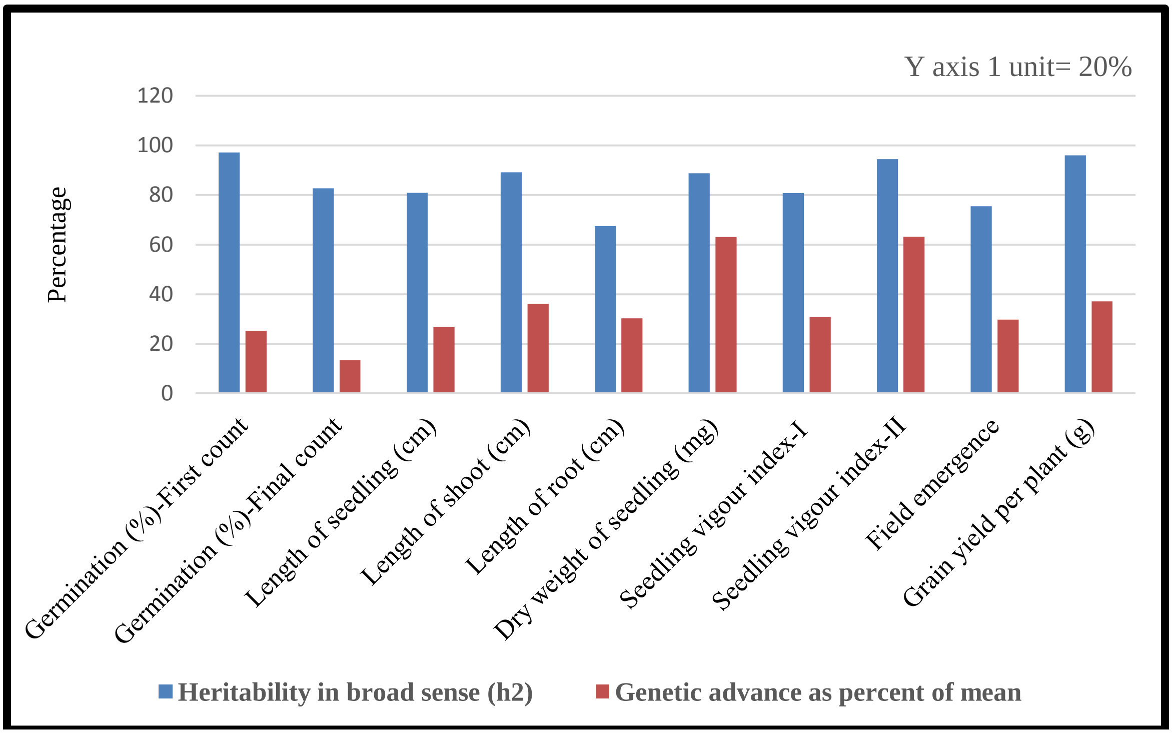

Fig. 2. Graphical representation of Heritability in Broad sense and Genetic Advance as % mean
Fig. 2. Graphical representation of Heritability and Genetic advance

Table 4. Correlation analysis for seedling vigour and yield traits in rice

Character		GER 1	GER 2	SL	SHL	RL	SDW	SV-I	SV-II	FE	GYP
GER 1	**G**	**1.00**	0.90**	0.21	0.00	0.31	-0.06	0.50**	0.21	0.15	0.08
	P	**1.00**	0.82**	0.19	0.00	0.25	-0.05	0.45**	0.21	0.11	0.08
GER 2	**G**		**1.00**	0.17	-0.02	0.27*	-0.18	0.53**	0.15	0.14	0.12
	P		**1.00**	0.15	-0.01	0.21	-0.16	0.50**	0.14	0.12	0.13
SL	**G**			**1.00**	0.75**	0.84**	0.83**	0.93**	0.86**	0.03	0.14
	P			**1.00**	0.66**	0.84**	0.69**	0.92**	0.76**	0.01	0.13
SHL	**G**				**1.00**	0.26*	0.64**	0.63**	0.65**	-0.03	0.13
	P				**1.00**	0.17	0.56**	0.57**	0.59**	0.01	0.13
RL	**G**					**1.00**	0.67**	0.82**	0.72**	0.07	0.10
	P					**1.00**	0.51**	0.81**	0.58**	0.01	0.08
SDW	**G**						**1.00**	0.65**	0.95**	0.05	0.21
	P						**1.00**	0.53**	0.93**	0.10	0.18
SV-I	**G**							**1.00**	0.80**	0.07	0.18
	P							**1.00**	0.71**	0.04	0.18
SV-II	**G**								**1.00**	0.07	0.27*
	P								**1.00**	0.09	0.25*
FE	**G**									**1.00**	-0.38**
	P									**1.00**	-0.33**

Table 5. Phenotypic (P) and Genotypic (G) path coefficients of seedling vigour and yield traits in rice

Character		GER 1	GER 2	SL	SHL	RL	SDW	SV-I	SV-II	FE	GYP
GER 1	**G**	**-1.3341**	-1.2035	-0.2830	0.0014	-0.4110	0.0807	-0.6706	-0.2738	-0.2061	0.0851
	P	**0.1750**	0.1441	0.0329	0.0002	0.0434	-0.0079	0.0788	0.0364	0.0200	0.0845
GER 2		0.7899	**0.8756**	0.1487	-0.0209	0.2324	-0.1616	0.4614	0.1298	0.1263	0.1261
	P	-1.4095	**-1.7114**	-0.2637	0.0108	-0.3564	0.2809	-0.8706	-0.2317	-0.1986	0.1304
SL	**G**	-0.1308	-0.1047	**-0.6166**	-0.4594	-0.5162	-0.5112	-0.5704	-0.5320	-0.0189	0.1432
	P	0.8863	0.7258	**4.7109**	3.1393	3.9892	3.2514	4.3666	3.5849	0.0426	0.1376
SHL	**G**	-0.0003	-0.0063	0.1977	**0.2654**	0.0687	0.1708	0.1682	0.1728	-0.0082	0.1308
	P	-0.0065	0.0307	-3.2356	**-4.8555**	-0.8143	-2.7274	-2.7790	-2.8645	-0.0349	0.1330
RL	**G**	0.3656	0.3150	0.9935	0.3072	**1.1867**	0.7985	0.9728	0.8490	0.0827	0.1001
	P	-1.7006	-1.4289	-5.8112	-1.1509	**-6.8625**	-3.5125	-5.6086	-4.0166	-0.0469	0.0870
SDW	**G**	0.1745	0.5323	-2.3915	-1.8563	-1.9409	**-2.8848**	-1.8642	-2.7350	-0.1356	0.2107
	P	0.0075	0.0273	-0.1148	-0.0935	-0.0852	**-0.1664**	-0.0887	-0.1557	-0.0166	0.1808
SV-I	**G**	-0.8814	-0.9239	-1.6219	-1.1113	-1.4373	-1.1331	**-1.7534**	-1.4110	-0.1230	0.1896
	P	2.1697	2.4515	4.4668	2.7581	3.9384	2.5692	**4.8189**	3.4244	0.1763	0.1838
SV-II	**G**	0.9138	0.6601	3.8412	2.8988	3.1854	4.2213	3.5830	**4.4524**	0.3155	0.2762*
	P	0.0556	0.0362	0.2034	0.1577	0.1564	0.2502	0.1899	**0.2673**	0.0251	0.2520*
FE	**G**	-0.0357	-0.0334	-0.0071	0.0071	-0.0161	-0.0109	-0.0162	-0.0164	**-0.2312**	-0.3832**
	P	-0.0241	-0.0245	-0.0019	-0.0015	-0.0014	-0.0210	-0.0077	-0.0198	**-0.2110**	-0.3354**

GER 1; *Germination (%) First count,* ***GER 2;*** *Germination (%) Final count,* ***SL;*** *Length of seedling (cm),* ***SHL;*** *Length of shoot (cm),* ***RL;*** *Length of root (cm),* ***SDW;*** *Dry Weight of Seedling (mg),* ***SV-I****; Seedling Vigour Index-I,* ***SV-II;*** *Seedling Vigour Index-II,* ***FE;*** *Field Emergence,* ***GYP;*** *Grain yield per plant (g)*

4. CONCLUSION

In conclusion, Analysis of variance revealed that all genotypes had shown the significant variation for all traits under study indicating that genotypes possessed inherent genetic differences. It was observed that seedling dry weight followed by seedling vigour index-II, had high heritability and high genetic advance as per cent of mean and indicating that inheritance was controlled by additive gene. Simple selection can be done to improve these traits. The remaining traits, seedling length, shoot length, root length, seedling vigour index-I, field emergence and germination (%) first count had low to moderate estimates of genetic advance, were largely influenced by non-additive gene effects. Analysis of correlation studies revealed that selection of plants with more seedling vigour index-II would result in improvement of yield. Path coefficient analysis revealed that higher positive direct effect on per plant grain yield was shown by seedling vigour index-I, seedling length seedling vigour index-II and germination (%)-first count so these traits can be considered as critical for improving yield and quality. Among all the characters seedling vigour index-II and seedling dry weight had shown high heritability and high genetic advance as per cent of mean, good correlation and positive direct effect on grain yield. Therefore, these characters should be prioritized during the selection process in order to identify better lines with more genetic potential for higher rice yield and high vigour.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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