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Correlation and path analysis in rice (*Oryza sativa* L.) for seed and seed vigour traits

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Abstract
An experiment comprising thirty-five diverse genotypes of rice maintained at division of plant breeding and genetics of MRCFC, SKUAST-K, Khudwani was carried out to assess the nature and magnitude of association among different seed and seed vigour traits. Data on twelve seed and seedling characters was recorded and analysed statistically for correlation and path analysis. Association studies revealed that seedling length (mm), shoot length (mm), germination (%), root length (mm), seed breadth (mm) and 1000 seed weight (g) showed high and significant positive association with seed vigour index at both genotypic and phenotypic levels. Seedling length (mm) and germination (%) showed highest direct positive effect on seed vigour index at both genotypic and phenotypic levels. Hence, these traits should be given priority in rice improvement programme and keeping in mind the importance of seed.

Keywords: Seed, seed vigour, correlation, path and *Oryza sativa* L.

Introduction
Rice (*Oryza sativa* L.) is the most important food crop of the world. It is the staple food of over half of the population. Rice is mainly a crop of tropics but can be cultivated in some area of temperate region too. Seed plays an important role for the success of any crop and it is the most important input for the success of any crop production programme. Seed vigour is an important factor that affects seedling establishment. Seeds low in vigour generally produces weak seedlings that are susceptible to environmental stresses. High vigour in seeds is expected to provide the growing seedlings the competitive advantage against various environmental stresses. Early vigour is a complex character and is a multiplicative end-product of many factors called vigour parameters. To make selection effective for early vigour, a thorough understanding of vigour indicating parameters, inter-relationship among them and with vigour is necessary (Rajendragouda *et al.* 2014) [12]. Correlation is a powerful tool to study the association of characters and was therefore very useful to decide selection strategy for improvement of a character without sacrificing gain in the other traits. Correlation and path analysis establish the extent of association between yield and its components and also bring out relative importance of their direct and indirect effects, thus giving an obvious understanding of their association with grain yield (Babu *et al.* 2012) [5]. The association of plant characters and yield thus assumes special importance in formulation of selection criteria for yield.

Materials and Methods
The present experiment comprising was carried out in the Division of Plant Breeding and Genetics at Mountain Research Centre for Field Crops, SKUAST-K, Khudwani, Anantnag (J&K). The material consisted of 35 diverse rice genotypes from Mountain Research Centre for Field Crops. The experiment was laid in three replications in laboratory conditions. Data on seed and seedling traits *viz.*1000 seed weight (g), seed length (mm), seed breadth (mm), L/B ratio, germination (%), seedling length (mm), root length (mm), shoot length (mm), root shoot ratio, seedling fresh weight (mg), seedling dry weight (mg) and seed vigour index were recorded from randomly selected samples of seed of each genotypes. The standard evaluation system for rice of IRRI (Anonymous, 1996) [3] was followed for recording observation for each character. The data recorded for each character was subjected to statistical analysis for correlation (Al-Jibourie *et al*, 1958) [2] and path coefficient analysis (Dewey and Lu, 1958) [7].

Results and Discussion
Correlation coefficient is a statistical measure which is used to find out the degree (strength) and direction of relationship between two or more variables. A positive value of correlation shows that the changes of two variables are in the same directions.

While selecting the suitable plant type, correlation studies would provide reliable information in nature to the extent and the direction of the selection, especially when the breeder want to combine high yield potential with desirable seed quality traits.
Correlation analysis among seed and seed related traits revealed that genotypic correlation was higher than phenotypic correlation in almost all the traits, indicating that the association is largely due to genetic reason and least affected by environment.

Genotypic Correlation coefficient
The correlation analysis among 12 seed and seed vigour traits for association among these traits at genotypic levels was worked out and results (table-1) revealed that seed vigour index showed a positive and significant correlation with seedling length (mm) (0.84**) followed by shoot length (mm) (0.75**), germination (%) (0.71**), root length (mm) (0.58**), seed breadth (mm) (0.59**) and 1000 seed weight (g) (0.38**). Because of improvement in one trait may bring improvement in other trait (Yadav *et al.,* 2011) [18] hence, strong positive association between these traits indicated a rapid and high improvement during selection. A negative and significant association with L/B ratio (-0.69**) and seed length (mm) (-0.66**) and a negative but non-significant association with root shoot ratio (-0.19) and seedling dry weight (g) (-0.05) was observed. Similar results were also reported by Singh and Singh, 2012 [15] for germination percentage, average shoot length, 100 seed weight in radish (*Raphanus sativus* L.)**,** Aswasthi *et al.,* 2016 for shoot length, root length and germination in pulse crop (*Vigna Spp*.)**,** Singh *et al*., 2000 [16] for shoot length, root length and test weight in wheat**,** Pathak and Chakrabarti, 2014 [10] for seedling shoot length in green gram (*Vigna radiata*)**,** Kumar *et al*., 2016 [8] for root length and shoot length in wheat**,** Sharma and Singh, 2012 [14] for root length in tomato**,** Nichal *et al*., 2015 [9] for seed germination, root length and shoot length in sunflower (*Helianthus annus* L.)**,** Bhardwaj and Kumar, 2012 [6] for germination (%) and seedling length in cucumber (*Cucumis sativus* L.) and Tyagi *et al.,* 2012 [17] for root length, shoot length and seedling length in soybean.

Phenotypic Correlation coefficient
At phenotypic level a significant positive correlation observed between seed vigour index and seedling length (mm) (0.84**), shoot length (mm) (0.75**), germination (%) (0.71**), root length (mm) (0.57**), seed breadth (mm) (0.48**) and 1000 seed weight (g) (0.38**). The strong positive association between these traits showed a highly favorable situation for improvement of these characters from breeding point of view (Yadav *et al.,* 2011) [18]. The character seedling fresh weight (g) (0.04) showed positive but non-significant association with seed vigour index. While as, negative significant association was observed with L/B ratio (-0.65**) and seed length (mm) (-0.64**). Whereas, traits like root shoot ratio (-0.18) and seedling dry weight (g) (-0.05) showed negative non-significant association. Similar results were also reported by Singh and Singh 2012 [15] for germination (%), average shoot length, 100 seed weight in radish (*Raphanus sativus* L.**,** Singh *et al*., 2000 [16] for shoot length, root length and test weight in wheat (*Triticum aestivum* L.)**,** Pathak and Chakrabarti, 2014 [10] for seedling shoot length in green gram (*Vigna radiata*)**,** Nichal *et al*., 2015 [9] for germination (%), root length and shoot length in sunflower and Tyagi *et al.,* 2012 [17] for root length, shoot length and seedling length in soybean.

Path coefficient analysis
As the number of independent variables influencing a particular dependent variable increases the amount of interdependence of variable also increases and thus indirect association becomes more complex and important. Under such situation, correlation alone is not sufficient to give true picture of association for effective manipulation of characters. Hence, path coefficient analysis become must to know which of the independent characters has the most direct effect on dependent character. In the present experiment path coefficient analysis revealed that the values of genotypic path coefficient were in general higher than the corresponding phenotypic path coefficient in most of the traits which might be due to considerable effect of environment on these traits. The results of present study are in consonance with those observed by Agahi *et al*., 2007 [1].

Genotypic path coefficient analysis
Perusal of table-2 revealed that highest direct effect on seed vigour index was exhibited by seedling length (0.703), germination (%) (0.500), shoot length (0.070), root shoot ratio (0.053), 1000 seed weight (0.038), seed length (0.006) and seedling dry weight (0.004). Positive direct effect of these traits on seed vigour indicates their importance in determining this complex character and therefore should be given preference for the improvement of this trait. The traits L/B ratio (-0.088), seed breadth (-0.087), seedling fresh weight (-0.071) and root length (-0.035) showed direct negative effect. Similar results were also reported by Singh *et al*., 2000 [16] for shoot length, root length in wheat by Pathak and Chakraborti, 2014 [10] for root shoot ratio, seedling shoot length, seedling dry weight, seedling root length, germination (%) in green gram (*Vigna radiata*), Kumar *et al.*, 2016 [8] for shoot length and germination (%) in wheat and by Singh and Singh, 2012 [15] for 100 seed weight, germination (%) and average shoot length in radish.

Phenotypic path coefficient analysis
The results of phenotypic path coefficient analysis (Table 2) showed the highest direct effect on seed vigour index was exhibited by seedling length (0.698), germination (0.498), shoot length (0.061), root shoot ratio (0.043), 1000 seed weight (0.034) and L/B ratio (0.028) (fig-2). While as, the character like seed length (-0.049), seedling fresh weight (-0.042), root length (-0.032), seedling dry weight (-0.018) and seed breadth (-0.010) showed negative direct effect on seed vigor index. Similar results were also reported by Sharma and Singh 2012 [13] for shoot length in tomato and Patta *et al.,* 2016 [1] for seedling length in wheat.

Table 1: Genotypic and phenotypic correlation coefficient between seed and seed vigour traits with seed vigour index in 35 rice genotypes.

S. No	Character		1000 seed weight (g)	Seed length (mm)	Seed breadth (mm)	L/B ratio	Germination (%)	Seedling length (mm)	Root length (mm)	Shoot length (mm)	Root shoot Ratio	Seedling fresh Weight. (g)	Seedling dry weight. (g)	Seed vigour index
1	1000 Seed Weight (g)	G	1.00	-0.15	0.28**	-0.24*	0.18	0.36**	0.14	0.35**	-0.28**	0.05	-0.01	0.38**
		P	1.00	-0.12	0.25*	-0.23*	0.19*	0.36**	0.14	0.34**	-0.26**	0.05	0.00	0.38**
2	Seed length (mm)	G		1.00	-0.71**	0.95**	-0.47**	-0.57**	-0.56**	-0.76**	0.32**	-0.08	-0.05	-0.66**
		P		1.00	-0.52**	0.84**	-0.44**	-0.55**	-0.55**	-0.74**	0.33**	-0.08	-0.04	-0.64**
3	Seed breadth (mm)	G			1.00	-0.91**	0.42**	0.50**	0.45**	0.55**	-0.13	-0.23*	-0.16	0.59**
		P			1.00	-0.86**	0.35**	0.41**	0.37**	0.45**	-0.07	-0.19*	-0.13	0.48**
4	L/B ratio	G				1.00	-0.50**	-0.58**	-0.56**	-0.72**	0.26*	0.05	0.05	-0.69**
		P				1.00	-0.48**	-0.55**	-0.53**	-0.68**	0.22**	0.05	0.04	-0.65**
5	Germination (%)	G					1.00	0.25**	0.19*	0.48**	-0.28*	-0.28**	-0.36**	0.71**
		P					1.00	0.25*	0.19*	0.48**	-0.27**	-0.28**	-0.35**	0.71**
6	Seedling length (mm)	G						1.00	0.71**	0.67**	-0.02	0.34**	0.26**	0.84**
		P						1.00	0.71**	0.67**	-0.02	0.34**	0.26**	0.84**
7	Root length (mm)	G							1.00	0.43**	0.32**	0.54**	0.48**	0.58**
		P							1.00	0.43**	0.31**	0.54**	0.48**	0.57**
8	Shoot length (mm)	G								1.00	-0.60**	0.08	-0.01	0.75**
		P								1.00	-0.58**	0.08	-0.01	0.75**
9	Root shoot ratio	G									1.00	0.15	0.27**	-0.19*
		P									1.00	0.15	0.27**	-0.18
10	Seedling fresh weight.(g)	G										1.00	0.92**	0.04
		P										1.00	0.91**	0.04
11	Seedling dry weight.(g)	G											1.00	-0.05
		P											1.00	-0.05
12	Seed vigour index	G												1.00
		P												1.00

Where, * and ** Significant at 1% and 5% level of significance respectively.

Table 2: Direct (diagonal) and indirect effect of different seed and seed vigour traits on seed vigour index in 35 rice genotypes

S. No	Character		1000 Seed weight (g)	Seed length (mm)	Seed breadth (mm)	L/B Ratio	Germination (%)	Seedling length (mm)	Root length (mm)	Shoot length (mm)	Root shoot ratio	Seedling fresh weight.(g)	Seedling dry weight.(g)	Seed vigour index
1.	1000 seed weight (g)	G	0.038	-0.006	0.011	-0.009	0.007	0.014	0.005	0.013	-0.011	0.002	0.000	0.380
		P	0.034	-0.004	0.008	-0.008	0.006	0.012	0.005	0.012	-0.009	0.002	0.000	0.376
2.	seed length (mm)	G	-0.001	0.006	-0.005	0.006	-0.003	-0.004	-0.004	-0.005	0.002	-0.001	0.000	-0.662
		P	0.006	-0.049	0.025	-0.041	0.022	0.027	0.027	0.036	-0.016	0.004	0.002	-0.636
3.	seed breadth (mm)	G	-0.024	0.062	-0.087	0.079	-0.036	-0.043	-0.039	-0.048	0.011	0.020	0.014	0.590
		P	-0.003	0.005	-0.010	0.009	-0.004	-0.004	-0.004	-0.005	0.001	0.002	0.001	0.483
4.	L/B ratio	G	0.021	-0.084	0.080	-0.088	0.044	0.051	0.049	0.063	-0.023	-0.004	-0.004	-0.687
		P	-0.007	0.024	-0.024	0.028	-0.013	-0.016	-0.015	-0.019	0.006	0.001	0.001	-0.651
5.	Germination (%)	G	0.092	-0.234	0.209	-0.249	0.500	0.123	0.094	0.239	-0.141	-0.141	-0.178	0.715
		P	0.093	-0.221	0.174	-0.238	0.498	0.122	0.093	0.237	-0.133	-0.139	-0.176	0.710
6.	Seedling length (mm)	G	0.253	-0.397	0.350	-0.406	0.173	0.703	0.495	0.469	-0.014	0.237	0.181	0.841
		P	0.249	-0.382	0.287	-0.383	0.171	0.698	0.492	0.465	-0.013	0.235	0.179	0.838
7.	Root length (mm)	G	-0.005	0.020	-0.016	0.020	-0.007	-0.025	-0.035	-0.015	-0.011	-0.019	-0.017	0.576
		P	-0.005	0.017	-0.012	0.017	-0.006	-0.022	-0.032	-0.014	-0.010	-0.017	-0.015	0.574
8.	Shoot length (mm)	G	0.024	-0.053	0.038	-0.050	0.033	0.047	0.030	0.070	-0.042	0.006	-0.001	0.748
		P	0.021	-0.045	0.028	-0.042	0.029	0.041	0.026	0.061	-0.036	0.005	0.000	0.745
9.	Root shoot ratio	G	-0.015	0.017	-0.007	0.014	-0.015	-0.001	0.017	-0.032	0.053	0.008	0.014	-0.185
		P	-0.011	0.014	-0.003	0.010	-0.012	-0.001	0.013	-0.025	0.043	0.006	0.012	-0.178
10.	Seedling fresh Weight.(g)	G	-0.003	0.006	0.017	-0.004	0.020	-0.024	-0.039	-0.006	-0.011	-0.071	-0.065	0.040
		P	-0.002	0.003	0.008	-0.002	0.012	-0.014	-0.023	-0.003	-0.006	-0.042	-0.038	0.040
11.	Seedling dry Weight.(g)	G	0.000	0.000	-0.001	0.000	-0.002	0.001	0.002	0.000	0.001	0.004	0.004	-0.052
		P	0.000	0.001	0.002	-0.001	0.006	-0.005	-0.008	0.000	-0.005	-0.016	-0.018	-0.052

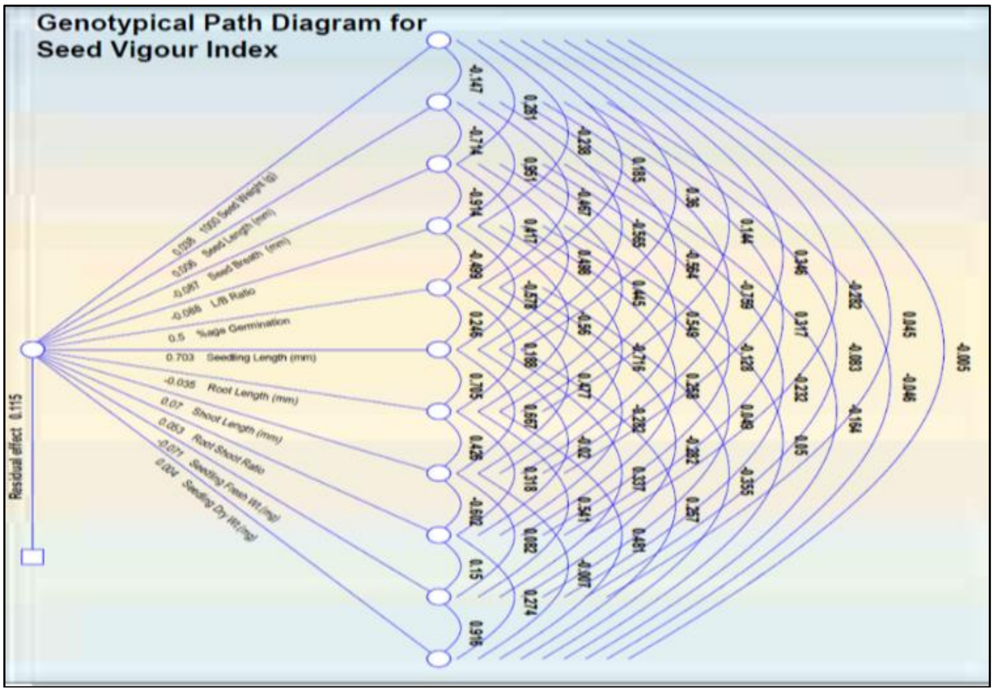

Fig 1: Genotypic path diagram for seed and seed vigour traits

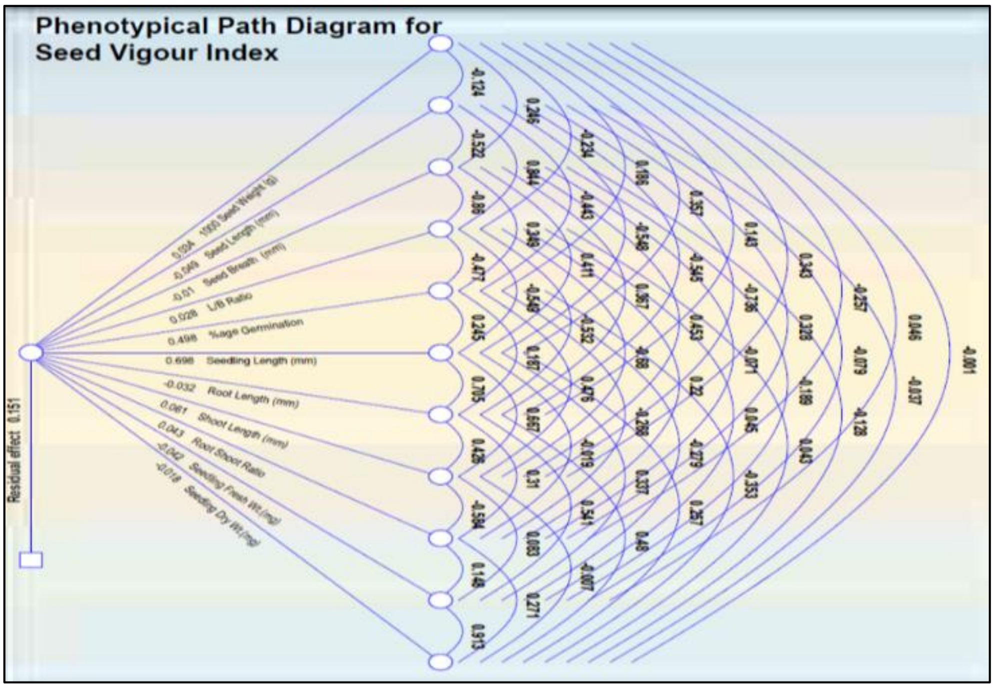

Fig 2: Phenotypic path diagram for seed and seed vigour trait

Conclusion

The genetic architecture of seed vigour is based on the balance and overall net effect produced by various seed and seedling related components interacting with one another. From the correlation and path analysis studies, it may be concluded that seedling length had significant and positive association with seed vigour index, shoot length, germination, root length, seed breadth and 1000 seed weight also seedling length and germination percentage had direct effect on seed vigour index. Hence, utmost importance should be given to these traits during selection programme.

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