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INTER RELATIONSHIP AND PATH CO-EFFICIENT ESTIMATION OF SEEDLING TRAITS IN RICE UNDER COLD STRESS

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Abstract

Thirty seven cold tolerant rice genotypes were evaluated to measure the association between germination and seedling vigour traits, their direct and indirect influence on seedling vigour index at 13°C temperature. Direct positive effect and significant positive association on seedling vigour index were contributed by germination percentage, root and shoot length and coleoptiles length>5mm, indicating that these traits contributed maximum to seedling vigour index compared to other characters. Hence, direct selection for all these traits will help in improvement of seedling vigour index which is an important criterion to be considered for the development of cold tolerant genotypes.

Key words : *Correlation, cold tolerance, path analysis, 13°C temperature*

The rabi season has low temperature varying from 8°C to 16°C starting from December to first fortnight of February. The optimum day temperature before heading is generally 31 - 32°C and optimum night temperature is 21 - 22°C and for the period 15 days after heading it varies from 8°C to 16°C. In view of this rice might suffer from low temperature at the seedling stage of the crop. Even low temperature at the crop establishment and tillering stage (vegetative phase) of the crop might affect the growth of the crop. Conventional high yielding varieties in adoption have little tolerance to low temperature. In view of such factors affecting rice production, high seedling vigour is essential for attaining maximum production as it is required for good stand establishment and successful crop performance in transplanted or direct seeded rice. Hence, the varieties possessing high seed and seedling vigour traits associated with higher yield is the prime requisite for efficient plant breeding programmes to meet the challenge of developing cold tolerant varieties. Seed vigour is an important characteristic of seed quality that determines rate of early embryo growth leading to seedling germination, emergence and growth for the development of a photo synthetically independent seedling. Seeds with strong vigour may significantly improve the speed, uniformity of seed germination, final percentage of germination and lead to perfect field emergence, good crop performance and even high yield under suboptimal conditions.

For rational approach towards the improvement of yield and its components, the association of characters with yield and the extent of environmental influence on the characters are very much essential. Therefore, the knowledge of association of component characters with yield has greater importance to plant breeders, as it helps in their selection with more precision and accuracy. The degree of relationship and association of these components with yield can be measured by correlation coefficients. But selection based on correlation without taking into consideration the interactions between the component characters may sometimes be misleading. Moreover, it does not give an exact position of the relative importance of direct and indirect effect of the various characters on yield. Hence, path analysis separates correlation coefficient into components which measure the direct and indirect effects. Path coefficient analysis provides an exact picture of the relative importance of direct and indirect effects of each of the component character towards seedling vigour index. With a view to establish effective mean for improvement of rice, character associations as well as the nature and the extent of direct and indirect effects on seedling vigour index were investigated.

MATERIALS AND METHODS

About thirty seven rice genotypes collected from the VPKS, Almora, RRS, Palampur and SKAUT, Kashmir along with important cold tolerant varieties of ANGRAU, Hyderabad were comprised the basic material for the study. Seed of genotypes were germinated in two temperature conditions viz., 28°C for seven days (control), and 13°C for 28 days (cold) as described by Cruz and Milach (2004). The experiment was carried out Quality control Lab, PJTSAU, Rajendranagar, Hyderabd under the controlled conditions during 2014-15. Seeds of each genotype were placed on Petri dishes containing two layers of germination paper, wet with distilled water and 1 ml of 2.5 ppm Benomyl solution to avoid contamination and transferred to a BOD germinator regulated to 28°C for the control and 13°C for the cold treatment. The experiment was conducted in a randomized block design with three replicates. Each Petri dish contained 20 seeds and the mean value of the investigated trait for the 20

Table-1: Phenotypic (P) and Genotypic (G) correlation coefficients among seedling vigour traits cold tolerant genotypes of rice.

Characters	Temp.	Germination (%)	Germination Index	Root length	Shoot length	Seedling growth	Coleoptile length	REDCOL	5mm	PERCOL	Seedling vigour
Germination (%)	G	1.000	0.987**	-0.166	-0.142	-0.161	0.402**	-0.006	1.003**	1.003**	0.399**
	P	1.000	0.953**	-0.129	-0.116	-0.128	0.2685**	-0.026	0.982**	0.982**	0.535**
Germination Index	G		1.000	-0.092	-0.079	-0.089	0.359**	-0.135	0.997**	0.997**	0.450**
	P		1.000	-0.076	-0.070	-0.076	0.2681**	-0.112	0.959**	0.9594**	0.546**
Root length	G			1.000	0.811**	0.945**	0.310**	-0.072	-0.144	-0.144	0.789**
	P			1.000	0.802**	0.941**	0.2864**	-0.059	-0.114	-0.114	0.718**
Shoot length	G				1.000	0.958**	0.455**	0.054	-0.114	-0.114	0.802**
	P				1.000	0.956**	0.4178**	0.033	-0.098	-0.098	0.727**
Seedling growth	G					1.000	0.407**	-0.005	-0.134	-0.134	0.836**
	P					1.000	0.3758**	-0.010	-0.111	-0.111	0.761**
Coleoptile length	G						1.000	0.315**	0.397**	0.397**	0.606**
	P						1.000	0.3416**	0.2804**	0.280**	0.502**
REDCOL	G							1.000	-0.049	-0.049	0.008
	P							1.000	-0.048	-0.048	-0.009
5mm	G								1.000	0.863**	0.655**
	P								1.000	1.000	0.535**
PERCOL	G									1.000	0.623**
	P									1.000	0.535**
Seedling vigour	G										1.000
	P										1.000

*Significant at P = 0.05 level, **Significant at P = 0.01 level.

seeds was considered one replicate. Seeds germinated at 13°C had their root, shoot and coleoptile length measured weekly for a period of 28 days and for seeds germinated at 28°C this measure was made seven days after the beginning of the experiment. Based on the mean data recorded on germination (%),root length, shoot length (cm), seedling length (cm), seedling vigour index, coleoptiles length (mm) and coleoptiles length >5mm. The parameters germination Index, Percentage of seeds with Coleoptile superior to 5 mm (PERCOL5) and percentage of Reduction in Coleoptile length (REDCOL) were calculated using the following the formulas. Germination index (GI): GI = (N14+N21/2) / 20 x 100, where N14 = number of germinated seeds 14 days after the beginning of the cold treatment; N21 = number of germinated seeds 21 days after the beginning of the cold treatment; 20 being the total number of seeds per genotype per replication. For the GI calculation only the seeds presenting coleoptile and radicule were considered.

Percentage of seeds with coleoptile superior to 5 mm (PERCOL5): obtained considering all the germinated seeds 28 days after the beginning of the cold treatment and by verification of the percentage that presented coleoptile length superior to 5 mm, according to the formula: PERCOL5 = (number of seeds with coleoptile > 5 mm) x 100/20.

Percentage of reduction in coleoptile length (REDCOL): obtained through comparison of average coleoptile length 28 days after germination at 13°C (cold treatment) with that obtained 7 days after germination at 28°C (control), and calculating the percentage of reduction in coleoptile length by germination under cold temperature, according to the formula: REDCOL = [(col. length under cold temperature x 100)/ col. length under control] –100, where coleoptile length is the average of the 20 seeds evaluated per replication per genotype.

Phenotypic and genotypic correlation coefficients were computed by out for all possible combinations of characters as per the procedure outlined by (1). Path analysis was carried out following the method suggested by (2). Analysis was carried out by using WINDOW STAT software package.

RESULTS AND DISCUSSION

Genotypic correlations in general were high as compared to corresponding phenotypic correlations which indicated strong inherent association between the characters. Genotypic and phenotypic correlation

Table-2 : Phenotypic (P) and Genotypic (G) path co-efficient analysis for seedling vigour traits cold tolerant genotypes of rice.

Characters		Germination	Germination Index	Root length	Shoot length	Seedling growth	Coleoptile length	REDCOL	5mm	PERCOL	Seedling vigour
Germination	G	2.6699	2.6363	-0.4441	-0.3794	-0.4303	1.0725	-0.0160	2.6772	2.6772	0.399**
	P	0.7337	0.6995	-0.0944	-0.0851	-0.0941	0.197	-0.0189	0.7211	0.7211	0.535**
Germination Index	G	-3.0323	-3.0710	0.2814	0.2439	0.2746	-1.1009	0.4145	-3.0625	-3.0625	0.450**
	P	-0.0015	-0.0015	0.0001	0.0001	0.0001	-0.0004	0.0002	-0.0015	-0.0015	0.546**
Root length	G	-2.4669	-1.3588	14.8300	12.0336	14.0108	4.5941	-1.0707	-2.1397	-2.1397	0.789**
	P	-0.2238	-0.1323	1.7398	1.3965	1.6381	0.4983	-0.1023	-0.1979	-0.1979	0.718**
Shoot length	G	-2.4112	-1.3476	13.7690	16.9686	16.2589	7.7133	0.9082	-1.9263	-1.9263	0.802**
	P	-0.2243	-0.1347	1.5523	1.9339	1.8502	0.8081	0.0639	-0.1894	-0.1894	0.727**
Seedling growth	G	4.6854	2.5994	-27.4690	-27.8590	-29.0751	-11.8227	0.1552	3.9052	3.9052	0.836**
	P	0.3401	0.2026	-2.4953	-2.5355	-2.6503	-0.996	0.0266	0.2938	0.2938	0.761**
Coleoptile length	G	-0.0666	-0.0594	-0.0513	-0.0753	-0.0674	-0.1657	-0.0522	-0.0658	-0.0658	0.606**
	P	0.005	0.005	0.0053	0.0078	0.007	0.0187	0.0064	0.0052	0.0052	0.502**
REDCOL	G	0.0017	0.0379	0.0203	-0.0150	0.0015	-0.0885	-0.2811	0.0139	0.0139	0.008
	P	-0.0003	-0.0011	-0.0006	0.0003	-0.0001	0.0035	0.0103	-0.0005	-0.0005	-0.009
5mm	G	1449.3810	1441.4760	-208.5483	-164.0860	-194.1464	574.3961	-71.2471	1445.4520	1445.4520	0.655**
	P	0.3276	0.3198	-0.0379	-0.0326	-0.037	0.0935	-0.0161	0.3333	0.3333	0.535**
PERCOL	G	-1448.3620	-1440.4620	208.4017	163.9707	194.0099	-573.9923	71.1970	-1444.4360	-1444.4360	0.623**
	P	-0.4214	-0.4113	0.0488	0.042	0.0475	-0.1202	0.0208	-0.4287	-0.4287	0.535**

Residual effect (phenotypic) = 0.1008, Residual effect (Genotypic) = 0.051, Bold: Direct effects, Normal: Indirect effects

*Significant at P = 0.05 level, **Significant at P = 0.01 level

coefficients studied are presented in (Table 1). Seedling vigour Index showed positive significant correlation with germination percentage, germination index, root, shoot and seedling length, coleoptile length, coleoptile length > 5MM and PERCOL except REDCOL at both genotypic and phenotypic level. This indicated that all these characters were important for identification of cold tolerant genotypes. Hence, these characters could be considered as criteria for selection for cold tolerant genotypes as these were mutually and directly associated with seedling vigour index. Germination percentage and germination index had positively significant correlation with coleoptile length, coleoptiles length > 5MM, PERCOL and seedling vigour at genotypic and phenotypic level. At both level shoot length exhibited positively significant correlation with seedling growth, coleoptile length and seedling vigour index. Similarly, seedling growth with coleoptile length and seedling vigour index, coleoptile length with REDCOL, Coleoptiles length >5mm, REDCOL and seedling vigour index registered positive significant association at both levels. This clearly indicated the strong association of other traits on seedling growth traits with seedling vigour index. (3) reported positive significant association for the all the seedling vigour traits. This was also supported by (4), that correlations between cold tolerance and germination and reproductive stages was low or zero. Germination index plays a vital role in the chilling tolerance mechanism of rice plant (5). The correlation coefficients were inadequate to interpret the cause and effect relationships. However, path analysis technique furnishes a method of portioning the correlation coefficients between various characters into direct and an indirect effect and provides the actual contribution of an attribute and its influence through the other traits. Jiang et al. 2008 reported that low temperature affects positive correlations between the germination and seedling stages. (6) reported positive and significant correlation with seedling length. Correlations in cold tolerance among different growth stages for rice have been reported and it was suggested that varieties with high germination and seedling vigour under low temperature conditions are also likely to be more tolerant to low temperature exposure at the booting and flowering stages (7). (8) reported positive correlation between early seedling cold tolerances with flowering stage cold tolerance. In contrast (9) reported non significant correlation of cold tolerance between the seedling and reproductive stages. Further, it was reported that germination index play vital role in chilling tolerance mechanism of rice plant (5). (10) opined that PERCOL is a good characteristic to distinguish cold-tolerant from cold-sensitive rice genotypes, hence clear separation of genotypes can be made based on the observation of

PERCOL after 28 days. REDCOL is an important parameter to assess the tolerance of a genotype to cold stress and the negative correlation between these two parameters was in accordance with the results of (11). The negative association between PERCOL and REDCOL helps in identifying cold tolerant genotypes at laboratory level.

Path coefficient analysis (Table-2) revealed that germination percentage, root length, shoot length and coleoptile length>5mm recorded highest positive direct effect on seedling vigour index, indicating that selection for these characters are likely to bring about genotypes with cold tolerance directly. Germination Index, seedling growth and PERCOL showed negative direct effect on seedling vigour index. The residual effects permit precise explanation about the pattern of interaction of other possible components of cold tolerance. Phenotypic (0.1008) and genotypic residual effects (0.051) were very low, indicating that some other traits were also influencing seedling vigour index.

Cold tolerance is based on the balance or overall net effect produced by various germination and seedling vigour traits with one another. Characters viz., germination percentage, root and shoot length and coleoptile length >5 mm had direct positive effect and significant positive association with seedling vigour index, indicating that these traits contributed maximum to seedling vigour index compared to other characters. Hence, these traits should be taken into consideration while selecting desirable cold tolerant genotypes for the development of cold tolerant genotypes at 13°C temperature.

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