ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Association studies for physiological parameters and early vigour traits under anaerobic condition in rice (*Oryza sativa* L.)

Srilakshmi Chaitanya M*, Krishna Veni B, Lal Ahamed M, Girija Rani M and Jaya Lalitha K

Department of Genetics and Plant Breeding, Agricultural College, Bapatla 522101, Andhra Pradesh
* Corresponding author (email: mangalapurichaitanya@gmail.com)

Received: 3rd Dec. 2017, Accepted: 1st Feb. 2018

Abstract

Forty eight high yielding rice genotypes were studied to determine the association of traits that contribute for germination and growth of seedlings under anaerobic conditions. The character association studies revealed that germination percentage under 14 days of submergence showed significant and positive correlation with all other parameters under study. Free amino acid concentration manifested positive and significant relationship with shoot length at 7 and 14 days under anaerobic conditions, while total sugars exhibited significant positive relationship with shoot length, dry matter production, germination percentage and vigour index at 7 days under submergence. The studies of path analysis revealed maximum direct effect for vigour index at 14 days of submergence followed by root length and number of leaves at 14 days of submergence.

Key words: Anaerobic germination, Rice, Path analysis, Correlation.

Introduction

Direct seeding of rice is being adopted in irrigated low land ecosystem also because it reduces labour costs in addition to other benefits. Wide adoption of direct seeded rice practice has been hindered by poorly levelled fields, heavy rainfall and poor drainage system which cause accumulation of water in the fields shortly after sowing leading to poor crop establishment. This is due to the inability of most rice varieties to germinate and reach the water surface under complete submergence. Hence, tolerance of anaerobic condition during germination is an essential trait for direct seeded rice cultivation both in rainfed as well as in irrigated ecosystems. Varieties that can germinate in flooded soils could be beneficial for direct seeded systems not only in low land areas but also for intensive irrigated systems where early flooding can suppress weeds (Ismail *et al*., 2012). This will consequently result in enormous savings in production costs as opposed to when rice is transplanted. It can also reduce the cost of manual or mechanical weeding or the use of hazardous chemicals for weed control. The literature pertaining to the association of various characters on anaerobic germination is very limited. Hence an attempt was made to determine the direct and indirect effects of various traits and association of different vigour related characters on anaerobic germination ability of rice genotypes.

Materials and Methods

The experiment was carried out with 48 rice genotypes during *kharif*, 2016 at Regional Agricultural Research Station, Maruteru, Andhra Pradesh and material used are presented in Table 1.

Table 1: Material Used In The Experiment

1 -	MTU4870	13 -	NLR20084	25 -	MTU2067	37 -	BPT4358
2 -	NLR33892	14 -	BPT2590	26 -	JGL17004	38 -	NLR4002
3 -	MTU5249	15 -	BPT2593	27 -	RGL1414	39 -	MTU1001
4 -	MTU7029	16 -	MTU2077	28 -	BPT1768	40 -	BPT2675
5 -	BPT2571	17 -	MTU3626	29 -	MTU1064	41 -	BPT2270
6 -	BPT2660	18 -	IR85961-23-1-2-1	30 -	MTU2716	42 -	AC39416A
7 -	BINADHAN11	19 -	NLR4001	31 -	BPT3291	43 -	MTU1140
8 -	BPT2644	20 -	AC39397	32 -	BPT2231	44 -	BPT2573
9 -	BPT2295	21 -	JGL3828	33 -	BPT5204	45 -	MTU1166
10 -	BPT2782	22 -	BPT2411	34 -	MTU1061	46 -	BPT2740
11 -	RGL2537	23 -	BPT2595	35 -	MTU1075	47 -	MTU5293
12 -	BPT2673	24 -	BPT2507	36 -	MTU5182	48 -	BPT2743

Screening for tolerance to anaerobic germination was conducted as per the method delineated by Reddy *et al.*(2015). Sterilized seeds were placed in petri dishes with moistened filter papers and incubated at 30^0C for 48 hrs for germination. After 3 days of sowing fifteen pre-germinated seeds were kept in seedling trays (35.5×10×4.5cm) at about 1 cm soil depth in two replications per treatment in Completely Randomized Design. Each tray consisted of three rows and 10 holes (2.5 cm) in each row. After sowing, the trays were submerged carefully in concrete tanks filled with 10 cm depth of water.The water level was maintained at 10cm depth above the soil surface in the trays for 7 &14 days. Data was recorded on five randomly selected seedlings per genotype per replication for root length at 7 & 14 days after submergence, shoot length at 7 & 14 days after submergence, number of leaves at 7 & 14 days after submergence, dry matter at 7 & 14 days after submergence by following standard methods (Reddy *et al*. 2015). Vigour index was calculated at 7 and 14 days of submergence by following the method suggested by Vijay *et al*. (2010).Number of plants survived after 7 & 14 days of submergence were counted and germination percentage was calculated as per standard procedure. Sugar concentration in normal seeds was estimated by using anthrone method described by Hedge and Hofreiter (1962) while amino acid concentration in seeds was estimated by using ninhydrin method described by Moore and Stein (1948). Phenotypic and genotypic correlations were worked out by using the formulae suggested by Falconer (1964). Path coefficient analysis suggested by Wright (1921) and elaborated by Dewey and Lu (1959) was used to calculate the direct and indirect contribution of various traits to anaerobic germination.

Results and Discussion

The aim of correlation studies is primarily to know the suitability of various characters for indirect selection because any particular trait may bring about changes in other associated characters (Singh, 1998). In the present investigation, the results of character association studies revealed that germination percentage at 14 days of submergence showed significant and positive association with all characters under study *viz.*,shoot length at7 & 14 days after submergence, root length at7 & 14 days after submergence, dry matter at 7 & 14 days after submergence, vigour index at 7 & 14 days after submergence, germination percentage at 7 days of submergence,number of leaves at 7 & 14 days after submergence, total soluble sugars (0.377& 0.384)and free amino acids(0.261& 0.267) at both genotypicand phenotypic levels respectively (Table 2). The results indicated that genotypes with high anaerobic germination percentage also possessed longer shoot and root length, more number of leaves, high vigour index,higher amount of free aminoacids and total soluble sugars. The cumulative effect of all these traits ultimately resulted in inducing tolerance to submergence at seedling stage under direct sowing. Among the early vigour traits, dry matter at 7& 14 days of submergence manifested positive association with all other characters under study while root length at 7 & 14 days of submergence exhibited positive relationship with all other characters under study except with free aminoacids.This suggests that the presence of free amino acids in the endosperm will enhance coleoptile elongation or germination of genotypes which was previously reported by Atwell *et al.*(1982). Free aminoacids manifested positive and significant association with shoot length under 7 days after submergence (0.118 &0.117) &14 days after submergence (0.2050& 0.202) both at phenotypic and genotypic levels.Vigour index at 7 & 14 days of submergence and total soluble sugars also exhibited positive relationship with all other characters under study. Soluble sugar concentration in seed and its transport from the endosperm to the coleoptile are reported to be closely associated with coleoptile elongation under anoxia (Furuhata *et al*. 2006; Kato-Noguchi *et al*.2010).

The observed correlation between the vigour related traits and its component character is the net result of the direct and indirect effects of the component character through other vigour attributes. The correlation coefficients observed among vigour traits may sometimes be misleading since, it may be over or under estimate because of its association with other characters. Hence, the correlation coefficient needs to be split into direct and indirect effects, using path coefficient analysis for critical evaluation. Thus, the correlation and path analysis in combination, can give a better insight, into cause and effect relationship between different pairs of characters. Studies of path analysis revealed that vigour index at 14 days of submergence (0.5885& 0.5674) manifested maximum positive direct effect followed by root length at 14 days of submergence (0.5701& 0.3857), number of leaves at 14 days after submergence (0.3240 &0.2435) at genotypic and phenotypic levels respectively (Table 3). These traits also exhibited positive correlation coefficients indicating the true relationship and selection through these traits will be effective for improvement of anaerobic germination. These findings are in agreement with the results reported by Pavan Shankar (2015). Shoot length at 14 days after submergence (-0.1881 and -0.4192) and number of leaves at 7 days of submergence (-0.1339 and -0.2191) manifested negative direct effect but manifested positive association with anaerobic germination percentage at 14 days of submergence. Hence, the direct effects may be the casual factors for positive correlation and the indirect casual factors are to be considered simultaneously while exercising selection to improve anaerobic germination.

Table 2: Estimates of correlation coefficients among early vigour traits in rice (*Oryza sativa* L.)

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Shoot length at 7 daysof submergence (1)	P	1.000	0.197	0.540**	0.015	0.397**	0.076	0.219*	0.16	0.282**	0.346**	0.191	0.118	0.291**	0.205*
	G	1.000	0.190	0.529**	0.016	0.369**	0.067	0.18	0.153	0.259*	0.289**	0.175	0.117	0.283**	0.194
Shoot length at 14 days of submergence (2)	P		1.000	0.378**	0.760**	0.476**	0.682**	0.281**	0.706**	0.381**	0.329**	0.459**	0.205*	0.226*	0.545**
	G		1.000	0.349**	0.708**	0.398**	0.650**	0.249*	0.672**	0.348**	0.293**	0.419**	0.202*	0.221*	0.515**
Root length at 7 days of submergence (3)	P			1.000	0.478**	0.078	0.034	0.369**	0.286**	0.183	0.042	0.042	-0.134	0.128	0.271**
	G			1.000	0.447**	0.078	0.023	0.300**	0.270**	0.173	0.03	0.029	-0.132	0.124	0.255*
Root length at 14 days of submergence (4)	P				1.000	0.270**	0.573**	0.369**	0.669**	0.471**	0.214*	0.250*	-0.082	0.122	0.596**
	G				1.000	0.242*	0.519**	0.303**	0.620**	0.429**	0.18	0.217*	-0.079	0.117	0.557**
Dry matter at 7 days of submergence (5)	P					1.000	0.593**	0.373**	0.226*	0.580**	0.558**	0.587**	0.338**	0.412**	0.469**
	G					1.000	0.530**	0.305**	0.197	0.497**	0.494**	0.549**	0.309**	0.376**	0.429**
Dry matter at 14 days of submergence (6)	P						1.000	0.263**	0.628**	0.558**	0.770**	0.463**	0.075	0.18	0.525**
	G						1.000	0.223*	0.589**	0.525**	0.731**	0.440**	0.072	0.171	0.491**
Number of leaves at 7 days of submergence (7)	P							1.000	0.431**	0.446**	0.231*	0.254*	0.127	0.072	0.275**
	G							1.000	0.383**	0.401**	0.243*	0.225*	0.113	0.064	0.244*
Number of leaves at 14 days of submergence (8)	P								1.000	0.501**	0.384**	0.344**	0.033	0.162	0.577**
	G								1.000	0.475**	0.347**	0.309**	0.032	0.16	0.557**
Germination percentage at 7 days of submergence (9)	P									1.000	0.580**	0.571**	0.265**	0.432**	0.685**
	G									1.000	0.566**	0.497**	0.253*	0.417**	0.637**
Vigour index at 14 days of submergence (10)	P										1.000	0.372**	0.14	0.341**	0.400**
	G										1.000	0.336**	0.127	0.316**	0.364**
Vigour index at 7 days of submergence (11)	P											1.000	0.449**	0.346**	0.733**
	G											1.000	0.426**	0.326**	0.713**
Free amino acids (12)	P												1.000	0.388**	0.267**
	G												1.000	0.387**	0.261*
Total soluble sugars (13)	P													1.000	0.384**
	G													1.000	0.377**
Germination percentage under 14 days of ubmergence (14)	P														1.000
	G														1.000

*Significance at 5% level , **significance at 1% level

Table 3: Direct and indirect effects of vigour related traits on germination percentage at 14 days under submergence among 48 genotypes of rice (*Oryza sativa* L.)

Sl. No	Character		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	Shoot Length 7 DAS under anaerobic conditions	P	**0.0002**	-0.0008	-0.0001	-0.0000	-0.0001	-0.0001	-0.0001	-0.0002	-0.0004	0.0004	-0.0003	-0.0002	-0.0004
		G	**0.0059**	0.0011	0.0032	0.0009	0.0023	0.0004	0.0013	0.0009	0.0016	0.0020	0.0011	0.0007	0.0017
2	Shoot Length 14 DAS under anaerobic conditions	P	-0.0358	**-0.1881**	-0.0065	-0.1337	-0.0752	-0.1228	-0.0471	-0.1268	-0.0656	-0.0552	-0.0791	-0.0381	-0.0417
		G	-0.0827	**-0.4192**	-0.1586	-0.3185	-0.1993	-0.2858	-0.1180	-0.2959	-0.1599	-0.1378	-0.1926	-0.0858	-0.0946
3	Root Length 7 DAS under anaerobic conditions	P	0.0412	0.0271	**0.0779**	0.0347	0.0060	0.0017	0.0233	0.0210	0.0135	0.0023	0.0022	-0.0102	0.0096
		G	0.0563	0.0395	**0.1044**	0.0499	0.0081	0.0035	0.0385	0.0298	0.0191	0.0043	0.0043	-0.0140	0.0133
4	Root Length 14 DAS under anaerobic conditions	P	0.0065	0.2724	0.1717	**0.3847**	0.0929	0.1995	0.1165	0.2385	0.1648	0.0692	0.0834	-0.0303	0.0449
		G	0.0086	0.4331	0.2727	**0.5701**	0.1541	0.3267	0.2101	0.3813	0.2683	0.1222	0.1425	-0.0467	0.0693
5	Dry Matter7 DAS under anaerobic conditions	P	-0.0053	-0.0057	-0.0011	-0.0035	**-0.0145**	-0.0077	-0.0044	-0.0028	-0.0072	-0.0071	-0.0079	-0.0044	-0.0054
		G	0.0392	0.0470	0.0077	0.0267	**0.0989**	0.0586	0.0369	0.0223	0.0573	0.0550	0.0580	0.0334	0.0407
6.	Dry matter 14 DAS under anaerobic conditions	P	-0.0055	-0.0536	-0.0018	-0.0427	-0.0437	**-0.0824**	-0.0183	-0.0485	-0.0432	-0.0602	-0.0363	-0.0059	-0.0141
		G	-0.0084	-0.0761	-0.0038	-0.0640	-0.0662	**-0.1116**	-0.0294	-0.0700	-0.0623	-0.0860	-0.0517	-0.0084	-0.0200
7	No.of Leaves 7 DAS under anaerobic conditions	P	-0.0241	-0.0334	-0.0401	-0.0405	-0.0405	-0.0298	**-0.1339**	-0.0513	-0.0536	-0.0325	-0.0301	-0.0151	-0.0085
		G	-0.0480	-0.0616	-0.0808	-0.0807	-0.0817	-0.0577	**-0.2191**	-0.0943	-0.0978	-0.0506	-0.0556	-0.0277	-0.0157
8	No of Leaves 14 DAS under anaerobic conditions	P	0.0371	0.1636	0.0658	0.1510	0.0479	0.1433	0.0934	**0.2435**	0.1156	0.0846	0.0752	0.0078	0.0390
		G	0.0517	0.2286	0.0926	0.2167	0.0732	0.2033	0.1395	**0.3240**	0.1624	0.1243	0.1115	0.0106	0.0526
9	Germination percentage 7 DAS under anaerobic conditions	P	0.0417	0.0560	0.0279	0.0691	0.0801	0.0846	0.0646	0.0765	**0.1612**	0.0912	0.0800	0.0408	0.0673
		G	0.0207	0.0280	0.0134	0.0346	0.0426	0.0411	0.0328	0.0369	**0.0736**	0.0426	0.0420	0.0195	0.0318
10	Vigour Index 7 DAS under anaerobic conditions	P	0.0156	0.0158	0.0016	0.0097	0.0267	0.0396	0.0131	0.0188	0.0306	**0.0541**	0.0182	0.0068	0.0171
		G	0.0270	0.0257	0.0032	0.0168	0.0437	0.0603	0.0181	0.0300	0.0454	**0.0783**	0.0291	0.0109	0.0267
11	Vigour Index 14 DAS under anaerobic conditions	P	0.0990	0.2377	0.0163	0.1230	0.3114	0.2499	0.1277	0.1753	0.2818	0.1905	**0.5674**	0.2420	0.1849
		G	0.1124	0.2703	0.0244	0.1471	0.3455	0.2724	0.1494	0.2025	0.3358	0.2187	**0.5885**	0.2642	0.2038
12	Free Amino Acids	P	0.0048	0.0084	-0.0054	-0.0032	0.0128	0.0029	0.0047	0.0013	0.0105	0.0052	0.0177	**0.0415**	0.0160
		G	0.0113	0.0197	-0.0129	-0.0078	0.0324	0.0072	0.0121	0.0031	0.0255	0.0134	0.0432	**0.0962**	0.0373
13	Total Soluble Sugars	P	0.0191	0.0150	0.0084	0.0079	0.0255	0.0116	0.0040	0.0108	0.0283	0.0214	0.0221	0.0262	**0.0678**
		G	0.0108	0.0083	0.0047	0.0045	0.0153	0.0066	0.0026	0.0060	0.0160	0.0126	0.0128	0.0144	**0.0371**
14	Germination percentage 14 DAS under anaerobic condition	P	0.1945*	0.5151**	0.3146**	0.5565**	0.4293**	0.4903**	0.2435**	0.5562**	0.6366**	0.3635**	0.7127**	0.2610**	0.3768**
		G	0.2048*	0.5444**	0.2702**	0.5954**	0.4689**	0.5250**	0.2748**	0.5766**	0.6850**	0.3990**	0.7331**	0.2673**	0.3840**

*Significance at 5% level , **significance at 1% level

References:

Atwell BJ, Waters I and Greenway H. 1982.The effect of oxygen and turbulence on elongation of coleoptiles of submergence-tolerant and in-tolerant rice cultivars. *Journal of Experimental Botany.* 33: 1030-1044.

Dewey DR and Lu KH. 1959. A correlation and path coefficient analysis of components of crested Wheat grass seed production. *Agronomy Journal.* 51: 515-518.

Falconer DS. 1964. *An Introduction of Quantitative Genetics-Second edition*.

Oliver and Boyd, Edinburgh. 312-324.

Furuhata M, Iwaki Y and Arima S. 2006. Effects of the metabolites in the seeds and seedling emergence rate on the percentage of seedling emergence and establishment in rice direct-seeded under submerged conditions. *Japanese Journal of Crop Science*. 75: 182–190.

Hedge JE and Hofreiter BT. 1962. In: *Carbohydrate Chemistry* 17 (*Eds* Whistler, R.L and Be Miller, J.N) Academic Press, New York.

Ismail AM, David EJ, Evangelina SE, Georgina VV and Aurora MB. 2012. Adaptation to flooding during emergence and seedling growth in rice and weeds, and implications for crop establishment. *AoBPLANTS* : pls019; doi:10.1093/aobpla/pls019.

Kato-Noguchi H, Yasuda Y and Sasak, R. 2010. Soluble sugar availability of aerobically germinated barley, oat and rice coleoptiles in anoxia. *Journal of Plant Physiology*. 167: 1571–1576.

Moore S and Stein WH. 1948. In: *Methods in Enzymology* (*Eds*.Colowick, S.P and Kaplan, N.D) Academic Press, New York 3. 468.

Pavan Shankar, H.P. 2015. Genetic variability studies on early vigour, yield and quality traits in dry direct sown rice (*Oryza sativa* L.) genotypes. *M.Sc (Ag) Thesis.* Department of Genetics and Plant Breeding, Acharya N.G Ranga Agricultural University, Guntur, India.

Reddy,A.V., Girija, R.M., Satyanarayana, P.V., Suryanarayana, Y., Chamundeswari, N., Ravikumar, B.N.V.S., Ramana, R.P.V and Vishnuvardhan, K.M. 2015. Physiological and molecular response of rice genotypesfor different types of flooding. *Current Biotica.* 8(4): 345-350.

Singh, P. 1998. *Cotton Breeding*. Kalyani Publishers, New Delhi. 191-211.

Vijay, D., Dadlani, M and Vashisht, V. 2010. Comparative studies of natural and accelerated ageing in soybean seeds. *Crop Research.* 39(1,2&3): 153-159.

Wright, S. 1921. Correlation and causation. *Journal of Agricultural Research*. 20: 557-585.