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STUDIES ON CORRELATION AND PATH ANALYSIS FOR MORPHO PHYSIOLOGICAL TRAITS IN RICE GENOTYPES (*ORYZA SATIVA*) UNDER SUBMERGENCE AND NORMAL ENVIRONMENT

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Abstract

The experiment was carried out to explore correlation and path co-efficient analysis in 26 genotypes under two environment namely submergence and normal condition. The twelve characters were recorded. The genotypic correlation coefficient showed higher magnitude than phenotypic correlation co-efficient which indicate masking (or) modifying effect of environment. Under submergence condition the trait grain yield per plant had positive and significant correlation with days to flowering, number of tillers per plant, number of panicles per plant, panicle length and inter cellular CO_2 concentration at both genotypic and phenotypic level. But in normal condition grain yield per plant had positive and significant correlation with days to first flowering, plant height, number of tillers per plant, number of panicles per plant, photosynthetic rate, stomatal conductance and inter cellular CO_2 concentration at both phenotypic level. So it could be inferred that grain yield per plant and other above mentioned traits could be used as selection criteria for the improvement grain yield per plant. Scrutiny in path analysis indicated maximum direct effect on grain yield was exhibited by number of panicles per plant under submergence and normal condition. Hence the trait should be taken in account of breeding programme to develop maximum threshold yield obtaining new rice varieties and hybrids.

Key words: Correlation and Path analysis in rice, Under submergence, normal environment

Introduction

Rice is a cereal crop belonging to genus *Oryza* of family *Poaceae* and tribe *Oryzeae*. The two cultivated rice species, *Oryza sativa* L. (Asian Rice) and *Oryza glaberrima* Steud, (African Rice), belongs to a species group called *Oryza sativa* complex together with the five wild taxa, *O. rufipogon, O. longistaminata Chev.* et *Roehr., O. barthii A. Chev., O. glumaepatula* Steud. and O. *meridionalis* Ng. It is an important cereal crop, grown under diverse agro-ecological conditions. It is also a major food crop, as it ranks second to wheat among the most cultivated cereals in the world. To feed the ever growing population, the targeted rice production of World, China and India for the year 2030 were envisaged as 771.02, 168.90 and 130.02 million tonnes respectively.

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. Grain yield is a complex character and is the end - product of various traits. Therefore knowledge regarding the correlation of grain yield with other component characters is valuable for understanding the correlated response to selection for yield. Path coefficient analysis is helpful to recognize direct and indirect causes of correlation and also enables us to compare the causal factors on the genetic basis of their relative contributions. Hence the present study of correlation and path analysis would serve path for future breeding programmes.

Materials and Methods

The present investigation was carried out to study the submergence tolerance of 26 rice genotypes including submergence tolerant check variety Swarna sub 1 during Samba, 2016. The pot culture studies carried out at the pot culture yard of Department of Genetics and Plant Breeding Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu. The statistical analysis carried out to study the genetic divergence, variability and character association of the selected rice genotypes. The experimental material for this genetic divergence

study comprised of twenty six genotypes collected from Directorate of Rice Research, Hyderabad. The details of the materials are presented in table 1.

Table 1: List of Genotypes used in Study

Genotypes	Variety	Origin
G1	AURC 4101	Directorate of Rice Research, Hyderabad
G2	AURC 4102	Directorate of Rice Research, Hyderabad
G3	AURC 4103	Directorate of Rice Research, Hyderabad
G4	AURC 4104	Directorate of Rice Research, Hyderabad
G5	AURC 4105	Directorate of Rice Research, Hyderabad
G6	AURC 4106	Directorate of Rice Research, Hyderabad
G7	AURC 4107	Directorate of Rice Research, Hyderabad
G8	AURC 4108	Directorate of Rice Research, Hyderabad
G9	AURC 4109	Directorate of Rice Research, Hyderabad
G10	AURC 4110	Directorate of Rice Research, Hyderabad
G11	AURC 4111	Directorate of Rice Research, Hyderabad
G12	AURC 4112	Directorate of Rice Research, Hyderabad
G13	AURC 4113	Directorate of Rice Research, Hyderabad
G14	AURC4114	Directorate of Rice Research, Hyderabad
G15	AURC4115	Directorate of Rice Research, Hyderabad
G16	AURC4116	Directorate of Rice Research, Hyderabad
G17	AURC4117	Directorate of Rice Research, Hyderabad
G18	AURC4118	Directorate of Rice Research, Hyderabad
G19	AURC 4122	Directorate of Rice Research, Hyderabad
G20	AURC4125	Directorate of Rice Research, Hyderabad
G21	AURC 4127	Directorate of Rice Research, Hyderabad
G22	AURC 4133	Directorate of Rice Research, Hyderabad
G23	AURC 4135	Directorate of Rice Research, Hyderabad
G24	AURC 4138	Directorate of Rice Research, Hyderabad
G25	AURC 4139	Directorate of Rice Research, Hyderabad
G26	(Swarna Sub 1)	International Rice Research Institute (IRRI) Philippines

Pot Culture Studies under Submergence

The seeds of each genotyps of rice were sown directly in pots during samba, 2016 (Aug. - Dec.) and the seedlings were thinned on tenth day after sowing, leaving three sturdy healthy seedlings per pot. Tillering stage plants were submerged in an outdoor cement concrete tank with a water depth of 1.5 m for 7 days the same rice genotype in pots without submergence was kept as control.

The experimental design was RBD with three replications. Eleven traits were recorded on single plant basis in three randomly selected plants of the each genotypes per replication.

The observations were recorded in normal and submerged plants on days to first flower, plant height, number of tillers per plant, number of panicles per plant, panicle length, 1000 grain weight, photosynthetic rate, stomatal conductance, intercellular CO_2 concentration, transpiration rate and grain yield per plant. The mean data were utilized for the statistical analysis.

Result and Discussion

Correlation Studies

Estimates of correlation between yield and yield component characters in rice genotypes in normal and submergence condition are presented in (Tables 2 and 3).

In normal condition days to first flowering had negatively by significant correlation with plant height at both genotypic level while in submergence it had positive significant correlation with photosynthetic rate, stomatal conductance, inter cellular CO_2 conc., transpiration rate and grain yield per plant at both genotypic and phenotypic level. In normal condition, it had positive significant correlation with number of tillers per plant, thousand grain weight and grain yield per plant at both genotypic and phenotypic level. While in submergence condition this character had positive significant correlation with panicle length at genotypic level. Other characters at both phenotypic and genotypic level were low values.

In normal condition, number of tillers per plant had positively significant correlation with number of panicles per plant, stomatal conductance, Inter cellular level and grain yield per plant at both genotypic and phenotypic level. It had positive significant correlation with thousand grain weight and negatively significant with panicle length at genotypic level. In submergence condition, it had positive correlation with number of panicles per plant, stomatal conductance, inter cellular CO_2 conc. and grain yield per plant at both genotypic and phenotypic level. In normal condition, this trait had positively significant correlation with panicle length, thousand grain weight, photosynthetic rate and grain yield per plant at both phenotypic and genotypic level. In submergence condition the character had positively significant correlation with panicle length, inter cellular CO_2 conc. and grain yield per plant at genotypic and phenotypic level.

In normal, this trait had positively significant correlation with grain yield per plant and all other characters were low and negligible values. In submergence condition this character had positively significant correlation with thousand grain weight and grain yield per plant positively

Table 2. Genotypic and phenotypic correlation among various characters in 26 rice genotypes in normal condition

Characters		Days to first flowering	Plant height	Number of tillers per plant	Number of panicles per plant	Panicle length	1000 grain weight	Photo synthetic rate	Stomatal conductance	Inter cellular CO_2conc.	Transpiration rate	Grain yield per plant
Days to first flowering	G	1.000	-0.493*	-0.122	-0.351	0.349	0.206	0.131	0.325	-0.207	0.364	0.781**
	P	1.000	-0.352	-0.051	-0.121	0.242	0.132	0.123	0.263	-0.100	0.337	0.601**
Plant height	G		1.000	0.086	-0.270	-0.030	0.487**	0.083	-0.085	0.254	0.289	0.488*
	P		1.000	0.116	-0.057	-0.019	0.455**	0.071	-0.076	0.135	-0.201	0.415*
No.of tillers per plant	G			1.000	0.876**	-0.617**	0.893**	0.341	0.481*	0.642*	0.055	0.539**
	P			1.000	0.819**	-0.012	-0.133	0.140	0.423*	0.665*	0.006	0.657**
No.of panicles per plant	G				1.000	0.640**	0.680**	0.540**	0.115	0.111	-0.040	0.616**
	P				1.000	0.834**	0.728**	0.508**	0.066	0.048	-0.013	0.791**
Panicle length	G					1.000	0.119	0.622**	-0.158	-0.182	-0.035	-1.189
	P					1.000	0.193	0.523**	0.099	0.005	-0.070	-0.122
1000 grain weight	G						1.000	0.678**	-0.077	0.007	-0.143	-0.006
	P						1.000	0.572**	0.153	-0.004	-0.132	0.661**
Photo synthetic rate	G							1.000	0.388*	0.409**	0.259	0.762**
	P							1.000	0.391*	0.446**	0.242	0.714**
Stomatal conductance	G								1.000	0.059	0.904**	0.347*
	P								1.00	0.010	0.719**	0.365
Inter cellular CO_2conc.	G									1.000	0.718**	0.556**
	P									1.000	0.800**	0.507**
Transpiration rate	G										1.000	0.791*
	P										1.000	-0.184

G - Genotypic correlation

P - Phenotypic correlation

* Significant 5%

** Significant 1%

Table 3. Genotypic and phenotypic correlation among various characters in 26 rice genotypes in submergence

Characters		Days to first flowering	Plant height	Number of tillers per plant	Number of panicles per plant	Panicle length	1000 grain weight	Photo synthetic rate	Stomatal conductance	Inter cellular CO_2 conc.	Transpiration rate	Grain yield per plant
Days to first flowering	G	1.000	0.189	0.291	0.365	-0.009	0.040	0.449*	0.526**	0.420**	0.597**	0.705**
	P	1.000	-0.014	0.200	0.190	-0.052	0.001	0.419*	0.601**	0.489**	0.685**	0.684**
Plant height	G		1.000	-0.020	-0.000	0.497**	0.048	-0.660**	-0.244	0.274	0.087	0.145
	P		1.000	0.049	0.104	-0.371	0.078	-0.393*	-0.023	0.126	0.172	0.164
No.of tillers per plant	G			1.000	0.976**	0.268	0.045	-0.281	0.383*	0.576**	0.280	0.804**
	P			1.000	0.888**	0.149	-0.000	-0.245	0.385*	0.547**	0.120	0.669**
No.of panicles per plant	G				1.000	0.351*	0.088	-0.277	-0.236	0.627**	0.229	0.888**
	P				1.000	0.412*	0.042	-0.233	-0.115	0.637**	0.145	0.774**
Panicle length	G					1.000	0.449*	0.274	-0.054	0.187	0.051	0.390**
	P					1.000	0.407*	-0.243	-0.077	0.094	-0.066	0.382**
1000 grain weight	G						1.000	0.079	-0.058	0.427*	-0.115	0.238
	P						1.000	0.070	-0.005	0.390*	-0.042	0.183
Photo synthetic rate	G							1.000	-0.036	0.408*	0.247	0.195
	P							1.000	0.120	0.392*	0.295	0.131
Stomatal conductance	G								1.000	-0.137	0.868**	0.210
	P								1.00	0.046	0.636**	0.014
Inter cellular CO_2 conc.	G									1.000	-0.165	0.620**
	P									1.000	0.008	0.614**
Transpiration rate	G										1.000	0.522**
	P										1.000	0.237

G - Genotypic correlation

P - Phenotypic correlation

* Significant 5%

** Significant 1%

Table 4. Genotypic path co-efficient analysis among various characters 26 rice genotypes in normal condition

Characters	Days to first flowering	Plant height	Number of tillers per plant	Number of panicles per plant	Panicle length	1000 grain weight	Photo synthetic rate	Stomatal conductance	Inter cellular CO_2 conc.	Transpiration rate	Grain yield per plant
Days to first flowering	**0.26403**	0.14382	0.21815	-2.80535	1.11187	0.67717	0.66450	1.21621	-0.25389	-0.68815	0.781**
Plant height	-0.13013	**-0.29181**	0.15364	-0.21292	-0.09394	0.94582	-0.42316	-0.31745	0.31197	0.54624	0.488**
No.of tillers per plant	0.93216	0.02503	**-1.79106**	6.99857	-1.96318	-2.94045	-1.72861	1.80101	0.17460	-0.10448	0.539*
No.of panicles per plant	0.09276	0.00778	-1.56980	**7.98497**	-2.03614	1.57953	-2.74085	0.43059	0.13618	0.07514	0.616*
Panicle length	0.09228	0.90862	1.10524	-5.11058	**3.18134**	-0.39065	0.10948	0.59047	0.22322	0.06650	-1.189*
1000 grain weight	0.05429	-0.08381	1.59915	-3.82971	0.37737	**3.29332**	-1.40877	0.28723	0.00838	0.27085	-0.006
Photo synthetic rate	0.03457	-0.02433	0.61006	4.31249	0.06863	0.91421	**-5.07492**	1.37551	0.25692	-0.49076	0.762
Stomatal conductance	0.08581	0.02475	-0.86195	0.91874	-0.50196	0.25276	-1.86531	**3.74234**	0.07190	-1.70885	-0.347*
Inter cellular CO_2conc.	-0.05459	-0.07413	0.25463	0.88540	0.57825	0.02247	-1.06169	0.21910	**1.22811**	0.22398	0.556*
Transpiration rate	0.09607	0.08428	-0.99895	0.31726	-0.11187	0.47166	1.31690	3.38147	-0.14545	**-1.89121**	0.791*

Residual effect-0.901

significant correlation at both genotypic and phenotypic level. It also had negative correlation with all other characters.

Thousand grain weight in normal condition positively significant correlation with photosynthetic rate at both genotypic and phenotypic level and with grain yield per plant at phenotypic level. In submergence condition this trait had positively significant correlation with in Inter cellular CO_2 conc. at both genotypic and phenotypic level.

In normal condition, the photosynthetic rate recorded positively significant correlation with stomatal conductance, inter cellular CO_2 conc. and grain yield per plant at both genotypic and phenotypic level. This trait had positive significant correlation with Intercellular CO_2 conc. at genotypic and phenotypic level in submergence condition, and all other character were low non-significant values. The stomatal conductance registered positively significant correlation with grain yield per plant at both genotypic and phenotypic level. And this trait had significantly positive correlation with transpiration rate at both genotypic and phenotypic level under normal condition. In submergence, this character had positively significant correlation with transpiration rate at genotypic and phenotypic level. Other characters were low values. In normal condition, the intercellular CO_2 conc. had positively significant correlation with grain yield per plant and transpiration rate at both genotypic and phenotypic level. In submergence condition, this trait had positively significant correlation with grain yield per plant at both genotypic and phenotypic level. Other traits in normal and submergence recorded low values. Transpiration rate had positive significant correlation with grain yield per plant in both normal and submergence condition at genotypic level only. The all other characters registered low and negligible values.

Path Co-efficient Analysis

Direct effect

In normal, the traits number of panicles per plant, panicles length, 1000 grain weight, stomatal conductance and intercellular CO_2 conc. had very high positive direct effect on grain yield per plant. While number of tillers per plant, photosynthetic rate and transpiration rate had very high negative direct effect on grain yield per plant. Days to first flowering had moderate positive and plant height had moderate negative direct effect on grain yield per plant. In submergence, the trait number of panicles per plant has very high positive direct effect; number of tillers per plant had very high negative direct effect on grain yield per plant, days to first flowering, plant height and transpiration rate had high positive direct effect; photosynthetic rate has high negative direct effect on grain yield per plant. Other traits had low or negligible positive and negative effect. (Table 4)

Table 5. Genotypic path co-efficient analysis among various characters in 26 rice genotypes in submergence

Characters	Days to first flowering	Plant height	Number of tillers per plant	Number of panicles per plant	Panicle length	1000 grain weight	Photo synthetic rate	Stomatal conductance	Inter cellular CO_2conc.	Transpiration rate	Grain yield per plant
Days to first flowering	**0.3690**	0.07207	-0.26455	0.64923	0.00002	0.00560	-0.10544	0.08977	0.04065	0.18031	0.705**
Plant height (cm)	0.60699	**0.38068**	0.91788	-1.80038	0.90084	0.00672	-0.27921	-0.04160	0.42657	0.02627	0.145
No. of tillers per plant	0.91073	-0.00748	**-0.90991**	1.73473	0.20045	-0.00628	0.71882	-0.05167	0.25580	0.08454	0.804**
No. of panicles per plant	0.01347	0.60108	0.88780	**1.77793**	0.40059	0.81225	-0.11722	0.04026	0.06069	0.06924	0.888**
Panicle length (cm)	-0.00033	-0.18902	0.34388	0.62408	**-0.00169**	0.22085	0.11581	-0.00921	0.01815	0.01538	0.390**
1000 grain weight (g)	0.00148	0.61828	-0.04085	0.15565	-0.50025	**0.13994**	0.23349	-0.00988	0.22040	-0.03464	0.238
Photo synthetic rate	0.00920	0.25136	0.25568	0.49285	0.00046	0.01108	**-0.42286**	-0.90613	0.03955	0.97470	0.195
Stomatal conductance	0.01940	-0.09274	0.27536	-0.41919	0.00009	0.90810	0.01518	**0.17075**	-0.01323	0.26247	0.210
Inter cellular CO_2 conc.	0.21549	0.10446	-0.52429	1.11416	-0.89032	0.05982	-0.17270	-0.02333	**0.09684**	-0.25001	0.620**
Transpiration rate	0.02202	0.03309	0.25454	0.40732	-0.01604	-0.01604	-0.10452	0.14829	-0.1602	**0.30222**	0.522**

Residual effect-0.991

Indirect Effect

In normal; this trait had very high positive indirect effect *via* panicle length and stomatal conductance on grain yield per plant; very high negative indirect effect *via* number of panicles per plant, high positive indirect effect thorough 1000 grain weight and negative indirect effect *via* photosynthetic rate. This trait had moderate positive indirect effect through number of tillers per plant and negative indirect effect *via* intercellular CO_2 conc. other traits were low and negligible value. In submergence, days to first flowering had high positive indirect effect on grain yield for plant *via* number of panicles per plant and moderate negative indirect effect *via* number of tillers per plant. Others characters had low and negligible indirect effect.

In normal condition, plant height had high positive indirect effect on grain yield per plant through 1000 grain weight, intercellular CO_2conc. and transpiration rate; high negative indirect effect *via* photosynthetic rate and stomatal conductance; moderate negative indirect effect *via* plant height and number of panicles per plant. In submergence, this trait had high positive indirect effect *via* number of tillers per plant, intercellular CO_2conc. and days to first flowering moderate negative indirect effect *via* photosynthetic rate.

In normal, number of tillers per plant had very high positive indirect effect on grain yield per plant *via* number of panicles per plant and stomatal conductance; very high negative indirect effect through panicle length, thousand grain weight and photosynthetic rate; low positive indirect effect *via* inter cellular CO_2 conc; low negative indirect effect *via* transpiration rate.

In submergence, number of tillers per plant had very high positive indirect effect *via* and number of panicles per plant and high positive indirect effect *via* days to first flowering on grain yield per plant; moderate negative indirect effect *via* photosynthetic rate and inter cellular CO_2conc. on grain yield per plant. Other traits were low and negligible value.

In normal, this trait had very high positive indirect effect on grain yield per plant *via* thousand grain weight and very high negative indirect effect *via* number of tillers per plant, panicle length and photosynthetic rate; high positive indirect effect *via* stomatal conductance; low positive indirect effect *via* inter cellular CO_2conc. Other characters had negligible indirect effects.

In submergence, this trait had high positive indirect effect on grain yield per plant *via* plant height, number of tillers per plant, panicle length and other traits had negligible values.

In normal, the panicle length had very high positive indirect effect *via* number of tillers per plant; very high negative indirect effect *via* number of panicles per plant, on grain yield per plant. This trait had high negative indirect effect *via* thousand grain weight moderate positive indirect effect *via* stomatal conductance and inter cellular CO_2conc. on grain yield per plant.

In submergence, this trait had high positive indirect effect on grain yield per plant *via* number of tillers per plant and number of panicles per plant, moderate positive indirect effect *via* thousand grain weight on grain yield per plant, low positive indirect effect *via* Inter cellular CO_2 conc..

In normal, this trait was recorded very high positive indirect effect *via* number of tillers plant; very high negative indirect effect *via* number of panicles plant and photosynthetic rate on grain yield per plant; high positive indirect effect *via* panicle length; moderate positive indirect effect *via* stomatal conductance and transpiration rate on grain yield per plant, other traits were positive and negative low values. In submergence, this trait had high positive indirect effect *via* plant height; High negative indirect *via* panicle length on grain yield per plant and moderate positive indirect effect *via* photosynthetic rate, Intercellular CO_2conc. on grain yield per plant. Other traits were positive and negative low values.

In normal condition, photosynthetic rate had very high positive indirect effect on grain yield per plant *via* number of panicles per plant and stomatal conductance; high positive indirect effect *via* number of tillers per plant, thousand grain weight; high negative indirect effect *via* transpiration rate; moderate indirect effect through inter cellular CO_2conc. other characters had low and negligible indirect effect. In submergence, this character had high positive indirect effect *via* number of panicles per plant and transpiration rate on grain yield per plant; high negative indirect effect *via* stomatal conductance; moderate positive indirect effect *via* number of tillers per plant and plant height.

In normal, stomatal conductance had very high negative indirect effect on grain yield per plant through photosynthetic rate and transpiration rate; high positive indirect effect *via* number of panicles per plant; high negative indirect effect *via* number of tillers per plant and panicle length; moderate positive indirect effect *via* plant height and thousand grain weights. In submergence, this trait had high positive indirect effect *via* thousand grain weight; high negative indirect effect *via* number of panicles per plant on grain yield per plant. Moderate indirect effect *via* number of tillers per plant and transpiration rate; low positive indirect *via* days to first flowering and photosynthetic rate on grain yield per plant.

In normal, this trait had very high negative indirect effect *via* photo synthetic rate; high positive indirect effect *via* number of panicles per plant and panicle length on grain yield per plant, moderate positive indirect effect *via* number of tillers per plant, stomatal conductance and transpiration rate. Other characters had low and negligible indirect effect. In submergence intercellular CO_2conc. had very high positive indirect effect on grain yield per plant *via* number of panicles per plant and high negative indirect effect through number of tillers per plant; moderate negative indirect effect *via* stomatal conductance and transpiration rate on grain yield per plant. Other traits were low and negligible values.

In normal, this trait had very high positive indirect effect *via* stomatal conductance and photosynthetic rate on grain yield per plant; high positive indirect effect *via* number of panicles per plant, thousand grain weight; high negative indirect effect *via* number of tillers per plant on grain yield per plant and all other characters had low indirect effect. In submergence, transpiration rate had high positive indirect effect *via* number of panicles per plant; moderate positive indirect effect *via* days to first flowering and number of tillers per plant on grain yield per plant. Other traits were low positive and negative indirect effect.

It as been generally accepted that correlation between different characters represents a coordination of physiological processes, which is often achieved through gene linkages (Mather and Jinks, 1971). Knowledge of the strength and type of association is an important pre reauisite for the formulation of breeding strategy. Grain yield is a complex character influenced by a large number of other component traits. A knowledge of the association between yield and its component traits and also between the component traits helps in improving the efficiency of selection.

Correlation studies revealed that the trait grain yield per plant has positive and significant correlation with days to first flowering, plant height, number of tillers per plant, number of panicles per plant, photo synthetic rate, stomatal conductance and inter cellular CO_2conc. both at genotypic and phenotypic level in normal condition. Similar results were observed by Saravanan and Sabesan (2010). While the trait number of tillers per plant had positive significant association with number of panicles per plant, stomatal conductance, number of panicles per plant had positive significant correlation with panicle length, thousand grain weight and photo synthetic rate, panicle length and thousand grain weight had positive significant association with photo synthetic rate at both genotypic and phenotypic level under normal condition.

In submergence, the trait grain yield per plant had positive and significant correlation with days to first flowering, number of tillers per plant, number of panicles per plant, panicles length and inter cellular CO_2 Conc. at

both genotypic and phenotypic level. Similar results were reported by Latha *et al*., (2003). While days to first flowering had positively significant correlation with photo synthetic rate, stomatal conductance, inter cellular CO_2conc. and transpiration rate, number of tillers per plant had positive. Significant association with number of panicles per plant, stomatal conductance and intercellular CO_2conc. number panicles per plant had positively. significant correlation with thousand grain weight; thousand grain weight and photo synthetic rate showed positive significant correlation with inter cellular CO_2conc. both at genotypic and phenotypic level.

The non-significant association of plant height with grain yield per plant in submergence significant positive association in normal reveal that preference of limited stem elongation upon submergence. Setter *et al*., (1997) also observed that genotypes with limited growth under submergence survived better than those which grow rapidly under submerged condition.

The non-significant association of plant height in normal condition. Positive association in normal reveal that preference of limited stem elongation upon submergence. Setter *et al.,* (1997) also observed that genotypes with limited growth under submergence survived better than those which grow rapidly under submerged condition.

Complete information about the complex trait like yield that is controlled by several other traits either directly or indirectly cannot be given by correlation co-efficient alone. Hence, the path coefficient analysis would be quite useful as it permits the separation of direct effect from indirect relation through other related traits by partitioning genotypic correlation coefficients (Dewey and Lu., 1959).

Number of panicles per plant, panicle length, 1000 grain weight, stomatal conductance and inter cellular CO_2conc. had very high positive direct effect on grain yield per plant. Saravanan and Sabesan (2010) reported similar results for productive tillers per plant and Suresh (2009) for panicle length. While number of tillers per plant, photo synthetic rate and transpiration rate had very high negative direct effect on grain yield per plant. Days to first flowering had moderate positive and indirect effect; plant height had moderate negative direct effect on grain yield per plant. Similar results were reported by Bhadru *et al*., (2011) and Jaiswal *et al*., (2007).

In submergence, the trait number of panicles per plant has very positive direct effect, number of tillers per plant had very high negative direct effect on grain yield per plant. Days to first flowering, plant height and transpiration rate had high positive direct effect on grain yield per plant. Similar results were reported by Badru *et al.,* (2011), Immanuel *et al*., (2011) and Raju *et al*., (2003).

In normal condition, days to first flowering had very high positive. Indirect effect *via* panicles length and stomatal conductance suggest that earliness. Plant height had high positive indirect effect through 1000 grain weight, intercellular CO_2conc. and transpiration rate. Similar findings were supported by Latha *et al*., (2003). Number of tillers per plant had very high positive indirect effect *via* panicles per plant and stomatal conductance.

The trait number of panicles per plant had very high positive indirect effect *via* thousand grain weight. Similar report by Chakraborty *et al*., (2001). The very high positive indirect effect of panicle length *via* number of tillers per plant. Some results stated by Raju *et al*. (2003). Thousand grain weight *via* number of tillers per plant. Similar results by Javed Iqbal Wattoo *et al*., (2010) transpiration rate *via* stomatal conductance and photo synthetic rate. Similar results were stated by Dhumal and Laware (2003).

In submergence, the very high positive indirect effect on grain yield per plant *via* number of panicles per plant suggest that earliness might aid in overcoming the submergence stress. The high positive indirect effect of plant height *via* number of tillers per plant, days to first flowering and inter cellular CO_2conc. in submergence indicates the importance of limited plant growth during this condition. Number of tillers per plant had very high indirect effect through number of panicles per plant; panicles per plant had high positive indirect effect *via* number of tillers per plant, panicles length and 1000 grain weight.

Similar results were obtained by Kavitha and Sree Rama Reddi (2001). Number of tillers per plant had low negative indirect effect *via* thousand grain weight on grain yield per plant indicate that genotypes with more panicles might suffer greater yield loss during submergence. The results of Mishra *et al*., (1996) corroborates with there findings. The high positive indirect effect of panicles length *via* number of tillers per plant and number of panicles per plant, same results were reported by Latha *et al*., (2003).

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