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Correlation and Path Coefficient analysis in Screening of Submergence Tolerance in Rice *(Oryza sativa* L.) Genotypes of Manipur

N. Reetisana**, *E.V.D. Sastry, Th Renuka, T. Julia and Artibashisha H. Pyngrope
Department of Genetics and Plant Breeding, College of Agriculture,
Central Agricultural University Imphal (Manipur), India.

(Corresponding author: N. Reetisana)*
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ABSTRACT: Submergence is one of the major abiotic stress conditions that affects rice production in rainfed lowland and flood affected areas. The present experiment was conducted in the experimental field of College of Agriculture, Central Agricultural University, Imphal, Manipur during *kharif* 2018 to evaluate seventy-six rice genotypes of Manipur along with four known checks (two susceptible and two tolerant) for submergence tolerance through correlation and path coefficient analysis to identify useful characters for improving crop yield under submergence stress. The correlation study revealed that in submerged condition, grain yield per plant was significantly and positively correlated with effective tillers per plant, spikelet per panicle, number of filled grains per panicle, spikelet fertility percentage and test weight. Path coefficient analysis revealed that spikelet per panicle, effective tillers per plant, test weight, spikelet fertility percentage, days to maturity and total tillers had high positive direct effect which indicated that these are the main contributors to grain yield per plant. Hence, selection of these characters would be effective for grain yield improvement of submergence tolerant rice genotypes.

Keywords: Correlation, path analysis, submergence, rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important primary cereal crop and major staple food for more than half of the world's population. It is the primary source of food for about 57% of the world's population and also played a major role as a staple food for over 2.7 billion people worldwide (Khush and Virk 2000). Globally, rain-fed lowland and deep-water rice account for about one-third of the total rice-growing area, which is about 50 Mha (Bailey-Serres and Voesenek 2010 and Singh *et al*., 2016). However, rain-fed fields are prone to flooding due to inadequate water management and changing climatic factors which leads to vagueness of rainfall affecting the rice yield. Thus, submergence is one of the major constraints to rice production in rain fed lowlands.

Traditional rice varieties are lower in yield however, it possesses some adaptive traits that are required for survival in the flooded condition. In order to harness the productivity potential of novel materials, it is important to understand the magnitude and association of various agro-morphological traits with grain yield under normal as well as flooding environment (Kulsum *et al*., 2019). The correlation coefficients indicate the magnitude of association between the characters and also provide information about interrelationship among yield and its components *i.e.* helpful in efficient selection strategy. Path coefficient analysis partitions correlation coefficients into direct and indirect effects presenting correlation in a more meaningful way in breeding and the contribution of each character to yield (Mohsin *et al*., 2009). In rice, information on correlation coefficient has been helpful as a basis for selection in a breeding programme and plant breeders used path analysis to help identify useful features as selection criteria for improving crop yields (Milligan *et al*., 1990). Therefore, the present study was carried with the objective of finding out associations among different traits of the rice genotypes under study and also to assess direct and indirect effects of some agro-morphological traits on grain yield per plant under submergence stress condition.

MATERIALS AND METHOD

The experiment was conducted in the experimental field of College of Agriculture, Central Agricultural University, Imphal, Manipur during kharif 2018 to evaluate 76 rice genotypes of Manipur along with four known checks (two susceptible and two tolerant). The experimental materials were planted in Augmented Randomized Block Design with replications of the checks. The experimental plot was divided into 5 blocks with 16 plots in first block and each 15 plots in the remaining four blocks. Fourteen days old seedlings were transplanted in a spacing of 20 cm between row to row and 20 cm between plant to plant. After seven days of transplanting, plants were kept in completely submerged condition for 14 days and after which excess water was drained out and kept just like in normal condition. The recommended package of practices was carried out to ensure healthy plant growth. The data

collected were subjected to standard statistical procedures and correlation and path coefficient analysis were done using the software R-studio.

RESULT AND DISCUSSION

Correlation coefficient analysis of grain yield per plant and yield related component traits showed both positive and negative associations (Table 1). Positive correlation result indicates that increase of one character will result in increase of the correlated character and it helps in simultaneous improvement of both the characters and negative association indicates that increase of one character will decrease the negatively correlated character.

Table 1: Correlation among eleven quantitative characters in 80 rice genotypes.

Character	Environment	Days to 50% flowering	Days to maturity	Plant Height (cm)	Total tillers per plant	Effective Tillers per plant	Panicle Length (cm)	Spikelet per panicle	Filled grains per panicle	Spikelet fertility %	Test weight (g)	Grain yield per plant (g)
Days to 50% flowering	Controlled	1.000										
	Submerged	1.000										
Days to maturity	Controlled	0.909**	1.000									
	Submerged	0.868**	1.000									
Plant Height (cm)	Controlled	0.065	0.116	1.000								
	Submerged	-0.059	0.056	1.000								
Total tillers per plant	Controlled	-0.236*	-0.097	0.298**	1.000							
	Submerged	-0.057	-0.002	-0.222*	1.000							
Effective tillers per plant	Controlled	-0.261*	-0.096	-0.198	0.912**	1.000						
	Submerged	0.006	0.017	-0.204	0.530**	1.000						
Panicle Length (cm)	Controlled	0.099	0.237*	0.121	0.167	0.195	1.000					
	Submerged	0.106	0.242*	0.193	0.009	-0.152	1.000					
Spikelet per panicle	Controlled	0.107	0.186	0.073	0.017	0.016	0.454**	1.000				
	Submerged	0.060	0.100	-0.091	-0.093	-0.078	0.444**	1.000				
Filled grains per panicle	Controlled	0.157	0.229*	0.022	0.053	0.037	0.385**	0.771**	1.000			
	Submerged	0.170	0.201	0.032	-0.082	0.061	0.412**	0.850**	1.000			
Spikelet fertility %	Controlled	0.051	0.055	-0.035	0.076	0.049	0.015	-0.080	0.553**	1.000		
	Submerged	0.204	0.216	0.188	-0.070	0.167	0.116	0.151	0.632**	1.000		
Test weight (g)	Controlled	-0.070	-0.052	0.276*	-0.131	-0.127	-0.151	0.056	-0.005	-0.063	1.000	
	Submerged	0.050	0.005	0.264*	-0.137	-0.045	-0.064	-0.108	-0.011	0.134	1.000	
Grain yield per plant (g)	Controlled	-0.109	0.058	0.095	0.510**	0.541**	0.322**	0.684**	0.539**	-0.030	0.406**	1.000
	Submerged	0.033	0.077	-0.057	0.179	0.407**	0.213	0.610**	0.650**	0.308**	0.267*	1.000

In controlled condition, total tillers per plant (0.510), effective tillers per plant (0.541), panicle length (0.322), spikelet per panicle (0.684), number of filled grains per panicle (0.539) and test weight (0.406) displayed positive and significant association with grain yield per plant whereas in submerged condition, effective tillers per plant (0.407), spikelet per panicle (0.610) , number of filled grains per panicle (0.650), spikelet fertility percentage (0.308) and test weight (0.267) displayed positive and significant association with grain yield per plant. The findings were in accordance with the results of Nandan *et al*. (2010) who also reported a significant positive association of number of spikelets per panicle, number of filled grains per panicle and spikelet fertility percentage with grain yield per plant. Kulsum *et al*. (2019) also observed positive and significant association of spikelet fertility percentage and test weight with grain yield per plant. Fiyaz *et al*. (2011) also reported significant positive association of number of effective tillers per plant and number of spikelets per panicle with grain yield per plant. A positive association of panicle length and grain yield per plant was also reported by Lakshmi *et al*. (2014). This result shows that grain yield per plant of the genotypes could be improved by selecting genotypes having higher performance for these characters. The detected positive and significant correlation of grain yield per plant with these characters indicated that effective tillers per plant, number of filled grains per panicle, spikelet fertility percentage and test weight simultaneously increased grain yield per plant in rice genotypes that were in submerged condition. Similar results were also revealed earlier by Mulugeta *et al*. (2012) in rain fed upland rice genotypes. Positive association of grain yield per plant was observed with days to maturity (0.058) and plant height (0.095) in controlled condition while in submerged condition positive association was recorded with days to 50% flowering (0.033), days to maturity (0.077), total tillers per plant (0.179) and panicle length (0.213). The positive association of grain yield per plant with days to maturity, plant height and panicle length was also reported by Kar *et al*. (2016).

Days to 50% flowering (-0.109) displayed negative correlation with grain yield per plant in controlled condition which means that any increase in days to 50% flowering could result in decrease of grain yield per plant that is in concordance with the findings of Kampe *et al*. (2018) that revealed negative association of days to 50% flowering with grain yield. However, in

submerged condition positive correlation (0.033) was recorded which reveals that increase in days to 50% flowering could result in increment of grain yield per plant. Days to 50% flowering have shown strong positive and significant correlation with days to maturity in both controlled and submerged condition. This indicated that increment of days to 50% flowering would lead to increment in days to maturity which might be attributed due to pleiotropic gene effects and linkage between genes for these characters which were in concordance with the findings of Iftekharuddaula *et al*. (2001); Kulsum *et al*. (2019) who reported strong positive and significant correlation of days to 50% flowering with days to maturity. In controlled condition, days to 50% flowering have shown negative and significant correlation with total tillers per plant (-0.236) and number of effective tillers per plant (-0.261). The results were in agreement with Gour *et al*. (2017) who have reported negative association of this trait with number of effective tillers per plant.

Days to maturity was found to be significant and positively correlated with panicle length in both controlled and submerged condition. This result was also found to be in concordance with Ranjitha (2019), who also reported positive significant association of days to maturity with panicle length. In controlled condition, filled grains were found to be significant and positively correlated with days to maturity but non-significant in submerged condition. Plant height was found to be positive and significantly correlated with test weight in both controlled and submerged condition. Plant height was positively and significantly correlated with total tillers in controlled condition while correlated negatively and significantly with total tillers in submerged condition. The correlation of total tillers per plant was found to be positive and significant with effective tillers per plant in both controlled and submerged condition. These results were in accordance with Nandan *et al*. (2010) for a positive association of number of tillers per plant with number of effective tillers per plant. Panicle length was found to be positive and significantly correlated with spikelet per panicle and number of filled grains per panicle in both controlled and submerged condition. Spikelet per panicle was found to be positively and significantly correlated with filled grains in both controlled and submerged condition. The correlation of number of filled grains was found to be positive and significant with spikelet fertility percentage in both controlled and submerged condition. Kar *et al*. (2016) also reported similar results for a positive association of spikelet fertility percentage with number of filled grains per panicle and test weight.

The correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the correlations (Wright, 1921) for better interpretation of cause-and-effect relationship. Path analysis permits estimation of direct effects of various traits on yield as well as their indirect effects via other component traits (Pham *et al*., 2016). Direct positive effect on grain yield per plant of some characters indicated that selection of these traits will be directly helpful for the improvement of grain yield per plant whereas negative indirect effects showed that effects of such traits are indirectly affecting the grain yield per plant in the negative direction (Kulsum *et al*., 2019). Therefore, path coefficient analysis was worked out for grain yield per plant and grain yield related traits. The results are presented in Table 2.

Table 2: Direct (diagonal bold values) and indirect effect of component traits on grain yield per plant.

Characters	Environment	Days to 50% flowering	Days to maturity	Plant height	Total tillers per plant	Effective tillers per plant	Panicle length	Spikelet per panicle	Filled grains per panicle	Spikelet fertility %	Test weight
Days to 50% flowering	Controlled	**-0.100**	0.084	0.005	-0.051	-0.104	-0.004	0.029	0.075	-0.014	-0.030
	Submerged	**-0.158**	0.105	0.002	-0.004	0.004	-0.003	0.034	0.025	0.007	0.018
Days to maturity	Controlled	-0.091	**0.092**	0.010	-0.021	-0.040	-0.010	0.051	0.107	-0.016	-0.021
	Submerged	-0.138	**0.120**	-0.002	0.000	0.008	-0.006	0.057	0.029	0.007	0.004
Plant height	Controlled	-0.006	0.011	**0.086**	-0.064	-0.080	-0.005	0.019	0.009	0.011	0.119
	Submerged	0.010	0.007	**-0.032**	-0.014	-0.082	-0.005	-0.051	0.004	0.006	0.096
Total tillers per plant	Controlled	0.024	-0.009	-0.026	**0.214**	0.363	-0.007	0.005	0.023	-0.022	-0.055
	Submerged	0.010	0.000	0.007	**0.062**	0.218	0.000	-0.051	-0.012	-0.002	-0.052
Effective tillers per plant	Controlled	0.026	-0.009	-0.017	0.194	**0.399**	-0.008	0.005	0.019	-0.014	-0.055
	Submerged	-0.002	0.002	0.006	0.033	**0.412**	0.004	-0.045	0.009	0.006	-0.015
Panicle length	Controlled	-0.010	0.022	0.010	0.036	0.076	**-0.044**	0.121	0.177	-0.006	-0.064
	Submerged	-0.017	0.029	-0.006	0.001	-0.062	**-0.025**	0.249	0.060	0.004	-0.022
Spikelet per panicle	Controlled	-0.011	0.017	0.006	0.004	0.008	-0.020	**0.268**	0.359	0.022	0.025
	Submerged	-0.010	0.012	0.003	-0.006	-0.033	-0.011	**0.565**	0.124	0.005	-0.041
Filled grains per panicle	Controlled	-0.016	0.021	0.002	0.011	0.016	-0.017	0.207	**0.467**	-0.150	0.000
	Submerged	-0.027	0.024	-0.001	-0.005	0.025	-0.010	0.481	**0.146**	0.021	-0.004
Spikelet fertility %	Controlled	-0.005	0.006	-0.004	0.017	0.020	-0.001	-0.022	0.257	**-0.273**	-0.025
	Submerged	-0.032	0.027	-0.006	-0.004	0.070	-0.003	0.085	0.092	**0.034**	0.048
Test weight	Controlled	0.007	-0.005	0.024	-0.028	-0.052	0.007	0.016	0.000	0.016	**0.424**
	Submerged	-0.008	0.001	-0.008	-0.009	-0.017	0.002	-0.062	-0.002	0.004	**0.368**

Residual effect for controlled = 0.048, Residual effect for submerged= 0.269

In controlled condition, highest positive direct effect was found with number of filled grains per plant (0.467) followed by test weight (0.424), effective tillers (0.399) and spikelet per panicle (0.268). Rokonuzzaman *et al*. (2008) also observed positive direct effect of number of effective tillers per plant on grain yield per plant. The highest negative direct effect was found with spikelet fertility percentage (-0.273)

which was followed by days to 50% flowering (-0.100). Whereas in submerged condition, highest positive direct effect was found with spikelet per panicle (0.565) while highest negative direct effect was found with days to 50% flowering (-0.158) followed by plant height (-0.032) and panicle length (-0.025). Similar results were also reported by Kar *et al*. (2016); Gour *et al*. (2017).

Days to 50% flowering exerts direct negative effect on yield in both controlled (-0.100) and submerged (-0.158) condition. Similar result was also reported by Kulsum *et al*. (2019) who revealed negative direct effect of days to 50% flowering on yield per plant. In submerged condition, negative indirect effect of days to 50% flowering on grain yield per plant *via* total tillers (-0.004) and panicle length (-0.003) were found.

Days to maturity showed direct positive effect on grain yield per plant in both controlled (0.092) and submerged (0.121) condition. The highest positive direct effect has been reported for days to maturity by Qamar *et al*. (2005) in rice. Days to maturity showed negative indirect effect *via* days to 50% flowering (-0.138), plant height (-0.002) and panicle length (0.006) under submergence condition.

Plant height was found to have positive direct effect (0.086) with grain yield per plant in controlled condition. This was similar with the findings of Kulsum *et al*. (2019) which revealed positive direct effect of plant height towards grain yield per plant. In submerged condition, plant height was found to have negative direct effect (-0.032) with grain yield per plant which was in agreement with the findings of Nikhil *et al*. (2014). Also, negative indirect effect was found *via* number of effective tillers per plant (-0.082) followed by spikelet per panicle (-0.051), total tillers (-0.014) and plant length (-0.005). Similar results were reported by Bhutta *et al*. (2019); Saleh *et al*. (2020). However, it showed positive indirect effect *via* test weight (0.096) followed by days to 50 % flowering (0.009), days to maturity (0.007) and spikelet fertility percentage (0.006).

In both controlled (0.213) and submerged (0.062) condition, total tillers per plant showed positive direct association with grain yield per plant. Similar findings were also reported by Fiyaz *et al*. (2011); Nikhil *et al*. (2014). Total tillers per plant showed highest positive indirect effect with effective tillers per plant (0.218) followed by plant height (0.007) and days to 50% flowering (0.009) while it showed highest negative indirect effect with test weight (-0.051) followed by spikelet per panicle (-0.051) under submerged condition.

In both the controlled (0.399) and submerged (0.412) condition, effective tillers per plant exerts positive direct effect on grain yield per plant. Highest positive direct effect has been reported for number of effective tillers by Rokonuzzaman *et al*. (2008) in rice. Under submergence, effective tillers per plant showed highest positive indirect effect *via* total tillers per plant (0.033), number of filled grains per panicle (0.009) and plant height (0.006) while highest negative indirect effect *via* spikelet per panicle (-0.045), days to 50% flowering (-0.002) and test weight (-0.015). Similar results were also reported by Kulsum *et al*. (2019).

Panicle length showed negative direct effect with grain yield per plant in both controlled (-0.043) and submerged (-0.025) conditions. This result was in agreement with the findings of Kulsum *et al*. (2019). It has shown highest positive indirect effect *via* spikelet per panicle (0.248), number of filled grains per panicle (0.029) and days to maturity (0.029) while highest negative indirect effect was shown *via* effective tillers per plant (-0.062), test weight (-0.022) and days to 50% flowering (-0.017) under submergence.

Spikelet per panicle was found to have direct positive effect with grain yield per plant in both controlled (0.268) and submerged (0.565) conditions. This result was in agreement with the findings of Fiyaz *et al*. (2011); Nikhil *et al*. (2014). Highest positive indirect effect was recorded *via* number of filled grains per panicle (0.124), days to maturity (0.012), spikelet fertility percentage (0.005) and plant height (0.003) while negative indirect effect was found highest *via* test weight (-0.040) followed by number of effective tillers per plant (-0.032) and panicle length (-0.011) under submergence.

In both controlled (0.467) and submerged condition (0.146), number of filled grains per plant exerts direct positive association with grain yield per plant. Similar findings were observed by Azarpour (2013); Moosavi *et al*. (2015). In submerged condition, highest positive indirect effect was shown with spikelet per panicle (0.481) followed by number of effective tillers per plant (0.025), days to maturity (0.024) and spikelet fertility percentage (0.021) while highest negative indirect effect was shown with number of filled grains per plant (-0.027) and followed by panicle length (-0.010).

Spikelet fertility percentage (-0273) exerts direct negative effect with grain yield per plant in controlled condition while in submerged condition, it (0.034) was found to have shown positive direct association with grain yield per plant. The positive direct effect has been reported for spikelet fertility percentage by Agbo and Obi (2005); Kulsum *et al*. (2019) in rice. It was also found to have shown highest positive indirect effect *via* number of filled grains per plant (0.092), spikelet per panicle (0.084) and effective tillers per plant (0.070) while negative indirect effect was found *via* days to 50% flowering (-0.032) followed by plant height (-0.006) and total tillers per plant (-0.004).

In both controlled (0.424) and submerged (0.368) condition, test weight was found to have direct positive effect with grain yield per plant. The result was in agreement with the findings of Harish *et al*. (2019); Saleh *et al*. (2020). Under submergence, indirect positive effect was recorded *via* panicle length (0.002), spikelet fertility percentage (0.004) and days to maturity (0.001) while indirect negative effect was found to be highest in spikelet per panicle (-0.062) followed by effective tillers per plant (-0.017), total tillers per plant (-0.009), plant height (-0.008) and days to 50% flowering (-0.008).

The residual effects were 0.048 and 0.269 in controlled and submerged condition respectively which indicated

that there might be some other characters that contribute 4.8% and 26.9% to the yield in both controlled and submerged condition respectively.

Therefore, selection of these characters which showed direct effect on grain yield per plant would be rewarding for the improvement of grain yield and those which showed indirect effect through other characters will be useful in grain yield improvement by indirect selection through such characters.

CONCLUSION

From the above study and investigation, it can be concluded that grain yield per plant in submerged condition was significantly and positively correlated with effective tillers per plant, spikelet per panicle, number of filled grains per panicle, spikelet fertility percentage and test weight. Path coefficient analysis revealed that spikelet per panicle, effective tillers per plant, test weight, spikelet fertility percentage, days to maturity and total tillers had high positive direct effect which indicated that direct selection based on these characters would be effective for grain yield improvement of submergence tolerant rice genotypes. Therefore, in breeding for submergence tolerance of rice genotypes these characters can be considered for improvement of yield in future however, further research can be carried out for affirmation of these results and for identifying other morpho-physiological traits that contributes in yield improvement under this stress condition.

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Conflict of interest. None.

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