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RESEARCH ARTICLE

Correlation and path analysis for grain yield and adaptive characters in rice under aerobic condition

■ **Hrishikesh Ojah, P. Talukdar and Rumjhum Goswami**

SUMMARY

Correlation and path analysis were carried out using fifty F_1 hybrids and their 15 parents for grain yield and its components in rice under aerobic condition to know the association among different traits and causes of association. Significant correlation with grain yield existed for 3 characters (number of productive tillers, spikelet fertility and chlorophyll content) apart from sufficient inter correlation among various adaptive characters. Path co-efficient analysis revealed the highest positive direct effect of root weight (1.65) on grain yield, followed by spikelet fertility (1.43) and plant height (0.92). Harvest index (1.25) through spikelet fertility exerted the highest indirect effect, followed by panicle harvest index (1.07) through spikelet fertility.

Key Words : Aerobic rice, Character association, Correlation, Path co-efficient

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Rice (*Oryza sativa* L.) is one of the world's most important food crops being grown in about 163 million ha annually of the worlds cultivated land (Degenkolbe *et al.*, 2013). Lowland rice occupies 55 per cent of the world rice area producing 75 per cent of world rice. The increasing shortage of water resources accelerates the development and adoption of aerobic rice system - an approach to reduce water inputs in rice by growing the crop aerobically like an irrigated upland crop such as wheat and maize. Early experiments on aerobic rice revealed that water input in aerobic rice was 50 per cent lower (only 470-650 mm) and water productivity was higher by 64-88 per cent than the irrigated lowland rice (Bouman *et al.*, 2002). Aerobic system of rice cultivation can save water upto 50 per cent. Aerobic rice varieties are designed to be high yielding, input responsive and weed competitive to attain high yields under aerobic soil conditions. They are better adapted

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to intensified management with moderate input use than traditional upland rice, which has low harvest index (HI) and is prone to lodging when fertilized.

The association of characters among themselves as well as with yield is very much essential for appropriate designing of programme towards the improvement of yield and its components. This knowledge helps plant breeder in their selection with more precision and accuracy. The degree of relationship and association of these components with yield can be measured by correlation co-efficients. But, selection based on correlation among characters does not consider the interaction between the component characters. Moreover, it does not give an exact position of the relative importance of direct and indirect effect of the various characters on yield. In path analysis, the correlation co-efficient between two traits is separated into the components which measure the direct and indirect effects (Ahmadizadeh *et al*., 2011). Path co-efficient analysis provides an exact picture of the relative importance of direct and indirect effects of each of the component character towards yield. To study the interrelationships between different yield attributing traits, the direct and indirect effects of different characters were worked out using path analysis. Path co-efficient analysis permits a thorough understanding of contribution of various characters by partitioning the correlation co-efficient into components of direct and indirect effects.

The present study was undertaken to study the character association and contribution of various yield influencing traits to establish appropriate plant attributes for selection to improve the yield of rice under aerobic condition.

MATERIAL AND METHODS

The experimental material consisted of 50 F_1 hybrids and their corresponding 15 parents which included ten traditional cultivars and five modern varieties. Traditional varieties are commonly grown in upland whereas modern varieties are grown both in lowland and upland. All these genotypes were raised in Randomized Block Design with 2 replications under aerobic condition only during the winter or sali season of 2015 at the the Instructional cum Research Farm, Sarat Chandra Sinha College of Agriculture, Assam Agricultural University, Dhubri, Assam, India. Plot size was 3m x 2m with spacing of 25 x 15 cm.

Data were collected on five plants except for days to anthesis and days to maturity for which the data was collected based on 50 per cent of the plant stand. Statistical analysis was computed by using WINDOSTAT software.

RESULTS AND DISCUSSION

The data (Table 1) revealed highly significant differences among the genotypes for all the characters indicating significant diversity among the genotypes to proceed further for statistical tests.

The phenotypic and genotypic correlations among all pairs of characters are shown in Table 2 and 3, respectively. The genotypic correlations in general, were higher than corresponding phenotypic correlations. This is due to the modified effect of environment on character association at the genetic level (Sarawgi, 1997). Patel *et al*. (2014) and Ratna *et al*. (2015) also reported similar results in rice. Grain yield was found to be positively correlated with only three characters (number of productive tillers, spikelet fertility and chlorophyll content). Kahani and Hittalmani (2015); Girish *et al*. (2006) and Chandrashekhar and Shailaja (2017) have reported a significant and positive association of grain yield with number of productive tillers per plant, single panicle

Table 1: Analysis of variance (ANOVA) for 17 quantitative traits in 65 genotypes under aerobic condition

Source	df	Mean sum of squares								
		PH	HGR	PT	DA	DM	PHI	SF	GY	HI
Replication	1	22.36	0.00	0.21	0.93	0.19	0.007	12.74	0.53	0.0103**
Entries	64	440.44**	0.04**	29.30**	79.91**	157.77**	0.004*	85.71**	7.57**	0.007**
Error	64	15.71	0.00	4.10	5.85	6.74	0.003	22.61	3.16	0.0016
		HGW	RWC	RW	SW	RSR	RV	Pro.		Chl.
Replication	1	0.038	25.94	79.67	171.58	0.121**	39.88	12.31		0.08*
Entries	64	0.057**	33.80**	124.20**	311.32**	0.034**	522.34	739.44**		0.11**
Error	64	0.013	14.94	33.93	43.97	0.013	122.58	53.92		0.02

DA- Days to anthesis; DM-Days to maturity; PT-Number of productive tillers; PH-Plant height; HGR-Height growth rate; PHI- Panicle harvest index; SF- Spikelet fertility; GY-Grain yield per plant; HI- Harvest index; RWC- Relative water content; Pro.- Proline content; Chl.-Chlorophyll content; RW- Root weight; SW- Shoot weight; RSR- Root shoot ratio; RV- Root volume

* and ** indicate significance of values at P<0.5 and 0.01, respectively

weight, biomass and harvest index both at phenotypic and genotypic levels under aerobic condition. All together seven characters exhibited only positive correlation. Results were in conformity with Sheeba *et al.* (2010) for spikelet fertility and panicle harvest index, Chakraborty *et al.* (2010) for spikelet fertility and number of productive tillers. Tiwari *et al.* (2012) reported high correlation of SF with yield. Selvaraj *et al.* (2011) and Nagaraju *et al.* (2013) reported high correlation of total number of productive tillers per plant with grain yield.

Table 2 : Correlation co-efficient at genotypic level

	DA	DM	PH	HGR	PT	PHI	SF	GY	HI	HGW	RWC	Pro.	Chl.	RW	SW	RSR
DM	0.94**															
PH	0.41**	0.40**														
HGR	-0.24**	-0.31**	0.75**													
PT	-0.07	-0.13	-0.24**	-0.15												
PHI	0.39*	0.49**	0.29*	0.00	0.18											
SF	0.42**	0.39**	-0.06	-0.33**	0.34**	0.75**										
GY	0.05	-0.02	0.14	0.16	0.37**	0.08	0.11*									
HI	0.44**	0.40**	0.17	-0.12	-0.09	0.62**	0.87**	0.37								
HGW	-0.34**	-0.23	-0.35*	-0.19	-0.09	-0.09	0.02	0.07	0.08							
RWC	0.29	0.30*	0.26*	0.06	0.10	0.64**	0.64**	-0.11	0.60*	-0.04						
Pro.	0.22	0.20	0.33**	0.18	-0.23*	0.17	0.23*	0.06	0.36**	-0.14	-0.03					
Chl.	0.03	-0.06	-0.19	-0.13	0.59**	0.20	0.34	0.61	0.26	0.04	0.23	-0.03				
RW	0.18	0.15	0.00	-0.10	0.26	0.19	0.27**	0.09	0.20	0.31	-0.20	0.13	0.14			
SW	0.25*	0.23*	0.35*	0.21*	0.18	0.54**	0.26**	-0.05	0.36*	0.06	0.22	0.37**	0.02	0.55*		
RSR	-0.02	-0.04	-0.35**	-0.35*	0.04	-0.27	0.04	0.08	-0.16	0.30*	-0.48	-0.14	0.05	0.61**	-0.32**	
RV	0.23	0.33*	-0.07	-0.29	0.16*	0.54*	0.32	-0.32	0.08	0.06	0.21	0.07	0.24*	0.05**	0.38**	-0.39

[DA- Days to anthesis; DM-Days to maturity; PT-Number of productive tillers; PH-Plant height; HGR-Height growth rate; PHI- Panicle harvest index; SF- Spikelet fertility; GY-Grain yield per plant; HI- Harvest index; RWC- Relative water content; Pro.- Proline content; Chl.-Chlorophyll content; RW- Root weight; SW- Shoot weight; RSR- Root shoot ratio; RV- Root volume]
* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Correlation co-efficient at phenotypic level

	DA	DM	PH	HGR	PT	PHI	SF	GY	HI	HGW	RWC	Pro.	Chl.	RW	SW	RSR
DM	0.89**															
PH	0.36**	0.36**														
HGR	-0.25**	-0.34**	0.75**													
PT	-0.05	-0.11	-0.20**	-0.11												
PHI	0.21*	0.26**	0.17*	0.02	0.06											
SF	0.27**	0.29**	-0.05	-0.24**	0.18**	0.43**										
GY	0.02	0.005	0.11	0.11	0.28**	0.03	0.19*									
HI	0.21**	0.19**	0.15	0.02	-0.001	0.31**	0.40**	0.15								
HGW	-0.26**	-0.16	-0.25**	-0.12	-0.06	0.15	-0.04	0.02	0.17							
RWC	0.16	0.20*	0.18*	0.046	-0.008	0.25**	0.41**	0.06	0.19*	-0.01						
Pro.	0.17	0.16	0.30**	0.16	-0.19*	0.15	0.19*	0.02	0.23**	-0.13	-0.007					
Chl.	0.07	-0.05	-0.15	-0.10	0.39**	0.11	0.23**	0.35	0.13	0.10	0.14	-0.009				
RW	0.11	0.08	-0.005	-0.06	0.19*	0.11	0.09	0.08	0.21*	0.20*	-0.03	0.08	0.14			
SW	0.22*	0.17*	0.30*	0.19*	0.14	0.28**	0.25**	0.07	0.17*	0.001	0.11	0.30**	0.04	0.42*		
RSR	-0.03	-0.03	-0.23**	-0.21*	0.05	-0.10	-0.11	0.009	0.07	0.22*	-0.12	-0.12	0.04	0.71**	-0.31**	
RV	0.17	0.20*	-0.04	-0.16	0.19*	0.21*	0.15	-0.11	0.09	0.07	0.07	0.03	0.19*	0.30**	0.36**	0.02

[DA- Days to anthesis; DM-Days to maturity; PT-Number of productive tillers; PH-Plant height; HGR-Height growth rate; PHI- Panicle harvest index; SF- Spikelet fertility; GY-Grain yield per plant; HI- Harvest index; RWC- Relative water content; Pro.- Proline content; Chl.-Chlorophyll content; RW- Root weight; SW- Shoot weight; RSR- Root shoot ratio; RV- Root volume]
* and ** indicate significance of values at P<0.5 and 0.01, respectively

The inter correlation between yield contributing characters may affect the selection for component traits either in favourable or unfavorable direction. Spikelet fertility and shoot weight had significant correlation with maximum number of characters (11) under study. Both these characters were found to be positively correlated with 10 characters and negatively correlated with one each. The result corroborated with the findings of Sathya and Jebaraj (2013) while working on aerobic rice.

Path co-efficient analysis at genotypic level (Table 4) revealed that the highest positive direct effect on grain yield was exerted by root weight (1.6504), followed by spikelet fertility (1.4305) and plant height (0.9173). Babu *et al.* (2012); Nagaraju *et al.* (2013) found similar results for number of grains per panicle and plant height, Chakraborty *et al*. (2010) and Chandrashekhar and Shailaja (2017) for spikelet fertility in boro rice and aerobic rice, respectively.

Negative direct effects were exerted by days to maturity, number of productive tillers, panicle harvest index, harvest index, relative water content, proline content, shoot weight and root shoot ratio. Nagaraju *et al.* (2013) reported negative direct effect for panicle length and harvest index.

Similarly, the highest indirect effect on grain yield was observed by harvest index (1.2466) through spikelet fertility followed by and panicle harvest index (1.0664) through spikelet fertility. Sheeba *et al.* (2010) also reported direct and indirect significant influence of spikelet fertility, leaf drying and dry root weight on grain yield under drought stress situation.

Total number of productive tillers per plant and spikelet fertility displayed significant positive correlation, and root weight and spikelet fertility exerted the highest positive direct effect on grain yield. Hence, spikelet fertility and total number of productive tillers per plant were the two most important traits which should be given due emphasis in formulating indirect selection criteria. This is in conformity with the reports of Chadrashekhar and Shailaja (2017) in aerobic rice, Chakraborty *et al.* (2010) in boro rice.

The residual effect was found to be 0.4079, indicating nearly 60 per cent of variation was contributed by these characters. Almost 40 per cent residual effect indicated that there could be still few characters other than the characters considered in this study influencing grain yield in aerobic situation which need to be considered in future studies. Kahani and Hittalmani (2015) also reported low residual effect in aerobic rice.

Bagheri *et al*. (2011); Bhadru *et al*. (2011) and Ratna *et al*. (2015) also reported direct effect of filled spikelets/panicle on single plant yield. Bhadru *et al*. (2011); Nayak *et al.* (2001) and Shanthi and Singh (2001) reported a significant positive association of plant height with yield and also had a positive direct effect on yield both at the phenotypic and genotypic levels.

Table 4 : Direct (diagonal) and indirect effect of characters on grain yield at genotypic level

Character	DA	DM	PH	PT	PHI	SF	HI	HGW	RWC	Pro.	Chl.	RW	SW	RSR	Correlation co-efficient of GY	Partial R^2
DA	0.15	-0.21	0.38	0.02	-0.02	0.61	-0.09	-0.17	-0.45	-0.08	0.02	0.30	-0.45	0.05	0.05	0.01
DM	0.14	-0.23	0.36	0.03	-0.03	0.56	-0.08	-0.11	-0.46	-0.07	-0.05	0.25	-0.41	0.08	-0.02	0.00
PH	0.06	-0.09	0.92	0.05	-0.02	-0.08	-0.03	-0.17	-0.40	-0.13	-0.13	0.00	-0.63	0.79	0.14	0.13
PT	-0.01	0.03	-0.22	-0.22	-0.01	0.48	0.02	-0.05	-0.16	0.09	0.42	0.42	-0.33	-0.10	0.37	-0.08
PHI	0.06	-0.11	0.27	-0.04	-0.06	1.07	-0.13	-0.04	-0.99	-0.06	0.14	0.31	-0.96	0.62	0.08	0.00
SF	0.06	-0.09	-0.05	-0.07	-0.04	1.43	-0.18	0.01	-1.00	-0.09	0.24	0.45	-0.47	-0.10	0.11	0.16
HI	0.07	-0.09	0.15	0.02	-0.04	1.25	-0.20	0.04	-0.93	-0.14	0.19	0.32	-0.64	0.37	0.37	-0.07
HGW	-0.05	0.05	-0.32	0.02	0.00	0.03	-0.02	0.49	0.06	0.05	0.03	0.51	-0.10	-0.69	0.07	0.03
RWC	0.04	-0.07	0.23	-0.02	-0.04	0.92	-0.12	-0.02	-1.56	0.01	0.16	-0.34	-0.39	1.08	-0.11	0.17
Pro.	0.03	-0.04	0.30	0.05	-0.01	0.33	-0.07	-0.07	0.05	-0.38	-0.02	0.22	-0.66	0.32	0.06	-0.02
Chl.	0.01	0.01	-0.17	-0.13	-0.01	0.49	-0.05	0.02	-0.36	0.01	0.71	0.23	-0.03	-0.12	0.61	0.43
RW	0.03	-0.03	0.00	-0.06	-0.01	0.39	-0.04	0.15	0.32	-0.05	0.10	1.65	-0.98	-1.37	0.09	0.15
SW	0.04	-0.05	0.32	-0.04	-0.03	0.38	-0.07	0.03	-0.35	-0.14	0.01	0.91	-1.78	0.72	-0.05	0.09
RSR	0.00	0.01	-0.32	-0.01	0.02	0.06	0.03	0.15	0.75	0.05	0.04	1.00	0.57	-2.26	0.08	-0.17

R Square = 0.83 Residual effect = 0.41

[DA- Days to anthesis; DM-Days to maturity; PT-Number of productive tillers; PH-Plant height; HGR-Height growth rate; PHI- Panicle harvest index; SF- Spikelet fertility; GY-Grain yield per plant; HI- Harvest index; RWC- Relative water content; Pro.- Proline content; Chl.-Chlorophyll content; RW- Root weight; SW- Shoot weight; RSR- Root shoot ratio; RV- Root volume]

The present investigation revealed that number of productive tillers and spikelet fertility were the two most potent characters that markedly influenced the grain yield. While designing indirect selection criteria for genetic improvement of aerobic rice, these two adaptive characters must appropriately be taken care of.

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