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Association studies for yield and its attributing traits in extra early rice genotypes

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Abstract
Association studies are one of the important biometrical tools for formulating a selection index as it reveals the strength of relationship among the group of characters. Correlation analysis and path coefficient analysis was carried out for yield and component traits in 10 rice genotypes involving three checks. Panicle length, grains per panicle and number of productive tillers per plant exhibited positive and significant association with single plant yield. Hence, selection for these traits will improve single plant yield.

Keywords: Extra early rice, correlation, path analysis, yield

Introduction

Rice (*Oryza sativa* L.) is most economically important food crop and grown across the world. Most people of the world depend on rice for their secured livelihood and a way of life. It is the staple food for more than 65 per cent of the people and provides employment and livelihood to 70 per cent of the Indians. There is a need to enhance the productivity of the rice to meet the growing demand under conditions of declining quantity and quality of land. The UN/FAO forecasts that the global food production needs to increase 40% by 2030 and 70% by 2050 (FAO, 2009). Yet globally, water is anticipated to become scarce and there is increasing competition for land, putting added pressure on agricultural production. In addition, climate change will reduces the reliability of food production through weather pattern changes and increased pressure from biotic factors of pests and diseases. Rice is very most important food crop of the developing world and the staple food for more than 60% of Indian populace, so it forms the bedrock of food security. The impacts of climate change are increasingly evident and extreme weather events around the world increasingly threaten food security. As a result, researchers predict a 12 to 14% decrease in rice production by 2050 compared with production in 2000, with tropical Asia being affected most (Wheeler & von Braun, 2013) [12]. To mitigate this problem and protect regional food security, it will be necessary to stabilize or increase rice production (Atlin, Cairns, & Das, 2017) [1]. Past research has shown that since the 1960s, breeding rice for high yield in Asia frequently targeted semidwarf stature, which increased the harvest index and panicle size, thereby increasing the sink capacity compared with older varieties (Khush, 1995) [8]. As a result of these efforts, most medium-duration elite genotypes now have a harvest index that approaches the theoretical maximum of 0.55 to 0.60 (Hay, 1995) [7]. Another problem is that elite accessions now produce numerous spikelets per unit of area by developing large panicles, with 150 to 200 spikelets per panicle (Peng *et al*., 2008) [10], in which grain filling is limited by a shortage of nonstructural carbohydrates or concurrent photoassimilation. This has become a bottleneck in recent high-yielding varieties (Dingkuhn *et al*., 2015) [3] At the same time, climate change has led researchers to pay more attention to whether or not cultivation systems can be adapted to reduce the risk of damage caused by drought, flooding, and saltwater intrusion. One approach is to use short-duration varieties (Campbell *et al*., 2016) [2]. In rainfed rice ecosystems, varieties with a growth duration of 95 to 105 d can both escape drought at the end of the wet season (Ohno *et al*., 2018) [9] and permit more intense cultivation, with dryland crops being established in the wet season immediately after the rice harvest to take advantage of the residual soil moisture (Haefele, Kato, & Singh, 2016) [6]. Short-duration varieties also have advantages over longer growth duration varieties which include less risk of typhoon-driven lodging and of pest damage (rodents, birds, and insects), combined with the higher sale price for providing the first harvests during a given cultivation season (Xu *et al*., 2018) [11].

In irrigated rice ecosystems, many farmers prefer short-duration varieties, since they often face serious water shortages late in the dry season. In Cambodia's Mekong Delta and Myanmar's Ayeyarwady (Irrawaddy) Delta, some farmers now produce two rice crops by growing short-duration varieties during the dry season but leave their fields fallow during the wet season because of the risk of flooding (Fukai & Ouk, 2012) [5]. Developing high-yielding short-duration varieties will improve our options for responding to climate change and the need for intensified cultivation. To develop such varieties, we must first understand how rice yield correlates with physiological characteristics in elite short-duration genotypes. Hence this study was proposed to identify promising and stable very early rice genotypes under direct seeded condition in aerobic situation and study the grain yield potential.

Materials and Methods

The present study was undertaken at Tamil Nadu Rice Research Institute, Aduthurai inKuruvai, 2021 a total of ten homozygous cultures were evaluated under direct seeding and transplanted conditions. In each condition the cultures were tested along with the early maturing checks viz., ADT 48, MDU 5 and WGL 14377. Under direct seeded rice (DSR) the pulverized soil was leveled and the seeds were dibbled in dry soil with the spacing of 20 cm between rows and each entry was raised in 3.6 m^2 plots. Immediately after sowing the field was irrigated. On third day after sowing pre-emergence herbicide Pendimethalin @ 2ml/liter was applied and on 21 days after sowing post emergence herbicide bispyribag sodium @ 80 ml/ac was applied to control the weeds. The field was irrigated once in 3 to 5 days until maturity.

Under transplanted condition (TPR), 25 days old seedling were transplanted in 3.6 m^2 plots with the spacing of 20 cm between rows and 15 cm between plants. Normal agronomic practices followed for TPR was followed throughout the crop period. Both trials were conducted in augmented block design in which the check entries were replicated thrice and the test entries were un-replicated. In both DSR and TPR biometric observations on flowering, plant height, tiller number and grain yield were recorded.

Results and Discussions

Mean performance and analysis of variance for the ten homozygous cultures and checks presented in Tables 1 and 2 revealed that significant and wide range of variability was observed for all the traits studied. Among them the following entries *viz*., AD 21088 (95 days), AD 21089 (98 days), AD 21152 (101days), AD 21154 (105 days) and AD 21155 (100 days), AD 21157 (99 days), AD 21157 (98 days), AD 21161 (95 days), AD 21162 (101 days) and AD 21170 (96 days) were found to be early maturing when compared to the checks, ADT 48 (102 days), MDU 5 (105 days) and WGL 14377 (100 days). Similarly under TPR also these entries were earliest to mature with the maturity duration of less than 105 days (Table 3).

The knowledge on trait associations in breeding materials is essential for varied reasons: (i) to perceive the diversity of breeding material (ii) to identify the trait through which a crop is able to grow successfully in a given ecological condition with optimum productivity (iii) to avoid characters that have little or no breeding value; (iv) it also enables us to narrow down to a very few traits that not only account for large amount of variation but have a breeding value correlated with trait of interest. The knowledge of relationship between the trait of interest and other characters is desirable to choose the appropriate selection programme during breeding. Correlation studies enable the breeder to determine the strength of relationship between various characters as well as the magnitude and direction of changes expected during selection. The present research was undertaken to find out the association and path analysis of diverse aspects for the contribution of yield in short period of life span 90-100 days.

Among the biometrical traits studied grains per panicle exhibited highest significant and positive (0.718** and 0.706) association with grain yield under direct sown and transplanted condition followed by number of productive tillers per plant (0.697**) in direct sown condition, panicle length (0.689 **) in transplanted condition. The traits panicle length showed positive and significant association with single plant yield through grains per panicle (0.782** and 0.680**) under both direct sown and transplanted condition. (Table 4 and Table 5).

Splicing of the correlation estimates in to direct and indirect effects was done using path coefficient analysis. Panicle Length (0.466 and 0.766) registered maximum positive direct effect on grain yield under both direct sown and transplanted conditions respectively, followed by number of productive tillers per plant (0.567) under direct sown condition. Among the indirect effects, all the five traits days to fifty percent flowering, plant height, number of productive tillers, panicle length and grains per panicle exhibited positive association with panicle length under both direct sown and transplanted condition whereas under transplanted condition only positive association was noticed with grains per panicle by all the traits (Table 6 and Table 7).

Table 1: Analysis of variance –Direct Seeded Rice

Source	Df	DFF	PH	NPT	PL	GPP	SPY
Total	41	14.146	24.652	4.792	13.983	459.508	4300.875
Replication	2	0.929	27.049	0.452	5.645	117.172	185.143
Genotypes	13	39.539**	60.051**	11.883**	37.632**	1367.168**	3374.000**
Error	26	2.467	6.768	1.581	2.801	32.012	16303.682

DFF- Days to 50% Flowering, PH-Plant Height, NPT-Number of Productive Tillers, PL-Panicle length, GPP- Number of Grains Per Panicle and SPY-single plant yield

** Significant at 0.01 level of probability

*Significant at 0.05 level of probability

Table 2: Analysis of variance –Transplanted Rice

Source	df	DFF	PH	NPT	PL	GPP	SPY
Total	41	18.707	37.541	5.847	14.228	402.207	9476.750
Replication	2	3.020	0.828	0.085	1.477	113.643	1963.428
Genotypes	13	51.254**	105.312**	18.217**	40.667**	1148.039**	2188.250**
Error	26	3.639	6.480	0.105	1.989	51.489	214.658

DFF- Days to 50% Flowering, PH-Plant Height, NPT-Number of Productive Tillers, PL-Panicle length, GPP- Number of Grains Per Panicle and SPY-single plant yield
** Significant at 0.01 level of probability
*Significant at 0.05 level of probability

Table 3: Mean performance of the quantitative traits under direct seeded and transplanted condition

S. No	Cultures	DSR						TPR					
		DFF	PH	NPT	PL	GPP	Yld(kg/ha)	DFF	PH	NPT	PL	GPP	Yld(kg/ha)
1	AD 21088	65.00	82.40	11.33	17.40	71.33	4583.33	68.67	80.60	13.00	18.23	71.33	4889.00
2	AD 21089	67.67	86.73	9.67	22.67	94.00	5667.00	72.33	91.50	11.00	24.80	94.00	6111.00
3	AD 21152	71.00	89.53	6.33	20.70	72.33	5167.00	74.67	93.00	12.00	21.23	101.67	4953.00
4	AD 21154	75.00	81.00	5.67	16.73	49.00	3333.00	78.00	85.00	14.00	20.10	115.33	5314.67
5	AD 21155	70.00	89.40	8.33	22.20	97.00	5417.00	73.00	86.50	9.00	23.43	97.00	5278.00
6	AD 21157	69.00	90.40	10.33	19.33	97.33	5000.33	67.00	95.00	12.00	19.60	97.33	5139.33
7	AD 21158	68.00	82.13	10.33	20.50	103.00	5167.33	71.00	80.50	13.00	20.23	104.67	5277.67
8	AD 21161	65.33	83.40	7.33	20.60	96.00	5000.00	65.00	84.00	10.00	22.40	131.67	6667.00
9	AD 21162	71.00	89.53	10.00	22.10	108.33	5500.33	74.67	86.60	14.00	23.13	109.33	5322.67
10	AD 21170	65.67	90.80	9.67	16.90	97.33	5215.00	70.00	91.50	11.00	22.33	127.33	6389.00
11	ADT 48	68.00	88.67	8.67	14.33	85.00	4750.00	72.00	86.00	7.00	15.63	101.67	5000.33
12	MDU 5	70.33	94.34	6.00	21.77	99.33	4005.00	75.00	94.50	10.00	20.13	102.67	3333.00
13	Turant dhan	59.67	82.16	5.33	11.83	43.67	3986.00	63.00	83.00	6.00	11.83	59.67	3055.67
14	WGL 14377	66.33	93.67	9.67	24.60	116.00	5167.00	70.00	100.20	13.00	25.97	121.33	5438.33
	Mean	68.00	87.44	8.48	19.41	87.83	4854.17	71.02	88.42	11.07	20.65	102.50	5154.91

DFF- Days to 50% Flowering, PH-Plant Height, NPT-Number of Productive Tillers, PL-Panicle length, GPP- Number of Grains Per Panicle, and SPY-single plant yield
** Significant at 0.01 level of probability
*Significant at 0.05 level of probability

Table 4: Genotypic Correlation - Direct Seeded Rice

	DFF	PH	NPT	PL	GPP	SPY
DFF	1.000	0.205	-0.141	0.406	0.134	-0.075
PH		1.000	0.113	0.559*	0.682**	0.387
NPT			1.000	0.320	0.645*	0.697 **
PL				1.000	0.782**	0.580 *
GPP					1.000	0.718 **
SPY						1.000

Table 5: Genotypic Correlation - Transplanted Rice

	DFF	PH	NPT	PL	GPP	SPY
DFF	1.000	0.194	0.471	0.412	0.311	0.033
PH		1.000	0.141	0.528*	0.357	0.043
NPT			1.000	0.589*	0.378	0.386
PL				1.000	0.680**	0.689 **
GPP					1.000	0.706 **
SPY						1.000

Table 6: Direct and Indirect effects of yield and its component traits in Direct Seeded Rice

	DFF	PH	NPT	PL	GPP
DFF	-0.207	0.036	-0.080	0.189	-0.014
PH	-0.042	0.176	0.064	0.261	-0.072
NPT	0.029	0.020	0.567	0.149	-0.068
PL	-0.084	0.099	0.181	0.466	-0.082
GPP	-0.028	0.120	0.366	0.364	-0.105

Residual Effect =0.5711073

Table 7: Direct and Indirect effects of yield and its component traits in Transplanted Rice

	DFF	PH	NPT	PL	GPP
DFF	-0.326	-0.089	-0.009	0.316	0.142
PH	-0.063	-0.458	-0.003	0.405	0.163
NPT	-0.154	-0.065	-0.020	0.451	0.173
PL	-0.134	-0.242	-0.012	0.766	0.311
GPP	-0.101	-0.163	-0.007	0.521	0.457

Residual Effect = 0 .433227
DFF- Days to 50% Flowering, PH-Plant Height, NPT-Number of Productive Tillers, PL-Panicle length, GPP- Number of Grains Per Panicle and SPY-single plant yield

Conclusion

Among the early cultures AD 21089 recorded highest yield of 5667 kg/ha under DSR followed by the cultures AD 21162 (5500 kg/ha) and AD 21155 (5417 kg/ha). In TPR the cultures *viz.*, AD 21161, AD 21170 and AD 21089 were found to be promising with the grain yield of more than 6 tones/ha which is 23.0, 18.0 and 13.0 per cent higher than the best check WGL 14377 (5405 kg/ha). One culture AD 21089 with the maturity of 98 days in DSR and 101 days in TPR was consistent in yield under both the situation with the yield increase of 10 per cent in DSR and 13.0 per cent in TPR over the best check WGL 14377.Association analysis revealed that the characters panicle length, grains per panicle and number of productive tillers per plant exhibited positive and significant association with single plant yield. Hence, selection for these traits will improve single plant yield.

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