Electronic Journal of Plant Breeding, 9(4): 1362-1369 (Dec 2018) DOI: 10.5958/0975-928X.2018.00170.9
ISSN 0975-928X

Research Article

Association studies in F_2 population for yield and quality traits in rice (*Oryza sativa* L.)

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(Received: 21 Aug 2018; Revised: 09 Dec 2018; Accepted: 10 Dec 2018)

Abstract
The experiment was carried out to explore correlation and path coefficient analysis in two F_2 populations of rice derived from the cross AD 16019 x ADT43 and AD16019 x WGL 14377 at TRRI, Aduthurai during 2016-18. In both the crosses single plant yield shows positive association with 1000 grain weight, plant height, number of productive tillers, panicle length. In the cross AD 16019 x ADT43 1000 grain weight and number of productive tillers per plant showed high direct positive effect on single plant yield and in the cross AD16019 x WGL 14377 only 1000 grain weight had high positive direct effect on single plant yield. Hence, selection of positively associated characters could bring improvement in yield and component characters.

Key words
Correlation, path analysis, 1000 grain weight.

Introduction

Rice is the staple food for two third of the Indian population. It contributes 43 per cent of caloric requirement and 20-25% of agricultural income. In India, rice is grown in an area of 43.5 million ha (23% of gross cropped area) with an annual production of 90 million tons (Viraktamath and Sundaram, 2010). To fulfill the requirement of ever increasing population, enhancing crop yield is one of the top most priorities in crop breeding programmes. Quality traits are another important consideration of rice breeding in India. Yield is a complex quantitative character controlled by many gene interactions with environment and is product of many yield components (Devi *et al.,* 2017). Correlation helps us to understand the influence of various components on the yield and Path coefficient analysis discerns the effects of correlation into direct and indirect effects. Present study was made to understand the association and path analysis of component characters for grain yield

Material and Methods

In the present study, F_2 population of two crosses of rice *viz.,* AD 16019 x ADT 43 and AD16019 x WGL 14377 and their parents were raised at Tamil Nadu Rice Research Institute, Aduthurai during *Rabi* 2017-2018. The female parent AD16019 was early maturing (98-100 days) and but poor in quality aspects. The male parents ADT 43 and WGL 14377 were adaptable varieties with good cooking quality, grain quality and yield. Twenty eight days old seedlings were space planted by adopting a spacing of 20 x 15 cm with a single plant in a hill. Each F_2 was raised with minimum of 1000 plants and individual plant observations were recorded on 300 randomly tagged plants. Data on single plant yield and yield attributes were recorded at appropriate crop growth stages. For grain length and breadth measurements, ten kernels were randomly selected and dehulled. Length and breadth of these kernels were measured in millimeter with the help of graph paper. The values were averaged and recorded in millimeter. The L/B ratio was calculated and the grain shape was classified by adopting Standard Evaluation System (IRRI, 1996). The Gel consistency (GC) was analysed based on the method described by Cagampang *et al.* (1973) and Alkali Spreading Value based on method developed by Little *et al*. (1958).

Results and Discussion

Correlation analysis was done by taking single plant yield as dependent variable. In AD 16019 x ADT 43 single plant yield showed strong positive significant association with productive tillers per plant and 1000 grain weight. It is inferred that selection of entries having 1000 grain weight and productive tillers on positive side can improve single plant yield in this

population. Similar findings were also reported by Selvaraj *et al.* (2011). Yield was positively correlated with plant height, panicle length, grain length, grain breadth and L/B ratio. This infers that grain size plays a major role in determining the yield of the plant. Similar findings were also reported by Ekka *et al.* (2011) for grain length and grain breadth.

Negative association of days to flowering, grains per panicle, gel consistency and alkali spreading value with single plant yield in accordance with the previous findings of Selvaraj *et al.* (2011), Premkumar *et al.* 2016 and Allam *et al.* (2015).

In the cross AD 16019 x ADT 43, grain length and grain breadth had shown negative and non-significant association with both the cooking properties *viz.*, gel consistency and alkali spreading value. This implies that the grain shape has no effect on cooking but positive association exists among themselves. The increase in length may increase the breadth in the grain shape however it is found that grain length shows significant positive association with the L/B ratio and grain breadth and grain breadth shows negative significant association with L/B ratio. This observation can be extrapolated that grain length determines the slender of the grain shape rather than grain breadth. Plant height registered positive correlation with most of the traits except 1000- grain weight similar findings were reported by Babu *et al.* (2012), grain length, L/B ratio and gel consistency. Panicle length exhibited positive association with many traits except gel consistency and grain breadth similar findings were reported by Ekka *et al.* (2011).
In the cross AD 16019 x WGL 14377, 1000 grain weight showed positive significant association with single plant yield. Ekka *et al.* (2011) also reported the similar result for the trait 1000 grain weight. Plant height, panicle length, productive tillers per plant and gel consistency also showed positive correlation with single plant yield. Similar results were reported by Rafii *et al.* (2014), Ekka *et al.* (2011) and Selvaraj *et al.* (2011).

Days to flowering, grains per panicle, grain length, grain breadth, L/B ratio and gel consistency expressed negative correlation with single plant yield. Similar results were reported by Selvaraj *et al.* (2011) for days to flowering, Rafii *et al.* (2014) for grain length, Umadevi *et al.* (2009) for grain breadth and Rawte & Saxena (2017) for L/B ratio.

Days to flowering exhibited positive significant association with plant height this explains that increase in the days to flowering may lead to selection of taller plants. For non-lodging nature early flowering with dwarf phenotype plants is found possible with selection of this population. In general, days to flowering showed negative correlation to many of the traits except plant height in the population derived from AD16019 x WGL 14377. Similar findings were reported by Umadevi *et al.* (2009).

Days to flowering recorded positive and non-significant association with almost all traits except grains per panicle and grain breadth. Plant height had positive association with grains per panicle similar findings were reported by Babu *et al.* (2012). Panicle length registered negative correlation with many traits except grains per panicle, 1000 grain weight and alkali spread value. Productive tillers per plant showed strong negative association with grains per panicle similar findings by Ekka *et al.* (2011) and Kole *et al.* (2010). Grains per panicle revealed negative correlation with most of the traits except gel consistency and alkali spreading value similar findings were reported by Allam *et al.* (2015). Thousand grain weight had strong negative association with grain length also negative correlation with grain breadth, L/B ratio and alkali spread value but positive association with gel consistency. Similar findings were reported by Umadevi *et al.* (2009) and Sowmiya and Venkatesan (2017). Grain length registered strong positive association with grain breadth and positive correlation with L/B ratio and alkali spreading value but negative correlation with gel consistency. Grain breadth showed positive association only with alkali spreading value. L/B ratio revealed positive correlation with gel consistency contrary findings were reported by Rawte & Saxena (2017). This indicates that, the grains that are shorter in shape take more time to cook. Gel consistency had positive correlation with alkali spreading value.

Thus, correlation studies revealed that number of productive tillers per plant and 1000 grain weight are the only reliable tools that can be used to isolate desirable segregants for grain yield from these two populations. Grain length decides the shape of the grain rather than breadth. Grain shape has no role in deciding the cooking properties of the grain. Selection for early flowering may result in population with dwarf/ semi-dwarf plants.

Correlation coefficients were divided into direct and indirect effect with the help of path analysis by taking

yield as the dependent factor. The results showed that in the cross AD 16019 x ADT 43, 1000 grain weight and productive tillers per plant and in AD 16019 x WGL 14377 cross, 1000 grain weight showed high positive direct effect on single plant yield which implies that the selection of this trait for yield improvement may be rewarding. The results were in accordance with Nandeshwar *et al.* (2010), Devi *et al.* (2017) and Rahman *et al.* (2014).

In AD 16019 x ADT 43 cross, productive tillers per plant and 1000 grain weight showed low to moderate positive indirect effect on single plant yield. Similar findings were reported by Singh *et al*. (2013), Patel *et al.* (2018), Venkanna *et al.* (2014), Akhtar *et al.* (2011), Seyoum *et al.* (2012) for number of productive tillers/plant, Babu *et al.* (2012), Venkanna *et al.* (2014), Ketan *et al.* (2014) and Aditya & Bhartiya (2013) for 1000 grain weight. The remaining traits showed negligible indirect effects on the single plant yield. Hence, productive tillers per plant and 1000 grain weight can be regarded as reliable traits for improving the yield. But in AD 16019 x WGL 14377 cross, all traits showed only negligible indirect effects and hence more traits need to be studied in this particular cross to enhance the yield.

Correlation studies also revealed the strong relationship of 1000 grain weight and productive tillers per plant to single plant yield. The high direct effect shown by these traits by path analysis reveal that these traits are highly useful in selection of superior segregants.

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Electronic Journal of Plant Breeding, 9(4): 1362-1369 (Dec 2018) DOI: 10.5958/0975-928X.2018.00170.9
ISSN 0975-928X

Table 1. Estimates of correlation coefficients of grain yield and component characters in AD 16019 x ADT 43.

	DF	PH	PL	NPT	NGP	TGW	L	B	L/B	GC	ASV	SPY
DF	1.000	0.066	-0.023	-0.184**	0.108	-0.198**	-0.179**	-0.003	-0.190**	0.016	-0.088	-0.248**
PH		1.000	0.076	0.035	0.075	-0.003	-0.001	0.051	-0.035	-0.002	0.021	0.032
PL			1.000	0.050	0.060	0.036	0.028	-0.004	0.036	-0.043	0.097	0.042
NPT				1.000	-0.080	0.456**	0.120*	0.064	0.055	-0.040	0.011	**0.738****
NGP					1.000	-0.098	-0.042	-0.095	0.064	0.083	-0.082	-0.047
TGW						1.000	0.096	0.068	0.032	0.013	0.109	**0.634****
L							1.000	0.512**	0.543**	-0.023	-0.059	0.088
B								1.000	-0.429**	-0.034	-0.020	0.016
L/B									1.000	0.012	-0.055	0.074
GC										1.000	-0.012	-0.029
ASV											1.000	-0.004
SPY												1.000

* Significant at P = 0.05 **Significant at P = 0.01

DF - Days to flowering, **PH** - Plant height, **PL** - Panicle length, **NPT** - Number of productive tillers per plant, **NGP** – Number of grains/panicle, **TGW** - 1000 grain weight, **L** – Grain length, **B** – Grain breadth, **L/B** – Grain length and breadth ratio, **GC** – Gel consistency, **ASV** – Alkali spreading value, **SPY** - Single plant yield.

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Table 2. Estimates of correlation coefficients of grain yield and component characters in AD 16019 x WGL 14377.

	DF	PH	PL	NPT	NGP	TGW	L	B	L/B	GC	ASV	SPY
DF	1.000	0.135*	-0.045	0.112	-0.038	0.018	0.007	-0.072	0.004	0.039	0.054	-0.044
PH		1.000	0.004	0.006	0.127*	0.034	-0.035	0.012	-0.010	0.056	0.038	0.027
PL			1.000	-0.007	0.033	0.008	-0.080	-0.086	-0.007	-0.023	0.023	0.007
NPT				1.000	-0.131*	0.066	-0.051	-0.053	-0.005	0.056	0.083	0.031
NGP					1.000	-0.055	-0.023	-0.073	-0.045	0.026	0.107	-0.049
TGW						1.000	-0.120*	-0.099	-0.062	0.031	-0.101	**0.909****
L							1.000	0.430**	0.084	-0.032	0.018	-0.112
B								1.000	-0.025	-0.073	0.010	-0.107
L/B									1.000	0.012	-0.101	-0.058
GC										1.000	0.031	0.043
ASV											1.000	-0.115*
SPY												1.000

* Significant at P = 0.05 **Significant at P = 0.01

DF - Days to flowering, **PH** - Plant height, **PL** - Panicle length, **NPT** - Number of productive tillers per plant, **NGP** – Number of grains/panicle, **TGW** - 1000 grain weight, **L** – Grain length, **B** – Grain breadth, **L/B** – Grain length and breadth ratio, **GC** – Gel consistency, **ASV** – Alkali spreading value, **SPY** - Single plant yield.

Table 3. Estimates of direct and indirect effects of component characters on grain yield in AD 16019 X ADT 43.

	DF	PH	PL	NPT	NGP	TGW	G.L	G.B	L/B	GC	ASV	SPY
DF	**-0.0825**	0.0013	-0.0000	-0.1024	0.0038	-0.0749	0.0015	0.0001	0.0005	-0.0002	0.0051	-0.2478
PH	-0.0054	**0.0194**	0.0001	0.0195	0.0026	-0.0012	0.0000	-0.0021	0.0001	0.0000	-0.0012	0.0318
PL	0.0019	0.0015	**0.0007**	0.0276	0.0021	0.0137	-0.0002	0.0001	-0.0001	0.0007	-0.0056	0.0423
NPT	0.0152	0.0007	0.0001	**0.5564**	-0.0028	0.1721	-0.0010	-0.0027	-0.0001	0.0006	-0.0006	0.7377
NGP	-0.0089	0.0015	0.0001	-0.0448	**0.0348**	-0.0369	0.0004	0.0040	-0.0002	-0.0013	0.0047	-0.0467
TGW	0.0164	-0.0001	0.0001	0.2536	-0.0034	**0.3776**	-0.0008	-0.0029	-0.0001	-0.0002	-0.0063	0.6338
G.L	0.0147	-0.0000	0.0001	0.0667	-0.0015	0.0361	**-0.0085**	-0.0215	-0.0014	0.0004	0.0034	0.0884
G.B	0.0003	0.0010	-0.0000	0.0359	-0.0033	0.0258	-0.0044	**-0.0419**	0.0011	0.0005	0.0011	0.0161
L/B	0.0157	-0.0007	0.0001	0.0308	0.0022	0.0119	-0.0046	0.0180	**-0.0027**	-0.0002	0.0032	0.0736
GC	-0.0013	-0.0000	-0.0000	-0.0222	0.0029	0.0048	0.0002	0.0014	-0.0000	**-0.0154**	0.0007	-0.0290
ASV	0.0073	0.0004	0.0001	0.0061	-0.0029	0.0412	0.0005	0.0008	0.0001	0.0002	**-0.0574**	-0.0036

Residual effect = 0.576; **Diagonal and bold indicates the direct effects**

* Significant at P = 0.05 **Significant at P = 0.01

DF - Days to flowering, **PH** - Plant height, **PL** - Panicle length, **NPT** - Number of productive tillers per plant, **NGP** – Number of grains/panicle, **TGW** - 1000 grain weight, **L** – Grain length, **B** – Grain breadth, **L/B** – Grain length and breadth ratio, **GC** – Gel consistency, **ASV** – Alkali spreading value, **SPY** - Single plant yield.

Table 4. Estimates of direct and indirect effects of component characters on grain yield in AD 16019 X WGL 14377.

	DF	PH	PL	NPT	NGP	TGW	G.L	G.B	L/B	GC	ASV	SPY
DF	**-0.0606**	0.0008	0.0001	-0.0026	0.0002	0.0163	0.0001	0.0019	-0.0000	0.0006	-0.0010	-0.0442
PH	-0.0082	**0.0057**	-0.0000	-0.0001	-0.0007	0.0309	-0.0003	-0.0003	0.0001	0.0009	-0.0007	0.0271
PL	0.0028	0.0000	**-0.0029**	0.0002	-0.0002	0.0068	-0.0007	0.0023	0.0000	-0.0004	-0.0004	0.0075
NPT	-0.0068	0.0000	0.0000	**-0.0229**	0.0007	0.0597	-0.0004	0.0014	0.0000	0.0009	-0.0016	0.0310
NGP	0.0023	0.0007	-0.0001	0.0030	**-0.0055**	-0.0496	-0.0002	0.0019	0.0003	0.0004	-0.0021	-0.0488
TGW	-0.0011	0.0002	-0.0000	-0.0015	0.0003	**0.9064**	-0.0010	0.0026	0.0004	0.0005	0.0020	0.9087
G.L	-0.0004	-0.0002	0.0002	0.0012	0.0001	-0.1087	**0.0085**	-0.0113	-0.0005	-0.0005	-0.0003	-0.1119
G.B	0.0044	0.0001	0.0002	0.0012	0.0004	-0.0898	0.0036	**-0.0263**	0.0001	-0.0012	-0.0002	-0.1073
L/B	-0.0002	-0.0001	0.0000	0.0001	0.0002	-0.0559	0.0007	0.0007	**-0.0057**	0.0002	0.0020	-0.0580
GC	-0.0023	0.0003	0.0001	-0.0013	-0.0001	0.0284	-0.0003	0.0019	-0.0001	**0.0168**	-0.0006	0.0427
ASV	-0.0033	0.0002	-0.0001	-0.0019	-0.0006	-0.0911	0.0001	-0.0003	0.0006	0.0005	**-0.0195**	-0.1153

Residual effect = 0.4108; **Diagonal and bold indicates the direct effects**

* Significant at P = 0.05 **Significant at P = 0.01

DF - Days to flowering, **PH** - Plant height, **PL** - Panicle length, **NPT** - Number of productive tillers per plant, **NGP** – Number of grains/panicle, **TGW** - 1000 grain weight, **L** – Grain length, **B** – Grain breadth, **L/B** – Grain length and breadth ratio, **GC** – Gel consistency, **ASV** – Alkali spreading value, **SPY** - Single plant yield.