Madras Agric. J., 95 (7-12) : 283-294 July-December 2008
https://doi.org/10.29321/MAJ.10.100583

Selection indices for simultaneous improvement of yield and drought tolerance in rice cultures

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Abstract : Seventeen genotypes were evaluated for seventeen characters in Randomized Block Design over three replications. Correlation and path analysis were done separately by keeping yield and root weight as dependant characters and the results were compared. Correlation studies indicated that selection based on five characters namely plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering and root length could improve yield and root weight. While further partitioning through path analysis indicated that selection based on number of fibrous roots per plant and plant height could improve simultaneously both yield and root weight of single plant.

Keywords : Yield, root weight, fibrous roots, correlation studies, path analysis.

Introduction

Rice is an important cereal crop in the world. It is grown under more diverse environmental conditions than any other major food crops in the world. Drought is a major yield limiting factor on almost half of the world's 70 million hectares of rainfed rice (O' Toole and Chang, 1979). In rice, global loss due to drought was estimated as high as $ 3.51 billion annually (Michael Gomez *et al.*, 2003). Therefore development of drought tolerant genotypes besides sustaining the yield potential of rice is important. Yield is a complex trait and many components contribute to the grain yield of a plant. Present study as carried out in this direction to find out the characters to be considered during selection of plants with both increased yield and drought tolerant characters through correlation and path analysis.

Materials and Methods

This experiment was done at Agricultural College and Research Institute, Killikulam, consisted of seventeen genotypes in Randomized Block Design over three replications. These seventeen genotypes were planted in four rows of four metres with the spacing of 20 cm X 15 cm. The seventeen genotypes included PMK 1, PMK 2, PMK 3, Vellai Chithiraikar, Sivappu Chithiraikar, Chithiraikar, Aruvan Kuruva, Thidal Kulichan, Kuliyadichan, Kuruvai Kalanjium, Poongar, Veeradanki, Ariyan, Norungan, Nootripattu, Varappu Kudainchan and 1R 64. The seventeen characters *viz.*, plant height, number of fibrous roots per plant (after shade drying of root, no. of fibrous roots per plant were counted manually), days to first flowering, days to 50 per cent flowering, root length, productive tillers per plant, root volume, harvest index, number of grains per panicle, root weight (roots were carefully pulled out of the soil without damage, shade dried and weighed), panicle length, 1000-grain weight, length and breadth ratio of grain , straw yield, relative water content of leaf, boot leaf area and single plant yield were studied. For these seventeen genotypes and characters correlation studies and path coefficient analysis were done

Table 1. Estimates of genotypic and phenotypic correlation coefficients between yield and yield components in drought tolerant rice cultures

Characters		Plant height (cm)	Fibrous roots/plant (no)	First flowering (days)	50% flowering (days)	Root length (cm)	Productive tillers/plant (no)	Root volume (cc)	Harvest index	Grains per panicle (no)
Plant height (cm)	G	1.000	0.532**	0.724**	0.632**	0.335	-0.166	0.399*	0.324	0.657**
	P	1.0001	0.417*	0.656**	0.548**	0.239	0.007	0.394*	0.247	0.588**
Fibrous roots / plant (no)	G		1.000	0.472**	0.478**	0.455**	0.437**	0.640**	0.118	0.703**
	P		1.000	0425*	0.424*	0.389*	0.253	0.541*	0.149	0.608**
First flowering (days)	G			1.000	0.983**	0.817**	-0.297	0.772**	0.088	0.803**
	P			1.000	0.963**	0.693**	-0.210	0.738**	0.096	0.771**
50% flowering (days)	G				1.000	0.888**	-0.325	0.738**	-0.004	0.801**
	P				1.000	0.708**	-0.268	0.745**	-0.015	0.782**
Root length (cm)	G					1.000	-0.590**	0.753**	-0.252	0.858**
						1.000	-0.332	0.636**	-0.153	0.688**
Productive tillers / plant (no)	G						1.000	-0.033	0.363*	-0.397*
							1.000	-0.020	0.322	-0.260
Root Volume (cc)	G							1.000	0.072	0.715**
	P							1.000	0.052	0.688**
Harvest Index	G								1.000	-0.092
	P								1.000	-0.089
Grains per panicle (no.)	G									1.000
	P									1.000

* Significance at 5% level, ** Significance at 1% level G = genotypic correlation coefficient; P = phenotypic correlation coefficient

Table 1. (Contd.) Estimates of genotypic and phenotypic correlation coefficients between yield and yield components in drought tolerant rice cultures

Characters		Root Weight(g)	Panicle Length(cm)	1000 grain Weight(g)	LB ratio grain	Straw Yield (g)	Relative water content of leaf (%)	Boot leaf Area (sq.mm)	Single plant yield (g)
Plant height (cm)	G	0.174	0.677**	0.462**	-0.519**	0.500**	0.161	0.633**	0.682**
	P	0.146	0.578**	0.407*	0.469**	0.406*	0.086	0.574**	0.548**
Fibrous roots / plant (no)	G	0.568**	0.693**	-0.106	-0.072	0.630**	0.326	0.348*	0.683**
	P	0.540**	0.513**	-0.084	-0.079	0.535**	0.201	0.262	0.603**
First flowering (days)	G	0.618**	0.917**	0.325	0.141	0.707**	-0.252	0.820**	0.685**
	P	0.580**	0.727**	0.313	0.141	0.626**	-0.186	0.756**	0.609**
50% flowering (days)	G	0.722**	0.942**	0.200	0.305	0.690**	-0.297	0.801**	0.605**
	P	0.688**	0.750**	0.199	0.301	0.629**	-0.212	0.745**	0.512**
Root length (cm)	G	0.799**	0.787**	-0.148	0.448**	0.664**	0.165	0.724**	0.399*
		0.606**	0.551**	-0.121	0.341*	0.463**	-0.083	0.606**	0.285
Productive tillers / plant (no)	G	-0.076	-0.127	0.189	-0.135	0.143	0.388*	-0.654**	0.416*
	P	-0.058	-0.073	0.102	-0.116	0.119	0.276	-0.395*	0.370*
Root Volume (cc)	G	0.820**	0.827**	0.242	0.300	0.698**	-0.064	0.631**	0.684**
	P	0.756**	0.704**	0.236	0.289	0.627**	0.017	0.605**	0.586**
Harvest Index	G	-0.171	-0.147	0.272	-0.477**	-0.285	0.209	0.084	0.442**
	P	-0.158	-0.095	0.205	-0.400*	-0.296	0.136	0.026	0.558**
Grains per panicle (no.)	G	0.652**	0.854**	-0.014	0.029	0.676**	-0.030	0.821**	0.560**
	P	0.614**	0.718**	-0.10	0.030	0.634**	-0.016	0.783**	0.477**

Table 1. (Contd.)

Characters		Root Weight(g)	Panicle Length(cm)	1000 grain Weight(g)	LB ratio grain	Straw Yield (g)	Relative water content of leaf (%)	Boot leaf Area (sq.mm)	Single plant yield (g)
Root weight (g)	G	1.000	0.831**	0.027	0.597**	0.695**	0.193	0.544**	0.503**
	P	1.000	0.676**	-0.018	0.557**	0.657**	0.142	0.493**	0.429*
Panicle length (cm)	G		1.000	0.311	0.261	0.888**	-0.043	0.744**	0.685**
	P		1.000	0.268	0.214	0.687**	-0.044	0.675**	0.509**
1000 grain weight (g)	G			1.000	-0.210	0.207	-0.062	0.309	0.360*
	P			1.000	-0.210	0.201	-0.046	0.300	0.315
LB ratio of grain	G				1.000	0.177	-0.442**	-0.001	-0.210
					1.000	0.168	-0.288	-0.004	-0.199
Straw yield (g)	G					1.000	-0.098	0.450**	0.735**
	P					1.000	-0.028	0.405*	0.616**
Relative water content of leaf (%)	G						1.000	-0.102	0.087
	P						1.000	-0.113	0.112
Boot leaf area (sq.mm)	G							1.000	0.463**
	P							1.000	0.362*

* Significance at 5% level, ** Significance at 1% level G = genotypic correlation coefficient; P = phenotypic correlation coefficient

Table 2. Estimates of genotypic and phenotypic correlation coefficients between root weight and different biometrical traits

Characters		Plant height (cm)	Fibrous roots/plant (no)	First flowering (days)	50% flowering (days)	Root length (cm)	Productive tillers/plant (no)	Root volume (cc)	Harvest index	No.of grains per panicle (no.)
Plant height (cm)	G	1.000	0.532**	0.724**	0.632**	0.335	-0.166	0.399*	0.324	0.657**
	P	1.0001	0.417*	0.656**	0.548**	0.239	0.007	0.394*	0.247	0.588**
Fibrous roots / plant (no)	G		1.000	0.472**	0.478**	0.455**	0.437**	0.640**	0.118	0.703**
	P		1.000	0425*	0.424*	0.389*	0.253	0.541*	0.149	0.608**
First flowering (days)	G			1.000	0.983**	0.817**	-0.297	0.772**	0.088	0.803**
	P			1.000	0.963**	0.693**	-0.210	0.738**	0.096	0.771**
50% flowering (days)	G				1.000	0.888**	-0.325	0.738**	-0.004	0.801**
	P				1.000	0.708**	-0.268	0.745**	-0.015	0.782**
Root length (cm)	G					1.000	-0.590**	0.753**	-0.252	0.858**
						1.000	-0.332	0.636**	-0.153	0.688**
Productive tillers / plant (no)	G						1.000	-0.033	0.363*	-0.397*
							1.000	-0.020	0.322	-0.260
Root Volume (cc)	G							1.000	0.072	0.715**
	P							1.000	0.052	0.688**
Harvest Index	G								1.000	-0.092
	P								1.000	-0.089
Grains per panicle (no.)	G									1.000
	P									1.000

* Significance at 5% level, ** Significance at 1% level G = genotypic correlation coefficient; P = phenotypic correlation coefficient

Table 2. Contd...

Characters		Panicle Length(cm)	1000 grain Weight(g)	LB ratio grain	Straw Yield (g)	Relative water content of leaf (%)	Boot leaf Area (sq.mm)	Root weight (g)
Plant height (cm)	G	0.677**	0.462**	-0.519**	0.500**	0.161	0.6338*	0.174
	P	0.578**	0.407*	-0.469**	0.406*	0.086	0.574**	0.146
Fibrous roots / plant (no)	G	0.693**	-0.106	-0.072	0.630**	0.326	0.348	0.568**
	P	0.513**	0.084	-0.079	0.535**	0.201	0.262	0.540**
First flowering (days)	G	0.917**	0.325	0.141	0.707**	-0.252	0.820**	0.618**
	P	0.727**	0.313	0.141	0.626**	-0.186	0.756**	0.580**
50% flowering (days)	G	0.942**	0.200	0.305	0.690**	-0.297	0.801**	0.722**
	P	0.750**	0.199	0.301	0.629**	-0.212	0.745**	0.688**
Root length (cm)	G	0.787**	-0.148	0.448	0.664**	-0.165	0.724**	0.799**
		0.551**	-0.121	0.341	0.463**	-0.083	0.606**	0.606**
Productive tillers / plant (no)	G	-0.127	0.189	-0.135	0.143	0.388*	-0.654**	-0.076s
	P	-0.073	0.102	-0.116	0.119	0.276	-0.395*	-0.058
Root Volume (cc)	G	0.827**	0.242	0.300	0.698**	-0.064	0.631**	0.820**
	P	0.704**	0.236	0.289	0.627**	-0.017	0.605**	0.756**
Harvest Index	G	-0.147	0.272	-0.477**	-0.285	0.209	0.084	-0.171
	P	-0.095	0.205	-0.400*	-0.296	0.136	0.026	-0.158
Grains per panicle (no.)	G	0.854**	-0.014	0.029	0.676**	-0.030	0.821**	0.652**
	P	0.718**	-0.010	0.030	0.634**	-0.016	0.738**	0.614**

Table 2. Contd...

Characters		Panicle Length(cm)	1000 grain Weight(g)	LB ratio grain	Straw Yield (g)	Relative water content of leaf (%)	Boot leaf Area (sq.mm)	Root weight (g)
Panicle length (cm)	G	1.000	0.311	0.261	0.888**	-0.043	0.774**	0.831**
	P	1.000	0.268	0.214	0.687**	-0.044	0.657**	0.676**
1000 grain weight	G		1.000	-0.210	0.207	-0.062	0.309	-0.027
(g)	P		1.000	-0.210	0.201	0.046	0.300	-0.018
LB ratio of grain	G			1.000	0.177	-0.442*	-0.001	0.597**
				1.000	0.168	-0.288	-0.004	0.557**
Straw yield (g)	G				1.000	-0.098	0.450**	0.695**
	P				1.000	-0.028	0.405*	0.657**
Relative water	G					1.000	-0.102	-0.193
content of leaf (%)	P					1.000	-0.113	-0.142
Boot leaf area	G						1.000	0.544**
(sq.mm)	P						1.000	0.493**

* Significance at 5% level, ** Significance at 1% level G = genotypic correlation coefficient; P = phenotypic correlation coefficient

Table 3. Direct and indirect effects of sixteen characters on single plant yield

Characters	Plant height (cm)	Fibrous roots/plant (no)	First flowering (days)	50% flowering (days)	Root length (cm)	Productive tillers/plant (no)	Root volume (cm)	Harvest index
Plant height (cm)	-0.255	0.147	0.332	-0.197	0.105	-0.006	-0.067	0.179
Fibrous roots/plant (no)	-0.133	0.280	0.216	-0.149	0.142	0 015	-0.108	0.065
First flowering (days I	-0.184	0.132	0.459	-0.306	0.256	-0.010	-0.130	0.049
50% flowering (days I	-0.161	0.134	0.451	-0.311	0.278	-0.011	-0.132	-0.002
Root length (cm)	-0.086	0.128	0.375	-0.276	0.313	-0.020	-0.127	-0.139
Productive tillers/plant (no)	0.042	0.123	-0.136	0.101	-0.184	0.034	0.005	0.200
Root volume (cc)	-0.102	0.180	0.353	-0.244	0.235	-0.001	-0.169	0.039
Harvest index	-0.083	0.033	0.040	0.001	-0.079	0 012	-0.012	0.553
Grains per panicle (no)	-0.167	0.197	0.368	-0.249	0.268	-0.014	-0.121	-0.051
Root weight (g)	-0.044	0.159	0.283	-0.225	0.249	-0.003	-0.138	-0.095
Panicle length (cm)	-0.173	0.194	0.421	-0.293	0.246	-0.004	-0.139	-0.081
1000 grain weight (g)	-0.118	-0.029	0.149	-0.062	-0.046	0 006	-0.041	0.150
LB ratio of grain	0.132	-0.020	0.065	-0.095	0.139	-0.005	-0.051	-0.263
Straw yield/plant (g)	-0.127	0.176	0.324	-0.215	0.207	0 005	-0.118	-0.157
Relative water content of loaf (%)	-0.041	0.092	-0.116	0.092	-0.052	0013	0.011	0.115
Boot leaf area (sq.cm)	-0.161	0.098	0.376	-0.249	0.227	-0.022	-0.106	0.046

Diagonal values represent the direct Residual effect - 0.0525

Contd.,,

through established biometrical techniques. Correlation studies were carried out as suggested by Johnson *et al.* (1955) and path analysis by Wright (1921) and Dewey and Lu (1959).

Result and Discussion

Correlation and path analysis were done separately by keeping yield as well as root weight as dependent characters and the results were compared. Studies on correlation of yield with its components (Table 1) indicated that the five characters namely plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering and root length had significant positive correlation with more number of characters including yield. While studying the correlation of root weight with its component (Table 2) traits excluding yield, it was found that the same five characters selected earlier had significant positive correlation with more number of traits. Plant height had significant positive correlation with days to 50 per cent flowering as reported by Kennedy and Rangasamy (1998), filled grains per panicle as found by Singh *et al.* (2000) and Lalitha and Sreedhar (1996). By compiling the results of correlation of characters with yield and root weight, it could be concluded that

Table 3. Contd...

Characters	Grains per panicle (no)	Root weight (g)	Panicle length (cm)	1000 grain weight (g)	LB ratio of grain	Straw yield/ plant(g)	Relative water content of leaf(%)	Boot leaf area (sq.cm)	Genotypic correlation coefficient
Plant height (cm)	-0.216	0.033	0.016	0.045	0 192	0.364	-0.013	0.023	0.682**
Fibrous roots/plant (no)	-0.231	0.109	0.017	-0.011	0 027	0.459	-0.027	0.012	0.683**
First flowering (days)	-0.264	0.118	0.022	0.033	-0.052	0.515	0.021	0.02')	0.685**
50% flowering (days)	-0.264	0.138	0.023	0.020	-0.112	0.502	0.024	0.029	0.605**
Root length (cm)	-0.282	0.153	0.019	-0.015	-0.165	0.483	0.014	0.026	0.399*
Productive tillers/plant (no)	0.131	-0.015	-0 003	0.019	0049	0.104	-0.032	-0.023	0.416*
Root volume (cc)	-0.235	0.157	0.020	0.024	-0.111	0.508	0.005	0.023	0.684**
Harvest index	0.030	-0.033	-0 004	0.027	0 176	-0.207	-0.017	0.003	0.442**
Grains per panicle (no)	-0.329	0.125	0.021	-0.001	-0.011	0.492	0.002	0.029	0.560**
Root weight (g)	-0.215	0.191	0.020	-0.0C2	-0.220	0.506	0.016	0.019	0.503**
Panicle length (cm)	-0.281	0.159	0.024	0.031	-0.096	0.646	0.004	0.02S	0.685**
1000 grain weight (g)	0.005	-0 005	0.008	0.100	0 077	0.151	0.005	0.011	0.360*
LB ratio of grain	-0.009	0.114	0.006	-0.021	-0.369	0.129	0.036	-0.001	-0.210
Straw yield/plant (g)	-0.223	0.133	0.021	0.021	-0.065	0.728	0.008	0.016	0.735**
Relative water content of leaf (%)	0.009	-0.037	-0.001	-0.006	0 163	-0.071	-0.082	-0.003	0.087
Boot leaf area (sq. cm)	-0.270	0.104	0.019	0.031	0 001	0.328	0.008	0.036	0.463**

Diagonal values represent the direct Residual effect - 0.0525

Table 4. Direct and indirect effects with root weight for different biometrical traits in drought tolerant rice cultures (excluding yield)

Characters	Plant height (cm)	Fibrous roots/plant (no)	First flowering (days)	50% flowering (days)	Root length (cm)	Productive tillers/plant (no)	Root volume (cm)	Harvest index
Plant height (cm)	**1.022**	0.060	-1.763	0.304	-0 008	0.078	0.205	0241
Fibrous roots plant (no)	0.534	**0.114**	-1.148	0.230	-0011	-0.207	0.329	0088
First flowering (days)	0.740	0.054	**-2.435**	0.473	-0019	0.141	0.397	0 065
50% flowering (days)	0.646	0.054	-2.395	**0.481**	-0 021	0.154	0.403	-0,003
Root length (cm)	0.343	0.052	-1.991	0.427	**-0.024**	0.279	0.387	-0.187
Productive tillers/plant (no)	-0.170	0.050	0.724	-0.LS7	0.014	**-0.473**	-0.017	0 269
Root volume (cc)	0.408	0.073	-1.880	0.377	-0018	0.015	**0.515**	0053
Harvest index	0.331	0.013	-0.214	-0.002	0.006	-0.172	0.037	**0.743**
Grains per panicle (no)	0.67!	0.080	-1.956	0.385	-0.020	0.188	0.368	-0.069
Panicle length (cm)	0.69?.	0.079	-2.234	0.453	-0019	0.060	0.426	-0.109
1000 grain weight (g)	0.472	-0.012	-0.791	0.0S6	0.003	-0.089	0.124	0 202
LB ratio of grain	-0.531	-0.008	-0.345	0.147	-0011	0.064	0.154	-0.354
Straw yield/plant	0.511	0.072	-1.723	0.332	-0.016	-0.06S	0.359	-0.212
Relative water content of leaf(%)	0.164	0.03''	0.615	-0.143	0.004	-0.184	-0.033	0 155
Boot leaf area (sq.cm)	0.64^	0.040	-1.998	0.385	-0.017	0.309	0.325	0 062

Diagonal values represent ihe direct

characters namely plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering and root length might lead to simultaneous increase in yield and root weight of single plant.

Selection of traits based on genotypic correlation alone may not be sufficient during selection programme. Further partitioning of genotypic correlation through path analysis into direct and indirect effects will be more important. The above selected five characters namely plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering and root length were studied to find their direct and indirect effect on yield and root weight through path analysis. Among the five characters selected for improving the grain yield, plant height and days to 50 per cent flowering had negative direct effects with yield (Table 3). Similar results were obtained by Shivani and Reddy (2000) and Sundaram (1992). Only three characters namely number of fibrous roots per plant, days to first flowering and root length had positive direct effects on yield. Hence for improving yield much weightage should be given for

While studying the partitioning of five traits, selected for root improvement,

Table 4. Contd...

Characters	Grains per panicle (no)	Panicle length (cm)	1000 grain weight (g)	LB ratio of grain	Straw yield/ plant(g)	Relative water content of leaf(%)	Boot leaf area (sq.cm)	Genotypic correlation coefficient
Plant height (cm)	-0.296	0.104	-0.134	-0.575	0.597	-0.027	0.366	0.174
Fibrous roots/plant (no.)	-0.316	0.106	0.031	-0.080	0.752	-0.055	0.201	0.568**
First flowering (days)	-0.361	0.141	-0.094	0.157	0.844	0.043	0.474	0.618**
50% flowering (days)	-0.360	0.144	-0.058	0.338	0.824	0.050	0.463	0.722**
Root length (cm)	-0.386	0.121	0.043	0.496	0.792	0.028	0.419	0.799**
Productive tillers/plant (no)	0.179	-0.019	-0.055	-0.149	0.171	-0.066	-0.378	-0.076
Root volume (cc)	-0.322	0.127	-0.070	0.332	0.834	0.011	0.364	0.820**
Harvest index	0.042	-0.023	-0.079	-0.528	-0.340	-0.035	0.049	-0.171
Grains per panicle (no)	**-0.450**	0.131	0.004	0.033	0.807	0.005	0.474	0.652**
Panicle length (cm)	-0.3H4	**0.153**	-0.090	0.289	1.060	0.007	0.447	0.831**
1000 grain weight (g)	0.0C7	0.048	**-0.290**	-0.233	0.247	0.011	0.178	-0.027
LB ratio of grain	-0.013	0.040	0.061	**1.107**	0.212	0.075	-0.001	0.567**
Straw yield/plant (g)	-0.304	0.136	-0.060	0.196	**1.194**	0.017	0.260	0.695**
Relative water content of leaf(%)	0.014	-0.007	0.018	-0.489	-0.116	**-0.169**	-0.059	-0.193
Boot leaf area (sq.cm)	-0.369	0.119	-0.089	-0.002	0.537	0.017	**0.578**	0.544**

Diagonal values represent the direct effects

Residual effect : 0.275

into direct and indirect effects, it was understood that only three characters namely plant height, number of fibrous roots per plant and days to 50 per cent flowering had positive direct effects (Table 4). Hence selection should be based on these characters while attempting to increase the root weight.

While there is a need to improve the yield besides increasing the root weight, selection has to be based on number of fibrous roots per plant alone. Because this is the only character, which has positive direct effect on both yield and root weight. But visual selection is not easier with number of fibrous roots per plant. Besides number of fibrous roots per plant, plant height may also be taken as the selection index for improving root weight as it has positive direct effect on root weight. Hence using fibrous root and plant height as selection criteria, simultaneous improvement of yield as well as root weight is possible which will result in more drought resistance nature.

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