Universal Impact Factor0.9285:2012; 1.2210:2013

Index Copernicus
ICV 2011: 5.09
ICV 2012: 6.42
ICV 2013: 15.8

NAAS Rating
2012 : 1.3;
2013-2014:2.69

Received on:
31st July 2015

Revised on:
20th October 2015

Accepted on:
28th October 2015

Published on:
1st December 2015

Volume No.
Online & Print
70 (2015)

Page No.
91 to 100

Life Sciences Leaflets is an international open access print & e journal, peer reviewed, worldwide abstract listed, published every month with ISSN, RNI Free- membership, downloads and access.

TRAITS ASSOCIATION AND PATH CO-EFFICIENT STUDIES IN RICE (*ORYZA SATIVA* L.) UNDER SODICITY

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ABSTRACT:

Rice is the most important staple food for 40 per cent of the world population and is grown under a wide range of agro climatic conditions. Salinity and sodicity are one of the major constraints that causes serious hazards in agriculture thereby limiting agricultural productivity. Keeping it in view the practical difficulties on reclamation of soil with gypsum, it is suggested to cultivate sodicity tolerant rice varieties. Development of rice varieties for salt affected areas is emphasized on the improvement of rice yield potential in specific environment. However, grain yield mostly depends on net result of yield contributing traits. The information related to the relationship between yield and its components in the breeding program particularly for sodicity is very limited. Hence, the present investigation was carried out to study the correlation and path analysis in six parents and their 30 F_1 hybrids of rice

(*Oryza sativa* L.) resulted from full diallel mating design under sodic environment. Investigation on correlation and path coefficient analyses revealed that there would be much scope for selecting promising high yielding, short statured with varying maturity groups in rice with inherent potential of sodicity tolerance, if selection pressure could be exerted on days to 50 percent flowering, plant height, spikelet fertility percentage, proline content, Na^+: K^+ ratio and root shoot ratio by devising suitable breeding method(s).

KEY WORDS: *Rice, Salt Tolerance, Correlation, Direct and Indirect effects.*

INTRODUCTION:

Rice occupies a pivotal place in Indian agriculture and is grown in diverse environmental conditions. A total of 800 million hectares of land throughout the world are salt affected either by salinity (397 million ha) or the associated condition of sodicity (434 million ha). In India alone, salt-affected soils have been estimated to occur in 8.6 million ha, of which about 3.0 million ha are coastal saline. In Tamil Nadu, out of 4.7 lakh hectares of salt affected soils, about 3.0 lakh hectares are in inland and 1.7 lakh hectares are confined to coastal areas. In inland salt affected soils, about 2.0 lakh hectares are alkali and 1.0 lakh ha are saline in nature. Grain yield is a polygenically controlled character with complex in inheritance (Selvaraj *et al*., 2011). It is influenced by number of component characters and environment either directly or indirectly. Hence, selection for one component may simultaneously affect related traits in a favorable direction. Therefore, identifying the characters, which are closely related and which have contributed to grain yield becomes highly essential (Rangare *et al*., 2012). Knowledge on inter- correlation between quantitative traits may facilitate breeders to decide upon the intensity and direction of selection pressure to be imparted on related traits for the simultaneous improvement.

Interrelationship of yield with other traits is considered as most valuable one while formulating any selection program. Correlation studies permit only a measure of relationship between two traits. The actual contribution of an attribute and its influence through other traits could be arrived at through the way of partitioning the genotypic correlation coefficient into direct and indirect effects by path coefficient analysis. This will be very much helpful in giving due weightage to important quantitative attributes under selection process. Path co-efficient analysis helps in selection of traits based on their direct and indirect effects which is much more useful than selection for yield *per se* alone. The knowledge on association among different traits with yield and interrelationship is essential to improve the selection efficiency. Keeping this objective in view, the present study was conducted to study the traits association and their direct and indirect effects on yield under sodicity.

MATERIALS AND METHODS:

The present study was conducted at Department of Plant Breeding and Genetics, Anbil Dharmalingam Agricultural College and Research Institute, Trichy, where the soil is found to be sodic in nature. The soil in the experimental field was sodic soil with a pH of 9.5 and ESP of 23. The water used for irrigating the experimental field was taken from the bore well with pH > 9.0 and RSC is 10 meq/l. Six parents *viz.*, BPT 5204, IR64, RNR 57979, TETEP, IW Ponni and FL 478 were crossed in a diallel mating design to produce 30 F_1 hybrids. The resultant hybrids along with parents were raised in randomized block design with three replications by adopting recommended cultural practice. Five plants were selected at random from each genotype in each replication to record data on 14 physio-morphological traits *viz*., days to 50 percent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, spikelet fertility percentage, 100 grain weight, single plant yield, dry root weight, dry shoot weight, root: shoot ratio, Na^+: K^+ ratio, chlorophyll content and proline content. The biometrical observations were recorded for yield, its components and physiological traits under sodicity as per the Standard Evaluation System (SES) for rice (IRRI, 1996). Statistical analyses for the above traits were done by following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis. The direct and indirect effects were classified based on the scale given by Lenka and Misra (1973).

RESULTS AND DISCUSSION:

Traits association

The yielding ability of rice is governed by polygenes. Knowledge on the association between yield and its component traits themselves can improve the efficiency of selection. Further, the inter relationship of complex characters of yield provide information about likely consequences of selection for simultaneous improvement of desirable characters under selection. Knowledge on inter-correlation between quantitative traits may facilitate breeders to decide upon the intensity and direction of selection pressure to be imparted on related traits for the simultaneous improvement.

The genotypic correlation co-efficient between yield, its components and physiological traits and also among the component traits were worked out and furnished in Table 1. In the present study, single plant yield recorded positive and significant association with spikelet fertility percentage (0.348) and proline content (0.438), while, it had non- significant positive association with number of filled grains per panicle (0.192), 100 grain weight (0.045), dry root weight (0.077) and root shoot ratio (0.156). Single plant yield exhibited negative and significant values with plant height (-0.399), while the trait registered non-significant and negative values with days to 50 percent flowering (- 0.272), number of productive tillers per plant (-0.039), panicle length (-0.147), dry shoot weight (- 0.070), Na^+: K^+ ratio (- 0.086) and chlorophyll content (-0.020).

In the present study, single plant yield showed positive and significant correlation with two traits *viz.*, spikelet fertility percentage and proline content. Spikelet fertility percentage is an important yield parameter under sodicity because it determines the number of filled grains per panicle and in turn contributes to yield. It has also been suggested that proline accumulation can serve as a selection criterion for the tolerance to any abiotic stress. Hence, the present study highlighted the significance two traits *viz.*, spikelet fertility percentage and proline content while excising selection of genotypes evaluated under sodicity as both traits were positively and significantly associated to each other. Wanichananan *et al*. (2003) reported the positive association of single plant yield with proline content. Shanthi *et al*. (2011) demonstrated that selection on spikelet fertility percentage would improve grain yield under salinity. Significant and negative correlation was established between single plant yield and plant height suggesting the possibilities of obtaining short stature, fertilizer responsive genotypes coupled with increased yield under sodicity. The result on significant and negative correlation of plant height with spikelet fertility per cent also confirmed the above finding. There is a positive relationship between low Na^+: K^+ ratio and salt tolerance making it as the best indicator of growth and yield under salt stress. The tolerant plants will accumulate low Na^+ ion and simultaneously there will be greater uptake of K^+ ion in leaves. In the present study, plant height had significant and negative association with Na^+: K^+ ratio (-0.414) suggesting that short statured genotypes might possess low Na^+: K^+ ratio thereby tolerance to sodicity will be resulted. The positive and significant inter-correlation between spikelet fertility percentage and dry root weight (0.465) might be an encouraging sign for the breeders while excising selection. The number of productive tillers per plant may play a role in salt tolerant genotypes due to the fact that salt affected plants will show the symptoms of stunted growth with reduced spikelets. The trait exhibited significant and positive correlation with the other physiological trait *viz.*, root- shoot ratio (0.342). The significant and positive inter correlation between root-shoot ratio and dry root weight (0.398) might also useful to obtain genotypes with more number of productive tillers. Significant and negative association between two physiological traits *viz.*, proline content and Na^+: K^+ ratio (-0.649) also indirectly would be useful while excising selection of genotypes under target environment for yield improvement. There was a negative and significant correlation between days to 50 percent flowering and spikelet fertility percentage (-0.687) indicating the possibility of development of mid-early or early duration rice varieties with more number of filled grains per panicle under problem soils. Panwar and Ali (2007) also obtained similar results for days to 50 percent flowering. Besides, genetic architecture of genotypes, shorter duration might also alleviate salt injury at various developmental growth stages in rice. Since, as there was negative and significant association between days to 50 percent flowering and dry root weight (0.642), the early duration variety possess increased dry root weight which might arise from the development of long and dense roots. More, dense and effective roots may alleviate salt injury. Generally, tall statured genotypes with loose panicles will tolerate salt injury. It is necessary to break the undesirable association between two traits. In the present set of materials, as there was a non-linear relationship between panicle length and spikelet fertility percentage, there would be a scope for the development of dense panicle with more number of filled grains through effective source sink relationship. There existed a positive and significant correlation between number of filled grains per panicle and dry shoot weight (0.318) which might be useful in excising selection. The inverse correlation between plant height and dry root weight (-0.521) might be encouraging due to the fact that short statured genotypes would have more root weight. Even though shoot and root associated traits are responsible for abiotic stress tolerance, root traits are believed to contribute more towards tolerance.

Path co-efficient analysis

Correlation studies permit only a measure of relationship between two traits. The actual contribution of an attribute and its influence through other traits could be arrived at through the way of partitioning the genotypic correlation coefficient into direct and indirect effects by path coefficient analysis. This will be very much helpful in giving due weightage to important quantitative attributes under selection process.

Direct effects

In the present investigation, the study revealed that dry shoot weight (2.460) and root shoot ratio (3.099) exhibited a very high positive direct effect on single plant yield. Two traits *viz.*, number of filled grains per panicle (0.349), 100 grain weight (0.477) registered high positive direct effect on single plant yield, while, other two traits *viz.*, spikelet fertility percentage (0.240) and chlorophyll content (0.297) had moderate effect. Proline content (0.149) exhibited positive and low positive direct effect, while, number of productive tillers per plant (0.085) had negligible positive direct effect on grain yield. Days to 50 per cent flowering registered a negligible negative effect (-0. 004) on single plant yield. Two traits *viz.*, Na^+: K^+ ratio (-0.273) and plant height (-0. 295) expressed moderate and negative direct effect on single plant yield. Manonmani and Ranganathan (2006) reported positive direct effect of yield with number of productive tillers per plant, number of filled grains per panicle and chlorophyll content.

Indirect effects

Days to 50 percent flowering showed negligible negative indirect effect through number of productive tillers per plant (-0.0003), plant height (-0.003), panicle length (-0.001) and root: shoot ratio (-0.0002).

Plant height expressed negative indirect effect through days to 50 percent flowering, panicle length, number of filled grains per panicle, 100 grain weight and chlorophyll content. Number of productive tillers per plant showed negligible indirect effect through rest of the traits. Spikelet fertility percentage had a moderate negative indirect effect through plant height (-0.223) which was found to be desirable for the breeders in excising selection for short statured plant genotype possessing more number of filled grains per panicle under salinity/ sodicity. Two traits *viz.*, panicle length (0.281) and 100 grain weight (0. 268) registered moderate positive indirect effect through dry root weight suggesting the possibility of selection of yield as well as physiological traits simultaneously. The finding was further evidenced through positive indirect effect of dry shoot weight with number of filled grains per panicle (0.783), spikelet fertility percentage (0.372), 100 grain weight (0.258) and chlorophyll content (0.815) and indirect effect of root shoot ratio with panicle length (0.227), dry shoot weight (1.23) and proline content (0.625).

Direct yield improvement under sodicity stress condition is difficult. Hence, yield improvement in sodic environments could be achieved by identifying secondary traits contributing to salt tolerance and selecting for those traits in a breeding program. From the foregoing discussion of association and path co-efficient studies in the present set of breeding materials, it was evident that there will be much scope for selecting promising high yielding, short statured with varying maturity groups in rice with inherent potential of sodicity tolerance, if selection pressure would be exerted on days to 50 percent flowering, plant height, spikelet fertility percentage, proline content, Na^+: K^+ ratio and root – shoot ratio by devising suitable breeding method(s). This finding was in accordance with Shanthi *et al*. (2011).

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Table 1. Genotypic correlation coefficients between different quantitative traits

	DFF	PHT	NPT	PL	NFGP	SFP	HGW	DRW	DSW	RSR	$Na^+:K^+$	CC	PC	SPY
DFF	**1.00**	0.668*	0.052	0.359*	-0.209	-0.687**	0.259	-0.642**	-0.181	0.038	-0.170	-0.166	-0.147	-0.272
PHT		**1.00**	-0.025	0.395*	0.163	-0.927**	0.247	-0.521**	-0.025	-0.122	-0.414*	0.038	-0.139	-0.399*
NPT			**1.00**	-0.067	-0.361*	-0.192	0.089	-0.239	-0.420*	0.342*	0.425**	-0.438**	0.083	-0.039
PL				**1.00**	0.028	-0.336*	0.264	-0.365*	-0.146	0.073	-0.192	0.104	-0.135	-0.147
NFGP					**1.00**	-0.074	-0.132	-0.060	0.318*	-0.302	-0.020	0.417*	-0.083	0.192
SFP						**1.00**	-0.134	0.465**	0.151	-0.042	0.304	0.075	0.122	0.348*
HGW							**1.00**	-0.347*	0.105	-0.244	-0.150	-0.111	0.082	0.045
DRW								**1.00**	-0.177	0.398*	0.630**	0.169	0.034	0.077
DSW									**1.00**	-0.949**	0.013	0.331*	-0.212	-0.070
RSR										**1.00**	0.166	-0.315*	0.201	0.156
$Na^+:K^+$											**1.00**	0.035	-0.649**	-0.086
CC												**1.00**	-0.316*	-0.020
PC													**1.00**	0.438**

*Significant at 5 per cent level

** Significant at 1 per cent level

DFF –Days to 50 percent flowering, **PHT** – Plant height, **NPT** – Number of productive tillers per plant, **PL**- Panicle length, **NFGP** –Number of filled grains per panicle, **SFP** – Spikelet fertility percentage, **HGW**- 100 grain weight, **SPY** – Single plant yield, **DRW** – Dry root weight, **DSW** – Dry shoot weight, **RSR**-Root :shoot ratio, **Na^+:K^+** - Na^+: K^+ ratio, **CC** – Chlorophyll content, **PC** – Proline content

Table 2. Direct and indirect effects of different quantitative traits as partitioned by path analysis

Trait	DFF	PHT	NPT	PL	NFGP	SFP	HGW	DRW	DSW	RSR	Na+:K+	CC	PC	SPY
DFF	**-0.004**	-0.003	-0.0003	-0.001	0.001	0.003	-0.001	0.003	0.0009	-0.0002	0.0008	0.0008	0.0007	-0.272
PHT	-0.196	**-0.295**	0.007	-0.116	-0.048	0.274	-0.073	0.153	0.007	0.036	0.122	-0.011	0.041	-0.399*
NPT	0.004	-0.002	**0.085**	-0.002	-0.031	-0.016	0.007	-0.020	-0.036	0.029	0.036	-0.037	0.007	-0.039
PL	-0.104	-0.114	0.019	**-0.290**	-0.008	0.097	-0.076-	0.105	0.042	-0.021	0.055	-0.030	0.039	-0.147
NFGP	-0.073	0.057	-0.126	0.010	**0.349**	-0.026	-0.046	-0.021	0.111	-0.105	-0.007	0.145	-0.029	0.192
SFP	-0.166	-0.223	-0.046	-0.081	-0.018	**0.240**	-0.032	0.112	0.036	-0.010	0.073	0.018	0.029	0.348*
HGW	0.124	0.118	0.042	0.126	-0.063	-0.064	**0.477**	-0.165	0.050	-0.116	-0.071	-0.053	0.039	0.045
DRW	0.499	0.401	0.185	0.281	0.046	-0.359	0.268	**-0.771**	0.136	-0.307	-0.486	-0.130	-0.026	0.077
DSW	-0.446	-0.063	-1.033	-0.361	0.783	0.372	0.258	-0.435	**2.460**	-2.337	0.033	0.815	-0.521	-0.070
RSR	0.120	-0.379	1.061	0.227	-0.936	-0.131	-0.757	1.23	-2.943	**3.099**	0.517	-0.978	0.625	0.156

$Na^+:K^+$	0.046	0.113	-0.116	0.052	0.005	-0.083	0.041	-0.172	-0.003	-0.045	**-0.273**	-0.009	0.177	-0.086
CC	-0.049	0.011	-0.130	0.031	0.124	0.022	-0.033	0.050	0.098	-0.094	0.010	**0.297**	-0.094	-0.020
PC	-0.022	-0.020	0.012	-0.020	-0.012	0.018	0.012	0.005	-0.031	0.030	-0.096	-0.047	**0.149**	0.438**

Residual effect = 0.57. Note: Diagonal and bold data indicated the direct effect.

DFF –Days to 50 per cent flowering, **PHT** – Plant height, **NPT** – Number of productive tillers per plant, **PL -** Panicle length, **NFGP** – Number of filled grains per panicle, **SFP** – Spikelet fertility percentage, **HGW -** 100 grain weight, **SPY** – Single plant yield, **DRW** – Dry root weight, **DSW** – Dry shoot weight, **RSR**- Root: shoot ratio, **Na^+: K^+**- Na^+: K^+ratio, **CC** – Chlorophyll content, **PC** – Proline content