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Research Note

Genetic variability, correlation and path coefficient analysis studies in rice (*Oryza sativa* L.) under alkaline soil condition

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Abstract:
Rice occupies a pivotal place in the Indian agriculture and has been grown under diverse ecological conditions and gets exposed to different environmental stresses like salinity, alkalinity, drought, cold etc. The experiment was conducted to study the response of rice genotypes and their quantitative traits under alkaline soil condition to examine the nature and magnitude of variability, heritability and genetic advance. Variability studies revealed significant differences among the genotypes for the traits studied. High values of heritability and genetic advance were observed for total spikelet per panicle, thousand grain weight and total biomass. Number of productive tillers, total spikelet per panicle, total biomass, days to 50 per cent flowering and plant height were the traits which exhibited significant positive association with grain yield. Path analysis revealed that their direct effects on grain yield through total biomass and harvest index were also very high. Thus these traits which contribute to the grain yield under alkaline soil condition could be exploited for further breeding programme.

Keywords: Rice, correlation, path coefficient analysis, soil alkalinity, grain yield

Rice (*Oryza sativa* L.) occupies a pivotal place in the Indian agriculture. Rice is also called as the “Grain of Life”, because it is not only the staple food for more than 70 per cent of the Indians but also a source of livelihood for about 120-150 million rural households. At the current rate of population growth accelerating at 1.8 per cent, rice requirement by the year 2020 would be around 140 million tones (Anon., 2004). Rice has been grown under diverse ecological conditions and gets exposed to different environmental stresses like salinity, alkalinity, drought, cold etc. Soil alkalinity and salinity are widespread problems in a number of rice growing countries, particularly in Asian continent. Among the South Asian countries, India has the largest area of about 13.3 million *ha*, followed by Bangladesh and Sri Lanka. In India alone, 6.7 million *ha* is characterized by coastal salinity, and inland alkaline and saline soils cover an area of about 6.6 million *ha* (2.64 million *ha* saline and 3.96 million *ha* saline-alkaline) (Anon., 2003). Alkali soils are characterized by a relatively less (EC < 4 dS/m at 25°C) salt concentration and/or high (> 8.2) pH and Exchangeable sodium percentage of >15 (Abrol *et al*., 1988).

Poor water management and excessive use of irrigation water are the chief causes for waterlogging and salt build up. Irrigation water contains an appreciable amount of dissolved salts and evapotranspiration leads to accumulation of salts in the soil surface (Gupta, 1970). The salt that is added to the soil by irrigation water gets added to the salts that are naturally occurring in the soil. This unavoidable accumulation of salts in soils due to excessive irrigation and poor water management practices leads to unfavourable soil-water–air relationship which results in problematic soils. Gradually the land goes out of cultivation, unless remedial measures are undertaken. Thus, salinity and alkalinity is a challenge to the permanence of irrigated agriculture. The principle involved in the improvement of saline / alkali soils include (a) establishment of drainage (b) replacement of adsorbed sodium by calcium (c) removal of excess salts and (d) the rearrangement and stable aggregation of soil particles. Several chemical amendments, such as gypsum, calcium chloride and acids, have proven to reclaim sodic soils effectively (Abrol *et al*., 1988). But, the cost of the amendments like sulphur and gypsum is increasing and it becomes difficult for the farmers to use them in quantities recommended for reclamation (Qadir *et al*., 1996). Rice varieties are known to exhibit wide variation in their tolerance to salinity and alkalinity (IRRI, 2006; Pathak *et al*., 2005). In this regard identification and evaluation of alkaline tolerant genotypes of rice along with proper management of soil was taken in Zonal Agricultural Research Station, Mandya, Karnataka, with the following objectives. Studying the genetic variability of rice genotypes under alkaline soil condition, studying relationship of different plant traits with grain yield through correlation and path analysis which would help in selection and further improvement and in identification of rice genotypes which are tolerant to alkaline condition which would be economical to the farmers in increasing their production.

The material for the present study consisted of 33 genotypes of rice collected from AICRP (Rice), Mandya, University of Agricultural Sciences, Bangalore and International Rice Research Institute, Philippines. Field experiment was conducted at Zonal Agricultural Research Station, Mandya, Karnataka. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. All cultural practices are followed as per the package of practices adopted for irrigated rice. Soil samples from all the three replications were collected and they were analyzed for parameters such as pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium using standard procedures.

Observations were recorded on five randomly selected plants in each replication for plant height, days to 50 per cent flowering, productive tillers per plant, panicle length, spikelets per panicle, spikelet fertility, total biomass, thousand grain weight, harvest index and grain yield per plant. Data for the above traits were subjected to statistical analysis *viz*., Analysis of variance (ANOVA), mean, range, genetic variability components such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as percent t mean (GAM). Correlation analysis was computed as per Karl Pearson (1932) and path coefficient analysis was carried out as suggested by Wright (1921).

Genetic variability in any crop is pre-requisite for selection of superior genotypes over the existing cultivars. Variance analysis for all the characters revealed significant variation among the genotypes studied (Table 1). Data from the soil analysis revealed that particular experimental soils are characterized by a relatively less EC < 4 dS/m (1.2), high pH > 8.2 (9.6) and Exchangeable sodium percentage is more than 15 (alkali soils). The phenotypic coefficient of variation (PCV) in general was higher than genotypic coefficient of variation (GCV) for all the characters studied indicated the influence of environment on the manifestation of these characters. However, the difference between PCV and GCV was less for the characters, total spikelet per panicle, thousand grain weight and days to 50 per cent flowering which indicated low environmental influence and predominance of genetic factors controlling variability in these traits.

The amount of genetic variation considered alone will not be of much use to the breeder unless supplemented with the information on heritability estimate, which gives a measure of the heritable portion of the total variation. It has been suggested by Burton and Devane (1953) that the GCV along with heritability estimate could provide a better picture of the amount of advance to be expected by phenotypic selection. Since genetic advance is dependent on phenotypic variability and heritability in addition to selection intensity, the heritability estimates in conjunction with genetic advance will be more effective and reliable in predicting the response to selection (Johnson *et al*., 1955). Heritability in broad sense includes both additive and non-additive gene effects (Hanson *et al*., 1956). While, narrow sense heritability includes only additive components (Johnson *et al*., 1955). In the present study, heritability in broad sense was estimated. Highest broad sense heritability was recorded in the case of total spikelet per panicle, thousand grain weight, days to 50 per cent flowering and total biomass. However, low heritability estimates were observed in the case of number of productive tillers and plant height. The expected genetic advance over mean of the characters was found to be highest for total spikelet per panicle followed by total biomass, grain yield per plant and thousand grain weight. The study clearly showed that there is ample scope to improve total spikelet per panicle, total biomass, grain yield per plant and thousand grain weight through selection.

<u>Correlation between characters</u>: Selection for a specific character is known to result in correlated response in certain other characters (Falconer, 1964). Generally, plant breeders make selection for one or two attributes at a time, then it becomes important to know the effect on other characters. Simple phenotypic correlation indicated broadly the type of association that exists between various attributes. But simple phenotypic correlations by themselves do not provide any reliable basis for selection. Hence the genotypic correlations, which are based on the

heritable part of the observed variation, enable the assessment of the pattern of inherent relationship that existed between various traits. The inter character correlation at phenotypic and genotypic levels among ten characters studied are presented in Table (2 and 3). High significant and positive correlation of grain yield per plant with plant height, days to 50 per cent flowering, number of productive tillers at genotypic level. Total spikelets per panicle and total biomass were significant and positively correlated with grain yield per plant both at phenotypic and genotypic levels.

The magnitude of genotypic correlation with grain yield per plant was highest in the case of number of productive tillers per plant followed by total biomass, total spikelets per panicle, plant height and days to 50 per cent flowering. Other yield components *viz*., plant height, days to 50 per cent flowering, number of productive tillers, panicle length, spikelet fertility and harvest index showed non-significant positive association with grain yield at phenotypic level. Similar findings were earlier reported by Nadarajan and Kumarvelu (1994) for panicle length and grains per panicle, by Balan *et al.,* (1999) for days to 50 per cent flowering, and Janardhanam *et al*., 2001 for number of grains per panicle.

Path coefficient analysis: Path coefficient analysis was carried out both at phenotypic and genotypic levels considering the grain yield as dependent character and yield attributes as independent characters. Each component has two-path action *viz.,* direct effect on yield and indirect effects through component characters, which were not revealed by correlation studies. The phenotypic and genotypic correlations were partitioned into direct and indirect effects on grain yield per plant and the data is presented in Table (4 and 5). Among the characters studied at phenotypic level, total biomass had highest direct positive effect on grain yield per plant followed by harvest index, spikelet fertility, thousand grain weight, number of productive tillers and days to 50 per cent flowering. The highest direct negative contribution to the grain yield was recorded by total spikelet per panicle followed by plant height and panicle length.

At genotypic level, with respect to positive direct effect, the contribution to grain yield per plant by total biomass was the highest followed by harvest index, plant height, days to 50 per cent flowering, panicle length and spikelet fertility. The direct negative effect of total spikelet per panicle was highest followed by thousand grain weight and number of productive tillers.

Among the different traits studied, total biomass and total spikelets per panicle showed the maximum direct effects on grain yield per plant at phenotypic level. While at genotypic level, total biomass, plant height and days to 50 per cent flowering showed maximum direct effects on yield. Thus, it is understood that biomass, plant height and days to 50 per cent flowering decide the yield, this is also in line with the physiological basis of the concept of developing "super rice" having the capacity to produce more biomass. These results are also in accordance with the previous studies (Deosarkar and Nerkar, 1994; Sarawagi *et al*., 1997; Bagali *et al*., (1999). It is also understood that the increased grain yield through the direct effect of biomass is through the indirect effect of plant height and days to 50 per cent flowering followed by moderate to low indirect effects of thousand grain weight, spikelet fertility and harvest index. These findings were in confirmation with earlier findings (Yolanda and Das, 1995; Sarawagi *et al*., 1997). Thus, total biomass appears to be important trait on which emphasis can be laid as a selection criteria for tolerance to alkalinity in Cauvery command area.

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Table 1. Genetic variability parameters for ten yield components in 33 rice genotypes under alkaline soil condition

Character	Mean	Range		GCV%	PVC%	Heritability (%)	GAM
		Min.	Max.				
Plant height (cm)	57.37	42.00	78.33	8.90	21.13	17.7	7.72
Days to 50% flowering	108.37	85.00	127.33	9.73	10.51	85.9	18.57
Number of productive tillers	6.101	4.00	8.33	5.41	24.93	04.7	2.45
Panicle length (cm)	18.05	13.60	20.67	6.84	10.97	38.9	8.80
Spikelet per panicle	77.14	26.00	122.00	32.55	33.09	96.8	65.9
Spikelet fertility (%)	83.78	59.53	92.07	6.26	10.90	33.0	7.40
Total biomass (g)	63.90	37.37	133.3	26.77	31.88	70.6	46.33
Thousand grain weight (g)	22.11	16.00	34.00	17.38	18.57	87.6	33.51
Harvest index (%)	42.46	26.01	49.60	10.22	14.15	52.1	15.19
Yield per plant (g)	5.40	2.80	9.60	24.53	31.75	59.7	39.07

Table 2. Phenotypic correlation coefficients among ten yield components in 33 rice genotypes under alkaline soil condition

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1.000	-0.159	0.133	0.230	0.066	0.318	0.247	0.088	-0.004	0.234
X_2		1.000	0.083	0.012	0.388*	-0.120	0.322	-0.431	-0.028	0.283
X_3			1.000	-0.050	0.088	0.162	0.188	0.027	0.096	0.237
X_4				1.000	0.377*	0.090	0.363*	-0.055	-0.154	0.268
X_5					1.000	0.016	0.673**	-0.294	-0.296	0.493**
X_6						1.000	0.114	0.192	-0.066	0.106
X_7							1.000	-0.326	-0.096	0.892**
X_8								1.000	-0.035	-0.301
X_9									1.000	0.349
X_{10}										1.000

***** = Significant P= 0.05 Probability level***
***** = Significant P=0.01 Probability level***

X_1 - Plant height (cm)
X_2 - Days to 50% flowering
X_3 - Number of productive tillers
X_4 - Panicle length (cm)
X_5 - Spikelet per panicle
X_6 - Spikelet fertility (%)
X_7 - Total biomass (g)
X_8 - Thousand grain weight (g)
X_9 - Harvest index (%)
X_{10} -Yield per plant (g)

Table 3. Genotypic correlation coefficients among ten yield components in 33 rice genotypes under alkaline soil condition

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1.000	-0.474	0.479**	0.100	0.120	0.382*	0.579**	0.446*	-0.146	0.512**
X_2		1.000	0.212	0.098	0.422*	-0.202	0.424*	-0.476	-0.058	0.405*
X_3			1.000	0.762**	0.246	0.197	0.671**	-0.044	0.628**	0.998**
X_4				1.000	0.617**	0.013	0.441*	-0.050	-0.373	0.279
X_5					1.000	0.059	0.810**	-0.324	-0.380	0.660**
X_6						1.000	0.152	0.360*	-0.137	0.139
X_7							1.000	-0.351	-0.271	0.902**
X_8								1.000	-0.023	-0.337
X_9									1.000	0.154
X_{10}										1.000

**** = Significant P= 0.05 Probability level; ** = Significant P=0.01 Probability level***

X_1 - Plant height (cm)
X_2 - Days to 50% flowering
X_3 - Number of productive tillers
X_4 - Panicle length (cm)
X_5 - Spikelet per panicle
X_6 - Spikelet fertility (%)
X_7 - Total biomass (g)
X_8 – Thousand grain weight (g)
X_9 - Harvest index (%)
X_{10} -Yield per plant (g)

Table 4. Phenotypic Path analysis of ten yield components influencing yield in 33 rice genotypes under alkaline soil condition

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	**-0.005**	-0.001	0.002	-0.001	0.000	0.008	0.231	0.001	-0.002
X_2	0.001	**0.003**	0.001	0.000	-0.002	-0.003	0.302	-0.007	-0.012
X_3	-0.001	0.000	**0.015**	0.000	-0.001	0.004	0.176	0.000	0.042
X_4	-0.001	0.000	-0.001	**-0.002**	-0.002	0.002	0.340	-0.001	-0.067
X_5	0.000	0.001	0.001	-0.001	**-0.006**	0.000	0.0631	-0.005	-0.130
X_6	-0.002	0.000	0.002	0.000	0.000	**0.024**	0.107	0.003	-0.029
X_7	-0.001	0.001	0.003	-0.001	-0.004	0.003	**0.938**	-0.005	-0.042
X_8	0.000	-0.001	0.000	0.000	0.002	0.005	-0.306	**0.016**	-0.015
X_9	0.000	0.000	0.001	0.000	0.002	-0.002	-0.090	-0.001	**0.438**

Residual = 0.0126

X_1 - Plant height (cm)
X_2 - Days to 50% flowering
X_3 - Number of productive tillers
X_4 - Panicle length (cm)
X_5 - Spikelet per panicle
X_6 - Spikelet fertility (%)
X_7 - Total biomass (g)
X_8 - Thousand grain weight (g)
X_9 - Harvest index (%)

Table 5. Genotypic Path analysis of ten yield components influencing yield in 33 rice genotypes under alkaline soil condition

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	**0.139**	-0..059	-0.039	0.012	-0.001	0.028	0.526	-0.015	-0.078
X_2	-0.066	**0.125**	-0.017	0.011	-0.004	-0.015	0.385	0.016	-0.031
X_3	0.067	0.027	**-0.081**	0.088	-0.002	0.014	0.601	0.001	0.284
X_4	0.014	0.012	-0.061	**0.116**	-0.006	0.001	0.401	0.002	-0.199
X_5	0.017	0.053	-0.020	0.072	**-0.009**	0.004	0.736	0.011	-0.203
X_6	0.053	-0.025	-0.016	0.001	-0.001	**0.073**	0.138	-0.012	-0.073
X_7	0.081	0.053	-0.062	0.051	-0.008	0.011	**0.909**	0.012	-0.145
X_8	0.062	-0.060	0.004	-0.006	0.003	0.026	-0.319	**-0.034**	-0.012
X_9	-0.020	-0.007	-0.058	-0.043	0.004	-0.010	-0.246	0.001	**0.534**

Residual = 0.0243

X_1 - Plant height (cm)
X_2 - Days to 50% flowering
X_3 - Number of productive tillers
X_4 - Panicle length (cm)
X_5* - *Spikelet per panicle
X_6 - Spikelet fertility (%)
X_7 - Total biomass (g)
X_8 - Thousand grain weight (g)
X_9 - Harvest index (%)