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Inter-relationship analysis for improvement of yield components in rice (*Oryza sativa* L.) under sodic soil

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Abstract
The experiment was conducted at A.N.D.U.A&T, main experiment station during 2015-2016 rice growing season in sodic soil environment. The objective of this test is to establish the nature of relation between grain yield and other yield components by partitioning the correlation co-efficient between yield and its component by using simple correlation analysis. The study was conducted with 10 parents and their 21 crosses (F_1) for eleven component characters including grain yield. The correlation studies of these crosses showed that grain yield per plant showed positive and significant correlation with harvest index, spikelet fertility (%), biological yield per plant and panicle bearing tiller per plant so they emerged as most important association for grain yield improvement in rice during breeding programme.

Keywords: Correlation, spikelet fertility, positive, negative correlation

Introduction
Rice (*Oryza sativa* L.) is one of the world's most important food crops and a primary source of food for more than half of the world populations. Rice is an important staple food crop in the world. Rice (*Oryza sativa* L., 2n=24) belongs to the family Poaceae (Graminae). Rice has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is a diploid species having 24 chromosomes. The *Oryza sativa* varieties are commonly grouped in to three subspecies namely: indica, japonica and javanica. . It is best suited to region which has high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37oC. Photo periodically rice is a short day plant, however, there are varieties which are non-sensitive to photo periodic condition. Rice is grown under different agro-climatic conditions and production systems but it is rated as an especially Salt-Sensitive Crop. Rice is the only the cereal which can be grown successfully in standing water. For the development of high yielding pure line as well as hybrid varieties in rice or any crop, the information on various genetic aspects of important plant characters is essential for planning and execution of a successful breeding programme. Selection for one component may simultaneously affect related traits in a favourable direction. Therefore, identifying the characters, which are closely related and which have contributed to grain yield becomes highly essential. 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 observe any influence on correlations among yield attributes under sodic environment.

Material and Methods
The basic material for the present investigation comprised of ten rice genotypes / varieties for seven lines *viz.*, IR11T197, IR11T104, IR11T205, FL-478, pant basmati-1, NDRK5009, IR 12T193 and three testers *viz.*,CSR-10,CSR-36 and Jaya was obtained from various place were utilized for the study. The genotypes were used for crossing programme in a line x tester analysis (7 lines x 3 testers). Field plot was well prepared for sowing of experimental material (31 genotypes – comprising 10 parents and 21 F_1's seeds). Their of 10 parents and 1 check varieties (Narendra Usar 3) were evaluated in Randomized Complete Block Design with three replications during *Kharif*, 2016 at (M.E.S of A.N.D.U.A&T, Kumarganj Ayodhya). The seeds of each entry were sown on 22st June, 2016 in separate plots and 22 days (14th July 2016) old seedlings were transplanted single seedling per hill in single row plots of 3 m length with inter and intra- row spacing of 20 cm and 15 cm, respectively. All the recommended cultural practices were followed to raise a good crop. The observations were recorded on five randomly selected competitive plants of a genotype in a plot in each replication for eleven

characters. The mean values of observations recorded on five plants of each plot were used for analysis. Observation were recorded on days to 50 per cent flowering, plant height, panicle bearing tillers per plant, panicle length, flag leaf area, spikelet's per panicle, spikelet fertility, 1000- grain weight, biological yield per plant, harvest-index and grain yield per plant. Association among different characters at genotypic and phenotypic levels was worked out as suggested by Searle (1961) [6]

$$\text{Genotypic correlation coefficients (rg)} = \frac{\text{cov. XY (g)}}{\sqrt{\text{var.Xg} \times \text{var.Yg}}}$$

$$\text{Phenotypic correlation coefficients (rp)} = \frac{\text{cov. XY (p)}}{\sqrt{\text{var.Xp} \times \text{var.Yp}}}$$

Where

Cov. XY (g) and Cov. XY (p) denotes genotypic and phenotypic covariance between characters X and Y, respectively. Var. X (g), Var. Y (g) and Var. X (p), Var. Y (p) denotes variance for characters X and Y at genotypic and phenotypic levels, respectively.

Results and Discussion

Grain yield or economic yield, in almost all the crops, is the complex character which manifests from multiplicative interactions of several other characters that are termed as yield components. The genetic architecture of grain yield in rice as well as other crops is based on the balance or overall net effect produced by various yield components directly or indirectly by interacting with one another. Therefore, selection for yield per se alone would not matter much as such unless accompanied by the selection for various component characters responsible for conditioning it. Thus, identification of important components and information about their association with yield and with each other are very useful for developing efficient breeding strategy for evolving high yielding varieties/hybrids. The correlation coefficient is the measure of degree of symmetrical association between two variables or characters which helps us in understanding the nature and magnitude of association among yield and yield components. The estimates of phenotypic correlation coefficients computed between eleven characters under study are presented in Table no. 01.The grain yield per plant exhibited highly significant and positive correlation with harvest index (0.583). Biological yield per plant (0.445), spikelet fertility (0.377) and panicle bearing tillers per plant (0.279), but it had negatively significant or highly significant phenotypic correlation viz; flag leaf area (-0.251) and day to 50% flowering (-0.361) respectively. Harvest index showed positive correlation of highly significant level with panicle bearing tillers per plant (0.248) but had negatively significant correlation for the characters spikelet per panicle (-0.240) and flag leaf area (-0.290) respectively. Biological yield per plant showed positive association with spikelet's fertility (0.339) and panicle length (0.305) but had negative association of highly significant degree with days to 50% flowering (-0.342) and spikelet's per panicle (-0.236). The 1000-grain weight showed of highly significant positive correlation with spikelets per panicle (0.526), spikelet fertility (0.495), panicle length (0.345),

Table 1: Estimates of phenotypic correlation coefficients between 11 traits in rice

S. No.	Traits	PH	PBTP	PL	FLA	SP	SF	GW	BYP	HI	GYP
1	D50F	0.315**	-0.293**	-0.090	0.493**	-0.322**	-0.339**	-0.404**	-0.342**	-0.119	-0.361**
2	PH		-0.105	0.149	0.462**	-0.181	-0.139	0.215*	-0.103	-0.039	-0.056
3	PBTP			-0.099	-0.029	0.485**	0.244*	0.333**	-0.141	0.248*	0.279**
4	PL				0.440**	0.122	-0.014	0.345**	0.305**	-0.204	-0.111
5	FLA					0.021	0.083	0.287**	-0.117	-0.290**	-0.251*
6	SP						0.232*	0.526**	-0.236*	-0.240*	-0.165
7	SF							0.495**	0.339**	0.019	0.377**
8	GW								0.004	-0.158	0.011
9	BYP									0.097	0.445**
10	HI										0.583**

Traits: D50F = Days to 50% flowering, PH = Plant height, PBTP = Panicle bearing tillers plant^{-1}, PL = Panicle length (cm), FLA = Flag leaf area (cm^2), SP = Spikelet's per panicle, SF = Spikelet Fertility (%), GW = Grain weight (g), BYP = Biological yield plant^{-1} (g), HI = Harvest index (%), GYP = Grain yield per plant. *,**.Significant at 5% and 1% probability level, respectively

panicle bearing tillers per plant (0.333), flag leaf area (0.287) and plant height (0.215) along with negative association with days to 50% flowering (-0.404). Spikelet's per panicle showed significant positive correlation with panicle bearing tillers per plant (0.485) along with negative correlation with day to 50% flowering (-0.322). Spikelet fertility showed significant positive association with panicle bearing tillers per plant (0.244) and spikelet's per panicle (0.232) along with highly significant and negative association with days to 50% flowering (-0.339). Flag leaf area showed positive correlation with days to 50% flowering (0.493), plant height (0.462) and panicle length (0.440). Panicle bearing tillers per plant had highly significant negative correlation with days to 50% Flowering (-0.293) while plant height recorded highly significant and positive association with days to 50% Flowering (0.315). The remaining estimates of phenotypic correlations in this analysis were non- significant.

The estimates of genotypic correlation coefficients between 11 eleven characters present in Table no 02 were generally similar in sign but higher in magnitude than the corresponding phenotypic correlation coefficients.

Table 2: Estimates of genotypic correlation coefficients between 11 traits in rice

S. No.	Traits	PH	PBTP	PL	FLA	SP	SF	GW	BYP	HI	GYP
1	D50F	0.326	-0.309	-0.106	0.494	-0.337	-0.348	-0.434	-0.365	-0.151	-0.384
2	PH		-0.103	0.162	0.486	-0.185	-0.145	0.227	-0.108	-0.058	-0.065
3	PBTP			-0.101	-0.0172	0.533	0.252	0.391	-0.137	0.362	0.323
4	PL				0.43	0.117	-0.036	0.364	0.303	-0.297	-0.125
5	FLA					0.007	0.072	0.289	-0.143	-0.380	-0.274
6	SP						0.24	0.548	-0.255	-0.308	-0.178
7	SF							0.510	0.352	0.047	0.417
8	GW								-0.011	-0.230	-0.001
9	BYP									0.083	0.457
10	HI										0.665

Traits: D50F = Days to 50% flowering, PH = Plant height, PBTP = Panicle bearing tillers plant^{-1}, PL = Panicle length (cm), FLA = Flag leaf area (cm^2), SP = Spikelet's per panicle, SF = Spikelet Fertility (%), GW = Grain weight (g), BYP = Biological yield plant^{-1} (g), HI = Harvest index (%), GYP = Grain yield per plant. *,**.Significant at 5% and 1% probability level, respectively.

In the present study, majority of significant estimates of correlations between yield and yield components were positive in nature. Out of 30 significant estimates among the total 55 correlations obtained between different character pairs, 20 correlation coefficients were positive in nature, while, 10 estimates were negative. This represents highly favourable situation for obtaining high response to selection in improving yield and yield components in rice. Thus, selection practiced for improving these traits individually or simultaneously would bring improvement in other due to correlated response. This suggested that selection would be quite efficient in improving yield and yield components.

Day to 50% flowering had significant negative association with panicle bearing tillers per plant, spikelet's per panicle, spikelet fertility, 1000-grain weight, biological yield per plant and grain yield per plant which represents a favourable situation for obtaining high yielding and early flowering genotypes. Similarly, significant negative associations were observed for grain yield with flag leaf area, biological yield per plant with spikelet's per panicle. Harvest index showed unfavourable negative association with flag leaf area and spikelet's per panicle, while it had one positive association with panicle bearing tiller per plant. In order to take care of occurrence of negative correlations along with majority of positive correlations between important yield components, a reasonable compromise would be required for attaining their proper balance for obtaining maximum combined contribution towards manifestation of grain yield. However, occurrence of positive and significant or non-significant correlations for 45 out of 55 character pairs revealed a far less complex situation in respect of character associations encountered in the present study than generally encountered in rice. This would make easier to attain proper balance between yield and yield components in context of rice genotypes used in present study. The estimates of correlation coefficients obtained in present study are broadly in conformity with previous reports in rice (Qamar *et al*., 2005; Ramakrishanan *et al*., 2006; Zahid *et al*., 2006; Kishore *et al*., 2007; Rangare *et al*., 2012; Krishnamurthy and Kumar, 2012) [3, 7, 1, 5].

Grain yield per plant showed positive and strong correlation with harvest index, biological yield per plant, panicle bearing tillers per plant and spikelet fertility to emerge as most important associates of grain yield in rice under sodic soil. In the present study, majority of significant estimates of correlations between yield and yield components were positive in nature which represents highly favourable situation because selection practiced for improving these traits individually or simultaneously would bring improvement in others due to correlated response. This suggested that selection would be quite efficient in improving yield and yield components in context of sodic soil.

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