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Associations study of salt affected rice (*Oryza sativa* L.)

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Abstract
Rice (*Oryza sativa*) is the principal food crop of about half of the people of the world. It is the world's third largest crop after maize and wheat. The importance of rice is not only as a fundamental commodity and primary food source for more than half of the world's population, but also as emerges from the complex rice based ecosystems that influence issues of global concern such as food security and development. Dynamic era of agricultural development and rapidly changing climatic conditions necessitate to continuous evaluation of rice germplasm and local rice land races. In this regards the present investigation was comprised of 30 lines of rice Germplasm along with three checks viz., Narendra Usar 3, Sarjoo 52 and IR 28. The material, comprising indigenous as well as exotic germplasm lines, exhibited wide spectrum of variation for various agronomic and morphological characters. In the present study, phenotypic and genotypic correlations were computed between twelve characters in sodic soil. The grain yield per plant exhibited a very strong positive association with biological yield per plant, followed by grains per panicle, spikelets per panicle and panicle bearing tillers per plant at phenotypic as well as genotypic levels. Thus, biological yield per plant, grains per panicle, spikelets per panicle and panicle bearing tillers per plant emerged as most important associates of grain yield per plant in rice. However, grain yield per plant had strong negative association at genotypic and phenotypic levels with days to 50% flowering. The path-coefficient analysis was carried out by using phenotypic as well as genotypic correlation coefficients between twelve characters to resolve direct and indirect effects of different characters on grain yield per plant. At phenotypic as well as genotypic levels, biological yield per plant exhibited very high positive direct effect on grain yield per plant, followed by harvest index. The high direct effect of biological yield per plant possessing highly significant positive association with grain yield per plant, highlighted the importance of this trait for rice improvement.

Key words: rice, correlation, path-coefficient

Introduction
Rice (*Oryza sativa* L.) is a "Global Grain", cultivated widely across the world and is the major staple for billions of people. Global demand for food is rising because of population growth, increasing affluence and changing dietary habits. To meet this demand, the global food production needs to increase by over 40% by 2030 and 70% by 2050 (FAO, 2009). Rice is the major source of calories of more than half of the total global population. The importance of rice is not only as a fundamental commodity and primary food source for more than half of the world's population, but also as emerges from the complex rice based ecosystems that influence issues of global concern such as food security and development. More than 90 per cent of the world's rice is grown and consumed in Asia, known as rice bowl of the world, where 60 per cent of the earth's people and two third of world's poor live (Khush and Virk, 2000). Rice being the staple food for more than 70 per cent of our national population and source of livelihood for 120-150 million rural households, is backbone to the Indian Agriculture.
Protein containt of milled rice is 6-7 per cent, rice however, compares favourably with other cereals in amino acid content. The biological value of protein is high, the fat content of rice is low (2.0-2.5%) and much of the fat is lost during milling. Rice contains a low percentage of calcium (Ca). Rice grain contains as much B group vitamin as wheat. Milled rice losses valuable proteins, vitamins and minerals in the milling process during which embryo and aleurone layer are removed and much of the loss of nutrients can be avoided through parboiling process.
The by-products of rice milling are used for a variety of purposes. Rice bran is used as cattle and poultry feed. Rice hull can be used in manufacture of insulation materials, cement and cardboard as a litter in poultry keeping. Rice straw can be used as cattle feed as well as litter during winter.*Oryza sativa* is a diploid species having 24 chromosomes. The *Oryza sativa* rice variety of the world are commonly grouped into three subspecies namely: indica, japonica and javanica.

1. Indica: - Rice grown in India belongs to this indica subspecies. They are characterized by having leaves slightly pubescent and pale green colour. Indica are awn less or possess short and smooth awns. The fruit is caryopsis, elongated, thin, narrow and slightly flattened.
2. Japonica: - The varieties developed in japan belong to this subspecies. These varieties are adapted for cultivation in the subtropical and warm temperate region. Japonica varieties mostly have oval and round grains. They may be awned or awn less leaves having narrow and dark green in colour.
3. Javanica: - They are characterized by a stiff straw, long panicle with awned grain, sparse tillering habit, long duration and low sensitively to difference in day length. These are found mainly in Indonasia.

Rice is cultivated worldwide over an area of about 156.68 million hectares with an annual production of about 680.19 million tonnes with an average productivity of 5.15 tonnes per hectare (Anonymous, 2014). India is the largest rice growing country, while China is the largest producer of rice. In India, during 2014-15 the rice crop had production of 103.04 mt. However, in Uttar Pradesh it was grown on 5094 mha with production of 15.30 mt. The average productivity of Uttar Pradesh is 257.3 kg/ha which is more than the national average productivity (Anonymous, 2014).

Although, the average productivity of rice is much lower in India than the average productivity at world level. The development of high yielding, widely adapted pureline rice varieties coupled with advances in production technology in past four decades has enabled us to cope up with the demand of rice to a satisfactory level. However, rapidly increasing demand due to ever increasing Indian population has forced us to search for another quantum jump in rice production. The projection of India's rice production target for 2020 AD is 115-120 million tonnes, which can be achieved only by increasing the rice production by over 2.0 million tonnes/year in the coming decade (Viraktamath and Shobha Rani, 2008). This has to be done against backdrop of diminishing natural resource bases like land, labour and water, which is a huge challenge (Subbiah, 2006). Considering the rapidly decreasing availability of agricultural land due to urbanization and industrialization, utilization of different eco-systems and under exploited stress environments for rice production would be needed. Thus, adoption of high yielding rice varieties to various stress environments and under-utilized lands such as sodic and other problematic soils would be an important strategy to meet this challenge.

Rice (*Oryza sativa* L.) plant is one of the most suitable crops for saline soil, though it is considered moderately sensitive to salinity. The common practice is to cultivate rice with elevated level of salt tolerance on salt affected marginal lands. Today, the most economic and sustained way to overcome the problems of food scarcity and salt stress is to develop salt tolerant varieties. Salinity affects rice growth in varying degrees at all stages starting from germination to maturation (Manneh, 2004). So far, conventional breeding methods for salt tolerance have been found ineffective due to the strong environmental effects on genotypic expression and the low narrow sense heritability of salt tolerance (Gregorio, 1997; Gregorio and Senadhira, 1993). This hinders the development of an accurate, rapid and reliable screening technique under natural condition. On the other hand, screening under controlled condition has the benefit of reduced environmental effects and the hydroponics system is free from the difficulties associated with soil related stress factors.

Materials and methods

The present investigation was carried out during *kharif*, 2015. at Genetics and Plant Breeding farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar, (Kumarganj), Faizabad (U.P.), India. Geographically, Narendra Nagar is situated between 26.47ºN latitude and 82.12ºE longitude and at an altitude of 113 meters above the mean sea level in the gangatic plains of eastern U.P. The climate of district Faizabad is semi-arid with hot summer and cold winter. The soil type of experimental site was silty loam, low in organic carbon, nitrogen, phosphorus and rich in potash. The soil of the experimental site was partially reclaimed sodic soil {ECe=2.21(dSm^{-1}); pH=9.27}. The experimental material for the present investigation was comprised of 30 lines of rice Germplasm along with three checks viz., Narendra Usar 3, Sarjoo 52 and IR 28. The material, comprising indigenous as well as exotic germplasm lines, exhibited wide spectrum of variation for various agronomic and morphological characters. All the 30 genotypes were grown during *"kharif"* season of 2015 under irrigated condition. The experimental material was sown and transplanted on 05.07.2015 and 06.08.2015, respectively. The 33 entries were evaluated in Randomized Complete Block Design with 3 replications under sodic soil during *kharif*, 2015. Each genotype/treatment was grown by transplanting single seedling per hill in single row plots of 3 meter length following inter-row and intra-row spacing of 20 cm and 15 cm, respectively. The electrical conductive and pH of the experimental plot were measured using standard procedure. The recommended cultural practices were followed to raise a good crop. Data were recorded on twelve yield contributing characters *viz.* Days to 50% flowering, Days to maturity, Plant height (cm), Flag leaf area (cm^2), Panicle length (cm), Effective tillers per plant, Spikelets per panicle, Spikelet fertility (%),1000-grain weight (g), Biological yield per plant (g), Harvest index (%),Grain yield per plant (g). Data recorded on the above characters were subjected to estimate the Analysis of variance for Randomized Block Design (Panse and Sukhatme , 1967), Computation of correlation coefficients (Searle, 1961) and Non-hierarchical Euclidean cluster analysis (Beale,1969 and Spark,1973).

Table 1: Estimates of phenotypic correlation coefficients between different characters in rice (*Oryza sativa* L.)

Characters	Plant height (cm)	Flag leaf area (cm^2)	Panicle bearing tillers per plant	Panicle length (cm)	Spikelets per panicle	Grains per panicle	Spikelet fertility (%)	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%))	Grain yield per plant (g)
Days to 50% flowering	0.596**	-0.046	-0.105	-0.117*	-0.127	-0.124	0.023	-0.419**	-0.353**	0.064	-0346
Plant height (cm)		-0.053	-0.105	0.375**	0.110	0.131	0.209*	-0.271*	-0.179	-0.058	-0.181

Flag leaf area (cm^2)			-0.002	0.096	0.121	0.141	0.125	-0.076	0.176	0.139	0.204
Panicle bearing tillers per plant				0.081	0.432**	0.416**	-0.093	0.275**	0.381**	0.116	4.422
Panicle length (cm)					0.258*	0.285*	0.233*	0.136	-0.004	-0.215	-0.019
Spikelets per panicle						0.972**	-0.081	0.199	0.482**	0.114	0.519
Grains per panicle							0.100	0.204*	4.493**	0.110	0.530**
Spikelet fertility (%)								0.024	0.028	-0.082	0.004
1000-grain weight (g)									0.240*	0.492	0.285**
Biological yield per plant (g)										-0.105	0.968**
Harvest index (%)											0.115**

*, ** Significant at 5 (%) and 1 (%) probability levels, respectively

Table 2: Estimates of genotypic correlation coefficients between different characters in rice (*Oryza sativa* L.)

Characters	Plant height (cm)	Flag leaf area (cm^2)	Panicle bearing tillers per plant	Panicle length (cm)	Spikelets per panicle	Grains per panicle	Spikelet fertility (%)	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%))	Grain yield per plant (g)
Days to 50% flowering	0.637	-0.049	-0.160	0.123	-0.125	-0.134	0.009	-0.444	-0.373	0.071	-0.369
Plant height (cm)		-0.056	-0.147	0.380	0.112	0.136	0.286	-0.275	-0.182	-0.091	-0.189
Flag leaf area (cm^2)			-0.039	0.097	0.142	0.151	0.158	-0.079	0.184	0.193	0.215
Panicle bearing tillers per plant				0.093	0.646	0.615	-0.277	0.379	0.559	0.253	0.638
Panicle length (cm)					0.269	0.293	0.309	0.138	-0.003	-0.268	-0.018
Spikelets per panicle						1.009	-0.024	0.210	0.498	0.138	0.545
Grains per panicle							0.078	.0213	0.505	0.108	0.547
Spikelet fertility (%)								0.030*	0.040	-0.192	0.012
1000-grain weight (g)									0.245	0.077	0.298
Biological yield per plant (g)										-0.170	0.978
Harvest index (%)											0.093

Results and Discussions

The phenotypic and genotypic correlation coefficients computed between the twelve characters under study are presented in Table-1 and 2, respectively. Grain yield per plant exhibited highly significant and positive phenotypic correlation with biological yield per plant (0.968), grains per panicle (0.530) and spikelets per panicle (0.519). Grain yield per plant also had significant correlation in positive and negative direction with panicle bearing tillers per plant (0.422) and days to 50% flowering (-0.346) respectively. The phenotypic correlations of grain yield with remaining six characters were non-significant in either direction. Biological yield per plant showed highly significant and positive phenotypic association with grains per panicle (0.494) and spikelets per panicle (0.482) and significant and positive phenotypic association with panicle bearing tillers per plant (0.381). However, biological yield per plant had significant and negative correlation with days to 50% flowering (-0.353). Grains per panicle emerged with positive phenotypic correlation of highly significant and significant degree with spikelets per panicle (0.927) and panicle bearing tillers per plant (0.416), respectively. The strong positive associations grain yield with biological yield per plant, grains per panicle, spikelets per panicle and panicle bearing tillers per plant are agreement with earlier findings of Shivani *et al.* (2000), Raut *et al.* (2009) [6], Saravanan and Sabesan (2009) [4], Wattoo *et al.* (2010) [8], Sarangi *et al.* (2013), and Verma *et al.* (2013).

The estimates of genotypic correlation coefficients (Table-2) between twelve characters showed close parallelism in direction with their corresponding phenotypic correlation coefficients (Table-1). The genotypic correlations were, in general, higher in magnitude than the corresponding correlations at phenotypic level.

The path-coefficient analysis was carried out by using phenotypic as well as genotypic correlation coefficients between twelve characters to resolve direct and indirect effects of different characters on grain yield per plant. The direct and indirect effects of different characters on grain yield at phenotypic level are presented in Table 3. In the path coefficient analysis using phenotypic correlations among twelve characters, biological yield per plant (0.976), followed by harvest index (0.219) produced highest positive direct effect on grain yield per plant. The direct effects of remaining nine characters was too low to be considered important. In case of indirect effects, biological yield per plant exerted substantial positive indirect effects in grain yield per plant via grains per panicle (0.482), spikelets per panicle (0.470), panicle bearing tillers per plant (0.371), 1000- grain weight (0.234) and flag leaf area (0.172). In contrast, biological yield per plant exhibited considerable negative indirect effects on grain yield per plant via days to 50% flowering (-0.344), plant height (-0.174) and harvest index (-0.102).The remaining estimates of indirect effects in this analysis were negligible. The estimate of residual factors was also very low (0.057). The high direct effect of biological yield per plant possessing highly significant positive association with grain yield per plant, highlighted the importance of this trait for rice improvement. Yadav *et al.* (2008) [3], Sarvanand and Sabesan (2009) [4], Makwana *et al* (2010), Nanadan *et al.* (2010), Madhavilatha *et al.* (2013), Anant Kumar *et al* (2015) have also found high direct contribution of biological yield per plant and harvest-index on grain yield per plant. Thus, biological yield per plant followed by harvest-index emerged as most important direct contributor towards the grain yield. Direct effects of remaining characters on grain yield per plant were too low to be considered important.

The direct and indirect effect of different characters on grain yield at genotypic level are presented in Table 4. In the path analysis at genotypic level, the biological yield per plant (1.011), followed by harvest index (0.224) exerted highest positive direct effect on grain yield per plant. The direct effects of rest of the characters very low in this analysis.

Biological yield per plant contributed substantial positive indirect effects on grain yield per plant via panicle bearing tillers per plant (0.503), grains per panicle (0.511), spikelets per panicle (0.503), 1000-grain weight (0.248), and flag leaf area (0.186) while it had considerable negative indirect effects on grain yield per plant via days to 50% flowering (-0.377), plant height (-0.184) and harvest index (-0.179). The remaining estimates of indirect effects were too low to be considered of any consequence. The estimate of residual factors was negligible in this analysis. The high order positive direct and indirect contribution of biological yield per plant was also recorded by Chaudhary and Motiramani (2003), Khedikar *et al.* (2004), Zia-ul-Qamar *et al.* (2005), Jaiswal *et al.* (2007) Yadav *et al.* (2008) [3] Makwana *et al.* (2010) and Madhavilatha *et al.* (2013). Thus, the maximum direct effect of biological yield per plant corroborates the findings of Verma and Srivastava (2004) and Anant Kumar *et al* (2015). The negligible residual factor on grain yield suggested that no other major yield components were left over.

Table 3: Direct and indirect effects of different characters on grain yield per plant at phenotypic level in rice germplasm (*Oryza sativa* L.)

Character	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility %	1000-grain weight	Biological yield/ plant	Harvest index	Grain yield/ plant (g)
Days to 50%flowering	-0.013	-0.008	0.001	0.001	-0.002	0.002	0.002	-0.000	0.005	0.005	-0.001	-0.346
Plant height (cm)	0.010	0.017	-0.001	-0.002	0.006	0.002	0.002	0.004	-0.005	-0.003	-0.001	-0.181
Flag leaf area (cm^2)	-0.000	-0.000	0.003	-0.000	0.000	0.000	0.001	0.000	-0.000	0.001	0.000	0.204*
Panicle bearing tillers/ plant	-0.001	-0.001	-0.000	0.016	0.001	0.005	0.005	-0.001	0.003	0.005	0.001	0.422**
Panicle length (cm)	0.003	0.009	0.002	0.002	0.024	0.006	0.007	0.006	0.003	-0.000	-0.005	-0.019
Spikelets /panicle	0.003	-0.003	-0.003	-0.011	-0.006	-0.025	-0.024	0.002	-0.005	-0.012	-0.003	0.519**
Grains /panicle	-0.003	0.004	0.004	0.011	0.008	0.026	0.027	0.003	0.006	0.013	0.003	0.530**
Spikelet fertility %	-0.000	-0.003	-0.002	0.001	-0.003	0.001	-0.002	-0.015	-0.000	-0.000	0.001	0.008
1000- grain weight	-0.014	-0.009	-0.003	0.009	0.005	0.007	0.007	0.001	0.033	0.008	0.002	0.285*
Biological yield/ plant	-0.344	-0.174	0.172	0.371	-0.004	0.470	0.482	0.027	0.238	0.976	-0.102	0.968**
Harvest index %	0.014	-0.013	0.031	0.025	-0.047	0.025	0.024	-0.018	0.011	-0.023	0.219	0.005

Residual effect = 0.1121 Bold figures indicate the direct effects.

Table 4: Direct and indirect effects of different characters on grain yield per plant at genotypic level in rice germplasm (*Oryza sativa* L.)

Character	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility %	1000-grain weight	Biological yield/ plant	Harvest index	Grain yield/ plant (g)
Days to 50%flowering	-0.016	-0.010	0.001	0.003	-0.002	0.002	0.002	-0.000	0.007	0.006	-0.001	-0.369

Plant height (cm)	0.012	0.019	-0.001	-0.003	0.007	0.002	0.003	0.005	-0.005	-0.003	-0.008	-0.189
Flag leaf area (cm^2)	0.001	0.001	-0.014	0.001	-0.001	-0.002	-0.002	-0.002	0.001	-0.003	-0.003	0.215
Panicle bearing tillers/ plant	-0.002	-0.002	-0.001	0.014	0.001	0.009	0.008	-0.003	0.005	0.006	0.003	0.638
Panicle length (cm)	0.005	0.016	0.004	0.004	0.041	0.011	0.012	0.013	0.006	-0.000	-0.011	-0.018
Spikelets /panicle	-0.002	0.002	0.003	0.011	0.005	0.018	0.018	-0.000	0.004	0.009	0.002	0.544
Grains /panicle	0.005	-0.005	-0.005	-0.021	-0.010	-0.034	-0.034	-0.003	-0.007	-0.017	-0.004	0.547
Spikelet fertility %	0.000	0.001	0.001	-0.001	0.001	-0.000	0.000	0.004	0.000	0.000	-0.001	0.012
1000- grain weight	-0.010	-0.006	-0.002	0.009	0.003	0.005	0.005	0.001	0.022	0.006	0.002	0.298
Biological yield/ plant	-0.377	-0.184	0.186	0.565	-0.003	0.503	0.511	0.041	0.248	1.011	-0.179	0.978
Harvest index %	0.016	-0.021	0.043	0.057	-0.060	0.031	0.024	-0.043	0.017	-0.038	0.224	0.039

Residual effect = 0.0025 Bold figures indicate the direct effects.

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