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Study correlation coefficients and their direct and indirect relationships between yield and its component traits in Rice (*Oryza sativa* L.) germplasm under saline-alkaline soil

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Abstract
Rice (*Oryza sativa* L., 2n= 24) is a plant belonging to the family Poaceae (Gramineae). It is one of the three major food crops of the world and forms the staple diet of about half of the world's population. Uttar Pradesh is an important rice growing state in the country. The area and production of rice in the state is about 5.09 million ha. and production of 15.30 million tones, with productivity of 2573 kg/ha. (Anonymous, 2014). Nearly, 6.73mha of soil in India is salt affected and categorized into two broad groups' alkaline and saline soils. Recent estimates indicate that more than 1.5mha of salt affected area has been reclaimed and is contributing about 10 million tonnes additional food grains to the central pool. The simple correlations between different characters at genotypic (g) and phenotypic (p) levels were estimated as below according to Searle (1961) [2]. Correlation coefficient studies indicated biological yield per plant, plant height, panicle length and spikelets fertility were positively correlated with each other. On the other hand, panicle bearing tillers per plant, panicle length, biological yield, harvest index and grains per panicle were found to be positively and significantly associated with grain yield per plant possessing direct impact on yield.

Keywords: Correlation, coefficients, indirect, Rice, *Oryza sativa* L.

Introduction
Rice protein is biologically the richest virtue of its high digestibility (88%) among cereal proteins and also provides minerals and fiber. Calories from rice are particularly important for the poor accounting for 50-80% of the daily caloric intake. Rice can also be utilized snack in brewed beverages, flour, oil, syrup, and religious ceremonies. Rice is also believed to have medicinal properties. The *Oryza sativa* rice variety of the world are commonly grouped in to three subspecies namely: indica, japonica and javanica. The average temperature required throughout the life period of the crop ranges from 21 to 37°C. At the time of till ring the crop requires a high temperature for growth. Photo periodically rice is a short day plant, However, there are varieties which are non-sensitive to photo periodic condition. Protein content of milled rice is 6-8 per cent, rice however, compares favorably 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).

Material and Methods
The present investigation was carried out during *Kharif*, 2015 at Research Farm of Department of Genetics & Plant Breeding, Narendra Deva University of Agriculture and Technology, Kumargunj, Faizabad (U.P). The experiment was conducted to evaluate eighty four germplasm lines including four checks under irrigated, saline-alkaline soil condition. (44% 8.9 pH ESP, 2.45dsm^{-1} E.C.) and in Augmented Block Design. The entire experimental field was divided into ten blocks of equal size. Five competitive plants from each plot were randomly selected for recording observations on all thirteen traits, except days to 50 per cent flowering and grain yield per plant, which was recorded on the plot basis. Averages of the data from the sampled plant of each plot in respect of different characters were used for various statistical analyses. The data were recorded for the following characters: Days to 50 per cent flowering, Flag leaf area (cm^2), Plant height (cm), Panicle bearing tillers per plant, Panicle length (cm), Spikelets per panicle, Grains per panicle, Spikelet fertility (%), Biological yield per plant (g), Harvest-index (%), Test weight (g), L/B ratio, Grain yield per plant (g).

The nature of associations among different characters was studied by using phenotypic and genotypic correlations (Searle, 1961) [2].

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all the thirteen characters, which validated further statistical and genetical analyses. The assessment of existing variability in rice genotypes was done by computing means, range and least significant differences. The nature of associations among different characters was studied by using phenotypic and genotypic correlations (Searle, 1961) [2].

Correlation coefficient

The grain yield, in almost all the crops, is referred to as super character, which results from multiplicative interaction of several other traits that are termed as yield components. Thus, 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, identification of important yield components and information about their association with yield and also with each other is very useful for developing efficient breeding strategy for evolving high yielding varieties. In this respect, the correlation coefficient, which provides symmetrical measurement of degree of association between two variables or characters, helps us in understanding the nature and magnitude of association between yield and its components.

In the present study, simple correlation was computed among the thirteen characters (Table 1). The grain yield per plant exhibited highly significant and positive association with biological yield, test weight, grains per panicle, spikelet fertility, and spikelet per panicle while, harvest index showed significant positive correlation. Thus, these characters emerged as important traits associated with grain yield. An increase/improvement in above characters followed by selection effect to positively grain yield. The available literature also identified positive association on above characters with grain yield in rice Wattoo *et al.* (2010), Nandan *et al.* (2010) [3] Chaturvedi *et al*. (2011) [4], Pandey *et al.* (2012) [5], Muhammad *et al*. (2012) [6], Osman *et al*. (2012), Kiani (2012) [7], Dhurai *et al.* (2014) [8] and Rahaman *et al.* (2014) Anant Kumar *et al* (2015).

The other traits *viz*., L/B ratio, flag leaf area panicle bearing tillers per plant, panicle length and spikelet's per panicle were positively correlated with each other having significant positive correlation with grain yield. These traits also exhibited positive and significant correlation with most of the other characters showing significant positive association with grain yield per plant. Spikelets per panicle had highly significant positive association with grains per panicle and positively significant correlated with spikelet fertility (%), biological yield and Test weight. Similarly, biological yield per plant was highly significant and positively associated with their test weight components, *viz*., plant height positive significant correlated with panicle bearing tillers per plant, spikelet /panicle, spikelet fertility, biological yield per plant was highly significant positive correlated with number of grains per panicle which were also positively associated with grain yield. Thus, it indicates that panicle length, panicle bearing tillers per plant, spikelets per panicle, plant height and spikelet fertility considered were as important grain yield influencing characters in present the study. The available literature has also indicated positive association of grain yield and the characters mentioned above in rice (Agahi *et al.*, 2007; Mustafa *et al.*, 2007 [10]; Singh *et al.*, 2007 [14]; Yadav, 2008 [11]; Arumugam *et al.*, 2008; Raut *et al*., 2009 [11]; Reddy *et al.*, 2010 [12]; Wattoo *et al.*, 2010; Nandan *et al.*, 2010 [3] and Seyoum *et al*. 2012) [13]. Anant Kumar *et al* (2015).

However, days to 50 per cent flowering, showed non-significant negative correlation with grain yield per plant with some other important yield components like spikelets per panicle, panicle length and panicle bearing tillers per plant. This suggest that there is possibility to combining high performance for grain yield and yield components with early flowering and maturity for developing early maturing high yielding varieties.

Conclusion

Correlation coefficient studies indicated biological yield per plant, plant height, panicle length and spikelets fertility were positively correlated with each other. On the other hand, panicle bearing tillers per plant, panicle length, biological yield, harvest index and grains per panicle were found to be positively and significantly associated with grain yield per plant possessing direct impact on yield. Hence, due emphasis should be given to select these traits to enhance grain yield in rice under saline-alkaline condition. Based on the high inter cluster distance between cluster II and VIII, hybridization between genotypes of these two cluster II Narendra2009, IR14T-121, NDRK50059, IR14T 113, IR14T105, NDRK 50064, CSR23 (check) IR13T147, IR8418, NDRK5019, IR12T 193, NDR-502, IR14T102, IR12T195, IR13T-144, and NDRK50053 may produce promising genotypes in segregating generations. The grain yield per plant exhibited a very strong positive association with biological yield per plant, test weight, grains per panicle, spikelet per panicle and spikelet fertility. The high positive direct contribution towards grain yield per plant was exhibited by biological yield per plant and harvest index. However, other characters contributing substantially positive direct effect on grain yield were spikelets per panicle, panicle bearing tillers per plant, L/B ratio, days to 50% flowering, plant height, panicle length, spikelet fertility%, grains per panicle, flag leaf area and test weight emerged as most important indirect yield component. The characters identified above may be considered during formulating selection strategy in rice for developing high yielding varieties under saline-alkaline soil.

Table 1: Genotypic correlation coefficients between different characters in rice germplasm

Characters	Days to 50% flowering	flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelet's/ panicle	Grains/ panicle	Spikelet/ fertility %	Biological yield	Harvest Index	Test weight (g)	L/B ratio	Grain yield per plant (g)
Days to 50% flowering	1.0000	0.1368	-0.0660	0.0388	0.1480	0.0917	0.1177	0.1762	-0.1246	0.0630	0.0421	-0.1515	-0.0999
Flag leaf area (cm^2)		1.0000	0.0527	0.0642	-0.0804	0.0886	0.1151	0.1945	0.0897	0.1672	0.1610	0.3203	0.1129
Plant height (cm)			1.0000	0.1138	-0.1110	0.1508	0.1697	0.2240	-0.0506	0.0008	-0.0926	0.1743	-0.0412
Panicle bearing tillers per plant				1.0000	0.1464	0.0470	0.0743	0.1861	0.0389	0.0016	-0.1473	0.2270	0.0803
Panicle length (cm)					1.0000	-0.1627	-0.1885	-0.3576	0.0616	0.0477	-0.0198	-0.3920	0.0886
Spikelet's per panicle						1.0000	0.9964	0.5524	0.3152	0.1250	0.3291	-0.3186	0.3049
Grains per panicle							1.0000	0.6176	0.3139	0.1363	0.3599	-0.2451	0.3072
Spikelet fertility %								1.0000	0.2416	0.2238	0.4732	0.2850	0.2716
Biological yield (g)									1.0000	0.0354	0.9743	0.1217	0.9701
Harvest index%										1.0000	0.3408	0.5139	0.2508
Test weight (g)											1.0000	-0.2100	0.9896
L/B ratio												1.0000	0.2602
Grain yield per plant (g)													1.0000

,* Significant at 5% and 1% probability levels, respectively.

Table 2: Phenotypic correlation coefficients between different characters in rice germplasm.

Characters	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelet's/ panicle	Grains/ panicle	Spikelet/ fertility (%)	Biologic yield	Harvest Index	Test weight (g)	L/B ratio	Grain yield per plant (g)
Days to 50% flowering	1.0000	0.1088	-0.0567	0.0343	0.1447	0.0824	0.1186	0.1669	-0.1256	0.0629	0.0366	-0.0389	-0.1000
Flag leaf area (cm^2)		1.0000	0.0528	0.0549	-0.0167	0.1245	0.1117	-0.0210	0.0789	0.0866	0.0285	0.2090	0.0824
Plant height (cm)			1.0000	0.0928	-0.0932	0.1166	0.1389	0.1481	-0.0551	0.0150	-0.0884	0.1124	-0.0424
Panicle bearing tillers per plant				1.0000	0.1323	0.0900	0.1170	0.1477	0.0292	-0.0001	-0.0892	0.0109	0.0686
Panicle length (cm)					1.0000	-0.1332	-0.1310	-0.1098	0.0306	0.0546	-0.0550	0.0738	0.0622
Spikelet's per panicle						1.0000	0.9787**	0.2618*	0.2797*	0.1006	0.2587*	-0.0605	0.2737*
Grains per panicle							1.0000	0.4460**	0.2940**	0.1229	0.2681*	-0.0540	0.2919**
Spikelet fertility (%)								1.0000	0.1964	0.1820	0.1782	0.0267	0.2218**
Biological yield(g)									1.0000	-0.0003	0.6509**	0.1117	0.9653**
Harvest index%										1.0000	0.2664*	0.1512	0.2355*
Test weight (g)											1.0000	-0.0548	0.6817**
L/B ratio												1.0000	0.1649

,* Significant at 5% and 1% probability levels, respectively.

Table 3: Genotypic direct and indirect effects of different characters on grain yield per plant in rice germplasm

Characters	Days to 50% flowering	Flag leaf area (cm²)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelet's/ panicle	Grains/ panicle	Spikelet/ fertility %	Biological yield	Harvest Index	Test weight (g)	L/B ratio
Days to 50% flowering	0.0265	0.0036	-0.0018	0.0010	0.0039	0.0024	0.0031	0.0047	-0.0033	0.0017	0.0011	0.0040
Flag leaf area (cm^2)	-0.0017	-0.0127	-0.0007	-0.0008	0.0010	-0.0011	-0.0015	-0.0025	-0.0011	-0.0021	-0.0020	0.0041
Plant height (cm)	-0.0004	0.0003	0.0061	0.0007	-0.0007	0.0009	0.0010	0.0014	-0.0003	0.0000	-0.0006	-0.0011
Panicle bearing tillers per plant	0.0012	0.0019	0.0035	0.0303	0.0044	0.0014	0.0023	0.0056	0.0012	0.0000	-0.0045	-0.0069
Panicle length (cm)	0.0022	-0.0012	-0.0016	0.0021	0.0146	-0.0024	-0.0028	-0.0052	0.0009	0.0007	-0.0003	0.0057
Spikelet's per panicle	0.0399	0.0385	0.0656	0.0204	-0.0708	0.4349	0.4334	0.2402	0.1371	0.0544	0.1431	0.1386
Grains per panicle	-0.0562	-0.0549	-0.0810	-0.0355	0.0900	-0.4756	-0.4773	-0.2948	-0.1498	-0.0651	-0.1718	-0.1170
Spikelet fertility (%)	0.0077	0.0085	0.0098	0.0082	-0.0157	0.0243	0.0271	0.0439	0.0106	0.0098	0.0208	-0.0125
Biological yield(g)	-0.1261	0.0908	-0.0512	0.0393	0.0623	0.3188	0.3175	0.2444	1.0116	0.0359	0.9856	-0.1231
Harvest index%	0.0137	0.0362	0.0002	0.0004	0.0103	0.0271	0.0296	0.0485	0.0077	0.2167	0.0739	-0.1114
Test weight (g)	-0.0021	-0.0079	0.0046	0.0073	0.0010	-0.0162	-0.0178	-0.0234	-0.0481	-0.0168	-0.0494	-0.0104
L/B ratio	-0.0046	0.0097	0.0053	0.0069	-0.0119	-0.0097	-0.0074	0.0086	0.0037	0.0156	-0.0064	-0.0303
Grain yield per plant (g)	-0.0999	0.1129	-0.0412	0.0803	0.0886	0.3049	0.3072	0.2716	0.9701	0.2508	0.9896	-0.2602

Residual effect = 0.0895, Bold figures indicate the direct effects.

Table 4: Phenotypic direct and indirect effects of different characters on grain yield per plant in rice germplasm

Characters	Days to 50% flowering	flag Leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelet's/ panicle	Grains/ panicle	Spikelet/ fertility %	Biological yield	harvest Index	Test weight (g)	L/B ratio	Grain yield per plant
Days to 50% flowering	0.0143	0.0016	-0.0008	0.0005	0.0021	0.0012	0.0017	0.0024	-0.0018	0.0009	0.0005	-0.000S6	-0.1000
Flag leaf area (cm^2)	-0.0024	-0.0219	-0.0012	-0.0012	0.0004	-0.0027	-0.0025	0.0005	-0.0017	-0.0019	-0.0006	-0.0046	0.0824
Plant height (cm)	-0.0005	0.0005	0.0086	0.0008	-0.0008	0.0010	0.0012	0.0013	-0.0005	0.0001	-0.0008	0.0010	-0.0424
Panicle bearing tillers per plant	0.0015	0.0024	0.0040	0.0432	0.0057	0.0039	0.0051	0.0064	0.0013	0.0000	-0.0039	0.0005	0.0686
Panicle length (cm)	0.0010	-0.0001	-0.0007	0.0010	0.0073	-0.0010	-0.0010	-0.0008	0.0002	0.0004	-0.0004	0.0005	0.0622
Spikelet's per panicle	0.0066	0.0099	0.0093	0.0072	-0.0106	0.0799	0.0782	0.0209	0.0223	0.0080	0.0207	-0.0048	0.2737**
Grains per panicle	-0.0126	-0.0119	-0.0148	-0.0125	0.0140	-0.1043	-0.1066	-0.0475	-0.0313	-0.0131	-0.0286	0.0058	0.2919**
Spikelet fertility (%)	0.0006	-0.0001	0.0005	0.0005	-0.0004	0.0010	0.0017	0.0037	0.0007	0.0007	0.0007	0.0001	0.2218*
Biological yield (g)	-0.1225	0.0770	-0.0538	0.0285	0.0299	0.2730	0.2869	0.1917	0.9760	-0.0003	0.6353	0.1091	0.9653**
Harvest index%	0.0150	0.0206	0.0036	0.0000	0.0130	0.0240	0.0293	0.0434	-0.0001	0.2384	0.0635	0.0360	0.2355*
Test weight (g)	-0.0001	-0.0001	0.0003	0.0003	0.0002	-0.0009	-0.0009	-0.0006	-0.0023	-0.0009	-0.0035	0.0002	0.6817**
L/B ratio	-0.0008	0.0045	0.0024	0.0002	0.0016	-0.0013	-0.0012	0.0006	0.0024	0.0033	-0.0012	0.0217	0.1649

Residual effect = 0.0956, Bold figures indicate the direct effects.

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