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INTERRELATIONSHIPS IN SCENTED AND NON-SCENTED RICE (*Oryza sativa* L.)FOR YIELD AND ITS COMPONENTS TRAITS UNDER SODIC SOIL

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ABSTRACT

An investigation of interrelationships and cause-effect analysis of grain yield and its attributing traits was carried out to find out best one among one hundred four diverse accessions of rice under salt stress soil{pH =9.2;EC = 2.21 (dSm^{-1}); ESP=45.00}. The analysis of variance revealed highly significant differences among genotypes. Results revealed that grain yield per plant was found to have strong positive association at both phenotypic and genotypic levels (possessing different maturity groups) with biological yield per plant (0.921) followed by effective tillers per plant (0.358), spikelets per panicle (0.358), plant height (0.351), days to maturity (0.241), days to 50% flowering (0.237) and spikelet fertility percentage (0.196). A few traits were inter-correlated with each other. Path analysis identified biological yield per plant followed by harvest index as major direct contributors towards expression of grain yield per plant, while effective tillers per plant, panicle length, spikelets per panicle and spikelet fertility emerged as most important indirect yield components. Hence, emphasis should be given to select these traits as selection criteria to develop high yielding rice varieties under sodic soil conditions. Furthermore, promising genotypes CSR 43 produced highest grain yield per plant followed by AGAMI-MI, NDR 6242, NDRK 50032 and Johar which may be utilized as donors for rice sodic soil improvement.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop of the world because of being the major source of calories of more than half of the total global population. It is widely grown in tropical and subtropical regions (Bhatt *et al*., 2016). 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. Salinity is a serious problem affecting 1/3 of all irrigated land in the world. Nearly, 6.73 million hectares of soils in India are salt affected and categorized into two broad groups alkali and saline soils. Hence, every year more and more land is becoming non-productive because of salt accumulation in soil in coastal as well as certain inland saline tracks.

Breeding salt tolerant crop varieties is considered to be the most pragmatic approach for better yield under saline conditions (Shannon *et al*., 1998). In order to step up the production potential, there is, thus, an urgent need to launch dynamic breeding programmes to develop rice varieties suitable for normal and stress environments. Substantial genetic variability is essential for initiating an effective breeding programme and therefore, it becomes imperative to evaluate the level of genetic variability existing in the crop germplasm collections to identify promising lines for exploitation as donor parents in recombination breeding programmes. In germplasm evaluation, correlation coefficient is used to find out the degree (strength) and direction of relationship between two or more variables. The concept of path analysis was developed by Wright (1921) but the technique was first used for plant selection by Dewey and Lu (1959). Path-coefficient is simply a standardized partial regression coefficient, which splits the correlation coefficient into the measures of direct and indirect effects. Thus, used in plant breeding programs to determine the nature of the relationships between yield and yield components that is useful as selection criteria to improve the crop yield. In this context, a good number of research works in rice has been reported by many workers *viz*., Nayak *et al*. (2001), Vanisree *et al*. (2013) and Kumar *et al*.(2018).

Hence, an attempt was made to assess and compare direct selection parameters and interrelationships between eleven characters of rice under sodic soil condition and to short out promising genotypes to be utilized as donors for rice improvement.

MATERIALS AND METHODS

Plant materials for the present investigation consisted of one hundred diverse rice genotypes along with four checks *viz*.,Pokkali, NarendraUsarDhan 3(tolerant), Sarjoo 52(moderately tolerant) and IR 28(susceptible) were evaluated in augmented design (Federer, 1956).These materials were grown under sodic soil{pH =9.2;EC = 2.21 (dSm^{-1}); ESP=45.00}at the Research Farm of Department of Genetics and Plant Breeding, N.D. University of Agriculture & Technology, Faizabad (U.P.) during Kharif, 2012.The experimental field was sub-divided in to 10 blocks of 14 plots each. The four checks were allocated randomly to four plots in each block, while remaining 10 plots in a block were used for accommodating the unreplicated test genotypes. The climate of district Faizabad is semi-arid with hot summer and cold winter and the soil of the experimental site was partially reclaimed sodic soil {pH =9.2;EC = 2.21 (dSm^{-1}); ESP=45.00}.The seeds were sown on 19 June, 2012 in separate pots and 28 days (17 July, 2012) old seedlings were transplanted in sodic soil as single seedling per hill in single row plots of 3 m length at spacing of 20 cm between row and 15 cm between plants. All the recommended agronomical practices were adopted to raise a good crop. The fertilizers were applied @ 120:60:60, N:P:K though urea, DAP and murate of potash, respectively. The mean data was recorded for all the characters studied *viz*., days to 50% flowering, days to maturity, plant height(cm), effective tillers per plant, panicle length(cm), spikelets per panicle and spikelet fertility(%), 1000-grain weight(g), biological yield per plant(g), harvest index(%) and grain yield per plant(g). Statistical analysis was carried out according to standard stistical procedure (Federer, 1956). The simple correlations between different characters were estimated according to Searle (1961) while path coefficient analysis following, Dewey and Lu (1959) to examine genetic interrelationships in existing divers rice genotypes.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the genotypes. Correlation coefficient and path co-efficient among the eleven characters have been depicted in Table 1 and 2, respectively. The 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 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.

In the present investigation, simple correlation coefficients were computed among eleven characters (Table 1). The grain yield per plant exhibited highly significant and positive association with biological yield per plant (0.921), spikelet per panicle (0.358), effective tillers per plant (0.358) and plant height (0.351). Grain yield per plant also showed significant and positive association with spikelet fertility (0.196), days to maturity (0.241) and days to 50% flowering (0.237). This indicated that biological yield per plant (0.921), spikelets per panicle (0.358), effective tillers per plant (0.358) and plant height (0.351) were the strongest associates of grain yield followed by spikelet fertility (0.196), days to maturity (0.241) and days to 50% flowering (0.237). Thus, the high yielding rice genotypes under sodic soil condition are likely to possess higher biological yield per plant, spikelets per panicle, effective tillers per plant and spikelet fertility along with undesirable tall stature, late flowering and late maturity. The strong positive associations of grain yield with characters mentioned above have also been reported earlier in rice (Sashidhar *et al*., 2005; Agathi *et al*., 2007; Bughio *et al*., 2009; Pandey *et al*., 2012, Eswara Reddy *et al*., 2014, Allam *et al*., 2015, Kumar and Verma, 2015. The biological yield per plant, having highest positive correlation with grain yield per plant showed highly significant and positive correlation with plant height, effective tillers per plant, days to maturity, days to 50% flowering and spikelets per panicle along with significant and positive correlation with panicle length but it had highly significant and negative association with 1000-seed weight. The strong positive association of biological yield per plant with the characters like plant height, effective tillers per plant, panicle length which have increasing effect on over all biomass production appears logical. Similarly, positive associations of days to maturity and days to flowering with biological yield per plant and grain yield per plant are justified as greater duration of vegetative and reproductive phase may be helpful in increasing the biomass production due to greater availability for time for growth and accumulation of photo-syntheses.

Harvest index exhibited highly significant and negative association with biological yield per plant, days to 50% flowering, days to maturity and plant height and significant and negative association with 1000-grain weight, besides having highly significant and positive association with 1000-grain weight. Similarly, 1000-grain weight recorded highly

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

Characters	Days to maturity	Plant height (cm)	Effective tillers / plant	Panicle length (cm)	Spikelets / panicle	Spikelet fertility (%)	1000 -grain weight (g)	Biological yield/ plant (g)	Harvest index (%)	Grain yield/ plant (g)
Days to 50% flowering	0.995**	0.112	0.029	-0.150	0.270**	0.023	-0.598**	0.352**	-0.343**	0.237*
Days to maturity		0.110	0.043	-0.148	0.269**	0.029	-0.567**	0.354**	-0.339**	0.241*
Plant height (cm)			-0.005	0.542**	0.288**	-0.044	-0.252*	0.462**	-0.314**	0.351**
Effective tillers/plant				-0.055	-0.106	0.193	0.030	0.363**	-0.033	0.358**
Panicle length (cm)					0.093	-0.164	0.067	0.238*	-0.238*	0.152
Spikelets/panicle						-0.005	-0.142	0.339**	-0.039	0.358**
Spikelet fertility %							0.057	0.189	-0.002	0.196*
1000 -grain weight (g)								-0.276**	0.328**	-0.167
Biological yield/plant (g)									-0.340**	0.921**
Harvest index %										0.037

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

Table 2: Direct and indirect effects of different characters on grain yield per plant in rice germplasm

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillers/ plant	Panicle length (cm)	Spikelets / panicle	Spikelet fertility (%)	1000 - grain weight (g)	Biological yield/ plant (g)	Harvest index (%)	Grain yield/ plant (g)
Days to 50% flowering	-0.0969	0.0830	-0.0032	-0.0004	-0.0005	0.0054	0.0000	0.0091	0.3746	-0.1342	0.2369
Days to maturity	-0.0964	0.0834	-0.0032	-0.0006	-0.0005	0.0054	-0.0001	0.0087	0.3767	-0.1326	0.2409
Plant height (cm)	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108	-0.0108
Effective tillers/ plant	-0.0028	0.0036	0.0001	-0.0140	-0.0002	-0.0021	-0.0004	-0.0005	0.3866	-0.0128	0.3575
Panicle length (cm)	0.0146	-0.0123	-0.0155	0.0008	0.0033	0.0019	0.0003	-0.0010	0.2539	-0.0934	0.1524
Spikelets/ panicle	-0.0262	0.0225	-0.0082	0.0015	0.0003	0.0199	0.0000	0.0022	0.3619	-0.0155	0.3583
Spikelet fertility (%)	-0.0022	0.0024	0.0013	-0.0027	-0.0005	-0.0001	-0.0019	-0.0009	0.2018	-0.0009	0.1963
1000-grain weight (g)	0.0580	-0.0473	0.0072	-0.0004	0.0002	-0.0028	-0.0001	-0.0153	-0.2945	0.1286	-0.1665
Biological yield/ plant (g)	-0.0341	0.0295	-0.0132	-0.0051	0.0008	0.0068	-0.0004	0.0042	1.0657	-0.1332	0.9210
Harvest index %	0.0332	-0.0282	0.0090	0.0005	-0.0008	-0.0008	0.0000	-0.0050	-0.3623	0.3917	0.0371

Residual effect = 0.1098 ;Bold figures indicate the direct effects

significant or significant correlations of negative nature with days to 50% flowering, days to maturity and plant height. The above discussion revealed that rice genotypes with higher grain yield and biomass production potential had higher mean performance for plant height, effective tillers per plant, spikelet per panicle, panicle length and spikelet fertility and late flowering and late maturity but lesser 1000-grain weight and harvest index. Spikelets per panicle showed highly significant and positive correlation with days to 50% flowering, days to maturity and plant height which also had highly significant and positive correlation with panicle length. This suggested that taller and late flowering and late maturing genotypes had higher number of spikelet per panicle. In addition, days to 50% flowering recorded highly significant and positive association with days to maturity.

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of yield components on grain yield (Table 2). Path analysis provides clearer picture of character associations for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that it points out the causes and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. The results of path coefficient analysis carried out using simple correlation coefficients among 11 characters are given in Table 2. Biological yield per plant followed by harvest index, showed very high positive direct contribution on grain yield per plant. Thus, biological yield per plant and harvest index emerged as major direct yield components. The available literature has also identified biological yield per plant and harvest index as important direct contributors to grain yield per plant (Mishra and Verma, 2002; Sashidhar *et al*., 2005; Pandey *et al*., 2012, Kumar *et al*.,(2018). The direct effects of remaining eight characters *viz*., days to 50% flowering, days to maturity, plant height, effective tillers per plant, panicle length, spikelets per panicle, spikelet fertility and 1000-grain weight were very low and non-significant indicating their negligible direct contribution towards grain yield. These results are in conformity with those of Kumar and Nilanjaya, 2014.

Indirect effects of effective tillers per plant, panicle length, spikelets per panicle and spikelet fertility were high order positive via biological yield per plant on grain yield per plant. Thus, the above four characters emerged as most important indirect yield contributing characters because they showed substantial positive direct effects on grain yield per plant via biological yield per plant. The four characters mentioned above have also been found as important contributors to grain yield in rice by earlier workers (Yadav *et al*., 2008; Babu *et al*., 2003, Singh *et al*., 2010).

In contrast, days to 50% flowering and days to maturity exerted high order positive indirect effect via biological yield per plant and substantial negative indirect effects via harvest index on grain yield per plant. Similarly, 1000-grain weight and harvest index showed high order positive indirect effect via harvest index and high order negative indirect effect via biological yield per plant on grain yield per plant. The biological yield per plant, which had highest positive direct effect on grain yield per plant, also exerted considerable negative indirect on grain yield per plant via harvest index. Thus, characters like days to 50% flowering, days to maturity, 1000-grain weight, harvest index and biological yield per plant may also be considered as important indirect yield components of complex nature due to their contrasting positive and negative indirect effects via one or another character. Thus, these five characters need special attention at the time of formulation of selection strategy due to their contrasting direct and indirect effects. The existence of negative as well as positive direct and/or indirect effects by same character presents a complex situation where a compromise is needed to attain proper balance of different yield components in determining ideotype for high grain yield in rice. The occurrence of contrasting positive and negative direct/indirect effect by same character via one or another character as observed in present study is in conformity with earlier reports of Madhavilatha *et al*. (2005), Karad and Pol (2008), Singh *et al*.(2010) and Kumar and Verma (2015) and Kumar *et al*.(2018).

In contrary to most of the previous reports in rice, comparatively smaller proportion of direct and indirect effects of different characters attained high order values in present study. Majority of the estimates of direct and indirect effects were too low to be considered of any consequence. This may be attributed to presence of very high genetic variability and diversity in the fairly large number of germplasm lines. The existence of different character combinations in diverse germplasm lines might have led to different types of character associations in different lines. Thus, presence of several contrasting types of character associations and inter relationships might have resulted into cancellation of contrasting associations by each other ultimately leading to lowering of the net impact or effect. The existence of substantial positive indirect effects of days to 50% flowering and days to maturity on grain yield per plant via biological yield per plant was also recorded. This indicated that late flowering and late maturity had considerable positive contribution towards expression of grain yield and therefore, development of strains combining high yield with early maturity could be tedious task. Previous workers have also observed high order positive contribution of days to flowering on grain yield (Shivani and Reddy, 2000; Mahto *et al.*, 2003, Singh *et al.*, 2010 and Kumar and Verma (2015) Kumar *et al.*(2018).

In the present study, path analysis identified biological yield per plant and harvest-index as important direct yield contributing characters. Effective tillers per plant, panicle length, spikelets per panicle and spikelet fertility emerged as most important indirect yield components, while days to 50% flowering, days to maturity, 1000-grain weight, harvest index and biological yield appeared as important but complex indirect yield contributors due to their contrasting positive and negative indirect effect via different characters. These findings are in close association with the results of Verma and Srivastava (2004) and Kumar and Verma (2015) Kumar *et al.*(2018).

The characters, mentioned above, merit due consideration at the time of devising selection strategy aimed at developing high yielding varieties in rice for sodic soil. Besides, the promising genotypes *viz.*, CSR 43, AGAMI-MI, NDR 6242, NDRK 50032 and Johar may be utilized as donors for rice improvement under sodic soil.

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