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Estimates indirect selection parameters through correlation coefficient in rice (*Oryza sativa* L.)

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Abstract
The goal of the current study titled "Estimates indirect selection parameters through correlation coefficient in rice (*Oryza sativa* L.)" was to estimate correlation coefficient. The experimental material comprises of 104 genotypes *viz;* 20 lines, 4 testers and 80 crosses developed by adopting “line x tester” mating design were evaluated during *Kharif*, 2020. The majority of significant estimates of correlations between yield and yield components in this study were positive, indicating a highly favourable situation because selection for improving these traits individually or simultaneously would result in improvements in others due to correlated responses. Selection, it is believed, would be highly effective in enhancing yield and yield components for the development of new plant types. Grain yield per plant possessed positive and highly significant correlation with harvest index, biological yield per plant, grains per panicle, hulling percentage, kernel length after cooking, panicle length, spikelets per panicle and 1000 grain weight at both phenotypic and genotypic levels. Therefore, these characters emerged as most important associates for grain yield in rice. Days to 50% flowering showed positive and highly significant correlation with days to maturity, L/B ratio, Plant height, panicle length and kernel length after cooking whereas other characters like hulling percentage and harvest index; Days to maturity showed correlation with L/B ratio, panicle length, kernel length after cooking, plant height, harvest index and hulling percentage; Plant height showed positive and highly significant correlation with panicle length and biological yield per plant; Panicle length had highly significant positive correlation with harvest index, grain yield per plant, kernel length after cooking and hulling percentage; Spikelets per panicle showed correlation with 1000-grain weight, grains per panicle, and grain yield per plant; Grains per panicle showed highly significant and positive correlation with grain yield per plant, harvest index, 1000 grain weight and hulling percentage; 1000-grain weight exhibited significant and positive correlation with biological yield per plant; Biological yield per plant had highly significant and positive association with grain yield per plant, hulling percentage and gel consistency; Harvest index had highly significant and positive association with grain yield per plant, kernel length after cooking and hulling percentage; Hulling percentage shows highly significant and positive association with grain yield per plant; L/B ratio showed positive and highly significant correlation with kernel length after cooking and Kernel length after cooking showed positive and highly significant correlation with grain yield per plant and for gel consistency.

Keywords: Line X tester, Correlation coefficient

Introduction
Rice (*Oryza sativa* L.) is a member of the Poaceae family and the genus Oryza. It is native to Southeast Asia. Rice is a C_3 plant that has a short day, is hydrophilic, and is self pollinated. Rice is cultivated in India, China, Japan, Korea, Thailand, and many other nations throughout the world and is the primary source of food for more than half of the world's population.

Rice comes in two cultivated varieties and twenty-two wild varieties, with the cultivated varieties being *Oryza sativa* and *Oryza glaberrima*. *Oryza glaberrima* has been cultivated in West Africa for over 3500 years, while Oryza sativa is farmed all over the world. Rice can be grown in a variety of environments and production systems, although the most prevalent method is submerged in water. Rice may be grown in a variety of environments, including irrigated, rainfed lowland, rainfed upland, and flood-prone ecosystems.

Rice is the world's second most grown cereal, and it is a staple food for about 60% of the world's population, particularly in Asia. Asia is known as the "rice bowl" because it produces and consumes more than 90% of the world's rice and occupies 197.59 million hectares of land with a production of 996.08 million tonnes production (FAOSTAT, 2019-20).

Rice is the most common staple food in at least 33 developing nations, accounting for 27% of dietary energy, 20% of dietary protein, and 3% of dietary fat.

Rice also accounts for more than 65 percent of caloric consumption, accounting for 23% of worldwide human per capita energy (Khush, 1997) [19]. The edible seed is a grain (caryopsis) with a length of 5–12 mm and a thickness of 2–3 mm. Yield is a crucial economic feature that results from the multiplicative interaction of its constituent characters. Breeders face issues selecting desirable parents when breeding crop plants for increased production. When selecting parents for enhancement of complicated quantitative features such as yield and its components, the choice of parents is critical since a high yielding genotype may or may not convey its superiority to progeny. Different employees employed various mating designs to help them choose parents and understand their genetic makeup.

Correlation in grouping with path analysis would give a better insight into cause and effect relationship between different pairs of characters (Jayasudha and Sharma, 2010) [7]. Knowledge of correlation between yield and its contributing characters are basic and foremost endeavor to find out guidelines for plant selection. The existing relationships between traits are, generally determined by the genotypic, phenotypic and environmental correlations. The phenotypic correlation measures the degree of association of two variables and is determined by genetic and environmental factors. The environmental correlation is mainly responsible for the association of traits of low heritability, such as grain yield.

The genotypic correlation on the other hand, which represents the genetic portion of the phenotypic correlation, is the only one of inheritable nature and therefore, used to orient breeding programme (Falconer, 1989) [5]. However, the correlation coefficient between two characters does not necessarily imply a cause and effect relationship. The inter-relationship could be grasped best if a coefficient could be assigned to each path in the diagram designed to measure the direct influence on it. Before placing strong emphasis on breeding for yield improvement trait, the knowledge on the association between yield and yield attributes will enable the breeder in the improvement of yield. The correlation coefficient may also help to identify characters that have little or no importance in the selection programme. The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective. In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield.

Material and Methods

The current study entitled "Estimates indirect selection parameters through correlation coefficient in rice (*Oryza sativa* L.)" was conducted at the Crop Research Centre and Technology Park of Sardar Vallabhbhai Patel University of Agriculture and Technology in Meerut during the Kharif season of 2018 and 2019. Meerut is located in the North Western Plain Zone at 29.010 latitude and 77.450 longitudes at an elevation of 217 metres above sea level. The soil is fertile and sandy loam.

Result and Discussion

The estimates of simple correlation coefficients (phenotypic and genotypic) computed between fourteen characters under study are presented in (Table 1 and 2). In general, genotypic correlations were higher than phenotypic ones in magnitude for all the characters. The characters which showed negative correlation at genotypic level also showed negative correlation at phenotypic level. The correlation coefficient is a statistical metric that determines the strength and direction of a link between two or more variables. As a result, it assesses the interdependence of two or more variables. It allows for a better knowledge of yield components, which aids plant breeders in their selection process (Johnson *et al.* 1955) [8]. Phenotypic correlation has limited practical utility for selection unless the genetic correlations between two characteristics are in the same direction when assessed independently. Linkage and pleiotropy can explain genetic connection. Because many observations are impacted by the same quantity of environmental variables, environmental correlation indicates non-genetic values. As a result, understanding correlation is quite important.

At Phenotypic level

Grain yield per plant possessed positive and highly significant correlation with harvest index (0.670), biological yield per plant (0.421), grains per panicle (0.383), hulling percentage (0.281), kernel length after cooking (0.212), panicle length (0.210), spikelets per panicle (0.200) and 1000 grain weight (0.106). Days to 50% flowering showed positive and highly significant correlation with days to maturity (0.592), L/B ratio (0.326), Plant height (0.229), panicle length (0.206) and kernel length after cooking (0.134) whereas other characters like hulling percentage (0.100) and harvest index (0.066) was found positive and non-significant. Days to maturity showed positive and highly significant correlation with L/B ratio (0.378), panicle length (0.267) and kernel length after cooking (0.180) while plant height (0.099), harvest index (0.071) and hulling percentage (0.043) showed positive and non-significant association. Plant height showed positive and highly significant correlation with panicle length (0.299) and biological yield per plant (0.198) whereas L/B ratio (0.079), kernel length after cooking (0.076) and hulling percentage (0.051) showed positive and non-significant association. Panicle length had highly significant positive correlation with harvest index (0.223), grain yield per plant (0.210), kernel length after cooking (0.179) and hulling percentage (0.140) while L/B ratio (0.109), biological yield per plant (0.045) and 1000 grain weight (0.033) showed positive and non-significant association. Spikelets per panicle showed highly significant and positive correlation with 1000-grain weight (0.345), grains per panicle (0.210), and grain yield per plant (0.200), while harvest index (0.096), biological yield per plant (0.021) and gel consistency (0.020) showed positive and non-significant association. Grains per panicle showed highly significant and positive correlation with grain yield per plant (0.383), harvest index (0.289), 1000 grain weight (0.219) and hulling percentage (0.155) while biological yield per plant (0.105) and kernel length after cooking (0.023) showed non-significant and positive correlation association. Characters like L/B ratio (-0.224) showed negative and highly significant correlation whereas, gel consistency (-0.102) showed negative and non-significant association with grains per panicle. 1000-grain weight exhibited significant and positive correlation with biological yield per plant (0.140) while for the characters like grain yield per plant (0.106), kernel length after cooking (0.086), harvest index (0.034) and L/B ratio (0.029) showed positive and non-significant correlation association.

Table 1: Phenotypic correlation among fourteen characters in rice

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Spikeletes/panicle	Grains/panicle	1000 grain weight (g)	Biological yield/plant (g)	Harvest index (%)	Hulling %age	L/B ratio	Kernel length after cokking (mm)	Gel consistency (mm)	Grain yield/plant (g)
Days to 50% Flowering	1.000	0.592**	0.229**	0.206**	-0.365**	-0.277**	-0.178**	-0.326**	0.066	0.100	0.326**	0.134*	-0.313**	-0.199**
Days to Maturity			0.099	0.267**	-0.430**	-0.258**	-0.277**	-0.316**	0.071	0.043	0.378**	0.180**	-0.328**	-0.228**
Plant Height (cm)				0.299**	-0.371**	-0.415**	-0.163**	0.198**	-0.181**	0.051	0.079	0.076	-0.144*	-0.033
Panicle Length (cm)					-0.188**	-0.045	0.033	0.045	0.223**	0.140*	0.109	0.179**	-0.239**	0.210**
Spikeletes/panicle						0.210**	0.345**	0.021	0.096	-0.189**	-0.160**	-0.201**	0.020	0.200**
Grains/panicle							0.219**	0.105	0.289**	0.155**	-0.224**	0.023	-0.102	0.383**
1000 grain weight (g)								0.140*	0.034	-0.108	0.029	0.086	-0.070	0.106
Biological yield/plant (g)									-0.165**	0.182**	-0.132*	0.040	0.124*	0.421**
Harvest index (%)										0.165**	0.042	0.206**	-0.054	0.670**
Hulling % age											-0.129*	0.123*	0.059	0.281**
L/B ratio												0.405**	-0.252**	-0.061
Kernel length after cokking (mm)													-0.186**	0.212**
Gel consistency (mm)														-0.003
Grain yield/plant (g)														1.000

* 5%, ** 1% level of significance

Table 2: Genotypic correlation among fourteen characters in rice

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Spikeletes/panicle	Grains/panicle	1000 grain weight (g)	Biological yield/plant (g)	Harvest index (%)	Hulling %age	L/B ratio	Kernel length after cokking (mm)	Gel consistency (mm)	Grain yield/plant (g)
Days to 50% Flowering	1.000	0.854**	0.250**	0.334**	-0.394**	-0.347**	-0.240**	-0.387**	0.095	0.119*	0.403**	0.135*	-0.328**	-0.230**
Days to Maturity			0.189**	0.256**	-0.473**	-0.279**	-0.368**	-0.392**	0.094	0.112*	0.433**	0.248**	-0.434**	-0.236**
Plant Height (cm)				0.468**	-0.464**	-0.428**	-0.197**	0.242**	-0.226**	0.073	0.096	0.088	-0.145*	-0.049
Panicle Length (cm)					-0.195**	-0.058	0.120*	0.062	0.263**	0.123*	0.128*	0.227**	-0.302**	0.269**
Spikeletes/panicle						0.242**	0.408**	0.059	0.093	-0.267**	-0.179**	-0.202**	0.024	0.206**
Grains/panicle							0.277**	0.110	0.325**	0.213**	-0.228**	0.014	-0.104	0.402**
1000 grain weight (g)								0.196**	0.038	-0.034	0.034	0.117*	-0.086	0.127*
Biological yield/plant (g)									-0.158**	0.274**	-0.113*	0.024	0.147**	0.448**
Harvest index (%)										0.234**	0.038	0.231**	-0.057	0.703**
Hulling % age											-0.148**	0.194**	0.132*	0.377**
L/B ratio												0.431**	-0.266**	-0.056
Kernel length after cocking (mm)													-0.191**	0.216**
Gel consistency (mm)														0.003
Grain yield/plant (g)														1.000

* 5%, ** 1% level of significance

Hulling percentage (-0.108) and gel consistency (-0.070) showed negative and non-significant correlation association for 1000-grain weight. Biological yield per plant had highly significant and positive association with grain yield per plant (0.421) and hulling percentage (0.182), positive and significant association observed for gel consistency (0.124). Harvest index (%) had highly significant and positive association with grain yield per plant (0.670), kernel length after cooking (0.206) and hulling percentage (0.165) but it shows positive and non-significant association with L/B ratio (0.042) while it showed negative and non-significant correlation with gel consistency (-0.054). Hulling percentage shows highly significant and positive association with grain yield per plant (0.281. L/B ratio showed positive and highly significant correlation with kernel length after cooking (0.405). Kernel length after cooking showed positive and highly significant correlation with grain yield per plant (0.212) and for gel consistency (-0.186) it showed negative and highly significant correlation. Positive associations between these characters have also been reported by Nandan *et al.,* (2010) [14]; Kumar *et al*., (2011) [12]; Basavaraja *et al.,* (2011) [3]; Bagheri *et al.,* (2011) [2]; Kiani (2012) [10]; Krishnamurthy and Kumar (2012) [11]; Pandey *et al.,* (2012) [15]; Sudharani *et al.,* (2013); Bhati *et al.,* (2015) [17]; Kumar *et al.,* (2018) [13] and Sreedhar and Reddy (2019) [16].

At Genotypic level

Grain yield per plant possessed positive and highly significant correlation with harvest index (0.703), biological yield per plant (0.448), grains per panicle (0.402), hulling percentage (0.377), panicle length (0.269), kernel length after cooking (0.216), spikelets per panicle (0.206) and 1000 grain weight (0.127), while negative and highly significant or significant correlation associated with days to maturity (-0.236) and days to 50% flowering (-0.230), whereas negative and non-significant associated with L/B ratio (0.056), plant height (-0.049) and gel consistency (-0.003). Days to 50% flowering showed positive and highly significant correlation with days to maturity (0.854), L/B ratio (0.403), panicle length (0.334), Plant height (0.250) whereas kernel length after cooking (0.135). Days to maturity showed positive and highly significant correlation with L/B ratio (0.433), panicle length (0.256), kernel length after cooking (0.248) and plant height (0.189). Plant height showed positive and highly significant correlation with panicle length (0.468) and biological yield per plant (0.242) whereas L/B ratio (0.096), kernel length after cooking (0.088) and hulling percentage (0.073). Panicle length had highly significant positive correlation with grain yield per plant (0.269), harvest index (0.263), kernel length after cooking (0.227) and L/B ratio (0.128), hulling percentage (0.123). Spikeletes per panicle showed highly significant and positive correlation with 1000-grain weight (0.408), grains per panicle (0.242), and grain yield per plant (0.206). Grains per panicle showed highly significant and positive correlation with grain yield per plant (0.402), harvest index (0.325), 1000 grain weight (0.277) and hulling percentage (0.213). 1000-grain weight exhibited highly significant and positive correlation with biological yield per plant (0.196) while for the characters like grain yield per plant (0.127), kernel length after cooking (0.117) positive and significant correlation was observed. Biological yield per plant had highly significant and positive association with grain yield per plant (0.448), hulling percentage (0.274) and gel consistency (0.147) positive and non-significant association observed for kernel length after cooking (0.024). Harvest index (%) had highly significant and positive association with grain yield per plant (0.703), hulling percentage (0.234) and kernel length after cooking (0.231). Hulling percentage shows highly significant and positive association with grain yield per plant (0.377), kernel length after cooking (0.194). L/B ratio showed positive and highly significant correlation with kernel length after cooking (0.431). Kernel length after cooking showed positive and highly significant correlation with grain yield per plant (0.216). Therefore, these characters emerged as most important associates for grain yield in rice. The strong positive association of grain yield with the characters mentioned above has also been reported in rice by earlier workers Jayasudha and Sharma (2010) [7]; Nandan *et al.,* (2010) [14]; Akhtar *et al.,* (2011); Kumar *et al.,* (2011) [12]; Basavaraja *et al.,* (2011) [3]; Bagheri *et al.,* (2011) [2]; Laxuman *et al.,* (2011); Kumar *et al.,* (2011) [12]; Kiani (2012) [10]; Kiani and Nematzadeh (2012) [10]; Krishnamurthy and Kumar (2012) [11]; Pandey *et al.,* (2012) [15]; Sudharani *et al.,* (2013) [17]; Bhati *et al.,* (2015) [4]; Kumar *et al.,* (2018) [13] and Sreedhar and Reddy (2019) [16].

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