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Correlation and path coefficient analysis for yield and its related traits in rice (*Oryza sativa* L.)

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Abstract
In-depth understanding on relationship between crop yield and its related traits is very crucial for every crop improvement programme. Considering the importance of trait association, present investigation has been done to find out interdependency among various traits and their effect on yield.132 rice germplasm has been evaluated along with 4 local checks using augmented randomized complete block design. Data were recorded on 14 quantitative traits. Results indicated that the crop yield has significant positive association with flag leaf breadth (0.283**) and flag leaf area (0.220*) and significant negative correlation with flag leaf length breadth ratio (-0.236**), grain length (-0.235**) and grain length breadth ratio (-0.174*). Inter-character correlation showed many significant positive and negative associations between various traits. Flag leaf length revealed significant positive correlation with flag leaf breadth (0.257**), flag leaf length breadth ratio (0.479**), flag leaf area (0.703**) and grain length (0.185*). Results of path coefficient analysis revealed that flag leaf area has highest positive direct effect on yield (0.739) followed by days to maturity (0.588). Highest negative direct effect on yield was exhibited by days to 50 percent flowering (-0.616) followed by flag leaf breadth (-0.38885), flag leaf length (-0.28213), grain length(-0.17095) and flag leaf length breadth ratio(-0.16353). Increase in crop yield is associated with increase in flag leaf area. Above results showed that flag leaf breadth and flag leaf area were most important trait that can be used as selection criteria.

Keywords: Rice, correlation, path, flag leaf area and flag leaf width

Introduction

Oryza sativa is staple meal for more than 50% of the world's population (Wu *et al*. 2013) [1]. It's an annual crop belongs to family poaceae. It's a diploid species with chromosome number 2n=24. It accounts for 43.86 mha of total cultivated area in India. It can be grown in varied conditions. Evolution of high yielding varieties with other beneficial agronomic characteristics is crucial to fulfill the growing demand for food. Yield is controlled by several components and constitutes a complex trait, thus it is more difficult to achieve genetic improvement in yield. To counteract this problem, it is advisable that selection should not only be limited to the grain yield but it should also takes into account other related traits (Yuan *et al*. 2011) [2]. Correlation analysis gives insight into the relationship between yield and its related traits and helps in selection of best genotypes from diverse group. Positive correlation of component traits with high heritability increases grain yield directly or indirectly (Hasan *et al*. 2013) [3]. However, correlation study between component traits can often leads to confusing results as it does not provide exact information about direct and indirect effects of different traits on yield (Codawat, 1980) [4]. Indirect selection of the component traits which are positively correlated with yield is a routine course of conduct in a breeding programme. Indirect selection has yielded productive results in many cases. In case of rice, yield and its contributing traits has been extensively studied both at genotypic and phenotypic level (Akinwal *et al*. 2011) [5]. Path coefficient analysis is a statistical tool which split correlation coefficient into direct and indirect effects. It allows estimation of contribution of each character to the yield and helps in determination of selection criteria to enhance yield of the plant. The current study has been carried out to find out relationships between grain yield and related morphological and physiological traits.

Materials and Method

The present investigation has been conducted during kharif 2019 at CRC, GBPUAT, Pantnagar. Augmented block design II has been used to test the materials. Planting material consisted of 132 germplasm lines and 4 local checks. Augmented design consists of 6 blocks and each block contains 26 plots. Transplanting of 26 days old seedlings was done in each plot. Data were recorded on 10 random plants. 14 quantitative traits *viz*. Days to 50 percent flowering (DF), Days to maturity (DM), Plant height at maturity (PH), Number of tillers per plant (NT), Panicle length (PL), Grain yield per plant (Y), Thousand grains weight (TW), Flag leaf length (FLL), Flag leaf breadth (FLB), Flag leaf length to Flag leaf breadth ratio (FLLBR), Flag leaf area(FLA), Grain length(GL), Grain breadth (GB) and Grain length to breadth ratio (GLBR) were taken into consideration. Statistical analysis was carried out using IBM SPSS STATISTICS. Simple correlation coefficient between different traits was estimated according to Searle, 1961.

Correlation coefficient (r) between trait x and y is calculated as

$$r_{xy} = \frac{\text{Cov.xy}}{\sqrt{(\text{Var.x X var.y})}}$$

Where

r_{xy}= Correlation coefficient between x and y.
Cov. xy = Covariance between characters x and y.
Var.x = Variance for x trait. Var.y = Variance for y trait.
Path coefficient analysis was carried out according to Dewey and Lu (1959) [7]. Direct and indirect path coefficients were calculated as described by Singh and Chudhary (1977) [8].

$$\mathrm{r_{yi}} = p_{yi} + \sum_{\substack{i'=1 \\ i'\neq 1}}^{k} r_{ii'} p_{yi'} \;\; for\ i \neq 1$$

r_{yi} = correlation coefficient between the ith causal variable (Xi) and effect variable (y)
$r_{ii'}$= correlation coefficient between the ith and i'th causal variables
p_{yi}=path coefficient (direct effect) of the ith causal variable (Xi)
$r_{ii'}\ p_{yi}$ = indirect effect of the ith causal variable via the i'th causal variable.

Results and Discussions

The present investigation of the relationship between grain yield and its related traits helps to reveal their importance in rice breeding programs. Results indicated that the crop yield has significant positive association with flag leaf breadth (0.283**) and flag leaf area (0.220*) and negative significant correlation with flag leaf length width ratio (-0.236**), grain length (-0.235**) and grain length breadth ratio (-0.174*) (Table 1). These results are in agreement with study of Zhang *et al*. (2015) [9] for flag leaf width (0.210*) and Rahman *et al.* (2014) [10] for flag leaf area. This shows that increase in crop yield is associated with increase in flag leaf area. Such kind of relationship has been studied by Peng *et al.* (1993) [11], IRRI (1995) [12] and Mohammad *et al.* (2002). Jennings and Beachell (1964) [14] studied that broad and short leaf has higher influence on crop yield which support that cultivar with higher flag leaf area gives more yield.

Non significant positive association was observed for crop yield with plant height, kernel breadth, flag leaf length, panicle length, test weight, number of tiller. Nearly similar results were reported by Sanghera *et al.* (2013) [15] and Suma *et al.* (2014) [16] for plant height and yield. Non significant negative association with yield was observed for days to 50 percent flowering and days to maturity. (Table 1.). Inter-character correlation showed many significant positive and negative associations between various traits. Flag leaf length revealed significant positive correlation with flag leaf breadth (0.257**), flag leaf length breadth ratio (0.479**) flag leaf area (0.703**), and grain breadth (0.185*). Flag leaf breadth showed significant positive association flag leaf area (0.864**) and plant height (0.303**). Similar results has been obtained by Ramesh *et al.* (2018) [17] for flag leaf breadth and plant height. Flag leaf breadth showed significant negative correlation with flag leaf length breadth ratio (-0.702**) and test weight (-0.258**). Flag leaf length breadth ratio revealed significant positive association with grain length (0.200*) and grain width(0.196*). Flag leaf area exhibits significant positive association with plant height(0.283**).Days to 50 percent flowering showed highest positive correlation with days to maturity(0.959).Grain length breadth ratio showed significant positive association with grain length (0.512**) and negative association with grain breadth(-0.622**). (Table 1). Significant positive correlation of grain length with grain length/ breadth ratio was reported by Patel *et al.* (2014) [18]. While negative correlation of grain breadth with grain length breadth ratio was reported by Srijan *et al.* (2016) [19]. Information regarding trait relationships helps in the selection process in crop improvement programme. (Gonçalves *et al*. 2017) [20].

Division of traits into direct and indirect effect helps in better understanding of the contribution each trait towards yield. It allows separating the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921) [21] for better interpretation of cause and effect relationship. Results of path coefficient analysis revealed that flag leaf area has highest positive direct effect on yield (0.739) followed by days to maturity (0.588) (Table 2). This direct and positive effect of flag leaf area was also found by Abarshahr *et al.* (2011) [22] and Shrestha *et al.* (2018) [24]. Highest negative direct effect on yield is exhibited by days to 50 percent flowering (-0.616) followed by flag leaf breadth (-0.38885), flag leaf length(-0.28213), grain length(-0.17095) and flag leaf length breadth ratio (-0.16353). Bhadru *et al*., (2011) [23] reported negative direct effects of flag leaf width and spikelet fertility percent, on grain yield per plant. Tejaswini *et al.* (2018) [25] and Archana *et al.* (2018) [26] studied similar results for negative direct effect of grain length on yield. Direct effect of tiller number, plant height, panicle length, grain length and length breadth ratio can be neglected due to very weak value. Flag leaf breadth showed positive indirect correlation through flag leaf area and flag leaf length breadth ratio.

Conclusion

The critical analysis of correlation and path coefficient analysis showed that flag leaf breadth and flag leaf area possessed positive direct effect and positive association with yield. Flag leaf plays important role in photosynthesis Flag leaf has important role in increasing crop yield as it is the key source of assimilation during grain filling. Therefore, flag leaf breadth and flag leaf area may be utilized as an important selection criteria in rice breeding programmes.

Table 1: Estimates of correlation coefficient for yield and yield related traits in rice germplasm

	NT	FLL	FLB	FLLBR	FA	DF	DM	PH	PL	GL	GB	GLBR	TW	Y
NT	1.000	0.078^{NS}	0.118^{NS}	-0.021^{NS}	0.130^{NS}	-0.046^{NS}	-0.029^{NS}	-0.127^{NS}	0.056^{NS}	-0.131^{NS}	-0.080^{NS}	0.006^{NS}	-0.031^{NS}	0.104^{NS}
FLL		1.000	0.257**	0.479**	0.703**	0.141^{NS}	0.138^{NS}	0.100^{NS}	0.121^{NS}	0.123^{NS}	0.185*	-0.059^{NS}	-0.136^{NS}	0.023^{NS}
FLB			1.000	-0.702**	0.864**	0.084^{NS}	0.094^{NS}	0.303**	-0.030^{NS}	-0.112^{NS}	-0.052^{NS}	-0.023^{NS}	-0.258**	0.283**
FLLBR				1.000	-0.270**	-0.005^{NS}	-0.010^{NS}	-0.168^{NS}	0.140^{NS}	0.200*	0.196*	-0.015^{NS}	0.148^{NS}	-0.236**
FA					1.000	0.136^{NS}	0.140^{NS}	0.283**	0.036^{NS}	-0.013^{NS}	0.046^{NS}	-0.041^{NS}	-0.265**	0.220*
DF						1.000	0.959**	0.044^{NS}	-0.009^{NS}	0.161^{NS}	-0.030^{NS}	0.139^{NS}	-0.049^{NS}	-0.067^{NS}
DM							1.000	0.044^{NS}	-0.034^{NS}	0.140^{NS}	-0.021^{NS}	0.114^{NS}	-0.077^{NS}	-0.017^{NS}
PH								1.000	0.090^{NS}	0.113^{NS}	-0.020^{NS}	0.126^{NS}	-0.131^{NS}	0.066^{NS}
PL									1.000	0.066^{NS}	-0.013^{NS}	0.041^{NS}	0.093^{NS}	0.006^{NS}
GL										1.000	0.063^{NS}	0.512**	0.061^{NS}	-0.235**
GB											1.000	-0.622**	0.120^{NS}	0.018^{NS}
GLBR												1.000	-0.105^{NS}	-0.174*
TW													1.000	0.072^{NS}
Y														1.000

*, ** Significant at 0.05 and 0.01 levels, respectively

Table 2: Estimates of Path coefficient analysis (direct and indirect effect of various traits on yield)

	NT	FLL	FLB	FLLBR	FA	DF	DM	PH	PL	GL	GB	GLBR	TW	Y
NT	0.04766	-0.02204	-0.04584	0.00346	0.09596	0.02819	-0.01703	-0.00360	0.00171	0.02234	-0.00060	-0.00028	-0.00543	0.104^{NS}
FLL	0.00372	-0.28213	-0.10002	-0.07828	0.51943	-0.08703	0.08148	0.00286	0.00372	-0.02111	0.00138	0.00278	-0.02380	0.023^{NS}
FLB	0.00562	-0.07257	-0.38885	0.11476	0.63791	-0.05198	0.05547	0.00862	-0.00094	0.01912	-0.00039	0.00108	-0.04521	0.283**
FLLLBR	-0.00101	-0.13505	0.27288	-0.16353	-0.19979	0.00300	-0.00588	-0.00477	0.00432	-0.03420	0.00146	0.00072	0.02593	-0.236**
FA	0.00619	-0.19841	-0.33584	0.04423	0.73862	-0.08407	0.08217	0.00804	0.00112	0.00216	0.00034	0.00193	-0.04649	0.220*
DF	-0.00218	-0.03986	-0.03281	0.00080	0.10080	-0.61599	0.56430	0.00124	-0.00028	-0.02745	-0.00023	-0.00657	-0.00852	-0.067^{NS}
DM	-0.00138	-0.03906	-0.03666	0.00163	0.10314	-0.59068	0.58848	0.00124	-0.00104	-0.02388	-0.00016	-0.00537	-0.01349	-0.017^{NS}
PH	-0.00604	-0.02834	-0.11784	0.02745	0.20876	-0.02685	0.02567	0.02844	0.00276	-0.01928	-0.00015	-0.00594	-0.02300	0.066^{NS}
PL	0.00265	-0.03411	0.01185	-0.02296	0.02678	0.00565	-0.01986	0.00255	0.03076	-0.01136	-0.00009	-0.00193	0.01633	0.006^{NS}
GL	-0.00623	-0.03484	0.04350	-0.03272	-0.00934	-0.09892	0.08221	0.00321	0.00204	-0.17095	0.00047	-0.02414	0.01071	-0.235**
GB	-0.00382	-0.05217	0.02014	-0.03211	0.03362	0.01878	-0.01256	-0.00056	-0.00039	-0.01077	0.00744	0.02933	0.02098	0.018^{NS}
GLBR	0.00029	0.01661	0.00888	0.00250	-0.03023	-0.08579	0.06694	0.00358	0.00126	-0.08744	-0.00463	-0.04719	-0.01841	-0.174*
TW	-0.00148	0.03829	0.10023	-0.02418	-0.19577	0.02991	-0.04525	-0.00373	0.00286	-0.01044	0.00089	0.00495	0.17540	0.072^{NS}

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