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# CHARACTER ASSOCIATION AND PATH ANALYSIS STUDIES OF YIELD AND QUALITY PARAMETERS IN BASMATI RICE (*ORYZA SATIVA* L.)

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## ABSTRACT

A study of correlation and path analysis was undertaken in 23 genotypes of basmati rice for grain yield, its componenttraits and grain quality traits. Yield per plant had highly significant positive genotypic and phenotypic correlation with days to maturity ($r_p$ = 0.3998, $r_g$ = 0.4190), effective panicles ($r_p$ = 0.7295, $r_g$ = 0.7443), spikelets per panicle ($r_p$ = 0.4892, $r_g$ = 0.5069) and amylose content ($r_p$ = 0.4155, $r_g$ = 0.4490). Kernel L/B ratio showed positive and significant correlation with KLAC ($r_p$ = 0.5510, $r_g$ = 0.5790) and showed negative and significant correlation with elongation ratio ($r_p$ = -0.4235, $r_g$ = -0.4397). Correlation studies indicated that close relationshipbetween genotypic and phenotypic correlation coefficients and magnitude of genotypic correlation were higherthan their corresponding phenotypic correlation for most of the characters. Path coefficient analysis revealed that the number of characters chosen for the study were very much appropriate as evident from low value of residual effect (0.1614).Effective panicles per plant imparted the highest positive direct effects (0.6169) on yield followed by test weight (0.5545), spikelets per panicle (0.5268), kernel length (0.3364) and spikelet fertility (0.2175). The study suggested that days to maturity, effective panicles, spikelets per panicle, spikelet fertility, test weight, kernel length, kernel L/B ratio, KLAC, elongation ratio are important traits which should be used asselection criteria to develop high yielding and better quality varieties in basmati rice.

## INTRODUCTION

Basmati Rice (*Oryza sativa* L.) popularly known as 'scented pearl' is a natural gift exclusively to Indian sub-continent. It is a special type of aromatic rice known the world over for its extra long grains, pleasant and distinct aroma. Traditional basmati rice varieties are very low yielding due to their poor harvest index, tendency to lodging and increasing susceptibility to foliar diseases; hence there is a need to develop new varieties combining the grain quality attributes of basmati with high yield potential (Amarawathi *et al.,* 2008). Grain yield is a complex polygenic character controlled by many genes interacting with the environment and is the product of many factors called yield components. However, direct selection for yield alone is usually not very effective or may often be misleading. Hence, selection based on its contributing characters could be more efficient and reliable (Kumar *et al.,* 2013a; Kumar *et al.,* 2013b).The study of correlation between plant characters is of great importance to a plant breeder as it provides a measureof the degree of association between yield and other yieldattributes. Correlation studies permit only a measure of relationship between two traits. Therefore, path coefficient analysis becomes necessary as it indicate separation of direct and indirect effects via other related characters by partitioning through correlation coefficients. The study of correlations (genotypic andphenotypic) and path coefficient analysis of yield would be of help in selection of yield component traits in the genetic improvement of quantitative traits, which are positively correlated.In order to improve the yield potential without sacrificing the special quality features of basmati, knowledge on the correlation between yield and its component characters can help improve the efficiency of selection.In this regards, a good number of research works in basmati rice and other quality rices has been reported by many workers viz., Zahid *et al.* (2006), Vanisree *et al.* (2013), Nayak *et al.* (2001),Khedikar *et al.* (2004), Amarawathi *et al.* (2008), Cheema *et al.* (1998), Christopher *et al.* (2000).

Hence,the present study was conducted to know the extent of character association and path analysis for both yield and quality traits in a set of 23 basmati rice genotypes.

## MATERIALS AND METHODS

The experimental material used in the study comprised of twenty three basmati rice genotypes grown in different agro-ecological zones of India. Two non-basmati genotypes were also included in the study. The genotypes included under study are TBD-1, TBD-2, TAROARI BASMATI, BASMATI 370, KASTURI BASMATI, SONASAL BASMAT, RANBIR BASMATI, PUSA 2517-2-51-1, PUSA BASMATI-1,PUSA BASMATI-1S-97, PUSA 44, PUSA SUGANDH-3, PUSA SUGANDH-5, HUBR-2-

1, BASMATI-24-1, BASMATI-24-5, BASMATI-24-7, VASUMATI, PUSA SUGANDH-2, CSR-30(YAMINI), JP-2, PUSA 1460, PUSA 1121(Pusa Sugandh-4), MAHI SUGANDHA and TYPE-3.All genotypes were evaluated for grain yield and its attributing characters following randomized complete block design (RBD) with three replications during *kharif* season of two consecutive years of 2010 and 2011 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. Transplanting was done 25 days after sowing of seeds in nursery bed in a 4m$^2$ plot. Plant to plant distance was 15cm, row to row distance was 20cm and the crop was raised as per recommended package of practices to ensure normal crop. Observations were recorded on yield attributes viz., days to maturity, plant height (cm), panicle length (cm), effective panicles per plant (no.), spikelets per panicle (no.), spikelet fertility (%), test weight (gm) and yield per plant (gm) of ten randomly selected plants in each entry in a replication. Observations were also recorded to study grain quality characters viz., kernel length (mm), kernel breadth (mm), kernel L/B ratio, kernel length after cooking (mm), elongation ratio, alkali spread value (Little *et al.,* 1958) and amylose content (Juliano 1971). For statistical analysis, INDOSTAT software was used. The mean of the 25 genotypes were analyzed statistically by the method outlined by Ostle (1966). The analysis of variance for different characters was carried out in order to assess the genetic variability among genotypes as given by Cochran and Cox (1950). The level of significance was tested at 5% and 1% using F table values given by Fisher and Yates (1963). Correlation coefficients were estimated as suggested by Burton (1952) and path analysis was carried out following Dewey and Lu (1959).

## RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among genotypes for all yield traits and some quality traits indicating the presence of adequate variability among the genotypes. However, other quality traits exhibited little variation as the genotypes under study are basmati and there should not be any deviation from basmati quality.

A thorough understanding of the association of plant characters among themselves and with yield is essential for successful crop improvement programme. It enables the breeders to manipulate the expression of these traits in crop improvement. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its components and among themselves. Correlation analysis provides information on the nature and magnitude of the association of different component characters with grain yield, which is regarded as a complex trait which the breeder is ultimately interested in. It also helps us to understand the nature of inter-relationship among the component traits themselves. Therefore this kind of analysis could be helpful to the breeder to design selection strategies to improve the grain yield. Thegenotypic correlation coefficients in general were higher than the corresponding phenotypic correlation coefficients indicating a fairly strong inherent interrelationship among the traits are presented in Table 1. This finding corroborates with those of Zahid *et al.,* 2006 and Sawarkar and Senapati, 2014.

Grain yield showed positive and significant correlation with days to maturity ($r_p$=0.3998,$r_g$=0.4190), effective panicles ($r_p$=0.7295,$r_g$=0.7443), spikelets per panicle ($r_p$=0.4892, $r_g$=0.5069) and amylose content ($r_p$=0.4155, $r_g$=0.4490). Similar findings were reported earlier with days to maturity by Reddy *et al.* (2013), with effective panicles by Kole *et al.* (2008), Babu *et al.* (2012), with spikelets per panicle by Cheema *et al.* (1998), Reddy *et al.* (2013). However Vanisree *et al.* (2013), Tirumala rao *et al.* (2014) reported no significant association of effective panicles with grain yield. Grain yield showed no correlation with most of the quality characters. This finding is in consonance with Christopher *et al.* (2000) and Ekka *et al.* (2011).

Days to maturity showed positive and significant correlation at genotypic level with effective panicles ($r_g$=0.3310) and negative and significant correlation at genotypic level with panicle length ($r_g$=-0.3322) and spikelet fertility ($r_g$=-0.3576). Negative association between days to maturity and spikelet fertility also reported by Hasan *et al.* (2013). Plant height showed positive and significant correlation with panicle length ($r_p$=0.4941, $r_g$=0.5040) and amylose content ($r_p$=0.3412, $r_g$=0.3510)and negative significant association with alkali spread value ($r_p$=-0.6273, $r_g$=-0.6308) however it is not correlated with yield. Similar findings were reported by Kole *et al.* (2008), Babu *et al.* (2012),Reddy *et al.* (2013) , Vanisree *et al.* (2013), Hasan *et al.* (2013), Tirumala rao *et al.* (2014) however all these workers showed positive significant association of plant height with yield which is in contrast with present finding. At least in case of basmati rice, plant height is not a key determinant of grain yield and it is evident from traditional tall basmati genotypes are poor yielders.

Panicle length showed positive and significant correlation with test weight ($r_p$=0.3674, $r_g$=0.3781), kernel L/B ratio ($r_p$=0.3370, $r_g$=0.3593) and amylose content ($r_p$=0.3775, $r_g$=0.4044) and showed positive and significant correlation at genotypic level with kernel length ($r_g$=0.3318). The results for the trait test weight are in unison with Gopinath *et al.* (1984), Yogameenakshi *et al.* (2004), Babu *et al.* (2012), Reddy *et al.* (2013), Hasan *et al.* (2013) and Tirumala rao *et al.* (2014) and incontrast with Kole *et al.* (2008) and Vanisree *et al.* (2013); correlation with kernel length are in agreement with Ekka *et al.* (2011). Effective panicles per plant had positive and significant association with grain yield per plant while negative and non-significant association with test weight and kernel length. The results were in unison with Reddy *et al.* (1995), Roy *et al.* (1995), Reddy *et al.* (1997), Babu *et al.* (2012). However, effective panicles showed negative and significant correlation with kernel breadth ($r_p$=-0.3933, $r_g$=-0.4550). Spikelets per panicle showed negative and significant correlation with test weight ($r_p$=-0.3576, $r_g$=-0.3791). Similar finding reported by Kole *et al.* (2008), Vanisree *et al.* (2013), Tirumala rao *et al.* (2014). Spikelet fertility showed positive and significant correlation with kernel L/B ratio ($r_g$= 0.3302).

Test weight showed positive and significant correlation with kernel length ($r_p$=0.7088, $r_g$= 0.7579), kernel breadth ($r_p$=0.5205, $r_g$=0.6142), kernel L/B ratio ($r_p$=0.4417, $r_g$=0.4870) and KLAC ($r_p$=0.5269, $r_g$=0.5516). Similar kinds of findings are reported by Ekka *et al.* (2011). Kernel length showed positive and significant correlation with kernel breadth ($r_p$=0.3400, $r_g$=0.3822), kernel L/B ratio ($r_p$=0.8188,

**Table 1: Genotypic ($r_g$) and Phenotypic ($r_p$) correlation coefficient among different polygenic traits in basmati rice**

| Character | | Days to Maturity | Plant Height (cm) | Panicle Length (cm) | Effective Panicles | Spikelets/ Panicle | Spikelet Fertility % | Test Weight (100 Grain Wt.) | Kernel Length (mm) | Kernel Breadth (mm) | Kernel L/B ratio | KLAC (mm) | Elongation Ratio | Alkali Spread Value | Amylose Content (%) | Grian yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to Maturity | $r_p$ | - | -0.2700 | -0.3213 | 0.3273 | 0.3276 | -0.2927 | -0.0631 | 0.0707 | -0.0795 | 0.0438 | 0.2714 | 0.1667 | 0.2071 | 0.0418 | 0.3998* |
| | $r_g$ | - | -0.2717 | -0.3322* | 0.3310* | 0.3297 | -0.3576* | -0.0645 | 0.0713 | -0.0939 | 0.05 | 0.2753 | 0.1685 | 0.2072 | 0.0358 | 0.4190* |
| Plant Height (cm) | $r_p$ | | | 0.4941** | 0.2298 | 0.0983 | 0.0911 | 0.0216 | -0.0478 | -0.0439 | 0.0101 | 0.1923 | 0.2427 | -0.6273** | 0.3412* | 0.2837 |
| | $r_g$ | | | 0.5040** | 0.2315 | 0.0981 | 0.1086 | 0.0203 | -0.048 | -0.0511 | 0.0116 | 0.1939 | 0.2458 | -0.6308** | 0.3510* | 0.2922 |
| Panicle Length (cm) | $r_p$ | | | | -0.0667 | 0.1484 | -0.0221 | 0.3674* | 0.3243 | 0.0576 | 0.3370* | 0.1977 | -0.2817 | -0.1826 | 0.3775* | 0.2317 |
| | $r_g$ | | | | -0.0695 | 0.1521 | -0.031 | 0.3781* | 0.3318* | 0.07 | 0.3593* | 0.2058 | -0.2933 | -0.1843 | 0.4044* | 0.239 |
| Effective Panicles | $r_p$ | | | | | 0.2939 | -0.0533 | -0.1552 | -0.2513 | -0.3933* | -0.0432 | -0.0654 | 0.2278 | -0.1908 | 0.2317 | 0.7295** |
| | $r_g$ | | | | | 0.2977 | -0.0554 | -0.1748 | -0.2538 | -0.4550** | -0.04 | -0.0665 | 0.2327 | -0.1943 | 0.2436 | 0.7443** |
| Spikelets/ Panicle | $r_p$ | | | | | | -0.2239 | -0.3576* | -0.2602 | -0.2885 | -0.1318 | -0.1763 | 0.1502 | 0.0301 | 0.3057 | 0.4892** |
| | $r_g$ | | | | | | -0.2628 | -0.3791* | -0.2617 | -0.3248 | -0.1406 | -0.18 | 0.1529 | 0.0304 | 0.3167 | 0.5069** |
| Spikelet Fertility % | $r_p$ | | | | | | | 0.0734 | 0.2219 | -0.0886 | 0.2762 | 0.053 | -0.0763 | 0.0305 | -0.0537 | 0.0722 |
| | $r_g$ | | | | | | | 0.054 | 0.2647 | -0.1661 | 0.3302* | 0.0723 | -0.0829 | 0.0286 | -0.0675 | 0.0338 |
| Test Weight (100 Grain Wt.) | $r_p$ | | | | | | | | 0.7088** | 0.5205** | 0.4417* | 0.5269** | -0.2773 | 0.2124 | 0.2006 | 0.2616 |
| | $r_g$ | | | | | | | | 0.7579** | 0.6142** | 0.4870** | 0.5516** | -0.3212 | 0.24 | 0.2304 | 0.2419 |
| Kernel Length (mm) | $r_p$ | | | | | | | | | 0.3400* | 0.8188** | 0.6161** | -0.5108** | 0.2707 | 0.1414 | 0.1898 |
| | $r_g$ | | | | | | | | | 0.3822* | 0.8506** | 0.6214** | -0.5143** | 0.2722 | 0.1473 | 0.1972 |
| Kernel Breadth (mm) | $r_p$ | | | | | | | | | | -0.2217 | 0.1742 | -0.1529 | 0.2338 | -0.0753 | -0.1235 |
| | $r_g$ | | | | | | | | | | -0.1555 | 0.1942 | -0.1728 | 0.2601 | -0.1088 | -0.1613 |
| Kernel L/B ratio | $r_p$ | | | | | | | | | | | 0.5510** | -0.4235* | 0.1084 | 0.1764 | 0.237 |
| | $r_g$ | | | | | | | | | | | 0.5790** | -0.4397* | 0.1169 | 0.2031 | 0.2549 |
| KLAC (mm) | $r_p$ | | | | | | | | | | | | 0.266 | 0.234 | 0.2025 | 0.2113 |
| | $r_g$ | | | | | | | | | | | | 0.2574 | 0.2396 | 0.2061 | 0.2166 |
| Elongation Ratio | $r_p$ | | | | | | | | | | | | | -0.1279 | 0.0299 | 0.0443 |
| | $r_g$ | | | | | | | | | | | | | -0.1261 | 0.0276 | 0.0416 |
| Alkali Spread Value | $r_p$ | | | | | | | | | | | | | | -0.1062 | -0.0426 |
| | $r_g$ | | | | | | | | | | | | | | -0.1173 | -0.0386 |
| Amylose Content (%) | $r_p$ | | | | | | | | | | | | | | | 0.4155* |
| | $r_g$ | | | | | | | | | | | | | | | 0.4490* |

**Significance at $p = 0.01$ *Significance at $p = 0.05$

**Table 2: Path coefficient (genotypic) analysis showing direct (bold) and indirect effects of component traits in basmati rice**

| Character | Days to Maturity | Plant Height (cm) | Panicle Length (cm) | Effective Panicles | Spikelets/ Panicle | Spikelet Fertility % | Test Weight(100 Grain Wt.) | Kernel Length (mm) | Kernel Breadth (mm) | Kernel L/B ratio | KLAC (mm) | Elongation Ratio | Alkali Spread Value | Amylose Content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to Maturity | 0.1876 | -0.0510 | -0.0623 | 0.0621 | 0.0618 | -0.0671 | -0.0121 | 0.0134 | -0.0176 | 0.0094 | 0.0516 | 0.0316 | 0.0389 | 0.0067 |
| Plant Height (cm) | -0.0257 | 0.0947 | 0.0477 | 0.0219 | 0.0093 | 0.0103 | 0.0019 | -0.0045 | -0.0048 | 0.0011 | 0.0184 | 0.0233 | -0.0597 | 0.0332 |
| Panicle Length(cm) | -0.0065 | 0.0099 | 0.0197 | -0.0014 | 0.0030 | -0.0006 | 0.0074 | 0.0065 | 0.0014 | 0.0071 | 0.0040 | -0.0058 | -0.0036 | 0.0080 |
| Effective Panicles | 0.2042 | 0.1428 | -0.0429 | 0.6169 | 0.1837 | -0.0342 | -0.1079 | -0.1565 | -0.2807 | -0.0247 | -0.0410 | 0.1436 | -0.1199 | 0.1503 |
| Spikelets/Panicle | 0.1737 | 0.0517 | 0.0801 | 0.1568 | 0.5268 | -0.1384 | -0.1997 | -0.1379 | -0.1711 | -0.0741 | -0.0948 | 0.0806 | 0.0160 | 0.1669 |
| Spikelet Fertility % | -0.0778 | 0.0236 | -0.0067 | -0.0121 | -0.0572 | 0.2175 | 0.0117 | 0.0576 | -0.0361 | 0.0718 | 0.0157 | -0.0180 | 0.0062 | -0.0147 |
| Test Weight (100 Grain Wt.) | -0.0358 | 0.0113 | 0.2097 | -0.0969 | -0.2102 | 0.0300 | 0.5545 | 0.4202 | 0.3406 | 0.2700 | 0.3059 | -0.1781 | 0.1331 | 0.1277 |
| Kernel Length (mm) | 0.0240 | -0.0162 | 0.1116 | -0.0854 | -0.0880 | 0.0891 | 0.2550 | 0.3364 | 0.1286 | 0.2862 | 0.2091 | -0.1730 | 0.0916 | 0.0496 |
| Kernel Breadth (mm) | 0.0148 | 0.0080 | -0.0110 | 0.0716 | 0.0511 | 0.0262 | -0.0967 | -0.0602 | -0.1575 | 0.0245 | -0.0306 | 0.0272 | -0.0410 | 0.0171 |
| Kernel L/B ratio | -0.0153 | -0.0036 | -0.1098 | 0.0122 | 0.0430 | -0.1009 | -0.1488 | -0.2599 | 0.0475 | -0.3056 | -0.1769 | 0.1344 | -0.0357 | -0.0621 |
| KLAC(mm) | -0.0035 | -0.0025 | -0.0026 | 0.0009 | 0.0023 | -0.0009 | -0.0071 | -0.0080 | -0.0025 | -0.0075 | -0.0129 | -0.0033 | -0.0031 | -0.0027 |
| Elongation Ratio | -0.0048 | -0.0070 | 0.0083 | -0.0066 | -0.0043 | 0.0024 | 0.0091 | 0.0146 | 0.0049 | 0.0125 | -0.0073 | -0.0284 | 0.0036 | -0.0008 |
| Alkali Spread Value | -0.0144 | 0.0438 | 0.0128 | 0.0135 | -0.0021 | -0.0020 | -0.0167 | -0.0189 | -0.0181 | -0.0081 | -0.0167 | 0.0088 | -0.0695 | 0.0082 |
| Amylose Content (%) | -0.0014 | -0.0135 | -0.0155 | -0.0094 | -0.0122 | 0.0026 | -0.0089 | -0.0057 | 0.0042 | -0.0078 | -0.0079 | -0.0011 | 0.0045 | -0.0384 |
| $r_g$ Yield/ Plant (gm) | 0.4190* | 0.2922 | 0.2390 | 0.7443** | 0.5069** | 0.0338 | 0.2419 | 0.1972 | -0.1613 | 0.2549 | 0.2166 | 0.0416 | -0.0386 | 0.4490* |
| Partial $R^2$ | 0.0786 | 0.0277 | 0.0047 | 0.4592 | 0.2670 | 0.0073 | 0.1341 | 0.0663 | 0.0254 | -0.0779 | -0.0028 | -0.0012 | 0.0027 | -0.0173 |

R Square = 0.9740; Genotypic Residual Effect = 0.1614

$r_g$=0.8506), KLAC ($r_p$=0.6161, $r_g$=0.6214) and showed negative and significant correlation with elongation ratio ($r_p$=-0.5108, $r_g$=-0.5143). Alkali spread value and amylose contents are negatively correlated.Similar kind of result was reported for Kernel length and kernel L/B ratio by Christopher *et al.* (2000) and for negative association of kernel length with elongation ratio by Amarawathi *et al.* (2008). Pleiotropy and / or linkage may also be the genetic reasons for this type of negative association. According to NeWall and Eberhart (1961) when two characters show negative phenotypic and genotypic correlation it would be difficult to exercise simultaneous selection for these characters in the development of a variety. Hence, under such situations, judicious selection programme might be formulated for simultaneous improvement of such important developmental and component characters. Kernel L/B ratio showed positive and significant correlation with KLAC ($r_p$=0.5510, $r_g$=0.5790) and showed negative and significant correlation with elongation ratio ($r_p$=-0.4235, $r_g$=-0.4397).

From the above discussion it is evident that grain yield can be increased whenever there is an increase in characters that showed positive and significant association with grain yield. Hence, these characters can be considered as criteria for selection for higher yield as these were mutually and directly associated with yield. However, as simple correlation does not provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the correlations (Wright, 1921) for better interpretation of cause and effect relationship.

The estimates of path coefficient analysis are furnished for yield and yield component characters in Table 2. Path coefficient analysis revealed that the number of characters chosen for the study were very much appropriate as evident from low value of residual effect (0.1614). Eight characters viz., days to maturity, plant height, panicle length, effective panicles per plant, spikelets per panicle, spikelet fertility, test weight and kernel length had positive direct effect while six characters namely kernel breadth, kernel L/B ratio, kernel length after cooking, elongation ratio, alkali spread value and amylose content imparted negative direct effect on grain yield. Effective panicles per plant imparted the highest positive direct effects (0.6169) on yield followed by test weight (0.5545), spikelets per panicle (0.5268), kernel length (0.3364) and spikelet fertility (0.2175). These findings were also corroborated by Cheema *et al.* (1998), Meenakshi *et al.* (1999), Nayak *et al.* (2001), Madhavilatha (2002), Satish *et al.* (2003), Khedikar *et al.* (2004), Kole *et al.* (2008). However, Ekka *et al.* (2011) reported negative direct effect of kernel length on grain yield, Vanisree *et al.* (2013) reported negligible association of effective tillers with grain yield, which are in contrast with present finding.On the other hand, negative direct effect on grain yield were recorded by kernel breadth (-0.1575), kernel L/B ratio (-0.3056), KLAC (-0.0129) elongation ratio (-0.0284), alkali spread value (-0.0695) and amylose content (-0.0384).Similar kind of results was reported by Zahid *et al.* (2006) and Ekka *et al.* (2011). Although kernel L/B ratio, KLAC and elongation ratio had the negative direct effect on grain yield but overall effect on yield is positive due to indirect positive effect of test weight, kernel length and effective panicles.Therefore, genetic improvement of these characters through selection would be helpful in improving yield of basmati rice.

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