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# Studies on Character Associations and Path Coefficient Analysis in Rice bean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] Germplasm

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**Abstract**

The correlation and path coefficient analysis were carried out with 28 diverse genotypes of rice bean including three checks *viz*., PRR-1, PRR-2 and BRS-1 were evaluated in Randomized Complete Block Design with three replications. The characters studied were days to 50 per cent flowering, days to maturity, plant height, stem thickness, number of primary branches per plant, leaflet size , number of pods per plant, number of seeds per pod, pod length,100 seed weight and seed yield per plant. Grain yield per plant exhibited very strong positive association with number of pods plant$^{-1}$, pod length, leaflet size, number of seeds pod$^{-1}$ and number of primary branches at phenotypic and genotypic level. Path- coefficient analysis was carried out at genotypic as well as phenotypic level, identified number of pods per plant as major positive direct contributors followed by number of seeds pod$^{-1}$, leaflet size and plant height to seed yield plant$^{-1}$. Number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ exhibited high order positive indirect effect on seed yield plant$^{-1}$ via pod length whereas, number of pods plant$^{-1}$ followed by leaflet size exhibited highest positive indirect effect on seed yield. The characters identified above merit due consideration in formulating effective selection strategy in rice bean for developing high yielding varieties.

***Keywords:*** Correlation, path coefficient analysis, yield, rice bean

## 1. Introduction

Legume is widely recognized to be a symbol of sound agriculture economy, being a major source of protein for vegetarian human diet and with unique capacity to improve the soil fertility through nitrogen fixation. The capacity to fixation atmospheric nitrogen relationship with rhizobia has made the legumes essential component of sustainable agriculture. Pulse contain a high percentage of quality protein nearly three times as much as cereals. Apart from traditional tropical pulses example chickpea, mung bean, lentil, pigeon pea, urd bean and pea (Chandel and Singh, 1984). The rice bean is a multipurpose crop with a good potential to be used as food, fodder and green manure. Immature pods and leaves of rice bean are used as vegetable. The nutritional quality of rice bean appears to be the best among all traditional pulses (Arora, 1986; Chandel et al., 1988). The correlation coefficients are worked out to describe the degree of association between independent and dependent variables. Path coefficient analysis measures the direct influence of one variable upon another and permits the separation of correlation coefficients into components of direct and indirect effects. This gives clear picture of direct and indirect effects of the various traits on grain yield of plant. The object of breeding mostly confined to evaluate different genotypes of rice bean under high hills, low temperature and rain-fed condition of Himalayas from a set of germplasm collected from different places at hills and plains of India. Moreover, information on extent of association between various yield attributes and relative importance and direct and indirect influence of each of the component traits on yield could prove helpful in formulating an effective breeding strategy for randomized the productivity of rice bean at specific region of Uttarakhand.

## 2. Methods and Materials

The present investigation was carried out during *Kharif* 2014 at Research Block of Crop Improvement, College of Forestry, Ranichauri, TehriGarhwal, Uttarakhand. The experimental site, College of Forestry, Ranichuari is located at 10 km away from Chamba (Reshikesh-Gangotri road) at an altitude of about 2100 m above mean sea level, lying between 30$^0$ 15'

N latitude and 78° 30’ E longitudes under mid hill zones of Uttarakhand. The field evaluations of the genotypes were carried out in the experimental block of Department of Crop Improvement. The experimental materials for the present investigation comprised of 28 diverse entries of rice bean obtained from the Department of Crop Improvement, College of Forestry, Ranichauri. The experiment was conducted in the Randomized Complete Block Design (RBD) during *kharif* season under rainfed condition. There were 25 entries along with the three check was planted during the first week of June, 2014. The seeds were sown on 03 June, 2014, at about 4–6 cm depth by opening furrow with *kutla.* Each furrow was manually dribbled with seed and covered with soil immediately. The recommended row to row distance 30 cm and 15 cm between plants was maintained after germination by thinning of extra plant population after 20 days of germination. At maturity, crop was cut from the ground level with the help of sickles and tied into bundles and tagged. The bundles were allowed to dry under the sun for 8–10 days. Manual threshing of bundles of individual plot was done.

## 3. Results and Discussion

### *3.1. Correlations coefficient*

In the present investigation also the phenotypic and genotypic correlation coefficients were worked out.The estimates of correlation coefficients among different pairs of characters at phenotypic and genotypic (Table 1 and 2) showed a close resemblance to each other. A detail of the results of inter character association is given below:

A perusal of Table 1 showed that seed yield per plant was highly significant and positive phenotypic correlation with number of pods per plant (0.734) followed by pod length (0.632), leaflet size (0.609), number of seeds per pod (0.591), number of primary branches (0.296) and plant height (0.294) while it showed negative and highly significant phenotypic correlation with stem thickness (-0.557), days to maturity (-0.490) and days to 50% flowering (-0.402). Number of pods per plant showed highly significant positive phenotypic correlation with pod length (0.644) but it showed negative and highly significant correlation with stem thickness (-0.577)

Table 1: Estimates of genotypic correlation coefficients between different characters in rice bean

| Characters | DM | PH | ST | PL | NPP | LS | NPB | NSP | SW | |
|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50 % flowering | 0.508 | -0.089 | 0.268 | -0.648 | -0.564 | -0.482 | -0.279 | -0.398 | -0.033 | -0.581 |
| Days to maturity | | -0.287 | 0.298 | -0.545 | -0.660 | -0.395 | -0.751 | -0.776 | -0.029 | -0.640 |
| Plant height (cm) | | | 0.044 | 0.425 | 0.221 | 0.491 | 0.356 | 0.315 | 0.182 | 0.359 |
| Stem thickness (mm) | | | | -0.540 | -0.764 | -0.681 | -0.223 | -0.501 | 0.053 | -0.677 |
| Pod length (cm) | | | | | 0.788 | 0.732 | 0.621 | 0.851 | 0.043 | 0.795 |
| No.of pods per plant | | | | | | 0.848 | 0.776 | 0.942 | 0.130 | 0.987 |
| Leaflet size (cm) | | | | | | | 0.010 | 0.541 | 0.167 | 0.890 |
| No. of primary branches | | | | | | | | 0.944 | -0.178 | 0.720 |
| No. of seeds per pod | | | | | | | | | 0.176 | 0.835 |

*: Significant at (*p*=0.05) level; **: Significant at (*p*=0.01) level; DM: Days to maturity; PH: Plant height (cm); ST: Stem thickness (mm); PL: Pod length (cm); NPP: No. of pods per plant; LS: Leaflet size (cm); NPB: No. of primary branches; NSP: No. of seeds per pod; SW: 100 seed weight; CWSY: Correlation with seed yield (g)

Table 2: Estimates of phenotypic correlation coefficients between different characters in rice bean

| Characters | DM | PH | ST | PL | NPP | LS | NPB | NSP | SW | CWSY |
|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50 % flowering | 0.343** | -0.102 | 0.176 | -0.390** | -0.301** | -0.273* | -0.021 | -0.224* | -0.009 | -0.402** |
| Days to maturity | | -0.277* | 0.190 | -0.327** | -0.480** | -0.248* | -0.195 | -0.339** | 0.003 | -0.490** |
| Plant height (cm) | | | 0.022 | 0.305** | 0.174 | 0.316** | 0.091 | 0.164 | 0.118 | 0.294** |
| Stem thickness (mm) | | | | -0.444** | -0.577** | -0.488** | -0.147 | -0.390** | 0.054 | -0.557** |
| Pod length (cm) | | | | | 0.644** | 0.497** | 0.177 | 0.616** | 0.036 | 0.632** |
| No.of pods per plant | | | | | | 0.529** | 0.323** | 0.529** | 0.149 | 0.734** |
| Leaflet size (cm) | | | | | | | 0.106 | 0.384** | 0.097 | 0.609** |
| No. of primary branches | | | | | | | | 0.338** | -0.058 | 0.296** |
| No. of seeds per pod | | | | | | | | | 0.132 | 0.591** |

*: Significant at (*p*=0.05) level; **: Significant at (*p*=0.01) level

followed by days to maturity (-0.480) and days to 50% flowering (-0.301). Number of seeds per pod possessed highly significant and positive phenotypic correlation with pod length (0.616) followed by number pods plant$^{-1}$ (0.529), leaflet size (0.384) and number of primary branches (0.338) while it was highly significant and negative phenotypic correlation with stem thickness (-0.390) and days to maturity (-0.339) and significant and negative association with days to 50% flowering (-0.224). Leaflet size exhibited highly significant and positive phenotypic correlation with number of pods per plant (0.529) followed by pod length (0.497) and plant height (0.316) but it had highly significant and negative phenotypic correlation with stem thickness (-0.488) while, days to 50% flowering (-0.273) and days to maturity (-0.248) showed significant and negative phenotypic correlation with leaflet size. Days to maturity recorded highly significant and positive phenotypic correlation with days to 50% flowering (0.343) whereas, number of primary branches showed highly significant and positive phenotypic correlation with number of pods per plant (0.323). Pod length showed highly significant and positive phenotypic correlation with plant height (0.305) while, it had negative and highly significant phenotypic correlation with stem thickness (-0.444), days to 50% flowering (-0.390) and days to maturity (-0.327). The estimates of phenotypic correlation coefficient for rest of the characters pairs were non-significant.

The estimates of genotypic correlation coefficient between different characters showed close parallelism in direction with their corresponding phenotypic correlation (Table 2). The genotypic correlations were slightly higher in magnitude than corresponding correlation at phenotypic level.

The grain yield in almost all the crops is referred to as super character which results from multiplicative interactions of several other characters that are termed as yield components. Thus, genetic architecture of grain yield in rice bean as well as other crops is based on balance or overall net affected produced by various yield components directly or indirectly 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 variety. In this respect, the correlation coefficient which provides symmetrical measurement of degree of association between two variables or characters, help us in understanding the nature and magnitude of association among yield and yield components.

Grain yield per plant was significantly and positively correlated at phenotypic levels with number of pods per plant, number of seeds per pod, leaflet size, number of primary branches and days to maturity. It indicated that for improvement of seed yield per plant in rice bean selection should be practiced keeping in the view number of seeds per pod, number of primary branches, leaflet size, number of pods plant$^{-1}$ and days to maturity. Similar results on correlation have been also reported by Changkija and Rungsung (2009) in rice bean that grain yield per plant was significantly and positively associated with number of pods per plant and number of seeds per pod at phenotypic level indicating that these characters were principle yield components. Tabasum et al. (2010) observed in mung bean that seed yield had positive and significant correlation with number of pods plant$^{-1}$ and number of seeds pod$^{-1}$, Gaikwad et al. (2011); Ali et al. (2011) reported that grain yield plant$^{-1}$ exhibited highly significant and positive association with number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ in chickpea, Ahmed et al. (2012); Narasimhmulu et al. (2013) observed in mung bean that seed yield had positive and significant correlation with number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ and Jivani et al. (2013) reported that grain yield plant$^{-1}$ exhibited highly significant and positive association with number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ in chickpea, Shanko et al. (2014) exhibited that seed yield had positive and significant correlation with number of primary branches and number of seeds pod$^{-1}$ in cowpea, Bharti et al. (2014); Kumar et al. (2014) observed that grain yield plant$^{-1}$ had strong significant and positive association with number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ in black gram. Ojwang et al. (2016) signifi-cant ($p<0.05$) and positive correlation coefficients between yield and pods plus grain as well as shelling per-centage were recorded, indicating that this is an important variable for cultivar selection in vegetable pigeon pea. Pal et al. (2016) coefficient revealed a significant and positive correlation on Dry matter (0.946 g plant$^{-1}$), no. of branches (0.938 plant$^{-1}$), no. of pods (0.943 plant$^{-1}$), no. of grains (0.902) and test weight (0.951) were significantly and positively correlated with grain yield in pigeon pea. Pandey et al. (2016) correlation analysis biological yield plant$^{-1}$, pods plant$^{-1}$, 100-seed weight, harvest index and secondary branches plant$^{-1}$ had highly significant positive correlation with seed yield in pigeon pea. Yahaya and Ankrumah (2017) studied showed significant ($p<0.01$) positive associations between all the measured characters and grain yield in chick pea.

*3.2. Path coefficient analysis*

Correlation study only provides information on the relationship and does not give an idea on the cause of this relation and sometimes information obtained is misleading with respect to identification of yield components. Path analysis is one which provides information on the cause of such association (Wright, 1921; Dewey and Lu, 1959).

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct or indirect effects of yield components on seed yield to provide clear picture of character associations for formulating efficient selection strategy. Path analysis differs from simple correlations in that it points out the causes and their relative importance, whereas the latter measures simply the mutual association ignoring the causation. The results of various causes influencing seed yield per plant (effect) are shown in Table 3 and 4 at the phenotypic and genotypic levels, respectively.

*3.2.1. Phenotypic path coefficient analysis*

The direct and indirect effects of different characters on seed yield per plant at phenotypic level are presented in Table 3. The highest positive direct effect on seed yield plant$^{-1}$ were exerted by number of pods per plant (0.318) followed by leaflet size (0.190), number of seeds pod$^{-1}$ (0.182) and plant height (0.102) while highest negative direct effect on seed yield were exerted by stem thickness (-0.143) and days to maturity (-0.107). Number of pods plant$^{-1}$ (0.205) and number of seeds pod$^{-1}$ (0.112) exhibited high order positive indirect effect on seed yield plant$^{-1}$ via pod length. Number of pods plant$^{-1}$ (0.168) exhibited considerable positive indirect effect on seed yield via number of seeds per pod and leaflet size. The number of pods plant$^{-1}$ (0.102) also made positive indirect effect on seed yield via number of primary branches. Leaflet size (0.101) made substantial positive indirect effect on seed yield via number of pods per plant. Number of pods per plant (-0.183) were exhibited highest negative indirect effect on seed yield via stem thickness. Number of pods plant$^{-1}$ (-0.153) also exhibited negative indirect effect on yield via days to maturity. The rest of the estimates of indirect effects obtained in path analysis at phenotypic level were negligible. The estimate of residual factor obtained in phenotypic path analysis was 0.5429.

Table 3: Estimates of path coefficients between different characters in rice bean at genotypic level

| Characters | DF | DM | PH | ST | PL | NPP | LS | NPB | NSP | SW | CWSY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | -0.207 | -0.105 | 0.018 | -0.055 | 0.134 | 0.117 | 0.100 | 0.057 | 0.082 | 0.006 | -0.581 |
| Days to maturity | 0.083 | 0.164 | -0.047 | 0.049 | -0.089 | -0.108 | -0.065 | -0.123 | -0.127 | -0.004 | -0.640 |
| Plant height (cm) | -0.016 | -0.052 | 0.180 | 0.008 | 0.076 | 0.040 | 0.088 | 0.064 | 0.057 | 0.032 | 0.359 |
| Stem thickness (mm) | 0.027 | 0.030 | 0.004 | 0.103 | -0.055 | -0.078 | -0.070 | -0.023 | -0.051 | 0.005 | -0.677 |
| Pod length (cm) | 0.239 | 0.201 | -0.157 | 0.199 | -0.369 | -0.291 | -0.270 | -0.229 | -0.314 | -0.016 | 0.795 |
| No.of pods per plant | -0.470 | -0.551 | 0.184 | -0.638 | 0.658 | 0.834 | 0.708 | 0.648 | 0.786 | 0.109 | 0.987 |
| Leaflet size (cm) | -0.116 | -0.095 | 0.118 | -0.164 | 0.176 | 0.204 | 0.241 | 0.002 | 0.130 | 0.040 | 0.890 |
| No. of primary branches | 0.014 | 0.039 | -0.018 | 0.011 | -0.032 | -0.040 | -0.000 | -0.052 | -0.049 | 0.009 | 0.720 |
| No. of seeds per pod | -0.143 | -0.278 | 0.113 | -0.179 | 0.305 | 0.337 | 0.194 | 0.338 | 0.358 | 0.063 | 0.835 |

DF: Days to 50% flowering

Table 4: Estimates of path coefficients between different characters in rice bean at phenotypic level

| Characters | DF | DM | PH | ST | PL | NPP | LS | NPB | NSP | SW | SYP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | -0.127 | -0.043 | 0.013 | -0.022 | 0.049 | 0.038 | 0.034 | 0.002 | 0.028 | 0.001 | -0.402 |
| Days to maturity | -0.037 | -0.107 | 0.029 | -0.020 | 0.035 | 0.051 | 0.026 | 0.021 | 0.036 | -0.000 | -0.490 |
| Plant height (cm) | -0.010 | -0.028 | 0.102 | 0.002 | 0.031 | 0.017 | 0.032 | 0.009 | 0.016 | 0.012 | 0.294 |
| Stem thickness (mm) | -0.025 | -0.027 | -0.003 | -0.143 | 0.063 | 0.082 | 0.069 | 0.021 | 0.056 | -0.007 | -0.557 |
| Pod length (cm) | -0.013 | -0.011 | 0.010 | -0.015 | 0.033 | 0.021 | 0.016 | 0.006 | 0.020 | 0.001 | 0.632 |
| No.of pods per plant | -0.095 | -0.153 | 0.055 | -0.183 | 0.205 | 0.318 | 0.168 | 0.102 | 0.168 | 0.047 | 0.734 |
| Leaflet size (cm) | -0.052 | -0.047 | 0.060 | -0.093 | 0.094 | 0.101 | 0.190 | 0.020 | 0.073 | 0.018 | 0.609 |
| No. of primary branches | -0.001 | -0.009 | 0.004 | -0.007 | 0.008 | 0.015 | 0.005 | 0.047 | 0.016 | -0.002 | 0.296 |
| No. of seeds per pod | -0.041 | -0.061 | 0.030 | -0.071 | 0.112 | 0.096 | 0.070 | 0.061 | 0.182 | 0.024 | 0.591 |

SYP: Seed yield plant$^{-1}$ (g); Residual effect = 0.5429

*3.2.2. Genotypic path coefficient analysis*

The direct and indirect effects of different characters on seed yield per plant at genotypic level are presented in Table 4. The highest positive direct effect on seed yield per plant at genotypic level was recorded by number of pods per plant (0.834) followed by number of seeds per pod (0.358), leaflet size (0.241), plant height (0.180), days to maturity (0.164) and stem thickness (0.103). In contrast, high order negative direct effects on seed yield were exerted by pod length (-0.369) and 100 seed weight (-0.209). The direct effects of remaining characters were too low to be considered important. Number of pods per plant (0.786) followed by leaflet size (0.130) exhibited highest positive indirect effect on seed yield while high order negative indirect effect on seed yield were exhibited by pod length (-0.314) and days to maturity (-0.127) via number of seeds per pod. High order of positive indirect contribution shown by number of pods per plant (0.708) followed by leaflet size (0.241), number of seeds per pod (0.194) and days to 50% flowering (0.100) while pod length (-0.270) exerted substantial negative indirect effects on grain yield via leaflet size. Number of pods $plant^{-1}$ (0.658) followed by number of seeds $pod^{-1}$ (0.305), leaflet size (0.176) and days to 50% flowering (0.134) exerted substantial positive indirect effects on grain yield via pod length. Number of pods per plant (0.648) followed by number of seeds $pod^{-1}$ (0.338) exhibited positive indirect effects on seed yield while pod length (-0.229) and days to maturity (-0.123) exerted negative indirect effects on seed yield via number primary branches. Number of seeds $pod^{-1}$ (0.337) followed by leaflet size (0.204) and days to 50% flowering (0.117) exerted positive indirect effects on seed yield while negative indirect effects on grain yield via number of pods per plant were exhibited by pod length (-0.291) and days to maturity (-0.108). Pod length (0.239) exhibited high order positive indirect contribution towards seed yield $plant^{-1}$ via days to 50% flowering whereas, number of pods $plant^{-1}$ (-0.470), number of seed $pod^{-1}$ (-0.143) and leaflet size (-0.116) exerted substantial negative indirect effect on seed yield via days to 50% flowering. High order positive indirect effect on seed yield $plant^{-1}$ were exerted by pod length (0.201) via days to maturity, while negative indirect effects on grain yield were exerted by number of pods $plant^{-1}$ (-0.551), number of seeds $pod^{-1}$ (-0.278) and days to 50% flowering (-0.105) via days to maturity. Pod length (0.199) exhibited positive indirect effects on grain yield while high order negative indirect effects on grain yield were exerted by number of pods per plant (-0.638), number of seeds $pod^{-1}$ (-0.179) and leaflet size (-0.164) via stem thickness. No. of pods $plant^{-1}$ (0.184), leaflet size (0.118) and number of seeds $pod^{-1}$ (0.113) also made substantial positive indirect effects on grain yield while pod length (-0.157) were exhibited negative indirect effects on seed yield via plant height. Number of pods $plant^{-1}$ (0.109) also exerted positive indirect effects on seed yield via 100 seed weight. The rest of the estimates of indirect effects at genotypic level were too low to be considered important.

Evaluation of entire genotypic and phenotypic path analysis revealed that the characters, *viz*. number of pods $plant^{-1}$, leaflet size, number of seeds $pod^{-1}$ and plant height exhibited high positive direct effect on yield. These traits also had significant correlation with seed yield $plant^{-1}$ both at genotypic and phenotypic levels. Hence, the relative information of these characters might be considered during the time of selection procedure for improving the seed yield in rice bean. The residual effect of both genotypic and phenotypic path coefficients suggested that more number of characters should be in-corporate to account the entire variability of rice bean crop in mid hills of Uttarakhand.

Similar results have been also reported by Tabasum et al. (2010) reported in mung bean, Sharma and Saini (2011), Gaikwad et al. (2011), Naveed et al. (2012) in chickpea and Manggoel et al. (2012) observed in cowpea, Jivani et al. (2013) in chickpea, Rao et al. (2013) reported in pigeon pea, Shanko et al. (2014) in cowpea and Punia et al. (2014) reported in urd bean. Ojwang et al. (2016), Pal et al. (2016); Pandey et al. (2016) in pigeon pea, Yahaya and Ankrumah (2017) in chick pea.

## 4. Conclusion

A very strong positive correlation of seed yield $plant^{-1}$ at genotypic and phenotypic level was observed with number of pods per plant, pod length, leaflet size, number of seeds per pod and number of primary branches. Path-coefficient analysis was carried out at genotypic as well as phenotypic level, indentified number of pods per plant as major positive direct contributors followed by number of seeds $pod^{-1}$, leaflet size and plant height to seed yield $plant^{-1}$.

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