Studies on Association between Yield and Yield Attributing Traits in Cluster Bean [Cyamopsis tetragonoloba (L.) TAUB.] Genotypes

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A B S T R A C T

The experiment was conducted on 56 cluster bean genotypes to study the correlation among pod yield per plant components and their direct and indirect effects on pod yield per plant. This study helps in identifying the characters which mainly contributed towards pod yield. Plant height, number of clusters per plant, average weight of 50 pods, pod length, pod girth and 100 seed weight had positive association with pod yield per plant at phenotypic and genotypic levels. Significant positive direct effect at genotypic level were shown by number of branches per plant, internodal length, days to first harvest, number of clusters per plant, number of pods per cluster and average weight of 50 pods.

Keywords: Correlation, Path analysis, Cluster bean, Pod yield

Introduction

Cluster bean [Cyamopsis tetragonoloba (L.) Taub] is also known as guar bean, has a chromosome number of 2n= 2x=14. It is an arid legume crop, mostly cultivated in the arid and semi-arid areas as it is drought tolerant. The long deep taproot system enables the plant to grasp maximum water from the soil making it an ultimate drought resistant crop. It has the freedom from serious pests and diseases and long storage life of the harvested pods.

It is a self-pollinated crop belonging to family leguminosae. Guar is characterized as a short day erect or bushy annual plant. It has been reported that the cultivated species C. tetragonoloba was developed from a drought tolerant wild African species C. senegalensis (Mudgil et al., 2014), while Vavilov (1951) suggested India to be the centre of variability for cluster bean. The crop is widely grown in countries like India, Pakistan, Indonesia and other parts of Southern and South eastern Asia as a vegetable and fodder crop for a long time.

Cluster bean is rich in dietary fibre, potassium and folate which protect the heart from various cardiovascular complications. It is a reservoir of different amino acids including glutamine, arginine, aspartic acid and leucine.
Iron and calcium present in cluster bean helps in strengthening the bones. It also works as a good laxative, stimulating bowel movement, improving digestive system and help in flushing out unwanted chemicals.

Yield is a complex character and is known to be associated with a number of component characters and is highly affected by environmental variations. These characters are themselves interrelated. Such interdependence of the contributing factors affects their direct relationship with yield, thereby making correlation coefficients unreliable as selection indices. An understanding of correlation between yield and its attributing characters is essential to formulate guide lines for crop selection. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective. The path coefficient analysis reveals that, whether the association of the component characters with pod yield per plant is due to their direct effect on pod yield per plant, or is a consequence of their indirect effect via some other trait(s). Several path coefficient analysis have been conducted in cluster bean (Singh et al., 2005). Correlation alone may not give complete information but when used in conjunction with path coefficient analysis will give a better measure of cause and effect relationship existing between different pairs of characters (Rai and Dhamati, 2014).

To provide basis for selection and yield improvement in cluster bean, the present investigation was undertaken to determine the degree of association among characters and to measure direct and indirect effects of various component characters on pod yield per plant.

**Materials and Methods**

An investigation comprised of 56 genotypes of cluster bean (Table 1) was carried out at College of Horticulture, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district during kharif season of 2018. Genotypes were evaluated with two replications with spacing of 45 cm x 15 cm. Optimum management practices were followed uniformly for raising the crop.

The mean values of the genotypes in each replication were used for analysis of variance. Results and values were subjected to randomized complete block design. Critical differences were calculated at five per cent level.

Observations were recorded on five competitive and randomly selected plants from each plot in each replication for all the genotypes viz., plant height (cm), plant spread (cm), number of branches per plant, leaf area (cm\(^2\)) internodal length (cm), days to Flower Initiation, days to 50% flowering, days to first harvest, number of clusters per plant, number of pods per cluster, average weight of 50 pods (g), pod length (cm), pod girth (mm), number of seeds per pod, 100 seed weight (g), protein content of pods (%) and pod yield per plant (g).

The correlation co-efficient among all character combinations at phenotypic and genotypic levels were analysed employing formula suggested by Al-Jibouri et al., (1958) and path co-efficient analysis was done by following Dewey and Lu (1959).

**Results and Discussion**

The results of the analysis of variance for 17 characters of 56 cluster bean genotypes are presented in Table 2. The results indicated that there is highly significant variation among the genotypes for almost all the characters under study. The presence of genotypic correlation may be either due to pleotropic action of genes.
or due to linkage or more likely both. If a positive genotypic correlation was observed for pair of characters, certainly the improvement in one character will in turn improve the correlated character. If the improvement in one character results in a decrease in other character, this will also help the breeder in the selection of characters if necessary.

In the present study (Table 3 and 4), plant height, leaf area, number of clusters per plant, average weight of 50 pods, pod length, pod girth and 100 seed weight had positive association with pod yield per plant at phenotypic and genotypic levels. Similar result was found by Singh et al., (2005), Rai and Dharmati (2014) and Divya and Abdul (2016). Number of branches per plant had negative non-significant correlation with pod yield per plant. This suggests that selection of non-branching types would result in better yielding genotypes. Characters that showed negative phenotypic and genotypic correlation with pod yield per plant were days to 50% flowering and days to first harvest. Days to flower initiation showed significant negative association only at genotypic level with pod yield per plant. These were in agreement with the results reported by Patil et al., (2016).

Plant spread, number of branches per plant, internodal length, number of pods per cluster, number of seeds per pod and protein content of pods had no significant association with pod yield per plant indicating that improvement of these characters might have not affected the pod yield per plant of cluster bean.

As a guideline for the interpretation of the results of path analysis, the following broad points may be kept in view (Singh and Chaudhary, 1977). If the correlation coefficient between a causal factor and the effect is almost equal to its direct effect, then the correlation explains the true relationship and a direct selection through this trait will be effective.

If the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be the cause of the positive correlation. In such situations, the indirect causal factors are to be considered simultaneously for selection. Correlation coefficient may be negative but the effect is positive and high. Under these circumstances, restricted simultaneous selection model is to be followed i.e., restrictions are to be imposed to nullify the undesirable indirect effects to make use of the direct effect. If the correlation coefficient is negative and direct effect is also negative, then we have to drop selection based on that character.

The residual effect determines how best the causal factors account for the variability of the dependent factor. If the residual effect is high, some other factors which have not been considered here need to be included in this analysis to account fully for the variation in yield.

In the present study (Table 5 and 6), significant positive direct effect at genotypic level were shown by number of branches per plant, internodal length, days to first harvest, number of clusters per plant, number of pods per cluster and average weight of 50 pods. Plant height, number of clusters per plant and 100 seed weight exhibited significant positive direct effect at phenotypic level. These results were in accordance with the findings of Patil et al., (2016).

Significant negative direct effect was exhibited by plant spread, leaf area, days to 50% flowering, pod length and protein content at genotypic level. Leaf area displayed significant negative direct effect at phenotypic level.
Table 1 List of cluster bean genotypes used in the present study

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<tr>
<th>Treatment</th>
<th>Genotypes</th>
<th>Source</th>
<th>Treatment</th>
<th>Genotypes</th>
<th>Source</th>
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<td>RGC-1038</td>
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<td>NBPGR, Jodhpur</td>
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<td>IC-51063</td>
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<td>T25</td>
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<td>NBPGR, Jodhpur</td>
<td>T53</td>
<td>Thar Bhadavi</td>
<td>CIAH, Bikaner, Rajasthan</td>
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<tr>
<td>T26</td>
<td>IC-116607</td>
<td>NBPGR, Jodhpur</td>
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<td>MDU-1</td>
<td>TNAU, Coimbatore</td>
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<td>NBPGR, Jodhpur</td>
<td>T55</td>
<td>Chitra Gold</td>
<td>Vagro seeds Pvt. Ltd, Hyderabad</td>
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<td>T28</td>
<td>IC-116619</td>
<td>NBPGR, Jodhpur</td>
<td>T56</td>
<td>Pusa Navbahar (Check)</td>
<td>IARI, New Delhi</td>
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</table>
Table 2: Analysis of variance for different characters in cluster bean genotypes

<table>
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<tr>
<th>S. No</th>
<th>Characters</th>
<th>Mean sum of squares</th>
<th>Replications df= 1</th>
<th>Treatments df= 55</th>
<th>Error df= 55</th>
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<tbody>
<tr>
<td>1</td>
<td>Plant height (cm)</td>
<td></td>
<td>5.99</td>
<td>12935.65 **</td>
<td>1305.46</td>
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<tr>
<td>2</td>
<td>Plant spread (cm)</td>
<td></td>
<td>10.78</td>
<td>11345.61 **</td>
<td>210.50</td>
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<td>3</td>
<td>Number of branches per plant</td>
<td>0.0027</td>
<td>178.19 **</td>
<td>1.23</td>
<td></td>
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<tr>
<td>4</td>
<td>Leaf area (cm²)</td>
<td>17.004</td>
<td>48135.68 **</td>
<td>1135.00</td>
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<tr>
<td>5</td>
<td>Internodal length (cm)</td>
<td>0.065</td>
<td>102.59 **</td>
<td>15.14</td>
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<tr>
<td>6</td>
<td>Days to flower initiation</td>
<td>0.009</td>
<td>70.06 *</td>
<td>43.49</td>
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<tr>
<td>7</td>
<td>Days to 50 % flowering</td>
<td>0.57</td>
<td>119.96 **</td>
<td>59.43</td>
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<tr>
<td>8</td>
<td>Days to first harvest</td>
<td>0.08</td>
<td>522.56 **</td>
<td>29.42</td>
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<tr>
<td>9</td>
<td>Number of clusters per plant</td>
<td>0.0013</td>
<td>12.24 **</td>
<td>5.83</td>
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<tr>
<td>10</td>
<td>Number of pods per cluster</td>
<td>0.0063</td>
<td>12.26 **</td>
<td>0.34</td>
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<tr>
<td>11</td>
<td>Average weight of 50 pods (g)</td>
<td>70.72</td>
<td>165194.78 **</td>
<td>8365.78</td>
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<td>Pod length (cm)</td>
<td>0.041</td>
<td>242.88 **</td>
<td>10.76</td>
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<td>13</td>
<td>Pod girth (mm)</td>
<td>44.13</td>
<td>1556.75 *</td>
<td>939.96</td>
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<tr>
<td>14</td>
<td>Number of seeds per pod</td>
<td>0.000057</td>
<td>4.66 **</td>
<td>0.040</td>
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<tr>
<td>15</td>
<td>100 seed weight (g)</td>
<td>0.000072</td>
<td>27.73 **</td>
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<td>Pod yield per plant (g)</td>
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<td>167535.80 **</td>
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<td>17</td>
<td>Protein content of pods (%)</td>
<td>0.0053</td>
<td>1064.49 **</td>
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</table>

* Significant at 5 % level of significance  ** Significant at 1 % level of significance
Table 3: Genotypic correlation coefficients for different characters of cluster bean genotypes

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<th>Characters</th>
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<th>PS</th>
<th>NB</th>
<th>LA</th>
<th>INL</th>
<th>DFI</th>
<th>DFF</th>
<th>DFH</th>
<th>NCPP</th>
<th>NPPC</th>
<th>AWP</th>
<th>PL</th>
<th>PG</th>
<th>NSPP</th>
<th>HSW</th>
<th>PC</th>
<th>PYP</th>
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<td>PH</td>
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<td>-0.536**</td>
<td>0.421**</td>
<td>0.062</td>
<td>-0.415**</td>
<td>-0.194*</td>
<td>-0.290**</td>
<td>-0.050</td>
<td>0.156</td>
<td>0.448**</td>
<td>0.309**</td>
<td>0.187*</td>
<td>-0.222*</td>
<td>0.308**</td>
<td>-0.103</td>
<td>0.477**</td>
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<tr>
<td>PS</td>
<td>1.000</td>
<td>0.934**</td>
<td>-0.122</td>
<td>0.176</td>
<td>0.143</td>
<td>-</td>
<td>0.423**</td>
<td>0.543**</td>
<td>-0.079</td>
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<td>-0.036</td>
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<td>NB</td>
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<td>-0.307**</td>
<td>0.170</td>
<td>0.192**</td>
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<td>-0.173</td>
<td>0.036</td>
<td>-0.049</td>
<td>-</td>
<td>0.262**</td>
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<td>0.373**</td>
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<td>0.695**</td>
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<td>0.194*</td>
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<td>0.528**</td>
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<td>0.289**</td>
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<td>-0.118</td>
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<td>-0.034</td>
<td>0.305**</td>
<td>-0.051</td>
<td>0.225*</td>
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<td>0.182</td>
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*, ** significant at 5% and 1% level, respectively

PH: Plant height (cm); PS: Plant spread (cm); NB: Number of branches per plant; LA: Leaf area (cm²); INL: Internodal length (cm); DFI: Days to Flower Initiation; DFF: Days to 50% flowering; DFH: Days to first harvest; NCPP: Number of clusters per plant; NPPC: Number of pods per cluster; AWP: Average weight of 50 pods (g); PL: Pod length (cm); PG: Pod girth (mm); NSPP: Number of seeds per pod; HSW: 100 seed weight (g); PC: Protein content of pods (%); PYP: Pod yield per plant (g)
| Characters   | PH         | PS         | NB         | LA         | INL        | DFI        | DFF        | DFH        | NCPP       | NPPC       | AWP        | PL         | PG         | NSPP       | HSW        | PC         | PYP        |
|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| PH           | 1.000      | -          | 0.387**    | 0.046      | -          | -0.099     | -0.033     | 0.138      | 0.382**    | 0.233*     | 0.031      | 0.031      | 0.280**    | -0.036     | 0.434**    | 0.093      |
| PS           | 1.000      | 0.903**    | -0.125     | 0.179      | 0.044      | -0.121     | 0.389**    | 0.309**    | -0.075     | -0.166     | -0.040     | 0.043      | 0.050      | -0.176     | -0.036     | 0.056      |
| NB           | 1.000      | -          | 0.149      | 0.087      | -0.027     | 0.409**    | -0.145     | -0.016     | 0.033      | -0.050     | -          | -          | -0.158     | -0.158     | -0.036     |
| LA           | 1.000      | 0.019      | -0.174     | -0.157     | -0.131     | 0.196*     | -0.085     | 0.317**    | 0.258**    | 0.083      | 0.014      | 0.101      | 0.101      | 0.010      | 0.230*     |
| INL          | 1.000      | 0.035      | 0.263**    | -0.045     | -0.066     | 0.056      | -0.026     | 0.057      | -0.050     | 0.193*     | 0.025      | 0.088      | -0.147     | -0.147     | -0.018     |
| DFI          | 1.000      | 0.189*     | 0.061      | -0.042     | -0.073     | -0.102     | -0.153     | 0.107      | 0.088      | 0.229*     | 0.008      | -0.147     | -0.147     | -0.147     | -0.147     |
| DFF          | 1.000      | -0.097     | -0.223*    | 0.104      | -0.101     | -0.090     | -0.102     | -0.158     | -0.230*    | -0.230*    | -0.230*    | -0.230*    | -0.230*    | -0.230*    | -0.230*    |
| DFH          | 1.000      | -0.140     | -0.079     | -          | -0.147     | -0.036     | -0.138     | -0.240*    | -0.140     | -0.240*    | -0.240*    | -0.240*    | -0.240*    | -0.240*    | -0.240*    |
| NCPP         | 1.000      | -0.086     | 0.173      | 0.311**    | 0.240*     | 0.152      | 0.166      | 0.131      | 0.423**    | 0.131      | 0.423**    | 0.131      | 0.423**    | 0.131      | 0.423**    |
| NPPC         | 1.000      | -0.138     | -0.167     | 0.005      | 0.062      | -0.107     | 0.048      | 0.048      | 0.048      | 0.048      | 0.048      | 0.048      | 0.048      | 0.048      | 0.048      |
| AWP          | 1.000      | 0.750**    | 0.283      | 0.253**    | 0.499**    | -0.347**   | 0.347**    | -0.347**   | -0.347**   | -0.347**   | -0.347**   | -0.347**   | -0.347**   | -0.347**   | -0.347**   |
| PL           | 1.000      | 0.338**    | 0.201*     | 0.418**    | 0.357**    | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      | 0.063      |
| PG           | 1.000      | 0.119      | 0.110      | 0.058      | 0.203*     | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      | 0.018      |
| NSPP         | 1.000      | 0.061      | 0.458**    | 0.139      | 0.139      | 0.061      | 0.458**    | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      |
| HSW          | 1.000      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      | 0.139      |

* * significant at 5% and 1% level, respectively

PH Plant height (cm); PS Plant spread (cm); NB Number of branches per plant
LA Leaf area (cm²); INL Internodal length (cm); DFI Days to Flower Initiation
DFF Days to 50% flowering; DFH Days to first harvest; NCPP Number of clusters per plant
NPPC Number of pods per cluster; AWP Average weight of 50 pods (g); PL Pod length (cm)
PG Pod girth (mm); NSPP Number of seeds per pod; HSW 100 seed weight (g)
PC Protein content of pods (%); PYP Pod yield per plant (g)
**Table 5** Path coefficient analysis for different characters of cluster bean genotypes at genotypic level

| Character | PH   | PS   | NB   | LA   | INL  | DFI  | DFF  | DFH  | NCPP | NPPC | AWP  | PL   | PG   | NSPP | HSW  | PC   | PYP  |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| PH        | -0.030 | 0.013 | 0.016 | -0.013 | -0.002 | 0.013 | 0.006 | 0.009 | 0.002 | -0.005 | -0.014 | 0.009 | 0.006 | 0.007 | 0.009 | 0.003 | 0.477 |
| PS        | 0.801 | -1.952 | -1.824 | 0.237 | -0.343 | -0.279 | 0.562 | -0.825 | -1.060 | 0.153 | 0.333 | 0.069 | -0.297 | 0.118 | -0.352 | 0.111 | -0.057 |
| NB        | -0.367 | 0.641 | 0.686 | -0.211 | 0.117 | 0.131 | -0.024 | 0.299 | 0.294 | -0.099 | -0.232 | 0.119 | -0.025 | -0.034 | 0.179 | 0.058 | -0.181 |
| LA        | -0.364 | 0.105 | 0.266 | -0.865 | -0.014 | 0.288 | 0.213 | 0.125 | -0.322 | 0.076 | 0.761 | 0.601 | 0.437 | 0.167 | 0.457 | 0.013 | 0.376 |
| INL       | 0.052 | 0.150 | 0.145 | 0.014 | 0.850 | -0.024 | 0.246 | -0.019 | -0.101 | 0.065 | 0.030 | 0.029 | 0.044 | -0.297 | 0.118 | -0.352 | 0.111 |
| DFI       | -0.005 | 0.002 | 0.002 | -0.004 | 0.000 | 0.012 | 0.008 | -0.002 | -0.001 | -0.001 | -0.003 | 0.004 | 0.004 | 0.002 | -0.000 | -0.643 |
| DFF       | 0.149 | 0.221 | 0.027 | 0.189 | -0.222 | -0.513 | -0.767 | 0.130 | 0.352 | -0.112 | 0.081 | 0.040 | -0.120 | 0.212 | 0.133 | -0.384 |
| DFH       | -0.112 | 0.164 | 0.169 | -0.056 | -0.009 | -0.049 | -0.065 | 0.387 | -0.035 | -0.035 | -0.142 | 0.062 | 0.068 | 0.057 | 0.099 | 0.050 |
| NCPP      | -0.069 | 0.749 | 0.591 | 0.514 | -0.163 | -0.067 | -0.632 | -0.126 | 1.379 | -0.084 | 0.594 | 0.755 | 0.993 | 0.346 | 0.383 | 0.303 | 0.638 |
| NPPC      | 0.039 | -0.020 | -0.036 | -0.022 | 0.019 | -0.024 | 0.036 | -0.023 | -0.015 | 0.248 | 0.038 | 0.043 | -0.032 | 0.010 | 0.015 | 0.012 | 0.102 |
| AWP       | 0.483 | -0.184 | -0.365 | 0.950 | -0.038 | -0.295 | -0.114 | -0.397 | 0.465 | -0.167 | 1.080 | 0.867 | 0.630 | 0.285 | 0.566 | 0.479 | 0.093 |
| PL        | -0.116 | 0.013 | 0.065 | -0.259 | 0.013 | 0.129 | 0.020 | 0.060 | -0.204 | 0.064 | -0.300 | 0.373 | 0.253 | 0.081 | 0.164 | 0.025 | 0.425 |
| PG        | 0.008 | 0.007 | 0.002 | 0.022 | 0.013 | -0.016 | 0.011 | -0.008 | 0.031 | 0.002 | 0.025 | 0.029 | 0.043 | 0.012 | 0.010 | 0.005 | 0.585 |
| NSPP      | 0.036 | -0.010 | 0.008 | -0.032 | 0.008 | -0.025 | 0.026 | 0.024 | -0.041 | -0.010 | -0.043 | 0.036 | 0.047 | 0.163 | 0.026 | 0.556 |
| HSW       | -0.054 | 0.032 | 0.046 | -0.093 | -0.039 | 0.083 | 0.048 | 0.045 | -0.049 | 0.019 | 0.092 | 0.077 | 0.040 | 0.028 | 0.175 | 0.011 |
| PC        | 0.026 | 0.014 | 0.021 | 0.004 | -0.007 | -0.006 | 0.044 | 0.032 | -0.055 | -0.013 | 0.022 | 0.017 | -0.004 | 0.029 | 0.015 | 0.252 |

Residual effect = 0.699

PH Plant height (cm); PS Plant spread (cm); NB Number of branches per plant
LA Leaf area (cm²); INL Internodal length (cm); DFI Days to Flower Initiation
DFH Days to 50% flowering; DFF Days to first harvest; NCPP Number of clusters per plant
NPPC Number of pods per cluster; AWP Average weight of 50 pods (g); PL Pod length (cm)
PG Pod girth (mm); NSPP Number of seeds per pod; HSW 100 seed weight (g)
PC Protein content of pods (%); PYP Pod yield per plant (g)
Table 6 Path coefficient analysis for different characters of cluster bean genotypes at phenotypic level

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<th>Character</th>
<th>PH</th>
<th>PS</th>
<th>NB</th>
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<th>DFI</th>
<th>DFF</th>
<th>DFH</th>
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<th>NPPC</th>
<th>AWP</th>
<th>PL</th>
<th>PG</th>
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Residual effect = 0.699

PH Plant height (cm); PS Plant spread (cm); NB Number of branches per plant
LA Leaf area (cm²); INL Internodal length (cm); DFI Days to Flower Initiation
DFH Days to 50% flowering; DFH Days to first harvest; NCPP Number of clusters per plant
NPPC Number of pods per cluster; AWP Average weight of 50 pods (g); PL Pod length (cm)
PG Pod girth (mm); NSPP Number of seeds per pod; HSW 100 seed weight (g)
PC Protein content of pods (%); PYP Pod yield per plant (g)
Plant height, number of branches per plant, internodal length, days to first harvest, number of clusters per plant, number of pods per cluster and average weight of 50 pods and 100 seed weight can be identified as the major characters contributing towards pod yield and selection based on these characters can be effective for developing high yielding varieties of cluster bean genotypes.

Earlier findings of Saini et al., (2005) supported the above conclusion.

The present study indicated that, character association and path analysis prompted that selection for improvement in respect to pod yield would be more effective based on characters like plant height, leaf area, internodal length, days to first harvest, number of clusters per plant, number of pods per cluster, average weight of 50 pods, pod length, pod girth and 100 seed weight. Since these characters recorded significant genotypic and phenotypic correlation with high direct effect on pod yield.

**Acknowledgement**

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**References**


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