but it showed positive correlation with grain yield per plant. Similarly, days to 50 per cent flowering had positive direct effect, but had negative association with grain yield per plant. The results of the present study indicated that an ideal bajra plant should have high spike yield per plant, spike length, spike thickness and 1000 grain weight since they expressed significant correlation with maximum direct effect on grain yield per plant.

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Madras Agric. J., 95 (1-6): 195-199 January-June 2008
https://doi.org/10.29321/MAJ.10.100561

**Research Notes**

# Association and cause-and-effect analysis in $F_2$ generation of mungbean (*Vigna radiata* (L.) Wilczek).

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Pulses are the second most important source of protein and is considered as a rich source of protein especially for vegetarian population of India. Seed yield being a complex character, controlled by polygenes and to make effective selection for higher yield, the estimates of genotypic and phenotypic correlations between yield component characters and *inter se* association among themselves along with their direct and. indirect effects on yield are essential to ensure effective simultaneous selection involving two or more characters. The consistency

**Table 1. Estimates of genotypic (rg) and phenotypic (rp) correlation coefficients for eleven characters in $F_2$ generation of mungbean.**

| Characters | | Days to 50% flowering | Plant height (cm.) | Number of primary branches | Number of clusters per plant | Number of Pod per cluster | Number of pods per plant | Number of seeds per pod | Pod length (cm.) | Days to maturity | 100-seed weight (g) | Seed yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | rg | 1.0000 | 0.0098 | 0.0778 | -0.1078 | 0.0575 | -0.2053 | -0.0850 | -0.0059 | 0.0618 | -0.1588 | -0.1472 |
| | rp | 1.0000 | 0.0026 | 0.0674 | -0.0924 | 0.0025 | -0.0683 | -0.0216 | -0.0164 | 0.0355 | -0.1225 | -0.0913 |
| Plant height (cm.) | rg | | 1.0000 | -0.0637 | 0.1921 | 0.6194** | 0.2199 | 0.5515** | 0.3216* | 0.4429** | -0.1837 | 0.5380** |
| | rp | | 1.0000 | 0.0908 | 0.3093* | 0.4270* | 0.3509* | 0.3560* | 0.2618 | 0.3059 | -0.1169 | 0.5059*’ |
| Number of primary branches | rg | | | 1.0000 | 0.1321 | -0.0952 | 0.0947 | 0.1904 | -0.1379 | -0.2585 | 0.1492 | -0.0032 |
| | rp | | | 1.0000 | 0.2564 | -0.0360 | 0.2925 | 0.2219 | 0.0375 | -0.2121 | 0.0992 | 0.1811 |
| Number of clusters per plant | rg | | | | 1.0000 | -0.0642 | 0.9111** | 0.4584** | 0.6328** | -0.4542** | 0.3377* | 0.7960** |
| | rp | | | | 1.0000 | 0.0021 | 0.8200** | 0.3021 | 0.3659* | -0.3462* | 0.2457 | 0.7124** |
| Number of pods per cluster | rg | | | | | 1.0000 | 0.1470 | -0.0039 | -0.3168* | 0.8242** | -0.5871** | 0.2835 |
| | rp | | | | | 1.0000 | 0.1908 | 0.1628 | -0.1399 | 0.6302*” | -0.4450** | 0.2367 |
| No. of pods per plant | rg | | | | | | 1.0000 | 0.3687* | 0.4150* | -0.3945* | 0.2795 | 0.7387** |
| | rp | | | | | | 1.0000 | 0.3526* | 0.2521 | -0.3038* | 0.1699 | 0.7557** |
| Number of seeds per pod | rg | | | | | | | 1.0000 | 0.8081** | -0.1470 | -0.2596 | 0.4277* |
| | rp | | | | | | | 1.0000 | 0.4621** | -0.1457 | -0.1565 | 0.3368 |
| Pod length (cm.) | rg | | | | | | | | 1.0000 | -0.8275** | 0.2232 | 0.6756** |
| | rp | | | | | | | | 1.0000 | -0.5187** | 0.1653 | 0.4153* |
| Days to maturity | rg | | | | | | | | | 1.0000 | -0.4156* | -0.1031 |
| | rp | | | | | | | | | 1.0000 | -0.4017* | -0.1296 |
| 100-seeds weight (g) | rg | | | | | | | | | | 1.0000 | 0.2669 |
| | rp | | | | | | | | | | 1.0000 | 0.2076 |
| Seed yield (g) per plant | rg | | | | | | | | | | | 1.0000 |
| | rp | | | | | | | | | | | 1.0000 |

*,** Significant at 0.05 and 0.01 level of significance, respectively.

**Table 2. Direct (diagonal) and indirect effects of component traits attributing to yield for eleven characters in $F_2$ generation of mungbean at genotypic (G) and phenotypic (P) levels.**

| Characters | | Days to 50% flowering | Plant height (cm.) | Number of primary branches | Number of clusters per plant | Number of Pod per cluster | Number of pods per plant | Number of seeds per pod | Pod length (cm.) | Days to maturity | 100-seed weight (g) | Seed yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | G | **-0.1128** | -0.0211 | 0.0074 | -0.0304 | 0.1787 | 0.1994 | -0.0848 | -0.0101 | 0.0268 | -0.3002 | -0.1471 |
| | P | **-0.0266** | 0.0003 | 0.0005 | -0.0152 | 0.0001 | -0.0387 | 0.0010 | -0.0053 | 0.0095 | -0.0170 | -0.0914 |
| Plant height (cm.) | G | -0.0011 | **-2.1686** | -0.0061 | 0.0542 | 1.9238 | -0.2136 | 0.5504 | 0.5543 | 0.1918 | -0.3471 | 0.5380 |
| | P | -0.0001 | **0.1103** | 0.0007 | 0.0507 | 0.0119 | 0.1985 | -0.0170 | 0.0851 | 0.0819 | -0.0162 | 0.5058 |
| Number of primary branches | G | -0.0088 | 0.1381 | **0.0955** | 0.0373 | -0.2958 | -0.0919 | 0.1900 | -0.2377 | -0.1120 | 0.2820 | -0.0033 |
| | P | 0.0018 | 0.0100 | **0.0078** | 0.0420 | -0.0010 | 0.1655 | -0.0106 | 0.0122 | -0.0568 | 0.0138 | 0.1811 |
| Number of clusters per plant | G | 0.0122 | -0.4166 | 0.0126 | **0.2823** | -0.1995 | -0.8848 | 0.4575 | 1.0907 | -0.1967 | 0.6383 | 0.7960 |
| | P | 0.0025 | 0.0341 | 0.0020 | **0.1639** | 0.0001 | 0.4640 | -0.0144 | 0.1189 | -0.0927 | 0.0341 | 0.7125 |
| Number of pods per cluster | G | -0.0065 | -1.3432 | -0.0091 | -0.0181 | **3.1058** | -0.1428 | -0.0038 | -0.5460 | 0.3570 | -1.1097 | 0.2836 |
| | P | •0 0001 | 0.0471 | -0.0003 | 0.0004 | **0.0280** | 0.1079 | -0.0078 | -0.0455 | 0.1688 | -0.0618 | 0.2367 |
| No. of pods per plant | G | 0.0232 | -0.4769 | 0.0090 | 0.2572 | 0.4567 | **-0.9711** | 0.3679 | 0.7153 | -0.1709 | 0.5283 | 0.7387 |
| | P | 0.0018 | 0.0387 | 0.0023 | 0.1344 | 0.0053 | **0.5658** | -0.0168 | 0.0819 | -0.0814 | 0.0236 | 0.7556 |
| Number of seeds per pod | G | G.G096 | -1.1960 | 0.0182 | 0.1294 | -0.0120 | -0.3580 | **0.9980** | 1.3929 | -0.0637 | -0.4907 | 0.4277 |
| | P | 0.0006 | 0.0393 | 0.001 7 | 0.0495 | 0.0045 | 0.1995 | **-0.0478** | 0.1502 | -0.0390 | -0.0217 | 0.3368 |
| Pod length (cm.) | G | 0.0007 | -0.6973 | -0.0132 | 0.1787 | -0.9838 | -0.4030 | 0.8064 | **1.7237** | -0.3584 | 0.4220 | 0.6758 |
| | P | 0.0004 | 0.0289 | 0.0003 | 0.0600 | -0.0039 | 0.1426 | -0.0221 | **0.3251** | -0.1389 | 0.0229 | 0.4153 |
| Days to maturity | G | -0.0070 | -0.9605 | -0.0247 | -0.1282 | 2.5597 | 0.3831 | -0.1467 | -1.4264 | **0.4331** | -0.7856 | -0.1032 |
| | P | -0.0009 | 0.0337 | -0.0017 | -0.0568 | 0.0176 | -0.1719 | 0.0070 | -0.1686 | **0.2678** | -0.0558 | -0.1296 |
| 100-seeds weight (g.) | G | 0.0179 | 0.3983 | 0.0143 | 0.0953 | -1.8234 | -0.2714 | -0.2590 | 0.3848' | -0.1800 | **1.8902** | 0.2670 |
| | P | 0.0033 | -0.0129 | 0.0008 | 0.0403 | -0.0124 | 0.0962 | 0.0075 | 0.0537 | -0.1076 | **0.1389** | 0.2078 |

of correlation and selection parameters over different generations is necessary to ascertain whether testing of progenies in early generation for seed yield and other complexly inherited characters is a reliable index of their performance in the subsequent generations. Therefore, the present study has been undertaken to derive information on character association and path coefficient analysis of various traits with seed yield in $F_2$ generation of mungbean.

Experimental material consisted $F_2$ seeds of 16 crosses and 16 parents of mungbean, raised during *kharif*, 2004 in 1 x 1 sq.m. plots with inter and intra row spacing of 40 cm and 15 cm respectively. The experiment was laid in randomized complete block design with three replications at the Field Experimentation Center, Department of Genetics and Plant Breeding, Allahabad Agricultural Institute-Deemed University, Allahabad. Data were recorded on 10 randomly selected plants from each $F_2$ population for days to 50% flowering, plant height (cm), number of primary' branches per plant, number of clusters per plant number of pods per cluster, number of pods per plant, number of seeds per pod, pod length (cm), days to maturity and 100-seed weight (g) and seed yield per plant (g). The mean data over three replications were used for statistical analysis. The genotypic and phenotypic correlation coefficients were estimated following Al-Jibouri *et al.* (1958) and the measures of direct and indirect effects were obtained according to the procedure proposed by Dewey and Lu (1959).

In formulating a selection programme for the improvement of yield in any crop, the knowledge of inter-relationship of yield with other traits is of great value. Because of such inter-relationship, the exercise of selection pressure on one character may bring with it, the unavoidable change in other components so that net improvements achieved deviates from anticipation. Hence, the information on the correlation between yield and its component characters is a pre-requisite for crop improvement. In the present study, number of cluster per plant, number of pods per plant, pod length and plant height exhibited significant and positive association with seed yield per plant indicating the importance of these characters while making selection (Table. 1). These results are in agreement with earlier reports of Sharma (1999) and Rajan *et al.* (2000) in $F_2$ generation of mungbean. The interrelationship among these traits were also found to be positive and significant. Therefore, selection for any of these traits will result in improvement of other traits and ultimately seed yield. Number of pods per plant was found to be the most important character determining seed yield as it associated positively with all characters, expect days to 50% flowering and days to maturity. It had significant and positive association with number of clusters per plant. These results are in accordance with Singh *et al.* (1995). Pod length also exhibited significant and positive association with seed yield per plant followed by number of clusters per plant, number of seeds per plant and plant height (Hegde *et al.*, 1996).

As the correlation coefficients are insufficient to explain true relationship for effective manipulation of the character, path coefficients were worked out. Path coefficient analysis facilitates partitioning of the correlation coefficient into direct contribution of each of the component to yield and its indirect effect through other components. Path coefficient analysis in this study revealed, that all characters under the study had positive direct effect on seed yield at the phenotypic level, except days

to 50% flowering and number of seeds per pod, while no. of pods per plant exerted highest direct effect on seed yield per plant (Joseph and Santoshkumar, 1999 and Rajan *et al*, 2000). This indicates the importance of number of pods per plant, as a reliable component character for selection programme. In the present study, pod length had also received highly significant association with seed yield per plant through its net direct positive effect. Shanmugasundaram and Rangaswamy (1995) and Bhelkar *et al.*, (2003) had also reported the importance of pod length in $F_2$ generation of black gram and cowpea, respectively.

From the present investigation, it could be concluded that the characters, *viz.*, number of pods per plant, number of clusters per plant, pod length, plant height, and days to maturity should be taken into consideration while formulating selection programme to improve seed yield in mungbean.

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