Association Analysis for Yield and its Component Traits in F3 and F4 Populations of Pigeonpea (Cajanus cajan (L.) Mill Sp.)

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Abstract
An investigation was carried out in pigeon pea to understand the association among the yield components and their direct and indirect effects on the seed yield. Character association studies indicated that days to maturity, number of seeds per plant, number of pods per plant, test weight (gm), seed yield per plant (gm) shows significant positive correlation with seed yield per plant at genotypic and phenotypic level in F3 and F4 generation. Path coefficient analysis revealed that number of seeds per pod, number of pod per plant and test weight (gm) were the most important character which can be strategically used to improve yield in Pigeon pea.

Keywords
Correlation; Path analysis; Intergeneration correlation; Pigeonpea

Background
Pigeonpea (Cajanus cajan (L.) Mill Sp.) is an important leguminous short lived perennial cultivated as annual crop in semi-arid tropical and subtropical regions of the world. It is generally cultivated as a sole crop or as a mixed crop with short duration cereals or legumes as well as with other crops like cotton and groundnut. Across the globe, pigeonpea is cultivated on 4.86/million ha, with an annual production of 4.1 million tons and productivity of 844 kg/ha. India is the leading producer of pigeonpea in the world accounting for 4.09/million ha area, 3.27 million tons of production and productivity of 800 kg/ha (DCA 2011). Pigeonpea is a hardy and drought tolerant crop assuring sustainable returns from marginal lands with minimum input, hence it is considered as very suitable crop for sustainable agriculture. Pigeonpea though predominantly a self-pollinated crop has cross pollination ranging from 5 to 70% (Saxena et al., 1990). The choice of an appropriate selection/breeding method and its success for improvement of quantitative traits largely depends on the extent of genetic variability present in segregating material and gene action. Knowledge on genetic architecture of yield and related traits plays an important role in deciding breeding strategies and methodologies for crop improvement. In comparison to other economically important crops, relatively less effort has been made to understand the genetics of important quantitative traits in pigeonpea. Additive and dominant/non-additive effects have been reported to be important in determining yield, plant height, and protein content (Saxena and Sharma, 1990). Pleiotropic effects of gene, physiological changes, and highly sensitive nature of pigeonpea towards the environmental changes make it difficult to interpret the inheritance of yield and associated traits (Byth et al., 1981). Information about nature and magnitude of gene action can be useful for breeding program (Shashikumar et al., 2010). Yield and its component characters that are quantitative in nature exhibit all the three types of gene action (Saxena, 2008). The correlation among the yield and yield contributing characters provides reliable information on nature and direction of selection and also useful as a basis for selecting desirable plant type. Correlation coefficient enables to identify characters or combination of characters, which might be useful as indications of high yield by way of evaluating the relative influence of various characters as well. It provides reliable information on the consequence of selection for simultaneous improvement of desirable yield component characters. Path coefficient analysis is the best method to evaluate the cause and effect...
relationship between yield and its contributing traits. The present study was undertaken to derive information on genotypic correlation, direct and indirect effect of various traits

**Result and Discussion**

Genotypic and phenotypic correlation provides a measure association among different characters and also helps in identifying the traits in selection program. It is observed (Table 1; Table 2; Figure 1) from that the value of genotypic correlation were higher than the phenotypic correlation among all the combination which already reported by Sodavadiya (2009), Dhedhi et al (1997) and Pandey and Singh (2002). At the genotypic and phenotypic level correlation analysis showed that presence of strong positive association between seed yield per plant was test weight, number pod per plant, plant height, and number of secondary branches in both F3 and F4 generation. Such positive interrelationship between seed yield and these traits has also reported in pigeonpea by veeraswamy (1973), padi (2003), vange (2009), D. Badaru (2010), similarly a negative correlation was observed in days to 50% flowering and pod bearing length with seed yield per plant in both generations the same result reported by Vange (2009) as well as Kaveris (2007), reported negative significant in greengram.

![Figure 1](image1.jpg)

**Figure 1** Correlation of Seed yield/plant in F3 and F4 generation

Analysis of all the important seed yield component like no of pod per plant which significantly and positively associate with days to maturity, no of secondary branches, number of seeds per pod, number of seeds per plant and days to 50% flowering which similarly reported by sathish kumar (2006), Mahajan et al (2007), and D. Badaru (2010). These analyses indicate the importance of traits for increasing seed yield. The high degree of association found in between seed yield and number of pod per plant at genotypic and phenotypic level in both F3 and F4 generation, this is most reliable component of yield which can be used as blinker of seed yield and the same result reported by D.Badru (2010).

The test weight (gm) also consider as important component of seed yield which significantly and positively correlate with days to maturity, number of primary branches, number of seed per pod, number of seeds per plant and negative and significantly associate with days to 50% flowering in F3 generation only. Another important yield component is seeds per plant which is positively and significantly correlate with plant height, number of secondary branches, number of seeds per pod in both the generation and negatively and significantly correlate with days to maturity and number of primary branches at genotypic level in both generations.

Path coefficient is an excellent means of studying direct and indirect effect of interrelated studying complex traits path coefficient measures the direct influence of one variable on another variable. The path coefficient analysis of seed yield per plant and it’s another component are presented in table (Table 3; Table 4; Figure 2). The path coefficient revealed that number of pod per plant gives the highest positive direct effect toward seed yield per plant (0.413 in F3 and F4) followed by test weight (0.396 in F3 and 0.408 in F4), number of seeds per plant ( 0.379 in F3) and number of secondary branches (0.264 in F3). The same

![Figure 2](image2.jpg)

**Figure 2** Direct effect of path analysis in F3 and F4 generation with all yield component
result raveled earlier by Marekar and Nerkar (1987), Salunke et al (1995), H.P.Thinki and S.L.Sawargaonkar (2010). Further days to 50% flowering was found to contribute seed yield per plant indirectly through number of pod per plant (0.255) and test weight was found indirectly via number of seeds per plant (0.255) and number of pod per plant (0.265) in only F3 and number of seeds per pod was found indirectly effect to seed yield via number of seed per plant (0.174) and number of pod per plant (0.169) and negatively indirectly effect via number of primary branches similarly number of seeds per plant indirectly effecting via secondary branches per plant (0.166) and number of pods per plant (0.166) and negatively affect via days to 50% flowering and primary branches in F4 generation. Direct and indirect effects were worked out as per Dewey and Lu (1959). The residual effect on seed yield per plant was moderate indicating that the most contributing characters were including in path analysis, thus from correlation and path analysis it can be concluded that the number of seeds per pod, number of pod per plant and test weight plays major role as major yield component in both the early and late generation, therefore selection of many characters would be offer the scope for equally improvement of all the traits which directly providing seed yield and it is similarly reported by Firoz Mahomad (2006) and D.Badru (2010). Effectiveness of single plant selection was observed by reveling intergeneration correlation coefficients and it gives estimation of gene action at some extent. If the correlation coefficient is high, it would mean high heritable portion and probably the additive component (Table 5; Figure 3).

In the present study, significant correlation were observed for days to maturity, number of seeds per plant, number of pods per plant, test weight (gm), seed yield per plant (gm) in both the generation Indicating these traits are mostly governed by additive gene action and suitability of these traits for selection on individual plant basis in the advanced generations of segregating populations. These findings were supported by Reddy et al (1985).

**Material and Method**

The segregating material was generated by hybridization of Gulyal white with resistant variety Maruti. A total of 180 F2 based on performance were selfed and advanced to F3 generation from single F2 plants were sown during Kharif 2009 at Agriculture Research Station Gulbarga, evaluated them for yield and yield component traits. The experiment was laid out in a Randomized Complete Block Design with two replications. The sowing adopted on 30 cm between the plant and 60 cm between the rows. Each 20 plants in F3 progeny was grown in single row of 6 M with five plants were randomly chosen and tagged for recording data on various morphological traits plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pod per plant, number of seeds per pod, number of seeds per plant, pod bearing length (cm), and other traits viz. seed yield (Kg/ha), seed yield per plant (g) test weight (g), days to 50% flowering, days to maturity were recorded on plant basis. The analysis of variance carried out as suggested by Panse and Sunhatme (1985). Seeds collected from selfed F3 plants were used to raise F4 generation in the next kharif season during 2010. These 180 progenies were again evaluated in Randomized Block Design with as two replications at Agriculture Research Station Gulbarga. Five plants were randomly chosen and tagged for recording 12 quantitative traits recorded in F3 generation. Data recorded from both F3 and F4 generations were statistically analyzed (Panse and Sunhatme) computed genetic parameters. The data were subjected to association analysis as per method given by Al-jibouri (1958) and path analysis according to Dewey and Lu (1959).

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Figure 3 Intergeneration correlation in F3 and F4 of all the characters
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Table 1 Genotypic correlation coefficients of seed yield and component traits among recombinant lines (F₃) of Gullyal white×Maruti cross in pigeonpea

| Characters                  | Days to 50% flowering | Days of maturity | Plant height (cm) | No of primary branches | No of secondary branches | No of seeds/pod | No of seeds/ plant | Pod bearing length (cm) | Test weight (gm) | Seed yield/ plant (gm) |
|-----------------------------|------------------------|------------------|-------------------|------------------------|--------------------------|-----------------|-------------------|------------------------|-----------------|------------------------|
| Days to 50% flowering       |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.173**                | -0.112           | -0.82             | -0.091                 | -0.113                   | 0.153*          | 0.052             | -0.123                 | -0.062          |                        |
| P                           | 0.167**                | -0.102           | -0.031            | -0.092                 | -0.107                   | 0.142*          | 0.035             | -0.118                 | -0.027          |                        |
| Days of maturity            |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.128                  | -0.062           | 0.243**           | 0.126                  | -0.274**                 | 0.173**         | 0.073             | 0.354**                | 0.304**         |                        |
| P                           | 0.114                  | -0.054           | 0.114             | 0.112                  | -0.128                   | 0.169**         | 0.062             | 0.176**                | 0.285**         |                        |
| Plant height (cm)           |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.178**                | 0.506**          | 0.322**           | 0.151*                 | 0.174**                  | 0.071           | -0.123            | 0.367**                | 0.284**         |                        |
| P                           | 0.158*                 | 0.427**          | 0.217**           | 0.146*                 | 0.161**                  | 0.070           | -0.113            | 0.367**                | 0.284**         |                        |
| No of primary branches      |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.488**                | -0.024           | -0.124            | -0.108                 | -0.150*                  | -0.063          | -0.124            |                        |                 |                        |
| P                           | 0.330**                | -0.021           | -0.114            | -0.105                 | -0.129                   | -0.052          | -0.115            |                        |                 |                        |
| No of secondary branches    |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.533**                | 0.357**          | 0.571**           | -0.012                 | 0.537**                  | 0.544**         |                 |                        |                 |                        |
| P                           | 0.436**                | 0.220**          | 0.313**           | -0.011                 | 0.417**                  | 0.529**         |                 |                        |                 |                        |
| No of seeds/pod             |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.514**                | 0.236**          | 0.074             | 0.643**                | 0.384**                  |                 |                 |                        |                 |                        |
| P                           | 0.427**                | 0.189**          | 0.062             | 0.495**                | 0.333**                  |                 |                 |                        |                 |                        |
| No. of seeds/ plant         |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.492**                | -0.092           | 0.158*            |                        | 0.558**                  |                 |                 |                        |                 |                        |
| P                           | 0.408**                | -0.087           | 0.143*            |                        | 0.433**                  |                 |                 |                        |                 |                        |
| No of pods/plant            |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 0.061                  | 0.149*           | 0.670**           |                        | 0.638**                  |                 |                 |                        |                 |                        |
| P                           | 0.035                  | 0.128            | 0.638**           |                        |                         |                 |                 |                        |                 |                        |
| Pod bearing length (cm)     |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 1                      | -0.074           | -0.097            |                        |                         |                 |                 |                        |                 |                        |
| P                           | 1                      | -0.072           | -0.088            |                        |                         |                 |                 |                        |                 |                        |
| Test weight (gm)            |                        |                  |                   |                        |                          |                 |                   |                        |                 |                        |
| G                           | 1                      | 0.645**          |                 |                        |                         |                 |                 |                        |                 |                        |
| P                           | 1                      | 0.624**          |                 |                        |                         |                 |                 |                        |                 |                        |

Note: *: Significant at 0.05 probability level; **: Significant at 0.01 probability
Table 2 Genotypic correlation coefficients of seed yield and component traits among recombinant lines (F4) of Gullyal white×Maruti cross in pigeonpea

| Characters                          | Days to 50% flowering | Days of maturity | Plant height (cm) | No of primary branches | No of secondary branches | No of seeds/pod | No of seeds/plant | No of pods/plant | Pod bearing length (cm) | Test weight (gm) | Seed yield/plant (gm) |
|-------------------------------------|------------------------|------------------|-------------------|------------------------|--------------------------|----------------|-------------------|-------------------|------------------------|-----------------|------------------------|
| Days to 50% flowering               |                        |                  |                   |                        |                          |                |                   |                   |                        |                 |                        |
| G                                   | 1                      | 0.462**          | 0.129             | -0.11                  | -0.127                   | -0.132          | -0.126           | 1.1               | -0.047                 | -0.125          | -0.129                 |
| P                                   | 1                      | 0.253**          | 0.126             | -0.09                  | -0.123                   | -0.108          | -0.111           | 1.28              | -0.022                 | -0.101          | -0.112                 |

Days of maturity

| G                                   | 1                      | 0.566**          | -0.129             | 0.153*                 | 0.119                    | -0.137          | 0.361**          | -0.124           | 0.192**                | 0.355**         |                        |
| P                                   | 1                      | 0.358**          | -0.112             | 0.149*                 | 0.112                    | -0.123          | 0.221**          | -0.114           | 0.171**                | 0.314**         |                        |

Plant height (cm)

| G                                   | 1                      | 0.545**          | 0.626**            | 0.349**                | 0.105                    | 0.543**          | 0.127             | -0.144*          | 0.469**                |                 |                        |
| P                                   | 1                      | 0.341**          | 0.286**            | 0.226**                | 0.096                    | 0.190**          | 0.11              | -0.112           | 0.433**                |                 |                        |

No of primary branches

| G                                   | 1                      | 0.418**          | -0.141*            | -0.131                | 0.119                    | -0.136          | -0.137           | -0.123           |                        |                 |                        |
| P                                   | 1                      | 0.332**          | -0.126            | -0.124                | 0.096                    | -0.114          | -0.125           | -0.114           |                        |                 |                        |

No of secondary branches

| G                                   | 1                      | 0.622**          | 0.570**            | 0.574**                | -0.098                   | 0.569**          | 0.574**          |                  |                        |                 |                        |
| P                                   | 1                      | 0.428**          | 0.485**            | 0.257**                | -0.083                   | 0.525**          | 0.523**          |                  |                        |                 |                        |

No of seeds/pod

| G                                   | 1                      | 0.616**          | 0.575**            | 0.139                  | 0.589**                  | 0.674**          |                  |                  |                        |                 |                        |
| P                                   | 1                      | 0.353**          | 0.438**            | 0.114                  | 0.465**                  | 0.517**          |                  |                  |                        |                 |                        |

No. of seeds/plant

| G                                   | 1                      | 0.880**          | -0.045             | 0.657**                | 0.564**                  |                  |                  |                  |                        |                 |                        |
| P                                   | 1                      | 0.538**          | -0.037             | 0.484**                | 0.544**                  |                  |                  |                  |                        |                 |                        |

No of pods/plant

| G                                   | 1                      | -0.093           |                  | 0.254**                | 0.699**                  |                  |                  |                  |                        |                 |                        |
| P                                   | 1                      | -0.137           |                  | -0.109                 |                        |                  |                  |                  |                        |                 |                        |

Pod bearing length (cm)

| G                                   | 1                      |                  |                  |                      |                        |                  |                  |                  |                        |                 |                        |
| P                                   | 1                      |                  |                  |                      |                        |                  |                  |                  |                        |                 |                        |

Test weight (gm)

| G                                   | 1                      |                   |                  |                      |                        |                  |                  |                  |                        |                 | 0.654**                |
| P                                   | 1                      |                   |                  |                      |                        |                  |                  |                  |                        |                 | 0.550**                |

Corr. seed yield/plant (gm)

| G                                   | 1                      |                   |                  |                      |                        |                  |                  |                  |                        |                 | 1                      |
| P                                   | 1                      |                   |                  |                      |                        |                  |                  |                  |                        |                 | 1                      |

Note: *: Significant at 0.05 probability level; **: Significant at 0.01 probability
### Table 3: Genotypic path matrix of seed yield in recombinant lines (F$_3$) of Gulyal white×Maruti cross in pigeonpea

| Traits                        | Days to 50% flowering | Days of maturity | Plant height (cm) | No of primary branches | No of secondary branches | No of seeds/pod | No of seeds/plant | Pod bearing length (cm) | Test weight (gm) | Corr. seed yield/ plant |
|-------------------------------|-----------------------|------------------|-------------------|------------------------|--------------------------|----------------|-------------------|------------------------|----------------|-------------------------|
| Days to 50% flowering         | 0.2884                | 0.1932           | 0.1568            | -0.1006                | -0.291                   | -0.1616        | -0.1908           | 0.2569                 | 0.0474         | -0.2614                 | -0.062          |
| Days of maturity              | 0.0454                | 0.2432           | 0.0605            | -0.1543                | 0.0519                   | 0.1525          | -0.1453               | 0.1515                 | 0.1767         | 0.0768                 | 0.3055**         |
| Plant height (cm)             | 0.0388                | 0.0328           | 0.2875            | 0.0251                 | 0.0424                   | 0.0435          | 0.0525               | 0.0597                 | 0.0361         | -0.2512                 | 0.3672**         |
| No of primary branches        | -0.1217               | -0.125           | 0.2108            | 0.2363                 | 0.1999                   | -0.0708         | -0.1356               | -0.1012                | -0.1476        | -0.0694                 | -0.1243         |
| No of secondary branches      | -0.1798               | 0.0587           | 0.0684            | -0.0284                | 0.2638                   | 0.0861          | 0.0638               | 0.1465                 | 0.1156         | 0.1233                 | 0.5436**         |
| No. of seeds/pod              | -0.1715               | 0.0546           | 0.0667            | -0.1724                | 0.1871                   | 0.1681          | 0.1675               | 0.1645                 | -0.1658        | 0.0851                 | 0.3839**         |
| No. of seeds/plant            | -0.1557               | -0.1468          | 0.0839            | -0.0621                | 0.1376                   | 0.1515          | 0.3791               | 0.1746                 | -0.1712        | 0.1667                 | 0.5576**         |
| No of pods/plant              | 0.0126                | 0.0862           | 0.0268            | -0.1765                | 0.0678                   | 0.0456          | 0.0828               | 0.4129                 | -0.0644        | 0.1764                 | 0.6702**         |
| Pod bearing length (cm)       | -0.1875               | -0.1952          | 0.2435            | -0.1853                | -0.0149                  | 0.2779          | -0.0544               | -0.1837                | 0.2573         | -0.0546                 | -0.0969         |
| Test weight (gm)              | -0.2386               | 0.1299           | -0.2375           | -0.1654                | 0.2423                   | 0.2159          | 0.2554               | 0.2652                 | -0.2194        | 0.3968                  | 0.6446**         |

Note: Residual effect=0.2963

### Table 4: Genotypic path matrix of seed yield in recombinant lines (F$_4$) of Gulyal white×Maruti cross in pigeonpea

| Traits                        | Days to 50% flowering | Days of maturity | Plant height (cm) | No of primary branches | No of secondary branches | No of seeds/pod | No of seeds/plant | Pod bearing length (cm) | Test weight (gm) | Corr. seed yield/ plant |
|-------------------------------|-----------------------|------------------|-------------------|------------------------|--------------------------|----------------|-------------------|------------------------|----------------|-------------------------|
| Days to 50% flowering         | 0.2597                | -0.1283          | 0.1356            | -0.1281                | -0.1424                  | -0.0889        | -0.1235           | 0.0464                 | 0.0783         | -0.1291                 |
| Days of maturity              | 0.1216                | 0.2676           | 0.0596            | -0.0778                | 0.1138                   | 0.0738          | -0.1269           | 0.0575                 | 0.0439         | 0.3552**                |
| Plant height (cm)             | 0.0582                | 0.0945           | 0.1407            | 0.0478                 | 0.0895                   | 0.0465          | 0.0453            | 0.0275                 | -0.1276        | 0.4691**                |
| No of primary branches        | -0.0765               | -0.1278          | 0.0759            | 0.1589                 | 0.0769                   | -0.1655        | -0.0866           | 0.0977                 | 0.087          | -0.1628                 | -0.1228         |
| No of secondary branches      | -0.1779               | 0.0585           | 0.0679            | 0.0886                 | 0.2543                   | 0.0457          | 0.1398            | 0.1279                 | -0.1459        | 0.1148                  | 0.5737**         |
| No. of seeds/pod              | -0.1175               | 0.0627           | 0.1185            | -0.1847                | 0.1548                   | 0.2391          | 0.1741            | 0.1685                 | -0.0886        | 0.1468                  | 0.6737**         |
| No. of seeds/plant            | -0.1725               | -0.1266          | 0.1425            | -0.1644                | 0.1655                   | 0.1466          | 0.3501            | 0.1656                 | -0.1378        | 0.1945                  | 0.5635**         |
| No of pod/plant               | 0.0456                | 0.0349           | 0.0432            | -0.1443                | 0.0732                   | 0.0645          | 0.1437            | 0.4134                 | -0.0539        | 0.1245                  | 0.7448**         |
| Pod bearing length (cm)       | -0.0578               | -0.0339          | 0.1668            | -0.1295                | -0.0687                  | 0.0715          | -0.0956           | 0.1965                 | -0.0987        | -0.0108                 |
| Test weight (gm)              | -0.0964               | 0.0788           | -0.1256           | -0.0529                | 0.1245                   | 0.1328          | 0.1459            | 0.1263                 | -0.0878        | 0.4081                  | 0.6537**         |

Note: Residual effect=0.162

### Table 5: Analysis of intergeneration correlation 12 quantitative traits in recombinant line (F$_3$) and (F$_4$) of Gulya white×Maruti cross generation

| Source of variation | Day to 50% flowering | Days of maturity | Plant height (cm) | No. of primary branches | No. of secondary branches | No of seeds per pod | No of seeds per plant | No of pods per plant | Pod bearing length (cm) | Test weight (gm) | Seed yield per plant (gm) |
|---------------------|----------------------|------------------|-------------------|------------------------|--------------------------|-------------------|----------------------|---------------------|------------------------|----------------|--------------------------|
| Correlation         | 0.07                 | 0.66**           | 0.09              | -0.01                  | 0.15                     | -0.05             | 0.25**               | 0.53**              | -0.15                  | 0.79**         | 0.71**                   |

Note: *, Significant @ 5%; **: Significant @ 1%