Studies on Character Association and Causal Relationship of Seed Yield and Its Components in Early Maturing Genotypes of Pigeon Pea (Cajanus cajan L.)

N. Borah, A. Sarma, D. Sarma, A. Bhattacharjee, D. Bordoloi

ABSTRACT
The present investigation was undertaken with the objective to estimate the interrelationship of characters for seed yield in early maturing genotypes of pigeon pea (Cajanus cajan L.). The material consisted of twenty-one pigeon pea genotypes among which nineteen were early maturing genotypes received from ICRISAT (The International Crops Research Institute for the Semi-Arid Tropics), Hyderabad and two were local varieties collected from BNCA, AAU (Biswanath Chariali College of Agriculture, Assam Agricultural University), Jorhat. The experiment was conducted during kharif 2017-18 in randomized block design (RBD) with three replications at ICR farm, Assam Agricultural University, Jorhat. The estimates of genotypic correlations, in general, were found higher than the corresponding phenotypic correlation coefficients indicating strong association between two characters but the phenotypic values were lessened by the influence of environment. The seed yield per plant had shown significant positive correlation with plant height, pods per plant, pod length and harvest index both at phenotypic and genotypic level. Pods per plant and pod length had shown high positive direct effects on seed yield per plant at both genotypic and phenotypic level. At genotypic level, days to first flowering were lessened by the influence of environment. The seed yield per plant had shown significant positive correlation with plant height, pods per plant, pod length and harvest index both at phenotypic and genotypic level. Pods per plant and pod length had shown high positive direct effects on seed yield per plant at both genotypic and phenotypic level. Pods per plant and pod length had shown high direct effects on seed yield/plant and hence direct selection for these traits may contribute towards improvement in seed yield/plant.

Key words: Correlation coefficient, Path analysis, Pigeon pea, Seed yield.

INTRODUCTION
Pigeon pea (Cajanus cajan (L.)) is one of the major grain legume crops in the tropical and subtropical regions of the world. India is the primary Centre of origin and diversification for pigeon pea (Van der Maesen, 1990). India is the largest producer of pigeon pea contributing 75-80 per cent of world production. It is grown on 4.43 mha area in India, with total production of 4.25 mt and productivity of 960 kg/ha. In Assam, the area is 6 thousand ha, production 4.9 thousand tonnes and productivity 833 kg/ha (Agricultural Statistics, 2018).

Pigeon pea also known as ‘arhar, tur or red gram’ is both a food crop (dried peas, flour or green vegetable peas) and a forage or cover crop. It has the ability to fix atmospheric nitrogen. It offers multiple benefits-protein rich seed (21-25% protein), fuel, fodder and erosion control. It is cultivated mainly as kharif crop and both as a sole crop and mixed crop. Considering the average crop duration of pigeon pea, it is very difficult to grow this crop in mixed cropping system. In Assam intercropping is done with green gram/black gram and sesame. Traditional varieties of pigeon pea are long duration types taking more than ten months to mature and cannot be fitted into multiple crop system. Therefore, it is essential to develop high yielding, early maturing and relatively short statured types, which could respond to better management and can be suitably fitted in newly developed multiple and intercropping patterns (Ramanujan and Singh, 1981).

Yield is a dependent character. It depends on various characters and environmental conditions that exist during crop growth. It is therefore, essential to study association of characters among themselves and with yield of crop. This can be done by character association studies. Genotypic correlation provides a measure of genotypic association between two characters and helps to identify more useful relationship between characters. Indirect associations become complex and important when a number of variables are included in the study of correlation. A study on correlation alone is not enough to give an exact picture of relative importance of direct and indirect influence of each of the component traits on seed yield. In such cases more refined technique as path coefficient analysis helps to find out direct and indirect causes of character association. Every component character has a direct effect on yield. The effects of an independent one on dependent traits via other independent trait are known as indirect effects. If correlation is due to direct effect, it reflects true relationship and
selection is practiced for such a character for improving the yield. In case, the effect is indirect through another component trait, the breeder has to select the latter trait through which indirect effect is exerted.

**MATERIALS AND METHODS**

The material for the present study comprised of twenty-one genotypes. The nineteen genotypes were collected from the ICRISAT, Hyderabad and two genotypes from BNCA, AAU. The experiment was conducted in randomized block design (RBD) with three replications during kharif 2017. The plot size was 3m × 1.5m and the seeds were sown at a spacing of 60cm × 15cm. Five plants were selected at random from each genotype in each of the three replications for recording detailed observations. Observations were recorded for fourteen quantitative traits. Data were subjected to association analysis using INDOSTAT statistical analysis software.

**RESULTS AND DISCUSSION**

**Correlation coefficient analysis**

The estimates of genotypic correlations were higher than the corresponding phenotypic correlation coefficients (Table 1) which indicated that there is strong association between these two characters but the phenotypic values were lessened by the influence of the environment. Similar findings were reported by Thanki and Sawargaonkar (2013), Saroj et al. (2013) and Meena et al. (2017). Seed yield per plant had shown significant positive correlation with plant height, pods per plant, pod length and harvest index both at phenotypic and genotypic level indicating that these characters are useful for taking them as the basis of selection for improving yield. Pushpavalli et al. (2018) reported significant and positive correlations of seed yield with number of pods per plant at both phenotypic and genotypic level. Similar results were also found by Sodavadiya et al. (2009) and Thanki and Sawargaonkar (2013). At genotypic level seed yield per plant had also shown positive significant correlation with the characters plant height, clusters per plant, days to initial pod setting, days to maturity, pods per plant, pod length, hundred seed weight and harvest index. Thus indicating that these characters influence the seed yield in pigeon pea and can serve as traits for improvement. At genotypic level, days to maturity showed significant positive correlation with the characters plant height, pods per plant, pod length, hundred seed weight and harvest index. All the genotypes showed significant positive correlation between these two characters but the phenotypic values were lessened by the influence of the environment.

**Table 1: Correlation coefficient between different characters.**

| Characters | BPP | PPP | PL | SPP | SW | HI | SYP |
|------------|-----|-----|----|-----|----|----|-----|
| BPP        | 0.405** | 0.223 | 0.238** | 0.232 | 0.222 | 0.195 | 0.173 |
| PPP        | 0.329** | 0.274* | 0.296** | 0.298** | 0.293** | 0.272** | 0.244** |
| PL         | 0.321** | 0.267* | 0.286** | 0.288** | 0.283** | 0.263** | 0.245** |
| SPP        | 0.338** | 0.285** | 0.305** | 0.307** | 0.302** | 0.282** | 0.264** |
| SW         | 0.346** | 0.300** | 0.321** | 0.323** | 0.318** | 0.298** | 0.280** |
| HI         | 0.363** | 0.316** | 0.336** | 0.338** | 0.333** | 0.313** | 0.295** |
| SYP        | 0.383** | 0.338** | 0.357** | 0.360** | 0.355** | 0.335** | 0.317** |

**Note:**
- Above diagonal = Genotypic correlation coefficient.
- Below diagonal = Phenotypic correlation coefficient.
- *Significant at 5% level of significance.
- **Significant at 1% level of significance.

**DISCUSSION**

The estimates of genotypic correlations were higher than the corresponding phenotypic correlation coefficients (Table 1) which indicated that there is strong association between these two characters but the phenotypic values were lessened by the influence of the environment. Similar findings were reported by Thanki and Sawargaonkar (2013), Saroj et al. (2013) and Meena et al. (2017). Seed yield per plant had shown significant positive correlation with plant height, pods per plant, pod length and harvest index both at phenotypic and genotypic level indicating that these characters are useful for taking them as the basis of selection for improving yield. Pushpavalli et al. (2018) reported significant and positive correlations of seed yield with number of pods per plant at both phenotypic and genotypic level. Similar results were also found by Sodavadiya et al. (2009) and Thanki and Sawargaonkar (2013). Also at genotypic level seed yield per plant had also shown positive significant correlation with the characters plant height, clusters per plant, days to initial pod setting, days to maturity, pods per plant, pod length, hundred seed weight and harvest index. Thus indicating that these characters influence the seed yield in pigeon pea and can serve as traits for improvement. At genotypic level, days to maturity showed significant positive correlation with the characters plant height, clusters per plant, days to 90% flowering, days to initial pod setting, days to maturity, pods per plant, pod length, hundred seed weight and harvest index. All the genotypes showed significant positive correlation between these two characters but the phenotypic values were lessened by the influence of the environment.

**Table 1: Correlation coefficient between different characters.**

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| PL         | 0.321** | 0.267* | 0.286** | 0.288** | 0.283** | 0.263** | 0.245** |
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| SW         | 0.346** | 0.300** | 0.321** | 0.323** | 0.318** | 0.298** | 0.280** |
| HI         | 0.363** | 0.316** | 0.336** | 0.338** | 0.333** | 0.313** | 0.295** |
| SYP        | 0.383** | 0.338** | 0.357** | 0.360** | 0.355** | 0.335** | 0.317** |

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- Above diagonal = Genotypic correlation coefficient.
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- **Significant at 1% level of significance.
and Nerkar (1992) and Salunke et al. (1995) reported significant and positive association of days to maturity with grain yield per plant. But seed yield is influenced by its various components directly and indirectly via other traits, which creates a complex situation for making selection. Correlation does not tell anything related to the cause and effect relationship (Roy, 2000). Knowledge of correlation alone is often misleading as the correlation observed may not be always true.

**Path coefficient analysis**

Path coefficient analysis is a very powerful statistical tool that indicates the effect of independent variables (causes) on dependent variables (seed yield), while recognizing the impacts of multi collinearity (Akanda and Mundt, 1996). In the present study path coefficient analysis was carried out to estimate the direct and indirect contribution of various traits to seed yield per plant (Table 2.1 and Table 2.2). At genotypic level, days to first flowering showed highest positive direct effect (10.87) on seed yield per plant followed by pods per plant (1.705) and pod length (1.737). Dahiya and Singh (1994), Salunke et al. (1995), Paul et al. (1996), Sodavadiya et al. (2009), Linge et al. (2010), Bhadru (2010) and Saroj et al. (2013) reported positive direct effect on yield with days to maturity, pods per plant, pod length, seeds per pod and hundred seed weight. Days to first flowering (10.865) exhibited the maximum positive direct effect on seed yield per plant. Rao et al. (2013) reported days to flowering had negative direct effect on seed yield but indirect effects through plant height, number of pods per plant, test weight were positive. Days to maturity contributed to seed yield indirectly via days to first flowering, days to 50% flowering, days to initial pod setting and harvest index. Chandirakala and Subbaraman (2010) and Sreelakshmi et al. (2010) reported that days to maturity had positive direct effect on grain yield per plant. The residual effect was 0.54 which indicates that 46% genetic variability is present among the studied genotypes. Pushpavalli et al. (2018) also reported high residual value of 0.82. At phenotypic level, plant height (0.266), branches per plant (0.959), pods per plant (0.728), pod length (0.229) and harvest index (0.050) had positive direct effect on seed yield. The residual effect was found to be 0.36 indicating that there are some more characters which contribute towards the seed yield/plant. Lal et al. (2002) also reported low residual effect.

Pods per plant and pod length had shown high direct effects on seed yield per plant at both genotypic and phenotypic level, hence direct selection for these traits may contribute towards increase in seed yield/plant. Vange and Moses (2009), Sreelakshmi et al. (2010), Thanki and Sawargaonkar (2013) and Garje et al. (2014) reported positive direct effect of number of pods per plant on grain yield per plant. Moreover, Vange and Moses (2009) and Chandirakala and Subbaraman (2010) reported that pod length had positive effect on grain yield per plant. Hence, the emphasis should be placed on these characters.

### Table 2.1: Path analysis for different characters at genotypic level.

| Characters | PH | CPP | BPP | DTHF | DTF | DTFF | DTM | HI | SW | PPP | SPP | Residual effect |
|------------|----|-----|-----|------|-----|------|-----|----|----|-----|-----|----------------|
| PH         | 1.096*** | -0.559 | 0.034 | 5.236 | -0.323 | 0.119 | 0.089 | 0.141 | 0.034 | 0.234 | 0.229 | 0.821 |
| CPP        | -0.354*** | 0.023 | 1.100 | -0.162 | -0.655 | 0.316 | 1.131 | 1.468 | 1.472 | -0.763 | -0.722 | 0.948 |
| BPP        | 1.096*** | -0.559 | 0.034 | 5.236 | -0.323 | 0.119 | 0.089 | 0.141 | 0.034 | 0.234 | 0.229 | 0.821 |
| DTHF       | 0.023*** | 0.023 | 1.100 | -0.162 | -0.655 | 0.316 | 1.131 | 1.468 | 1.472 | -0.763 | -0.722 | 0.948 |
| DTF        | 0.119*** | 0.023 | 1.100 | -0.162 | -0.655 | 0.316 | 1.131 | 1.468 | 1.472 | -0.763 | -0.722 | 0.948 |
| DTFF       | -0.559 | -0.323 | -0.162 | -0.655 | 0.316 | 1.131 | 1.468 | 1.472 | -0.763 | -0.722 | 0.948 |
| DTM        | 0.034 | 0.119 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 |
| HI         | 0.234 | 1.468 | 1.472 | -0.722 | -0.763 | -0.763 | -0.763 | -0.763 | -0.763 | -0.763 | -0.763 |
| SW         | 0.229 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 |
| PPP        | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 | 0.821 |

Note: Bold figures indicate direct effects. PH: Plant height, DTF: Days to first flowering, DTHF: Days to 50% flowering, DTFF: Days to 90% flowering, DTM: Days to maturity, BPP: Branches per plant, CPP: Clusters per plant, PPP: Pods per plant, PL: Pod length, SPP: Seeds per pod, SW: 100 Seed weight, HI: Harvest index, SYP: Seed yield per plant.
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Table 2.2: Path analysis for different characters at phenotypic level.

| Characters | PH | BPP | CPP | DTFF | DTM | PPP | Pl | SPP | SW | HI | Residual effect |
|------------|----|-----|-----|------|-----|-----|----|-----|-----|----|----------------|
| PH         | 0.056 | -0.11 | 0.011 | -0.024 | 0.044 | -0.006 | 0.000 | -0.002 | 0.049 | 0.036 | 0.36 |
| BPP        | 0.009 | 0.089 | -0.142 | -0.452 | 0.419 | -0.342 | 0.348 | 0.090 | 0.072 | 0.155 | 0.322 |
| CPP        | 0.002 | 0.028 | 0.036 | 0.267 | 0.672 | 0.332 | 0.286 | 0.193 | 0.149 | -0.176 | -0.07 |
| DTFF       | 0.013 | -0.003 | 0.003 | -0.073 | 0.014 | -0.002 | 0.001 | -0.015 | -0.014 | 0.014 | 0.014 |
| DTM        | 0.008 | -0.001 | 0.010 | -0.019 | 0.021 | -0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.022 |
| PPP        | 0.007 | 0.025 | 0.014 | 0.009 | 0.016 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |
| Pl         | 0.012 | -0.030 | 0.149 | -0.285 | 0.093 | -0.285 | 0.093 | -0.285 | -0.285 | -0.285 | -0.285 |
| SPP        | -0.006 | 0.032 | -0.12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| SW         | 0.013 | 0.027 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| HI         | 0.013 | -0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: Bold figures indicate direct effect.

Correlation coefficient analysis revealed significant positive correlation of plant height, pods per plant, pod length and harvest index with seed yield per plant both at phenotypic and genotypic level indicating that these characters are useful for taking them as the basis of selection for improving yield. The path analysis studies indicated that the characters pods per plant and pod length had shown high positive direct effects on seed yield per plant at both genotypic and phenotypic level, hence direct selection for these traits may contribute towards increase in seed yield/plant. Also days to first flowering exhibited the maximum positive direct effect on seed yield per plant.

**CONCLUSION**

Correlation coefficient analysis revealed significant positive correlation of plant height, pods per plant, pod length and harvest index with seed yield per plant both at phenotypic and genotypic level indicating that these characters are useful for taking them as the basis of selection for improving yield. The path analysis studies indicated that the characters pods per plant and pod length had shown high positive direct effects on seed yield per plant at both genotypic and phenotypic level, hence direct selection for these traits may contribute towards increase in seed yield/plant. Also days to first flowering exhibited the maximum positive direct effect on seed yield per plant.

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