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**Research Note**

# Correlation and path analysis studies in seed quality and storability characteristics of *Pongamia* genotypes

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**Abstract**
*Pongamia* is an important source for biodiesel production. As it is propagated only though seed, seed storage behaviour plays a major role in deciding the success of any afforestation programme. Keeping this in view, an experiment was conducted during 2014 and 2015 to find out correlations among twenty four *pongamia* genotypes for sixteen seed storability traits. Fifteen traits have a positive significant correlation with seed storability at both genotypic and phenotypic levels. The genotypic correlation coefficient values were recorded to be higher than corresponding phenotypic values. Seed storability trait expressed positive significant correlation with all fourteen traits, except with the number of simple leaves. Initial seed quality traits like seed germination, speed of germination and number of trifoliate leaves and storability traits like speed of germination, seedling length, seedling dry weight, seedling vigour index-I and number of trifoliate leaves after seed storage showed positive direct effect on *pongamia* seed storability both at genotypic and phenotypic levels. Seedling vigour index- II and seedling length before storage showed direct negative effect on *pongamia* seed storability at both genotypic and phenotypic association levels. Hence, it is revealed that the selection and breeding on the basis of traits that show positive direct effect may aid in the tree improvement programmes of the species for high seed storability in *pongamia*.

**Key words**
*Pongamia,* correlation, path, seed storability

*Pongamia pinnata* (L.) Pierre (also known as *Millettia pinnata* or Indian Beech) locally known as Karanja is an indigenous tree to India is a perennial, fast-growing, leguminous tree, widely distributed on the Indian subcontinent, south-east Asia, Oceania, northern Australia, the East-African coast and southern China (Murphy et al. 2012). In addition, Pongamia has been introduced to other parts of the world, including the United States (Kazakoff et al. 2011). It is a versatile leguminous tree (Savita et al. 2010) and as a potential source of biodiesel (Naik et al. 2008). As a nodulating and nitrogen-fixing legume the nitrogen (N) fertilizer requirements of Pongamia are potentially minimal or eliminated. This is an advantage for a biofuel crop as N fertilizer inputs detract from the net energy gain, a fact often overlooked in choosing biofuel crops (Hill et al. 2006). *Pongamia pinnata* is regarded as a sustainable biofuel feedstock of the future because of its abundant production of oil-rich seeds, tolerance to abiotic stress and for its ability to undergo biological nitrogen fixation (minimizing nitrogen inputs). However, it needs extensive domestication through selection and genetic improvement.

The ultimate goal of any tree improvement programme is to improve not only growth and yield traits of tree species but also to improve seed storability. Correlation shows the extent of association between seed traits, which may form additional criteria for selection in breeding program. Correlated quantitative traits are of a major interest in an improvement program, as the improvement of one character may cause simultaneous correlated changes in the other characters. The genotypic correlation is an estimated value, whereas, phenotypic correlation is a derived value from the genotype and environmental interaction (Chaturvedi and Pandey, 2004). The genotypic correlation indicates genotypic association among the traits and is, therefore, a more reliable estimate value for examining the degree of relationship between character pairs. Police et al. (2011) also reported a significant correlation among various seed germination and seedling traits suggesting them as an important selection criterion for breeding and improvement of *Pongamia* species.

The path analysis permits the separation of direct effects from that of the indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 1959). Path analysis of seed physiological traits associated with seed storability was carried out to unlock the direct and indirect contributions of seed physiological characters on seed storability. Keeping in view of the importance of the tree and its propagation by seeds, the present experiment was designed with the objective to identify genotypes of *Pongamia pinnata* with good seed storability.

About 8700 genotypes of *pongamia* were collected from Adilabad and Ranga Reddy districts of

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Telangana during the year 2002. From these genotypes, 110 were screened out based on the characters like *viz*., early maturity, seed oil content, crop canopy with less branching, less height and girth, good yield potential *etc* and were planted in the nursery and fields of Tree Oils India limited, Zaheerabad during August, 2003. Finally, 24 genotypes were screened based on their efficiency and performance. Pongamia seeds were collected from these candidate plus trees which were identified at farm of Tree Oils India Limited, Zaheerabad during February, 2014. Seed physiological and storability studies were carried in the Department of Seed Science and Technology, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during 2014 and 2015 to study the existence of correlations among 24 genotypes of *Pongamia pinnata* for seed quality and storability traits.

A laboratory experiment was laid out in completely randomized design with four replications by storing 2 kilograms seed of each genotype in cloth bags. Seed physiological parameters were studied immediately after harvesting and also after six months of storage. Standard germination test was employed as per ISTA, 2007 using sand method (Mariappan *et al.* 2014) by placing hundred seeds in large germination trays in four replications and germination per cent was expressed using below formula at 21 days after sowing. The data recorded as percentage were transformed to the respective angular (arc sine) values before subjecting them to statistical analysis.

$$\text{Germination per cent} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Seedling Vigour Index I and Seedling Vigour Index-II were calculated as suggested by Abdul-Baki and Anderson (1973). The seedling length was measured on linear scale from 10 normal seedlings, which were randomly selected from the standard germination test. The product of the seedling length and germination percentage was tabulated for the estimation of Seedling Vigour Index I. For seedling dry weight, ten normal seedlings from each replication of germination test were selected at random and kept for oven drying overnight at 60°C and were weighed in mg (ISTA, 1999) and the values were multiplied with germination percentage for the calculation of Seedling Vigour Index II. Speed of germination was calculated using below formula.

$$\text{Speed of germination} = \frac{G1}{T1} + \frac{G2}{T2} + \frac{G3}{T3} + \text{-----} + \frac{Gn}{Tn}$$

where, G1 = Number of seeds germinated on 1$^{st}$ day; G2 = Number of seeds germinated on 2$^{nd}$ day; G3 = Number of seeds germinated on 3$^{rd}$ day; T1 = Day one, T2 = Day two, T3 = Day three; Gn = Number of seeds germinated on nth day, Tn = nth day. The number of simple and trifoliate leaves with fully opened lamina was counted on the day of final count.

The data were analyzed statistically by adopting CRD (Completely Randomized Design) techniques, as described by Panse and Sukhatme (1976). The data recorded as percentage were transformed to the respective angular (arc sine) values prior to analysis. The traits were analyzed using analysis of variance to understand the significant difference among the traits of TOILs under consideration (Gomez and Gomez, 1984). To test the significance of correlation coefficients, the estimated values were compared with the table value (statistical table by Fisher and Yates, 1963) at n-2 degrees of freedom (where n denotes the number of genotypes tested) at 5% and 1% level of significance, respectively. Path coefficient analysis was done using genotypic correlation coefficients following Dewey and Lu (1959).

Correlation shows the extent of association between the traits, which may form additional criteria for selection in breeding program. Correlated quantitative traits are of a major interest in any improvement program, as the improvement of one character may cause simultaneous correlated changes in the other character. The genotypic correlation is an estimated value, whereas, phenotypic correlation is a derived value from the genotype and environmental interaction (Righter, 1945). The genotypic correlation indicates genotypic association among the traits and is, therefore, a more reliable estimate value for examining the degree of relationship between character pairs.

The correlation study was employed using the data collected from seed quality parameters to throw light on the association of traits for good seed storability. In general, the genotypic correlation coefficient values were higher than corresponding phenotypic values (Table 1). Correlation study of sixteen quantitative traits revealed that among 240 (120 genotypic and 120 phenotypic) correlations, 2 genotypic and 5 phenotypic combinations were significant to 5% level along and 105 genotypic and 101 phenotypic combinations were significant at 1 % level. Seed storability (germination after storage) expressed positive significant correlation at genotypic and phenotypic levels with seven initial seed quality traits like seed germination (0.64 and 0.62), speed of germination (0.54 & 0.54), seedling length (0.51 & 0.48), seedling dry weight (0.73 & 0.66), Seedling Vigour Index - I (0.68 & 0.65), Seedling Vigour Index - II (0.74 & 0.69) and number of trifoliate leaves (0.31 & 0.27) and with seven seed storability traits like speed of

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germination (0.84 & 0.83), seedling length (0.76 & 0.76), seedling dry weight (0.78 & 0.77), Seedling Vigour Index - I (0.99 & 0.99), Seedling Vigour Index - II (0.95 & 0.95), number of simple leaves (0.57 & 0.55) and number of trifoliate leaves (0.67 & 0.61) after six months of seed storage. Initial seed quality parameters like speed of germination, seedling length, seedling dry weight, seedling vigour index-I and II showed significant positive correlation. Number simple leaves before seed storage showed significant positive correlation with speed of germination before storage. Number of trifoliate leaves showed significant positive correlation with all the traits except for number of simple leaves. Speed of germination after storage showed significant positive correlation with all the traits except with no. of simple and trifoliate leaves of freshly harvested seed. Seed germination after storage showed a significant positive correlation with all the traits except for the number of simple leaves of freshly harvested seed.

A strong inherent association was observed between traits like seed germination, speed of germination, seedling length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and number of trifoliate leaves with that of seed storability which had significant positive correlation with each other. In the similar line of work Deebe *et al.* (2011) reported that the high estimates of genotypic correlations than the corresponding phenotypic correlations indicated the presence of strong inherent association between pod and seed traits in *pongamia* with significant positive correlation. Before seed storage, number of simple leaves exhibited negative non-signification correlation with all traits. But six months after storage, this same trait showed a positive significant correlation with all traits under study. A significant correlation among various seed germination and seedling traits was revealed by Police et al. 2011 suggesting these correlations as an important selection criterion for breeding and improvement of *Pongamia* species.

The path analysis permits the separation of direct effects from that of the indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 1959). Path analysis of seed physiological traits associated with seed storability was carried out to unlock the direct and indirect contributions of seed physiological characters on seed germination after six months of storage and is presented in the Table 2 and Figure 1. Seven traits showed positive direct effect on *pongamia* seed storability. Seedling vigour index after seed storage had highest direct positive effect (g= 1.473, p= 1.080) on seed storage. This is followed by seedling dry weight after storage (g= 0.549, p= 0.099), initial seed germination (g= 0.139, p= 0.110), speed of germination after storage (g= 0.038, p= 0.021), number of trifoliate leaves before storage (g=0.023, p=0.026), speed of germination before storage (g= 0.015, p= 0.033) and number of trifoliate leaves after storage (g= 0.017, p= 0.012) at both genotypic and phenotypic levels. Seedling length after storage, seedling vigour index-II before and after seed storage showed direct negative effect on *pongamia* seed storability at both genotypic and phenotypic association levels. Hence, seeds with good initial seed germination may be selected for conservation and further tree improvement programmes as they possess good seed storability.

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**Table 1. Correlation matrix of seed quality traits in relation to seed storability in *Pongamia pinnata***

| S. No. | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | G | 0.685** | 0.418** | 0.778** | 0.890** | 0.895** | 0.046 | 0.335** | 0.547** | 0.635** | 0.696** | 0.658** | 0.692** | 0.459** | 0.658** | 0.638** |
| | P | 0.673** | 0.417** | 0.758** | 0.880** | 0.882** | 0.035 | 0.292** | 0.528** | 0.617** | 0.671** | 0.642** | 0.671** | 0.439** | 0.590** | 0.623** |
| 2 | G | 1.000 | 0.547** | 0.719** | 0.733** | 0.737** | 0.300** | 0.384** | 0.432** | 0.439** | 0.547** | 0.563** | 0.621** | 0.489** | 0.454** | 0.539** |
| | P | 1.000 | 0.518** | 0.668** | 0.707** | 0.697** | 0.259* | 0.351** | 0.427** | 0.437** | 0.542** | 0.559** | 0.616** | 0.468** | 0.401** | 0.536** |
| 3 | G | | 1.000 | 0.705** | 0.778** | 0.684** | 0.101 | 0.381** | 0.435** | 0.531** | 0.616** | 0.545** | 0.585** | 0.567** | 0.466** | 0.507** |
| | P | | 1.000 | 0.688** | 0.789** | 0.673** | 0.092 | 0.353** | 0.409** | 0.493** | 0.563** | 0.513** | 0.540** | 0.509** | 0.444** | 0.476** |
| 4 | G | | | 1.000 | 0.875** | 0.950** | -0.078 | 0.370** | 0.586** | 0.743** | 0.848** | 0.756** | 0.786** | 0.577** | 0.759** | 0.726** |
| | P | | | 1.000 | 0.847** | 0.948** | -0.028 | 0.323** | 0.518** | 0.672** | 0.766** | 0.689** | 0.718** | 0.511** | 0.658** | 0.664** |
| 5 | G | | | | 1.000 | 0.952** | 0.079 | 0.432** | 0.578** | 0.676** | 0.769** | 0.714** | 0.765** | 0.570** | 0.651** | 0.678** |
| | P | | | | 1.000 | 0.933** | 0.064 | 0.381** | 0.552** | 0.644** | 0.723** | 0.685** | 0.725** | 0.530** | 0.599** | 0.651** |
| 6 | G | | | | | 1.000 | 0.064 | 0.391** | 0.604** | 0.709** | 0.833** | 0.775** | 0.828** | 0.504** | 0.721** | 0.740** |
| | P | | | | | 1.000 | -0.044 | 0.331** | 0.551** | 0.657** | 0.768** | 0.724** | 0.771** | 0.462** | 0.647** | 0.694** |
| 7 | G | | | | | | 1.000 | 0.113 | -0.238 | 0.030 | -0.092 | -0.186 | -0.193 | 0.487** | -0.084 | -0.187 |
| | P | | | | | | 1.000 | 0.121 | -0.189 | 0.025 | -0.072 | -0.160 | -0.162 | 0.412** | -0.034 | -0.160 |
| 8 | G | | | | | | | 1.000 | 0.198* | 0.231* | 0.329** | 0.286** | 0.284** | 0.409** | 0.506** | 0.314** |
| | P | | | | | | | 1.000 | 0.165 | 0.199* | 0.291** | 0.244* | 0.249* | 0.338** | 0.356** | 0.270* |
| 9 | G | | | | | | | | 1.000 | 0.627** | 0.582** | 0.829** | 0.749** | 0.464** | 0.554** | 0.835** |
| | P | | | | | | | | 1.000 | 0.623** | 0.569** | 0.822** | 0.734** | 0.452** | 0.502** | 0.826** |
| 10 | G | | | | | | | | | 1.000 | 0.927** | 0.761** | 0.719** | 0.841** | 0.909** | 0.764** |
| | P | | | | | | | | | 1.000 | 0.918** | 0.760** | 0.713** | 0.816** | 0.815** | 0.761** |
| 11 | G | | | | | | | | | | 1.000 | 0.781** | 0.819** | 0.742** | 0.911** | 0.777** |
| | P | | | | | | | | | | 1.000 | 0.771** | 0.818** | 0.709** | 0.804** | 0.768** |
| 12 | G | | | | | | | | | | | 1.000 | 0.969** | 0.551** | 0.654** | 0.993** |
| | P | | | | | | | | | | | 1.000 | 0.962** | 0.533** | 0.594** | 0.993** |
| 13 | G | | | | | | | | | | | | 1.000 | 0.507** | 0.635** | 0.954** |
| | P | | | | | | | | | | | | 1.000 | 0.485** | 0.569** | 0.949** |
| 14 | G | | | | | | | | | | | | | 1.000 | 0.779** | 0.574** |
| | P | | | | | | | | | | | | | 1.000 | 0.682** | 0.555** |
| 15 | G | | | | | | | | | | | | | | 1.000 | 0.669** |
| | P | | | | | | | | | | | | | | 1.000 | 0.607** |

* Significant at 5% level; **Significant at 1% level

**1**=Seed Germination (%)-BA; **2**=Speed of germination-BA; **3**=Seedling Length (cm)-BA; **4**=Seedling Dry Weight (g)-BA; **5**=SVI-I-BA; **6**=SVI-II-BA; **7**=No. of simple leaves-BA; **8**=No. of Trifoliate leaves-BA; **9**=Speed of germination-AA; **10**=Seedling Length (cm)-AA; **11**=Seedling Dry Weight (g)-AA; **12**=SVI-I-AA; **13**=SVI-II-AA; **14**=No. of simple leaves-AA; **15**=No. of Trifoliate leaves-AA;**16**=Seed Germination (%)-AA; SVI=Seedling Vigour Index; BA=Before Aging; AA=After Aging; G=Genotypic association; P=Phenotypic association

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**Table 2. Path coefficient analysis of seed quality and storability contributing characters in *Pongamia***

| S. No. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | G | **0.139** | 0.096 | 0.058 | 0.109 | 0.124 | 0.125 | 0.007 | 0.047 | 0.076 | 0.089 | 0.097 | 0.092 | 0.096 | 0.064 | 0.092 | 0.638 |
| | P | **0.110** | 0.074 | 0.046 | 0.084 | 0.097 | 0.097 | 0.004 | 0.032 | 0.058 | 0.068 | 0.074 | 0.071 | 0.074 | 0.048 | 0.065 | 0.624 |
| 2 | G | -0.011 | **0.015** | -0.008 | -0.011 | -0.011 | -0.011 | -0.005 | -0.006 | -0.007 | -0.007 | -0.008 | -0.009 | -0.010 | -0.008 | -0.007 | 0.539 |
| | P | -0.022 | **0.033** | -0.017 | -0.022 | -0.023 | -0.023 | -0.008 | -0.011 | -0.014 | -0.014 | -0.018 | -0.018 | -0.020 | -0.015 | -0.013 | 0.536 |
| 3 | G | -0.006 | -0.008 | **-0.014** | -0.010 | -0.011 | -0.010 | -0.001 | -0.005 | -0.006 | -0.008 | -0.009 | -0.008 | -0.008 | -0.008 | -0.007 | 0.508 |
| | P | 0.007 | 0.009 | **0.018** | 0.012 | 0.014 | 0.012 | 0.002 | 0.006 | 0.007 | 0.009 | 0.010 | 0.009 | 0.010 | 0.009 | 0.008 | 0.476 |
| 4 | G | 0.054 | 0.050 | 0.049 | **0.069** | 0.060 | 0.066 | -0.005 | 0.026 | 0.040 | 0.051 | 0.058 | 0.052 | 0.054 | 0.040 | 0.052 | 0.727 |
| | P | 0.000 | 0.000 | 0.000 | **-0.001** | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.664 |
| 5 | G | 0.041 | 0.034 | 0.036 | 0.040 | **0.046** | 0.044 | 0.004 | 0.020 | 0.026 | 0.031 | 0.035 | 0.033 | 0.035 | 0.026 | 0.030 | 0.679 |
| | P | -0.142 | -0.114 | -0.127 | -0.136 | **-0.161** | -0.150 | -0.010 | -0.061 | -0.089 | -0.104 | -0.116 | -0.110 | -0.117 | -0.085 | -0.096 | 0.652 |
| 6 | G | -0.364 | -0.299 | -0.278 | -0.386 | -0.387 | **-0.406** | 0.026 | -0.159 | -0.245 | -0.288 | -0.339 | -0.315 | -0.336 | -0.205 | -0.293 | 0.741 |
| | P | -0.012 | -0.010 | -0.009 | -0.013 | -0.013 | **-0.014** | 0.001 | -0.005 | -0.008 | -0.009 | -0.011 | -0.010 | -0.011 | -0.006 | -0.009 | 0.694 |
| 7 | G | 0.002 | 0.016 | 0.005 | -0.004 | 0.004 | -0.003 | **0.051** | 0.006 | -0.012 | 0.002 | -0.005 | -0.010 | -0.010 | 0.025 | -0.004 | -0.188 |
| | P | -0.001 | -0.005 | -0.002 | 0.001 | -0.001 | 0.001 | **-0.020** | -0.002 | 0.004 | -0.001 | 0.001 | 0.003 | 0.003 | -0.008 | 0.001 | -0.161 |
| 8 | G | 0.008 | 0.009 | 0.009 | 0.008 | 0.010 | 0.009 | 0.003 | **0.023** | 0.004 | 0.005 | 0.007 | 0.007 | 0.006 | 0.009 | 0.011 | 0.314 |
| | P | 0.008 | 0.009 | 0.009 | 0.008 | 0.010 | 0.009 | 0.003 | **0.026** | 0.004 | 0.005 | 0.008 | 0.006 | 0.006 | 0.009 | 0.009 | 0.271 |
| 9 | G | 0.021 | 0.016 | 0.016 | 0.022 | 0.022 | 0.022 | 0.009 | 0.007 | **0.038** | 0.024 | 0.022 | 0.031 | 0.028 | 0.018 | 0.021 | 0.835 |
| | P | 0.011 | 0.009 | 0.008 | 0.011 | 0.011 | 0.011 | -0.004 | 0.003 | **0.021** | 0.013 | 0.012 | 0.017 | 0.015 | 0.009 | 0.010 | 0.827 |
| 10 | G | -0.240 | -0.166 | -0.201 | -0.281 | -0.256 | -0.268 | -0.012 | -0.087 | -0.237 | **-0.378** | -0.351 | -0.288 | -0.272 | -0.318 | -0.344 | 0.764 |
| | P | -0.100 | -0.071 | -0.080 | -0.109 | -0.104 | -0.106 | -0.004 | -0.032 | -0.101 | **-0.161** | -0.149 | -0.123 | -0.115 | -0.132 | -0.132 | 0.762 |
| 11 | G | 0.382 | 0.301 | 0.338 | 0.465 | 0.422 | 0.457 | -0.051 | 0.181 | 0.319 | 0.509 | **0.549** | 0.429 | 0.449 | 0.407 | 0.500 | 0.777 |
| | P | 0.066 | 0.054 | 0.056 | 0.076 | 0.071 | 0.076 | -0.007 | 0.029 | 0.056 | 0.091 | **0.099** | 0.076 | 0.081 | 0.070 | 0.079 | 0.768 |
| 12 | G | 0.970 | 0.829 | 0.804 | 1.114 | 1.052 | 1.1422 | 0.274 | 0.421 | 1.221 | 1.121 | 1.151 | **1.473** | 1.427 | 0.811 | 0.963 | 0.994 |
| | P | 0.694 | 0.604 | 0.554 | 0.744 | 0.741 | 0.782 | -0.174 | 0.264 | 0.888 | 0.821 | 0.833 | **1.080** | 1.039 | 0.576 | 0.642 | 0.993 |
| 13 | G | -0.333 | -0.299 | -0.282 | -0.378 | -0.368 | -0.398 | 0.093 | -0.137 | -0.360 | -0.346 | -0.394 | -0.466 | **-0.481** | -0.244 | -0.306 | 0.954 |
| | P | -0.051 | -0.047 | -0.041 | -0.054 | -0.055 | -0.058 | 0.012 | -0.019 | -0.056 | -0.054 | -0.062 | -0.073 | **-0.076** | -0.037 | -0.043 | 0.949 |
| 14 | G | -0.014 | -0.015 | -0.017 | -0.018 | -0.017 | -0.015 | -0.015 | -0.013 | -0.014 | -0.026 | -0.023 | -0.017 | -0.015 | **-0.030** | -0.024 | 0.575 |
| | P | 0.048 | 0.051 | 0.056 | 0.056 | 0.058 | 0.051 | 0.045 | 0.037 | 0.050 | 0.090 | 0.078 | 0.059 | 0.053 | **0.110** | 0.075 | 0.556 |
| 15 | G | -0.011 | -0.008 | -0.008 | -0.013 | -0.011 | -0.012 | 0.001 | -0.008 | -0.009 | -0.015 | -0.015 | -0.011 | -0.011 | -0.013 | **0.017** | 0.669 |
| | P | 0.007 | 0.005 | 0.005 | 0.008 | 0.007 | 0.008 | 0.000 | 0.004 | 0.006 | 0.010 | 0.010 | 0.007 | 0.007 | 0.008 | **0.012** | 0.607 |

Genotypic Residual Effect = **0.0628;** Phenotypic Residual Effect = **0.0824**

**1**=Seed Germination (%)-BA; **2**=Speed of germination-BA; **3**=Seedling Length (cm)-BA; **4**=Seedling Dry Weight (g)-BA; **5**=SVI-I-BA; **6**=SVI-II-BA; **7**=No. of simple leaves-BA; **8**=No. of Trifoliate leaves-BA; **9**=Speed of germination-AA; **10**=Seedling Length (cm)-AA; **11**=Seedling Dry Weight (g)-AA; **12**=SVI-I-AA; **13**=SVI-II-AA; **14**=No. of simple leaves-AA; **15**=No. of Trifoliate leaves-AA;**16**=Seed Germination (%)-AA; SVI=Seedling Vigour Index; BA=Before Aging; AA=After Aging; G=Genotypic association; P=Phenotypic association

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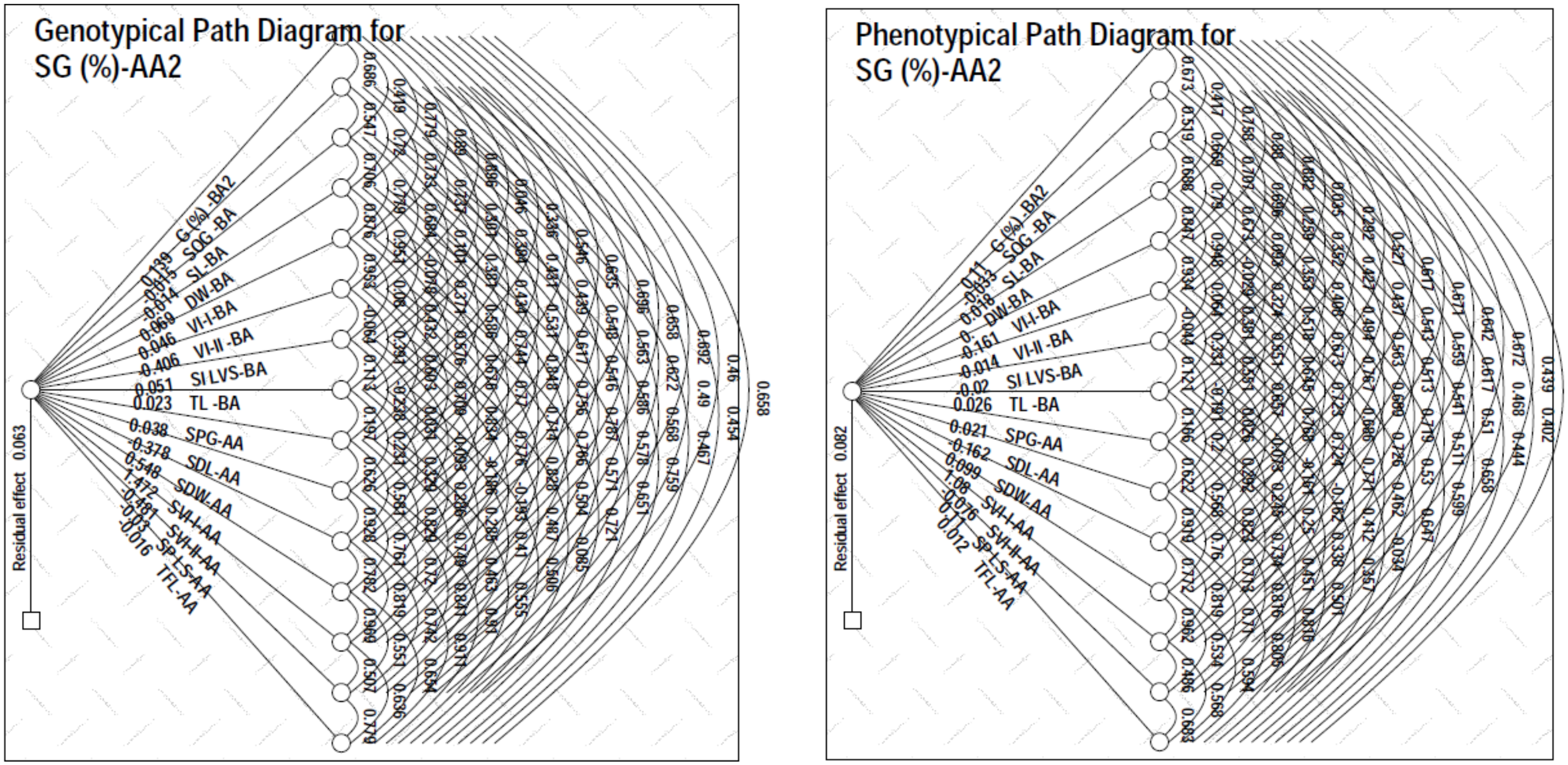


**Fig. 1. Path diagrams for 16 *Pongamia* seed traits at both genotypic and phenotypic levels**