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## Variability, Heritability and Genetic Advance of *Ailanthus excelsa*

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### ABSTRACT

#### Keywords

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Investigations were carried out to draw out information in 30 progenies of *Ailanthus excelsa* Roxb. genetic resources to elicit information on the Variability, Heritability and Genetic advance among the biometric and physiological attributes. The number of branches registered maximum PCV and GCV followed by volume index, plant height and basal diameter and chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio and total chlorophyll content had recorded low phenotypic coefficient of variation and genotypic coefficient of variation. Plant height, basal diameter, Volume index, chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio and total chlorophyll content had registered high heritability coupled with low, moderate and high genetic advance as percentage of mean

### Introduction

*Ailanthus excelsa* Roxb. is a tree belonging to family Simaroubaceae, indigenous to Central and Southern India and commonly it is known as Tree of Heaven. It is a large deciduous tree and will be growing 18-25 m tall with straight trunk and 60 to 80 cm in diameter. It is mainly used to making plywood as well as match splint production (Orwa *et al.*, 2009). Due to the demand of both plywood and

match wood this study has conceived. Rapid socio-economic changes are having profound impacts on all sectors including forestry. Societal transformations are changing people's perceptions of forests, while growing and often conflicting demands for forest-derived goods and services have increased the complexity of forest management. Concerns over climate change, escalating energy prices and deepening water deficits have moved forestry into the spotlight of global and

national development. Currently, the forest area in the country is around 23.81 per cent and in the state of Tamil Nadu it is around 17.59 per cent which is much low against the demanded requirement of 33.0 per cent. The productivity in terms of MAI is also one of the lowest comparing to the global average (FSI, 2011). The annual estimated production of wood from forest is estimated to be 3.173 million m<sup>3</sup> and the annual potential production of wood from outside the forests is estimated to be 42.77 million m<sup>3</sup> (FSI, 2011).

The country's timber imports value is growing at 12 per cent per annum and is likely to increase in years ahead. The liberalization of imports has benefited the domestic timber market, otherwise faced paucity of the desired wood in the required quantity and quality. However, there is a potential to increase the domestic production of industrial wood through tree planting, afforestation and reforestation programmes (Manoharan, 2001). Hence shrinking forest area associated with low productivity established a total mismatch between the demand and supply of both domestic and industrial wood requirement besides creating environmental disequilibrium (Parthiban *et al.*, 2011). The current supply of raw materials for industries like match wood, pulpwood, plywood, furniture and biomass energy in India particularly in Tamil Nadu is far behind the demand. Hence, to meet the growing raw material demand and also to meet the National Forest Policy (1988) Guidelines, the industries must expand sharply its plantation programme.

There are over 400 small-scale sector Splints and Veneer Industry involved in the manufacturing of veneers and splints in southern India of which 75% are located in Kerala (Bansal *et al.*, 2002). Per capita consumption of matches in India increased steadily from 2.45 sticks per capita in 1970 to 8.35 in 2013. There are wide fluctuations in

the annual growth rate in the consumption of matches varying from as low as 3 per cent (before 1970) to as high as 28 per cent. The rising levels of income, growing urbanization, swelling numbers of smokers, and changes in fuel consumption patterns indicates that the future rate of growth could be higher than the 6 per cent as supported by past trends (FAO, 2015). The major raw materials used in the production of safety matches are soft woods. Safety matches manufactured in India are of the standard type with wooden veneer or cardboard boxes and wooden splints.

Historically the Indian match industry depended on imported wood including Aspen (*Populus tremula*) from Sweden, Canada, America, and Russia; Cotton Wood (*Populus deltoides*) from Canada; Balsam Poplar (*Populus balsamifera*) from Manchuria; and Linden (*Tilia japonica*) from Japan. But the government quickly moved to encourage the use of indigenous woods by restricting the import. Even though there are number of alternative match wood species are available to replace the imported wood, *Ailanthus excelsa* occupies predominant position because of its suitability for the production quality match splints. However there is no systematic evaluation or improvement programme in order to utilize the existing genetic variation among broader genetic base population which warrants a systematic tree improvement programme in *Ailanthus excelsa* which will also address the shortage of suitable raw material to the match industries.

## **Materials and Methods**

### **Materials**

The species *Ailanthus excelsa* was chosen as the experimental material for the present study which consists of 30 progenies established as a progeny evaluation trial.

## Methods

### Estimation of Morphometric attributes Source of progenies

The predominant eleven *Ailanthus excelsa* distributed districts of Tamil Nadu viz., Coimbatore, Tirupur, Erode, Salem, Theni, Dindugal, Viruthunagar, Darmapuri, Krishnagiri, Villupuram, and Karur were surveyed and a total number of 30 candidate plus trees were selected. These selected CPTs were given with the accession number as FCRI AE. The details on the actual locations of the 30 selected candidate plus trees are presented in table 1.

### Estimation of variability

These parameters were estimated as per the method described by Johnson *et al.*, (1955).

### Genotypic Variance (G.V)

$$\sigma^2 g = (\sigma^2 p - \sigma^2 e) / r$$

Where,

$\sigma^2 g$  = Genotypic mean square

$\sigma^2 e$  = Error variance

r = Number of replications

### Phenotypic variance (P.V)

$$\sigma^2 p = (\sigma^2 g - \sigma^2 e)$$

Where,

$\sigma^2 g$  = Genotypic variance

$\sigma^2 e$  = Error variance

### Phenotypic co-efficient of variability

Phenotypic Co-efficient of Variation (PCV) was arrived by using the formula as described by Burton (1952).

$$PCV (\%) = \frac{(\text{Phenotypic Variance})^{1/2}}{\text{General Mean}} \times 100$$

### Genotypic co-efficient of variability

Genotypic Co-efficient of Variation (GCV) was arrived by using the Burton (1952) formula.

$$GCV(\%) = \frac{(\text{Genotypic Variance})^{1/2}}{\text{General Mean}} \times 100$$

### Estimation of Heritability (h<sup>2</sup>)

Broad sense heritability (h<sup>2</sup>) was calculated according to Lush (1940)

$$h^2 = (\sigma^2 g / \sigma^2 p)$$

Heritability percentage= h<sup>2</sup> x 100

### Estimation of genetic advance

Genetic advance was worked out based on method of Johnson *et al.*, (1955).

$$\text{Genetic Advance (GA)} = [(\text{Genotypic Variance} / \text{Phenotypic Variance})^{1/2} \times K$$

Where,

K = 2.06, a selection differential at 5 % selection intensity

### Genetic advance as percentage of mean

$$GA(\%) = \frac{GA}{\text{Grand Mean}} \times 100$$

## Results and Discussion

The genetic estimates viz., PCV, GCV, heritability and genetic advance as per cent of mean for the morphometric and biochemical attributes were furnished in Table 2 and 3. The results of cu are presented here under.

The plant height exercised low phenotypic and genotypic coefficient of variations to the tune of 20.06 and 17.72 per cent respectively.

Plant height recorded a higher heritability (78.00 %) and moderate genetic advance as percent of mean (32.27). The PCV and GCV for Basal diameter were 26.25 and 20.92 per cent respectively. The Basal diameter recorded higher heritability of 63.00 percentage and 34.36 was the moderate genetic advance as percentage of mean. The number of branches had recorded 165.32 and 101.76 per cent of PCV and GCV respectively. The number of branches

recorded moderate heritability of 37.00 per cent and highest genetic advance of 129.04 percentages which was the highest genetic advance among all the traits investigated. Volume index recorded medium phenotypic coefficient of variation (67.39) and genotypic coefficient of variation (59.22). It had recorded a higher heritability of 77.00 per cent and the resultant genetic advance as percent of mean was 99.98 percent.

**Table.1** Details of *Ailanthus excelsa* genetic resources and their location

| SI. No. | District     | Sources              | Name of sources | Latitude                | Longitude               |
|---------|--------------|----------------------|-----------------|-------------------------|-------------------------|
| 1       | Coimbatore   | Akkarai sengapalli   | FCRI AE 1       | 11 <sup>0</sup> 19'28"N | 77 <sup>0</sup> 04'53"E |
| 2       | Coimbatore   | S. Pungampalayam     | FCRI AE 2       | 11 <sup>0</sup> 03'24"N | 77 <sup>0</sup> 19'51"E |
| 3       | Coimbatore   | Cherannagar – 1      | FCRI AE 3       | 11 <sup>0</sup> 03'05"N | 76 <sup>0</sup> 56'32"E |
| 4       | Coimbatore   | Cherannagar – 2      | FCRI AE 4       | 11 <sup>0</sup> 03'05"N | 76 <sup>0</sup> 56'32"E |
| 5       | Coimbatore   | Teachers colony      | FCRI AE 5       | 11 <sup>0</sup> 09'37"N | 76 <sup>0</sup> 56'33"E |
| 6       | Coimbatore   | Annur – 1            | FCRI AE 6       | 11 <sup>0</sup> 14'03"N | 77 <sup>0</sup> 06'19"E |
| 7       | Coimbatore   | Annur – 2            | FCRI AE 7       | 11 <sup>0</sup> 14'03"N | 77 <sup>0</sup> 06'19"E |
| 8       | Coimbatore   | Alamelu mangapuram   | FCRI AE 8       | 11 <sup>0</sup> 02'45"N | 76 <sup>0</sup> 58'40"E |
| 9       | Coimbatore   | Vaikalpalam          | FCRI AE 9       | 10 <sup>0</sup> 58'53"N | 76 <sup>0</sup> 55'17"E |
| 10      | Tirupur      | Pogalur              | FCRI AE 10      | 11 <sup>0</sup> 15'25"N | 77 <sup>0</sup> 02'26"E |
| 11      | Tirupur      | Samundipuram         | FCRI AE 11      | 11 <sup>0</sup> 07'28"N | 77 <sup>0</sup> 18'60"E |
| 12      | Tirupur      | Kulathu thottam      | FCRI AE 12      | 11 <sup>0</sup> 03'33"N | 77 <sup>0</sup> 15'56"E |
| 13      | Tirupur      | Salakkudi            | FCRI AE 13      | 10 <sup>0</sup> 41'04"N | 77 <sup>0</sup> 36'22"E |
| 14      | Tirupur      | Chettipalayam        | FCRI AE 14      | 11 <sup>0</sup> 08'38"N | 77 <sup>0</sup> 20'28"E |
| 15      | Erode        | Appachimar madam     | FCRI AE 15      | 11 <sup>0</sup> 19'51"N | 77 <sup>0</sup> 28'47"E |
| 16      | Erode        | Perundurair          | FCRI AE 16      | 11 <sup>0</sup> 16'26"N | 77 <sup>0</sup> 35'18"E |
| 17      | Salem        | Pethanayakkanpalayam | FCRI AE 17      | 11 <sup>0</sup> 38'51"N | 78 <sup>0</sup> 30'20"E |
| 18      | Salem        | Idapadi              | FCRI AE 18      | 11 <sup>0</sup> 35'05"N | 77 <sup>0</sup> 50'20"E |
| 19      | Theni        | Uthamapalayam        | FCRI AE 19      | 9 <sup>0</sup> 48'20"N  | 77 <sup>0</sup> 19'40"E |
| 20      | Theni        | Thevaram             | FCRI AE 20      | 9 <sup>0</sup> 53'44"N  | 77 <sup>0</sup> 16'31"E |
| 21      | Theni        | Bodi                 | FCRI AE 21      | 10 <sup>0</sup> 01'00"N | 77 <sup>0</sup> 21'00"E |
| 22      | Dindugal     | Kallimandayam        | FCRI AE 22      | 10 <sup>0</sup> 35'28"N | 77 <sup>0</sup> 44'11"E |
| 23      | Viruthunagar | Srivilliputhur       | FCRI AE 23      | 9 <sup>0</sup> 30'44"N  | 77 <sup>0</sup> 38'03"E |
| 24      | Darmapuri    | Harur                | FCRI AE 24      | 12 <sup>0</sup> 03'05"N | 78 <sup>0</sup> 28'49"E |
| 25      | Darmapuri    | Papparetipatti       | FCRI AE 25      | 11 <sup>0</sup> 54'49"N | 78 <sup>0</sup> 21'57"E |
| 26      | Krishnagiri  | Oothangarai          | FCRI AE 26      | 12 <sup>0</sup> 15'57"N | 78 <sup>0</sup> 32'07"E |
| 27      | Villupuram   | Thiruvakkarai        | FCRI AE 27      | 12 <sup>0</sup> 01'34"N | 79 <sup>0</sup> 39'06"E |
| 28      | Villupuram   | Mathangadipattu      | FCRI AE 28      | 11 <sup>0</sup> 57'59"N | 78 <sup>0</sup> 45'28"E |
| 29      | Villupuram   | Pudupattu            | FCRI AE 29      | 11 <sup>0</sup> 58'21"N | 78 <sup>0</sup> 53'52"E |
| 30      | Karur        | Salikaripatti        | FCRI AE 30      | 10 <sup>0</sup> 45'04"N | 78 <sup>0</sup> 10'70"E |

**Table.2** Variability estimates for biometric and biochemical attributes of *Ailanthus excelsa* Progenies

| S.No | Traits                    | PCV (%) | GCV (%) |
|------|---------------------------|---------|---------|
| 1.   | Plant height              | 20.06   | 17.72   |
| 2.   | Basal diameter            | 26.25   | 20.92   |
| 3.   | No. of branches           | 165.32  | 101.76  |
| 4.   | Chlorophyll a             | 23.07   | 23.05   |
| 5.   | Chlorophyll b             | 20.56   | 20.54   |
| 6.   | Chlorophyll a/b           | 10.22   | 10.18   |
| 7.   | Total chlorophyll content | 23.09   | 23.07   |
| 8.   | Volume index              | 67.39   | 59.22   |

**Table.3** Heritability (%) and Genetic Advance (%) estimates for biometric and biochemical attributes of *Ailanthus excelsa* Progenies

| S.No | Traits                    | Heritability (%) | GA (%) of Mean |
|------|---------------------------|------------------|----------------|
| 1.   | Plant height              | 78.00            | 32.27          |
| 2.   | Basal diameter            | 63.00            | 34.36          |
| 3.   | No. of branches           | 37.00            | 129.04         |
| 4.   | Chlorophyll a             | 99.00            | 47.45          |
| 5.   | Chlorophyll b             | 99.00            | 42.27          |
| 6.   | Chlorophyll a/b           | 99.00            | 20.87          |
| 7.   | Total chlorophyll content | 99.00            | 47.50          |
| 8.   | Volume index              | 77.00            | 99.98          |

The chlorophyll 'a' recorded low PCV of 23.07 and GCV of 23.05. Heritability and genetic advance as percentage of mean for this trait were high 99.00 per cent and 47.45 respectively. Phenotypic coefficient of variation (20.56) and genotypic coefficient of variation (20.54) for chlorophyll 'b' content were low. The heritability was 99.00 per cent and the resultant genetic advance as percentage of mean was 42.27. The phenotypic coefficient of variation and genotypic coefficient of variation for chlorophyll a/b ratio were low which were in the order of 10.22 and 10.18 respectively. It had recorded high heritability value of 99.00 per cent and the resultant genetic advance as percent of mean was 20.87. The *Ailanthus excelsa* progenies registered medium

phenotypic coefficient of variation and genotypic coefficient of variation for total chlorophyll content which was 23.09 and 23.07 per cent respectively. Total chlorophyll content also registered high heritability of 99.00 per cent and genetic advance as percent of mean were also medium 47.50 per cent.

The assessment of genetic variability is a key to progress in tree improvement (Zobel, 1981) and is a useful tool in determining the strategies for tree improvement and breeding of any species. If the variability in a population is largely due to genetic cause with least environmental effect, probability of isolating superior genotype is a prerequisite for obtaining higher yield. As yield is ultimate expression of various yield contributing

characters, direct selection for yield could be misleading (Islam and Rasul, 1998 and Nath and Alam, 2002). This is difficult to judge what proportion of observed variability is heritable and what proportion of non-heritable *i.e.*, environmental. The process of breeding such population is primarily conditioned by variations in plant characters. So it becomes necessary to partition the observed variability into its different components and to have an understanding of parameters such as genetic coefficient of variation, heritability and genetic advance.

The present study revealed that significant amount of variability existed among different *Ailantus excelsa* progenies in terms of biometric and biochemical characters investigated *viz.*, plant height, basal diameter, number of branches volume index, chlorophyll 'a', chlorophyll 'b', and total chlorophyll content and chlorophyll 'a'/b ratio.

Among the morphometric traits, highest heritability was recorded by plant height followed by volume index, basal diameter and number of branches. Similarly, high heritability estimates for volume index was earlier reported in *Eucalyptus* (Balaji, 2000); *Casuarina* (Ashok Kumar and Paramathma, 2005); *Bombax ceiba* (Chaturvedi and Pandey, 2005); *Azadirachta indica* (Dhillon *et al.*, 2003), *Simarouba glauca* (Kumaran *et al.*, 2010); *Melia dubia* (Kumar 2011 and Saravanan, 2012) and *Leucaena leucocephala* (Chavan and Keerthika, 2013).

To understand the causes of variation, apportioning of total phenotypic variation is having more utility. The genetic variation which is heritable can be exploited for further improvement programme. In the current study, volume index had recorded moderate PCV and GCV coupled with high heritability and genetic advance. The PCV and GCV for

plant height and basal diameter were low whereas both the parameters registered high heritability and moderate genetic advance. Highest GCV and PCV were recorded for number of branches, however the heritability was moderate and genetic advance was high. Higher GCV for volume index in teak (Arun Prasad, 1996), number of branches in *Eucalyptus tereticornis* and low GCV for height in *Eucalyptus tereticornis* were earlier reported (Surendran and Chandrasekaran, 1984 and Paramathama 1992). Similarly low GCV and PCV for height and collar diameter were also reported in *Bambusa pallida* (Singh and Beniwal, 1993). The exhibition of low PCV and GCV for plant height, diameter at breast height and volume index in the present study is in conformity with the above assertions. The genotypic and phenotypic coefficient of variation for height, basal diameter and volume recorded in the current study provided evidences for existence of adequate genotypic variations (Kumar *et al.*, 2010) and thus lend support for exploitation of genetic variability for further improvement in this multiple utility species.

The relative values of PCV and GCV give an idea about the magnitude of variability present in a genetic population. In the current study, the estimates of GCV were less than PCV for many traits indicating the role of environment in the expression of the traits. The variability parameter estimates in the study are in close approximation with the findings of genetic parameters in *Azadirachta indica* (Dhillon *et al.*, 2003), *Pongamia pinnata* (Kumaran, 1991) and also in progenies of *Dalbergia sissoo* (Dogra *et al.*, 2005) which lend support to the findings of current investigation.

Heritability has an important place in tree improvement programme as it provides an index of relative strength of heredity versus environment. Dorman (1976) reported that

heritability is very important in tree improvement programme. It is also useful for ranking importance of each trait in cross breeding programme. Gains from tree breeding programme depend on type and extend of genetic variability. The best gains are for characteristics that are strongly under genetic control and have a wide range of variability (Zobel, 1971). Heritability expresses the degree to which a character is influenced by heredity as compared to the environment *Melia dubia*, (Saravanan, 2012). Estimation of broad sense heritability for various characters showed high heritability for height, basal diameter, number of branches, and volume index. The results are in agreement with the studies carried out by Gera *et al.*, (2001) in *Tectona grandis* which showed high heritability in plant height and collar diameter. Studies on *Pongamia pinnata* showed that heritability varies with changing environment and age (Rao *et al.*, 2011).

In the current study, high heritability was recorded by the plant height, followed by volume index and basal diameter which might be due to the complexity of quantitative trait prone to high environmental influences. The maximum heritability estimate recorded for plant height in the current study indicated the predominance of additive gene action for this character as reported in teak (Anmol *et al.*, 1997). The high heritability values for plant height, volume index and basal diameter in the present study indicated the predominance of heritable variation for these important traits.

Although heritability in broad sense may give useful indication about the relative value of selection in the material at hand, to arrive at a more reliable conclusion, heritability and associated genetic gain should be considered jointly. In the current study, the trend of genetic advance as per cent of mean was high in no. of branches followed by volume index

and low in plant height and basal diameter indicating a wide scope of genetic improvement possibility in the species. The findings of current study are in line with those of Gangoo *et al.*, (1997) in *Populus nigra* and Ramachandra (1996) in *Acacia catechu*. Other research workers have also reported similar results in *Terminalia arjuna* (Srivastava *et al.*, 1993), *Grewia optiva* (Sharma and Sharma, 1995) and also in *Eucalyptus grandis* (Subramanian *et al.*, 1995) which lend support to the results of current investigation.

The best gains could be achieved for the characteristics that are strongly under genetic control and have wide range of variability. The characters with high heritability coupled with higher genetic gain could act as a reliable indicators as evidenced in *Prosopis cineraria* and also in poplars (Tiwari *et al.*, 1994 and Singh *et al.*, 2001). Hence the high heritability coupled with high genetic gain for volume in the current study indicated that this character is strongly under genetic control.

Among biochemical traits total chlorophyll content expressed high PCV (23.09) respectively and GCV (23.07) followed by chlorophyll 'a' with PCV and GCV of 23.07 and 23.05. Heritability was 99.00 per cent for chlorophyll 'a', chlorophyll 'b', and total chlorophyll content and chlorophyll 'a'/b ratio. Volume index had exhibited 77 per cent heritability. High genetic advance as percentage of mean was observed in volume index as 107.20 per cent followed by traits total chlorophyll content 47.50 per cent and chlorophyll 'a' 47.45 per cent. The results agree with the findings of Seghal *et al.*, (1989) were that heritability, genotypic and phenotypic coefficient of variation for biochemical traits were in seed sources of *Pinus roxburghii*. Radhakrishnan (2001) also reported that the biochemical traits of *Albizia lebbeck* showed high PCV, GCV heritability

and genetic advance as per cent mean among the 30 seed sources.

Hence concluded, in the present investigation, number of branches registered maximum PCV and GCV followed by volume index, plant height and basal diameter. The biochemical attributes viz., chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio and total chlorophyll content had recorded low phenotypic coefficient of variation and genotypic coefficient of variation. It was observed that biometric attributes viz., Plant height, basal diameter and Volume index had registered high heritability coupled with moderate and high genetic advance as percentage of mean. All the biochemical attributes viz., chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio and total chlorophyll content exhibited high heritability with high and low genetic advance.

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