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Variability, broad sense heritability, genetic advance of *Toona ciliata* M. Roem., progenies

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Abstract
Field experiments were carried out at FC&RI Mettupalayam, among the 16 progenies of *Toona ciliata* M Roem were evaluated for its phenotypic and genotypic coefficient of variance, broad-sense heritability and genetic advance for biometric and biochemical attributes viz. plant height, basal diameter, volume index, chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio, total chlorophyll and carotenoids. Among the biometric and biochemical attributes, the phenotypic coefficient of variation was higher than the genotypic coefficient of variation, which revealed that environmental factors played a major role. Among the biometric characters, the volume index registered high PCV, GCV, broad-sense heritability and genetic advance as percent of mean, followed by basal diameter and plant height. As a result, these parameters could be employed as selection criteria to boost the volume of *Toona ciliata*. Among the biochemical attributes, chlorophyll 'a' registered higher PCV, GCV, broad-sense heritability and genetic advance as percent of mean followed by chlorophyll b, chlorophyll a/b ratio carotenoids and total chlorophyll content. As a result of the current study, variability parameters indicate that this species has a wider scope of genetic improvement.

Keywords: toona, variability, broad-sense heritability, genetic advance

Introduction
Toona ciliata comes under the family is called Meliaceae, which is native to India, Australia, Indo-china peninsula, Pacific Islands and southern china. It is commonly known as Australian red cedar or Chinese mahogany. It is a shade bearer and the tree attains 30m height with a well-spreading crown. The growing population and their continually increasing demand for forest-based goods and services such as timber and supplementary forest-derived products rising day by day Deepanjali, (2018) [4]. The wood of Toona is more valued because of its colour, durability and timber quality Zhan *et al*., (2019) [26]. The current forest and tree cover of the country is 21.67 percent (71.22 million ha) and 2.89 percent (9.51 million ha) respectively. The annual harvest of timber from the forest declined from 10 million m^3 in the 1970s to 4 million m^3 in 1990 and currently it is 3 million m^3. The annual timber production of TOF is 85 million m^3 in 2020. The total wood demand of India is 153 million m^3 in 2020 and the productivity of wood is only 60 million m^3 Shrivastava & Saxena, (2017) [21].
To meet the demand of large-sized wood, the policy of importing wood has been liberalized since the 1990s. The total import of round wood and sawn wood logs were 6 million cubic meters from 2014-15 to 2019-20. India imports all types of wood except pulp, paper and newsprints Rai and Chakrabarti, (2001) [18]. The importing of wood increases day by day so to meet out the wood demand we need to identify and screen alternate fast-growing multipurpose trees. *Toona ciliata* is one among the best fast-growing and alternative species which could be used as raw material for wood-based industries.
The study of genetic analysis becomes more valuable in tree improvement programme because it increases the chances of recovering superior genotypes Zobel and Talbert (1984) [28]. Such a diverse and rapidly expanding species has got little research and attention, especially when it comes to improving the species through systematic tree breeding. As result, the current research was created to improve the species through a systematic tree improvement programme to address the shortage of wood-based industries raw material. None of the studies have indicated about genetic diversity in *Toona ciliata* against this backdrop the current investigation has been carried out.

Materials and Methods
The species *Toona ciliata* was selected as the experimental material for the present study

which consists of 16 progenies established as a progeny evaluation trial at Forest College and Research Institute, Mettupalayam, Coimbatore and Tamil Nadu during the year of 2020-2021 at the espacement of 4 m * 4m. The predominant *Toona ciliata* distributed three different states of India *viz*., Tamil Nadu, Karnataka and Punjab were surveyed and a total number of sixteen candidate plus trees were selected. These elected CPTs were given with the consent number as FCRI TC. The details on the actual locations of the 16 elected candidate plus trees were presented in table 1

Biometric observations *viz*., Tree height (cm), Basal girth (cm) was recorded at 60 days intervals for four different growth phases. The plant height was measured in centimeters with the help of measuring tape from ground level to the foremost tip of the stem. The Basal diameter was measured in centimeters with the help of a digital caliper at the base of the stem (near the ground level). After estimating the plant height and basal diameter, the volume index was calculated using the formula suggested by (Manavalan, 1990) [17].

Estimation of biochemical attributes viz., the chlorophyll (a, b and total) as well as carotenoid content in leaves were estimated by the method of (Yoshida *et al*., 1971) [25], chlorophyll is extracted in 80 % acetone and absorbance are read in a spectrophotometer. Using the absorption coefficients the amount of chlorophyll is calculated. The data was quantitatively expressed in mg/gm.

Weigh 0.25 grams of freshly collected leaf samples of different genotypes were grinded and extracted in 10 ml of 80 % acetone with help of pestle and mortar to get fine paste. Then, the solution centrifuged at 3000 rpm for 10 minutes. The collected supernatant was transferred to the 50 ml volumetric flask and the volume was made to 25 ml with 80 % acetone. Then, the absorbance was recorded at 480, 510, 645, 652 and 663 nm against the blank (80% acetone) in the spectrophotometer. The amount of chlorophyll and carotenoids present in the leaf extract was calculated with the absorbance of samples taken at different wavelengths using the formulas.

The method provided by Johnson *et al.* (1955) [9] was used to evaluate genetic characteristics such as Phenotypic and Genotypic variances. Burtons Phenotypic and Genotypic coefficients of variation (PCV and GCV) were calculated (1952). According to Lush, heritability was estimated in a broad sense (1940). Following Johnson *et al*., (1955) [9], a genetic advance was devised.

Results and Discussion

Table 2 depicts the mean values of the biometric parameters viz., plant height (cm), Basal diameter (cm) and the physiological parameters viz., Chlorophyll 'a' (mg gm^{-1}), Chlorophyll 'b' (mg gm^{-1}), Total Chlorophyll (mg gm^{-1}), Chlorophyll a/b ratio, Carotenoids (mg gm^{-1}) contents of sixteen genotypes at forest college and research institute, Mettupalayam.

Height is an important indicator of growth and site. The genotypes which showed maximum height of 242.9 cm were recorded in FCRI TC 02 followed by FCRI TC 11 and FCRI TC 01 i.e., 179.9 cm and 174.8 cm respectively. The minimum height was observed among FCRI TC 03 (119.9 cm) followed by FCRI TC 04 (128.8 cm). The height of 180 days old plantation of different *Toona* genotypes is found to be in a range from 119 – 245 cm. Among the sixteen genotypes studied, the FCRI TC 02 was recorded with the maximum basal diameter of 5.1 cm followed by FCRI TC 15 with a basal diameter of 4.9 cm. The minimum basal diameter was shown by the FCRI TC 03 (3.0 cm) and 4 (3.0 cm) which are on par with each other.

Among the observation taken, it was found that the FCRI TC 02 which possesses higher chlorophyll 'a' (1.675 mg gm^{-1}), chlorophyll 'b' (0.75 mg gm^{-1}) and carotenoids content (0.817 mg gm^{-1}) has also shown maximum height (242.9 cm) and basal diameter (5.1cm). This result was in concordance with the findings of Larekeng *et al*., 2019 [15]. He revealed that the chlorophyll content maintains the photosynthesis process and it is directly proportional to plant growth and development. A leaf that owns higher chlorophyll content would perform efficiently in absorbing sunlight for enhanced energy production during photosynthesis. The generated energy is utilized by the trees for their growth and development process. Thus, high chlorophyll content will enhance the photosynthetic rate and finally, it will improvise the quality and quantity of yield and nutrient content (Larekeng *et al*., 2019) [15].

Then approaching to the results of genetic estimates namely phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance as percent of mean for the biometric and physiological parameters of *Toona ciliata* were computed in table 3. The phenotypic coefficient of variation and genotypic coefficient of variation for the chlorophyll 'a' was found to be with the least value. The heritability and genetic advance as percentage of mean were found to be high with 96 % and 45.15 respectively. The chlorophyll 'b' was observed with a low PCV of 21.46 and GCV of 20.74. Heritability and genetic advance as percentage of mean for this trait were high with 93 % and 41.27 respectively.

Table 3 describes the genetic analysis for biometric and physiological variables including phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad-sense heritability and genetic advance as percent of mean displayed below.

Among the three biometric attributes viz, Plant Height, Basal diameter and Volume Index. Plant height recorded a moderate genotypic and phenotypic coefficient of variation. The genotypic and phenotypic values of the plant height were 10.83 and 27.24 respectively. Plant height that recorded low heritability and low genetic gain percentage of mean was 16.0% and 8.87% respectively. The phenotypic coefficient of variance and genotypic coefficient of variance for basal diameter was 21.04 and 10.84 percent of the mean, respectively. Among the three biometric attributes, basal diameter had the highest broad sense heritability (27.00 %) and the lowest genetic advance percent of the mean (11.63%). The volume index had secured high phenotypic and genotypic coefficient of variance of 61.43 and 28.94 percent, respectively, as well as moderate broad-sense heritability and high genetic advance as percent of mean 22.00% and 28.09 percent, respectively. Among the three biometric attributes, the phenotypic coefficient of variance (PCV) is higher than the genotypic coefficient of variance (GCV).

Among the biochemical attributes, chlorophyll 'a' had the highest values for the phenotypic coefficient of variance and genotypic coefficient of variance at 22.87 and 22.39 percent, respectively, and it had the highest broad-sense heritability of 96.00 and genetic advance with 45.15 percent respectively. Chlorophyll 'b' had a phenotypic coefficient of variance (PCV) of 21.46 percent and a genotypic coefficient of variance (GCV) of 20.74 percent. It had a broad-sense

heritability rate of 93.00 percent and a genetic advance rate of 41.27 percent. Total chlorophyll registered low phenotypic and genotypic coefficients of variance among the biochemical attributes. It has a registered PCV of 10.58% and GCV of 09.55 %, as well as low broad-sense heritability and 81.00% and a low genetic advance of 17.55%. Chlorophyll a/b ratio and carotenoids registered a medium phenotypic coefficient of variance and genotypic coefficient of variance among the biochemical attributes. The chlorophyll a/b ratio and carotenoids had PCV of 22.23 and 18.06 percent, respectively, and GCV of 21.37 and 17.64 percent. The chlorophyll a/b ratio had 92.00% medium broad-sense heritability and a 42.33 percent genetic advance. Cartenoids registered high broad-sense heritability 95.00% and medium genetic advance 35.49%. Among the biometric and biochemical attributes phenotypic coefficient of variance was higher than the genotypic coefficient of variance and volume index registered maximum PCV 61.43% and GCV 28.94% and chlorophyll 'a' registered maximum broad sense heritability 96.00 % and genetic advance 45.15% percent of the mean.

The estimation of genetic variation is an important tool in the tree improvement program (Zobel, 1971) [27]. If a population's variability is mostly attributable to genetic factors with little environmental influence, isolating superior progenies is a precondition for getting a greater yield (Islam and Rasul, 1998) [8]. The level of variability in the base population, which may be assessed using multiple indices like phenotypic and genotypic variances as well as phenotypic and genotypic coefficient of variances, is crucial to tree breeding strategy.

In the present study, the biometric and biochemical characters such as plant height, basal diameter, volume index, chlorophyll 'a', chlorophyll 'b', chlorophyll a/b ratio, total chlorophyll and carotenoids were investigated, it showed that significant variability among the various *Toona ciliata* progenies.

Volume index had the highest heritability among the biometric parameters, followed by basal diameter and plant height. Current study results also similar to previous results have been reported in *Simarouba glauca* (Kumaran *et al*., 2010) [14]; *Melia dubia* (Saravanan, 2012) [20]; *Eucalyptus* (Balaji, 2000) [2]; *Azadirachta indica* (Dhillon *et al*., 2003) [5]; *Leucaena leucocephala* (Chavan and Keerthika, 2013); *Santalum album* (Krishnakumar, 2017) [12]; *Neolamarkcia cadamba* (Thirunirai Selvan *et al.,* 2018) [23].

The kind and extent of genetic variability determine the gains from the tree breeding programmes. The best improvements are for traits that are heavily influenced by genetic and have a broad range of variation (Zobel, 1971) [27]. Heritability is particularly crucial in tree improvement programmes, according to Dorman (1976) [6]. It's also helpful for determining the relative relevance of each character in a cross-breeding scheme.

The greatest benefits could be made for traits that are significantly influenced by genetics and have a wide range of variability. Characters having a high heritability and a high genetic gain could be used as credible markers, as shown in earlier reports of poplars and *Prosopis cineraria* (Tiwari *et al.,* 1993 and Singh *et al.,* 2001) [24]. As a result, the present study's high heritability and significant genetic gain for volume suggested that this attribute is strongly influenced by genetics.

The level of variability contained in a genetic population can be estimated using the relative values of the Phenotypic Coefficient of Variance and genotypic Coefficient of Variance. For many qualities, Genotypic estimations were lower than the Phenotypic Coefficient of Variance in the current study, showing the importance of the environment in the expression of the traits. The study's estimates of variability parameters are quite near to the findings of genetic parameters in *Pongamia pinnata* (Kumaran, 1991) [13]; *Santalum album* (Krishnakumar, 2017) [12]; *Neolamarkcia cadamba* (Thirunirai Selvan *et al.,* 2018) [23]; *Ailanthus excelsa* (Kanna *et al.,* 2019) [10]

The high Phenotypic Coefficient of Variance and Genotypic variance was registered at Volume index. The similar findings also registered in Teak (Arun Prasad, 1996) [1]. In *Bambusa pallida* poor Phenotypic Coefficient of Variance and Genotypic Coefficient of Variance for height and basal diameter were also noted (Singh and Benewal, 1993). The PCV and GCV of Plant height, Basal Diameter and Volume Index recorded in this present study provided evidences for the existence of adequate Genotypic Variations (Krishnakumar *et al.,* 2017) [12], implying that genetic variability can be exploited for further improvements.

Among the biochemical attributes chlorophyll 'a' registered maximum Phenotypic Coefficient of Variance and Genotypic Coefficient of Variance as well as high heritability and genetic advance followed by chlorophyll 'b', carotenoids, chlorophyll a/b ratio and total chlorophyll content. The present study findings are strongly agreed with (Kanna *et al.,* 2019) [10] in *Ailanthus excelsa.*

Table 1: Details and actual locations of 16 *Toona ciliata* progenies

S.no	Sources	District	State	Name of sources	Latitude	Longitude
1.	Katteri, Nilgiri hills	Nilgiri	Tamil Nadu	FCRI TC 1	$11^0$33'31"N	$076^0$79'7"E
2.	Aravenu, Kotagiri stretch	Nilgiri	Tamil Nadu	FCRI TC 2	$11^0$32'43"N	$076^0$95'58"E
3.	Nadugani, Gudulur division TC1	Nilgiri	Tamil Nadu	FCRI TC 3	$11^0$47'21"N	$076^0$41'31"E
4.	Nadugani, Gudulur division TC2	Nilgiri	Tamil Nadu	FCRI TC 4	$11^0$44'59"N	$076^0$41'27"E
5.	Pandalur, Gudulur division	Nilgiri	Tamil Nadu	FCRI TC 5	$11^0$33'71"N	$076^0$93'66"E
6.	Devala, Gudular division	Nilgiri	Tamil Nadu	FCRI TC 6	$11^0$33'52"N	$076^0$92'50"E
7.	Choondi, Gudulur division	Nilgiri	Tamil Nadu	FCRI TC 7	$11^0$32'40"N	$076^0$92'60"E
8.	Thadiyankudisai TC4	Dindigul	Tamil Nadu	FCRI TC 8	$10^0$29'44"N	$077^0$70'50"E
9.	Thadiyankudisai TC3	Dindigul	Tamil Nadu	FCRI TC 9	$10^0$29'27"N	$077^0$70'19"E
10	Pongalarmedu, Thadiyankudisai beat	Dindigul	Tamil Nadu	FCRI TC 10	$10^0$31'98"N	$077^0$65'40"E
11	Sampallioothu, Thadiyankudisai beat	Dindigul	Tamil Nadu	FCRI TC 11	$10^0$31'03"N	$077^0$65'29"E
12	Kodagu	Kodagu	Karnataka	FCRI TC 12	$12^0$14'43"N	$075^0$93'95"E
13	Ponampet	Kodagu	Karnataka	FCRI TC 13	$12^0$14'47"N	$075^0$94'51"E
14	Ludhiana TC5	Ludhiana	Punjab	FCRI TC 14	$30^0$90'10"N	$075^0$80'71"E
15	Ludhiana TC6	Ludhiana	Punjab	FCRI TC 15	$30^0$90'10"N	$075^0$80'71"E
16	TC 02	Ludhiana	Punjab	FCRI TC 16	$30^0$90'10"N	$075^0$80'71"E

Table 2: Biometric and physiological parameters of 16 *Toona ciliata* progenies

No	Source Name	Height (cm)	Basal diameter (cm)	Volume Index (cm^3)	Chlorophyll 'a' (mg gm^{-1})	Chlorophyll 'b' (mg gm^{-1})	Total Chlorophyll (mg gm^{-1})	a/b ratio	Carotenoids (mg gm^{-1})
1	FCRI TC 01	174.8	4.6	4065.9	1.234	0.494	2.497	1.727	0.564
2	FCRI TC 02	242.9	5.1	6375.8	1.675	0.75	2.234	2.424	0.817
3	FCRI TC 03	119.6	3	1167.5	1.08	0.551	1.961	1.63	0.537
4	FCRI TC 04	128.8	3	1465.7	0.794	0.303	1.836	1.097	0.379
5	FCRI TC 05	136.3	3.5	1718.9	0.902	0.491	2.316	1.393	0.498
6	FCRI TC 06	173.4	4.6	4188	1.501	0.623	2.409	2.124	0.574
7	FCRI TC 07	159.2	3.9	2514.5	1.263	0.626	2.019	1.888	0.645
8	FCRI TC 0	158.8	4.5	3313.6	1.069	0.484	2.207	1.553	0.514
9	FCRI TC 09	137.2	4.3	2637.9	1.101	0.519	2.121	1.619	0.528
10	FCRI TC 10	157.2	4	2755.2	0.993	0.515	1.929	1.507	0.5
11	FCRI TC 11	179.9	4.5	4656.7	1.654	0.714	2.619	2.367	0.678
12	FCRI TC 12	133.7	3.6	1756.9	0.978	0.47	2.079	1.447	0.565
13	FCRI TC 13	168.2	4.7	4085.8	1.335	0.562	2.376	1.896	0.609
14	FCRI TC 14	156.3	4.8	3793.6	1.054	0.44	2.397	1.493	0.509
15	FCRI TC 15	150.6	4.9	4077.7	1.063	0.465	2.287	1.528	0.613
16	FCRI TC 16	153.8	4.3	2984.2	0.915	0.432	2.12	1.347	0.457

Table 3: Genetic estimation of 16 *Toona ciliat*a progenies

	GCV	PCV	Heritability	GA (%)
Plant height	10.83	27.24	0.16	8.87
Basal diameter	10.90	21.04	0.27	11.63
Volume index	28.94	61.43	0.22	28.09
Chlorophyll 'a'	22.39	22.87	0.96	45.15
Chlorophyll 'b'	20.74	21.46	0.93	41.27
Total chlorophyll	9.55	10.58	0.81	17.75
a/b ratio	21.37	22.23	0.92	42.33
Cartenoids	17.64	18.06	0.95	35.49

Conclusion

As a result, the volume index had the highest Phenotypic Coefficient of Variance and Genotypic Coefficient of Variance followed by basal diameter and plant height. The PCV and GCV for the biochemical parameters Chlorophyll 'a', Chlorophyll 'b', Total Chlorophyll, Chlorophyll a/b ratio and carotenoids content were low. It was discovered that biometric parameters such as Plant height, Volume Index and basal diameter had significant broad sense heritability and medium genetic advance as a percent of mean. Chlorophyll 'a', chlorophyll 'b', total chlorophyll, chlorophyll a/b ratio and carotenoids content were showed high heritability and high to medium genetic advance.

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