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Variability, heritability, genetic gain, genetic advance and correlation in morphological and seed characteristics in *Toona ciliata*

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Abstract
Toona ciliata is an important timber species of India which is found in H.P. as natural populations, mostly along the cultivated fields and roads. In fact this is a multipurpose tree species of tropical and subtropical areas. Seeds of *Toona ciliata* were collected from ten locations and morpholological chraacters study in three locations to study the extent and pattern of variation with respect to various traits. Variability and genetic estimates for number of flower and inflorescence length showed low genotypic coefficient of variability, low to moderate genetic gain and high heritability; h=0.41 and 0.62 respectively for both the characters. It indicates that these traits are under additive genetic control and may be considered effective for selection. Positive and significant correlation was observed between flower number and inflorescence length (r = 0.94) and negative correlation was observed between leaflet number and fruit setting (r = -0.24).

Keywords: Genetic gain, genetic advance, heritability, correlation, phonological studies, seed studies, *Toona ciliata*

Introduction
For establishing priorities for the conservation and improvement of tree genetic resources understanding of the diversity among and between tree populations is essentially required. Determination of the amount, cause and nature of variation present in the species of interest is the first step towards any improvement work. All the differences among trees are the result of three things viz., the genetic differences among trees, different environment in which tree is growing and interaction between tree genotype and environment in which they grow. Continuous development is possible if variation exists in a species. Variations are essential for adaptation and improvement and the amount of variation determine the potential for improving species through breeding programmes. In natural population of a species, the presence of land masses, water bodies and mountains cause variation. High genetic variation within and among populations has been demonstrated and this distribution of variation and evolutionary histories can lead to the recommendations of future breeding programmes (Namkoong, 1984) [1].
Study of variation is the first step for any tree improvement programme, which start with the field survey and selection from the entire range of species distribution and subsequently delimitation of seed sources capable of providing the best adapted trees. The use of quantitative characters has been and remains, the essential basis for phenotypic selection in any breeding programme. However ability of these characters to provide measures of genetic variation and estimate of genetic similarity among population is limited by time and precision of genetic expression. Thus the study of phenotypic variation in the species indirectly provides the requisite genetic structure necessary for further breeding work. After a particular cycle of selection and improvement programme by which superior and genetically diverse population has been obtained, the aim of tree breeder is to systematically exploit their genetic worth.In the family Meliaceae a wide range of variation exists than any comparable group due to its size. This diversity is a source of rich material for the study of evolution but at the same time it is also a source of taxonomic difficulty. More than in any other family, the taxonomic uncertainty has been due to the diffuse and often reticulate nature of variation. Among all plant families, the trees of Meliaceae are more useful to human beings, chiefly for their high quality timbers and for the ease with which they can be grown in plantations. *Toona ciliata* belonging to family Meliaceae, is the best known Indian timber species, popularly known as toon and red

cedar. The other timber yielding species of the genus occurring in India are *Toona febrifuga*, *T. microcopa* and *T. serrata*. Meliaceae is in fact the backbone of forest industries in many countries (Bahadur 1988) [2]. In India it is found throughout the Sub-Himalayan tract and the valleys of the outer Himalayas, plains of Assam, Madhya Pradesh, Tamil Nadu, Karnataka, Eastern and Western Ghats occurring up to an elevation of 1200 m (rarely 1300 m) in western peninsula Khasi hills and Manipur (Singh 1982) [3]. It is a characteristic tree of Eastern alluvial secondary semi-evergreen forests in Assam (Champion and Seth. 1968) [4], ecologically tree is restricted to the site where the absolute shade temperature varied from 37.5^0- 47.5 ^{0}C and the absolute mean from -1 to 17.5 ^{0}C, the annual rainfall ranges from 1100-4000 mm. Success of tree improvement generally depends upon the combination and expression of characters in the new genotypes which holds the key for boosting the productivity and yield of the economic product. In this context, regulation of variation through reproductive system forms the basic approach which is dependent upon the information pertaining to reproductive biology as the biological process. Therefore, the studies on reproductive biology and breeding system are pre-requisite for developing appropriate strategies for tree breeding. There is a felt need to take up the detailed study of *Toona ciliata* - a multipurpose, timber species, particularly because of its typical inflorescence showing indeterminate growth pattern.

Material and Methods

Present investigation was carried out during 2010 in the Department of Tree Improvement and Genetic Resources, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh Seed study need to cover an extended vast stretch of species distribution hence ten seed sources of *Toona ciliata* were selected from different parts of H.P with 5 trees from each seed source (Table 1). These sites were coded as S1, S2, S3, S4, S5, S6, S7, S8, S9 and S10 respectively. Seeds were collected from the selected trees and processed separately for further seed studies in the departmental laboratory. Seed germination studies were carried out in laboratory. Three replications per treatment with 100 seeds per replication were placed in petriplates in Completely Randomized Design (CRD). Three locations were randomly selected for study of phenological such as leafing, flowering, fruiting and morphological studies such as floral morphology, floral biology and breeding system of *Toona ciliata*. The locations selected were Jaunaji (L1), Dharja (L2) and Kandaghat (L3) and from each locations 9 medium sized trees were selected (Table 1a). And from each locations 9 medium sized trees were selected and marked with yellow paint after removing the bark. On each tree 5 branches were tagged/marked with metallic tags and numbered from 1-5. Further it is important to mention here that the selected trees were not lopped in the previous year as well as during the study period. One year old branches were selected to conduct the study. Selection of trees was done on the basis of different morphological traits *viz*., height, diameter, crown spread and tree form, freedom from diseases and insect pest attack. The trees so selected were marked with durable yellow paint after removing the bark. Coefficients of variability, heritability, genetic advance and genetic gain were calculated by the formula used by Burton and Devane (1953) [6] and Johnson *et al.,* (1955) [7]. Genotypic, phenotypic and environmental correlations were also estimated for all possible pairs.

Result and discussion

Population extended from subtropical foot hill of Solan district continuing from Jaunaji, Kandaghat, Renuka, Palampur, Mandi, Rajgarh, Parwanoo, Nagni, Nainikhad till Bilaspur district. Within these growing limits a lot of variation was observed among the different seed sources. Maximum GCV (%) was recorded for seed germination (80.20%), while the minimum was recorded for number of flower (7.86%). Table-7 also depicted the similar pattern with the seed germination showing the maximum phenotypic coefficient of variability (85.64%) and minimum value for number of flower (9.14%). The maximum value for heritability (Broad Sense) was found for the inflorescence length with 0.62 whereas minimum value was recorded for seed germination (0.24). Maximum value of the genetic advance was obtained for fruit setting with 26.9 while the minimum genetic advance was found for seed weight with 0.63. Genetic gain was observed to be highest for seed weight with value of 43.26 percent and the least was recorded for seed germination with value of 4.89 percent. Genetic estimates for number of flowers, inflorescence length, fruit setting calculated revealed the heritability values (broad sense) of 0.41, 0.62 and 0.48 respectively. The leaflet size was also found to be under strong genetic control (0.57). (Table 7).

Genetic estimates for seed weight and seed germination calculated revealed the heritability values (broad sense) of 0.46 and 0.24 respectively. The seed weight was also found to be under strong genetic control (0.46). Higher genotypic coefficient of variability has been found for seed traits from different sites. The present findings are supported by the observations of Kaushik in *Toona ciliata* (1993) [8] that higher genotypic coefficient of variability has been found for seed traits from altitudinal ranges compared to zonal separations except for seed weight.

Higher phenotypic coefficient of variability has been found for seed traits from different sites (Table 7).

Variance analysis depicted highly significant differences for seed germination per cent indicated considerable amount of variability in the material under study. Brown seed colour was the most depicted seed colour from all the seed sources as compared to light brown and dark brown. It is evident that there is sufficient seed colour variation within each seed source. (Table 6)

The results of present study are parallel to the findings of Srivastava (1995) [9] in *Bauhinia variegata*.

Correlation analysis as depicted in Table 8 revealed that flower number showed highly significantly correlation with inflorescence length (r= 0.941). However, non-significant positive correlation exists between flower number and leaflet size (r= 0.343), non-significant positive correlation also exists between flower number and fruit setting (r=0.08) and non-significant positive correlation also exists between flower number and pollen size (r=0.193) A non-significant negative correlation exist between flower number and leaflet number (r= -0.185).

Inflorescence length showed positive non-significant correlation with leaflet size (r= 0.431), non-significant positive correlation with fruit setting (r=0.092) and non-significant positive correlation with pollen size (r= 0.221); whereas, a non-significant negative correlation exists between Inflorescence length and leaflet number (r= -0.044). Leaflet size showed non-significant positive correlation with pollen size (r= 0.055) whereas a non-significant negative correlation exists between leaflet size and leaflet number(r= -0.008); leaflet size and fruit setting (r= -0.181). Leaflet number

showed non-significant positive correlation with pollen size (r= 0.376). Leaflet number showed non-significant negative correlation with fruit setting (r= -0.249). Fruit setting showed non-significant negative correlation with pollen size (r= -0.099).

The expression of a character is sum total of the contribution of so many other character and therefore, screening/selection should be done on the basis of components contributing towards that character. The biometrical tool for helping this is correlation which gives the nature and degree of association between various traits. So, the knowledge of association of different characters is the first hand information for any improvement programme (Table 8). Positive and significant correlation coefficients among various floral characteristics namely inflorescence length and flower number 0.94 was recorded (Table 8) Similar findings were reported by Dhillon *et al*., (1995) [10] in *Dalbergia sissoo*.

The above result supports the findings of in *Santalum album.*

Table 1: Selected seed sources of *Toona ciliata* in H.P.

Locations	Altitude	Latitude	Longitude	Code
Kandaghat	1180	30º59´N	77º07´E	S1
Renuka	1060	30º37´N	77º25´E	S2
Bilaspur	660	31º19´N	76º46´E	S3
Mandi	800	31º44´N	76º56´E	S4
Jaunaji(Solan)	1400	30º54´N	77º06´E	S5
Rajgarh	1760	30º51´N	77º18´E	S6
Parwanoo	540	30º47´N	76º54´E	S7
Palampur	1280	32º07´N	76º31´E	S8
Nagni(Nurpur)	725	32º06´N	76º16´E	S9
Nainikhad	960	32º33´N	78º07´E	S10

Table 1a: Three selected study sites for phenological, morphological and breeding system of *Toona ciliata.*

Locations	Altitude	Latitude	Longitude	Code
Jaunaji	1400	30º54´N	77º06´E	L1
Dharja	1215	30º51´N	77º10´E	L2
Kandaghat	1180	30º59´N	77º07´E	L3

Table 2: Mean number of leaflets and leaflet size in different sites

Tree No.	Mean number of leaflets/leaf			Mean leaflet size (cm)		
	L1	L2	L3	L1	L2	L3
T1	12.4	13.4	11.8	8.26	8.64	9.60
T2	13.8	13.8	13.2	7.20	9.60	8.84
T3	16.0	12.6	12.4	8.42	8.84	9.60
T4	13.0	12.6	14.0	8.64	9.60	7.20
T5	15.4	13.6	12.2	9.60	8.84	8.42
T6	13.6	14.2	12.8	8.84	6.70	8.64
T7	13.0	13.4	12.8	6.70	8.84	6.70
T8	16.0	16.2	16.4	9.62	6.70	8.84
T9	16.2	13.2	12.4	9.58	9.62	6.70
MEAN	14.38	13.67	13.11	8.54	8.60	8.28

Table 3: Mean inflorescence length and number of flowers at different sites

Tree no.	Mean inflorescence length (cm)			Mean number of flowers		
	L1	L2	L3	L1	L2	L3
T1	25.70	23.40	17.60	569.80	528.20	528.20
T2	18.20	23.00	23.00	442.20	507.00	507.00
T3	20.32	17.40	26.60	465.40	477.40	477.40
T4	18.94	21.00	22.20	444.00	506.60	506.60
T5	24.14	26.20	20.40	519.40	588.40	588.40
T6	24.32	24.40	20.40	528.00	531.60	531.60
T7	20.22	21.60	19.20	492.60	502.40	502.40
T8	21.24	16.40	21.20	504.40	404.20	404.20
T9	21.86	22.00	20.00.	511.80	511.80	507.40
Mean	21.66	21.71	21.29	497.51	506.40	505.91

Table 4: Mean pollen size (µm) of *Toona ciliata* at different sites

Tree No.	Jaunaji (L1)	Dharja (L2)	Kandaghat (L3)
T1	27.86	28.14	27.64
T2	27.64	27.64	28.04
T3	28.14	28.04	28.18
T4	27.64	28.22	27.64
T5	28.04	27.98	27.64
T6	28.22	28.18	28.04
T7	27.98	27.64	28.14
T8	28.18	28.14	28.22
T9	28.04	27.64	27.64
Mean	27.97	27.96	27.91

Table 5: Mean fruit setting in different seed sources

Tree No.	Jaunaji (L1)	Dharja (L2)	Kandaghat (L3)
T1	10.8	12.0	10.2
T2	10.6	11.4	13.4
T3	10.0	10.6	11.0
T4	9.8	11.0	12.8
T5	9.8	14.8	12.0
T6	11.4	10.4	11.4
T7	11.0	9.2	10.6
T8	10.8	13.4	12.0
T9	2.2	15.2	12.4
Mean	9.6	12	11.76

Table 6: Performance of seed sources for seed traits

Seed sources	100 Seed weight (gm.)	Seed Germination (%)	Seed colour Depicted in decreasing proportion → →→		
S1Kandaghat	0.18	4.44 (8.07)	Brown	Light Brown	Dark Brown
S2 Renuka	0.23	13.96 (17.01)	Light Brown	Brown	Dark Brown
S3Bilaspur	0.23	6.60 (10.34)	Brown	Light Brown	Dark Brown
S4Mandi	0.28	27.63 (31.48)	Light Brown	Brown	-
S5Jaunaji	0.26	25.60 (29.95)	Brown	Dark Brown	Light Brown
S6Rajgarh	0.29	0.33 (1.35)	Brown	Light Brown	Dark Brown
S7Parwanoo	0.30	27.78 (31.65)	Brown	Light Brown	-
S8Palampur	0.29	15.6 (21.48)	Brown	Light Brown	Dark Brown
S9Nagni	0.26	12.00 (19.45)	Light Brown	Brown	-
S10Nainikhad	0.31	12.11 (18.02)	Dark Brown	Brown	Light Brown
Mean	0.25	15.10 (19.15)			
CD (0.05)	0.05	8.32			

Figures in parenthesis are arc sine transformed value

Table 7: Genetic Estimates for different characters of *Toona ciliata*

Character studied	Genotypic coefficient of variability	Phenotypic coefficient of variability	Heritability (h)	Genetic advance	Genetic gain
No of flower	7.86	9.14	0.41	10.42	9.14
Inflorescence length	11.75	11.03	0.62	19.01	11.03
Leaf let Size	11.82	11.65	0.57	18.46	11.65
Fruit setting	18.75	20.15	0.48	26.9	20.15
Number of Leaf let	8.52	11.06	0.33	10.15	11.06
100 seed weigh (gm.)	31.05	45.66	0.46	0.11	43.26
Seed Germination (%)	80.22	85.64	0.24	15.35	4.89

Table 8: Simple correlation for different characters of *Toona ciliata*

	Flower number	Inflorescence length	Leaf let size	Leaflet number	Fruit setting	Pollen size
Flower number	1	0.941*	0.343	-0.185	0.08	0.193
Inflorescence length		1	0.302	-0.044	0.092	0.221
Leaf let size			1	-0.008	-0.181	0.055
Leaflet number				1	-0.249	0.376
Fruit setting					1	-0.099
Pollen size						1

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