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Original scientific paper

EVALUATION OF GROWTH PERFORMANCE OF HALF SIB PROGENIES OF *Toona ciliata* M. ROEM UNDER FIELD CONDITIONS

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The study was conducted to evaluate the juvenile growth performance of half sib progenies of twenty four genotypes of *Toona ciliata* M. Roem under field conditions of Punjab, India. Seed source (S_3) Ludhiana exhibited outstanding performance for growth parameters. Among genotypes progenies of S_3G_7 (Ludhiana), S_3G_8 (Ludhiana), S_1G_1 (Talwara) and S_2G_4 (Kamahi Devi) were found to be most promising for growth traits. The phenotypic coefficient of variation values were observed higher for all the parameters than genotypic coefficient of variation. Moderate heritability and genetic gain was observed for branch angle and plant height. Highly significant and positive genotypic and phenotypic correlations were observed for plant height with collar diameter and stem straightness and collar diameter with number of branches per plant. The genotypes were clustered into three distinct groups with maximum diversity of (30.68) between clusters I and cluster III and can be utilized for future heterotic breeding.
Keywords: Seed source, genotype, variability, heritability, correlation, divergence

INTRODUCTION

Genus *Toona* belongs to family Meliaceae and is represented by five species i.e., *T. calantas*, *T. ciliata*, *T. fargesii*, *T. sinensis* and *T. sureni* mainly distributed in southern and eastern Asia to New Guinea and Australia (EDMONDS, 1995). *Toona* species are among the most valuable timbers of tropics and in fact the backbone of forest based industries in many countries throughout the world (BAHADUR, 1988) owing to its high quality timber and for the ease with which they can be grown in plantations. *T. ciliata* is a fast growing large deciduous tree attaining a height of upto 20-30 m with a clean bole of up to 9-12 m height. It is native to Australia and has been distributed naturally in India, Burma, Laos, Pakistan, Thailand, Malaysia, Indonesia,

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and China. In India, the species is distributed throughout the sub- Himalayan tract and the valleys of outer- Himalayas, plains of Assam, Madhya Pradesh, Tamil Nadu, Karnataka, Eastern and Western Ghats up to an elevation of 1200 m in Western Peninsula, Khasi hills and Manipur (SINGH, 1982) covering a wide variety of forest types. In the western sub-Himalayan tract it is chiefly found in moist localities (TROUP, 1921), in sheltered ravines, along streams and even in swamp forest, while in the Western Ghats, it is found mostly in wet evergreen forests; with scattered occurrences in moist deciduous forests (RAI, 1985). It is also a characteristic tree of Eastern alluvial secondary semi-evergreen forests in Assam (CHAMPION and SETH, 1968) and in Punjab *T. ciliata* is largely distributed in Kandi region which mainly comprises of dry deciduous scrub forest (DEEPANJLI, 2018). *T. ciliata* is a light-demander and an early pioneer species in forest succession that spreads rapidly in cleared areas or in disturbed forests (WEBER, 2003).

The versatile timber of *T. ciliata* is used for building houses and ships, furniture, musical instruments, carvings, and numerous other uses. The timber is rated as moderately durable i.e. it is moderately resistant to shoot borer attack with moderate weight, strength and hardness. *T. ciliata* is commonly cultivated as an avenue tree and the leaves are widely used as an animal fodder in India (EDMONDS, 1993 and 1995) and as an ornamental and wayside tree throughout much of tropical Africa and Asia (FENTON *et al.*, 1977). It possesses many important biological properties that accounts for its traditional uses in medicinal treatments and dye preparation etc. The flowers yield a red coloring matter known as “gunar” which is used as a dye while the bark produces tannin used in leather industry. Bark is bitter, astringent, antiperiodic and in traditional medicines used for treating infant dysentery, ulcer, leprosy, fever, headache and blood complaints, rheumatism, etc. (DIVAKAR, 2017).

Progeny testing is a prerequisite to estimate the genetic worth of parents while screening the naturally available genetic variations so as to isolate good genotype rather than merely selecting the good phenotypes (KEDARNATH, 1982) as well as to achieve maximum gain per unit area. Further, knowledge of correlation among quantitative traits is useful to predict the response of other traits while selecting one. For complex traits e.g., yield of timber, selection based on highly correlated character is more effective than the direct selection (KUMAR *et al*., 2013).

MATERIALS AND METHODS

The study was conducted at teaching area of Department of Forestry & Natural Resources, Punjab Agricultural University, Ludhiana, India, situated at 30° 54′ 16″ N, 75° 47′ 38″ E at an elevation of 247 m above mean sea level, with an average annual rainfall of 604.88 mm. The tree improvement programme on *T. ciliata* was initiated by the Department of Forestry & Natural Resources in 2017. Plus trees were selected, three each from twelve seed sources using base line method from the states of Punjab and Himachal Pradesh of India. Seeds were collected from each plus tree separately per seed source and the progenies were established under nursery conditions by DEEPANJLI (2018). In the present investigation, superior one year old half sib progenies of twenty-four genotypes of *T. ciliata* from eight 8 seed sources representing two state of Punjab and Himachal Pradesh of India (Figure 1; Table 1) were selected from nursery trial and planted out under field conditions in the month of January, 2018 using complete randomized block design (CRBD) with 4 plants each in 4 replications at the spacing of 5×4 m in east-west (row distance) direction. The texture of the soil was clayey loam. The trial was irrigated at fortnight intervals in summer season and at monthly intervals in winter. Weeding was done at monthly intervals.

Observations were recorded in the month of January, 2019 for plant height (cm), collar diameter (cm), number of branches per plant, branch angle (°) and stem straightness (visually scored from 1- least straight to 5- most straight). Analysis of variance (ANOVA) was done according to PANSE and SUKHATME (1989). The contrast analysis was performed to test the difference among eight seed sources. The mean and range values of growth traits were calculated and the coefficients of variation were estimated. The expected genetic advance at 5% selection intensity and genetic gain was calculated by the formula as suggested by BURTON and DE VANE (1953) and JOHNSON *et al*. (1955). The different components of variances (genotypic and phenotypic correlation coefficients) were calculated by the method given by SINGH and CHAUDHARY (1985). The cluster analysis between genotypes was assessed using Mahalanobi's D^2 analysis as detailed by RAO (1952).

Table 1. Details of Toona ciliata genotypes used in the study:

Code Name	Seed sources (Districts)	Genotypes	Latitude (°)	Longitude (°)	Altitude (above msl)
S1	Talwara (Hoshiarpur, Punjab)	G1	31° 55' 52"	75° 53' 38"	380
		G2	31° 56' 20"	75°52'30"	367
		G3	31°56'55"	75°48'28"	350
S2	Kamahi Devi (Hoshiarpur, Punjab)	G4	31° 64' 23"	75° 53' 29"	368
		G5	31°54'24"	75°49'24"	330
		G6	31°59'35"	75°58'47"	394
S3	Ludhiana, Punjab	G7	30° 50' 43"	75° 53' 12"	255
		G8	30°46'04"	75°51'27"	250
		G9	30°47'32"	75°51'11"	250
S4	Sujanpur (Hamirpur, HP)	G10	31°48'59"	76°31'3"	726
		G11	31°48'05"	76°28'06"	610
		G12	31°47'57"	76°27'58"	601
S5	Salouni (Hamirpur, HP)	G13	31° 31' 42"	76° 27' 49"	805
		G14	31°33'46"	76°28'45"	807
		G15	31°63'26"	76°28'43"	808
S6	Chabutra (Hamirpur, HP)	G16	31° 44' 27"	76° 28' 24"	750
		G17	31°44'28"	76°28'30"	749
		G18	31°44'20"	76°28"36"	740
S7	Shah Talai (Bilaspur, HP)	G19	31° 26' 09"	76° 32' 28"	610
		G20	31°27'09"	76°32"28"	613
		G21	31°26'03"	76°32'38"	618
S8	Suhari Takoli (Una, HP)	G22	31° 40' 23"	76° 14' 50"	630
		G23	31°40'12"	76°14'58"	625
		G24	31°40'23"	76°14'50"	626

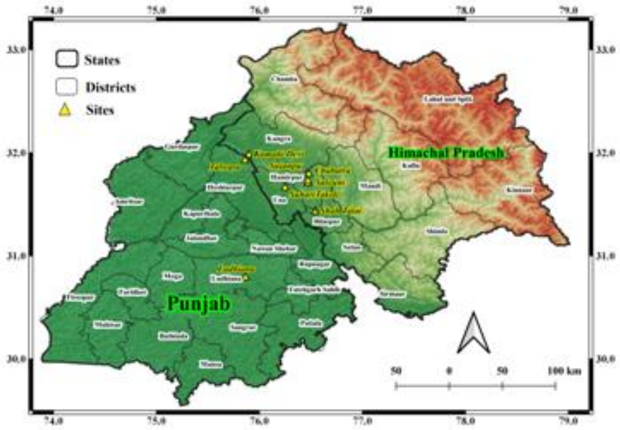

Figure 1. Map depicting the selected seed sources of *Toona Ciliata*.

RESULTS AND DISCUSSION

Significant variation was observed among the half sib progenies for the observed traits indicating the presence of genetic diversity among the genotypes (Table 2). The mean values for plant height ranged between 78.56-117.44 cm, 1.60-3.03 cm for collar diameter, 10-20 for number of branches per plant, 43.44-61.88^0 for branch angle and 3.25-4.25 for straightness score.

Mean values revealed that overall S_3 (Ludhiana) exhibited outstanding growth with highest values for plant height, collar diameter and stem straightness among seed sources. However, among genotypes S_3G_7, S_3G_8, S_1G_1 and S_2G_4 progenies were found best performing with maximum plant height (117.44 cm, 111.06 cm, 110.69 cm and 105.00 cm) and collar diameter (2.38 cm, 2.80 cm, 2.68 cm and 3.00 cm).

Since, the progenies representing diverse seed sources were planted in the same experimental area; the variation in traits may be attributed to genotypic differences between the progenies or due to genotype x environment interaction. The above results are in line with the result findings of DEEPANJLI (2018) who evaluated these genotypes at nursery level and reported that genotypes from Punjab seed sources performed better than the genotypes from Himachal Pradesh seed sources which reflects the genotype x environment interaction, indicating that the genotypes from cold climate could not habituate with harsh conditions of Punjab. Similarly, MIN *et al.* (2017) reported that progenies of *T. ciliata* from western provenances showed significantly higher height and collar diameter growth as compared to progenies from eastern provenances.

The genotypic coefficient of variance (GCV %) (Table 3) was found maximum for collar diameter (12.04 %) whereas the phenotypic coefficient of variation (PCV) was found maximum (25.79 %) for number of branches per plant. The phenotypic coefficient of variation values were found higher than genotypic coefficient of variation (GCV) for all the parameters which reflects that the environment had a great influence on the traits.

Table 2. Effect of seed source and genotypes on growth traits of Toona ciliata progeny

Seed source	Genotypes	Growth traits				
		Plant height (cm)	Collar diameter (cm)	Number of branches per plant	Branch angle (°)	Stem straightness (1-5)
S1(Talwara)	G1	110.69	2.68	14.00	47.50	3.75
	G2	94.67	2.62	16.00	47.81	3.75
	G3	87.92	2.89	20.00	57.13	3.25
	Mean	97.76	2.73	16.67	50.81	3.58
S2 (Kamahi Devi)	G4	105.00	3.00	18.00	55.94	4.25
	G5	94.36	2.35	15.00	48.56	3.25
	G6	81.75	1.92	15.00	56.56	3.50
	Mean	93.70	2.42	16.00	53.69	3.67
S3 (Ludhiana)	G7	117.44	2.38	15.00	43.44	4.25
	G8	111.06	2.80	16.00	43.88	3.50
	G9	94.94	3.03	16.00	57.50	3.75
	Mean	107.81	2.74	15.67	48.27	3.83
S4 (Sujanpur)	G10	101.06	2.31	15.00	53.44	3.50
	G11	98.27	2.45	17.00	51.56	3.50
	G12	80.38	2.18	13.00	51.88	3.25
	Mean	93.24	2.31	15.00	52.46	3.42
S5 (Salouni)	G13	99.31	2.13	10.00	53.13	3.75
	G14	94.29	1.73	14.00	49.19	3.50
	G15	105.69	2.28	18.00	56.88	3.75
	Mean	99.76	2.05	14.00	53.07	3.67
S6 (Chabutra)	G16	99.25	2.59	16.00	53.75	3.75
	G17	95.63	2.31	15.00	52.50	3.50
	G18	78.56	2.17	14.00	52.50	4.00
	Mean	91.15	2.36	15.00	52.92	3.75
S7 (Shah Tarai)	G19	79.38	1.60	14.00	46.25	3.50
	G20	85.06	2.27	12.00	52.19	3.75
	G21	87.36	1.79	12.00	51.25	3.25
	Mean	83.93	1.89	12.67	49.90	3.50
S8 (Suhari Takoli)	G22	81.75	1.95	15.00	61.88	3.25
	G23	95.63	2.25	17.00	52.81	3.75
	G24	89.69	2.35	15.00	49.38	4.00
	Mean	89.02	2.18	15.67	54.69	3.67
CD (at 0.05 level of significance)						
Seed source		9.63	0.42	NS	3.90	NS
Genotype		16.69	0.73	5.06	NS	0.74

Moderate heritability with moderate genetic gain was recorded for branch angle (0.49 and 13.25%) and plant height (0.36 % and 11.57%) which revealed that the trait were under moderate genetic control, since they indicate the heritable additive component of variance and can be undertaken for further improvement of the species. Low heritability was found in collar diameter (0.23), number of branches (0.12) and straightness score (0.06) which may be attributed to evaluation at juvenile stage. Similar findings were reported by PARTHIBAN (2019) where he has attributed that low heritability of traits may be due to evaluation at juvenile stage.

Table 3. Genetic estimates for growth characters of Toona ciliata progenies

Parameter	Mean	Range	Coefficient of variation (%)		H^2_{bs}	Genetic advance	Genetic advance as per cent of mean
			Genotypic	Phenotypic			
Plant height (cm)	94.55	78.56-117.44	9.38	15.66	0.36	10.94	11.57
Collar diameter (cm)	2.33	1.73-3.03	12.04	25.29	0.23	0.28	12.00
Number of branches per plant	14.90	10-20	9.02	25.79	0.12	0.97	6.51
Branch angle (°)	51.47	43.44-61.88	9.17	13.08	0.49	6.82	13.25
Straightness score	3.64	3.25-3.83	3.58	14.98	0.06	0.06	1.65

Table 4. Genotypic and phenotypic correlation among growth characters of T. ciliata progenies

		Plant height	Collar diameter	Number of branches per plant	Branch angle	Straightness score
Plant height	G		0.734*	0.467*	-0.357*	0.709*
	P		0.417*	0.283*	0.065	0.191
Collar diameter	G			0.714*	0.010	0.447*
	P			0.418*	0.136	0.194
Number of branches per plant	G				0.275*	0.186
	P				0.236*	-0.028
Branch angle	G					-0.297*
	P					-0.250*
Straightness score	G					
	P					

G denotes genotypic correlation; P denotes phenotype correlation; * denotes significant at 5% level of significance

Strong correlation (Table 4) of plant height with collar diameter (0.734) and stem straightness (0.709) and collar diameter with number of branches per plant (0.714) at genotypic level revealed the existence of linkage or pleiotropy or both between the correlated traits. Therefore, these characters must be given proper emphasis during selection programme and can be exploited for indirect selection especially in the traits demanding destructive sampling and finds support with the findings of PARTHIBAN (2019) and DEEPANJLI (2018) in different seed sources of *T. ciliata*, THAKUR and THAKUR (2015) in *Melia azedarach*, SINGH *et al.* (2015) in *Populus deltoides*, THAKUR *et al.* (2014) in *Ulmus villosa* and WANI *et al.* (2008) in *Bauhinia variegata*.

Table 5. Composition of clusters for morphological traits among Toona ciliata progenies

Clusters	Number of genotypes	genotypes
I	3	S_1G_1, S_3G_7, S_3G_8
II	12	S_1G_2, S_8G_{24}, S_2G_5, S_4G_{10}, S_6G_{17}, S_4G_{11}, S_8G_{23}, S_6G_{16}, S_5G_{15}, S_1G_3, S_2G_4, S_3G_9
III	9	S_2G_6, S_8G_{22}, S_4G_{12}, S_7G_{21}, S_5G_{14}, S_7G_{19}, S_5G_{13}, S_6G_{18}, S_7G_{20}

Table 6. Cluster means of morphological traits of Toona ciliata

Morphological traits	Cluster		
	I	**II**	**III**
Plant height (cm)	113.06	98.18	83.54
Collar diameter (cm)	2.62	2.42	2.12
Branch angle (°)	44.94	52.76	53.22
Number of branches per plant	15.00	15.58	14.44
Straightness score	3.83	3.67	3.53

The clustering pattern of all the genotypes has been represented in Table 5. The genetic divergence dendrogram (Figure 2.) distributed the genotypes into three clusters. Cluster II comprised maximum (12) twelve genotypes *viz.* S_1G_2, S_8G_{24}, S_2G_5, S_4G_{10}, S_6G_{17}, S_4G_{11}, S_8G_{23}, S_6G_{16}, S_5G_{15}, S_1G_3, S_2G_4 and S_3G_9. Cluster III comprised nine genotypes *viz.* S_2G_6, S_8G_{22} , S_4G_{12}, S_7G_{21}, S_5G_{14} , S_7G_{19}, S_5G_{13}, S_6G_{18} and S_7G_{20} whereas cluster I comprised minimum (3) genotypes *viz.*S_1G_1, S_3G_7 and S_3G_8. The clustering pattern revealed significant variability present among the genotypes. Cluster II and III included genotypes from all locations but cluster one included genotypes only from two locations. This indicated that the pattern of genetic divergence is independent of geographical distribution of the genotype and may be attributed to the genetic makeup of the genotypes. The above results find the support of the findings of PARTHIBAN (2019) in *T. ciliata* and SINGHDOHA (2017) in *Acacia nilotica*. Maximum cluster mean for plant height (113.06 cm), collar diameter (2.62 cm) and straightness score (3.83) was observed in cluster I whereas the maximum cluster mean for branch angle (53.22°) was observed in cluster III and maximum cluster mean for number of branches per plant (15.58) was observed in cluster II. Similarly, wide diversity (30.68) existed between the progenies belonging to cluster I and III, hybridization between genotypes belonging to these clusters is expected to result in desired segregation for quantitative traits while producing heterotic hybrids. Similar results were reported by BEHERA *et al.* (2017) in *Eucalyptus* and KUMAR *et al.* (2016) in *Dalbergia sissoo.*

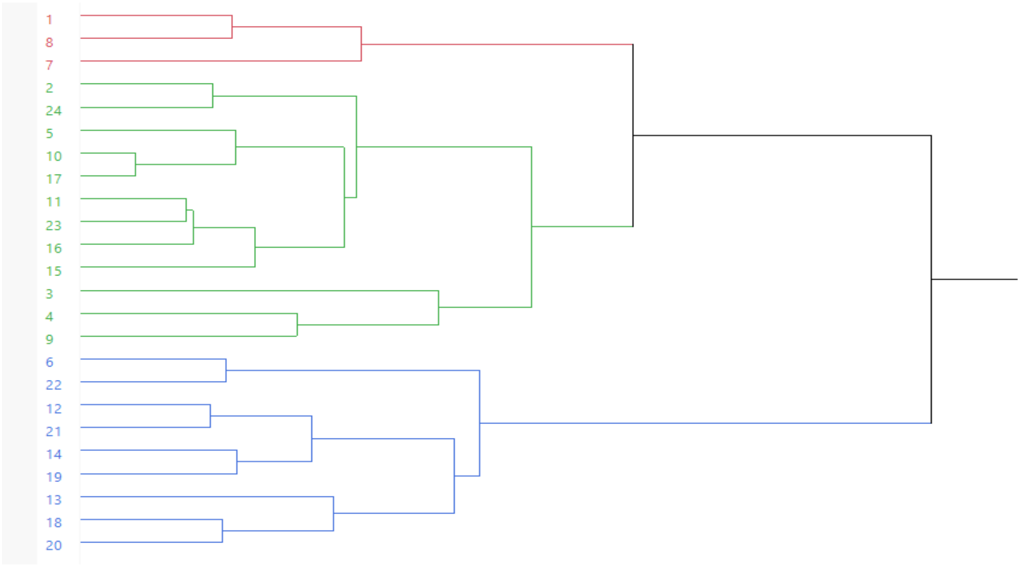

Figure 2. Dendrogram depicting genetic divergence of genotypes
Note: 1=S_1G_1, 8=S_3G_8, 7=S_3G_7, 2=S_1G_2, 24=S_8G_{24}, 5=S_2G_5, 10=S_4G_{10}, 17=S_6G_{17}, 11=S_4G_{11}, 23=S_8G_{23}, 16=S_6G_{16}, 15=S_5G_{15}, 3=S_1G_3, 4=S_2G_4, 9=S_3G_9, 6=S_2G_6, 22=S_8G_{22}, 12=S_4G_{12}, 21=S_7G_{21}, 14=S_5G_{14}, 19=S_7G_{19}, 13=S_5G_{13}, 18=S_6G_{18} and 20=S_7G_{20}

Table 7. Inter-cluster distance in three clusters of Toona ciliata

Cluster	I	II	III
I	0.000	16.827	30.675
II		0.000	14.691
III			0.000

CONCLUSION

The progenies performance revealed significant differences among seed sources and genotypes for growth characters in *T. ciliata* and appreciable improvement in growth parameters can be achieved by further selection from experimental trial. The progenies of Seed source (S_3) Ludhiana and genotypes S_3G_7 (Ludhiana), S_3G_8 (Ludhiana), S_1G_1 (Talwara) and S_2G_4 (Kamahi Devi) performed better for growth traits under consideration. Moderate heritability and genetic gain was observed for branch angle and for plant height. Plant height, collar diameter and stem straightness have strong genotypic correlation and must be given proper emphasis during selection programme. Similarly, wide diversity (30.68) existed between the genotypes belonging to cluster I and III, in future hybridization between genotypes belonging to these clusters is expected to produce heterotic hybrids.

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OCENA PARAMETARA RASTA KOD POTOMSTVA U POLUSRODSTVU *Toona ciliata* M. ROEM U POLJSKIM USLOVIMA

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Izvod

Istraživanje je sprovedeno kako bi se procenile performanse juvenilnog rasta potomstva u polusrodstvu kod dvadeset četiri genotipa vrste *Toona ciliata* M. Roem u poljskim uslovima u Pendžabu, Indija. Izvor semena (S3) Ludhiana pokazao je izvanredne performanse za parametre rasta. Među ispitivanim genotipovima, potomstva S3G7 (Ludhiana), S3G8 (Ludhiana), S1G1 (Talvara) i S2G4 (Kamahi Devi) nađene su kao najperspektivnija za osobine rasta. Primećeno je da je fenotipski koeficijent varijacije veći za sve parametre nego genotipski koeficijent varijacije. Utvrđena je umerena heritabilnost i genetička dobit za ugao grananja i visinu biljke. Zabeležene su visoko značajne i pozitivne genotipske i fenotipske korelacije za visinu biljaka sa prečnikom stable i prečnikom stable sa brojem grana po biljci. Genotipovi su grupisani u tri različite grupe sa maksimalnim diverzitetom (30.68) između klastera I i III grupe i mogu se ubuduće koristiti za oplemenjivanje.

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