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Application of Factor Analysis Techniques for Phenotypical Variation in *Toona ciliata* Provenances

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Abstract

The present study was conducted to estimate the genetic variability for the phenotypic characters and seed traits of *Toona ciliata* among the 12 provenances. Most of the characters differed significantly among those provenances. The characters like leaf length, inflorescence length and number of flowers per inflorescence had high coefficient of variability, heritability and genetic advance, indicated importance of these characters for selection purpose. Thirteen traits of *Toona ciliata* were classified into four basic factors by applying the factor analysis technique of multivariate analysis. The first factor had variance of 4.02 (30.9% of total variation), second factor had variance 3.08 (23.7% of total variation), third factor had variance of 2.22 (17. 3% of total variation) and the fourth factor had variance 1.17 (9.0% of total variation), i.e. aggregating to 80.9% of total variation. The first factor extracted was the combination of tree height, crown length, crown area, hundred seed weight and seed width. The second factor is a combination of inflorescence length, number of flowers per inflorescence, clear bole height and seed length dewinged. The third factor signifies the combination of number of leaflets per leaf, crown spread and seed length with wings and fourth factor signifies the trait leaf length only. These factors could be used for further breeding program for exploiting the hybrid vigor for higher biomass.
Key words : Coefficient of variability, Heritability, Phenotypic characters, Seed traits, *Toona ciliata.*

Toona ciliata, being one of the foremost and fast growing species in the family Milianceae, can also be an alternative to solve the problem of fuel wood and timber *Toona ciliata* is a large, fast growing, often deciduous species of quality timber in India and is grown throughout the sub-Himalayan tract and valleys of outer Himalayas, plains of Assam, Madhya Pradesh, Tamil Nadu, Karnataka and Eastern and Western Ghats, occurring upto an elevation of 1,500 m (1). In its natural habitat it occurs frequently on moist localities such as ravines, stream banks of swamps (2) with best growth in deep rich moist loamy soil and is often sound along cultivated fields and road sides in Himachal Pradesh and Uttar Pradesh. In India the species have been neglected for many years because of their scanty and scattered distribution. Variation studies in general help us to compare the population and to select superior trees for breeding purpose. Provenance is one of the major aspect for variation studies. The essence of natural variation involves all the differences that can be observed or measured between living things. For effective utilization of natural variation, the genetic and environmental components are first and foremost to be seen. Univariate statistical analysis are not adequate as they ignores the correlation among the variables and sometimes the conclusions may be misleading, while the multivariate analysis takes into account the interdependence and relative importance of the various characters involved and yields more meaningful information. The aim of multivariate analysis is to reduce the number of variables by employing suitable linear transformation and to chose a few linear combination in some optimum manner. Factor analysis is a data reduction techniques for investigating the interdependence and to describe convariance relationship among many variables in terms of a few underlying but unobservable random quantity called factor. The present work was conducted in Himachal Pradesh to study the genetic variability with respect to phenotypic characters and seed traits of *Toona ciliata.* The factor analysis technique is also used to various characters collected from 12 different provenances of the state of Himachal Pradesh.

Table 1. Mean, SE (mean), range and coefficient of variation for phenotypical traits in *Toona ciliata.*

Characters	Mean	SE (M)	Range	CV (%)
X_1	32.47	1.04	27.37—37.96	11.09
X_2	15.33	0.41	12.52—17.48	9.30
X_3	27.23	1.06	21.86—38.23	13.49
X_4	164.30	10.03	129.2—203.2	21.16
X_5	16.97	0.84	13.97—20.41	17.06
X_6	2.37		1.84—2.65	10.42
X_7	14.09	0.17	12.03—17.87	20.49
X_8	8.50	0.42	7.48—10.23	17.03
X_9	62.59	5.29	41.80—74.96	29.31
X_{10}	0.37	0.01	0.33—0.43	16.75
X_{11}	11.75	0.23	10.84—12.21	7.01
X_{12}	4.62	0.11	3.95—5.26	8.74
X_{13}	2.05	0.05	1.88—2.22	9.13

Methods

The state of Himachal Pradesh was divided into three altitudinal provenances, viz. upto 700 m, 700—1,100 m and above 1,100 m. Under each altitudinal provenances, four provenances were selected randomly from different parts of the state where each provenance was demarcated keeping in view the difference of $^1/_2$ degree latitude among them and also the overriding importance of major rivers as natural barriers. Thus 12 provenances were selected for the study. From each provenance 15 phenotypically superior trees were selected and the following characters were observed : X_1=Leaf length (cm), X_2=Number of leaflet per leaf, X_3=Inflorescence length (cm), X_4=Number of flowers per inflorescence, X_5=tree height (m), X_6=Clear bole height (m), X_7=Crown length (m), X_8=Crown spread (m), X_9=Crown area (m^2), X_{10}=100 seed weight (g), X_{11}=seed length with wings (mm), X_{12}=seed length dewinged (mm), and X_{13}=Seed width (mm).

Randomized block design was used to test the significance of provenance variation. Genotypic and phenotypic coefficient of variability were worked out by the formula suggested by Burton and Devane (3). Heritability and genetic advance were calculated by the formula used by Burton and Devane (3) and Johnson et al. (4). Genetic gain was calculated by the method suggested by Johnson et al. (4).

Factor analysis was applied in accordance with Lawley and Maxwell (5), Ramchander et al. (6) and Sharma and Chaudhary (7) to study the relative contribution, made by different traits. This technique is also employed to extract the basic factors underlying the observed growth and seed traits of *Toona ciliata.* Factor analysis is a mathematical model that describes the relationship of factors and avoids the deficiencies of principal component analysis. The purpose of factor analysis is to group the variable in different factors such that correlation within factors are high and between factors are small. For extraction of factors, principal component and maximum likelihood methods are widely used. Harman (8) suggests that extracting the common factors before the cumulative sun of eigen values exceeds the sum of estimated communalities. Kaiser (9) suggested that as many fac-

Table 2. The component of variation in *Toona ciliata* for phenotypical traits.

Characters	Component of variances: Genotypic	Environmental	Phenotypic	Coefficient of variation (%): GCV	PCV	Heritability (%)	Genetic advance	Genetic gain
X_1	57.29	12.97	70.27	23.31	25.82	81.54	14.08	43.36
X_2	2.08	2.03	4.11	9.40	13.22	50.53	2.11	13.77
X_3	48.21	13.50	61.71	25.50	28.85	78.12	12.64	46.43
X_4	961.90	1209.30	2171.20	18.88	28.36	44.30	42.53	25.88
X_5	3.50	8.39	11.89	11.03	20.32	29.45	2.09	12.33
X_6	0.025	0.261	0.086	6.67	12.37	29.02	2.95	8.78
X_7	0.845	8.33	9.189	6.52	21.50	9.20	0.57	4.08
X_8	1.68	2.09	3.78	15.24	22.86	44.49	1.78	20.91
X_9	91.18	336.54	427.72	15.26	33.04	21.32	9.08	14.51
X_{10}	0.00046	0.00384	0.0043	6.85	20.96	10.69	0.01	4.61
X_{11}	0.054	0.678	0.732	2.18	8.06	7.37	0.13	1.22
X_{12}	0.854	0.163	1.031	20.24	22.25	82.27	1.78	37.95
X_{13}	0.149	0.035	0.184	19.53	21.96	80.98	0.71	36.19

Table 3. Eigen value of factor analysis for phenotypical traits of *Toona ciliata.*

Compo-nents	Eigen values	Percent of variation	Total variation
1	4.017	30.897	30.897
2	3.078	23.679	54.576
3	2.224	17.259	71.835
4	1.167	8.976	80.810
5	0.882	6.782	87.593
6	0.663	5.122	92.715
7	0.438	3.366	96.081
8	0.235	1.807	97.887
9	0.191	1.471	99.358
10	0.046	0.351	99.709
11	0.030	0.234	99.943
12	0.007	0.027	99.970
13	0.001	0.030	100.00

Table 4. Rotated factor matrix for phenotypical traits of *Toona ciliata.*

Charac-ters	Factors 1	2	3	4	Communa-lities
X_1	-0.256	0.472	0.516	**0.561**	0.870
X_2	-0.202	0.283	**0.653**	-0.049	0.549
X_3	-0.471	**0.704**	0.234	0.294	0.859
X_4	0.203	**0.740**	-0.036	-0.546	0.888
X_5	**0.867**	0.373	-0.210	0.212	0.980
X_6	0.139	**0.791**	0.134	-0.041	0.665
X_7	**0.834**	0.487	-0.157	-0.044	0.960
X_8	0.601	-0.265	**0.640**	-0.074	0.845
X_9	**0.881**	0.079	0.354	-0.059	0.910
X_{10}	**-0.756**	0.015	0.473	-0.217	0.842
X_{11}	-0.329	-0.0160	**0.513**	0.296	0.459
X_{12}	0.215	**-0.692**	0.622	-0.056	0.914
X_{13}	**0.564**	-0.419	-0.036	0.519	0.764

tors should be extracted as variable with eigen values greater than or equal to one.

Results and Discussion

The general mean, standard error of mean, range and coefficient of variation of different characters are presented in Table 1. The result indicated that a wide range of variability was observed in all the characters. The coefficient of variation ranged from 7.01 to 29.31% in seed length with wing and crown area respectively.

Table 2 presents the genotypic and phenotypic coefficient of variability, heritability, genetic advance and genetic gain for the different characters. The results revealed that phenotypic coefficient of variability for all the characters was higher than genotypic coefficient of variability. Higher genotypic and phenotypic coefficient of variability for leaf length, inflorescence length, number of flowers per inflorescence and crown area was found, therefore, suggesting wide genetic diversity for these characters. Seed lengths with wings, seed weight, crown length and clear bole height were least influenced by the provenances; it shows that the provenances have less effect on these characters of *Toona ciliata.* The magnitude of heritability indicates the reliability of genotypes with which they can be identified with their phenotypic expression. The heritability ranged from 9.20 to 82.27% in crown length and seed length dewinged respectively. Seed length (dewinged) and seed width with higher heritability and low genetic advance implies that heritability was mostly due to non-genetic effect. Thus these characters should not be relied upon for the purpose of selection. High coefficient of variability, heritability and genetic advance were observed for leaf length, inflorescence length and number of flowers per inflorescence. So these estimates indicate good opportunities in the improvement of these characters by practicing selection which is the basic tool (10). The studies are in line with Cotterill and Dean (11). The genetic constitution of a population of trees reflects the environmental conditions under which the trees are evolved (12) and the expression of the genetic variability depends upon the environment in which trees are further grown. The variation existing may be due to the variation of individual stands and efficient selection can be based on the deep understanding of genetic variation between and within population in the breeding program.

The factor analysis technique was applied to extract the basic factors underlying the observed traits of *Toona ciliata.* The factors were extracted one by one, on the basis of eigen values which are presented in Table 3. The other factors corresponding to eigen values less than unity were not taken into consideration. These factors are ignored due to Guttmen's lower bound principle according to which any eigen value less than unity ($\lambda<1$) should be ignored. Ignoring the non-significant correlations, then orthogonal factors are extracted. The centroid method of analysis (5) was used in arriving at the factors. The following factors are obtained. Factor 1 : 0.867 X_5 + 0.834 X_7 + 0.881 X_9 + 0.756 X_{10} + 0.564 X_{13}, Factor 2 : 0.704 X_3+ 0.740 X_4 + 0.791 X_6 + 0.622 X_{12}, Factor 3 : 0.653 X_2 + 0.640 X_8 + 0.513 X_{11}, and Factor 4 : 0.561 X_1.

The first factor had variance of 4.02 (30.9% of total variation), second factor had variance 3.08 (23.7% of total variation), third factor had variance of 2.22 (17.3% of total variation) and the fourth factor had variance 1.17 (9.0% of total variation), i.e. aggregating to 80.9% of total variation.

The rotated factor matrix and the communalities were obtained through orthogonal transformation (Table 4). The first factor extracted was the combination of tree height (X_5), crown length (X_7), crown area (X_9), hundred seed weight (X_{10}) and seed width (X_{13}) traits. The second factor is a combination of inflorescence length (X_3) number of flowering per inflorescence (X_4), clear bole height (X_6) and seed length dewinged (X_{12}). The third factor signified the combination of number of leaflets per leaf (X_2), crown spread (X_8) and seed length with wings (X_{11}) and fourth factor signified only one trait i.e. leaf length (X_1). Results of such work have been reported by Abraham and Hoobarkrt (13); Jalikop et al. (14); Zhang and Cui (15) and Jaiswal and Kanaujia (16). Thus 13 traits of *Toona ciliata* were classified into four basic factors by applying the factor analysis technique of multivariate analysis. These factors could be used for further breeding program for exploiting the hybrid vigor for higher biomass.

References

1. Singh R. V. 1982. *Toona ciliata* M Rome. *In* Fodder trees of India. Oxford and IBH Publ. Co., New Delhi, India.
2. Troop R. S. 1921. Silviculture of Indian trees. Claren-don Press, Oxford, UK.
3. Burton G. W. and E. W. Devane. 1953. Estimating heritability in tall fescus (*Festuca arundineae*) from replicated clonal material. Agron. J. 4 : 78—81.
4. Johnson H. W., H. F. Robinson and R. E. Comstock. 1955. Estimates of genetic and environmental variability in Soyaben. Agron. J. 47 : 314—318.
5. Lawley D. N. and A. E. Maxwell. 1963. Factor analysis as a statistical method, Butterworths, London, UK.
6. Ramchander P. R., S. R. Biswas, D. P. Singh and C. S. Pathak. 1979. Factor analysis in onion (*Alium cepa* L.). Curr. Sci. 48 : 137.
7. Sharma S. K. and S. K. Chaudhary. 1985. Factor analysis of berry and its seed characteritics in potato. Genetica Iberica 37 : 77—82.
8. Harman H. H. 1976. Modern factor analysis. *In* K. E. Intein, A. Ralston and H. S. Wift, editors. Minres method of factor analysis. Statistical methods for digital computers. John Willey, New York, USA.
9. Kaiser H. F. 1958. The varimax criterion for analytic rotation in factor analysis. Psychometra 23 : 187—200.
10. Lantz W. C. 1975. Natural variation. Review material for genetic gain in forest tree improvement, the third decade. A. B. Thielges, editor. Loursiana State Univ. Div. Counting Educ., Baton Rouge, Louiaiana, USA.
11. Cotterill P. P. and C. A. Dean. 1988. Changes in the genetic control of growth of radiata pine to 16 years and efficiencies of early selection. Silv. Genet. 37 : 138—146.
12. Cambell R. K. 1979. Genecology of Douglas-fir in the watershed in the Oregon Cascados. Ecology 60 : 1036—1050.
13. Abraham T. P. and A. Hoobarkrt. 1973. An application of Factor Analysis for interpretation of soil analysis data. J. Indian Soc. Agric. Stat. 5 : 105—112.
14. Jalikop S. H., R. Singh and S. R. Biswas. 1984. Applications of factor analysis in grape. Indian J. Hort. 41 : 251—255.
15. Zhang M. and H. W. Cui. 1993. Application of factor analysis to cucumber breeding. Rep. Cucurbit Gen. Coop. 16 : 27—29.
16. Jaiswal U. C. and A. S. Kanaujia. 1994. Identifications of variables for over all efficiency in Indian buffaloes—A factor analysis approach. Indian J. Dairy Sci. 47 : 470—474.