Gregor Mendel Foundation Proceedings 2007: 39-44.

Variability of seed related characters in teak (*Tectona grandis* L.f.) from Western Ghat region

Sojan Jose and Indira E.P.
Kerala Forest Research Institute, Peechi, Thrissur 680 653 Kerala

Abstract: *The present study analyses the variability of nineteen seed related characters, with respect to morphological, physiological and biochemical aspects, in ten teak (Tectona grandis L.f.) populations from Kerala, Karnataka and Tamil Nadu part of Western Ghats. The data were subjected to multivariate analysis. Correlations were estimated between all the traits and also between the latitude, longitude, altitude and mean annual rain fall at the areas of the seed sources. Significant variability is found to exist in all the studied characters except mesocarp thickness and length- breadth ratio of shell diameter. Positive correlations were found between germination percentage and longitude where as germination is negatively correlated with latitude and endocarp ash. Rainfall has positive correlations with mesocarp lignin content. Altitude is positively correlated with fruit filling percentage. A multiple regression equation was fitted to predict germination using seed viability (through tetrazolium test), endocarp ash and mesocarp lignin (R^2 = 0.56). Clustering was done to look in to the over all similarity between the ten populations and the results show three different groups where seed source from Doddaharve (Mysore) stands separately.*

INTRODUCTION

Teak (*Tectona grandis* L.f), a member of the family Verbenaceae, is one of the leading tropical timbers in the world and is well known for its aesthetic beauty, strength and durability. Teak is naturally found in the peninsular India below 24 degree latitude. India is considered as a centre of genetic diversity of teak. Information on the extent, nature and distribution of genetic diversity in a species is important for effective breeding and conservation strategies. Naturally distributed in different climatic and edaphic zones, teak has developed different ecotypes during the processes of evolution. Wide variation in the performance of different ecotypes has been previously recognized (Keogh, 1982; White, 1993). Teak exhibits a great variability between provenances and land races in various quantitative and qualitative traits (Keiding *et al*., 1986). Variation in physical characteristics of the drupes and germination was reported in seven provenances from the Kerala state of India (Jayasankar *et al*., 1999). Germination of teak fruits was observed to be highly variable from source to source (Indira and Basha , 1999; Sivakumar *et al*., 2002).

Kertadikara and Prat (1995) opined that studies on the variability in seed characters and germination behaviour of a species will help in identifying the seed lots for a planting program. Molecular marker studies have shown that Western Ghat region forms a separate genecological zone and teak from this region is more diverse when compared to central Indian region (Nicodemus *et al*., 2005). The present study investigates the variability in various morphological, biochemical and physiological traits of teak drupes from the western Ghat region. When the seeds were put in the nursery, many of the provenances did not give enough germination. Hence, it was decided to develop a model so as to predict the germination of a particular seed source by analyzing any of the biochemical/physiological/ morphological variations.

MATERIALS AND METHOD

Ten different provenances (seed sources) covering Karnataka, Kerala and Tamil Nadu were selected (Fig.1) and the longitude and altitude of the area were measured using a GPS (Table 1). The annual rainfall data was compiled from the website http://www.worldclim.org as per Hijmans *et al*. (2005). From each locality, seeds were collected from 10 randomly selected trees and the seeds were bulked. Nineteen characters related to the seeds were noted down (Table 2). From each lot of bulked seeds three replications with twenty seeds each were taken and physical measurements were taken for shell diameter (vertical and transverse here after length and breadth respectively), drupe diameter (vertical and transverse here after length and breadth respectively), fruit weight, shell weight, mesocarp weight, mesocarp thickness, maximum possible germination and drupe filling percentage. Measurements of shell were taken after removing the mesocarp from the seed. The difference between the drupe and shell measurement gave the values for mesocarp measurement. For 25 seed weight, drupes were broken and undamaged seeds were collected. Twenty five seeds with three replications were weighed using highly precise electronic balance. 100 drupe weight was taken using seed lots containing hundred seeds with three replications.

Seed viability

Twenty seeds with three replications were soaked in 1% solution of 2,3,5 triphenyl tetrazolium chloride for 4 hours in the dark. Completely stained seeds were counted as viable and expressed in percentage.

Maximum possible germination

The drupes having at least one locule filled with visually healthy seed are considered as germinable and the percentage of these drupes was given as MPG percentage.

Germination test

Three replications of hundred seeds were taken and the seeds were pretreated with water i.e., alternate wetting (1 day) and drying (1 day) for 4 cycles. They were sown in trays filled with sand. Multiple seedlings from one fruit were counted as one. Germination was expressed in percentage after one year long observation.

Ash Content

Ash content of the mesocarp and endocarp were gravimetrically estimated. One gram of finely powdered mesocarp and endocarp were treated at 600^{o}C in a muffle furnace for four hours. The remaining ash was weighed and expressed as percentage of ash content.

Lignin

The lignin content of wood and pulp is generally determined as Klason lignin in accordance with the standard method TAPPI T 222 om-88 (Schwanninger and Hinterstoisser, 2002) and the same method is used here for mesocarp and endocarp.

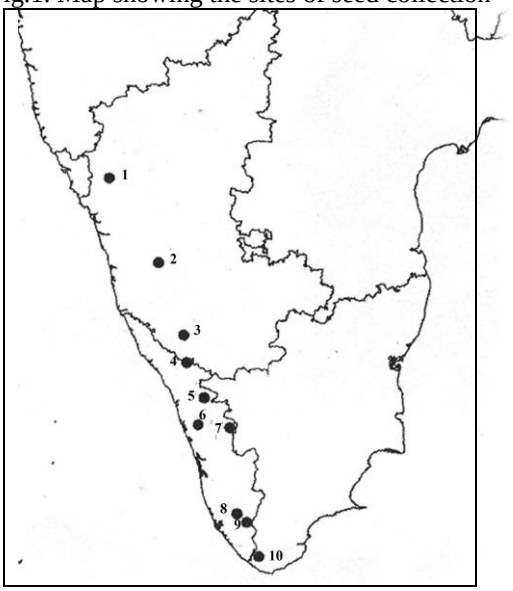
Statistical analysis

The data were subjected to analysis of variance and correlation was estimated between all the traits and the geo-climatic data to know their relationship. Multiple linear regression equations were worked out to predict the germination from other variables. Clustering was carried out to understand the overall similarity between the provenances. All the analyses were carried out using SPSS 16.0.

Table 1. Details of the selected provenances

No	Provenance	Longitude (°)	Latitude (°)	Altitude(m)	Rainfall (mm)
1	Hudsa	74° 37’	15° 15’	480	1860
2	Mandagadde	75° 29’	13° 46’	592	1536
3	Doddaharve	75° 57’	12° 24’	877	1258
4	Wynad	76° 05’	11° 53’	752	2137
5	Nilambur	76° 21’	11° 20’	68	2353
6	Vazhani	76° 13’	10° 46’	58	2730
7	Parambikulam	76° 48’	10° 26’	560	1890
8	Konni	76° 57’	9° 10’	220	2229
9	Arienkavu	77° 07’	8° 59’	381	1694
10	Ashambu	77° 18’	8° 22’	200	1226

Fig.1. Map showing the sites of seed collection



RESULTS AND DISCUSSION

The seeds from different provenances were phenotypically different in colour, shape, size etc. (Fig. 2). The Mean performance of different variables is given in Table 2. Provenances are significantly different for all characters except for length- breadth ratio of the shell diameter and mesocarp thickness. Seed characters like maximum possible germination, drupe length and breadth, shell weight, drupe filling percentage and hundred drupe weight were highest in the seeds from Doddaharve and lowest in Mandagadde. Twenty five seed weight and mesocarp weight were highest for seeds from Parambikulam and lowest in Hudsa and Mandagadde. Drupes and shells from Wayanad showed maximum roundness where as seeds from Asahmbu showed minimum roundness as interpreted from the drupe and shell length-breadth ratio. Shell length and breadth was highest for Wayanad and Ashambu respectively where as it was lowest for Mandagadde. Wayanad seeds were found to have a bigger average shell length when compared to breadth. Endocarp ash was highest in Nilambur and was lowest in Konni where as mesocarp ash was highest in Hudsa and lowest in Arienkavu. Lignin content of the endocarp was highest in Mandagadde and lowest in Ashambu where as mesocarp lignin was highest in Vazhani and lowest in Mandagadde. The ashambu provenance showed maximum seed viability and the seeds from Parambikulam, Hudsa and Arienkavu showed the lowest seed viability. Germination was highest for seeds collected from Konni where as it was lowest for seeds from Hudsa (Table 3).

Table 2. Mean performance of different variables

No.	Parameters	Mean	SD
1	25 seed weight(g)	0.45**	0.05
2	Endocarp ash(%)	1.97**	0.24
3	Endocarp lignin(%)	34.54**	1.65
4	Mesocarp lignin(%)	42.05**	2.53
5	Mesocarp ash(%)	4.45**	1.05
6	MPG(%)	37.5**	16.89
7	Shell diameter (L)(mm)	0.93**	0.07
8	Shell diameter (B) (mm)	0.98**	0.07
9	Shell diameter (L/B)	0.95^{ns}	0.05
10	Drupe diameter(L)(mm)	1.23**	0.10
11	Drupe diameter (B)(mm)	1.36**	0.12
12	Drupe diameter (L/B)	0.91**	0.04

13	Shell weight(gm)	0.38**	0.08
14	Mesocarp weight(g)	0.18**	0.06
15	Mesocarp thickness(mm)	0.17^{ns}	0.03
16	Drupe filling %	12.17**	7.53
17	100 drupe weight(g)	53.01**	13.16
18	Seed viability (%)	25.5*	9.06
19	Germination (%)	12.67**	5.73

*Note: **, *, significant at 0.01level, 0.05 level respectively; ns -non-significant*

Table 3. Provenance mean for each of the fruit characters

Provenance	Parambikulam	Vazhani	Ashamb	Hudsa	Konni	Wayanad	Arienkav	Maddagadde	Doddaharve	Nilambur
25 seed weight (g)	0.53	0.40	0.45	0.36	0.48	0.44	0.45	0.48	0.50	0.42
Endocarp ash (%)	1.59	2.09	1.97	2.08	1.52	2.02	2.04	2.21	1.95	2.22
Endocarp lignin(%)	33.04	34.63	32.11	34.29	35.69	34.61	34.88	37.02	32.47	36.67
Mesocarp lignin(%)	45.30	45.88	39.71	43.05	42.46	43.11	42.35	37.58	40.30	40.80
Mesocarp ash(%)	5.55	4.58	4.75	5.64	3.49	4.59	2.51	3.24	5.47	4.67
MPG(%)	45.00	20.00	43.33	23.33	36.67	58.33	30.00	18.33	70.00	30.00
Shell diam (L) (mm)	0.97	0.88	0.92	0.87	0.86	1.05	0.88	0.83	1.03	0.96
Shell diam (B) (mm)	1.04	0.89	1.07	0.95	0.97	1.011	0.93	0.87	1.07	1.00
Shell diam (L/B)	0.93	0.99	0.87	0.92	0.89	1.04	0.95	0.96	0.97	0.96
Drupe diam (L) (mm)	1.37	1.15	1.19	1.18	1.17	1.36	1.15	1.10	1.38	1.23
Drupe diam (B) (mm)	1.51	1.24	1.42	1.33	1.33	1.39	1.32	1.16	1.57	1.33
Drupe diam (L/B)	0.91	0.93	0.84	0.89	0.88	0.98	0.87	0.95	0.88	0.93
Shell weight (g)	0.41	0.29	0.46	0.39	0.36	0.42	0.31	0.24	0.53	0.40
Mesocarp weight(g)	0.29	0.13	0.21	0.15	0.16	0.22	0.13	0.15	0.26	0.14
Meso.thickness (mm)	0.22	0.16	0.16	0.17	0.16	0.17	0.17	0.14	0.21	0.15
Drupe filling %	14.17	5.42	13.75	6.25	9.58	19.17	9.17	5.42	29.58	9.17
100 drupe weight (g)	65.75	39.72	64.75	49.94	48.96	55.19	42.92	33.84	77.10	51.96
Seed viability(%)	16.67	35.00	40.00	16.67	38.33	23.33	16.67	20.00	23.33	25.00
Germination (%)	20.00	18.67	14.00	1.00	22.00	14.00	10.00	7.00	9.00	11.00

Correlations were estimated between all the traits and the geo-climatic data. Positive correlations were found between germination percentage and longitude where as germination was negatively correlated with latitude and endocarp ash. A higher endocarp ash may be due to the presence of higher inorganic components like Calcium which help in increasing cell wall rigidity and thickness (Schroeder,1982) and it may affect germination adversely. Altitude is positively correlated with fruit filling percentage. Rainfall has positive correlations with mesocarp lignin content. The lignin is found to help in withstanding the

deterioration during weathering and it increases water impermeability in many seeds and thus an increase in mesocarp lignin might be an adaptation which is helpful to evade the chances of attack of seed pathogens which are active during continuous rains. The role of lignin in disease resistance in plants is well established (Hijwegen, 1963; Milosevic and Slusarenko,1996). Previous works in this species are of various opinions on the effect of seed size on germination. Kumar (1979) and Syam (1988) support the use of bigger seeds for better germination where as Indira *et al*., (2000) and Sivakumar *et al*., (2002) are of the opinion that seed size does not have significant effect on germination. Jayasankar *et al.* (1999) have found that teak seed size has got negative relation with germination. However, the present study did not show any significant correlation between seed size and germination and it is in agreement with the views of Indira *et al.* (2000) and Sivakumar *et al.* (2002).

Fig. 2. Seeds from different seed sources

To find out the factors which affect the germination of seeds, multiple linear regression equation was fitted considering germination percentage as dependent variable and all other variables as independent variables. Results show that the three variables which affect the germination are endocarp ash, seed viability and mesocarp lignin.

$y = -7.730 - 11.201x_1 + 0.219\ x_2 + 0.883\ x_3$ (Adj.$R^2 = 0.56$),

where y= germination (%) , x_1 = endocarp ash (%), x_2 = see viability (%) and x_3 = mesocarp lignin(%)

Jayasankar *et al.* (1999) have obtained a multiple regression equation to predict germination from seed parameters were the R^2 values is 0.366 only but Sivakumar *et al*. (2002) have obtained a non linear polynomial regression model with the R^2 value 0.599. Clustering was done by computing Euclidean distances between every pair of the seed source to see over all similarity in the seeds. Three clusters were obtained (Table 4). The seeds from Doddaharve were found to stand separate.

From the above study it is concluded that the teak seed related characteristics exhibit large variability. Seed characters like maximum possible germination, drupe length and breadth, shell weight, drupe filling percentage, 100 drupe weight were highest in the seeds from Doddaharve whereas Mandagadde was found to be inferior in many of the studied characters. Seeds from Doddaharve are entirely different from other teak provenances of Western Ghats included in the present study. Konni provenance showed the highest germination. The multiple regression equation developed is useful to predict germination using the seed characters such as endocarp ash, mesocarp lignin and seed viability determined through tetrazolium test.

Table 4. Different clusters

Cluster	Provenances
1 (5 provenances)	AKV, NBR, HUD, MDG, VZNI
2 (4 provenances)	ASB,KNI, PRM, WYN
3 (only 1 provenance)	DRV

REFERENCES

Hijmans R.J., Cameron S.E., Parra J.L., Jones P.G. and Jarvis A., 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.

Hijwegen T., 1963. Lignification, a possible mechanism of active resistance against pathogens. *Netherlands Journal of Plant Pathology* 69: 314-317.

Indira E. P. and Basha S. C., 1999. Effect of seeds from different sources on germination and growth in teak (*Tectona grandis* L.f.) nursery. *Annals of Forestry* 7(1): 39–44.

Indira E.P., Basha C.S. and Chacko K.C., 2000. Effect of seed size grading on the germination and growth of teak (*Tectona grandis* L.f.) seedlings. *Journal of Tropical Forest Science* 12(1):21-27.

Jayasankar S., Babu L.C., Sudhakara K. and Unnithan V.K.G., 1999. Provenance variation in seed and germination characteristics of teak (*Tectona grandis* L.f.). *Seed Science & Technology* 27:131-139.

Keiding H., Lauridsen E. B. and Wellendorf H., 1986. Evaluation of an international series of teak provenance trials. Danida Forest Seed Centre, Denmark. p. 81.

Keogh R. M., 1982. Teak (*Tectona grandis* L.f.) provisional site classification chart for the Caribbean, Central America, Venezuela and Columbia. *Forest Ecology and Management* 4: 143–153.

Kertadikara A.W.S. and Prat D., 1995. Isozyme variation among teak (*Tectona grandis* L.f.) provenances. *Theoretical & Applied Genetics* 90 (6):803-810.

Kumar A., (1979) Effect of fruit size and source on germination of teak seeds. *Sri Lanka forester* 14 (1/2): 58-63.

Milosevic N. and Slusarenko A.J., 1996. Active oxygen metabolism and lignification in the hypersensitive response in bean. *Physiological & Molecular Plant Pathology*. 49: 143-157.

Nicodemus A., Nagarajan B., Narayanan C., Varghese M. and Subramanian K., 2005. RAPD variation in Indian teak populations and its implications for breeding and conservation. In: K.M.Bhat, K.K.N.Nair, K.V.Bhat, E.M.Muralidharan and J.K.Sharma (Eds.) Proceedings of International conference on Quality timber products of teak from sustainable forest management held at KFRI, Peechi, India, Dec.2003: 321-330.

Schroeder C.A., 1982. Progress report on study of sclereid formation in Avocado fruit pericarp. California Avocado Society Yearbook 66: 161-165.

Schwanninger M. and Hinterstoisser B., 2002. Klason Lignin: Modifications to improve the precision of the standardized determination. *Holzforschung* 56: 161-166.

Sivakumar V., Parthiban K.T., Gurudev Singh B., Gnanambal V.S., Anandalakshmi R., Geetha S.,2002. Variability in drupe characters and their relationship on seed germination in Teak (*Tectona grandis* L.f.). *Silvae Genetica* 51(5–6): 232–237.

Syam V., 1988. Investigations on production of healthy seedlings of teak in the nursery. M.Sc. thesis, College of Forestry, Kerala Agriculture University, Kerala, India.p. 136.

White K. J., 1993. Research results: a selection of annotated references of Teak (*Tectona grandis* L.f.). Occasional Paper, Forestry Research Support Programme for Asia and Pacific, No. 19. p. 22.