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Physiological Variation Measured Using Chlorophyll Fluorescence Meter in Seedlings of Teak (*Tectona Grandis* L.F.) Raised from 38 Seed Sources in Kerala

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ABSTRACT

Seedling vigour of progenies of 38 teak seed production areas (SPAs) in Kerala was assessed based on the photosynthetic activity using chlorophyll fluorescence meter. Fluorescence attributes such as Fv/Fm, Fv/Fo, Fo/Fm, ETo/RC, DIo/RC, ETo/CSo and PI (absolute) were recorded for all seed sources. Result showed that there was a significant variation among 38 SPAs for various chlorophyll fluroscence attributes. Fv/Fm ranged from 0.78 to 0.82 with an overall mean of 0.79, whereas PI ranged from 22.44 (N1) to 48.38 (A3) showing wide range of variation among SPAs indicating scope for further selection of seed source for raising quality seedlings. Among five seed zones studied, progenies rasied using Achencoil and Konni zone recorded the highest Fv/Fm and Perfomance Index values indicating more photosynthetic efficiency in the seed source. Hence, these seed sources can be utilized for raising seedlings for planting in drier areas or wastelands.

Keywords:

Chlorophyll flueroscence, photosynthesis, Seed production area, seedling vigour, Teak

INTRODUCTION

Seedling selection and progeny testing are the two rigorous breeding methods being practiced for the improvement of forest trees based on the early seedling/sapling vigour at field condition (Kedharnath 1986). Progeny evaluation at seedling stage aims to derive preliminary information for developing juvenile-mature correlation of traits of economic importance. Apart from seedling growth attributes, physiological characterization like photosynthetic potential is also very important in evaluation of quality of the nursery stock. There are many methods for physiological characterization at seedling stage and chlorophyll fluorescence is one among them that analyse the photosynthetic attributes in plant system.

Vidaver and his associates opined that chlorophyll fluorescence is a useful physiological test due to its non-invasive, non-destructive and rapid nature (Vidaver et al. 1989). The study on chlorophyll fluorescence parameters in tree seedling is very scanty in tropical tree species. In the present study efforts have been made to evaluate progenies raised from 38 seed production areas of teak (*Tectona grandis* L.f) in Kerala for their physiological attributes using chlorophyll flueroscent meter.

It is known that teak is one of the important commercial timber species of the

tropics that contributes about 90 per cent quality hardwood timber and this is mainly due to its very good timber values in terms of mechanical and quality parameters like strength, workability, attractiveness, lightness, resistance to termite, fungus and weather, and seasoning capacity without splitting, cracking or materially altering shape (Granger 1998; Tewari 1998). Therefore, greater demand for quality timber of teak from both international and domestic market is expected in recent days. Due to this, the plantations of this species are increasing tremendously in the country (Subramanian et al. 2000). Moreover, the quality as well as quantity of wood can only be assured when quality seedlings are planted and silviculturally managed in the field.

Therefore, seeds are collecting from clonal seed orchards and seed production areas, which are raised and managed by the forest departments at different States, for raising quality seedlings in large scale. Hence, evaluation of seed production areas of teak for their seed quality and nursery performance was undertaken in Kerala (Prabhu 2007). The part of this study that dealing with the influence of seed sources on seedling vigour and photosynthetic attributes at seedling level was presented in this manuscript.

MATERIALS AND METHODS

The present study was undertaken in 38 different Seed Production Areas of teak located in five different seed zones *viz.* Wayanad, Parambikulam, Nilambur, Konni and Achencoil in Kerala, India (Fig. 1). Nursery studies were carried out in the Central Nursery of Kerala Forest Department located at Chettikulam in Chalakudy Division, Thrissur, Kerala. This nursery area has a warm humid climate with mean annual rainfall of 2700 mm. The mean minimum and mean maximum temperatures of the nursery area during the study period were 21^{0}C and 33^{0} C, respectively.

Fruits were collected from randomly marked sample plots (minimum of 3 plots) of size 40 x 40 m from each SPA during March – April months. Dried and cleaned fruits were subjected to pre-sowing treatment of alternate wetting and drying for seven days (Prabhu 2007). Further, treated fruits were spread on sand bed and covered with wet gunny bags. The seed beds were irrigated daily. Pre-germinated seeds were hand picked and dibbled in root trainers filled with potting mixture. The block type root trainers of 24 cells with cell capacity of 150 cc were used. The potting mixture consisted of sieved compost, sieved sand, sieved soil and burnt rice husk mixed in the proportion of 65:20:10:5 by volume. De-oiled neem cake 10 kg, Phorate insecticide (0.25 kg), Dithane M 45 (0.2 kg) and single super phosphate (4.5 kg) were also added to the one cubic meter potting mixture (Prabhu 2007 and Gunaga et al. 2005). In the experiment, four replications of forty-eight seedlings (two root trainer blocks of 24 cells) were used following randomized block design (RBD).

The root trainer cells dibbled with pre-germinated seeds were kept under shade house (50% shade) for thirty days. Later, they were shifted to hardening area and retained upto 90 days for recording growth observations. A portable chlorophyll fluorometer (Plant Efficiency Analyser, Handy PEA, Hansatech, and King's Lynn, UK) was used to measure different chlorophyll fluorescence parameter such as Fv/Fm, Et_0/Rc, Di_0/Rc, Et_0/CS_0 and PI (ABS) and data were recorded in the computer using the software of chlorophyll fluorescence meter. The details of each parameter are presented in table 1.

To record photosynthetic parameters, four replications of four seedlings each were selected randomly from all the 38 SPAs and one fully matured leaf from each seedling was selected to estimate the above mentioned chlorophyll fluorescence parameters. Before recording observations, all seedlings were transferred to a shade house to homogenise the condition for about one hour. This was mainly to reduce environmental changes in the yield of chlorophyll fluorescence (Strasser et al. 1999). Further, data were subjected to nested analysis of variance using SAS software so as to identify the variation between different seed zones and SPAs within the seed zones.

RESULTS AND DISUCUSSION

Changes in chlorophyll fluorescence efficiency provide important information on photosynthetic activity of studied plants. This is a

Table 1. Different chlorophyll fluorescence parameter

Sl. No	Equation/ Index	Details of the equation or index
1	Fv/Fm	This is a measure of the intrinsic (or maximum) efficiency of Photosystem II (PSII) (*i.e.* the quantum efficiency if all PSII centres were open. Fv = Fm-Fo where Fm is the maximum fluorescence and Fo is the minimal or initial level of fluorescence before excitation.
2	ET_0/RC	It is a specific flux and it estimates the electron transport capacity per reaction centre. In an efficient leaf this value should be high.
3	DI_0/RC	It is a specific flux and it is defined as 'the ratio of total dissipation to the amount of active reaction centres'. Its value increases due to the high dissipation of the inactive reaction centres.
4	ET_0/CS_0	It is a one of the phenomenological fluxs estimating electron transport capacity at the leaf cross section
5	PI_{ABS}	Another parameter, namely, the Performance Index (PI) is a synthesized parameter, taking into account several other parameters as can be seen from the following equation. $PI = \frac{ABS}{CS} \times \frac{RC}{ABS} \times \frac{TR}{DI} \times \frac{ET}{dQ_A/dt}$ (Strasser et al. 1999) where, *ABS* = Photon flux absorbed by chlorophyll A *CS* = Crossectional area of the leaf; *RC* = Numberof reaction centres; *TR* = Trapping flux of energy; *DI* = Dissipated photon flux; *ET* = Energy flux corresponding to electron transport; dQ_A/dt = Flux of excitons trapped per reaction centre; PI is expected to be high for an efficiently functioning leaf.

rapid and convenient method for non-destructive estimates of photosynthetic performance. Among various fluorescence measurements, Fv/Fm and PI (absolute) are probably the simplest to identify the superior seed source or genotype for large scale plantation programmes. The higher value of these parameters indicate genotypes or seed zone that suitable for drier conditions or wasteland development programmes as these genotypes may withstand high stress or environmental fluctuation.

All the chlorophyll fluorescence parameters studied showed wide ranging values among teak SPAs (Table 2). SPA of A3 located in Achencoil seed zone recorded the lowest Fo/Fm (0.21), DIo/RC (0.38) and the highest Fv/Fo value (3.85). The opposite trend was observed in SPA of N5 located in the Nilmbur for these characters. ETo/RC ranged between 0.96 (N1, W3, W4) and 1.09 (K8) with overall mean of 1.03. While, SPA of W9 located in Waynad zone recorded the highest ETo/CSo (356.5) and SPA of P6 located in Parambikulam seed zone registered the least value (281.6). Among all these parameters, Performance index, which indicates the overall seedling growth and vigour, ranged from 22.44 (N1) to 48.38 (A3) showing wide variation among SPAs indicating scope for further selection of seed production areas for raising quality seedlings suitable for drier conditions or wasteland development programmes.

Influence of five seed zones on various photosynthesitc parameters like Fv/Fm, Fv/Fo, Fo/Fm, ETo/RC, ETo/CSo, DIo/RC and PI (absolute) was recorded (Table 3). Fv/Fo and ETo/CSo were found to be highest in Achencoil seed zone, while Fo/Fm had the lowest value. Nilambur seed zone recorded lowest values for ETo/CSo, ETo/Rc and Fv/Fo (Table 3). Higher value of Fv/Fm as an indicator high photosynthetic efficiency was highest in Achencoil seed zone, followed by Konni zone. Considering performance index, Achencoil seed zone was found to be superior (40.75), followed by

Table 2: Details of chlorophyll fluorescence parameters of different teak SPAs

SPA code	Year (Estbl.)	Location	Fv/Fm	Fv/Fo	Fo/Fm	ETo/ RC	DIo/ Rc	ETo/ CSo	PI (abs)
Niambur Seed Zone									
N_1	1951	Kangirkadavu	0.78	3.06	0.25	0.96	0.56	284.09	22.44
N_2	1943	Chathamporai	0.79	3.12	0.24	1.01	0.54	297.08	23.25
N_3	1944	Chathamporai	0.79	3.28	0.24	0.99	0.51	295.81	27.33
N_4	1945	Chathamporai	0.78	3.12	0.25	0.99	0.59	298.04	25.92
N_5	1956	Erampadam	0.78	2.99	0.26	0.98	0.58	292.47	23.77
N_6	1939	Edacode(North)	0.79	3.27	0.24	1.02	0.51	299.38	27.87
N_7	1961	Sankarncode	0.80	3.48	0.23	1.04	0.46	320.26	35.85
Waynad Seed Zone									
W1	1948	Tholpetty	0.80	3.39	0.23	1.02	0.48	308.10	33.47
W2	1949	Tholpetty	0.78	3.18	0.24	1.00	0.54	295.24	30.51
W3	1953	Camp Road	0.79	3.35	0.24	0.96	0.50	296.55	33.96
W4	1954	Camp Road	0.78	3.10	0.25	0.96	0.57	285.70	26.83
W5	1955	Camp Road	0.78	3.12	0.25	0.98	0.53	289.82	28.26
W6	1958	Thettu Road	0.79	3.30	0.24	1.03	0.52	311.57	34.04
W7	1962	Tholpetty	0.79	3.19	0.24	1.05	0.56	327.92	27.99
W8	1963	Tholpetty	0.80	3.46	0.23	1.04	0.48	342.04	33.90
W9	1939	Thettu Road	0.80	3.50	0.23	1.04	0.46	356.54	41.62
Parambikulam seed zone									
P1	1943	Thoonakadavu	0.79	3.33	0.24	1.03	0.51	315.24	31.34
P2	1944	Thoonakadavu	0.81	3.63	0.22	1.08	0.44	335.72	39.04
P3	1945	Thoonakadavu	0.79	3.22	0.24	1.06	0.52	323.91	29.47
P4	1945	Thoonakadavu	0.78	3.18	0.24	1.02	0.52	315.51	26.55
P5	1946	Thoonakadavu	0.79	3.19	0.24	1.00	0.54	306.85	26.20
P6	1947	Thoonakadavu	0.78	3.04	0.25	0.99	0.55	281.56	22.91
P7	1953	Peruvari	0.78	3.11	0.24	1.07	0.55	313.44	25.48
P8	1954	Peruvari	0.79	3.20	0.24	1.08	0.55	317.06	29.47
P9	1955	Anapady	0.80	3.45	0.23	1.06	0.47	325.09	35.84
Konni seed zone									
K_1	1947	Kummanoor	0.80	3.34	0.23	1.08	0.51	323.52	31.23
K_2	1949	Kummanoor	0.79	3.31	0.24	1.05	0.54	311.67	31.68
K_3	1950	Vattapara	0.79	3.19	0.24	1.08	0.54	329.05	27.11
K_4	1955	Nadavathumoozhy	0.79	3.37	0.23	1.04	0.51	326.19	31.97
K_5	1956	Nadavathumoozhy	0.79	3.19	0.25	1.01	0.56	318.63	28.19
K_6	1960	Kadiyar	0.78	3.12	0.25	1.05	0.58	323.02	25.03
K_7	1950	Nellidapara	0.79	3.44	0.23	1.02	0.48	318.02	34.54
K_8	1959	Kondodi	0.81	3.56	0.22	1.09	0.46	325.70	34.99
K_9	1965	Kondodi	0.79	3.30	0.24	1.07	0.53	310.49	27.99
K_{10}	1963	Perunthumoozhy	0.80	3.54	0.22	1.04	0.45	310.90	36.31
Achencoil seed zone									
A_1	1943	Chempala	0.80	3.50	0.22	1.03	0.44	320.65	38.30
A_2	1943	Achencoil	0.80	3.51	0.22	1.03	0.45	337.48	35.57
A_3	1942	Achencoil	0.82	3.85	0.21	1.01	0.38	331.78	48.38
		Mean	0.79	3.30	0.24	1.03	0.51	313.12	30.97
		CD@ 5%	0.02	0.326	0.014	0.077	0.099	22.10	8.55

Table 3: Seed zone variation for chlorophyll fluorescence parameters

Seed zones	Fv/Fm	Fv/Fo	Fo/Fm	ETo/RC	DIo/RC	ETo/Cso	PI $_{ABS}$
Nilambur	0.77^{b}	3.19^{b}	0.24^{a}	1.00^{b}	0.54^{a}	298.16^{b}	26.63^{b}
Wayanad	0.78^{ab}	3.29^{b}	0.24^{a}	1.01^{b}	0.51^{a}	312.61^{ab}	32.29^{b}
Parambikulam	0.77^{b}	3.26^{b}	0.24^{a}	1.04^{a}	0.52^{a}	314.93^{ab}	29.59^{b}
Konni	0.78^{ab}	3.33^{b}	0.23^{ab}	1.05^{a}	0.52^{a}	319.72^{a}	30.90^{b}
Achencoil	0.79^{a}	3.62^{a}	0.22^{b}	1.02^{ab}	0.42^{b}	329.97^{a}	40.75^{a}
Mean±SE	**0.77**	**3.30**	**0.24**	**1.03**	**0.51**	**313.74**	**30.91**

Note: Values superscribed with same letter are not significantly different; Values superscribed with different letters are significantly different

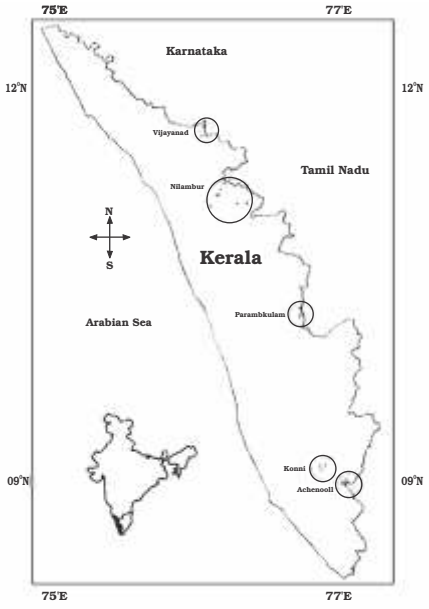

Figure 1: Locations of seed production areas of teak in Kerala, India

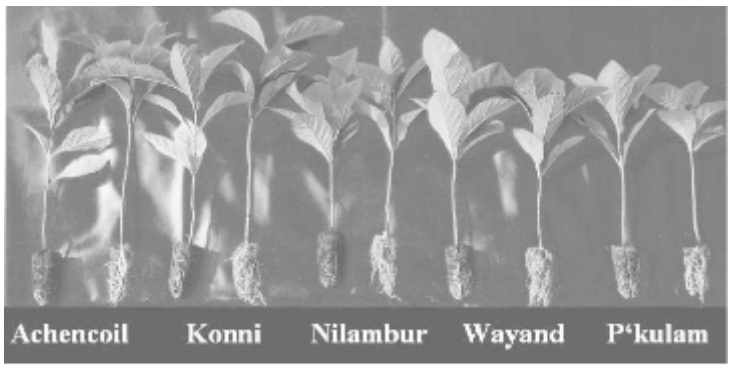

Photo 1: Variation in seedling growth among different seed zones (90 days after planting)

Wayanad (32.29) and Konni (30.90) seed zones (Photo 1).

DISCUSSION

Chlorophyll florescence meter is one of the important instruments used to record various photosynthetic parameters to asses the seed qulity and growth attributes in plant species. Review showed that there was a lack of information pertaining to evaluation of progenies on chlorophyll florescence parameters in tropical tree species. There are few reports on photosynthetic effiency parameters on other physiological attributes in different species. For instance, Husein and his associates reported diurnal variation in Fv, Fm, Fv and Fv/Fm in different *Ficus* spp. Maximum Fv/Fm of 0.736 and 0.758 was observed in *Ficus nemoralis* and *F. roxburgii*, respectively (Husein et al. 2004). Such diurnal changes in chlorophyll fluorescence of different species have been reported (Ehleringer et al. 1986; Joshi 1995).

Chacko (2005) reported variation in chlorophyll fluorescence of seedlings grown under different shade and irrigation regimes in teak. Subsequently, he has also recorded variation in performance Index, which ranged from 4.6 to 35.0 among various treatments of shade and irrigation regimes in teak seedlings. However, in the present study, the overall mean PI (absolute) was 30.5 recoreded among diffferent seed sources. Lastly, it is concluded that the seedlings raised from the seedlot of Achencoil seed zone performed better with respect to Fv/Fm and PI, which are found to be the best indices for determining the photosynthetic ability of seedlings. Hence, seedlots from Achencoil and Konni zones may be preferred for planting seedlings in drier areas.

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