HEARTWOOD COLOUR VARIATION IN HOME GARDEN TEAK (*TECTONA GRANDIS*) FROM WET AND DRY LOCALITIES OF KERALA, INDIA

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THULASIDAS, P. K., BHAT, K. M. & OKUYAMA, T. 2006. Heartwood colour variation in home garden teak (*Tectona grandis*) from wet and dry localities of Kerala, India. Colour of teak wood from homesteads was characterized in comparison with that grown in forest plantation by two methods of colour determination, namely, Munsell system and CIE 1976 (L* a* b*) system in order to interpret precisely the colour variation. As per the Munsell hue system, heartwood colour of home garden teak from wet locality was comparable to that of dry sites and forest plantation specimens. However, the chroma value indicated less saturation of colour in the former. The chromaticness index b* (yellowness) of wet site sample as determined by CIE 1976 (L* a* b*) system differed significantly ($p < 0.05$) from dry site and plantation specimens with more yellowness. No significant difference was observed among the samples collected from the different localities with regard to brightness (L*) and redness (a*) ($p < 0.05$). The results suggest that the paler colour (less yellowness) of wet site teak wood is the limiting factor of timber price of home garden teak as compared with the forest plantation.

Keywords: Home garden forestry, wood colour, site effect, colorimetry, wood quality

THULASIDAS, P. K., BHAT, K. M. & OKUYAMA, T. 2006. Variasi warna teras kayu dalam kayu jati (*Tectona grandis*) yang ditanam di rumah ladang dari lokasi kering dan lembap di Kerala, India. Warna kayu jati dari rumah ladang dicirikan sebagai perbandingan dengan kayu jati yang ditanam di ladang hutan. Dua kaedah penentuan warna iaitu sistem Munsel dan sistem CIE 1976 (L*a*b*) digunakan untuk mentafsirkan variasi warna dengan tepat. Mengikut sistem rona Munsell, warna teras kayu dalam kayu jati dari rumah ladang lokasi lembap sama dengan spesimen lokasi kering dan ladang hutan. Bagaimanapun, nilai kroma menunjukkan ketepuan warna yang berkurangan dalam spesimen rumah ladang dari lokasi lembap. Indeks kekromatikan b* (kekuningan) dalam sampel lokasi lembap seperti yang ditentukan melalui sistem CIE 1976 (L*a*b*) berbeza dengan signifikan ($p < 0.05$) daripada spesimen lokasi kering dan ladang hutan yang menunjukkan warna kuning yang lebih tinggi. Tiada perbezaan signifikan dicerap dalam sampel dari semua lokasi yang dikaji dari segi kecerahan (L*) dan kemerahan (a*) ($p < 0.05$). Keputusan menunjukkan bahawa warna lebih muda (kurang kekuningan) dalam kayu jati dari lokasi lembap merupakan faktor pengehad harga kayu dari rumah ladang berbanding kayu jati dari ladang hutan.

Introduction

Colour is one of the quality criteria of wood to assess its suitability for certain end-uses such as furniture and decorative veneers. Teak (*Tectona grandis*) is a premier hardwood valued for its attractiveness with golden yellow or brown colour. Other desirable properties include natural durability as well as good machining and finishing. In order to meet the growing demand for this valuable timber, teak is cultivated outside the forests such as in homesteads and farmlands in the tropics. Farmers cultivate teak in homesteads along with other agricultural crops to meet their domestic timber requirements and for better economic returns. Once the tree attains harvestable size in around 30–35 years the tree is generally felled in a shorter rotation than the conventional rotation of 50–70 years. Thus, teak trees felled in home gardens generally fetch a lower price in the timber market because the wood is considered inferior in its quality attributes such as colour, grain, texture, strength and durability to that grown in natural forest and forest plantation. Faster growth and shorter rotation of cultivated teak have been reported to cause wood to be paler in colour (Bryce 1966). As visual colour perception may vary from person to person, precise colour characterization

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is desirable for comparative purposes. Colour characterization of tropical timbers has been attempted using different methods (Hiller *et al.* 1972, Vetter *et al.* 1990, Minemura *et al.* 1998, Rink & Phelps 1989). Despite the increasing world-wide importance of teak as plantation species, adequate information is not available on its colour variation.

The purpose of this paper is to describe the colour variation in the heartwood of teak grown in homesteads of 'wet' and 'dry' localities of Kerala, India as compared with teak of the same age from a typical forest plantation in Kerala using Munsell and CIE 1976 (L* a* b*) systems.

Materials and methods

Five defect-free dominant teak trees (35 years old) each from 'wet' and 'dry' home gardens in Kerala were selected for the present study. Five dominant teak trees of the same age were felled from a typical forest plantation at Site Quality (SQ) II in Nilambur, Kerala for comparative study. Data on the conditions of the three sites and average size of sampled trees are given in Table 1. From each tree, 5 cm thick cross sectional disc was removed at breast height level and air-dried to 12% moisture content. From each disc, a radial strip of 3 cm wide was cut from inner to outer heartwood in opposite radii excluding the pith. The cut samples from the opposite radii were grounded in a Wiley mill. The powder was passed through No. 40 (420 μm) sieve and retained in No. 60 (250 μm). The colour of these samples was determined by two methods of colour determination, namely, the Munsell system (Munsell 1905, Munsell Color Company 1976) and the CIE 1976 (L* a* b*) (CIE 1976) system within a day or two after sample preparation to avoid colour changes caused by oxidation or light.

Munsell notation of colour difference is considered for visual interpretation as influenced by personal judgement of colour. The wood sample placed under the colour chart appeared through the round openings, allowing an easy comparison with the rectangular colour chips. The colour was then identified by its hue, value and chroma. Hue value ranged from 9.9R to 1.0Y, from red to yellow. The scale of value ranged from 0 for pure black to 10 for pure white. Value indicated lightness/brightness of a colour. Chroma was the departure of a colour from its neutral colour of the same value. Colours of low chroma were considered weak, while those of high chroma were highly saturated, strong or vivid.

The CIE 1976 (L* a* b*) system was used as the colorimetric method for providing more accurate and objective colour determination (Vetter *et al.* 1990). The CIE 1976 (L* a* b*) system was sensitive enough to detect small differences in colour parameters to describe between-site, between-tree, and within-species variation.

Table 1 Data on environmental conditions and size of sampled teak trees from wet and dry home gardens in Kerala compared with those from forest plantation in Nilambur, Kerala

Factor	Wet (Muvattupuzha, Ernakulam)	Dry (Nemmara, Palghat)	Forest plantation (Karulai, Nilambur)
Altitude (m asl)	20	40	60
North latitude	9° 59'	10° 35'	11° 15'
East longitude	76° 34'	76° 35'	76° 13'
Soil type	Loamy sand	Loamy sand	Loamy sand
Annual rainfall (mm)	2500–3500	1500–2300	2500–3000
Temperature range (°C)	17–34	26–37	17–37
Relative humidity (%)	Above 80	70	70
Tree age (year)	35	35	35
Mean tree height (m)	17.0	14.0	21.0
Mean dbh (cm)	39.6	24.0	31.0

dbh = diameter at breast height

The UV spectrophotometer (Shimadzu UV-3100PC) equipped with a reflectance attachment 'Type C' light source representing average day light with a colour temperature of 6500 K was used for the colour analysis. For measurement, wood sample was placed at the sample port facing the incident beam to the integrating spheroid in the visible spectrum (380–780 nm) of the UV spectrophotometer. The beam size was approximately 2.0 mm at the entrance port to the integrating spheroid.

A one-way ANOVA followed by Duncan's multiple range test ($\alpha = 0.05$) was used to determine the significance of colour variation between the home garden and plantation sites of tree sampling.

Results and discussion

Precise colour description is essential for evaluation of aesthetic quality of wood products. Generally, the colour prescription is of interest to industries in the context of better marketability of wood products especially furniture, decorative veneer, etc. For example, even slight difference in heartwood colour would yield the product of different value. The Munsell notation for wet site sampel was comparable with dry site and plantation specimens with regard to hue (Table 2). However, chroma value of the web site was less than that of dry site and plantation specimens. The wet site heartwood was paler due to this factor. The sample colour was red tending more towards yellow-red in the Munsell system. Proportionate to the decrease of the yellowish value, an increase in redness was observed. Similar tendency was reported in 32 Japanese hardwoods and 60 Malaysian timbers (Minemura *et al.* 1995, 1998). The variability in luminance (i.e. darkness or lightness) is the primary cause of heartwood colour variability (Phelps *et al.* 1983). The dry and plantation samples exhibited higher values for lightness index (Table 2).

Mean colour values determined through CIE 1976 (L* a* b*) system are also presented in Table 2. Chromaticness index redness (a*) and yellowness (b*) together contribute the chroma or saturation of colour. The percentage luminance, lightness/brightness index, is represented by the symbol L*. The three factors L* a* b* were highly saturated in the plantation specimen. Teak from Nilambur is reputed for its colour in the trade as Malabar teak. This is in agreement with the findings of Wilkins & Stamp (1990) in eucalypts that more saturated wood colour is found in silviculturally treated trees. This also proves that site quality has influence on wood colour (Rink 1987). The dry site of home garden forestry also exhibited a similar pattern of greater luminance. The redness index (a*) of the wet site sample was comparable with that of dry and plantation samples. However yellowness value (b*) in the wet sample was less; hence, its low luminance index (L*) (Table 2). The wet site sample which were paler (less yellow) also differed significantly ($p < 0.05$) from the dry site and plantation specimens, which were more yellowish in colour. The same trend was observed in the visual comparison using Munsell system (Table 2).

Table 2 Comparison of mean colour values with standard deviations (in parenthesis) as determined by Munsell and CIE 1976 (L* a* b*) system for 35-year- old teak from home garden and plantation forestry ($n = 5$)

Location	Munsell system			L * a* b* system		
	Hue	Value	Chroma	L* (Lightness/brightness)	a* (Redness)	b* (Yellowness)
Wet	8.86YR [a]	5.06 [a]	3.48 [b]	52.338 [a]	6.35 [a]	21.13 [b]
	(0.207)	(0.36)	(0.19)	(3.46)	(0.44)	(0.91)
Dry	9.18YR [a]	5.24 [a]	3.82 [a]	54.038 [a]	6.37 [a]	23.4 [a]
	(0.4)	(0.3)	(0.25)	(2.94)	(0.60)	(1.34)
Plantation	8.78YR [a]	5.48 [a]	3.9 [a]	56.396 [a]	6.848 [a]	23.44 [a]
	(0.32)	(0.3)	(0.2)	(2.87)	(0.88)	(0.94)

The difference between mean values for each parameter with 'a' are statistically non-significant at $p > 0.05$

Wood produced from drier areas with darker coloured heartwood in teak is similar to fast-growing eucalypts in areas of high rainfall which produced lighter coloured heartwood (Hillis 1978). The paler colour (less yellowness) of the wet site sample was also correlated with accelerated fast growth in teak (Table 1). On appearance, the dry locality teak wood displayed characteristic darker heartwood with decorative black streaks, probably due to slower growth and higher amount of extractives as related to the site or edaphic factors (Bhat 2003, Thulasidas & Bhat 2003). This is in agreement with observations by Gierlinger *et al.* (2004).

Conclusions

Although the Munsell hue for wet site heartwood was comparable with that of dry and plantation specimens, the chroma value indicated less saturation of colour in the former. The chromaticness index yellowness (b*) of wet site sample as determined by CIE 1976 (L* a* b*) system differed significantly ($p < 0.05$) from the dry and plantation specimens displaying more yellowness. No significant difference was observed between samples of different localities with regard to brightness (L*) and redness (a*) ($p > 0.05$). The results indicated that 35-year-old teak grown in homesteads of wet and dry localities differed significantly from plantation grown teak in its main quality attributes such as wood colour. The wood colour along with other quality parameters such as poor log form, visual defects such as bends and sound knots and low sawn timber output from dry site might influence the price of the teak timber from home garden forestry.

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