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Short communications

Teak Log Grading for Teak Plantation in Lao PDR

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ABSTRACT

This research aimed to improve the grading system for Lao teak logs. The methodology used the guidelines from VALTIP2 project development, with parameters used to identify plantation teak log quality such as the proportion of hardwood, bend, pipe, knots, decay, end splitting, insect hole, wane, and metal objects. Out of 90 teak logs, 18 teak logs were in grade A, 27 teak logs in grade B, and 45 teak logs was grade C. The proportions of hardwood and knot defects were significant at $p<0.05$. Logs in grade A had no defects and teak quality depend on silviculture management, log grade A without criteria needs to include more defects such as swelling, routing, and termites because these three defects occurred often in teak logs. The Lao government has approved rules for log grading for native species in which there are four criteria log bend, log routing, swelling, and log decay and only a short time is required for log analysis. This research into a different method using Lao government criteria resulted in a more complex method and took a long time because the plantation teak logs were small and had many defects.

Keywords: Teak log, grading, measurement and improving

INTRODUCTION

Teak (*Tectona grandis* Linn.f.) forest represents 7% of the total forest cover worldwide. Generally, teak plantation produces one third of global industrial wood (International Timber Trade Organization, 2014). The total area of teak plantation is 5,716,203 ha and Asia (5,409,131 ha) has more than Africa (206,550 ha), Central America (76,000 ha), and Oceania (7,022 ha) (William, 2009). Teak plantation establishment commenced in Laos PDR in 1942 and there has been a strong increase since 1980. The total forest plantation area in Laos PDR is 378,708 ha. However, over the last 20 years, up to 50,000 ha of plantation teak and other species have been established in the northern and southern provinces of Laos PDR, primarily by small landholders (Department of Forestry, 2013).

Log grading is used to separate logs into different quality groups to provide a way in which buyers and sellers can agree on value. Log grading is very important for the farmer, processor, and trader. Log grading in Laos initially allowed for16 defects in the 1990s but that rule was updated in 1996 and was reduced to 9 defects and in 2007 was further updated which reduced the defects to 4 (Ministry of Agriculture and Forestry, 2007). Currently, there are two sets of grading rules used in Laos: one by the Burapha Company for plantation teak resource and the other is the government grading rules for native forest logs. However, the Burapha Company criteria use eight parameters heartwood proportion, fresh knot, dead knot (sound), rotten knot (diameter and percentage), bend, end crack, insect holes, and metallic objects whereas there are four parameters in the government criteria total sweep, fluting, want or wane, and pipe (Hopewell *et al.,* 2014). Iternational Standard Organization (1989) has different rules for plantation log grading with nine defects slope of grain, deviation of grain, reaction wood, dabble pith, removed pith, scar, in bark, cancer, and false heart-sapwood. Based on the comparison of log grading between government and company rules by Silipanya *et al.* (2014), the different methods resulted in different amounts in log grades. For example, the Government criteria produced 100 percent of grade A but the Company criteria resulted in 32 percent grade A, 33 percent grade B and 35 percent grade C. A review of the literature did not find any standard grading rules for plantation teak logs.

MATERIALS AND METHODS

The materials used for this research consisted of a meter, grading guidelines, camera, record form, ruler, string, marker and computer. The study was conducted in the Sangthong District, 70 km from the capital, Vientiane, where the Faculty of Forest Science has developed an area of 1,303 ha since 1996 for modeling reforestation and forest research. The total plantation area is 101 ha, with enrichment planting of 60 ha using more than 20 species and 32 ha of teak. Teak logs (2m length) were cut by chainsaw and the diameters at the top and bottom ends of the log were measured and averaged and the volume calculated for each log. The grading process followed the nine steps listed in Table 1.

Table 1 Teak log grading summary.

Criterion	Grade A	Grade B	Grade C
Heartwood proportion	> 80%	60-80%	< 60%
Bend	Maximum 3% (6 cm on 2.1 m log) no multiple bends	Maximum 5% (11cm on 2.1 m log) no multiple bends	No limit no multiple bends
Pipe	< 10%	10 – 20%	> 20 – 30% (> 30% reject)
Knot	Maximum 2 knots/m all < 5 cm/m diameter per 2.1 m length	Maximum 4 knots all < 5 cm diameter per 2.1 m length	No limit
Total end split	Total split < 10% log length measured both ends	Total split < 33% log length measured both ends	Total split >= 33% < 50% log length (> 50% reject) measured both ends
Decay	Not permitted		No limit
Insect holes/galleries	Not permitted		No limit
Want/wane	Visual estimate of face (log end) area <5%	Visual estimate of face (log end) area <20%	No limit
Metal objects	Not permitted		

Source: Hopewell *et al.,* 2014.

The heartwood proportion (HP) was calculated as the sum of the shortest and longest diameter (d_{hs}, d_{hl}) of heartwood divided by the total shortest and longest diameter under bark ($d_{ts,}$ d_{tl}) multiplied by 100 to obtain a percentage and the measurement technique is illustrated in Figure 1.

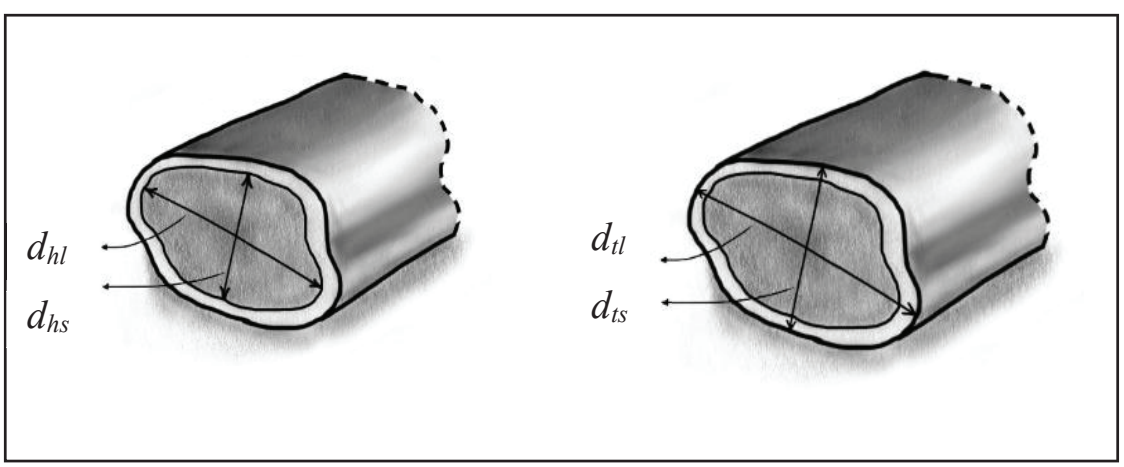

Figure 1 Heartwood proportion measurements (Hopewell *et al.,* 2014).

The percentage of log bend was calculated using the depth of curving (a) divided by length of the log then multiplied by 100 to obtain a percentage and the measurement technique is shown in Figure 2.

$$P = \frac{a}{L} \times 100$$

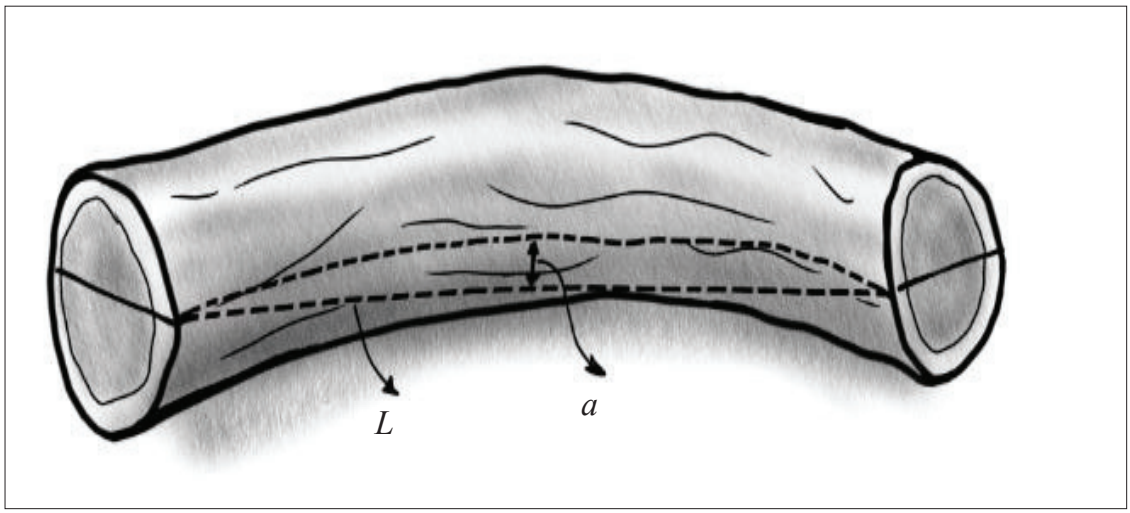

Figure 2 Bend measurements (round logs) (Hopewell *et al.,* 2014).

Pipe defect was calculated using the measured diameter of the hole (d) divided by the diameter of log (D) then multiplied by 100 to obtain a percentage and the measurement technique is shown in Figure 3.

$$P = \frac{d}{D} \times 100$$

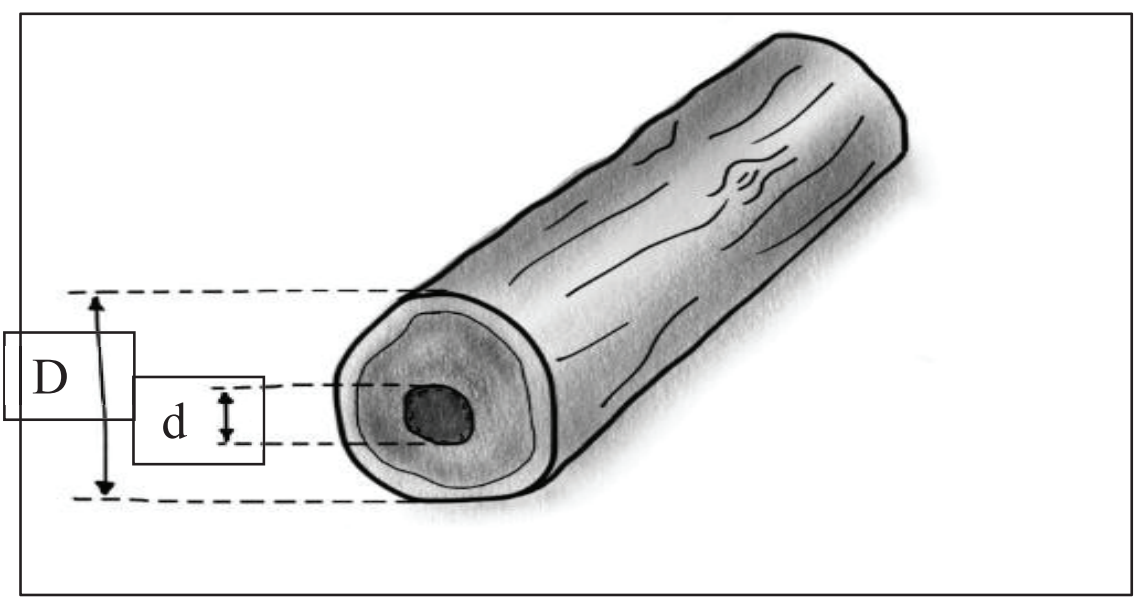

Figure 3 Pipe measurements (round logs) (Hopewell *et al.,* 2014).

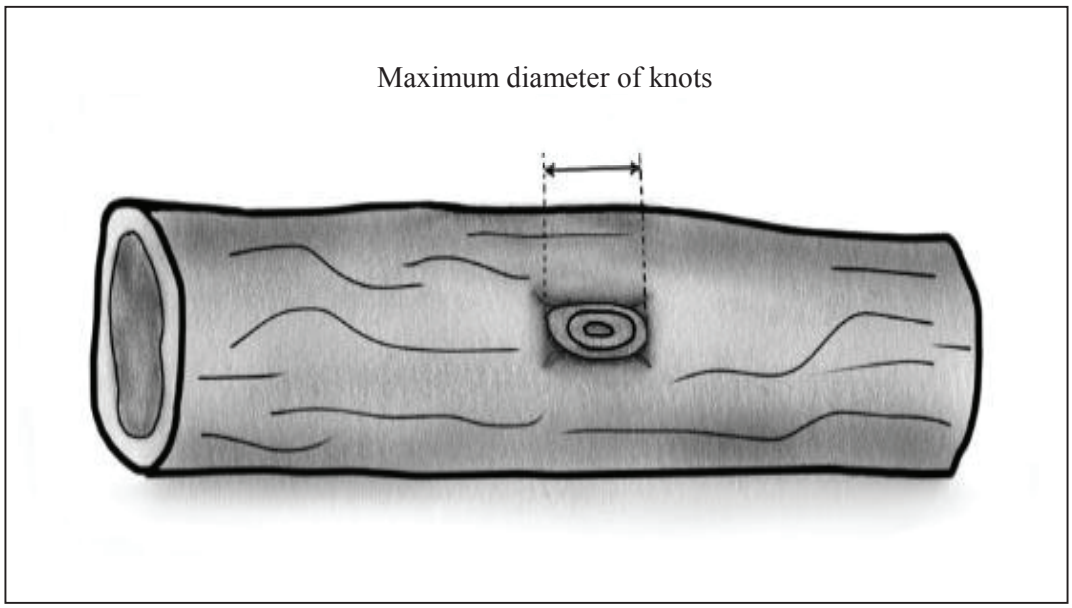

Figure 4 Knot measurements (round logs) (Hopewell *et al.,* 2014).

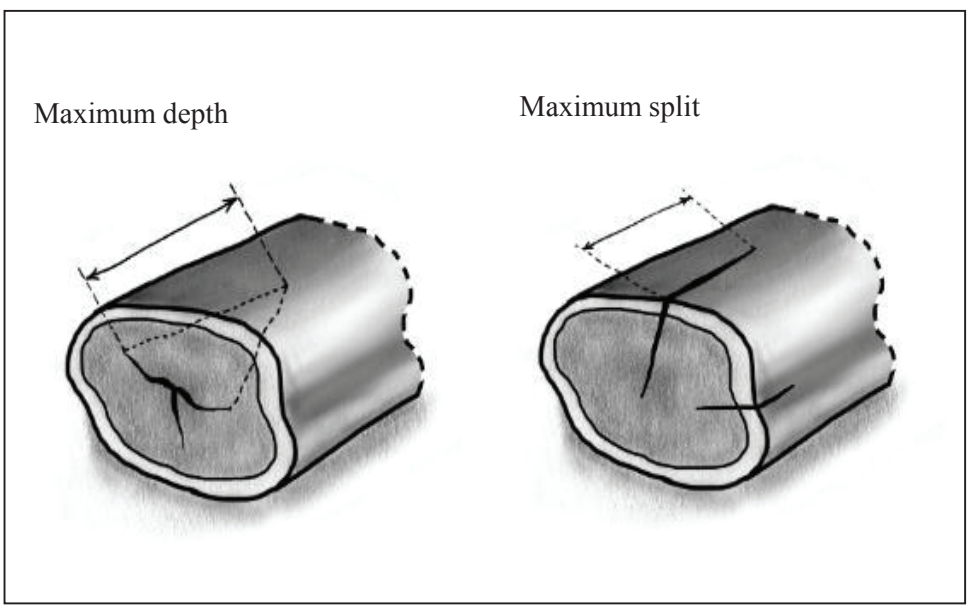

Figure 5 Internal end split measurement (Hopewell *et al.,* 2014).

RESULTS AND DISCUSSION

The method of Hopewell *et al*. (2014) was applied which was developed as part of the project "Enhancing Key Elements of the Value Chains for Plantation-Grown Wood in Lao PDR (VALTIP2)". This method has nine parameters ratio of hardwood, bend, pipe, knots, wane, decay, insect hole, end split, and metal objects. The teak was thinned from the plantation and crosscut into 2 m lengths, with 90 logs separated into three grades as shown in Table 2.

Table 2 Teak logs list from grading in 2 m log lengths.

Grade	Number of Logs	Average diameter (cm)	Volume (m^3)
A	18	21.65	1.3457
B	27	18.01	1.4593
C	45	16.43	1.9398

Grade A had the highest average diameter (minimum diameter 18.5 cm, maximum diameter 30 cm) and was usually a log from the base of the tree. Grade B had a medium average diameter (minimum diameter 14.7 cm, maximum diameter 25 cm) and grade C logs were the smallest from the top of the tree (minimum diameter 12.5 cm, maximum diameter 20.5 cm).

Defect occurred in the logs as knots because the teak had not been pruned. Teak log heartwood was 85.32 percent in grade A, 79.92 percent in grade B and 81.33 percent in grade C. Most of the logs were straight and only two logs were bent but it did not have a high impact. Teak knots had more impact on log grade; grade A had 2 knots per log, grade B had 4 knots per log and grade C had 6 knots per log, with 3 logs in grade 1, 22 logs in grade 2 and 45 logs in grade 3. Log end splitting was present in 3 logs in grade A and the length of split was 16.3 cm but in grades B and C this information was not available. Teak log wane occurred in one log and the other four defects were not found in the logs as shown in Table 3.

Table 3 Log defects.

Defects	Grade A		Grade B		Grade C	
	Average	defect log	Average	defect log	Average	defect log
Heartwood (%)	85.32	0	79.92	0	81.33	0
Bend (cm)	5	1	5	1	0	0
Pipe (cm)	0	0	0	0	0	0
Knot (N/log)	2	3	4	22	6	45
End Split (cm)	0	0	16.3	3	0	0
Wane (cm)	3.33	1	0	0	0	0
Decay	0	0	0	0	0	0
Insect hole	0	0	0	0	0	0
Metal object	0	0	0	0	0	0

Only two out of the nine parameters were significant *($P<0.05$)* in the grading processes ratio of hardwood and knots in the log. Teak log grade A (18 logs) had a mean heartwood of 85.32 percent, (minimum 80% and maximum 90%, standard deviation (SD) 3.02, standard error (SE) 0.71, and significance level (sig) 0.006). Teak log grade B (27 logs) had mean heartwood of 79.92 percent (SD 5.51, SE 1.06), and grade C (45 logs) had mean heartwood of 81.33 percent (SD 6.38, SE 0.95). There was a mean difference of 1.57 percent

between grades A and B (SE 1.70, sig 0.004) for grades A and C, the mean difference was 3.82 percent (SE 1.56, sig, 0.04) and between grades B and C the mean different was 1.74 percent (SE 1.36, sig 0.410 which was not significant as it was greater than 0.05).

Grade A had 1 knot on average per log (SD 0.66, SE 0.15), grade B had 2-3 knots per log (SD 1.53, SE 0.29), and grade C had 5-6 knots per log on average (SD 1.28, SE 0.19), and the results were highly significant because pruning was not conducted in the plantation. Therefore, the comparison among grades indicated grades A and B had a mean difference of 3 knots (SE 0.38, sig 0.00, which was highly significant). The comparison between grades A and C indicated a mean difference of about 6 knots (SE 0.35, sig 0.00, which was highly significant), and between grades B and C the mean difference was about 3 knots (SE 0.31 and highly significant). However, six criteria of defect were not found (pipe, split, wane, decay, insect hole, and metal object). There is a little more information on bend in Table 4.

Table 4 Multiple comparison of teak log defect.

Dependent Variable	Grade (I)	Grade (J)	Mean Difference (I-J)	Std. Error	Sig.	Remark
Hardwood	A	B	5.57*	1.70	0.004	*
		C	3.82	1.56	0.043	*
	B	C	-1.74	1.36	0.410	NS
Bend	A	B	0.09	0.22	0.911	NS
		C	0.27	0.20	0.374	NS
	B	C	0.18	0.18	0.562	NS
Knots	A	B	-2.42*	0.38	0.000	**
		C	-5.12*	0.35	0.000	**
	B	C	-2.69*	0.31	0.000	**

Table 5 illustrates that that the amount of heartwood in grade A was significantly different from grades B and C and that the knot defects in grades A, B, and C were highly significantly different.

Table 5 Duncan's analysis of heartwood and knot defect.

Defect	Grade	N	Subset for alpha = 0.05			F
			1	2	3	
Heartwood	B	27	79.70			5.405
	C	45	81.45			
	A*	18		85.27		
	Sig.		0.26	1.00		
Knots	A**	18	0.27			112.10
	B**	27		2.70		
	C**	45			5.40	
	Sig.		1.000	1.000	1.000	

Appropriate teak log grading needs improvement to some rules to increase wood quality and prices which may require grading processes including more than nine criteria such as teak color, teak fluting, and separate diameter classes and lengths. Raymond (2008) suggested including the dimensions of the log (diameter at both ends (or mid-diameter) and total length), cylindrical tendency (the more the log approaches a true cylinder in terms of roundness absence of fluting and low taper, the higher the quality); wood quality (percentage heartwood, color, homogeneity of color, number of rings per centimeter, strength and hardness are the primary characteristics of quality teak; durability is important particularly for certain end uses like garden furniture); and defects (the less defects that are present, the higher the log quality, where defects include knots, splitting, shake, heart rot, etc.). Log grading was separated into diameter classes using eight levels, with the minimum diameter beginning from 15 cm up to a final diameter of more than 50 cm, and the length of the log was divided into three classes: short (1-2.6 m), medium (2.6-5 m), and more than 5 m. In addition, there were four grades: A = logs straight, sound and cylindrical throughout the length; B = straight and sound logs without defects (not entirely cylindrical); C = log with minor defects; and D = log with defects. The Forest Industry Organization of Thailand has rules for teak log grading center log girth and length which based on Thai criteria of lengths and dimensions are related to price with a minimum log girth of 30 centimeter and length less than 2 m being USD 88 per cubic meter with more information on the application of these criteria shown in Table 2 (Forest Industry Organization, 2013). Eko *et al.* (2006) studied the small-diameter logs from community teak plantations in Java and Eastern Indonesia and reported the average heartwood portion of logs ranged from 52% to 78%. The average log with flute varied from 3.6% to 51.3%, while the average log with end split ranged from 23.1% to 61.1%. In comparison, logs from Perhutani's plantations in Cepu had an average heartwood percentage of 72%, logs with flute averaging 17% and logs with end split averaging 11%. All sources for grading teak log quality considered three points were significant, namely teak log quality, diameter, and length. Somyeeng (2004) studied log grading and merchantable volume of teak in Thong Pha Phum plantation, Kanchanaburi, Thailand and identified 13 parameters in 1,914 teak logs as detailed in Table 5.

Table 6 Thai criteria for teak defect analysis.

Type of Defects	Age range 12-17 years		Age range 18-26 years	
	Log No	Percentage	Log No	Percentage
No defects	1596	83.3	1569	78.4
Branches	37	1.9	47	2.3
Bend	101	5.3	164	8.2
Prong	91	4.8	132	6.6
Knot	6	0.3	14	0.7
Swelling	20	1	14	0.7
Route	5	0.3	9	0.4
Hollow	25	1.3	21	1
Groove	16	0.8	12	0.6
Hole	13	0.7	14	0.7
Fold	0	0	2	0.1
Termite	0	0	3	0.1
Two stems	4	0.2	0	0
Bark inner wood	0	0	1	0

Source: Somyeeng, 2004.

Thai teak plantations where pruning and thinning are undertaken can produce 83.3 percent of logs without defect in plantations aged 12-17 years and 78.4 percent in plantations aged 18-26 years. Comparing the Thai criteria with the Lao criteria developed by Hopewell *et al*. (2014), teak knots in Laos occurred on 70 of 90 logs or 77.77 percent but Somyeeng (2004) in Thailand reported 0.3 and 0.7 percent of knot defect. Teak plantations need to be managed by pruning to reduce teak knot defects and to increase teak log quality.

CONCLUSION

Log grading rules applied to 90 teak logs resulted in 18 logs being in grade A, 27 logs in grade B and 45 logs in grade C. Of nine parameters suggested for identifying log defect, the major ones were: the percentage of hardwood (grade A 85.32%,grade B 79.92% and grade C 81.33%); bend defect (2 logs in grades A and B, maximum 5 cm); and knot defect (70 of 90 logs).

At establishment, the ANOVA revealed that some defects presented significant differences ($p< 0.05$) in the proportion of hardwood and knot defects, though there was were no significant differences for seven parameters. Recommendations from the current research are that teak log grade A needs improving to be defect free. Pruning and thinning are good silvicultural options for improving log quality because both activities can reduce the knot defect and straighten the teak stem. Finally, more than three criteria need to be considered in the grading with consideration given to including swelling, bark inner, and termite defects.

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