CHARACTERISATION OF ACACIA AND EUCALYPTUS PLANTATION WOOD FOR VENEER PRODUCTION IN VIETNAM

Trinh Hien Mai[1], Adam Redman[2]
[1] *Vietnam National University of Forestry*
[2] *Department of Agriculture and Fisheries (DAF), Australia*

SUMMARY

This study presents the characterisation of three most commercially common Vietnamese hardwood plantation *Acacia mangium*, Acacia hybrid (*Acacia mangium × Acacia auriculiformis*), *Eucalyptus urophylla*) for veneer production. The aim of the study was to provide the veneer processing industry with linkages between current hardwood plantation resource characteristics and utilisation potential. Research results indicated that some species appear to perform better than others in terms of peeled veneer quality dependent on the final utilisation of the veneer or veneer based products. *Eucalyptus urophylla* produces veneer with higher stiffness and a higher proportion of stiffer material than the other species at a similar age, may be more suitable for structural products than the other species. Net recovery, which indicates the saleable volume recovered, varied between 49% and 55%, approximately double that reported for solid wood processing (sawmilling) of similar diameter and plantation species. A very high proportion of the recovered veneer meets the requirements of D-grade in accordance with Australian and New Zealand standard AS 2269.0:2012, only a small proportion meets the requirements of higher grade qualities, with the exception of 14 and 19-year-old *Eucalyptus urophylla*. In addition, a grading system for peeled logs in Vietnam was proposed in this study.

Keywords: *Acacia mangium,* Acacia hybrid*, Eucalyptus urophylla*, grade veneer, recovery.

1. INTRODUCTION

Vietnam has over 3 million hectares of plantation forests comprised of acacias (the most significant plantation species with a cover of approximately 43%, mainly *Acacia mangium, Acacia auriculiformis* and *Acacia* hybrids (*Acacia mangium × Acacia auriculiformis*), eucalypts (mainly *Eucalyptus urophylla*), rubberwood (*Hevea brasiliensis*), pine (*Pinus spp.*) and several fast-growing natives. The majority of these plantations were established to provide wood chip for the pulp and paper industry. However, in recent years there has been an emerging interest in conversion of the plantations into higher value export products such as sawn wood and veneer based products for furniture components, structural plywood, laminated veneer lumber (LVL), form ply and packaging.

Veneer processing is a large established industry in Vietnam. Since 2010 it was estimated that there were 6,224 enterprises and households participating in veneer processing and/or veneer-based products manufacture. A Vietnamese standard for grading veneers - TCVN 10316:2014 has been established, however, there is no widely used grading system for determining veneer log qualities. The implementation of a log grading standard, or widely adopted non-standardised system, will help align log quality with processing and product requirements, potentially producing better quality end products. A log grading system also allows for the implementation of a log purchasing cost structure.

The objectives of this research were to characterise the current *A. mangium*, *Acacia* hybrid *(A. mangium × A. auriculiformis)* and *E. urophylla* resource and to determine the peeled veneer quality. In addition, the study required feedback to the growers to improve current silvicultural and genetics work being undertaken in association with ACIAR projects in Vietnam (Redman et al., 2016). The study also provided data to define log grading standards for veneer logs and assisted in optimising veneer processing methods and product development.

2. RESEARCH METHODOLOGY

Plantation resource

The three plantation species were chosen based on the current and projected high volume of material for commercial use. These were: *E. urophylla, A. mangium* and an Acacia hybrid (*A mangium* × *A. auriculiformis*). Nine sites, three sites for each species were chosen for the study. At each site the trees were either of a different age or were grown under a different silviculture regime. All trees were of the appropriate age/size class representative of material currently in use for veneer production in Vietnam. Details of each trial site-species, age, location, stocking rate, thinning history, soil type, elevation are in table 1. All sites were considered to be flat.

Table 1. Trial site details

Species	Age (yrs)	Location	Original stocking rate (spha)	Thinning history	Soil	Elevation (m)
Acacia hybrid	7	Ba Vi, Ha Noi (21°05.572'N, 105°20.191'E)	2,000	unthinned	basalt	70
	11 (i)	Cau Hai, Phu Tho (21°32.768'N, 105°13.12'E)	1,100	To 800 spha at 8 yrs.	ferralite	200
	11 (ii)	Ba Vi, Ha Noi (21°06.952'N, 105°19.973'E)	1,500	unthinned	laterite	70
A. mangium	6	Ba Vi, Ha Noi (21°05.572'N, 105°20.191'E)	2,000	unthinned	basalt	70
	9	Cau Hai, Phu Tho (21°32.848'N, 105°11.273'E)	2,000	To 1,650 spha at 6 yrs.	ferralite	200
	14	Ba Vi, Ha Noi (21°07.902'N, 105°22.679'E)	1,500	unthinned	laterite	70
E. urophylla	11	Cau Hai, Phu Tho (21°32.462'N, 105°12.193'E)	1,100	To 800 spha at 8 yrs	ferralite	200
	14	Ba Vi, Ha Noi (21°10.575'N, 105°22.028'E)	not provided	unthinned	laterite	70
	19	Ba Vi, Ha Noi (21°09.437'N, 105°20.602'E)	1,700	To 570 spha at 2 yrs	ferralite	70

Note: As there are two 11-year-old *Acacia* hybrid sites, they are labelled 11(i) and 11(ii)

Peeled veneer assessments

The location of each trial plot was primarily based on soil, weather conditions and silviculture regime applications. At each location a plot of 15 m radius was established. Within each plot approximately 30 trees were randomly selected. Within the same plot a smaller subset of trees-enough to provide approximately 20 peeled logs-were randomly selected (using a random number generator) for harvesting and merchandising.

Peeler logs were transported to the Tien Phat Company's processing factory for peeling. The factory is located approximately 20 km North of Hanoi (Chuong My, Hanoi, Vietnam).

Logs were trimmed to a length of 1.3 m, rounded and peeled using a Ming Feng Chinese brand spindleless lathe. The target veneer sheet dimensions were 2.8 mm thick × 1.3 m (same as log length) × 0.95 m. The dimensions of each sheet were recorded to determine veneer recovery.

Green recovery provides a useful measurement of the maximum recovery possible taking into account log geometry (sweep, taper, roundness which affect rounding requirements) and lathe limitations (*e.g.* peeler core size and, length of ribbon wasted before desired thickness is achieved). Green recovery disregards internal log quality. Green veneer recovery (*GNR* %) was calculated as follows:

$$GNR = \frac{\sum_{i=1}^{n}(L_{ibillet} \times (WG_{ibillet} - WG_{iwaste}) \times TG_{ibillet})}{\sum_{i=1}^{n} V_i} \quad (1)$$

where $L_{ibillet}$ is the peeled billet length (m), $WG_{ibillet}$ is the total veneer ribbon width for a single billet (m, perpendicular to the grain), WG_{iwaste} is the width of veneer sheets from a single billet with major defects (*i.e.* wane, undersize thickness or too short) (m, perpendicular to the grain), $TG_{ibillet}$ is the average green veneer thickness taken from all measurements for a single billet (m), V_i is the individual billet volume, and n is the number of billets per trial.

After determining the green veneer recovery, the veneer sheets were air-dried for 2 to 3 days to a moisture content of approximately 25% before final drying in a steam-heated 30-daylight press dryer at 100°C for 30 minutes to a final moisture content target of 10%. Dried *veneer stiffness* was measured using an acoustic Bing tool as described by Brancheriau and Baillères (2002). The Bing device determines the dynamic modulus of elasticity (MoE) by analysing the natural vibration spectrum. To measure MoE, one end of the veneer (0.15 m in tangential direction × 1.3 m in longitudinal direction × 2.8 mm thick) was struck with a hammer and the dynamic aural signal was recorded using a microphone positioned at the other end of the veneer.

Veneer quality was assessed by visual grading in accordance with AS/NZS 2269.0:2012 (Australian and New Zealand standard, 2012). The veneer sheet dimensions for grading were 2.8 mm thick × 1.3 m (same as log length) × 0.80 m. This standard separates structural veneer into four main veneer surface qualities according to absence or severity of imperfections and defects (Table 2). The grade limiting defects assessed included: loose knots, sound knots, holes, gum veins, kino, insect tracks, splits, discolouration, bark pockets, compression, roughness, grain breakout, cumulative defects and wane.

Table 2. Veneer quality grade descriptions

Veneer grade	Description
A	A high quality appearance grade veneer suitable for clear finishing. This appearance grade quality should be specified for the face veneer in plywood where surface decorative appearance is a primary consideration.
B	An appearance grade suitable for high quality paint finishing. This face veneer quality should be specified for applications requiring a high quality paint finish.
C	Defined as a non-appearance grade with a solid surface. All open defects such as knot holes or splits are filled. Plywood with a quality C face is designed specifically for applications requiring a solid non-decorative surface such as in plywood flooring which is to be overlaid with a decorative flooring surface.
D	Defined as a non-appearance grade with permitted open imperfections. Plywood manufactured with face veneer quality D is the lowest appearance grade of plywood. It is designed specifically for structural applications where decorative appearance is not a requirement e.g. structural plywood bracing.

Dried veneer dimensions were measured to calculated veneer gross and net recoveries as described by McGavin (2017).

Gross veneer recovery provides a useful measurement of the maximum recovery of dried, graded veneer that meets the quality specifications of AS/NZS 2269.0:2012 (A-grade to D-grade). The F-grade is used for veneers failing to meet the lowest D-grade. This recovery includes the losses accounted for in green veneer recovery but also includes additional losses from visual grading (i.e. veneer that failed to meet grade) and the drying process (*e.g.* veneer shrinkage, splits etc.). Gross veneer recovery (GSR%) was calculated as follows:

$$GSR = \frac{\sum_{i=1}^{n}(L_{ibillet} \times WD_{iveneer} \times TD_{iveneer})}{\sum_{i=1}^{n} V_i} \quad (2)$$

where $WD_{iveneer}$ is the width (m, perpendicular to the grain) of dried veneer sheets from a single billet that meets the grade requirements of A, B, C, D grades in accordance with AS/NZS 2269.0:2012, $TD_{iveneer}$ is the average thickness of dried veneer sheets from a single billet that meet the grade requirements. $WD_{iveneer}$ was not measured as part of the study but was calculated using the green width of veneer sheets and a nominal tangential shrinkage value of 7%, a reported average for these species Bootle (2005).

Net veneer recovery provides a useful measurement of process efficiency, as it identifies the saleable product, taking into account the product manufacturing limitations. Net veneer recovery includes the losses accounted for in gross recovery but also includes the additional losses due to the trimming of veneer before, during and after product manufacture. The final plywood product size produced by the Tien Phat factory is 1,220 x 2,440 mm. The loss incurred when veneer sheets are reduced in width and length to the final product size is known as the trimming factor. In this study the length trimming factor was 1,220/1,300, which corresponds to reducing the veneer sheet parallel to the grain from 1,300 mm to 1,220 mm. The average width (perpendicular to the grain) of individual veneer sheets for all trials was 910 mm. Three sheets layed up side by side are required to meet the final veneer width of 2,440/(3*910)/mm, which corresponds to reducing the veneer sheet parallel to the grain from 2,730 mm to 2,440 mm. Net recovery (NR%) was calculated as follows:

$$NR = GSR \times \frac{1220}{1300} \times \frac{2440}{2730} \quad (3)$$

thus $NR = GSR \times 0.77002$ (4)

3. RESULTS AND DISCUSSION

3.1. Recovery

Green recovery

Green veneer recovery provides a useful measurement of the maximum recovery possible taking into account log geometry (sweep, taper, ovality) and lathe limitations (e.g., peeler core size) (Pham and Nguyen, 2004). Green veneer recovery disregards internal log quality. Green veneer recovery, for each species and age class, expressed as a percentage of billet volume, is presented in table 3.

Green recoveries were similar across species and age groups varying between 68 and 76% which is about twice the comparable recovery (green-off-saw, GOS) achieved when processing similar plantation resources using traditional, sawing techniques. For example Leggate et al. (2000) reported the green-off-saw recovery for solid wood processing (i.e. sawmilling) of six Queensland, Australia plantation sites (three species) as between 32.3 and 42.9%.

Table 3. Green recovery for three tree species aged 6 - 19 years

Species	Age (yrs)	Green recovery (%)
	7	72
Acacia hybrid	11 (i)	76
	11 (ii)	72
	6	74
A. mangium	9	67
	14	73
	11	72
E. urophylla	14	68
	19	78

Gross and net recovery

Gross veneer recovery provides a useful measure of the maximum recovery of dried, graded veneer that meets the relevant quality specifications; for example: AS/NZS 2269.0:2012 (A-grade to D-grade). Net veneer recovery provides a useful measurement of process efficiency, as it identifies the saleable product, taking into account the product manufacturing limitations. Net veneer recovery includes the losses accounted for in gross recovery but also includes the additional losses due to the trimming of veneer before, during and after product manufacture.

Table 4 presents the gross and net recovery values for each species and age group. Recovery values are consistent between species and age groups. Net recovery, which indicates the saleable volume recovered, varied between 49% and 55%. By comparison to solid wood processing, Leggate et al. (2000) reported net grade recovery values of between 8% and 19% for six plantation sites (three species). This suggests that rotary veneer processing has the potential to recover up to six times the volume of saleable product from the young plantation species when compared to classical sawmilling techniques. *E. urophylla* showed a slight increase in net recovery with increased age, whereas no significant difference was recorded for the other species.

Table 4. Gross and net recovery in veneer produced from three tree species aged 6 - 19 years

Species	Age (yrs)	Gross recovery (%)	Net recovery (%)
	7	60	50
Acacia hybrid	11 (i)	64	54
	11 (ii)	60	50
	6	62	52
A. mangium	9	59	49
	14	59	50
	11	61	51
E. urophylla	14	64	54
	19	65	55

The green, gross and net veneer recoveries are all in the same order of magnitude as those presented by Mc Gavin et al. (2014) for a range of Australian plantation eucalypt species also peeled using spindleless lathe technology.

3.2. Veneer Modulus of Elasticity

Stiffer veneer has better structural properties than low stiffness veneer and structural veneer based products are usually ranked and sold on their average stiffness properties, with stiffer structural products being generally more profitable.

Average veneer stiffness tends to increase with increasing age for each species before plateauing around age 14 years (see Table 5). This trend is indicative only as limited sites were investigated. Similar to the log stiffness results (Trinh et al., 2015), *E. urophylla* is considerably stiffer than the acacia species but also produces veneer with a wider stiffness variation. Larger variation in minimum and maximum veneer stiffness is expected for older plantations as older trees contain a higher proportion of stiffer outer wood as well as lower stiffness internal wood.

Table 5. Modulus of elasticity (MoE) in veneer produced from three tree species aged 6 - 19 years

Species	Age (yrs)	MoE *(MPa)
Acacia hybrid	7	9,822 (1,664)
	11 (i)	11,568 (2,244)
	11 (ii)	13,039 (1,951)
A. mangium	6	8,664 (1,481)
	9	10,871 (1,615)
	14	10,933 (1,972)
E. urophylla	11	9,789 (2,919)
	14	14,880 (3,874)
	19	13,836 (2,822)

* standard deviation is presented in parenthesis

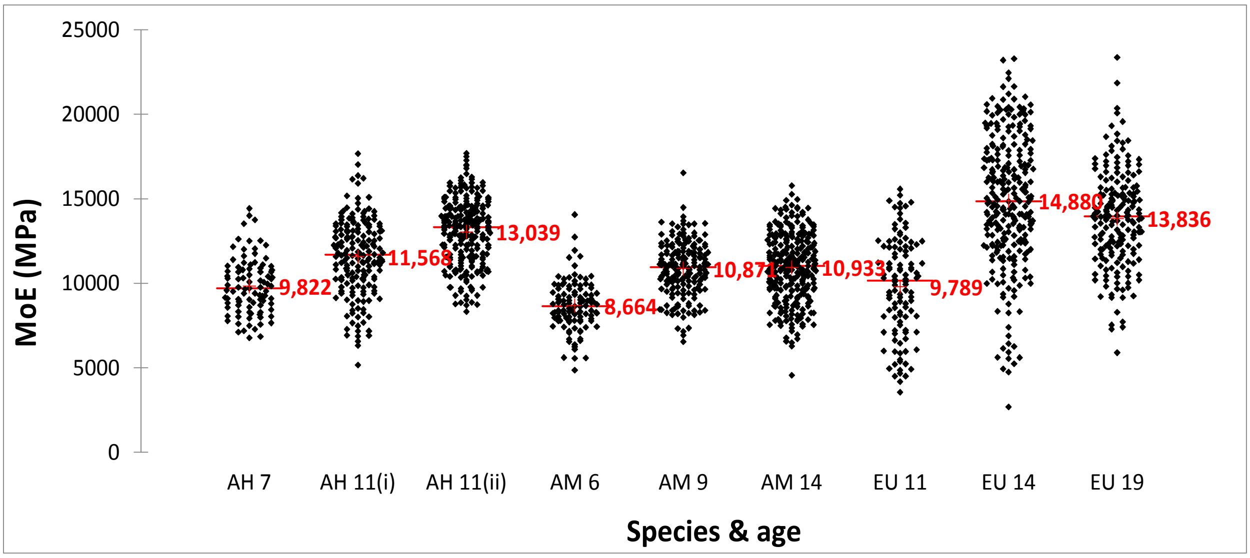

Figure 1. Distribution of veneer sheet stiffness (MoE)

3.3. Grade quality

Grading veneer for quality assessment, provides forest growers and processors with important information to characterise the resource and potentially improve veneer grade quality. Forest growers are able to use the grading natural feature information to improve forest practices and silviculture, and similarly veneer processors can use the process related defect data to improve processing practices. Additionally, grading provides processors with a means to estimate the economic value of the resource and optimal product utilisation.

Table 6 shows the veneer grading results for each species and age group, presented as the percentage of log volume. Across all species, loose knots have the most influence in restricting veneers from attaining a grade higher than D-grade (according to AS/NZS 2269.0:2012). Other defects common across all species and contributing to preventing veneers from attaining higher grades than D-grade are sound knots, cumulative defects, holes, grain breakout and roughness. The latter two are potentially influenced by the manufacturing process and therefore there is great opportunity to further optimise the process through the introduction of log pre-conditioning and lathe setup to reduce the defects.

Sound knots are a common defect, given the trees are relatively young and small in diameter. In general these knots are very small and are scattered in distribution rather than concentrated. Small and scattered knots will have the least amount of impact on structural properties (i.e. strength). Increased proportions of B-grade and C-grade veneer with increasing age were most evident for 19-year-old *E. urophylla*. These results are expected as the proportion of knot affected wood in the lower part of the tree decreases with age, due to natural and/or mechanical pruning of lower tree branches and subsequent occlusion of branch stubs with sound wood over time.

Table 6. Graded veneer (as a percentage of log volume) produced from three tree species aged 6 - 19 years

Species	Age (yrs)	A-grade (%)	B-grade (%)	C-grade (%)	D-grade (%)
	7	0	0	2	48
Acacia hybrid	11 (i)	0	<1	<1	52
	11 (ii)	0	1	1	48
	6	0	0	3	47
A. mangium	9	0	2	6	41
	14	0	1	4	45
	11	0	0	0	51
E. urophylla	14	1	11	14	28
	19	0	20	6	29

The recovery of lower grade veneers dominates across all sites with D grade veneers contributing to over 52% (and up to 100%) of the net recovery in all sites. For the acacia species, only a very small proportion of veneers met the B and C grade requirements. For the *E. urophylla* species, however, the proportion of B-grade veneer increased substantially with age from zero to 20% of the total recovery (or 36% of the net recovery) from ages 11 to 19. According to AS/NZS 2269.0:2012 B-grade structural veneer is suitable for face veneer and consequently could achieve a higher price. While D grade is the lowest visual grade quality for structural veneer, the veneers are suitable for face veneers on non-appearance structural panels as well as the core material for the vast majority of appearance and non-appearance structural panels.

3.4. A peeler log grade classification for Vietnam

Vietnam currently does not have a widely-used, standardised veneer log grading system for peeler logs. However, an assessment was conducted by researchers who were from project partner organisations within the ACIAR project which also reviewed the veneer log grading rules in typical Vietnamese companies (Ozarska et al., 2012). On the basis of this research project, a grading system relevant to processing small acacia and eucalypt plantation veneer logs was proposed for Vietnam (Table 7). The proposed peeler log grading system for Vietnam incorporates two grades; grade A and grade B, where grade A is of higher quality. For a log to meet grade A classification, all grade criteria must meet grade A classification. For instance, if one criterion meets class B then the log is classed as a grade B log. If a log displays a criterion outside either the grade A or grade B classification, it is considered a reject log, not fit for peeling. Special consideration may be given to accepting reject-logs, depending on the company and client specifications.

Table 7. Proposed grading system for peeler logs in Vietnam

Criteria	Grade A	Grade B
Knot	maximum diameter ≤ 10 cm	unlimited
Bend	maximum 3% – no multiple bends	maximum 4% – no multiple bends
Total end-split	total split ≤ 10% log length	total split ≤ 20% log length
Holes/insect holes	maximum diameter ≤ 5 mm	maximum diameter ≤ 20 mm
Decay	not permitted	permitted
Mould	not permitted	permitted
Metal objects	not permitted	not permitted

A log is assigned the grade resulting from the lowest grade encountered for each criterion. The metal object criterion is included to prevent peeling logs that have imbedded metal objects such as nails, fencing wire etc. Peeling logs with imbedded metal objects can cause severe damage to the lathe and injury to machine operators. There is no minimum diameter and/or log length proposed in the log grading specifications because this is subject to the limitations of machinery and should be specified separately by the independent processor or log buyer. For example, log specifications will vary depending on whether the lathe is spindled, spindleless or a hybrid type.

Generally Vietnamese companies are using spindleless lathes to peel their veneer. Spindleless lathes are favoured because they are capable of processing small diameter logs. Some companies in Vietnam are using eucalypt logs less than 8 years old from plantation forests with minimum diameters as small as 10 cm. Ideally, logs should be processed as soon as possible after harvesting, although sometimes longer storage can help by relieving growth stresses. Timely log processing is especially important in warmer climates where measures must be taken to maintain log quality suitable for producing quality veneers. This would certainly be the case in Vietnam.

4. CONCLUSIONS

Research results indicate that some species appear to perform better than others in terms of peeled veneer quality dependent on the final utilisation of the veneer or veneer based product. *E. urophylla*, which produces veneer with higher stiffness and a higher proportion of stiffer material than the other species at a similar age, may be more suitable for structural products than the other species. Net recovery, which indicates the saleable volume recovered, varied between 49% and 55%, approximately double that reported for solid wood processing (sawmilling) of similar diameter and plantation species.

A very high proportion of the recovered veneer met the requirements of D-grade in accordance with AS/NZS 2269.0:2012 with a small proportion meeting the requirements of higher grade qualities, with the exception of 14 and 19-year-old *E. urophylla*. The 14- and 19-year-old *E. urophylla* veneer showed promise achieving much higher proportions of the better B- and C-grade veneers with 20% of B-grade (face veneer) attained for the 19-year-old plantation. These results lend the hardwood veneer to be used in mainly non-appearance structural plywood products and/or core veneers. Another option to improve the visual grade quality is through defect docking, veneer jointing or multilaminar veneer production for furniture manufacture.

While the study has demonstrated that high quality veneer can be processed from young, fast-grown plantation hardwood and a range of veneer-based composite products can be manufactured with desirable structural qualities, certain species have qualities better suited to certain products. The inclusion of site information for each species and age class can be used by forestry researchers to further investigate the potential to improve site and clonal selection for longer-term breeding programs based on some of the tree, log and veneer grade quality and property trends presented in this study. Additional research is necessary to establish economic profitability parameters around veneer quality, rotation age and manufactured products.

Acknowledgements

The authors acknowledge the financial and in-kind support of all collaborators involved in the project and funding provided by the Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia.

REFERENCES

1. Adam Redman, Henri Bailleres, Gary Hopewell (2016). *Final report - Enhancement of veneer products from acacia and eucalyptus plantations in Vietnam and Australia*, the ACIAR project FST/2008/039.

2. Australian and New Zealand Standard *AS/NZS 2269.0:2012: Plywood-Structural-Specifications*. SAI Global Limited. www.saiglobal.com

3. Brancheriau L. and Bailleres H. (2002). Natural vibration analysis of clear wooden beams: a theoretical review. *Wood-science-and-technology 36(5)*: 367–383.

4. Barbara Ozarska, Nguyen Thanh Tung, Gerry Harris, Heiko Woerner (2012). Assessment of the current capabilities of the veneer processing and manufacturing companies in Vietnam. *Report of the ACIAR project FST/2008/039* "Enhancement of veneer products from acacia and eucalyptus plantations in Vietnam and Australia".

5. Bootle, K.R. (2005). *Wood in Australia – Types, properties and uses*, Edition 2. McGraw Hill, Sydney. 452 pp.

6. Leggate, W., Palmer, G., McGavin, R. and Muneri, A. (2000). Productivity, sawn recovery and potential rates of return from eucalypt plantations in Queensland. *Paper submitted to the IUFRO Conference*, The Future of Eucalypts for Wood Products, Launceston, March 2000.

7. McGavin R.L., Bailleres H., Lane F., Blackburn D., Vega M., and Ozarska B. (2014). Veneer recovery analysis of plantation eucalypt species using spindleless lathe technology. *Bioresources 9(1):* 613–627.

8. McGavin R.L. (2017). Section 8: *Veneer recovery* in A guide to manufacturing rotary veneer and products from small logs. *Aciar Monograph 182*.

9. Phạm Van Chuong and Nguyen Huu Quang (2004). *Wood – based panel production technology.* Agricultural publishing House, Hanoi, 2004.

10. Trinh Hien Mai, Adam Redman, Nguyen Thanh Tung, Nguyen Quang Trung, Henri Bailleres (2015). *Standing tree and log assessment of Acacia mangium, Acacia hybrid and Eucallyptus Urophylla*. Proceedings of the Conference on "Hardwood processing" September 2015, Quebec, Canada, ISBN 978-0-86488-571-5.

11. Vietnamese Standard *TCVN 10316:2014 Rotary Veneer*. Standard translated into English language by Vietnam National University of Forestry.

ĐẶC ĐIỂM CỦA GỖ KEO VÀ BẠCH ĐÀN RỪNG TRỒNG SỬ DỤNG CHO SẢN XUẤT VÁN BÓC Ở VIỆT NAM

Trinh Hien Mai[1], Adam Redman[2]

[1]*Trường Đại học Lâm nghiệp*

[2] *Cục Nông nghiệp và Thủy sản (DAF), Úc*

TÓM TẮT

Bài báo trình bày đặc điểm của 3 loại gỗ lá rộng rừng trồng phổ biến ở Việt Nam, bao gồm Keo tai tượng, Keo lai và Bạch đàn urophylla cho sản xuất ván bóc. Mục đích của nghiên cứu là cung cấp mối liên hệ giữa đặc điểm của nguồn nguyên liệu gỗ rừng trồng và khả năng sử dụng chúng cho công nghiệp sản xuất ván bóc. Kết quả của nghiên cứu cho thấy: Chất lượng ván bóc của một số loài tốt hơn các loài khác và việc phân loại chất lượng của ván bóc còn phụ thuộc vào sử dụng của ván bóc và sản phẩm từ ván bóc. Gỗ Bạch đàn urophylla có thể sản xuất ra ván bóc có độ cứng cao hơn những loài khác ở cùng độ tuổi, vì vậy phù hợp cho sản xuất các sản phẩm chịu lực. Tỷ lệ thu hồi ván bóc (tính cho đến khi sản xuất thành sản phẩm) dao động từ 49 - 55%, xấp xỉ gấp 2 lần so với tỷ lệ thu hồi khi sản xuất từ gỗ nguyên của cùng một loài và cùng cấp đường kính. Một tỷ lệ lớn ván bóc đạt cấp chất lượng loại D theo tiêu chuẩn AS/NZS 2269.0:2012, chỉ một tỷ lệ nhỏ của ván bóc đạt cấp chất lượng cao hơn, riêng với Bạch đàn urophylla ở cấp tuổi 14 và 19 thì kết quả khác với kết quả chung này. Bên cạnh đó, trong nghiên cứu này, một hệ thống phân loại gỗ khúc dùng để bóc ở Việt Nam đã được đề xuất.

Từ khóa: Bạch đàn urophylla, Keo tai tượng, Keo lai, phân loại ván mỏng, tỷ lệ thu hồi.

Received	**: 30/5/2018**
Revised	**: 03/9/2018**
Accepted	**: 11/9/2018**