EXTERNAL CHARACTERISATION OF PEELED VENEER FROM SOME PLANTATION SPECIES IN VIETNAM

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SUMMARY

Three Vietnamese plantation species *Acacia mangium,* Acacia hybrid (*A. mangium x A. auriculiformis*) and *Eucalyptus urophylla* in total nine sites (three sites per species) were chosen for this study. Each site had a different silvicultural or age regime and meet the requirements for veneer production. The largest trees in each site were harvested for peeled veneer trials with the veneer sheet dimensions were 2.8 mm thick × 1300 mm (same as log length) × 800 mm, then the veneer sheets were dried to a moisture content of 10% before assessment of knot and split characterisation and quality grading. The research results indicated that: The average number of knots in veneer sheet measured for each species tends to decrease with increasing age. The older *E. urophylla* plantations produced veneer with the least number of average knots, followed by *A. mangium* and then Acacia hybrid. Acacia hybrid produced higher levels of large knots (> 3 cm) compared to the other species investigated. The average number of end splits for the acacia species reduced with age but progressively increased with age for *E. urophylla*. The percentage of veneer affected by end split was lowest for the oldest *A. mangium* and *E. urophylla* plantations tested. The veneer grading was performed in accordance with Australian and New Zealand Standard AS/NZS 2269.0:2012. Loose and sound knots were the main reasons for preventing veneers achieving a grade quality higher than D-grade. Other defects common across all species and contributing to preventing veneers from attaining higher grades than D-grade are cumulative defects, resource holes, grain breakout and roughness. The latter two are considered manufacturing defects and therefore there is great opportunity to further optimise the process through the introduction of billet conditioning (steaming or boiling), lathe setup etc. to reduce these defects.

Keywords: Acacia, eucalyptus, knot, quality grading, split, veneer.

1. INTRODUCTION

With the growing demand of veneer-based products worldwide, veneer and plywood have become the dominant wood-based panel type, its capacity was 174 million m^3 representing 42% of all wood-based panel production in 2016, an increase of 32% from 2012 (FAO, 2016). According to the statistic data in forest production and trade field of Food and Agriculture Organization of the United Nations, Vietnam produced 1,050,000 m^3 veneer and exported 740,399 m^3 veneer in 2017 (FAO, 2017). The veneer and veneer-based products production in Vietnam has been increased in recent years. Currently, most plantation wood in Vietnam is being used for wood chip (pulp and paper feedstock) and construction materials (solid wood). A lesser proportion of plantation resource is being used for furniture making and other value-added products such as veneer and veneer-based products. The study from Hopewell *et al.* (2008) showed that the conversion of plantation hardwood into veneer can yield significantly higher recoveries when comparing with sawn timber processing. To promote the value of veneer-based products from plantation forest resources, it is necessary to study the effect of species, harvested age, site, silvicultural history, etc. on quality of veneer. The study of Vega *et al.* (2016) pointed out site had a significant effect on splitting, and upper logs split more than lower logs with storage, splitting increased with tree diameter breast height (DBH), but this relationship varied with site. Peng *et al.* (2014) suggested the improvement in veneer sheet quality could be achieved by pruning either just before or after the branch death. McGavin *et al.* (2014) identified the grade D, the lowest visual grade quality for structural veneer according to Australian and New Zealand Standard AS/NZS

2269.0:2012 was dominated across all eucalypts plantation species veneers in Laos.

Acacia mangium, Acacia hybrids (*Acacia mangium* × *Acacia auriculiformis*), eucalypts (mainly *Eucalyptus urophylla*) are of three main plantation wood species in Vietnam used for veneer production. The geometry, natural defects and other characteristics of standing trees and logs of these species were presented in a previous work (Trinh *et al.* 2015), the veneer stiffness, veneer recovery were studied by Trinh and Redman (2018). This study is a connection of above work and to give a picture of outside characteristics including knot, end splits and grading of the peeled veneer produced from three main plantation wood species in Vietnam.

2. MATERIAL AND METHOD

Plantation resource

Three Vietnamese plantation species selected for this work were: *Acacia mangium,* Acacia hybrid (*A. mangium* x *A. auriculiformis*) and *Eucalyptus urophylla,* harvested in Cau Hai, Phu Tho and Ba Vi, Ha Noi. In total nine sites, three per species were chosen for the study. Each site had a different silvicultural or age regime including trees of the appropriate age/size class to meet the requirements for veneer production. Details of each trial site including species, age, location, stocking rate, silvicultural history, soil type, elevation and slope were described in the previous work (Trinh and Redman, 2018).

Veneer processing

Logs were trimmed to a length of 1.3 m, rounded and peeled using a Ming Feng Chinese brand spindleless lathe after cutting down 2-3 days. During peeling a guillotine was used to clip 1,300 mm (length) x 950 mm (width) veneer sheets. Veneer sheets were divided into two sections such that 150 mm wide strips were removed from the veneer edge closest to the outside of the billet, leaving veneer sheets with width 800 mm. The target veneer sheet dimensions were 2.8 mm thick × 1300 mm (same as log length) × 800 mm, then the veneer sheets were air-dried in sunny weather 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%.

Knot characteristics

For each veneer sheet, the number of knots, number of knots with a small diameter larger than 3 cm (d > 3 cm), and the number of encased knots were recorded. Encased or dead knots are knots that have lost their fibrous connection with the surrounding wood; they can easily loosen and fall out or be knocked out.

End splits

For each veneer sheet, the number of end splits and length of the longest end split were recorded at each veneer end (cm). This allowed the calculation of the total number of end splits measured (both ends) and the total percentage of veneer length affected by end splits.

Visual grading

Veneer sheet quality was assessed by visual grading in accordance with Australian and New Zealand Standard AS/NZS 2269.0:2012 (Australian and New Zealand Standard, 2012). This standard separates structural veneer into 4 veneer surface qualities and a reject grade according to absence or severity of imperfections and defects (Table 1).

Grade recovery

Grade recovery is the net veneer recovery for each grade as defined by AS/NZS2269.0:2012 (i.e. A, B, C, D or F grades). Graded veneer recovery was calculated for each grade quality and is defined as NR_A, NR_B, NR_C and NR_D.

The grade score uses the flowing formula,

$$\text{Grade score} = 4\times NR_A + 3\times NR_B + 2\times NR_C + 1\times NR_D + 0\times NR_F$$

where, NR_F represents the recovery of veneers failing to meet grade A, B, C or D criteria.

Table 1. Veneer quality grading in accordance with AS/NZS 2269.0:2012

No	Criteria	Grade A	Grade B	Grade C	Grade D	Grade F
1	Intergrown knots	Not > 4 mm across, not > 4 per sheet; Pin knots not > 2 mm across	Not > 25 mm across or > 25 mm but not > 4 per sheet	Not > 50 mm across the grain	No limitations	-
2	Encased knots (sound and unsound)	Not allowed	Not allowed	Only sound knots Not > 50 mm across the grain	No limitations	-
3	Holes	Not > 6 mm	Not > 20 mm across and Not > 600 mm^2	Not > 50 mm across the grain	Not > 75 mm across the grain Not > 15,000 mm2	Holes > 75 mm
4	Splits	Not > 3 mm across grain (300 mm long)	Not > 3 mm across grain (500 mm long)	Individually 9 mm max.(half the sheet) Or 12 mm, 600 mm long, 2 per sheet max.	Max. 5 mm across (full length of sheet) Max. 15 mm across (half the lenght) Max. 25 mm across (1/3 the sheet lenght)	-
5	Bark/decay	Not allowed	Not allowed	Not allowed	Yes	-
6	Gum and resin pockets	Not allowed	Not allowed	Not allowed	Yes	-
7	Gum veins	Not allowed	Not allowed	No limitations	-	-
8	Insect tracks	Not allowed	Without resin/gum	Filled with resin/gum	-	-
9	Kino/bark	Not > 6 mm	Not > 20 mm across and Not > 600 mm^2	Not > 50 mm across the grain	Not > 75 mm across the grain	Kino > 75 mm
10	Discoloration	No	Yes	-	-	-
11	Compression	Fairly flat	Bit wavy	Splits will probably overlap	Splits will definitely overlap	-
12	Grain breakout	Not allowed	Not allowed	Not allowed	Yes	-
13	Cumulative defects	No	> 75 mm imperfections			Yes
14	Roughness	Slight (will disappear after sanding)	> Slight (will disappear after sanding)	Medium (fuzzy after sanding)	Too deep for sanding	
15	Holes - processing	Not > 6 mm	Not > 20 mm across and Not > 600 mm^2	Not > 50 mm across the grain	Not > 75 mm across the grain Not > 15,000 mm2	Holes > 75 mm
16	Discoloration - processing	No	Yes	Yes	Yes	-
17	Splits-processing	Not > 3 mm across grain (300 mm long)	Not > 3 mm across grain (500 mm long)	Individually 9 mm max.(half the sheet) Or 12 mm, 600 mm long, 2 per sheet max.	Max. 5 mm across (full length of sheet) Max. 15 mm across (half the length) Max. 25 mm across (1/3 the sheet lenght)	-
18	Wane	No	Yes	Yes	Yes	-

3. RESULTS AND DISSCUSSION

3.1. Knot characterisation

Small plantation logs are generally renowned for their high incidence of knots compared to logs from mature forests. A previous studies by McGavin *et al.* (2013) resulted in knots being one of the two major veneer grade limiting defects found in plantation eucalypts, along with resin pockets. As the results from this study will be used to develop plantation veneer grading rules, emphasis was given to characterising knots from the processed veneer.

The average number of knots, number of knots with small diameter greater than 3 cm and the number of encased knots in the dried veneer sheets are provided in Table 2. Figure 1 to Figure 3 scattergrams show the variation of these respective properties. Table 3 shows the results of ANOVA multiple comparison tests based on Tukey's significant difference test.

The average number of knots measured for each species tends to decrease with increasing age. The ANOVA analysis in table 3 showed more evident for *A. mangium* and *E. urophylla* where the number of knots was significantly less than the youngest plantation investigated for each species. Older *E. urophylla* plantations produced veneer with the least number of average knots, followed by *A. mangium* and then *Acacia hybrid*.

The average number of large knots (> 3 cm diameter) in veneer appears to increase for both acacia species with increasing standard deviation or spread in this parameter. *E. urophylla* plantations seem to produce veneer with the lowest average number of large knots decreasing with age. This can be explained by the knot measurements of peeling logs as presented in the previous study (Trinh *et al.*, 2015). Similar trends resulted for the number of encased or dead knots as for the large knots.

Table 2. Veneer sheet knot characteristic results

Species	Age (yr)	Number of Trees	Number of billets	Number of veneers	No. knots *	No. knots (d > 3cm) *	No. encased knots *
Acacia hybrid	7	4	18	93	41 (23)	5 (8)	4 (4)
	11 (i)	5	23	181	37 (22)	10 (9)	20 (12)
	11 (ii)	5	33	243	36 (21)	12 (12)	28 (22)
Acacia mangium	6	6	18	107	31 (19)	5 (7)	3 (3)
	9	5	25	182	20 (10)	9 (8)	10 (7)
	14	5	30	287	20 (16)	13 (18)	12 (10)
Eucalyptus urophylla	11	5	25	110	38 (17)	10 (6)	22 (9)
	14	5	38	262	12 (17)	4 (6)	6 (9)
	19	2	20	189	10 (16)	2 (5)	2 (4)

*Note: * standard deviation is presented in parenthesis*

i: 11-year-old Acacia hybrid trees harvested in Cau Hai, Phu Tho, ii: 11-year-old Acacia hybrid trees harvested in Ba Vi, Ha Noi.

Table 3. Veneer sheet number of knots, knots > 3 cm and encased knots ANOVA multiple comparison tests based on Tukey's Significant Difference Test

Species	Age (yr)	No. knots groups		No. knots > 3 cm groups			No. encased knots groups		
Acacia hybrid	7	Ah		Ah			Ah		
	11 (i)	Ah			Bh			Bh	
	11 (ii)	Ah			Bh				Ch
Acacia mangium	6	Am		Am			Am		
	9		Bm	Am				Bm	
	14		Bm		Bm				Cm
Eucalyptus urophylla	11	Au		Au			Au		
	14		Bu		Bu			Bu	
	19		Bu			Cu			Cu

Note: h, m, and u represent hybrid, mangium and urophylla respectively.

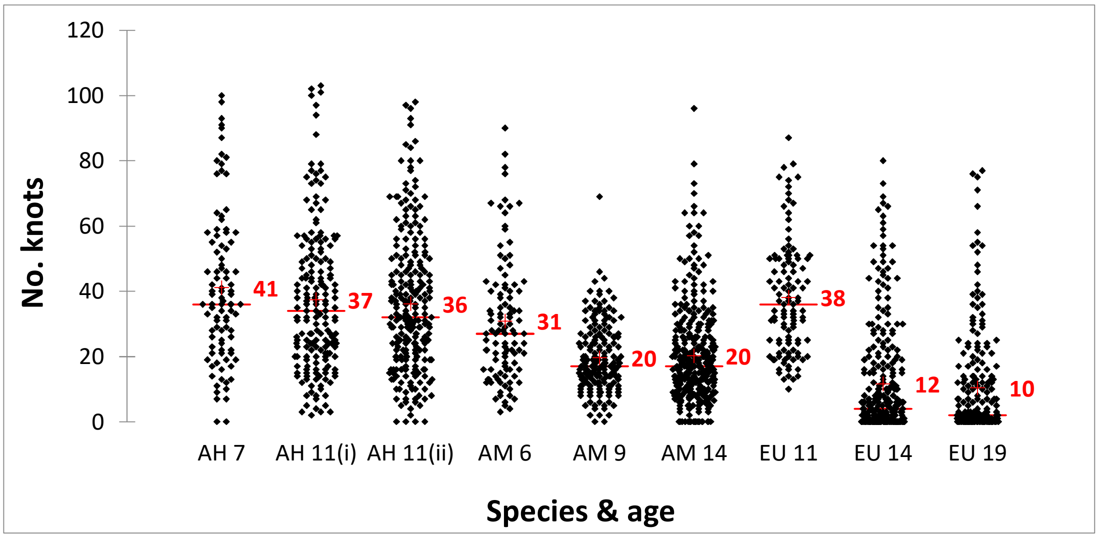

Figure 1. Distribution of number of knots in veneer sheets

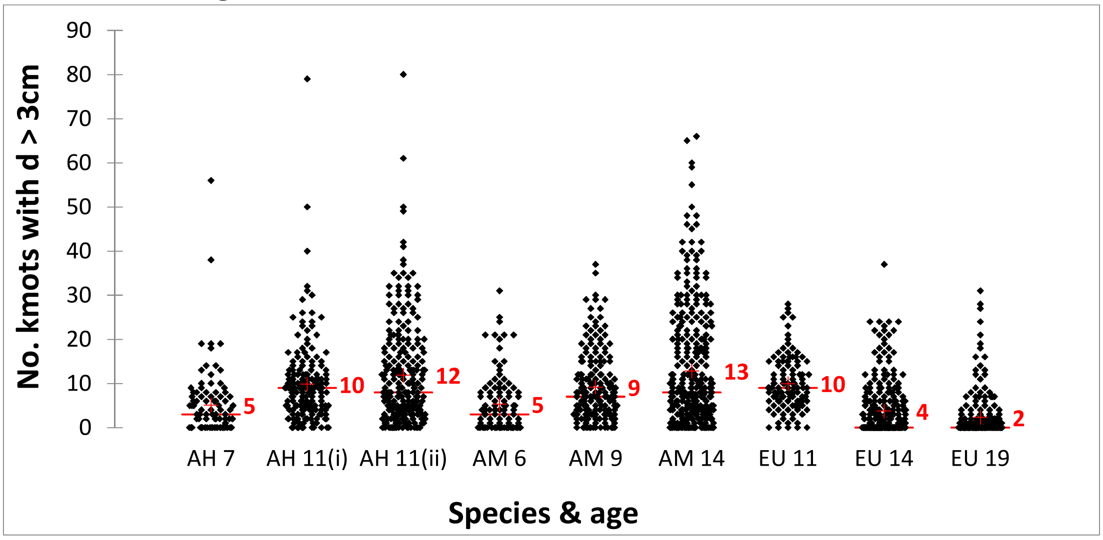

Figure 2. Distribution of number of knots in veneer sheets with small diameter greater than 3 cm

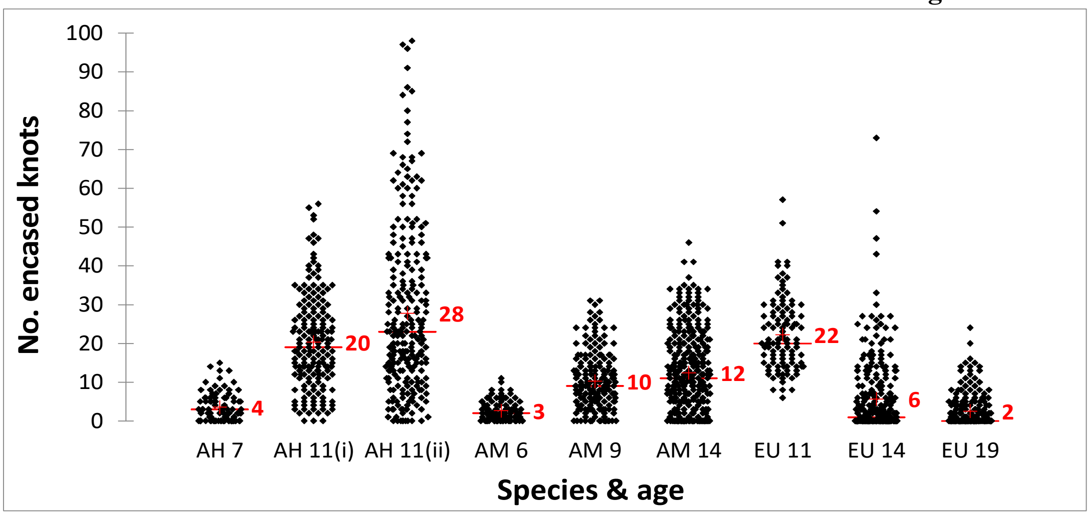

Figure 3. Distribution of number of encased knots in veneer sheets

3.2. End splits

The average number of end splits and the average percentage of veneer sheet length affected by end splits are provided in Table 4. Table 5 shows the results of ANOVA multiple comparison tests. Figure 4 and Figure 5 scattergrams show the variation of these respective properties.

Table 4. Veneer sheet end split results

Species	Age (yr)	Number of Trees	Number of billets	Number of veneers	No. of end splits *	% length end splits *
Acacia hybrid	7	4	18	95	19 (6)	52 (26)
	11 (i)	5	23	180	7 (3)	37 (33)
	11 (ii)	5	33	242	10 (7)	42 (30)
Acacia mangium	6	6	18	105	20 (8)	53 (34)
	9	5	25	186	8 (6)	57 (49)
	14	5	30	338	7 (5)	26 (23)
Eucalyptus urophylla	11	5	25	110	7 (5)	52 (46)
	14	5	38	289	11 (7)	37 (29)
	19	2	20	220	24 (13)	34 (27)

** standard deviation is presented in parenthesis.*

Table 5. Number of end splits and percentage of veneer sheet affected by end splits ANNOVA multiple comparison tests based on Tukey's Significant Difference Test

Species	Age (yr)	No. of end splits groups			% length end splits groups	
Acacia hybrid	7	Ah			Am	
	11 (i)		Bh			Bm
	11 (ii)			Ch		Bm
Acacia mangium	6	Am			Am	
	9		Bm		Am	
	14		Bm			Bm
Eucalyptus urophylla	11	Au			Au	
	14		Bu			Bu
	19			Cu		Bu

Note: h, m, and u represent hybrid, mangium and urophylla respectively.

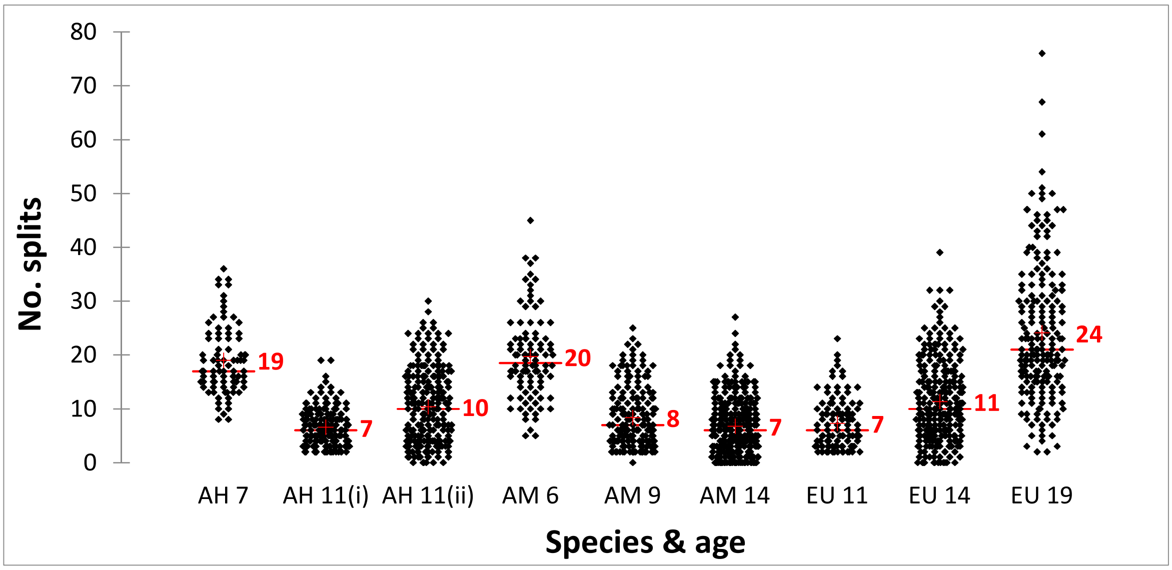

Figure 4. Distribution of number of veneer sheet end splits

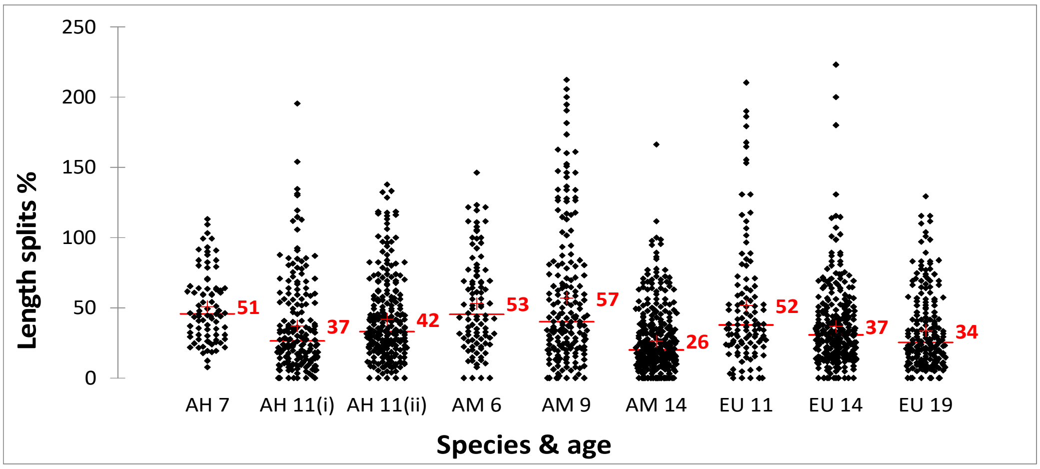

Figure 5. Distribution percentage of veneer sheet length affected by end splits

The average number of end splits for the acacia species reduced with age from the youngest trials but progressively increased with age for *E. urophylla*. This may be caused by environmental conditions, particularly those that can exacerbate growth stresses in trees, a leading cause of splits in logs. End splits in veneers can also be caused by manual handling and drying. Species with higher unit shrinkage and higher differential shrinkages (that is different rates and/or magnitude of shrinkage in tangential and radial planes) generally have a higher propensity to split during drying. The percentage of veneer affected by end split was lowest for the oldest *A. mangium* and *E. urophylla* plantations tested. Some studies on eucalypts indicated that log-end splitting is one of the single most important defects in veneer logs, the log-end splitting often happens after log cutting due to growing stresses in wood structure (Kubler, 1988). According to Benoit's study (2018), splits are one of the most important factors in lowering the quality grade of peeled veneer from eucalypts in Laos.

3.3. Visual grading

As detailed previously, grade recovery is the net veneer recovery for each grade as defined by AS/NZS2269.0:2012 (i.e. A, B, C or D grades). The F-grade is used for veneers failing to meet the lowest D-grade. Graded veneer recovery was calculated for each grade quality and is defined as NR_A, NR_B, NR_C and NR_D. Figures 6 to 14 illustrate the distribution of visually assigned grades for each defect. In addition, the last column of each chart shows the distribution of overall veneer grade according to AS/NZS 2269.0:2012. A ranking '*grade score*' was used to determine the most limiting defect to the least limiting. On the charts, the least limiting defect is the represented by the left most column, continuing in order to the most limiting defect represented by the second last right most column.

Figures 6 to 14 clearly demonstrate that across all species, loose knots have the most influence in restricting veneers from attaining a grade higher than D. Other defects common across all species and contributing to preventing veneers from attaining higher grades than D grade are sound knots, cumulative defects, resource holes, grain breakout and roughness. The latter two are considered manufacturing defects and therefore there is great opportunity to further optimise the process through the introduction of billet conditioning (steaming or boiling), lathe setup etc. 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, positive attributes compared to large knots or concentrated knots. Small and scattered knots will have the least amount of impact on structural properties (i.e. strength). Increased proportions of C and B grade veneer with increasing age were most evident for 19-

year-old *E. urophylla*. These results are expected as the proportion of knots 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 and the tree grows. In fact, 35% of the 19-year-old *E. uropyhlla* veneer attained B grade, a designated face veneer according to AS/NZS2269.0:2012.

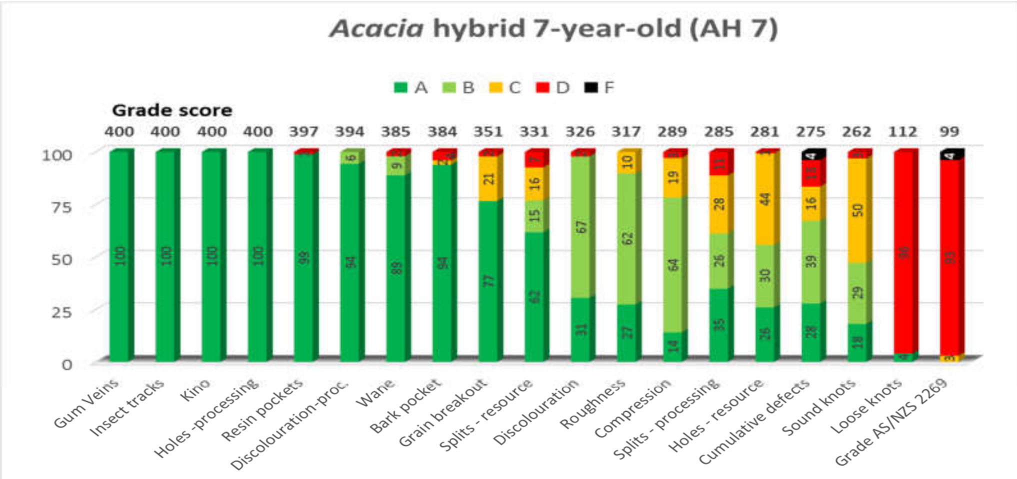

Figure 6. Distribution of grade quality and grade limiting features for 7-year-old *Acacia* hybrid

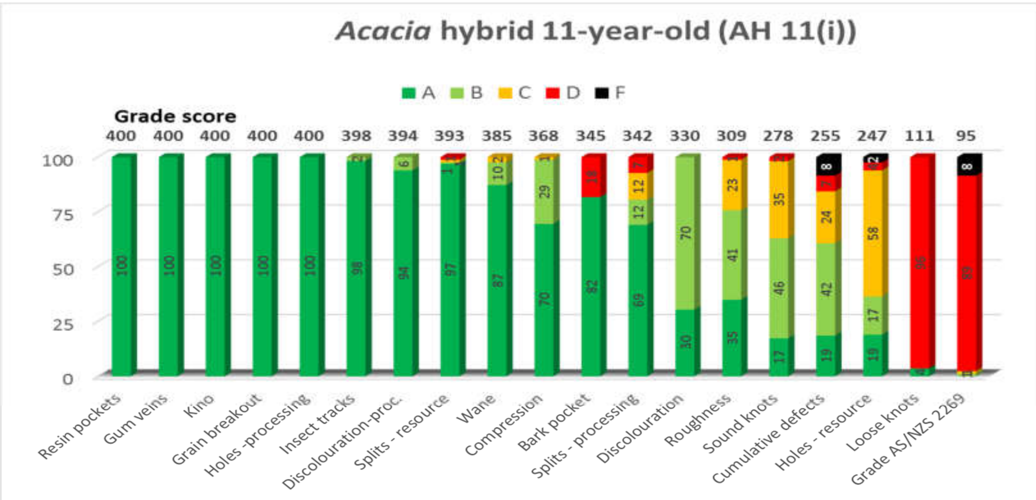

Figure 7. Distribution of grade quality and grade limiting features for 11-year-old *Acacia* hybrid – site 1

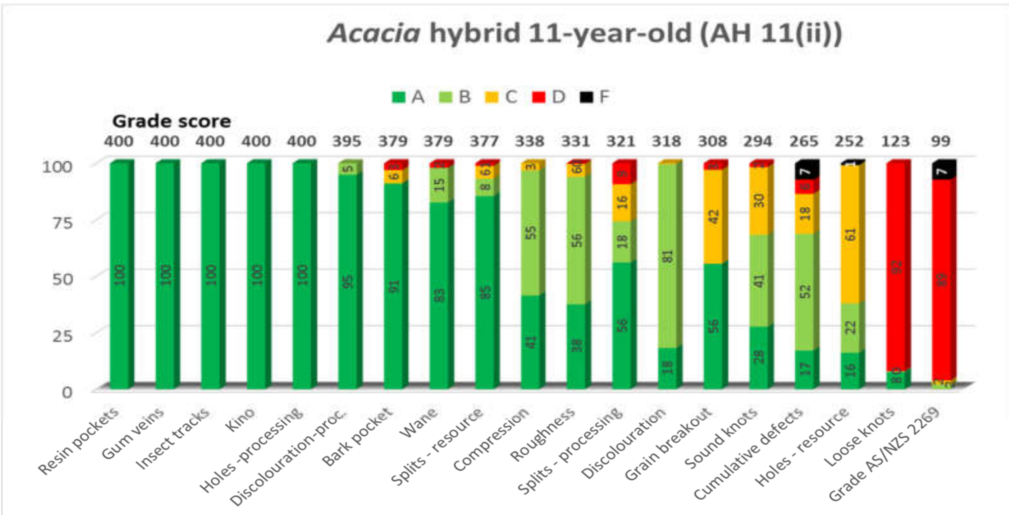

Figure 8. Distribution of grade quality and grade limiting features for 11-year-old *Acacia* hybrid – site 2

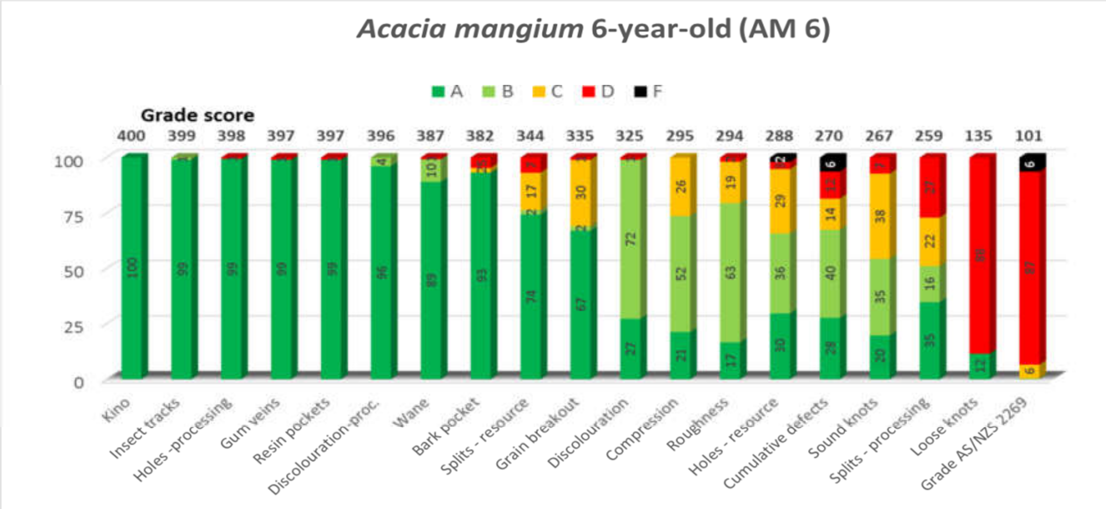

Figure 9. Distribution of grade quality and grade limiting features for 6-year-old *Acacia mangium*

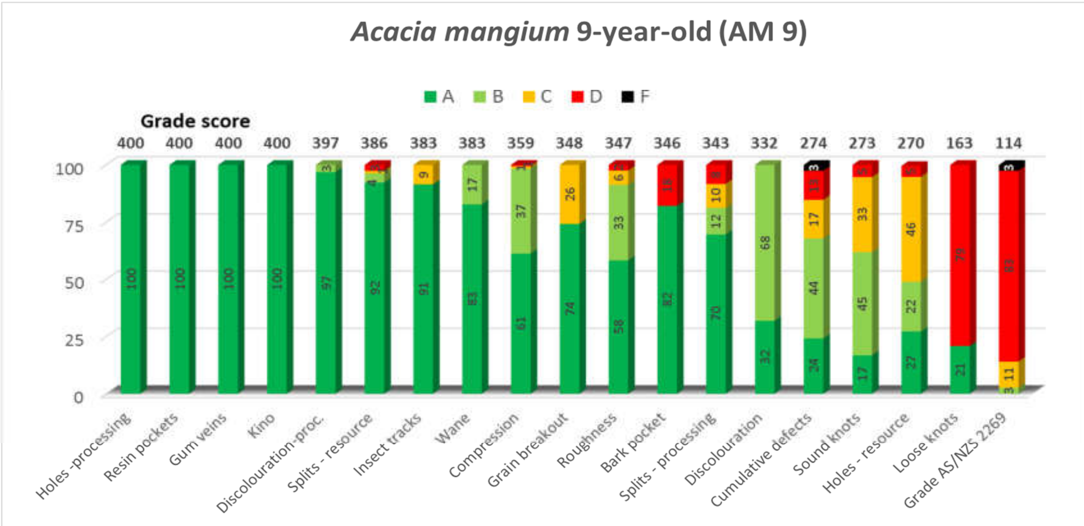

Figure 10. Distribution of grade quality and grade limiting features for 9-year-old *Acacia mangium*

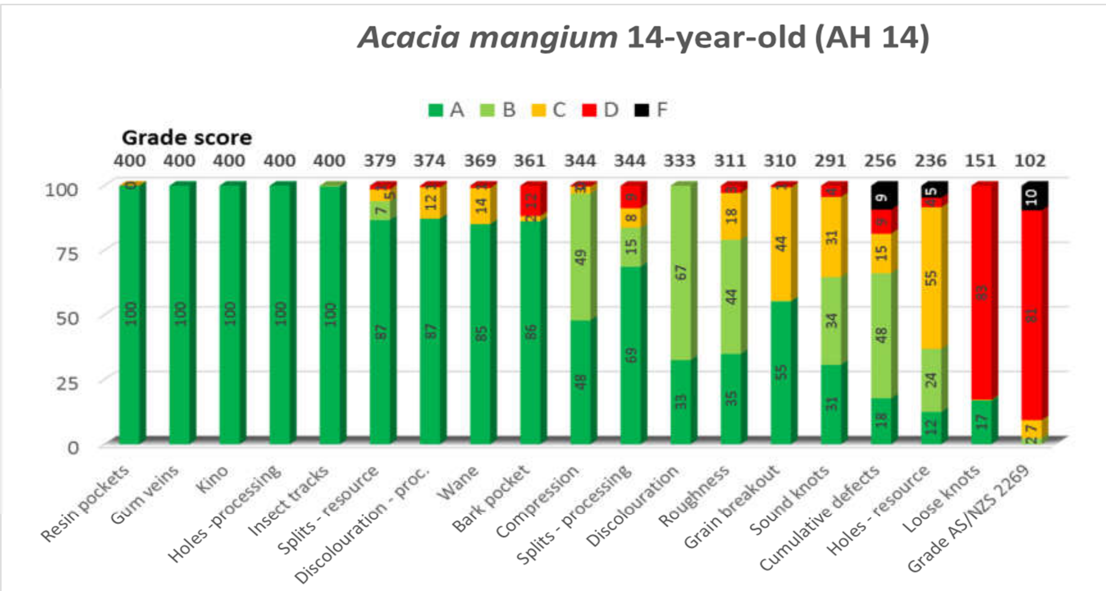

Figure 11. Distribution of grade quality and grade limiting features for 14-year-old *Acacia mangium*

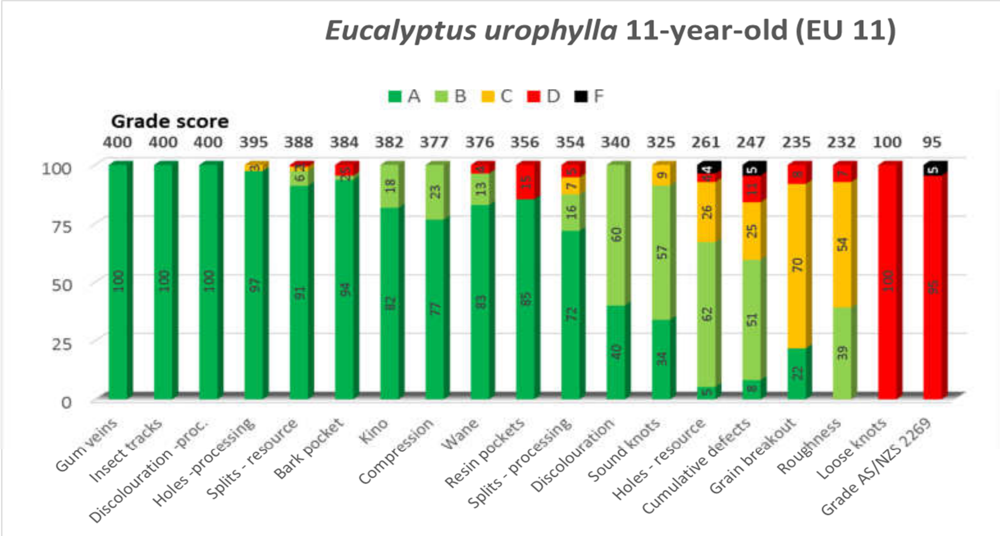

Figure 12. Distribution of grade quality and grade limiting features for 11-year-old *Eucalyptus urophylla*

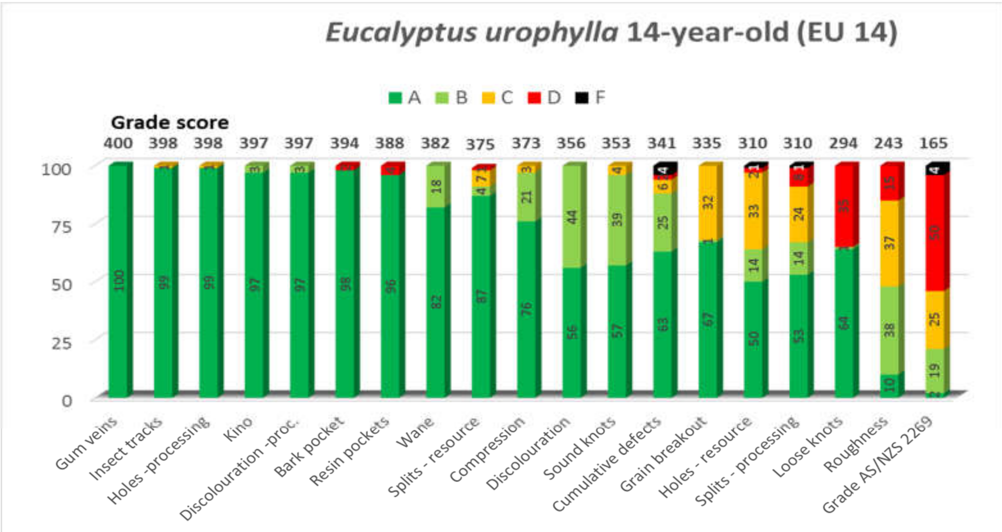

Figure 13. Distribution of grade quality and grade limiting features for 14-year-old *Eucalyptus urophylla*

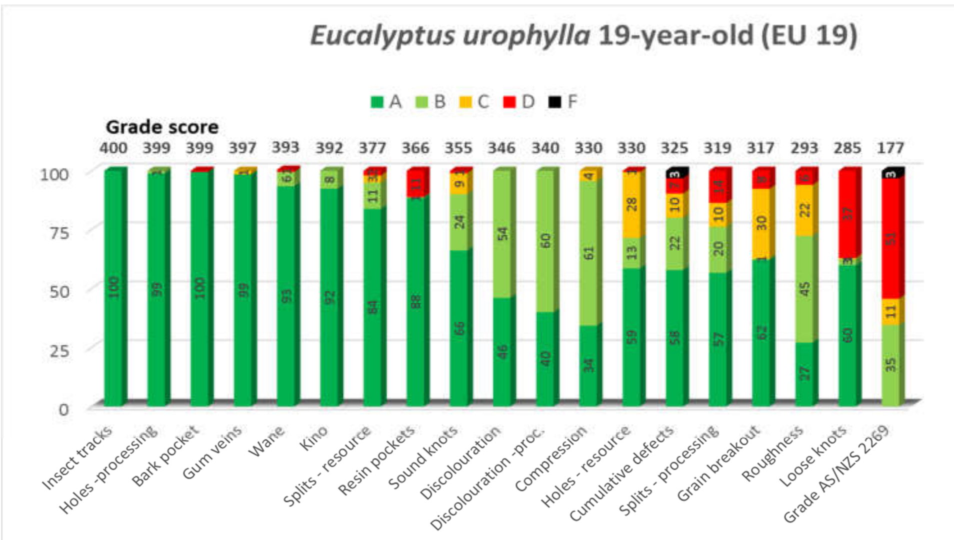

Figure 14. Distribution of grade quality and grade limiting features for 19-year-old *Eucalyptus urophylla*

A very high proportion of the recovered veneer meets the requirements of D-grade in accordance with Australian and New Zealand standard AS2269.0:2012 with a small proportion meeting the requirements of higher grade qualities, with the exception of 14 and 19-year-old *Eucalyptus urophylla*. These results lend the hardwood veneer to be used in mainly non-appearance structural plywood products and/or core veneers. For products which require higher appearance qualities and high mechanical properties, the plantation hardwood veneer could be mixed with either other high quality resources (i.e. native hardwood forest face veneers) or other overlay systems (e.g. very thin softwood face veneers, overlay papers…). Alternatively there may be application in LVL type products were structural properties are more emphasised than appearance qualities. Another option to improve the visual grade quality is through defect patching (removing a defect and replacing it with a patch of clear veneer) or veneer jointing (clipping out a defect and joining the veneer back together), or multilaminar veneer production for furniture production. The higher proportion of C and B grade veneers produced from 14 and 19-year-old *E. urophylla*, with 35% of B grade (face veneer) attained for the 19-year-old plantation, highlights the potential for this species to produce higher quality veneer at 14 years-old, more so than *A. mangium* at the same age, and much higher quality as the age increases. It is also likely the case for the acacia species, however the oldest acacia plantation investigated was 14-years-old. These results promote the necessity to investigate the economic benefits of longer plantation ages and profitability by producing a higher volume of higher quality veneer.

4. CONCLUSIONS

Outside characterisation of peeled veneers produced from *Eucalyptus urophylla, Acacia mangium* and *Acacia* hybrid *(A. mangium* x *A. auriculiformis)* plantation resources of three ages and site plots per species were assessed in this study. The average number of knots measured for each species tends to decrease with increasing age. The older *E. urophylla* plantations produced veneer with the least number of average knots, followed by *A. mangium* and then *Acacia hybrid*. *Acacia* hybrid produced higher levels of large knots (> 3 cm) compared to the other species investigated. The average number of end splits for the acacia species reduced with age but progressively increased with age for *E. urophylla*. The percentage of veneer affected by end split was lowest for the oldest *A. mangium* and *E. urophylla* plantations tested.

Loose and sound knots were the main reason for preventing veneers achieving a grade quality higher than D-grade. Opportunities exist to create a veneer grading standard for Vietnam as the grade limiting thresholds for knots in the Australian and New Zealand standard were developed for a plantation softwood resource and potentially penalises the hardwood veneer. Other defects common across all species and contributing to preventing veneers from attaining higher grades than D grade are cumulative defects, resource holes, grain breakout and roughness. The latter two are considered manufacturing defects and therefore there is an opportunity to further optimise the process through the introduction of billet conditioning (steaming or boiling), lathe setup etc. to reduce the defects.

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ĐẶC ĐIỂM NGOẠI QUAN CỦA VÁN BÓC TỪ MỘT SỐ LOÀI GỖ RỪNG TRỒNG Ở VIỆT NAM

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TÓM TẮT

Ba loại gỗ rừng trồng của Việt Nam: Bạch đàn urophylla (*E. urophylla*), Keo tai tượng (*A. mangium)* và Keo lai (*A. mangium x A. auriculiformis*) ở 9 ô tiêu chuẩn (3 ô tiêu chuẩn/loài) đã được lựa chọn cho nghiên cứu này. Mỗi ô tiêu chuẩn có các điều kiện lâm sinh hoặc độ tuổi khác nhau phù hợp cho sản xuất ván bóc. Các cây gỗ lớn trong mỗi ô tiêu chuẩn được sử dụng để bóc ván với kích thước ván: dày 2,8 mm, dài 1.300 mm (cùng chiều thớ gỗ), rộng 800 mm, ván được sấy đến độ ẩm 10% trước khi kiểm tra về mắt gỗ, vết nứt và phân loại chất lượng ván. Kết quả nghiên cứu cho thấy: Số lượng trung bình của mắt gỗ trong các tấm ván bóc có xu hướng giảm khi tuổi cây tăng lên. Ván bóc từ gỗ Bạch đàn urophylla ở cấp tuổi cao hơn có số lượng mắt trung bình ít nhất, tiếp theo là ván bóc từ gỗ Keo tai tượng rồi đến Keo lai. Ván bóc từ gỗ Keo lai có số lượng mắt gỗ kích thước lớn (đường kính > 3 cm) nhiều hơn so với hai loài Keo tai tượng và Bạch đàn urophylla. Số lượng vết nứt ở đầu các tấm ván bóc gỗ keo có xu hướng giảm dần theo độ tuổi, nhưng đối với gỗ Bạch đàn urophylla lại tăng theo độ tuổi. Tỷ lệ phần trăm theo chiều dài của ván mỏng bị ảnh hưởng bởi các vết nứt đầu thấp nhất đối với gỗ Keo tai tượng và Bạch đàn urophylla ở cấp tuổi lớn. Ván bóc đã được phân cấp chất lượng theo tiêu chuẩn Úc và Niu Di Lân AS/NZS 2269.0:2012. Mắt chết và mắt sống là nguyên nhân chính làm giảm cấp chất lượng của ván bóc tới cấp chất lượng loại D. Những khuyết tật phổ biến khác của ván bóc của các loài gỗ làm giảm cấp chất lượng ván là: hiện tượng tích tụ tự nhiên, lỗ thủng, đứt thớ gỗ và thô ráp bề mặt. Khuyết tật đứt thớ gỗ và thô ráp bề mặt được xếp vào khuyết tật do gia công và có thể cải thiện thông qua xử lý nhiệt khúc gỗ trước khi bóc (hấp hoặc luộc gỗ), điều chỉnh lưỡi dao bóc cho phù hợp… để giảm các khuyết tật này.

Từ khóa: Gỗ bạch đàn, gỗ keo, mắt gỗ, nứt đầu, phân loại chất lượng, ván mỏng.

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