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Research Note

Comparative Strength and Related Properties of Yemane (*Gmelina arborea* Roxb.) Coppice and Planted Stand

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The strength and related properties of 7- and 3-year-old first and second coppice and 3-year-old planted stand of yemane (*Gmelina arborea* Roxb.) were studied to generate information that could help tree farmers properly grow, harvest, and utilize yemane timber from a coppice stand. The properties were also compared to secondary data from previously tested yemane planted stands of various ages and localities. Based on FPRDI's Guidelines for the Improved Utilization and Marketing of Tropical Species, the strength properties of the 7-year-old yemane coppice were generally moderately low (C4) to low (C5) while relative density and shrinkage were moderately low, and moisture content above 100 %. The strength properties were lower than those of 5-, 10-, and 15-year-old yemane planted stands. The wood of 7-and 3-year-old yemane first and second coppice, respectively, is recommended for furniture and other moderately light to light construction purposes. The diameter and stem form of the coppice might warrant applications for the recommended end-uses. Hence, finger jointing or gluing may be advisable if wider boards are needed. The strength properties of 3-year-old coppice were comparable to 3-year-old planted stand but the former had higher compression-perpendicular-to-grain and shear than the latter.

Key Words: Coppice, *Gmelina arborea* Roxb., planted stand, relative density, shrinkage, strength properties

INTRODUCTION

Yemane (*Gmelina arborea* Roxb.) is among the fast growing Industrial Tree Plantation Species (ITPS) currently being used by the wood industry as an alternative source to the diminishing supply of premium and other commercial timbers from the natural-growth forests. One of the many advantages of yemane over the other ITPS is its capacity to quickly produce coppices of more than five stems which can be thinned by choice and which can provide quick cover after cutting. Previous studies showed that the first coppicing has significantly higher growth rate than the original stand (Perino 2003).

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The reported average diameter and height for a 7-year-old first generation stand were 10 cm and 7 m respectively, while the diameter and height of the first coppice regrowth of the same age averaged 27 cm and 16 m, respectively. This can be explained by the coppice trees' more established root system than that of the original stand. Roots that have gained strong foothold can extract as much nutrients available in the soil for the growth of the above-ground biomass. This is the most remarkable advantage of coppice stand than the original stand (Perino 2003)

Recent statistics showed around 840, 980 cu m is the log production from Philippine tree plantations (excluding data from ARRM) in 2005. Out of this, 151,763 cu m or

about 18% came from *Gmelina* tree plantations (FMB 2005). The bulk of the log harvested came from Regions 6, 9, 10, 11, 12, and 13.

In Malaysia, yemane was reported to produce more wood from plantation coppices than from planted seedlings. A 5-year-old plantation from seedlings yielded 104 m^3/ha or a mean annual increment (MAI) of 21 m^3 while the first coppice yielded 131 m^3 in four years or MAI of 33 m^3. In the second coppice crop, however, the yield was reduced to 138 m^3/ha in six years with MAI of 23 m^3. The MAI for planted seedlings varied from 17-25 m^3/ha (Setten 1973).

In the wake of the growing demand for alternative species for various end-uses, study on comparative strength and related properties (refer to some physical properties such as moisture content, relative density and volumetric shrinkage) of yemane coppice and planted stand is deemed necessary. Hence, this study aimed to test and evaluate the strength and related properties of yemane coppice timber to obtain information that could eventually guide local tree farmers on how to grow, harvest and utilize timber from a yemane coppice stand.

MATERIALS AND METHODS

Source and Description of Materials

Nine logs from 7-year-old yemane first coppice trees (four years of unthinned stems and three years of single growth stem) and three logs each from a 3-year-old second coppice and original planted stand (uncoppice) provided by the Ecosystems Research and Development Bureau (ERDB)/Department of Environment and Natural Resources (DENR) were used in the study. The log samples were cut from the ERDB experimental yemane plantation located at Paco, Norzagaray, Bulacan (Region III).

The diameter-at-breast-height (DBH) of the 7-year-old coppice was grouped into three classes: C = 17-30 cm, D = 30.1-40 cm and E = 40.1-6 1.1 cm. On the other hand, the DBH of the 3-year-old coppice ranged from 14.5-18 cm. In the planted stand, it measured 8.5-15 cm.

Sampling Procedure

Each log of the 7-year-old coppice was cut into three equal portions (total height /3) and marked butt, middle and top from which 1.37 m bolts were taken. A disc 150 mm thick was cut from each bolt where standard-size specimens for testing the physical/related properties were prepared. The remaining bolt was used for the strength properties. The sampling scheme used in the study was shown in Figure 1.

The 3-year-old second coppice and planted stand were each represented by three logs, each about 1.37 m long only, hence, sampling by diameter was not done. Moreover, the bolts had limited length, precluding mechanical analyses along the tree height level.

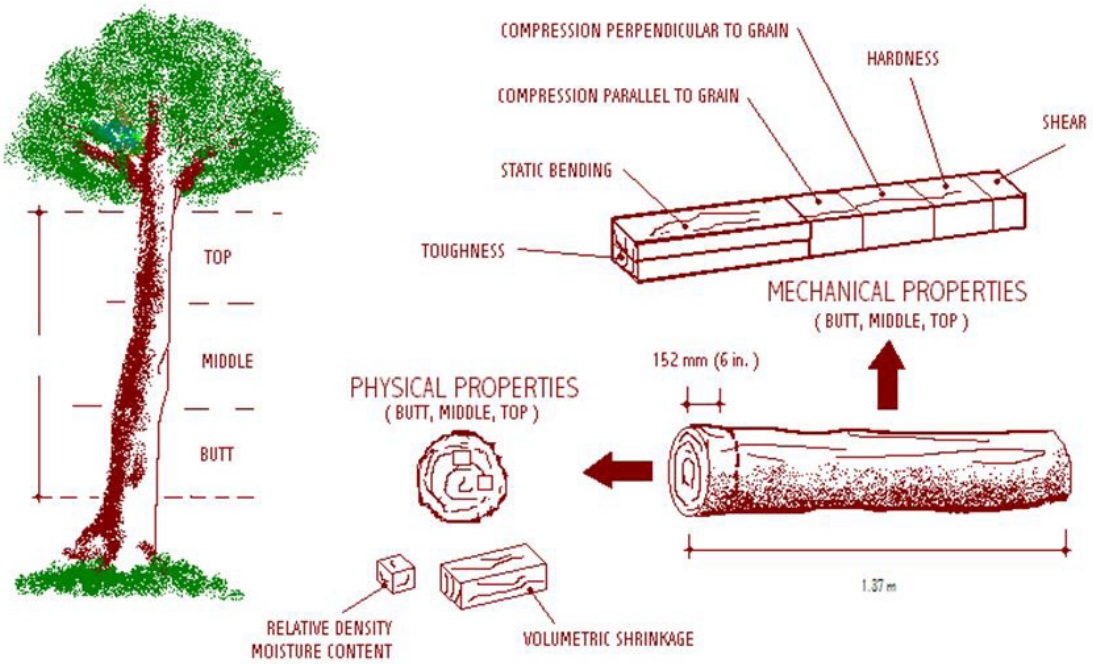


Figure 1. Sampling scheme used in the study.

Table 1. Dimensions (mm) of strength and related properties specimens.

Physical and Mechanical Properties	Dimensions (mm)
	T x W x L
Moisture Content (MC) and Relative Density (RD)	25 x 25 x 25
Volumetric Shrinkage (VS)	25 x 25 x 100
Static Bending (SB)	25 x 25 x 400
Compression Parallel to Grain (C //)	25 x 25 x 100
Compression Perpendicular to Grain (C ⊥)	50 x 50 x 150
Shear (S)	50 x 50 x 60
Hardness (H)	50 x 50 x 150
Toughness (To)	20 x 20 x 280

Laboratory Evaluation of Wood Properties

Strength and related properties were evaluated in accordance with the ASTM Designation D-143-52 (1998) or Standard Method of Testing Small Clear Specimens of Timber.

Analysis of Data

Data on the physical and mechanical properties were statistically analyzed using the Completely Randomized Design (CRD) with sub-sampling. Secondary data on strength and related properties of 5-, 10-, and 15-year-old yemane uncoppiced trees from different localities were also used for comparative evaluation of the wood properties of the 3- and 7-year-old yemane coppice as well as the 3-year-old uncoppiced trees from the same site.

RESULTS AND DISCUSSION

Strength and related properties of 7-year-old yemane coppice at different diameter classes were shown in Figures 2 and 3. On the other hand, the ANOVA for these properties was presented in Table 2.

Trees under diameter class E generally exhibited higher MOR and MOE than C and D but lower toughness and hardness than C. Other strength and related properties

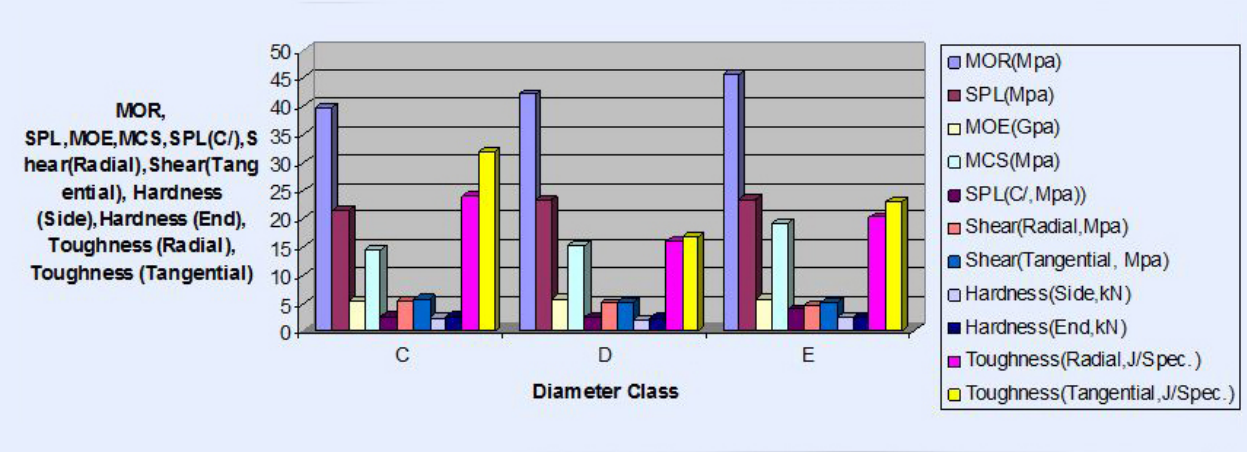


Figure 2. Strength properties of 7-year-old yemane (*Gmelina arborea* Roxb.) coppice at different diameter classes.

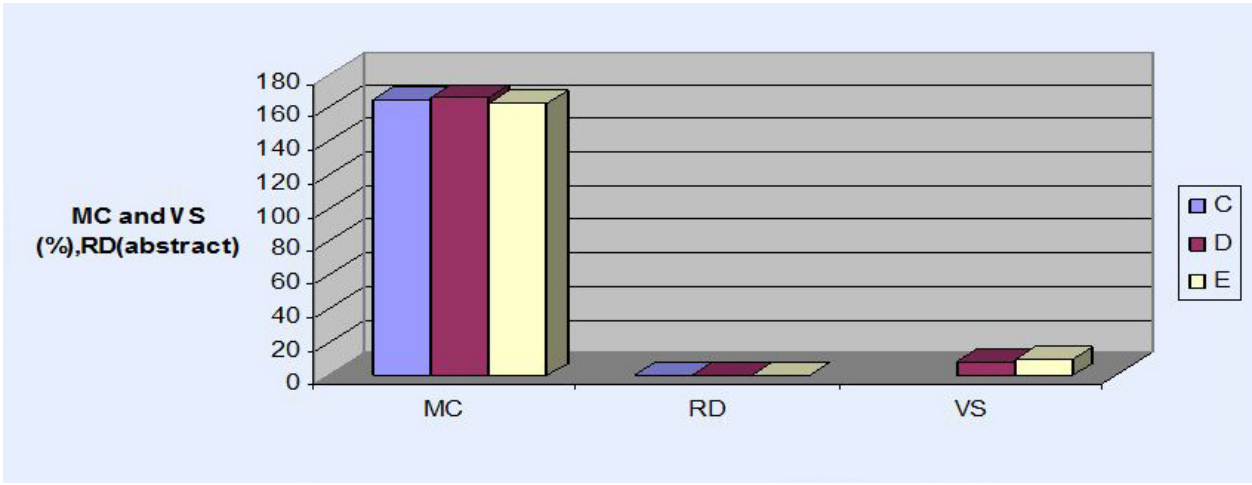


Figure 3. Physical/related properties of 7-year-old yemane (*Gmelina arborea* Roxb.) coppice at different diameter classes.

Table 2. ANOVA for strength and related properties of 7-year-old yemane (*Gmelina arborea* Roxb.) coppice.

Source of Variation	DF	F-Value						
		Static Bending			Compression		Shear	
		MOR	SPL	MOE	//-to Grain	/-to Grain	Radial	Tan.
Diameter (D)	2	2.62^{ns}	1.36^{ns}	2.06^{ns}	0.94^{ns}	0.04^{ns}	1.27^{ns}	1.81^{ns}
Tree (T) x (D)	3	4.950*	0.92^{ns}	2.36^{ns}	8.13**	4.91*	3.00^{ns}	0.77^{ns}
Height (H) x (T xD)	12	1.050^{ns}	1.36^{ns}	1.20^{ns}	0.85^{ns}	1.13^{ns}	1.29^{ns}	1.13^{ns}
Error	18							
Total	35							
R^2 (%)		75.5	56.59	65.77	70.9	63.1	67.2	51.8
CV		8.22	15.35	10.26	23.1	20.8	12.8	13.0

Source of Variation	DF	F-Value					
		Hardness		Toughness		Moisture Content	Relative Density
		Side	End	Tangential	Radial		
Diameter (D)	2	1.15^{ns}	0.04^{ns}	0.46^{ns}	0.11^{ns}	2.720^{ns}	0.220^{ns}
Tree (T) x (D)	3	2.32ns	1.40^{ns}	2.25^{ns}	2.04^{ns}	2.560^{ns}	5.03*
Height (H) x (T x D)	12	2.67*	1.60^{ns}	1.50^{ns}	1.58^{ns}	1.530^{ns}	1.30^{ns}
Error	18						
Total	35						
R^2 (%)		78.3	59.2	63.4	62.0	74.1	67.98
CV		10.5	11.8	49.5	49.6	23.8	5.44

**highly significant at alpha = 0.01 *significant at alpha = 0.05 ns = not significant

among diameter classes are almost the same. Nevertheless, all the properties did not significantly differ across the three diameter classes.

The effect of between trees was not significant except on MOR. C//, C/, and RD. The accelerated growth of trees under diameter E as compared to those of D and C could probably explain the significant differences on some properties between trees. It could be speculated that within the same site, certain trees react more in existing environmental conditions, i.e., some trees are able to use available nutrients more efficiently (Zobel 1961). The fast growth of tree resulted to low cell wall substance which lowered the properties of some trees. The effect of height was likewise not significant except on side hardness at alpha = 0.05.

7- and 3-Year-Old Coppice Versus 3-Year-Old Planted Stand

The strength properties and related properties of 3- and 7-year-old yemane coppice and 3-year-old planted stand were presented in Figures 4 & 5 while the ANOVA and Duncan Multiple Range Test (DMRT) on the effect of age on the strength and related properties of yemane coppice and planted stand were shown in Tables 3 and 4.

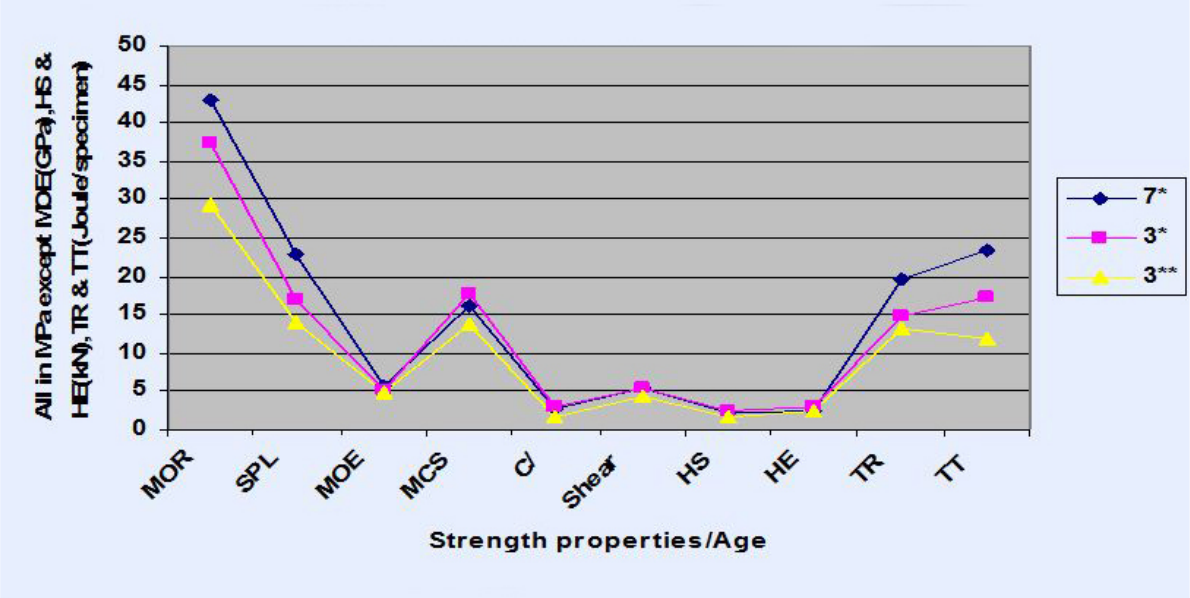
The effect of age on the strength and related properties of yemane coppice and planted stand was highly significant except in VS, C//, and toughness. The strength properties of 3- and 7-year-old coppice were comparable except in MOR and SPL, 7-year-old slightly higher than the 3-year-old. Generally, the 3-year-old planted stand had significantly lower strength properties than the 3-and 7-year-old coppice. The differences could be due to the 3-year-old planted stand's lower RD than those of the 7- and 3-year-old coppice. It is a common knowledge that RD correlates positively well with strength properties. Panshin and de Zeeuw (1970) reported that RD has been used as index of strength properties.

Alipon (1992) reported that because age is the dominant factor that affects the physical and mechanical properties of yemane from planted stand, strength properties increase with tree age. Hence, it is expected that the 7-year-old coppice would have higher strength properties than the 3-year-old. Deviation from the positive relationship between strength properties and tree age may probably be due to large percentage inclusion of juvenile wood on some portions of the 7-year-old samples. It could also be inferred that the established positive relationship between strength properties and age may not necessarily hold true yet for the 3- to 7-year-old, only as the tree gets older i.e, from 3- to 8- or 10-year-old and above.

7- and 3-Year-Old Coppice, and 3-Year-Old Planted Stand (Same Site) Versus Secondary Data from Planted Stand at Different Ages and Localities

Figure 6 showed the strength and related properties of 7-, and 3-year-old yemane coppice and 3-year-old from planted stand in Norzagay, Bulacan including secondary.

The strength properties of 7-year-old coppice were lower than those of 5-, 10-, and 15 year-old yemane trees from planted stand except in SPL, MOE and radial toughness of



MOR=Modulus of rupture MPa=145psi C/=Compression perpendicular -to-grain
SPL= Stress at proportional limit GPa=x1000MPa HS=Hardness, Side
MOE=Modulus of elasticity C//=Compression parallel-to-grain HE=Hardness, End
TR=Toughness, Radial TT=Toughness, Tangential

Figure 4. Strength properties of 7- and 3- year-old yemane (*Gmelina arborea* Roxb.) coppice and 3-year old planted stand.

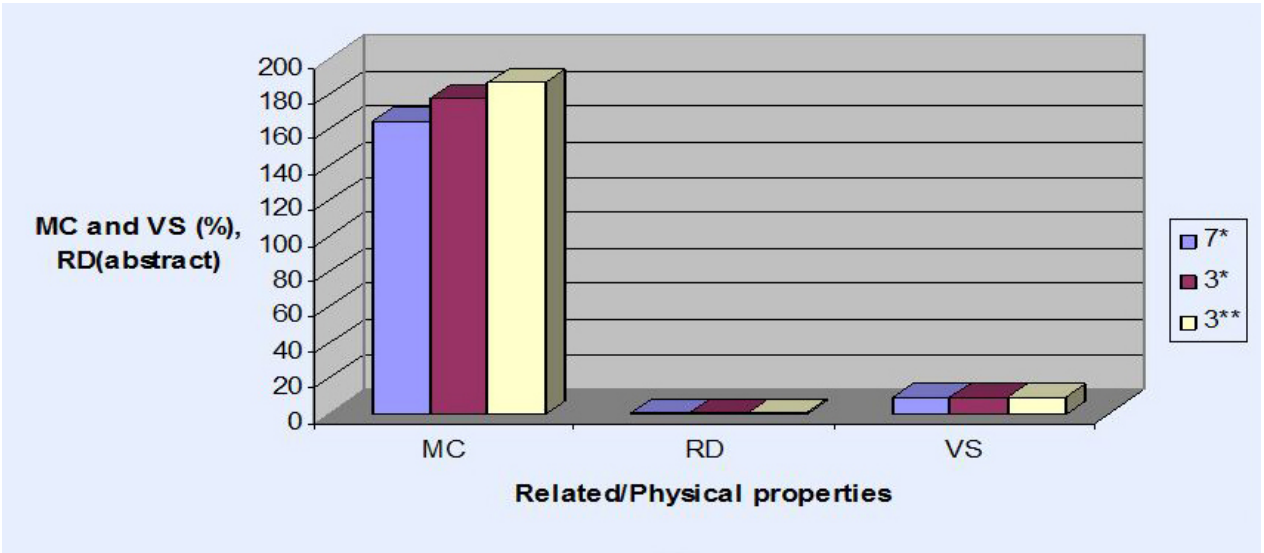


Figure 5. Related/Physical properties of 7- and 3- year-old yemane (*Gmelina arborea* Roxb.) coppice and 3-year old planted stand.

10-year-olds from Casiguran, Aurora. It is noticeable that the strength properties of 10-year-old from Nueva Vizcaya were higher than the 10-year-old from Casiguran, Aurora. The difference may be due to the effect of site conditions (Drow 1963, Larson 1957). For instance, the trees from Casiguran, Aurora were planted in logged-over areas while those in Nueva Viscaya were planted in grasslands. Likewise, Casiguran, Aurora had Type III climate (has no very pronounced maximum rain period) and Nueva Vizcaya on the other hand, had a Type II climate (has no dry season but has a very pronounced maximum rain period during November, December and January). These factors may have caused some variation on tree growth, wood formation and consequently on wood properties

Table 3. ANOVA for strength and related properties of 3- and 7-year-old yemane (*Gmelina arborea* Roxb.) coppice and 3-year-old planted stand.

		F - V a l u e						
Source of Variation	DF	Static Bending			Compression		Shear	
		MOR	SPL	MOE	//-to-Grain	/-to-Grain	Tangential	Radial
Age	2	15.01**	16.32**	3.66*	1.33ns	9.79**	4.97*	5.27**
Error	65							
Total	67							
R2 (%)		16.6	21.2	16.3	28.7	24.3	17.5	18
CV		38	40.5	13.2	5.2	29	17	17.1

		F - V a l u e						
Source of Variation	DF	Hardness		Toughness		MC	RD	VS
		Side	End	Tangential	Radial			
Age	2	10.90**	3.32*	1.67ns	2.97 ns	324.5**	26.21**	2.17 ns
Error	65							
Total	67							
R^2 (%)		31.2	12.1	56.6	57.3	23	6.96	14.3
CV		18.3	18.6	6.5	11	90.9	44.6	0.06

**highly significant at alpha = 0.01 *significant at alpha = 0.05 ns = not significant

Table 4. DMRT of the effect of age on physical and mechanical properties of yemane (*Gmelina arborea* Roxb.) coppice and planted stands.

Age	RD	VS	MOR	SPL	MOE	MCS	C/
7 *	0.40 a	8.88 a	44.9 a	23.6 a	5.66 a	16.7 a	3.00 a
3 *	0.39 a	9.66 a	37.4 b	17.0 b	5.13 a	17.7 a	2.85 a
3**	0.34 b	9.10 a	29.4 c	14.1 b	4.72 b	13.8 a	1.67 b

Age	Shear		Hardness		Toughness	
	Radial	Tangential	Side	End	Radial	Tangential
7 *	5.35 a	5.62 a	2.48 a	2.95a	20.0 a	23.5 a
3 *	5.30 a	5.45 a	2.38 a	2.59ab	14.9 a	17.3 ab
3**	4.09 b	4.29 b	1.55 b	2.31b	13.3 a	11.8 b

For each property, Means with the same letter are not significantly different
7*-year-old coppice
3*-year-old coppice
3**-year-old planted stand

(Lantican 1976).

End-use classification

Comparison of relative density, volumetric shrinkage and strength properties classification of yemane coppice and non-coppice trees from various localities is shown in Table 5.

Based on strength grouping devised at FPRDI (FORPRIDECOM 1980) the wood of 7- and 3-year-old yemane coppice falls under C5 (low) to C4 (moderately low). The recommended end-uses of the said wood per strength class is as follows:

C4 – For the production of pulp and paper, wood carving and sculpture, conventional furniture, drafting boards, toys, venetian blinds, crates, pallets, form wood, shingles and matchwood.

C5 – For light construction where strength, hardness and durability are not critical requirements such as mouldings, sash, door and panel cores, ceiling and acoustic panels, pulp and paper making, wall boards, pencil slats, spoons, core veneer, fans, wooden shoes, cigar boxes, buoys and floats.

The strength and related properties of 7-year-old yemane coppice under C4 are comparable to those of local wood species i.e., mayapis [*Shorea palosapis* (Blanco)

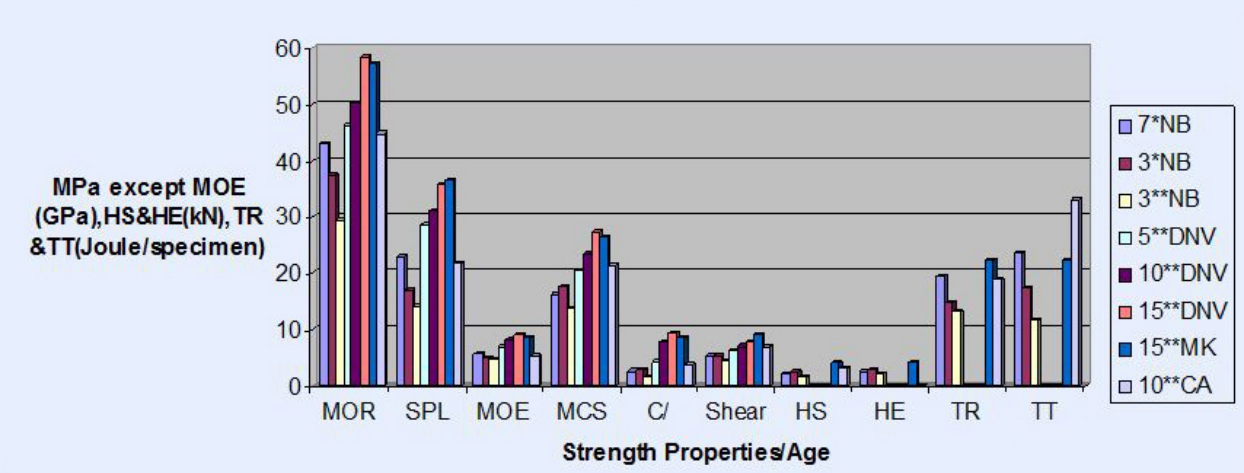


Figure 6. Strength properties of 3*- and 7*-year-old yemane coppice and 3**-year-old planted stand from Norzagaray, Bulacan versus those of planted stands at various ages and different localities.

7* Coppice Norzagaray, Bulacan (NV)
3* Coppice Norzagaray, Bulacan (NV)
3** Coppice Norzagaray, Bulacan (NV)
5** Planted Stand, Diadi, Nueva Viscaya (DNV)
10** Planted Stand, Diadi, Nueva Viscaya (DNV)
15** Planted Stand, Diadi, Nueva Viscaya (DNV)
15** Planted Stand, Makiling, Laguna (MK)
10** Planted Stand, Casiguran, Aurora (CA)

Table 5. Strength and related properties classification of 3*- and 7*-year-old yemane (*Gmelina arborea* Roxb.) copice and 3**-year-old planted stand from Norzagaray, Bulacan versus those of planted stands at various ages and different localities.

Property	Age/Locality							
	7*NB	3*NB	3**NB	5**DNV	10**DNV	10**CA	15**DNV	15**MK
Strength Properties								
Static Bending								
MOR(MPa)	C4	C5	C5	C4	C3	C4	C3	C3
MOE(GPa)	C5	C5	C5	C4	C3	C5	C3	C3
MCS(MPa)	C5	C5	C5	C4	C3	C4	C3	C3
C/(MPa)	C4	C4	C5	C3	C2	C3	C1	C1
Shear (Ave. R&T,MPa)	C4	C4	C5	C3	C3	C1	C2	C2
Physical/Related Properties								
RD (Abstract)	LRD	LRD	LRD	LRD	LRD	MLRD	MLRD	MLRD
VS (%)	MLVS	MLVS	MLVS	MLVS	MLVS	MLVS	MVS	MLVS

C1-High strength C3-Medium strength C5-Low strength
C2-Moderately high strength C4-Moderately low strength
MLRD-Moderately low RD LRD-Low RD MLVS-Moderately low VS MVS-Medium V

Merr.], almon (*Shorea almon* (Foxw.) and igem [*Dacrycarpus imbricatus* (Bl.) de Laub. var. patulus de Laub. (POD)]- On the other hand, yemane coppice under C5 are comparable to tiaong (*Shorea ovata* Dyer ex Brandis), anabiong [*Trema orientalis* (L.) Blume] and dita (*Alstonia scholaris* (L.) R. Br. var. scholaris].

CONCLUSIONS AND RECOMMENDATION

In general there is no significant variation in the strength and related properties of 3- and 7-year-old yemane coppice across varied diameter and height levels. Their RD and VS are classified low and moderately low, including MOR, MOE, compression, and shear strength. However, the 7-year-old coppice has a slightly higher MOR (C4) than the 3-year-old coppice (C5).

The RD (low), VS (mod. low), MOR (C5), compression parallel-to-grain of the 3-year-old yemane coppice is the same as those of 3-year-old yemane from planted stands. The former, however, has relatively higher compression perpendicular-to-grain and shear strength than the latter.

The strength properties of 5-, 10-, and 15-year-old yemane

from planted stands are generally higher than those of 7-year-old yemane coppice. However, the RD and VS are at par with those of the 5-, and 10-year-olds.

Based on its strength and related properties, 7-year-old yemane coppice can be used for making conventional furniture, wood carving, venetian blinds, crates and other wood products where hardness is not a critical requirement, i.e., wall board, core veneer, sash, door and panel cores.

The 3-year-old coppice and planted stand should be allowed to mature more because some of its properties although the same as the 7-year-old's is still increasing. Moreover, the diameter of the tree is still small.

The wood properties and timber yield of older yemane coppice stands should be investigated to ascertain their potential utilization and appropriate harvesting age or cutting cycle for higher return of investment.

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