Modulation of Moisture Content and Grouping of Wood from Fast-growth Tropical Species in Plantation

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Introduction

- Costa Rica posses a great stock of hardwood timber for sawmilling both from natural and plantation forests.
- However species growing in fast growth plantation condition had reached large commercial importance.
- Conservation of rainforest is a main objective for ecology tourist
- Only 50 000 ha of timber species were counted for forest plantations with production purposes, limiting the establishment of a sustainable wood trade market.
- Fast growth is usually find in tropical condictions
- Pinus and eucalyptus species are not importante in Costa Ric

Introduction

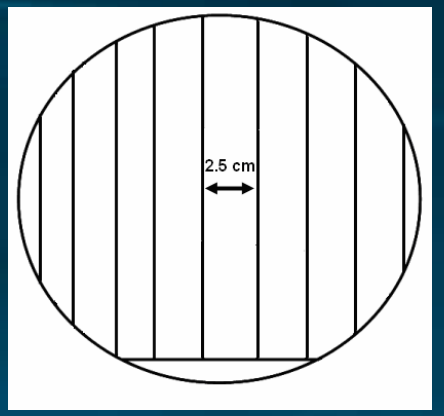
- **Agroforestry sistems is common utilized for reforestation**
- **Large scale kiln drying is not possibly with only one species**
- **Few studies on wood properties or behavior in industrial process of fast growth species from tropical climates are reported in the literature and are limited to a reduced number of characteristics.**
- **Wood tropical species from natural forestry is very different from fast growth plantation condictions**

Objetive

- **The aim of the present study was to established behavior moisture content of eight (*Acacia magnium*, *Alnus acuminata*, *Cupressus lusitanica*, *Swietenia macrophylla*, *Terminalia amazonia*, *Terminalia oblonga*, *Tectona grandis* and *Vochysia guatemalensis*) species growing in fast growing plantation condition in a tropical region of Costa Rica. And this information utilized for grouping of those species.**

Material

- Eight different pure plantations located at several part of Costa Rica were utilized.
- The initial planting density was 1111 trees/ha (3x3 m spacing); at the moment of evaluation the stands aged 9-18 years and presented a density of 495-575 trees/ha.
- A second thinning was applied in representative plot of all species, approximately were felled 60 trees in one hectare.


2.5 cm

Plantations condictions

Specie	*Acacia magnium*	*Alnus acuminata*	*Swietenia macrophylla*	*Terminalia oblonga*	*Terminalia amazonia*	*Tectona grandis*	*Cupressus lusitanica*	*Vochysia guantemalisis*
Age (Years)	9	9	10	10	14	13	18	8
Density (trees/ha)	556	338	480	495-575	452	475	525	515
Total height (m)	20.7	19	16.7	-	21.40	21.85	21.25	22.7
DBH (cm)	20.5	36.7	21.5	19.12	22.59	25.2	25.25	18.5
Gravity specific	0.45	0.34	0.51	0.55	0.49	0.57	0.43	0.32
Dry schedule *	T2-D4 & T6-D2	T10-E3	T6-D4	T3-C2	T3-C2	Schedule H (Adjust)	T3-C2	T2-D4

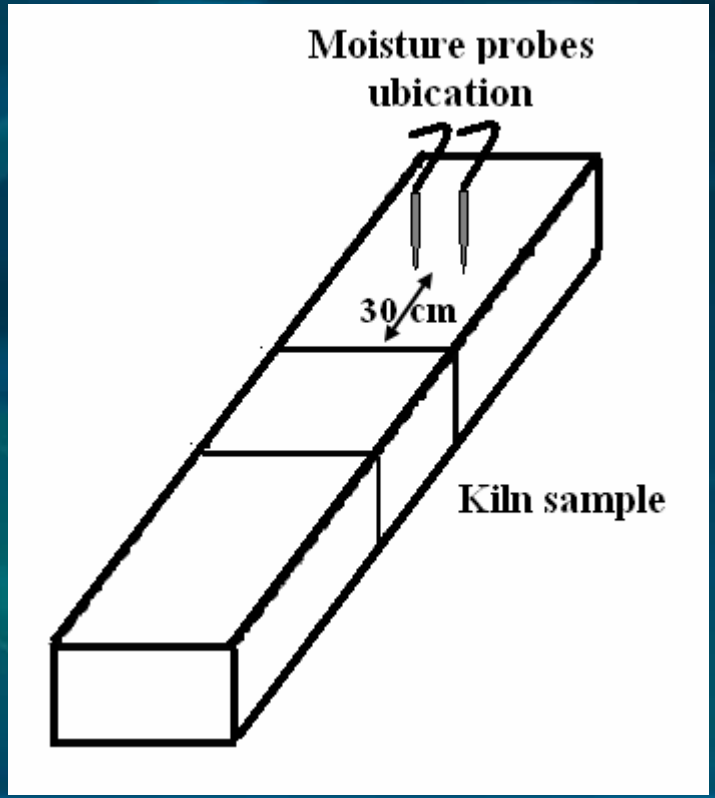
*Sydney et al. (1988).

Drying test

a small NARDI® 2 m3 capacity dry kiln.

Moisture content control

The pilot kiln had six moisture probes,. These probe measurements were used as reference to make changes to both the temperature and relative humidity inside the kiln. MC was also monitored using six kiln samples located at different pile heights. The probes measurements were located in the same boards. The kiln sample was weighted twice time per day and simultaneously was recorded the MC displayed for moisture probes.

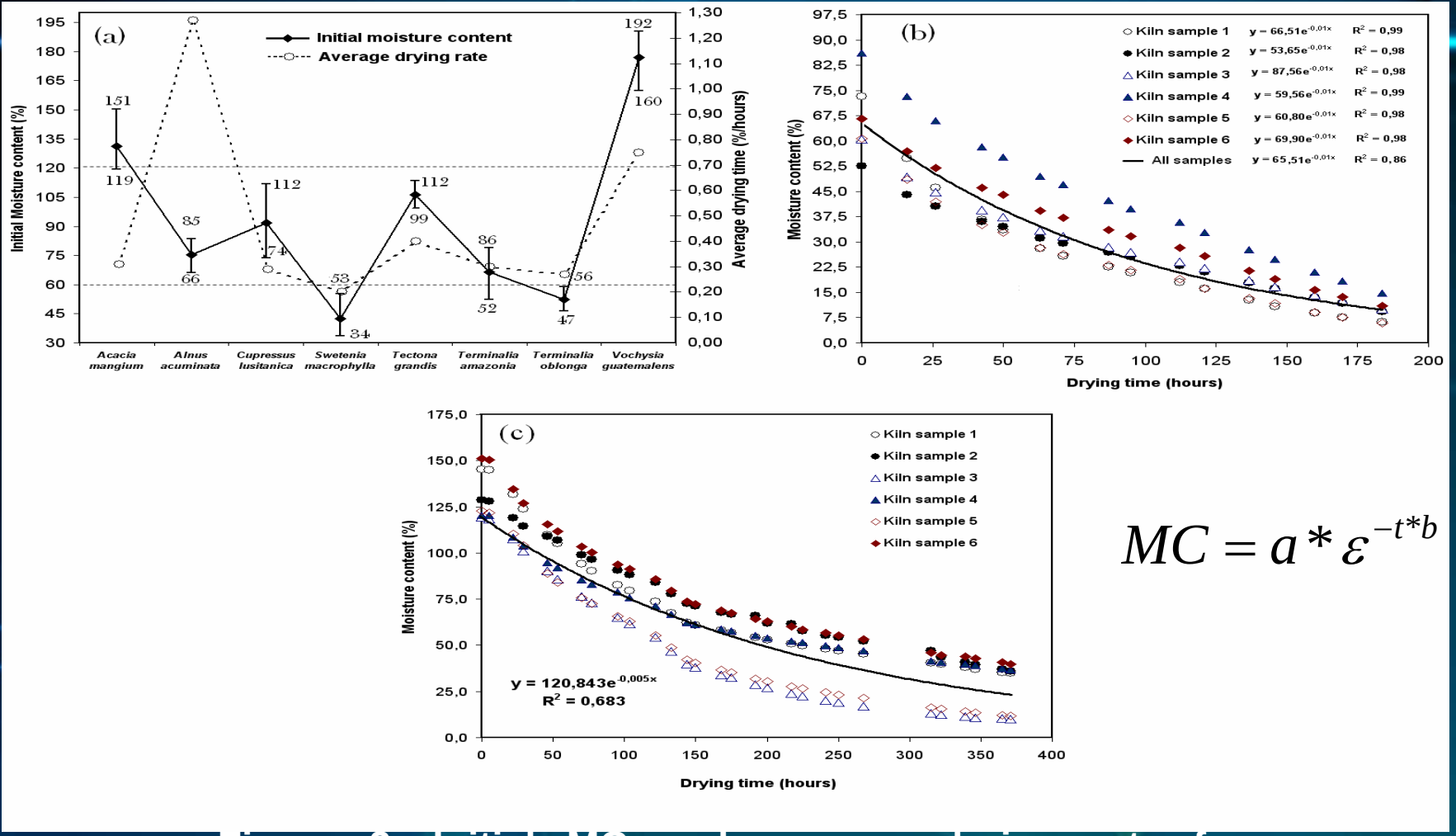


Results

Specie	*Acacia magnium*	*Alnus acuminata*	*Swietenia macrophylla*	*Terminalia oblonga*	*Terminalia amazonia*	*Tectona grandis*	*Cupressus lusitanica*	*Vochysia guantemalisis*
Initial MC (%)	134.49	75.5	42.42	52.57	66.61	106.39	91.91	176.9
Final MC (%)	17.28	9.46	13.3	9.11	12	10.8	11.8	7.58
Drying time (Hours)	376	52	147	159	183	237	274	227
Drying rate (% / hrs)	0.31	1.27	0.20	0.27	0.30	0.40	0.29	0.75
Dry groups*	1	5	4	4	4	3	3	2

*Dry groups utilized in linearized model

Results



$$MC = a * \varepsilon^{-t*b}$$

Figure 2. Initial MC and average drying rate for different fast-growth plantation species (a) and variation of MC with drying time in *Terminalia amazonia* (b) and *A. magium* (c).

$$MC = a * \varepsilon^{-t*b}$$

As expected, the MC decreases with time (hours) and the relationships between MC and drying time was modulated by exponential relation

$$\ln(MC) = \ln(a) - t * b$$

Table 2. Coefficients of linearizad model, determination coefficient and empirical equation for 8 fast growth species of Costa Rica.

Fast growth species	Coefficients of linearized model		Determination coefficients	Error (%)	Emperical equation
	b	Ln(a)			
A. manigum	-0.005**	4.794**	$R^2 = 0.683$	34.99	$y = 120.843e^{-0.005x}$
A. acuminata	-0.032**	4.392**	$R^2 = 0.923$	18.33	$y = 80.776e^{-0.032x}$
C. lusitanica	-0.009**	4.407**	$R^2 = 0.841$	31.86	$y = 82.026e^{-0.009x}$
S. macrophylla	-0.008**	3.900**	$R^2 = 0.801$	21.15	$y = 49.426e^{-0.008x}$
T. grandis	-0.011**	4.801**	$R^2 = 0.966$	14.34	$y = 121.575e^{-0.011x}$
T. amazonia	-0.010**	4.183**	$R^2 = 0.837$	24.60	$y = 65.530e^{-0.010x}$
T. oblonga	-0.007**	3.971**	$R^2 = 0.911$	12.05	$y = 53.232e^{-0.007x}$
V. guatemalensis	-0.012**	5.242**	$R^2 = 0.868$	31.66	$y = 189.076e^{-0.012x}$

** Statistically significant to α=0.01

The slope of predicted or linearized model

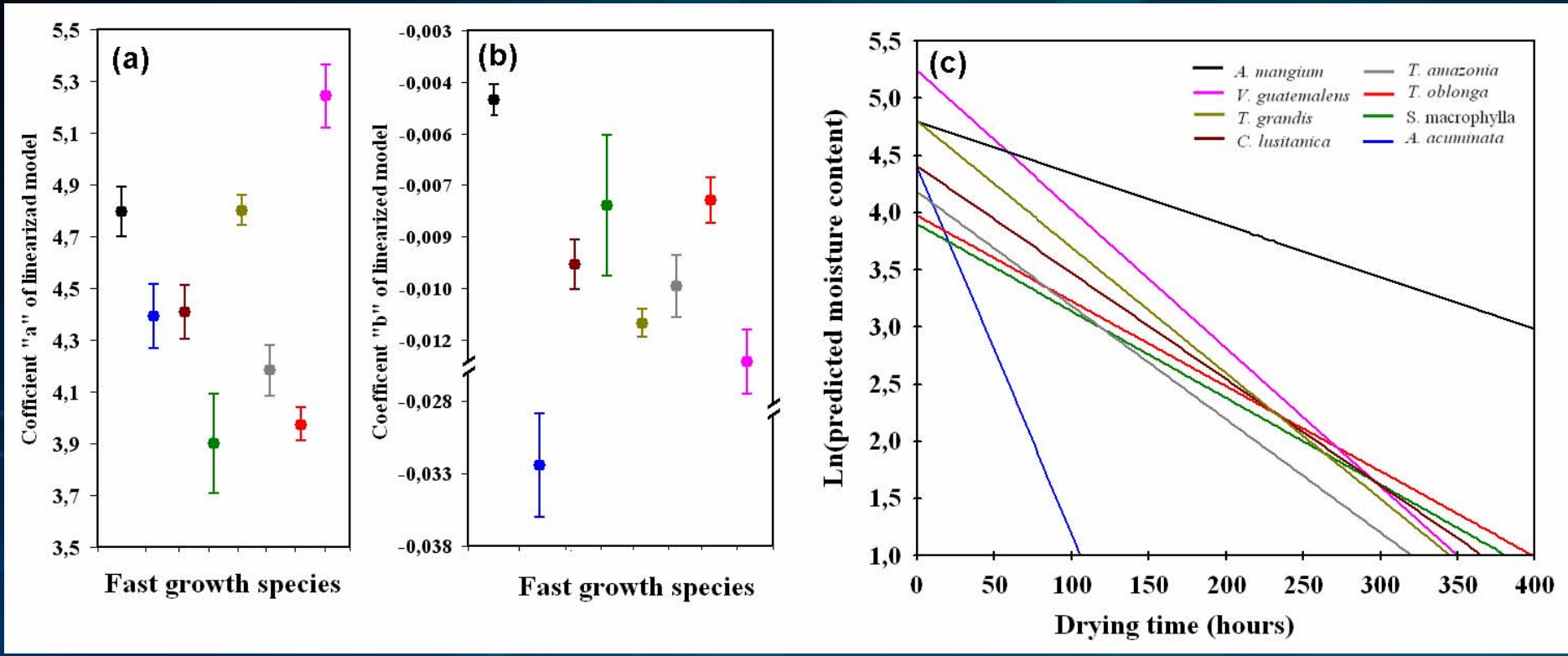


Figure 3. “a” and “b” values of linearized model (a and b) and regression slop of predicted drying time for different fast-growth plantation species (c).

Results

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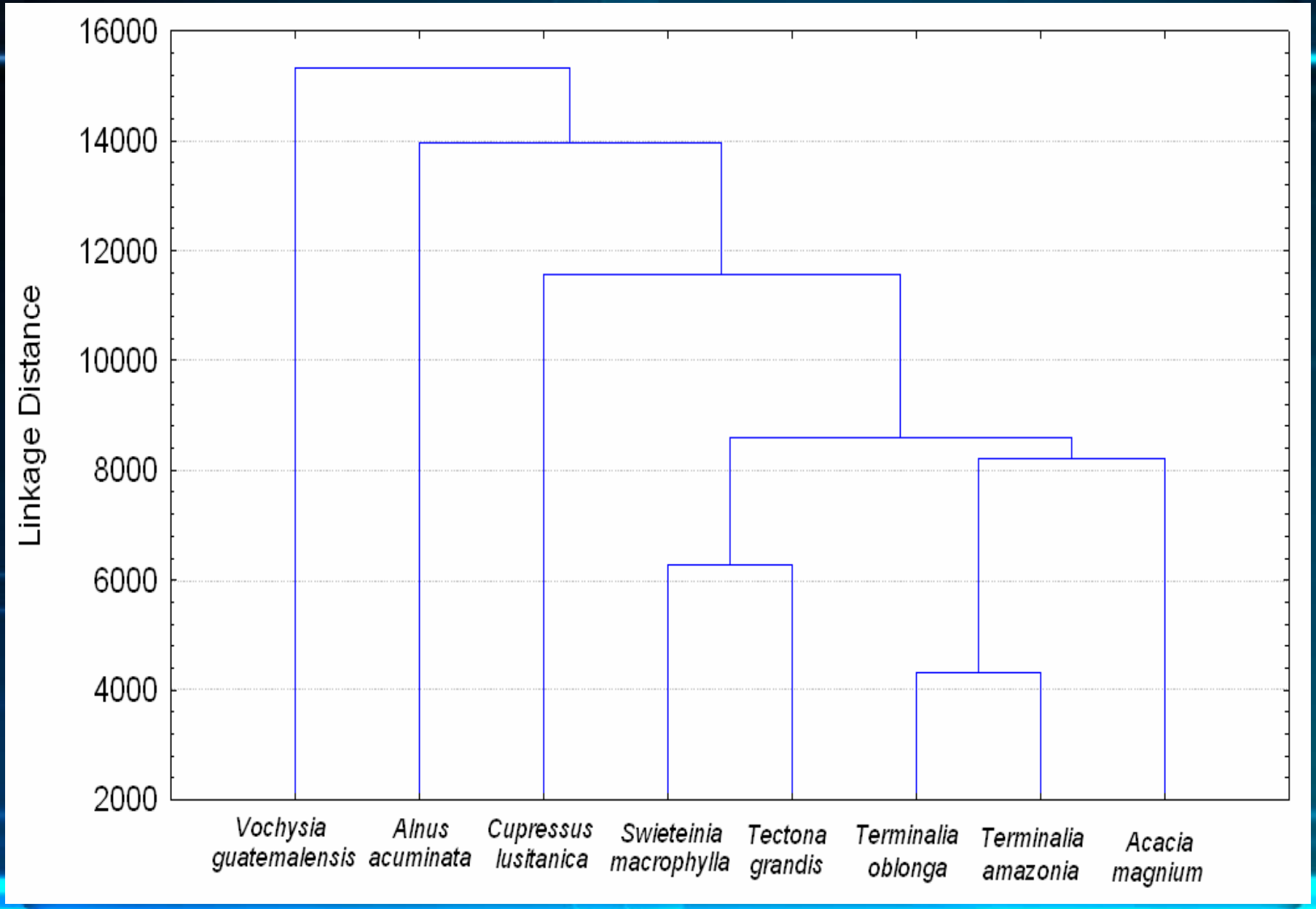
Especie		Aladeo (mm)		Encorvadura (mm)		Acanaladura (mm)		Arqueadura (mm)		Grietas (mm)		Rajaduras (mm)	
		Antes secado	Después secado	Antes secado	Después secado	Antes secado	Después secado	Presencia antes	Presencia después	Antes secado	Después secado	Antes secado	Después secado
Pochote	% de piezas con defecto	57,89	84,31	87,72	96,08	8,77	66,67	No se presentó	No se presentó	49,12	64,71	54,39	62,75
	Magnitud	4,34	4,55	9,14	5,90	2,97	2,81	No se presentó	No se presentó	36,27	46,41	66,56	89,80
Cipres	% con defecto	4,08	63,27	83,67	94,90	0 (no hay)	57,14	No se presentó	84,69	26,53	67,35	54,08	57,14
	Promedio antes	3,07	4,93	5,91	8,21	0 (no hay)	3,63	No se presentó	7,93	25,27	45,78	35,97	59,32
Amarrillon	% con defecto	6,25	58,75	97,50	97,50	0 (no hay)	72,50	66,25	71,25	28,75	32,50	92,50	97,50
	Promedio antes	3,17	3,53	15,21	18,03	0 (no hay)	1,82	3,43	5,85	45,48	49,42	239,94	235,86
Acacia	% con defecto	9,85	16,13	69,70	70,16	0 (no hay)	78,23	90,91	86,29	-	35,61	35,61	83,33
	Promedio antes	3,91	7,16	8,23	8,97	0 (no hay)	5,45	15,60	11,35	-	21,78	27,65	31,31
caoba	% con defecto	72,60	88,06	No se	midió	2,74	40,30	73,97	67,164	65,07	83,32	10,92	22,51
	Promedio antes	4,26	4,61	No se	midió	0,04	1,19	9,86	10,04	56,82	56,55	47,97	69,43
Cebo	% con defecto	no hay	70,67	73,89	89,33	0 (no hay)	100,00	80,89	89,33	17,47	23,17	10,92	22,51
	Promedio antes	no hay	8,77	8,76	24,00	0 (no hay)	5,76	7,55	7,61	92,33	113,00	47,97	69,43
sura	% con defecto	3,92	22,22	41,18	60,00	0 (no hay)	53,33	96,08	88,89	24,24	33,30	16,68	18,24
	Promedio antes	2,90	4,44	3,34	6,18	0 (no hay)	5,70	10,70	8,80	21,91	53,88	414,27	36,00
Jaul	% con defecto	43,75	41,48	32,62	71,85	0 (no hay)	91,11	92,20	80,74	42,55	37,77	31,20	49,09
	Promedio antes	3,00	8,54	3,43	6,97	0 (no hay)	3,38	1,33	7,97	22,40	53,11	11,14	18,51
Promedio magnitud		**3,08**	**5,82**	**6,75**	**9,78**	**0,38**	**3,72**	**6,06**	**7,44**	**37,56**	**54,99**	**111,43**	**76,21**
Promedio de porcentaje		**24,79**	**55,61**	**60,79**	**72,48**	**1,44**	**69,91**	**62,54**	**71,04**	**31,72**	**47,22**	**38,29**	**51,63**


Linkage Distance
16000
14000
12000
10000
8000
6000
4000
2000
Vochysia guatemalensis
Alnus acuminata
Cupressus lusitanica
Swieteinia macrophylla
Tectona grandis
Terminalia oblonga
Terminalia amazonia
Acacia magnium

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Dry groups with defects	1	5	3	4	4	3	6	2

*Dry groups utilized in linearized model

Conclusion

- The fast growth species utilized in the reforestation in Costa Rica have different drying time. However, it possible groups some of them according drying time. Five groups were established from a longest and shortest dying time. The first and second group is colleted *A. magnium* and *V. guatemalisis* respectively. In the third is set for *C. lusitanica* and *T. grandis*, the flowing group for: *S. macrophylla*, *T. amazonia* and *T. oblonga*. And last group with shortest drying time is compost for *A. acuminata.*

Others important topics

- **Wood quality**
- **Best schedule**