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EARLY GROWTH AND SURVIVAL OF SOME EUCALYPTS AND AUSTRALIAN TREE SPECIES PLANTED AT TUNG KULA RONGHAI DEVELOPMENT PROJECT IN NORTHEASTERN THAILAND

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บทคัดย่อ

งานทดลองภาคสนามของไม้ยูคาลิปตัสและไม้โตเร็วบางชนิดจากออสเตรเลีย ได้เริ่มขึ้นเมื่อปี พ.ศ. ๒๕๒๙ ณ บริเวณโครงการพัฒนาทุ่งกุลาร้องไห้ จังหวัดร้อยเอ็ด อันเป็นโครงการร่วมระหว่างกรมป่าไม้และศูนย์วิจัยการเกษตรระหว่างประเทศแห่งออสเตรเลีย ซึ่งผลการเจริญเติบโตทางความสูง เส้นผ่าศูนย์กลางที่ระดับผิวดินและอัตราการรอดตายในช่วง ๖ เดือนและ ๑๒ เดือนแรกชี้ให้เห็นว่า *Ecucalyptus camaldulensis* เป็นพรรณไม้ที่เหมาะสมสำหรับทุ่งกุลาร้องไห้ ไม้โตเร็วชนิดอื่นที่น่าสนใจสำหรับสภาพพื้นที่ดังกล่าว ได้แก่ *Eucalyptus tereticornis, E. houseana, Acacia auriculiformis, A. difficilis, A. cincinnata, A. holosericea, A. leptocarpa, A. plectocarpa, Melaleuca bracteata, M. cajuputi M. leucadendra,* และ *M. stenostachya* อย่างไรก็ตามผลรายงานเป็นเพียงผลในช่วงหนึ่งปีแรกเท่านั้น ต้นไม้ยังเล็กเกินกว่าสรุปและนำไปปฏิบัติได้

ABSTRACT

A field trial of Australian tree species was assessed for height and survival at six months and height, diameter at ground level and survival at twelve months after planting. The trial was established in 1986 at Tung Kula Ronghai re-afforestation project as a collaborative effort between the Royal Forest Department (RED) and the Australian Centre for International Agricultural Research (ACIAR).

Results to date indicate the importance attached to *Eucalyptus camaldulensis* by the Royal Forest Department. Nevertheless the results presented here clearly indicate the potential use of several other lesser-known, but promising fast-growing eucalypts (*E. tereticornis* and *E. houseana*), acacias (e.g. *A. auriculiformis A. difficilis, A. cincinnata, A. holosericea, A. leptocarpa,* and *A. plectocarpa*), and melaleucas (*M. bracteata, M. cajuputi, M. leucadendra* and *M. stenostachya*). The trial is still too young to make accurate future predications.

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INTRODUCTION

Thailand, together with other countries in South–East Asia, is facing a serious and rapid depletion of its native forests. Early this century about 70% of Thailand was forested (Feeny 1984) and by 1985 Landsat satellite imagery indicated that forests were reduced to about 30% of the land area (Anon 1986). The rate of forest reduction was estimated at 1.43 to 1.18 percent per year from 1930 through to 1975 and the major cause was attributed to an increase in the area under agricultural crops, especially the development of crops for the upland regions (Feeny 1984). Demand for wood for all purposes is increasing, especially for fuelwood for cooking and heating. Indirect costs of deforestation are considerable through decreases in soil fertility, increases in soil erosion and loss of valuable agriculture land through soil salinization. Other costs include loss of wildlife refuges and valuable forest germplasm.

There is general agreement amongst scientists that tree removal in water recharge zones (upper slopes and hill crests) in local and regional catchments can lead to rising watertables in lower lying areas. In this sense trees act as biological pumps in reducing subsurface flow. Trees can decrease soil erosion by reducing the impact of heavy rain on the soil, slowing surface run–off and minimizing ponding. The problem of rising watertables is exacerbated if salts are mobilised through evaporation and brought up into the plant root zone. This can seriousty reduce plant growth and, depending on severity and duration, lead to plant death. In summary, trees can provide an important biological solution in rehabitating damaged deforested landscapes.

One aim of the Tung Kula Ronghai Project is to reduce soil waterlogging and salinity in discharge areas by planting fast–growing tree species in the recharge zone (E. Loffler pers. comm.). While it is desirable to plant indigenous trees in this zone the reality is that there are few species, so far identified, capable of rapid growth in the first 5 to 10 years after planting. The main species currently planted is *Eucalyptus camaldulensis* (an exotic species from Australia).

E. camaldulensis has been identified as an important exotic species in Thailand but, despite this, is need to identify additional promising species and ways in which new species may be used. Australia has a wide range of valuable lesserknown tree species that can provide useful benefits (see Boland, 1971). In particular some species in the genus *Casuarina* (see Midgley *et al* 1983) and *Acacia* (see Turnbull 1986) have been spectacularly successful in selected environments overseas. ACIAR and the Royal Forest Department are collaborating to evaluate over 60 Australian species in well replicated trials over eight sites in Thailand.

The impetus for the T.K.R. tree species trial arose out of informal consultations in Australia between ACIAR/CSIRO and RFD staff engaged in the T.K.R. refforestation project. Because the ACIAR forestry project has a special interest in salt-tolerant Australian tree species (see Aswathappa *et al* 1986, 1987) it was considered desirable to establish a small evaluation trial of salt-tolerant species in the T.K.R. area. Such a trial is within the spirit of the research and development programme for the T.K.R. region.

The aim of this paper is to report on the results of the ACIAR/RFD field trial near Roi Et at age six and twelve months.

MATFRIALS AND METHODS

Soil chemical and physical characteristics of the trial site are given in Table 1. The soil is medium textured (sandy loam) with a very low clay content. The soil is highly acidic with a very low nutrient availability. Available phosphorus and cation exchange capacity are both very low.

Table 1. Soil Analysis of ACIAR/RFD field trial of Australian tree species at T.K.R. near Roi Et

Sarple No.	pH		OH %	Avail. P ppm	Exch. Cation me/100 g				B.S. %	CEC me/100 g	% Soil Composition			Soil Texture	EC m mho/cm	Depth where soil samples were collected
	1:1 H_2O	1:1 KCl			K	Ca	Mg	Na			Sand	Silt	Clsy			
1.	5.39		1.02	1.08	0.038	0.333	0.086	0.148	37.69	1.61	73.712	21.344	4.944	Sandy loam	0.025	0–10 cm
2.	4.96		0.90	0.89	0.023	0.350	0.087	0.104	31.97	1.76	73.64	22.216	4.144	Sandy loam	0.019	10–20 cm
3.	5.02		0.44	0.52	0.023	0.370	0.091	0.080	74.21	0.76	73.712	21.888	4.40	Sandy loam	0.009	20–30 cm
4.	5.07		0.80	1.79	0.052	0.217	0.062	0.084	40.89	1.02	75.64	20.616	3.744	Loamy sand	0.016	0–10 cm
5.	4.74		0.52	0.52	0.040	0.223	0.051	0.121	30.31	1.44	81.64	15.216	3.144	Loamy sand	0.014	10–20 cm
6.	4.50		0.38	nil	0.019	0.142	0.037	0.038	16.43	1.44	79.64	16.888	3.472	Loamy sand	0.015	20–30 cm
7.	4.45		0.66	2.66	0.037	0.323	0.094	0.076	39.85	1.33	73.64	21.088	5.272	Sandy loam	0.014	0–10 cm
8.	4.20		0.81	3.67	0.026	0.333	0.084	0.075	34.08	1.52	75.64	18.488	5.872	Sandy loam	0.018	10–20 cm
9.	4.60		0.66	1.68	0.040	0.373	0.093	0.163	45.54	1.47	73.64	20.088	6.272	Sandy loam	0.011	20–30 cm
10.	4.43		0.72	4.96	0.050	0.395	0.102	0.149	30.33	2.30	73.64	19.816	6.544	Sandy loam	0.020	0–10 cm
11.	4.53		0.63	2.44	0.046	0.738	0.100	0.186	40.07	2.67	73.64	19.288	7.072	Sandy loam	0.012	10–20 cm
12.	4.57		0.60	2.61	0.030	0.350	0.086	0.130	27.14	2.20	75.64	16.616	7.744	Sandy loam	0.011	20–30 cm
13.	4.66		0.59	2.75	0.058	0.475	0.124	0.221	42.25	2.08	75.64	19.288	5.072	Sandy loam	0.012	0–10 cm
14.	4.43		0.30	1.19	0.015	0.145	0.038	0.042	23.08	1.04	79.64	15.016	5.344	Loamy sand	0.015	10–20 cm
15.	4.55		0.38	1.16	0.014	0.169	0.051	0.045	25.86	1.08	79.64	16.088	4.272	Loamy sand	0.016	20–30 cm

Full details of all treatments (seedlots and one clone) are provided in Table 2. All seedlots were supplied by the Tree Seed Centre, Division of Forest research CSIRO. Each seedlot was collected from natural stands (herein called provenance) and no genetically improved seedlots were used. The *E. camaldulensis* clone included was derived by tissue culture from a selected seedling that survived in an intense seedling screening trial for salt tolerance (see Hartney & Kabay 1984). Selection of all material was biased towards those species potentially capable of surviving and growing in saline, tropical/subtropical, seasonal dry climates in northern Australia.

The seedlings were raised at Roi Et and field planting took place in June 1986. A randomised complete block design was used with each treatment consisting of three replications of 25 trees each arranged in a plot of 5×5 trees. Spacing was 2×2 m.

Site preparation included disc-ploughing twice in cross-direction. No weedicide was used and no fertilizer was applied. No attempt was made to apply nitrogen fixing, root nodule forming, micro-organism to either the acacias (*Rhizobia* spp.) or casuarinas (*Frankia* spp.) seedlings. The trial area was fenced.

Height and survival were assessed at 6 months. Separate analyses of variance were carried out for height, diameter at ground level and survival at 12 months. For survival an arcsin transformation was applied to the 12 month data before analyses. Three treatments (*Acacia ampliceps*, *A. ligulata*, and *Melaleuca acacioides*) were represented by only two replicates due to block irregularities. For this reason the missing data method described by Steel and Torrie (1981) was used. Duncan's new multiple range test was used to test the significance of the differences between treatment means. Each vertical line groups those treatments that are not significantly different at $P < 5\%$ level of significance.

Three treatments (*Eucalyptus*

Table 2. Origin data for treatments used in T.K.R. tree species trial.

Genus	Species	Treatment Number	No. of Parent Trees in Collection	Location	Lat	Long	Altitude
Acacia	ampliceps	14631	10	NE of Wave Hill NY	17 26	130 56	230
	aulacocarpa	13689	5	Oriomo River Prov PNG	8 43	143 9	20
	auriculiformis	13684	17	Balamuk PNG	8 54	141 18	18
	auriculiformis	13685	8	Bula Coastal Prov PNG	9 9	141 20	5
	cincinnata	13878	12	Julatten Area QLD	16 35	145 25	410
	cowleana	14634	22	SE of Hooker Creek NT	18 48	131 13	300
	crassicarpa	13682	11	Orlomo River Prov PNG	8 50	143 10	20
	difficilis	14623	41	S of Borroloola T' Off NT	16 21	133 22	235
	holoscricea	14637	10	E of Hooker Creek NT	18 20	130 41	310
	holosericea	14649	1	Wolf Creek Crater WA	19 10	127 48	360
	leptocarpa	15966	10	1-26 km S Musgrave QLD	14 53	143 31	98
	ligulata	14662	110	Fltzroy Rlver WA	18 29	125 45	180
	oraria	14961	8	39 km NW Calrns QLD	16 41	145 35	5
	plectocarpa	14696	13	Klmberley Reglon WA	16 18	128 15	150
	polystachya	13871	4	Brldle L.A. QLD	16 58	145 37	480
	saliclna	14592	5	22.6 km. W of Banana QLD	24 36	149 54	105
	victoriae	14489	Unknown	Tltree Station NT	2 28	133 2	552
Atalaya	hemiglauca	14976	25	34 km W Georgetown QLD	18 17	143 14	220
Casuarina	cunninghamiana	13514	5	11 km SE Petford QLD	17 25	144 59	560
	cristata	14593	1	SE of Bourke NSW	30 16	146 5	110
	cristata	14843	10	W Gllgandra NSW	31 43	148 40	290
	glauca	13144	5	S of Burrll Inlet NSW	35 24	150 26	0
	glauca	14408	9	Urunga Lagoon NSW	30 30	153 1	1
Dodonea	viscosa						
subsp.	angustissima	12783	Unknown	75 km NW Cobar NSW	30 58	145 23	0
	,,	13753	16	Ayeyonga Reserve NT	23 52	132 33	650
subsp.	spatulata	13755	15	Stanlcy Chasm NT	23 45	133 28	720

Genus	Species	Treatment Number	No. of Parent Trees in Collection	Location	Lat	Long	Altitude
Eucalyptus	argillacea	13700	2	Mt Isa & Kajabbl QLD	20 14	139 53	220
	argophloia	13713	6	S.F. 302 Ballon QLD	26 20	150 40	300
	camaldulensis	CML346		Wiluna WA			
	,,	14847	20	Emu ck Petford QLD	17 10	145 15	500
	houseana	11487	1	23 km E Inglls Gap WA	17 10	125 21	360
	melanophloia	14841	5	E. Narrabri NSW	30 18	150 25	240
	ochrophloia	11633	3	51 km N Yantabulla NSW	29 18	140 1	140
	orgadophila	13678	4	N of Clermont QLD	22 35	147 39	274
	tereticornis	12189	27	SW Mt Garnet QLD	18 30	144 45	875
	tessellaris	12967	10	NW of Mareeba QLD	16 58	145 15	450
Erythrina	vespertilio	14490	Unknown	Alleron Station NT	22 38	133 20	656
Melaleuca	acacioides						
subsp.	alsophila (?)	14873	15	SSE Laura QLD	15 37	144 28	90
	argentea	14904	10	W Wrotham Park QLD	16 41	143 54	135
	bracteata	14903	15	W Lakeland Downs QLD	15 50	144 54	180
	cajuputi	14878	10	N Mossman QLD	16 16	145 23	12
	leucadendra	14147	10	Weipa QLD	12 31	141 48	10
	nervosa	14879	10	NE Homestead QLD	20 20	145 42	320
	stenostachya	14149	10	38 km SE Weipa QLD	12 44	142 6	10
	viridiflora	14151	10	NW of Weipa QLD	12 31	141 48	10

houseana, *E. argophloia* and *Atalaya hemiglauca*) were represented by one replicate only because of insufficient seedlings due to seed germination difficulties and these treatments were not included in the ANOVA.

RESULTS

Height at 6 Months

Table 3 indicates results for height. Eight treatments were greater than 1 metre in height and these included *Eucalyptus ochrophloia* *E. camaldulensis* (14847), *E. tereticornis* *Melaleuca leucadendra* *E. camaldulensis* clone (CML 346), *M. stenostachya* *A. plectocarpa* and *A. leptocarpa*. Ten treatments were less than 30 cms in height.

Survival at 6 Months

survival percentages are given in Table 3. In general eucalypts survived well while acacias and melaleucas exhibited variable survival. *Acacia victoriae* seedlings exhibited complete mortality in the field.

Height at 12 Months

There were significant differences between treatments in height (Table 4, 5).

In the top group there were several eucalypts, acacias and melaleucas. The three top eucalypts were *E. camaldulensis*, *E. ochrophloia* and *E. tereticornis*. The identity of *E. ochrophloia* seedlot needs reconfirmation after flowering as seedlings resemble those of red gums (i.e. *E. tereticornis* and *E. camaldulensis*). The best acacias were *A. leptocarpa*, *A. cincinnata*, *A. plectocarpa* and *A. difficilis*, while the best melaleucas were *M. leucadendra* and *M. stenostachya*. Although there was only one replicate of *Eucalyptus houseana* the height was excellent.

The poorest treatments in height were *Casuarina cristata*, *Melaleuca acacioides* and *Dodonea viscosa* spp. *angustissima*. In general, growth of *Casuarinas* was poor with *Casuarina glauca* and *C. cunninghamiana* performing much better than *Casuarina cristata* (2 provenances).

Table 3. Ranking for mean height (cm.) and survival (%) at 6 months after field planting of ACIAR/RFD field trial of Australian tree species at Tung Kula Ronghai near Roi Et

SPECIES	Treatment number	Height	Survival
Eucalyptus ochrophloia	11633	142.16	91.7
Eucalyptus camaldulensis	14847	141.95	100.0
Eucalyptus tereticornis	12189	124.05	100.0
Melaleuca leucadendra	14147	119.19	100.0
Eucalyptus camaldulensis	CML346	110.22	100.0
Melaleuca stenostachya	14149	107.97	100.0
Acacia plectocarpa	14696	107.40	100.0
Acacia leptocarpa	14966	105.28	100.0
Acacia difficilis	14623	89.46	97.3
Acacia aulacocarpa	13689	88.56	97.2
Melaleuca argentea	14904	88.23	100.0
Melaleuca brocteata	14903	83.72	98.7
Acacia crassicarpa	13682	82.59	98.7
Melaleuca cajuputi	14878	79.59	100.0
Atalaya hemiglauca	14976	77.50	48.0
Acacia holosericea	14649	77.45	100.0
Acacia holosericea	14637	73.08	100.0
Acacia auriculiformis	13684	72.67	98.5
Melaleuca viridiflora	14151	69.00	88.4
Casuarina glauca	13144	67.67	100.0
Acacia auriculiformis	13685	67.44	96.0
Eucalyptus tessellaris	12967	57.00	100.0
Acacia cowleana	14634	56.46	98.7
Casuarina cunninghamiana	13514	55.77	100.0
Eucalyptus melanopholoia	14841	54.15	98.7
Eucalyptus argillacea	13700	52.33	98.7
Casuarina glauca	14408	48.61	100.0
Acacia polystachya	13871	42.17	98.7
Eucalyptus argophloia	13713	42.00	90.0
Eucalyptus orgodophloia	13678	42.00	100.0
Acacia cincinnata	13878	39.08	88.0
Melaleuca nervosa	14879	39.06	97.3
Eucalyptus houseana	11487	33.08	100.0
Dodonea viscosa spp. angustissima	12783	31.91	70.7
Acacia ampliceps	14631	30.55	44.1
Casuarina cristata	14843	28.85	96.0
Casuarina cristata	14593	28.78	58.6
Erythrina vespertilio	14490	25.83	90.7
Acacia oraria	14961	25.83	86.7
Acacia ligulata	14662	25.06	30.7
Dodonea viscosa spp. spatulata	13755	24.34	93.3
Acacia salicina	14592	24.04	80.7
Melaleuca acacioides	14873	22.75	36.6
Dodonea viscosa spp. angustissima	13753	19.31	69.3
Acacia victoriae	14489	*	*

*all plants were dead

Table 4. Summarised results of analysis of variance for height, diameter at ground level and survival at 12 months after planting of ACIAR/RFD field trial of Australian tree species at T.K.R. near Roi Et.

* and *** indicate significance at the 5 and 0.1% levels respectively.

ns indicates not significant at the 5% level.

Source of variation	Degree of freedom	Mean squares	F-ratio
Height (m.)			
Treatment	40	0.971	5.682***
Block	2	0.264	1.545ns
Error	77	0.171	
Diameter at ground level (cm.)			
Treatment	38	2.197	10.340***
Block	2	0.251	1.184ns
Error	73	0.212	
Survival (arcsine transformation)			
Treatment	40	1096.110	11.276***
Block	2	326.160	3.355*
Error	77	97.208	

Diameter at 12 Months

There were statistically significant differences in diameter at ground level amongst treatments (see Table 4 & 6). Greatest diameters were recorded for *Acacia plectocarpa*, *E. ochrophloia*, *E. camaldulensis*, *Acacia aulacocarpa*, *A. leptocarpa*, *E. tereticornis* and *Melaleuca leucadendra*. The diameter for *E. houseana* was the largest for the trial (only one replicate). Smallest diameters were recorded for *Acacia salicina*, *Casuarina cristata*, *Dodonea viscosa* ssp. *spatulata* and *Casuarina cristata*.

Table 5. Ranking for mean height (m.) at 12 months after field planting of ACIAR/RFD tree species trial at T.K.R. near Roi Et. Vertical lines group treatments that are not significantly different (p = .05)

SPECIES	Treatment number	Height
Eucalyptus camaldulensis	14847	2.17
Eucalyptus ochrophloia	11633	2.12
Eucalyptus tereticornis	12189	1.98
Acacia leptocarpa	14966	1.98
Acacia cincinnata	13878	1.86
Melaleuca leucadendra	14147	1.73
Acacia plectocarpa	14696	1.72
Acacia difficilis	14623	1.68
Melaleuca stenostachya	14149	1.57
Acacia crassicarpa	13682	1.53
Eucalyptus camaldulensis	CML346	1.51
Acacia holosericea	14649	1.46
Acacia holosericea	14637	1.43
Acacia aulacocarpa	13689	1.39
Melaleuca argentea	14904	1.28
Acacia auriculiformis	13685	1.13
Acacia auriculiformis	13684	1.11
Acacia cowleana	14634	1.08
Melaleuca bracteata	14903	1.02
Melaleuca cajuputi	14878	1.00
Melaleuca viridiflora	14151	0.97
Casuarina glauca	13144	0.88
Eucalyptus tessellaris	12967	0.83
Eucalyptus argillacea	13700	0.82
Acacia ampliceps	14631	0.79
Casuarina cunninghamiana	13514	0.79
Acacia ligulata	14662	0.78
Eucalyptus melanopholoia	14841	0.73
Melaleuca nervosa	14879	0.68
Casuarina glauca	14408	0.64
Acacia polystachya	13871	0.57
Eucalyptus orgodophloia	13678	0.51
Acacia oraria	14961	0.44
Acacia salicina	14592	0.41
Dodonea viscosa spp. angustissima	12783	0.40
Erythrina vespertilio	14490	0.33
Casuarina cristata	14843	0.32
Dodonea viscosa spp. spatulata	13755	0.32
Casuarina cristata	14593	0.30
Melaleuca acacioides	14873	0.30
Dodonea viscosa spp. angustissima	13753	0.24
Acacia victoriae	14489*	0.00
Eucalyptus houseana	11487**	2.13
Eucalyptus argophloia	13713**	0.57
Atalaya hemiglauca	14976**	0.10

*All plants were dead, not included in ANOVA

**Only one replication was planted, not included in ANOVA

Table 6. Ranking for mean diameter at ground level (cm.) at 12 months after field planting of ACIAR/RFD tree species trial at T.K.R. near Roi Et. Vertical lines group treatments that are not significantly different (p=.05)

SPECIES	Treatment number	D.G.L.
Acacia plectocarpa	14696	3.21
Eucalyptus ochrophloia	11633	3.20
Eucalyptus camaldulensis	14847	3.13
Acacia difficilis	14623	3.02
Acacia leptocarpa	14966	2.93
Eucalyptus tereticornis	12189	2.80
Melaleuca leucadendra	14147	2.76
Acacia crassicarpa	13682	2.51
Acacia aulacocarpa	13689	2.29
Acacia holosericea	14637	2.14
Acacia auriculiformis	13685	1.96
Acacia holosericea	14649	1.95
Acacia auriculiformis	13684	1.94
Melaleuca stenostachya	14149	1.59
Eucalyptus camaldulensis	CML346	1.59
Melaleuca bracteata	14903	1.58
Acacia ampliceps	14631	1.49
Melaleuca argentea	14904	1.49
Melaleuca cajuputi	14878	1.43
Eucalyptus tessellaris	12967	1.32
Acacia cincinnata	13878	1.29
Acacia ligulata	14662	1.28
Eucalyptus argillacea	13700	1.18
Melaleuca viridiflora	14151	1.15
Acacia cowleana	14634	1.14
Casuarina cunninghamiana	13514	0.96
Acacia polystachya	13871	0.95
Eucalyptus melanophloia	14841	0.93
Casuarina glauca	13144	0.86
Eucalyptus orgodophloia	13678	0.84
Melaleuca nervosa	14879	0.83
Erythrina vespertilio	14490	0.78
Acacia oraria	14961	0.76
Casuarina glauca	14408	0.72
Dodonea viscosa spp. angustissi	12783	0.60
Acacia salicina	14592	0.55
Casuarina cristata	14843	0.42
Dodonea viscosa spp. spatulata	13755	0.42
Casuarina cristata	14593	0.38
Acacia victoriae	14489 *	0.00
Eucalyptus houseana	11487 **	3.43
Eucalyptus argophloia	13713 **	0.61
Atalaya hemiglauca	14976 **	0.30
Melaleuca acacioides	14873 ≠	0.00
Dodonea viscosa spp. angustissi	13753 ≠	0.00

* All plants were dead, not included in ANOVA
** Only one replication was planted, not included in ANOVA
≠ D.G.L. not measured

Survival at 12 Months

Survival differed significantly between treatments (see Table 4 and 7). About one third of all treatments had better than 80% survival. It is clear that red gums (*E. camaldulensis* and *E. tereticornis*) had excellent survival while melaleucas (*M. bracteata*, *M. leucadendra*, *M. cajuputi*, *M. argentea* and *M. stenostachya*) also survive well. The most promisind acacias are *A. holosericea*, *A. plectocarpa*, *A. leptocarpa*, *A. crassicarpa* and A. *auriculiformis*.

About one quarter of the treatments had less than 50% survival. Of special note is the poor performance of *Casuarina cristata*, *Dodonea viscosa* (both subspecies), *Melaleuca acacioides*, *Acacia ampliceps*, *A. ligulata* and *A. salicina*.

DISCUSSION

A serious flaw in the trial was that although the species used were selected on the basis of their potential salt-tolerance the site was located on a non-saline area. On the positive side the trial does include treatments of *E. camaldulensis* (including 1 clone) and one treatment of *E. tereticornis*, (a closely related taxon to *E. camaldulensis*), which serve as useful markers for comparison with other species used in the trial, because *E. camaldulensis* is the preferred plantation species used in the T.K.R. region.

The number of treatments in the trial is high for a randomised complete block design. From a productivity view point it is unfortunate that the genetic potential for growth and survival under better nutritional conditions can't be assessed because fertilizer was not used in the trial. Nevertheless the results will be useful for local villagers who may not have access to fertilizer.

The performance of several acacia species e.g. *A. leptocarpa*, *A. cincinnata*, *A. plectocarpa*, *A. difficilis* and *A. holosericea* reflects the great wealth of tropical Australina acacias (other than the regularly planted *A. auriculiformis*) to perform well in this part of north-

Table 7. Ranking for mean survival at 12 months after field planting of ACIAR/RFD tree species trial at T.K.R. near Roi Et. Vertical lines group treatments that are not significantly different ($p = .05$)

SPECIES	Treatment number	Survival (%)	Arcsine transformed
Eucalyptus camaldulensis	CML346	100.0	90.0
Eucalyptus tereticornis	12189	100.0	90.0
Eucalyptus camaldulensis	14847	100.0	90.0
Melaleuca bracteata	14903	100.0	90.0
Melaleuca leucadendra	14147	98.7	86.2
Acacia holosericea	14637	98.7	86.2
Acacia plectocarpa	14696	98.7	86.2
Melaleuca cajuputi	14878	98.7	86.2
Acacia holosericea	14649	97.3	84.5
Melaleuca argentea	14904	97.3	84.5
Acacia leptocarpa	14966	97.3	84.5
Acacia crassicarpa	13682	97.3	82.3
Melaleuca stenostachya	14149	97.3	82.3
Acacia auriculiformis	13684	93.9	81.6
Eucalyptus tessellaris	12967	94.7	79.4
Eucalyptus argillacea	13700	96.0	78.5
Acacia difficilis	14623	96.0	78.5
Casuarina cunninghamiana	13514	94.7	76.8
Acacia aulacocarpa	13689	94.7	76.8
Melaleuca nervosa	14879	94.7	76.8
Acacia cowleana	14634	89.3	74.7
Acacia polystachya	13871	90.7	72.8
Casuarina glauca	14408	90.7	72.3
Eucalyptus melanopholoia	14841	90.7	72.3
Eucalyptus ochrophloia	11633	89.2	71.7
Acacia auriculiformis	13685	82.4	66.6
Eucalyptus orgodophloia	13678	80.0	65.5
Casuarina glauca	13144	80.0	63.7
Casuarina cristata	14843	76.0	61.8
Acacia oraria	14961	66.7	60.0
Melaleuca viridiflora	14151	73.2	59.4
Acacia cincinnata	13878	60.0	51.1
Dodonea viscosa spp. spatulata	13755	54.7	47.8
Dodonea viscosa spp. angustissima	12783	53.3	46.9
Melaleuca acacioides	14873	51.1	45.7
Erythrina vespertilio	14490	38.7	38.4
Casuarina cristata	14593	32.6	34.7
Acacia ampliceps	14631	25.5	28.7
Acacia ligulata	14662	22.0	27.8
Dodonea viscosa spp. angustissima	13753	20.0	25.9
Acacia salicina	14592	18.3	25.3
Acacia victoriae	14489*	0.0	0.0
Eucalyptus houseana	11487**	100.0	90.0
Eucalyptus argophloia	13713**	70.0	56.8
Atalaya hemiglauca	14976**	16.0	23.6

*All plants were dead, not included in ANOVA

**Only one replication was planted, not included in ANOVA east Thailand. These species are believed to be nitrogen fixing and could provide the Royal Forest Department with alternative species to *E. camaldulensis.*

The trial confirms, at this stage, the validity of the high priority the Royal Forest Department attaches to *Eucalyptus camaldulensis.* This species, especially of seed from northern Australian provenances is notable for fast early growth in several overseas tropical countries having seasonally dry climates (Boland 1981), The species is useful for poles and fuelwood because of its great strength, durability and burning properties. High quality furniture from slow grown, well seasoned timber is made in Australia but overseas the wood from fast grown plantation trees often splits and warps after felling and sawing. The species can be used for pulp and paper but is not considered ideal when compared with other eucalypts.

The performance of *Eucalyptus houseana* (11487) was outstanding being amongst the tallest treatments, with the largest diameter and highest survival (100%). Unfortunately this treatment consisted of one replicate and it is difficult to draw statistically meaningful conclusions. *E. houseana* performed well in the Laos/Australian Reafforestation Project in neighbouring Laos (Midgley pers. comm.). *E. houseana* belongs taxonomically to the northern red gum group of species.

The poorer relative performance of the *E. camaldulensis* clone (CML 346) was not unexpected as its origin, Wiluna W.A., has a temperate climate. Also of note was the large standard deviation in mean height growth at 6 months of this clone (data not presented). Nevertheless this treatment represents the first time a tissue culture clone of *E. camaldulensis* has been grown in Thailand and serious consideration should be given to cloning select northern Australian provenances of this species.

Good height, diameter, and survival records for several Melaleuca spp. e.g. *M. leucadendra*, *M. stenostachya*, *M. cajuputi*, and *M. bracteata* indicate the potential of this genus at this site. Several *Melaleuca* spp. are noted for their tolerance of seasonally waterlogged sites in tropical Australia. Nevertheless this genus must be carefully monitored for potential weediness over several seasons before any attempt is made to encourage local people to undertake community plantings.

Several acacias (*A. ampliceps*, *A. ligulata*, *A. salicina* and *A. victoriae*), two casuarinas (*C. glauca* and *C. cristata*) and two *melaleucas* (*M. viridiflora* and *M. acacioides*) had somewhat surprisingly poor survival and height growth. One probable reason for this is due to their ecological adaptation to alkaline soils when the trial site was strongly acidic (pH 4.2–5.4). The wide range of performance found among the *Acacia* species could reflect strong underlying biological differences in adaptation of plants to soil pH dependent nutrient availability or of symbionts (*Rhizobia*) to pH dependent nitrogen fixation. The low soil phosphorus levels and possibility of aluminium toxicity could present future problems.

Recent studies commissioned by ACIAR in Australia revealed interesting leaf oil properties in *E. camaldulensis* and several *Melaleuca* species that could provide important value-added products. Individual wild trees of *E. camaldulensis* in north Queensland have yielded high levels of steam distilled leaf oil (about 2% on a fresh leaf weight basis) with up to 80% cineole (a pharmaceutical oil). Selective breeding and/or clonal development could be employed to improve productivity of wood and yield of oil. In addition wild trees of *M. leucadendra* in north Queensland were found to contain high levels of methyleugenol and methylisoeugenol (both important ingredients in the perfumery and flavouring industries) in steam distilled leaves (Brophy and Lassak 1987).

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