

COMUNICAÇÕES
TECHINICAL NOTES



*Provenance differences of Terminalia superba
grown in Ecuador*

Diferentes procedências de *Terminalia
superba* no Equador

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ABSTRACT: A total of thirteen provenances of *Terminalia superba* Engler et Diels were obtained from CTFT/CIRAD for the establishment of trials in the Pacific lowlands of Ecuador. At eight years of age the best provenances for volume per tree were from Divo, Ivory Coast, Nola, Central African Republic and Mbalmayo, Cameroon and these differences were statistically significant. Further seed importations will take place to increase the genetic base of *T. superba*. Vegetative propagation and seed production are being undertaken in Ecuador.

KEY WORDS: Provenance, *Terminalia superba*, Vegetative Propagation, Seed production, Ecuador

RESUMO: Trinta procedências de *Terminalia superba* Engler et Diels foram obtidas junto ao CTFT / CIRAD para o estabelecimento de ensaios nas terras baixas do Equador, junto à costa do Pacífico. Aos oito anos as melhores procedências em volume por árvore foram as de Divo, Costa do Marfim, Nola, África Central e Mbalmayo, Camarão, que apresentaram diferenças significativas estatisticamente. Além disso as importações de sementes aumentaram a base genética de *Terminalia superba*. Propagação vegetativa e produção de sementes estão sendo estudadas no Equador.

PALAVRAS-CHAVE: Procedência, *Terminalia superba*, Propagação Vegetativa, Produção de sementes, Equador

INTRODUCTION

The importance of *Terminalia superba* Engler et Diels as a timber species has been known for many years (CTFT, 1959). The native range

of the species extends in West Africa from Sierra Leone to Angola. Individual trees can exceed 50 meters in height and the long clear



bole with very little taper allows easy processing for lumber or plywood. For a thorough review of *T. superba*, the reader is advised to consult (Groulez e Wood, 1985).

In the native forests of *T. superba* the species can be characterized as shade intolerant, strong apical dominance, large spreading mature crown, effective seed dispersal and low density wood with a straight grain (FAO, 1989). This was essentially the only species exported as lumber or logs from Zaire and the Congo until the 1950's.

Several West African countries in the late 1940's began developing plantations with *T. superba*. A number of advantages to plantation establishment were observed such as abundant seed production, relatively simple nursery practices and the ability of the species to grow well in cleared areas. Plantation yields in Africa have achieved 7.5 m³/ha/year on a 36 year rotation with final stocking of 75 trees per hectare and an average diameter at breast height of 60 cm (FAO, 1989). Given the initial success as a plantation species in West Africa and the willingness of the forest services in those areas to supply seeds to other countries, *T. superba* has been developed as an exotic plantation species in a number of countries.

There are no accurate statistics as to the number of hectares planted to *T. superba* plantations. However, the authors have observed the species being tested in trial or commercial plots in numerous countries of Africa, Asia and Latin America. One area where the species has been especially successful as an exotic is along the Pacific coast lowlands of Ecuador.

The first known introduction of *T. superba* to Ecuador occurred in 1975 in the province of Esmeraldas (Aguirre e Estevez, 1993). These authors reported that average diameter was 8.0 cm with a height of 8.9 m, at 4.5 years of age, with 59% survival. There were no significant differences in growth rate between the five provenances tested.

MATERIAL AND METHODS

In 1986, Fundación Forestal J.M. Durini, an NGO based in Ecuador, imported seed from different provenances of *T. superba*.

The objective of these seed importations was to find provenances with rapid growth rates and desirable wood properties, to allow plantations to supply wood for plywood and decorative timbers. In this regard, Fundación Forestal has tested in trials and small commercial plantations more than 75 native and exotic species, in the Pacific coast lowlands of Ecuador.

Seedlings were grown in the nursery of Fundación Forestal at Rio Silanchi and Pitzara, located in the Pacific lowlands. The seed was immersed in water for twelve hours and then allowed to dry for twelve hours and this was repeated twice prior to sowing. Sowing took place in beds followed by transfer to plastic bags using a substrate of topsoil. Seedlings were not fertilized in the nursery nor was mycorrhiza applied. Bags were maintained weed free, a condition required when using topsoil. Total time in the nursery for these seedlings was six months of which one month was the time required for the seed to germinate prior to transplanting to bags.

Site characteristics are given in Table 2.

The Rio Pitzara trials were secondary forest. Site preparation at that site was to cut regrowth and plant. Rio Silanche (Rodal 132) was bamboo prior to establishment of the trial. The bamboo was cut prior to planting. In Rodal 129 at Rio Silanche, the previous land use was secondary forest. This regrowth was cut and the site was planted.

The trial design was plots of 36 trees planted at five by five meter spacing. In the four trials there were four replications of each provenance. Certain provenances did not survive in all replications. In the first year following planting there were five weedings



Table 1

Geographic and climatic conditions of the T. superba provenances planted in Ecuador with seed received from CTFT/CIRAD.

Condições geográficas e climáticas das procedências de *T. superba* plantadas no Equador com sementes recebidas do CTFT/CIRAD.

Provenance	Code	Country	Lat. (°)	Lon. (°)	Alt. (m)	Prec. (mm)	Temp. (°C)
Bilala Myombe	83/3987	Congo	4.5S	12.2E	25	1586	25
N'Gouha 2	83/3988	Congo	3.0S	12.4E	200	1650	23
Titi	83/3991	Congo	3.2S	12.5E	150	1950	-
Gregbeu	83/3995	Ivory Coast	6.9N	6.7W	250	1550	-
Divo	83/4051	Ivory Coast	5.7N	5.4W	150	1550	-
Tai San Pedro	83/4952	Ivory Coast	5.2N	6.9W	150	1550	-
Pelezi	83/4059	Ivory Coast	6.9N	6.5W	280	1350	-
Bondoukou/Goumere	83/3996	Ivory Coast	8.0N	2.7W	350	1150	-
Mbalmayo	83/4061	Cameroon	3.5N	11.5E	640	1600	23
Mouloundou	85/4758	Cameroon	2.6N	15.4E	520	1450	-
Rumonge	81/3416	Burundi	4.0S	29.5E	780	-	-
Nola	85/4762	Cen.Afr.Rep.	-	-	-	-	-
Pepelou/Alindad	85/4760	Cen.Afr.Rep.	4.5S	21.2E	420	1400	-

Table 2

Site characteristics of the four trials planted to provenances of T. superba in Ecuador.

Características do sítio de quatro testes de procedência de *T. superba* no Equador.

Site	Site Characteristics		
	Alt. (m)	Temp. (°C)	Rainfall (mm year)
Rio Silanche Rodal 132	650	22	4000
Rio Silanche Rodal 129	650	22	4000
Rio Pitzara Rodal 471	450	24	4000
Rio Pitzara Rodal 460	450	24	4000

with machete, while at eight years of age only one weeding per year was undertaken. The trials were never fertilized, nor were the trees pruned. A thinning is planned following selection of the trees to be removed.

The trials were measured at eight years of age, for height and diameter. If the tree had top breakage no height was measured. Volume per tree was calculated using the formula:

$$VOL = (-55.4 + 0.0746x(DBHx3.14)^2)1000$$

where DBH is in cm and VOL is in cubic meters (Groulez; Wood, 1985). No volume formulas nor taper values were available for Ecuador.

The data from Rio Pitzara (Rodal 471 and Rodal 460) were analyzed, using analysis of variance (Table 3 and 4), while similar analysis for Rio Silanchi Rodal 129 is included in Table



Table 3

Analysis of variance and mean square values (MS) for survival (SURV), diameter at breast height (DBH), total height (ALT) and volume per tree (VOL) for *T. superba* provenances planted at Rio Pitzara Rodal 471, Ecuador. MS values followed by *, ** or *** differ at the 0.05, 0.01 or 0.001 levels respectively.

Análise de variância e para sobrevivência (SURV), diâmetro à altura do peito (DBH), altura total (ALT) e volume por árvore (VOL) para procedências de *T. superba* plantadas no Rio Pitzara Pomar 471, Equador. Os valores de MS seguidos de *, ** ou *** diferem aos níveis de 0.05, 0.01 ou 0.001, respectivamente.

SURV			DBH		
Source	df	MS	Source	df	MS
Prov	5	377	Prov	5	1367**
Block	3	574*	Block	3	101
Residual	5	138	ProvxBlock	15	192***
Total	23		Residual	710	26
Total 733					
ALT			VOL		
Source	df	MS	Source	df	MS
Prov	5	819***	Prov	5	1.688**
Block	4	150	Block	4	0.098
ProvxBlock	15	97***	ProvxBlock	15	0.234***
Residual	602	9	Residual	702	0.032
Total	625		Total	725	

Table 4

Analysis of variance and mean square values (MS) for survival (SURV), diameter at breast height (DBH), total height (ALT) and volume per tree (VOL) for *T. superba* provenances planted at Rio Pitzara Rodal 460, Ecuador. MS values followed by *, ** or *** differ at the 0.05, 0.01 or 0.001 levels respectively.

Análise de variância e para sobrevivência (SURV), diâmetro à altura do peito (DBH), altura total (ALT) e volume por árvore (VOL) para procedências de *T. superba* plantadas no Rio Pitzara Pomar 460, Equador. Os valores de MS seguidos de *, ** ou *** diferem aos níveis de 0.05, 0.01 ou 0.001, respectivamente.

SURV			DBH		
Source	df	MS	Source	df	MS
Prov	5	237	Prov	5	60
Block	3	2870	Block	3	1198**
Residual	15	960	ProvxBlock	15	142***
Total	23		Residual	487	32
Total 510					
ALT			VOL		
Source	df	MS	Source	df	MS
Prov	5	13	Prov	5	0.016
Block	3	624**	Block	3	0.315*
ProvxBlock	15	109***	ProvxBlock	15	0.063*
Residual	435	11	Residual	460	0.028
Total	458		Total	483	



Table 5

Analysis of variance and mean square values (MS) for survival (SURV), diameter at breast height (DBH), total height (ALT) and volume per tree (VOL) for *T. superba* provenances planted at Rio Silanchi Rodal 129, Ecuador. MS values followed by *, ** or *** differ at the 0.05, 0.01 or 0.001 levels respectively.

Análise de variância e para sobrevivência (SURV), diâmetro à altura do peito (DBH), al-tura total (ALT) e volume por árvore (VOL) para procedências de *T. superba* plantadas no Rio Silanchi Pomar 129, Equador. Os valores de MS seguidos de *, ** ou *** diferem aos níveis de 0.05, 0.01 ou 0.001, respectivamente.

SURV			DBH		
Source	df	MS	Source	df	MS
Prov	3	676	Prov	3	92
Block	3	1424*	Block	3	808*
Residual	9	339	ProvxBlock	9	140***
Total	15		Residual	305	0
			Total	320	

ALT			VOL		
Source	df	MS	Source	df	MS
Prov	3	178	Prov	3	0.510
Block	3	70	Block	3	0.246
ProvxBlock	9	53***	ProvxBlock	9	0.061
Residual	257	8	Residual	286	0.037
Total	272		Total	301	

Table 6

Mean values for total height (HT), diameter at breast height (DBH) and volume per tree (VOL) from eight year old provenance trials of *T. superba* planted in Rio Silanchi, Ecuador.

Valores para altura total (HT), diâmetro à altura do peito (DBH) e volume por árvore (VOL) de testes de procedência de *T. superba* plantados no Rio Silanchi, Equador aos 8 anos de idade.

Provenance	Code	Rodal 129			Rodal 132				
		SURV (%)	DBH (cm)	HT (m)	SURV (m ³)	VOL (%)	DBH (cm)	HT (m)	VOL (m ³)
Titi	83/3991	61	19.15	13.6	0.234	19	18.26	12.4	0.216
Divo	83/4051	92	24.60	14.1	0.429	86	19.27	13.9	0.256
Pelezi	83/405	36	15.69	10.8	0.186				
Bondoukou/Goumere	83/3996	14	11.30	-	0.061	36	20.23	12.6	0.306
Mbalmayo	83/4061	75	20.60	17.3	0.415	42	25.16	15.8	0.442
Mouloundou	85/4758	8	15.87	-	0.132	-	-	-	-
Nola	85/4762	69	25.35	15.4	0.453	69	21.82	14.7	0.343
Pepelou/Alindad	85/4760	0							



Table 7

Mean values for total height (HT), diameter at breast height (DBH) and volume per tree (VOL) from eight year old provenance trials of *T. superba* planted in Rio Pitzara, Ecuador.

Valores para altura total (HT), diâmetro à altura do peito (DBH) e volume por árvore (VOL) de testes de procedência de *T. superba* plantados no Rio Pitzara, Equador aos 8 anos de idade.

Provenance	Code	Rodal 460		HT	VOL	Rodal 471			
		SURV	DBH			SURV	DBH	HT	VOL
Bilala Myombe	83/3987					67	19.65	14.9	0.259
N'Gouha 2	83/3988					85	20.87	17.9	0.280
Titi	83/3991	82	21.65	16.6	0.336	97	22.44	19.4	0.354
Gregbeu	83/3995					92	27.94	23.6	0.547
Divo	83/4051	74	22.09	17.6	0.351	88	27.32	20.6	0.513
Tai San Pedro	83/4052					94	26.16	21.7	0.474
Pelezi	83/4059	55	15.03	2.1	0.167				
Mouloundou	85/4758	74	18.61	13.1	0.230				
Nola	85/4762	53	17.53	12.0	0.216				
Pepelou/Alindad	85/4760	56	17.28	11.7	0.223				

5. Mean values for the Rio Silanchi trials are in Table 6, while mean values for the Rio Pitzara sites are in Table 7.

RESULTS AND DISCUSSION

Provenance differences in the Rio Pitzara Rodal 471 were statistically significant for diameter at breast height, total height and volume per tree. In the Rio Pitzara Rodal 460 and Rio Silanchi trials, there were no significant differences between provenances for survival, diameter, height or volume. Both of these trials were characterized by large differences between blocks, thus reducing any possible differences between provenances. Since management was similar across sites, it is felt that block differences are a result of different soil physical and chemical properties.

In the provenance trial at Rio Pitzara, some of the individual trees had more than 0.5 cubic meters per tree, which with 90% survival (360 living trees per hectare) would re-

sult in a mean annual increment of 24 cubic meters. While difficult to replicate these research results on a larger scale, the species *Terminalia superba* has exhibited fast growth and good adaptability.

Provenance differences in the Rio Silanchi Rodal 132 trial was not compared using analysis of variance, due to the distance of almost 1000 meters between blocks. However, the better provenances for growth rate in this trial were from Divo, Nola and Mbalmayo. The other provenances had survival rates that were lower than acceptable levels. When survival is low, there are questions of the adaptability of the provenance, or the quality of seed and plan-ting stock used to establish the trial.

In the Rio Pitzara and Rio Silanchi trials, the Divo provenance from the Ivory Coast was amongst the best in terms of survival and volume production. Similar results were obtained for the Nola, Central Africa Republic and Mbalmayo, Cameroon. Provenance differences were not compared statistically between si-



tes, since there was insufficient seed germination to include all provenances at all sites. It is all too common in species, provenance and progeny trials for nursery practice to affect genotypes available for later selection.

FUTURE RESEARCH EFFORT

Further importations of *T. superba* seed are underway. The trees in the trials reported here began to produce seed in the eighth year after planting. Following a silvicultural thinning in these trials, further observations on seed production will be made. In addition, a clonal program has been initiated for the species. Research on grafts and rooted cuttings from twelve year old trees, as well as from seedlings, is

underway at the Buenos Aires nursery of Fundación Forestal. Initial attempts at rooted cuttings of scions taken from one year old seedlings gave a rooting success of 47%. These cuttings have been outplanted to observe their growth and form compared to seedlings. More defined silvicultural requirements, such as fertilizer and weeding, will be determined in trials.

Given that the likely product from plantations of *T. superba* will be lumber and plywood the wood quality is extremely important. As the trees get older processing trials will be undertaken. As with other species such as teak (*Tectona grandis*) there are justified concerns that plantation grown wood will not have the quality found in trees from the natural forest.

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The authors wish to acknowledge the CTFT/CIRAD, Laboratoire de Graines, Nogent-sur-Marne, France and specially François Grison and Yves Roederer for their collaboration to obtain the seed for these provenance trials. The authors thank the Oversea Development Administration of the British Government for providing funds to assist Dr. J.A. Wright to participate in the field work, analysis and writing up of these trial results.

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