6 Provenance Trials

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6.1 Introduction

The introduction of a tree species into a country is rarely carried out in a planned and systematic manner. Ideally, the full range of genetic variability should be evaluated for productivity and assessed for environmental impact prior to release of seed or vegetative material for planting programmes. In practice, however, most tree introductions take place in an *ad hoc* manner, sometimes through the interests of plant collectors, often by travellers or colonists bringing with them trees which they know to be useful in their homelands, and sometimes by foresters wishing to experiment with new species. Whatever the means of introduction, the eagerness to investigate new species coupled with a lack of appreciation of the genetic diversity contained within most species generally means that introductions are made without any prior formal evaluation and are usually of narrow genetic base (Hughes, 1994). Although introduced species frequently grow well in comparison with native species, it is the experience of foresters in both tropical and temperate countries that the initial source of seed used for introductions is rarely the most productive (Zobel and Talbert, 1984; Barnes and Simons, 1994).

Provenance trials enable a range of seed sources of a single species to be evaluated on a given site and provide evidence upon which to base future decisions surrounding seed procurement. However, they are frequently overlooked in introduction programmes partly due to the expense and practical difficulty in obtaining a wide range of seed sources, but also often due to a lack of understanding of their fundamental importance to future planting decisions. Large gains in productivity can be made through the selection of the best provenance of a species for a given site and purpose.

For *C. calothyrsus*, along with many other agroforestry tree species, the initial interest in the performance of the species developed from a limited selection of the genetic diversity contained within the species (Pottinger, 1996b). *C. calothyrsus* is planted widely in Indonesia, and until recently almost all seed available to researchers and those interested in planting programmes, came from this source. This 'land race' was itself derived from seed originating from a small area of Guatemala (see Chapter 7). In view of the growing international interest in *C. calothyrsus* for use on farms, combined with the lack of knowledge surrounding its genetic resources, a programme was initiated in 1990 at the Oxford Forestry Institute (OFI) to carry out a comprehensive exploration, collection and evaluation of *C. calothyrsus* and its close relatives (Macqueen 1991; Pottinger 1996b).

Investigation of the genetic resource in its native range

Between 1990 and 1994 an intensive investigation of the genetic resources *of C. calothyrsus* was undertaken throughout its native range. This involved mapping the complete distribution of the species, including previously unrecorded populations, the establishment of provenance boundaries, collection of seed from throughout the native range and a detailed review and re-classification of the taxonomy within the series *Racemosae* (Macqueen 1992; Macqueen and Hernández, 1997). Fifty provenances were recorded and over 50 kg of seed were eventually collected from eight countries. Provenance details and collection sites are listed in Table 6.1.

Within each provenance, seed was collected from a minimum of 25 trees spaced at least 50m apart with no phenotypic selection criteria employed in order to provide as broad a representation as possible of the genetic variation present (Macqueen 1993a). Most seed was bulked following collection but in a few cases where significant amounts of seed were available from a range of trees, individual collections were kept separate to accommodate the potential of carrying out family selection for later breeding efforts.

Table 6.1: Provenances of *Calliandra calothyrsus* included in the trials evaluated in the International *Calliandra* Trial Network.

Provenance	Country	OFI Identification No.	Altitude (m)	Rainfall (mm)
Georgesville	Belize	21/91, 48/92	350	1539
Gracie Rock	Belize	46/92	90	2313
Santa Cruz	Belize	22/91, 45/92	150	3068
Agua Zarcas	Costa Rica	59/93	200	2770
Fortuna	Costa Rica	18/91, 56/93, 108/94	85	4718
Los Chiles	Costa Rica	53/93	60	1944
San Isidro del General	Costa Rica	57/93	700	2951
San Miguel	Costa Rica	60/93	1300	1867
Santa María	Costa Rica	19/91	825	3222
Turrialba	Costa Rica	20/91, 54/93	800	2363
Upala	Costa Rica	55/93	100	2589
Alotenango	Guatemala	16/91, 47/92	1100	1203
Barillas	Guatemala	51/92, 35/93	1320	5829
Cobán	Guatemala	8/91	1300	2517
Flores	Guatemala	10/91	220	1994
Patulul	Guatemala	9/91, 51/92, 153/92, 34/93	330	3185
Santa María de Jesus	Guatemala	53/92, 33/93	1500	4236
Cofradia	Honduras	14/91	300	1091
Gualaco	Honduras	48/93	610	905
La Ceiba	Honduras	12/91, 17/91, 73/92, 15/96	80	2884
Lago Yojoa	Honduras	46/93	550	2596
Las Flores	Honduras	23/91, 75/93	1076	1688
San Esteban	Honduras	47/93	420	3318
Santa María	Honduras	13/91	500	1145
Trujillo	Honduras	15/91, 49/93	50	2715
Bandung	Indonesia	148/91	715	1949
Maduin	Indonesia	147/91	800	1884
Apic Apac	Mexico	60/92	860	898
Bombana	Mexico	61/92, 31/93	950	1256
Bonampak	Mexico	62/92	400	2156
Chilon	Mexico	49/92, 37/93	769	1515
Ixtapa	Mexico	40/92	1100	1701
Ococingo	Mexico	36/93	900-1500	1804
Plan del Rio	Mexico	44/92	240	1957
Union Juarez	Mexico	50/92	930	3786
La Puerta	Nicaragua	134/91, 109/94	600	1889
San Ramón	Nicaragua	11/91, 110/94	850	1394
Boquete	Panama	62/93	1200	3735
Cangandi	Panama	63/93	10	3036

6.2 International *Calliandra* Provenance Trial Network

Seed of *C. calothyrsus* collected between 1990 and 1994 was sent initially to the UK for temporary storage from where it was subsequently distributed to 48 organisations in 39 countries for the establishment of field trials to investigate the performance of the provenances. Two experimental designs were proposed to evaluate the performance of different provenances when grown principally for leaf production or fuelwood. However, in order to accommodate the many varied planting designs used on small farms, some degree of flexibility was permitted in spacing and cutting regimes.

Practical limitations to the collection of seed and trial management meant that only a proportion of the 50 provenances collected were sent to each collaborator. In addition, poor germination was encountered at a number sites, which also resulted in an unequal provenance representation across the trials.

Information provided by collaborators

Trial results were received from a number of collaborators, and this data formed the basis of the evaluation of the International *Calliandra* Trial Network. The evaluation was restricted to 37 provenances of *C. calothyrsus* (see Table 6.1). Altogether, data from 21 trials were included in the analysis, and a full list of these trials is given in Table 6.2. Provenance representation was unequal for the reasons described above, with none of the provenances planted on all the sites and several provenances represented in just one trial.

Evaluation methodology

Since stem length was the only trait assessed in a standard manner, it was used as a basic indicator of growth, although it is acknowledged that it is almost never a trait of any importance to growers of *C. calothyrsus*. Wood production and leaf production, the traits of interest to most growers, were assessed on most sites. The assessment methods, however, differed widely and were not always stated with the results. This meant that a combined analysis of all 21 trials was impossible. Direct comparisons across all sites for these traits were, therefore, difficult to make and the conclusions should be interpreted with caution.

To overcome the differences in assessment methodologies, a method of standardisation was needed in the expression of provenance performance on all the sites. The simplest such method is to use the site mean as a benchmark, and express provenance performance relative to this. The unequal representation of provenances in the trials, however, made this impossible, because each site mean would be biased by the set of provenances represented on that site. An alternative method is to use a control seedlot, or to form a benchmark using a subset of provenances. In this analysis, three provenances were represented on 19 sites, and the mean of these three provenances was used as the benchmark value on each site. Evaluation of provenance performance, relative to this benchmark was restricted to categorising performance into four classes: above all three provenances used in forming the benchmark; above the benchmark value; below the benchmark value; and below all three provenances. The frequency with which a provenance falls into each of these categories gives a robust guide to the stability of the provenance's performance across the sites, an important consideration when making recommendations about choosing provenances for a wide range of conditions.

Finally, since farmers are primarily interested simply in those provenances which produce the most wood or leaf material, a study was made of the frequency with which each provenance was one of the top three performing provenances on each site. Whilst this frequency is obviously affected by the number of sites the provenances are represented on and the number of provenances on each site, it gives a simple and quick guide to promising provenances.

Trial results

Stem length

Table 6.3 shows the mean stem length for each provenance at each site on which it was planted, with the overall site mean and pooled standard deviation (where known) given as a guide to variation within the site. Figure 6.1a shows the performance of the provenances in comparison to the benchmark, broken down into the four categories described above. The performances of the three provenances used to form the benchmark are shown relative to one other. Figure 6.1b shows the frequency with which each provenance was one of the top three performing provenances on a site.

From Figure 6.1a it can be seen that Flores from Guatemala was generally the best of the three benchmark provenances, whilst La Ceiba from Honduras was almost always the worst of these three. Of the other provenances, it can be noted that Georgesville and Gracie Rock, both from Belize, and the Costa Rican Santa María provenance always outperformed all three of the benchmark provenances.

Table 6.2: Trial details and site descriptions of *Calliandra calothyrsus* provenance trials.

Trial site	Trial code	Collaborating organisation	Site location	Site details		
				Altitude (m)	Rainfall (mm)	Soil pH
Australia						
Landsdowne	Lan. Aus		na	60	870*	5.8
Utchee Creek	Utc. Aus		na	250	3500	5.0
Cameroon						
Minkoameyos	Min. Cmr	IRA/ICRAF Agroforestry Programme	3°N, 11°E	813	1690	6.0
Nkoemvone	Nko. Cmr	IRA/ICRAF Agroforestry Programme	2°N, 12°E	630	1820	4.5
Yaounde	Yao. Cmr	IRA/ICRAF Agroforestry Programme	3°N, 11°E	813	1690	6.0
Colombia						
Santander de Quilichao	Quil. Col	Centro de Investigacíon Agricola Tropical	3°S, 76°W	1000	1800	4.0
Ethiopia						
Bako	Bak. Eth	Institute of Agricultural Research	6°N, 37°E	1000	1500	6.0
Fiji						
Nadruloulou	Nad. Fij	Fiji-German Forestry Project	17°S, 174°E	30	3410	na
Jamaica						
Cinchona	Cin. Jam	University of West Indies	18°N, 76°W	1550	2500	5.4
Kenya						
Embu	Emb. Ken	ICRAF	1°S, 37°E	1480	1200	na
Madagascar						
Antananarivo	Ant. Mdg	National Seed Bank	na	na	na	na
Mexico						
Yapacani	Yap. Mex	Centro de Investigacíon Agricola Tropical	na	945	1800	5.7
New Caledonia						
Port Laguerre	Lag. Nca	CIRAD Forêt	22°S, 165°E	300	1653	Acidic
Philippines						
Los Banos	Ban. Phl	Ecosystems Research & Development Bureau	14°N, 121°E	400	2200	4.6
Sri Lanka						
Doragala	Dor. Srl	GTZ	6°N, 81°E	426	1050	5.3
Pallekelle	Pal. Srl	GTZ	6°N, 81°E	1450	1500	4.5
Tanzania						
SUA farm	SFm. Tan	Sokoine University of Agriculture	6°S, 37°E	526	800	6.5
Gairo	Gai. Tan	Sokoine University of Agriculture	6°S, 36°E	1200	500	6.0
Uganda						
Kifu	Kif. Uga	ICRAF	2°N, 34°E	2000	1040	4.6
Zambia						
Misamfu	Mis. Zam	ICRAF	10°S, 31°E	1300	1360	Acidic
Zimbabwe						
Domboshawa	Dom. Zim	ICRAF	17°S, 31°E	1530	895	4.6

* The Landsdowne site in Australia was trickle irrigated.
na Data not available

Table 6.3: Summary of results from the *Calliandra calothyrsus* trial series: stem length (m).

Trial Site	**Min. Cmr**	**Nko. Cmr**	**Yao. Cmr**	**Quil. Col**	**Cin. Jam**	**Ant. Mdg**	**Yap. Mex**	**Lag. Nca**	**Kif. Uga**
Site mean	3.55	3.66	5.13	2.03	2.07	0.74	2.82	2.15	5.76
Std. dev.	-	-	-	*0.39*	*0.48*	-	*0.75*	-	*0.88*
Provenance:									
Georgesville				2.24		0.98	3.32		6.29
Gracie Rock								2.64	
Santa Cruz	3.08	2.73	5.27						
Agua Zarcas				2.14					
Fortuna	3.59	4.52	4.54	1.86		0.75		2.38	6.05
San Miguel							2.51		
Santa María (CR)				2.18					
Turrialba	3.54	3.14	5.27				2.89	1.96	
Upala				2.00					
Barillas	3.72	3.80	5.75			0.69	2.98		
Cobán	3.87	4.05	5.50				2.68		5.80
Flores	4.35	4.26	5.50	2.16	2.18	0.69	3.04	2.58	6.16
Patulul				2.20	2.54	0.65	3.24		
Santa María de Jesus	3.15	3.61	4.88	2.17	2.31	0.78	2.60	2.05	5.39
Gualaco								2.19	
La Ceiba	2.71	2.96	4.24	1.43	1.46	0.70	2.44	1.86	4.70
Lago Yojoa					1.83				
Las Flores							2.22		
San Esteban								1.82	5.14
Santa María (H)	3.14	3.28	4.82						
Trujillo			4.62		1.84				
Maduin	3.39	3.82	5.43	1.96		0.65		2.14	6.30
Apic Apac									
Bombana	3.92	4.21	5.01				3.12	2.67	6.42
Bonampak	4.15	3.85	5.80		2.34	0.74	3.18		
Chilon				2.05			2.62		
Ixtapa								1.39	
La Puerta	3.45	3.34	5.13			0.77		2.17	
San Ramón	3.64	3.70	5.17	2.02		0.79	2.77	2.04	5.02
Boquete				2.00					

Figure 6.1a: Performance of *Calliandra calothyrsus* provenances relative to 'benchmark' – stem length. The provenances used as a benchmark were Flores, Santa María de Jesus and La Ceiba.

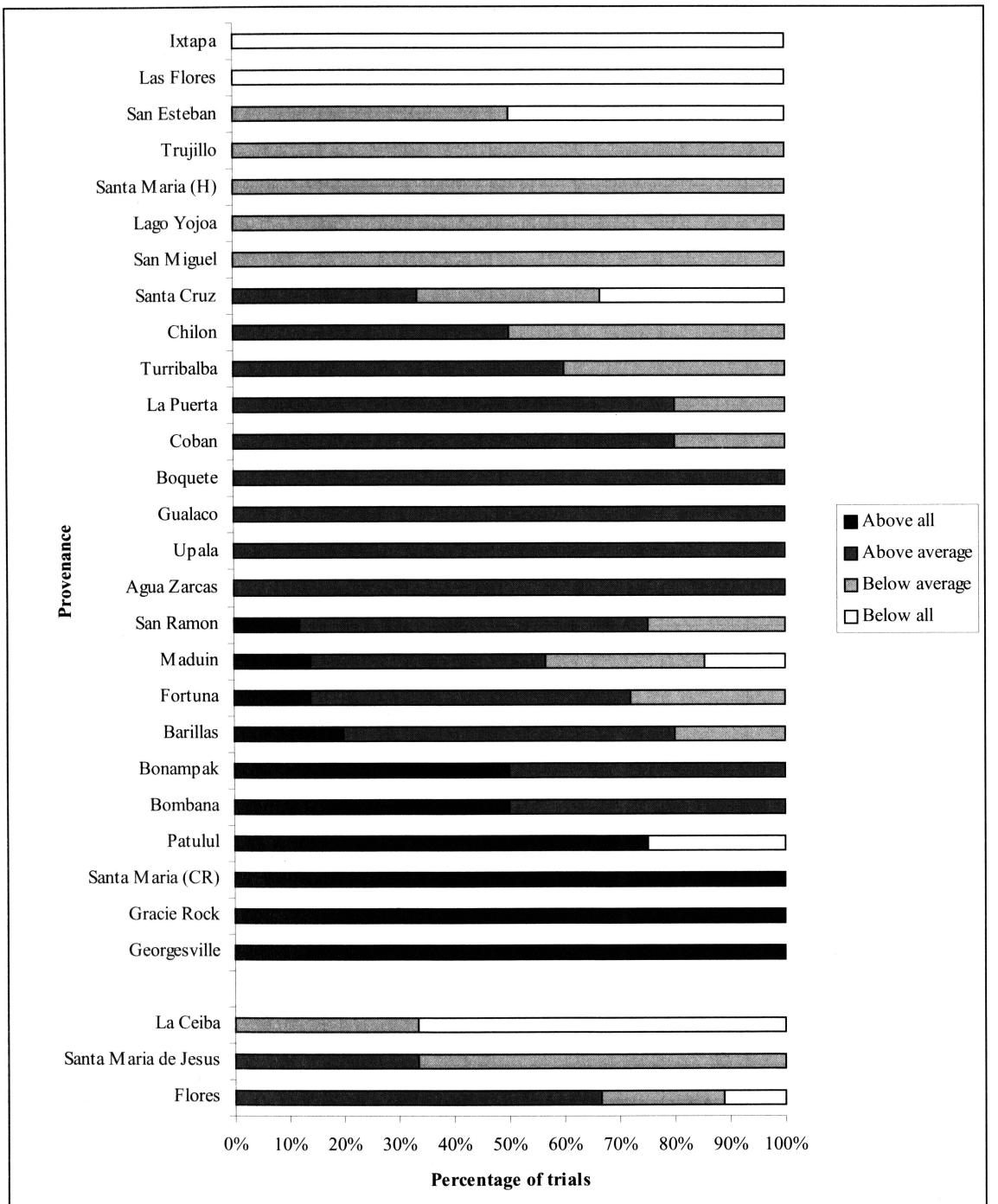
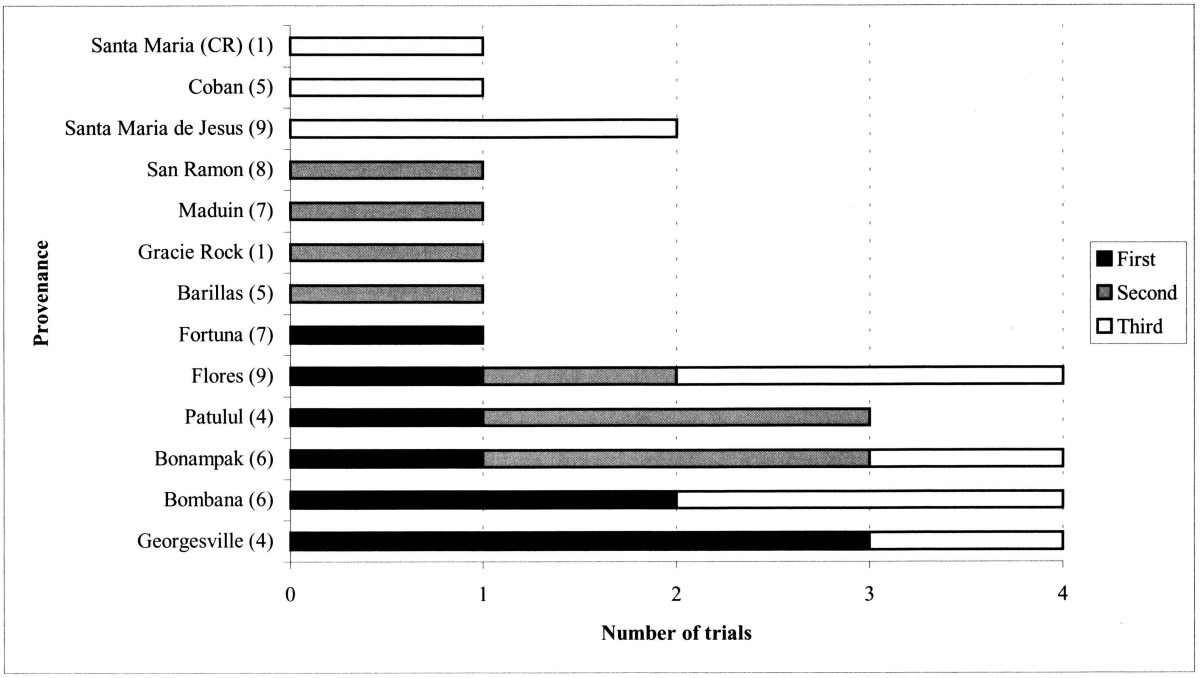


Figure 6.1b: Top performing provenances of *Calliandra calothyrsus* – stem length. Number of trials in which each provenance was assessed are shown in parentheses.



This is more significant in the case of Georgesville, since it was represented on four sites whereas the other two provenances appeared on only one site. All the Guatemalan provenances had above-average stem length, an interesting result that corresponds with results found in a study of *Gliricidia sepium* provenances (Dunsdon and Simons, 1996). The Honduran provenances were all below average for this trait. Figure 6.1b shows Georgesville to be among the top three performing provenances on all four sites at which it was represented and the top performer on three of those sites.

Wood production

Table 6.4 shows the mean wood production for each provenance at each site on which it was planted. The figures shown are a mixture of fresh weights and dry weights, expressed on a kilogram/tree or tonne/hectare basis. The overall site mean and pooled standard deviation are given where known. Figure 6.2a shows the wood production of each provenance relative to the benchmark, broken down into the four categories described earlier. The performances of the three provenances used to form the benchmark are shown relative to each other. Figure 6.2b shows the frequency with which each provenance was one of the top three performing provenances on a site.

Figure 6.2a clearly illustrates that there is much greater variation in provenance performance for wood production than for stem length. This is to be expected, and is in part due to the responses of the provenances to different management regimes and assessment methodologies. This greater variation in provenance performance means that the provenances that always had above-average wood production were those that were only represented on a small number of sites, Gracie Rock and Bandung being the only such provenances that were at more than one site. La Puerta, Georgesville, San Ramón and Barillas were all generally high wood producers. Once again the Guatemalan provenances generally performed well, as did the Nicaraguan provenances for wood production. It is also worth noting the above-average performance of the two Indonesian land-race seedlots. This is confirmed, in Figure 6.2b, by the high frequency with which Maduin in particular was one of the top three performing provenances, bettered only by San Ramón.

Table 6.4: Summary of results from the *Calliandra calothyrsus* trial series: wood production.

Trial site	Lan. Aus	Utc. Aus	Yao. Cmr	Bak. Eth	Nad. Fij	Cin. Jam	Emb. Ken	Ban. Phl	Dor. Srl	Pal. Srl	SFm. Tan	Gai. Tan	Kif. Uga	Mis. Zam
Site mean	4.07	1.55	29.5	0.89	2.43	33.3	3.31	0.82	1.75	1.25	7.35	9.43	28.5	2.18
Std. dev.	*0.98*	*0.51*	-	*0.42*	-	*22.2*	-	*0.82*	-	-	-	-	*12.5*	-
Provenance:														
Georgesville	5.68	1.55						0.73	1.84	1.05			24.6	
Gracie Rock				1.09	3.61									2.24
Santa Cruz			29.1								8.13			
Agua Zarcas				0.79										
Fortuna	3.38	1.37	31.2		2.79		3.04		2.06	1.03	6.51	14.73	23.2	
Los Chiles								0.85						
San Miguel											4.99	12.77		3.04
Turrialba	3.89	1.27	31.9	0.88					1.80	1.21				
Alotenango											7.15	10.50		
Barillas	3.74	1.74	33.9		2.56			0.93	1.59	1.49				2.23
Cobán	4.13	1.34	23.1	0.87			3.06		1.53	1.21			27.5	
Flores	4.59	1.73	32.5	0.74	1.77	43.1	2.44		1.28	1.30	9.72		32.8	1.70
Patulul	5.17	1.49				57.8			1.68	1.16	3.90			
S M de Jesus	4.13	2.03	21.7	0.97	1.21	37.6	4.44		1.63	1.24	5.60		24.8	1.68
Cofradia												9.16		0.94
La Ceiba	4.21	1.26	19.7	0.73	3.65	27.0	2.66		1.66		6.86		22.8	1.49
Lago Yojoa						10.9								
Las Flores	2.99	0.89												
San Esteban									1.64	1.29			28.0	
Santa María	3.30	1.49	25.1											
Trujillo			21.7			35.9								
Bandung											8.74	11.67		3.59
Maduin	3.77	2.21	35.3		1.40		3.68		1.88	1.28			34.8	1.32
Apic Apac												6.37		
Bombana			32.5	0.75	2.09				1.94	1.16	7.96	5.99	27.5	3.19
Bonampak			31.9			35.4								
Ixtapa	2.87	1.09		0.92							4.86			2.49
Ococingo								1.01						
Plan del Rio	3.71	1.03							2.51	1.53	7.83	7.81		1.70
Union Juarez	4.65	1.51							1.24	1.55	9.03			3.32
La Puerta	4.99	2.35	33.9											1.55
San Ramón	4.03	1.96	39.3	1.15	2.89		3.88	0.59	2.02	1.06	11.67	5.83	32.2	2.19
Cangandi					2.33									

Figure 6.2a: Performance of *Calliandra calothyrsus* provenances relative to 'benchmark' – wood production. The provenances used as a benchmark were Flores, Santa María de Jesus and La Ceiba.

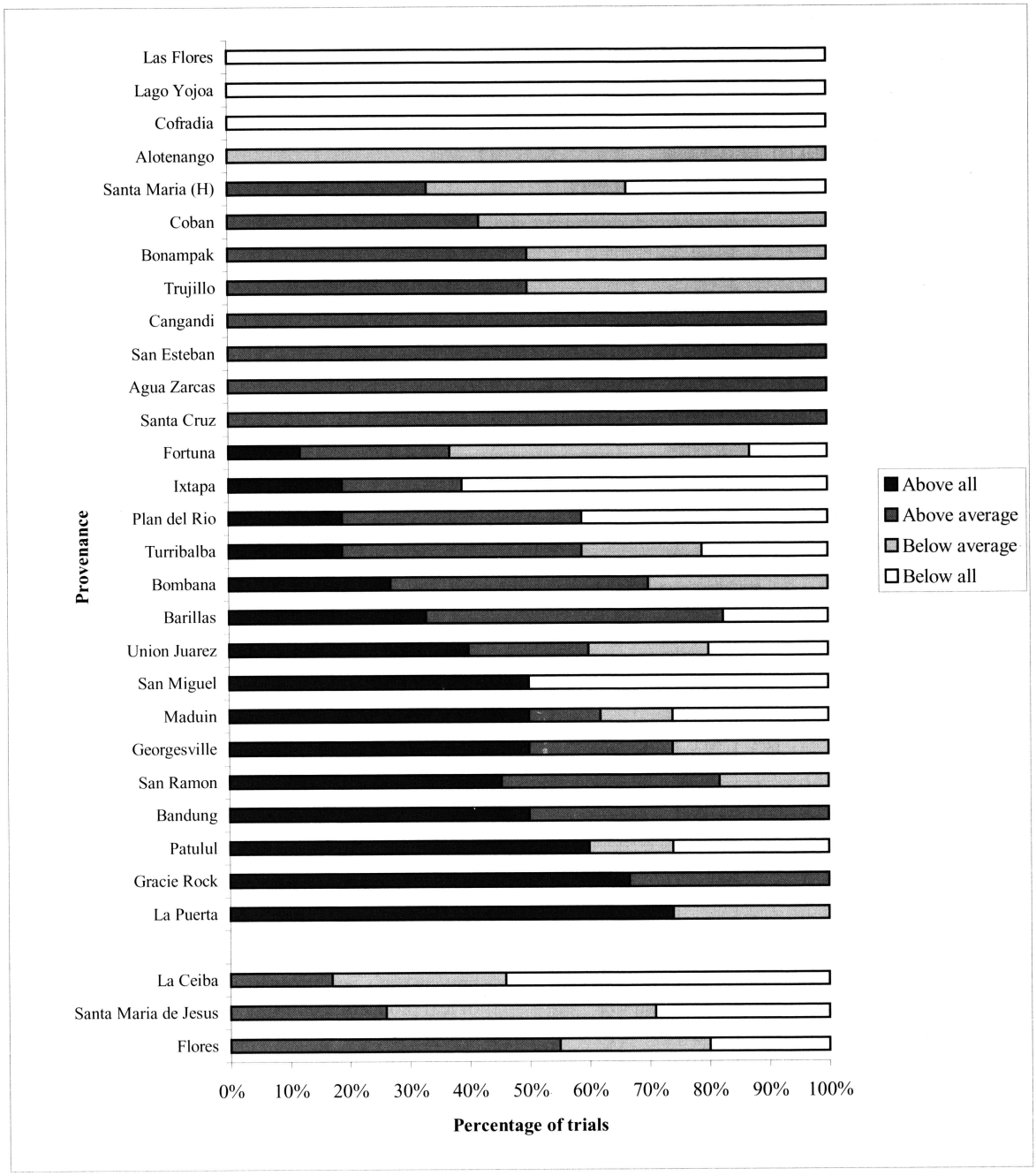
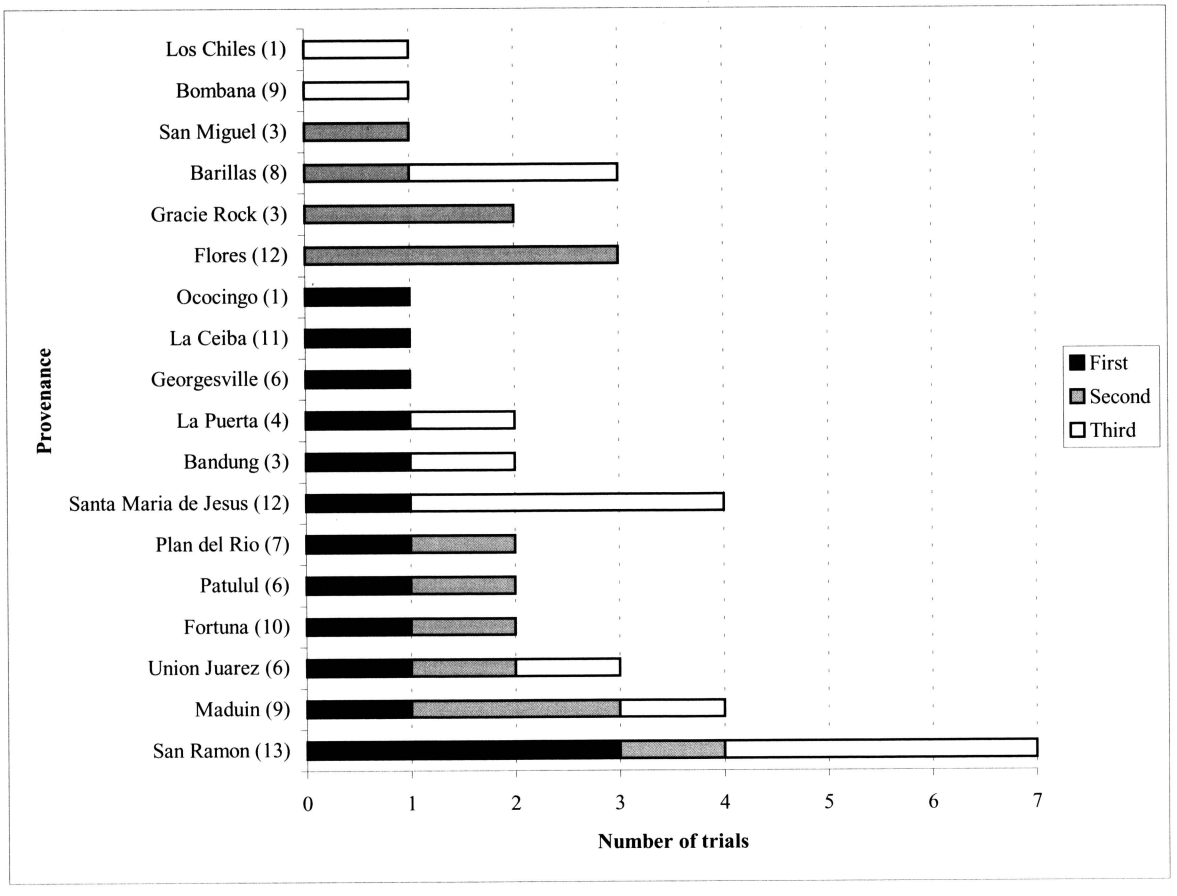


Figure 6.2b: Top performing provenances of *Calliandra calothyrsus* – wood production. Number of trials in which each provenance was assessed are shown in parentheses.



Leaf production

Table 6.5 shows the mean leaf production for each provenance at each site on which it was planted. The figures shown are again a mixture of fresh weights and dry weights, expressed on a kilogram/tree or tonne/hectare basis. The overall site mean and pooled standard deviation are given where known. Figure 6.3a shows the leaf production of each provenance relative to the benchmark, broken down into the four categories described earlier. The performances of the three provenances used to form the benchmark are shown relative to each other. Figure 6.3b shows the frequency with which each provenance was one of the top three performing provenances on a site.

It was expected that leaf production would show still greater variation in provenance performance than the other two traits, but this appears not to be the case. Comparing Figure 6.3a with Figure 6.2a shows that, on the contrary, there appears to be less variation in provenance performance for leaf production than for wood production. From Figure 6.3a, the performance of San Ramón is particularly notable. This provenance's performance was above average in terms of leaf production on every one of the 13 sites at which it was represented and outperformed all three of the benchmark provenances on nine of those sites. Figure 6.3b confirms this, showing San Ramón to be the top performing provenance on six sites and one of the top three performers on ten sites. With no below-average performances, San Ramón is clearly the 'best-bet' provenance for leaf production. As with wood production, the two Indonesian land-race seedlots are generally above-average performers, and the Nicaraguan provenances are generally above average. The performance of the Guatemalan provenances is more mixed for this trait.

Table 6.5: Summary of results from the *Calliandra calothyrsus* trial series: leaf production.

Trial site	Lan. Aus	Utc. Aus	Min. Cmr	Nko. Cmr	Yao. Cmr	Bak. Eth	Nad. Fij	Cin. Jam	Emb. Ken	Ban. Phl	Dor. Srl	Pal. Srl	Sfm. Tan	Gai. Tan	Kif. Uga	Mis. Zam	Dom. Zim
Site mean	3.96	2.35	1.62	1.29	5.19	2.01	1.33	52.5	5.85	0.57	2.68	2.68	3.52	4.39	8.20	0.64	3.28
Std. dev.	*0.86*	*0.67*	-	-	-	*0.31*	-	*34.2*	-	*0.42*	-	-	-	-	*4.46*	-	-
Provenance:																	
Georgesville	4.92	2.58								0.50	2.85	2.39			6.54		
Gracie Rock						2.20	1.69									0.56	
Santa Cruz			1.62	0.77	5.15								3.91				2.70
Agua Zarcas						1.81											
Fortuna	3.01	1.84	1.61	1.88	4.75		1.29		5.49		2.94	2.31	3.10	6.52	6.33		3.70
Los Chiles										0.65							
S I del General																	3.70
San Miguel													2.19	5.89		0.75	
Turrialba	3.19	1.80	1.95	1.11	5.15	2.18					2.80	2.63					
Alotenango													3.35	4.91			
Barillas	3.65	2.32	1.50	1.16	5.56		1.44			0.64	2.48	2.87				0.63	
Cobán	3.68	1.76	1.59	1.59	3.93	1.81			5.53		2.36	2.71			7.24		
Flores	4.94	2.41	1.85	1.41	5.49	1.66	1.07	63.1	4.69		2.08	2.57	4.57		7.40	0.47	4.30
Patulul	4.67	2.36						57.8			2.57	2.35	1.85				3.80
S M de Jesus	3.65	3.11	1.40	1.20	3.93	2.20	0.94	74.8	7.13		2.93	2.82	2.93		7.03	0.70	3.10
Cofradia														4.49		0.53	
La Ceiba	3.88	1.95	1.32	1.57	3.86	1.65	1.97	46.7	4.36		2.43		3.10		7.30	0.33	2.30
Lago Yojoa								18.0									
Las Flores	4.06	1.95															3.20
San Esteban											2.66	2.63			10.8		
Santa María	3.49	2.55	1.20	1.06	6.24												
Trujillo					3.19			57.9									
Bandung													4.27	5.18		0.71	
Maduin	3.67	3.06	1.91	1.15	5.76				5.77		2.70	2.84			7.90	0.69	2.70
Apic Apac														2.91			
Bombana			1.49	1.15	5.42	1.71	1.14				2.81	2.56	3.98		6.93	0.74	2.90
Bonampak			1.54	1.40	4.95			47.2									3.40
Ixtapa	3.39	1.87				2.21							2.44			0.63	
Ococingo										0.52							
Plan del Rio	4.08	1.97									3.52	3.02	3.76	4.03		0.57	
Union Juarez	4.26	2.43									2.20	3.34	4.44			0.61	
La Puerta	4.51	3.43	1.85	1.12	7.53											0.82	
San Ramón	4.18	2.64	1.89	1.51	6.92	2.66	2.08		7.96	0.55	2.94	2.46	5.40	2.80	12.5	0.88	3.50
Cangandi							0.91										

Figure 6.3a: Performance of *Calliandra calothyrsus* provenances relative to 'benchmark' – leaf production. The provenances used as a benchmark were Flores, Santa María de Jesus and La Ceiba.

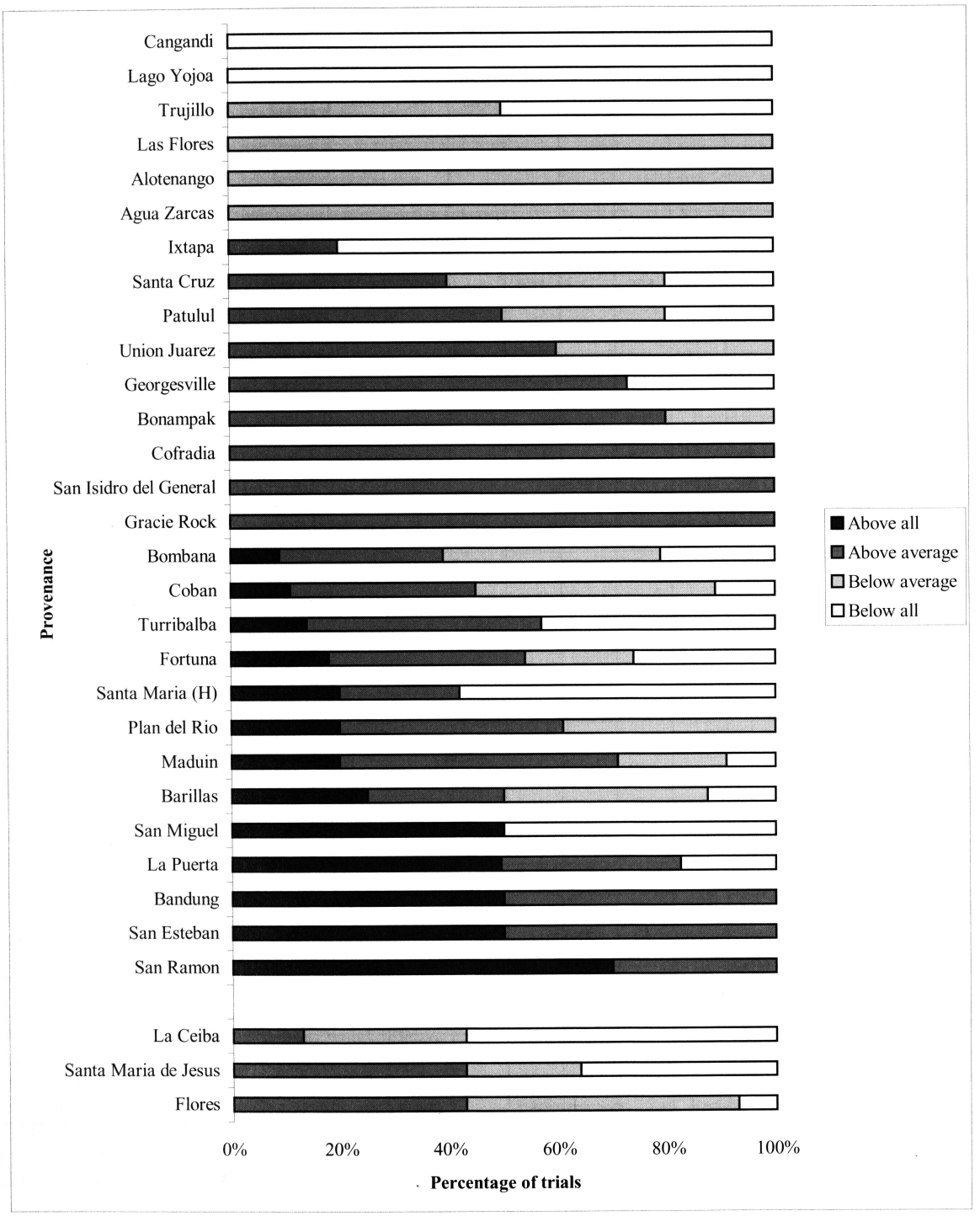
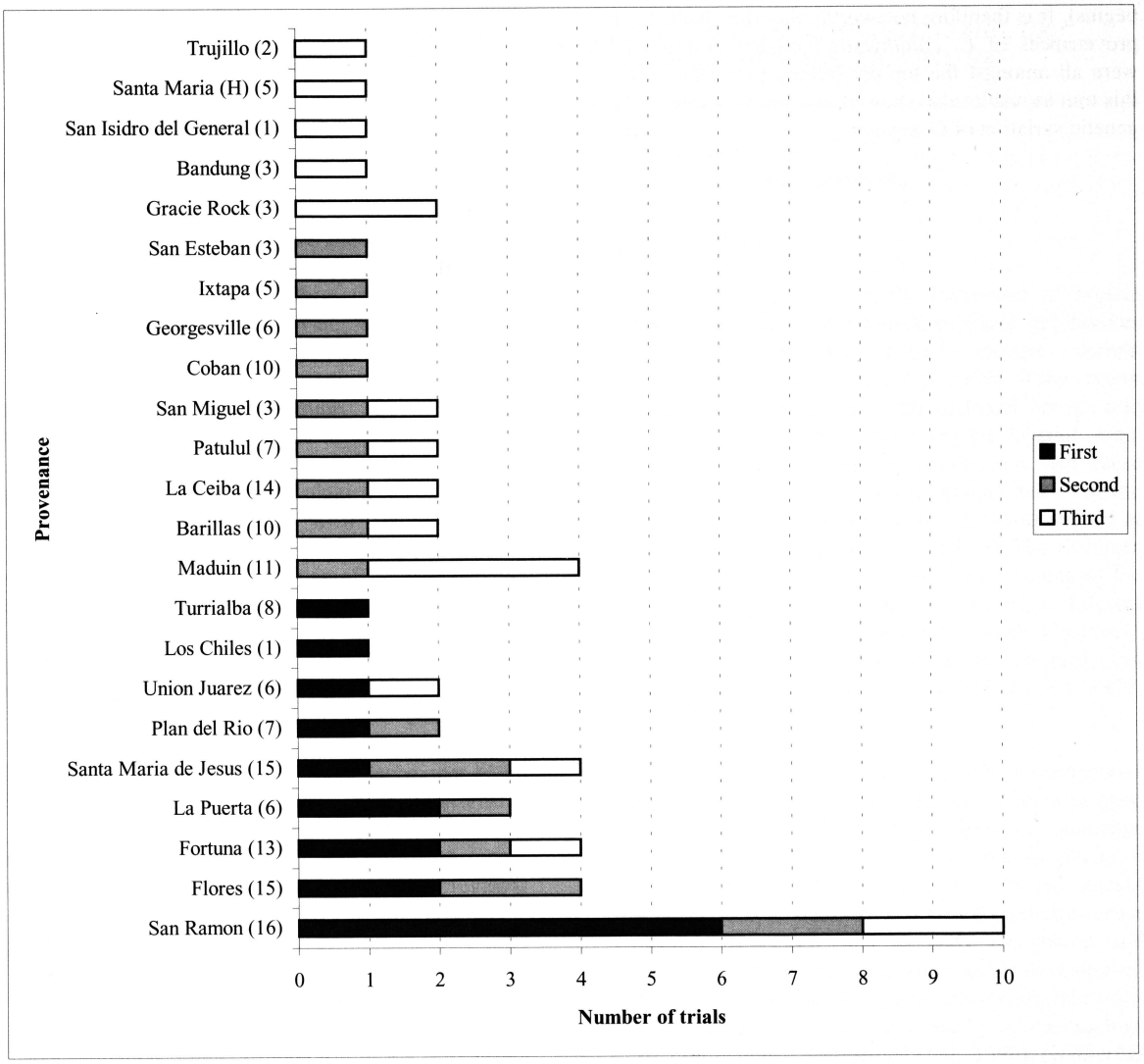


Figure 6.3b: Top performing provenances of *Calliandra calothyrsus* – leaf production. Number of trials in which each provenance was assessed are shown in parentheses.



Conclusions

Despite the incomplete nature of the data set upon which this analysis was based, and the resulting difficulty in making a direct cross-site comparison, there are a number of interesting and important conclusions that can be drawn.

Since wood production and leaf production are the two traits for which *C. calothyrsus* is generally planted, there is clearly one provenance that appears to be the most promising. In terms of frequency of top performance, and stability of above-average performance, the Nicaraguan provenance of San Ramón emerges as superior, especially strongly so for leaf production. This provenance could thus be recommended as a 'best bet' provenance for planting.

The Indonesian land-race seedlots were shown to be amongst the better performers, both in terms of leaf production and particularly wood production. These are already more widely distributed and available than the more-recently collected OFI seed sources, and it would seem that, with the exception of San Ramón, the newer seed sources have little benefit to offer over the land-race material in terms of wood and leaf production.

An interesting result was noted in the stem length analysis. This trait is often used as a basic indicator of growth as it generally less affected by management techniques (measurement takes place before lopping begins). It is therefore noteworthy that the Guatemalan provenances of *C. calothyrsus* included in this trial were all amongst the top-performing provenances for this trait as results also showed in a similar study of the genetic variation of *G. sepium.*