



JACARANDA COPAIA, A FAST-GROWING
NARROW-CROWNED NEOTROPICAL
SPECIES FOR LOWLAND PULPWOOD
PLANTATIONS

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A B S T R A C T

1. The principal ecological and silvicultural characteristics of Jacaranda copaia (Aublet) D. Don are present. Data (mainly from published literature) are given on occurrence in natural tropical rain forest and in post-logging natural regeneration. An annex provides, in a consistent format, growth data from about 31 monospecific trial plots in Brazil, Colombia, Costa Rica and Peru.

2. J. copaia is a wind-dispersed pioneer species capable of growing in poor exposed mineral soil. The rapid height growth is monopodial at least in the early stages. The capacity to grow through post-felling climber tangles and logging slash is aided by excellent self-pruning. Unless or until the crown breaks the stem is effectively unbranched. The conical young crown is formed by the 1-2m long bipinnate leaves, which leave a distinctive abscission scar in the bark when they are shed. Although the tree does not usually grow to a large size it is one of the fastest growing of Amazonian tree species in height and diameter. It coppices well.

Keywords:

Jacaranda copaia/neotropics/pulpwood/reforestation

A C K N O W L E D G E M E N T S

Dr. B. Rollet (on secondment from the Centre Technique Forestier Tropical, France, to the Departamento de Silvicultura, Faculdade de Ciências Agrárias do Pará, Brazil) provided data from Curuá-Una, Brazil.

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T A B L E O F C O N T E N T S

	Page
Introduction	1
Geographical distribution	2
Trees in rain forest	2
Phenology, seeds and nursery practice	3
Silviculture - natural regeneration	4
Silviculture - enrichment planting, nurse trees and agroforestry	5
Silviculture - monospecific plantations	6
Pests and pathogens	6
Utilization	7
Literature cited	7
Annex - growth data on <u>Jacaranda copaia</u> and <u>J. paraensis</u>	9

J A C A R A N D A C O P A I A , A F A S T - G R O W I N G
N A R R O W - C R O W N E D N E O T R O P I C A L
P L A N T A T I O N S

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I N T R O D U C T I O N

Jacaranda Juss. is a neotropical genus with about eighty species. The natural range extends from the northern islands of the Caribbean to Argentina. Several species are now widespread as ornamentals in the tropics and subtropics; the large bipinnate leaves have an attractive feathery appearance while the brilliant blue-purple-violet flowers are in most species held in erect panicles above the leaves, so that the whole crown appears to be a mass of flowers. The timber is usually pale coloured, light weight and non-durable under exposed conditions. The trees do not usually grow to a large size. Traditional tropical forest industries have tended to ignore the genus except as a second choice for light boxes and match manufacture. However some of the species have characteristics which make them suitable for pulpwood plantations.

This paper presents information on silviculture and growth of the best known species, J. copaia (Aublet) D. Don. The growth data are regrettably incomplete. Several institutions which have initiated studies on J. copaia over the years have suffered more than usually from inadequate direction, staff and funds. Consequently trial plots have been poorly maintained and/or unmeasured, previously collected data cannot now be located, and there is frequently no system for summarising, abstracting and exchanging data among fellow workers. A monographic treatment of J. copaia is being held back pending more satisfactory data. It is hoped that the presentation of this paper will help to stimulate the exchange of information among those organisations who hold unreleased data.

Record & Hess (1943) give 89 vernacular names for the timber species of Jacaranda. Confusion may arise between the botanical name of this genus in the family Bignoniaceae and the vernacular name jacarandá, applied in Brazil to species of the genera Dalbergia and Machaerium (Leguminosae, Fabaceae).

G E O G R A P H I C A L D I S T R I B U T I O N

J. copaia is found from Belize and Guatemala south to Mato Grosso (Rio Paca-Nova) in central Brazil. Further south it is replaced particularly by J. ovalifolia R.Br. (better known as J. mimosaeifolia D.Don.). J. copaia is a species of gaps and margins of primary lowland tropical rain forest, and of disturbed forests. It is apparently not found above 1000 m altitude in the centre of its range. It is an early arrival on exposed mineral soil and is able to tolerate low levels of nutrients and soil organic matter (Venegas, 1978). However its roots cannot penetrate hard pans and it does not seem to do well in rocky soils. It is sporadically common along roadsides and railways, and in gallery forest beside water courses in savanna areas. In northern South America J. copaia is a conspicuous component of riparian vegetation, especially in the lower reaches of rivers but above saline influence. Detailed distribution of the species has been mapped by Venegas (1978) for Colombia, and similar information should be available from Projeto Flora Amazônica in Brazil.

T R E E S I N R A I N F O R E S T

Trees of J. copaia in natural tropical rain forest tend to be taller and more slender than those in secondary vegetation. The tree may fork low down but the individual stems tend to be strongly erect and effectively separate trees. Growth is monopodial; until the crown breaks the self-pruning 1-2m long leaves are the 'branches'. Crown diameter is thus limited by leaf length until the stem begins to branch. In small natural gaps, and at close spacing in plantations, the stem may remain branchless to a height of 15m or more. Total heights of over 25m and diameters to 75cm have been reported. However the tallest trees rarely have large diameters (Record & Hess, 1943).

Summarising a series of reconnaissance forest inventories south of the Rio Amazonas in Brazil, Heinsdijk & Miranda Bastos (1963) reported mean estimated commercial heights of 15.2-18.6m for trees 25- <35cm dbh and 16.3-20.2m for trees 45- <55 cm dbh. Mean stems per hectare ranged from 0.1-1.1 and <0.1-0.4 for the same two diameter classes. Stem frequencies were higher in the more interrupted stretches of forest south and south east of Belém.

Huber (1910) classified J. copaia as a species of the canopy, at heights of 20-30m. Heinsdijk (1957) counted trees >25cm dbh with crowns completely emergent above the general level of the canopy. In the inventory between the Rios Tapajós and Xingú 50.2 per cent of the J. copaia trees were emergent.

The conspicuous erect inflorescences standing proud of the canopy are adapted to bird or insect pollination. Casual observation suggests that peduncles elongate slightly during fruit maturation, enhancing the range of the wind-dispersed seeds from the flag-like capsules.

P H E N O L O G Y , S E E D S A N D N U R S E R Y P R A C T I C E

Although Vattimo (1977, 1978) has separated J. paraensis (Huber) Vattimo and J. amazonensis Vattimo from J. copaia partly on fruit characters, they are here taken together. In general, flowering is in the dry season and fruiting follows about three months later. For much of Amazônia this means flowering in August-November and fruiting in December-March. Flowering is not closely synchronised in any one area. Some trees are apparently annual in flowering and fruiting while others in the same area are apparently biennial. A more intensive analysis of the phenological data summarised by Alencar *et al.* (1979) from Reserva Ducke, Manaus, shows that, in four two-year periods:

all five regularly observed trees fruited in 1969/70 and 1973/74;
four of the trees fruited in 1971/72.
three produced only small quantities of fruit in 1976 and two gave none;
none of the five trees fruited in 1975;
one tree halved its period to fruit in 1972/73 and 1973/74.

Dubois (1971), referring to Curuá-Una in east central Amazonia, noted good annual seed production which could be collected in March. The capsules dry and dehisce on the tree and the very light winged seeds are widely dispersed. Seeds must be collected by climbing the tree and clipping off the fruits. This is a disadvantage for large scale use.

Stands of J. copaia are being conserved as seed sources in Colombia (Dijk *et al.*, 1978); 12 trees on private lands in the north of Santander and 25 trees on private and government land at Gaviotas in Vichada.

SUDAM (1979) reported nursery work at Curuá-Una. There are 190-200,000 per kilo, with 70 per cent good seed and 80 per cent germination in 10-35 days. No pretreatment is necessary. Albrechtsen (1976) in a PRODEPEF nursery at Belém obtained 60-70 per cent germination, the first in 18 days, and seedling heights of 20-30 cm in 100-120 days. At Manaus only 12 per cent germination occurred from 2000 seeds (Loureiro, Silva & Alencar, 1979).

The seedlings are taprooted but robust. Wildings can be collected from the forest and grown on in the nursery without difficulty (Pitt, 1961).

J. copaia can be planted as potted stock, as stumps (Dubois (1971) left 20+cm of shoot attached) or as striplings, but the last take only 'fairly well' (Pitt, 1961). Bare root stock was tried by Pitt (1961) in sandy savanna at Porto Flatón, Amapá, and in sandy flanco soils at Curuá-Una but best survival was only 52 per cent at 2.7 years old.

SILVICULTURE - NATURAL REGENERATION

Information seems to be available only from Curuá-Una, Brazil. Pre-felling inventories showed very few mature trees in virgin forest in compartment 5 (as expected). At 15 months after selective felling and logging and with no silvicultural treatment, a survey for saplings (<3m tall) using 4m² quadrats showed the following (Pitt, 1961):

	closed canopy	25% light	50% light	75% light	full light
Percentage area per ha with each class of illumination	49.2	3.8	14.1	14.4	18.4
Stocked quadrats per ha	32	0	44	44	145
Mean height, m	0.25	-	?	1.15	1.20

Average annual height increments suggested by Pitt (1961) for the same intensities of illumination were:

height increment, m	0.13	0.3	0.3	0.7	1.0
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Dubois (1971) suggested considerably faster rates for tended regeneration: p_{mai_h} 2.5-3.0m and p_{mai_d} 2-3cm, as in plantations. Dubois also reported regeneration stocking at 7 years after felling. He counted trees >4m tall:

height class	4.5m	7.5m	8.5m	11.5m	12.5m	Total
stems/ha	3.1	6.3	3.1	3.1	12.5	28.1

The tallest J. copaia, apparently not within the quadrats, was 22m. The capacity of the species to grow through climber tangles and scrub was emphasised by Dubois. The self-pruning habit helps to prevent climbers from dominating the crown.

Pedroso (1973/74) reported results from strip felling experiments in 1960. 4 out of 10 300m² quadrats contained J. copaia; one tree was the largest among all the species in the natural regeneration in 1970-72:

Quadrat	stems / ha		mean heights, m			mean diameters, cm		
	all spp.	J. <u>copaia</u>	1970	1971	1972	1970	1971	1972
6	400	33	22.5	23.0	23.8	29.0	30.1	31.3
8	333	33	6.1	6.8	7.8	4.7	5.5	6.7
9	633	100	15.4	16.5	17.5	15.6	17.5	18.5
10	800	67	11.6	12.8	17.6	11.2	14.3	16.3

Pitt (1961) recommended the following procedure to secure establishment of the abundant natural regeneration of this species: open the canopy heavily after logging, clean the regeneration after 1-2 years, and favour J. copaia in subsequent 'thinnings'.

S I L V I C U L T U R E - E N R I C H M E N T P L A N T I N G , N U R S E T R E E S & A G R O F O R E S T R Y

Pitt (1961) recommended widely spaced (4-5m) group enrichment planting in unstocked areas resulting from intense fires when crown debris is burned after felling and logging. Data from trials at Curuá-Una are not available. In general a relatively low-value timber such as J. copaia cannot be used economically in enrichment schemes unless the matrix into which it is planted can be harvested at the same time as the planted stock.

Pitt (1961) also recommended the light-crowned J. copaia as a potential nurse species for more valuable slower-growing timber crops.

The International Council for Research in Agroforestry (ICRAF, 1980) has prepared a proposal with the Programa Nacional de Pesquisa Florestal (PNPF) and the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) for agroforestry projects in Brazilian Amazônia. The proposal includes the planting of J. copaia (and other timber trees) with perennial and annual agricultural crops.



SILVICULTURE - MONOSPECIFIC PLANTATIONS

Most of the data on J. copaia come from monospecific plots in plantations trials. Results of several of these trials have been reported only once, and comparisons between all the trials are difficult because site indices (or IUFRO dominant heights) have not been given. Further, because of re-numbering of experiments and plots, or through failure to refer to earlier publications, it is seldom clear whether subsequent reports from the same station refer to the same or to different experiments. Tabular summaries, annexed, present mainly published data in a consistent format. Site conditions are generally not included (because of limitations on space in a symposium paper) but may be obtained from the literature or from this author.

Other trials are known to have been established in Brazilian Amazonia, Colombia and Peru but data are not yet available. The plots on clayey soils at Jari Florestal e Agropecuária Ltda. in Pará, Brazil, were established in 1978 and were looking very promising in late 1979.

Loureiro, Silva & Alencar (1979) recommended 4x4m spacing in full light, spot-cleaning round each plant for the first two years, and annual cleaning along the planting lines. However since trees at Curuá-Una took two years to close canopy from an initial spacing of 2.5m, a spacing of 4m will involve considerable under-use of growing space and large weeding costs.

Ledoux (1969) emphasised the importance of good coppicing power in short-rotation pulpwood plantations. This power is well shown by roadside J. copaia which is slashed back and repeatedly regrows. It is resistant to hormonal arboricides applied in a frill girdle (Dubois, 1971).

PESTS AND PATHOGENS

Dubois (1971) views the species with some disfavour because it is liable to an unnamed shootborer at Curuá-Una in Brazil. Correa (1931) noted that a cerambycid bores J. mimosaeifolia. The borer of J. copaia does not appear to be widespread. Dubois (1976) reported foliage loss to a herbivorous insect, also unnamed, probably a beetle, in the trials at Trindade (annex, station 4). Ledoux (1964) found unidentified chalcids in young inflorescences at Mazagão in Amapá, Brazil. No pathological problems have been reported.

UTILIZATION

Several series of tests have shown that J. copaia can be used satisfactorily, by itself or in mixture with other species, to make soda and kraft pulps, a range of bleached and unbleached papers, and boards. These tests will be summarised in another publication.

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ANNEX - GROWTH DATA ON JACARANDA
COPAIA & J. PARAENSIS

Data are presented in a constant format of 11 items, supplemented by notes. The sequence of items is:

Station: location of the plantation or trial plot
p. year: year of planting
age: age in years at the time of assessment, to the nearest 0.1 year if known
shade: approximate percentage of overhead shade at the time of planting
plot size: number of trees planted (and replanted, if known)
reps: number of replicates of the plot
spac: initial spacing of the trees, in metres
height: mean total height of all surviving trees (unless otherwise qualified), in metres
dbh: mean over-bark diameter at breast height of all surviving trees (unless otherwise qualified), in cm
surv: percentage survival from the total of trees planted and replanted
ref: reference to the source in the literature.

The data are presented in alphabetic order of country. Within Brazil, data are in approximate order of location from east to west, and of date of establishment of the plots within location.

1. Station: Instituto Agronômico do Norte (IAN, now EMBRAPA), Belém, Pará, Brazil.
p. year: ? 1951
age: 8
shade: 0
plot size: ?
reps: ?
spac: 1 x 3m, to allow inter-row mowing
height: 15m
dbh: 19cm
surv: ?
ref: Lamb, Briscoe & Englerth (1960)
note: excellent bole form
2. Station: Igarapé-Acú (PRODEPEF), Bragança region east of Belém, Pará, Brazil
p. year: March 1975 March 1975
age: 1.1 1.1
shade: 0 40-60% in thinned scrub 6m tall
plot size: 36 Anderson group of 13 trees
reps: 5 5
spac: 1.5 x 1.5m 1 x 1m within groups, 10m between groups
height: 0.55m 0.65m
dbh: - -
surv: 37.8% 100%
ref: Dubois (1976)

3. Station: Igarapé-Açú (PRODEPEF), Bragança region east of Belém, Pará, Brazil
- | | | | |
|------------|---------------|--------------|---------------------------------|
| p. year: | March 1976 | March 1976 | March 1976 |
| age: | 0.5 | 0.5 | 0.5 |
| shade: | 0 | 0 | 40-60% in thinned scrub 6m tall |
| plot size: | 36 | 1-tree-plots | 1-tree-plots |
| reps: | 5 | 12 | ? |
| spac: | 1.5 x 1.5m | 3 x 3m | 3 x 8m |
| height: | 0.36m | 0.30m | 0.54 |
| dbh: | - | - | - |
| surv: | 98.8% | 91.7% | 100% |
| ref: | Dubois (1976) | | |
4. Station: Trindade (PRODEPEF), Bragança region south of Belém, Pará, Brazil
- | | | |
|------------|---|---|
| p. year: | March 1975 | March 1975 |
| age: | 1.1 | 1.1 |
| shade: | 0 | 40-60% in thinned secondary scrub |
| plot size: | 36 | Anderson group of 13 trees |
| spac: | 1.5 x 1.5 m | 1 x 1m within groups, 10 m between groups |
| height: | 1.57m | 0.65m |
| dbh: | - | - |
| surv: | 97.5% | 96.9% |
| ref: | Dubois (1976) | |
| note: | photo 26 in Dubois (1976) shows trees at least 4 m tall in one plot in full light | |
5. Station: Fazendinha-de-Fora, Amapá, Brazil
- | | | |
|------------|--|-----------------------------|
| p. year: | ? 1975 after strip ploughing of poor sandy soil, savanna | |
| age: | 1.5 | 2.0 |
| shade: | 0 | 0 |
| plot size: | 100 trees +
105 replanted | 100 trees +
90 replanted |
| reps: | 1 | 1 |
| spac: | 2.5 x 2.5m | 2.5 x 2.5m |
| height: | 0.12m | 0.25m |
| dbh: | - | - |
| surv: | 2% | 2% |
| ref: | Pitt (1961) | |
| note: | 1/2 dessertspoonful of P ₂ O ₅ fertilizer in each planting and replanting hole | |
6. Station: Sawmill training centre (now CTM-SUDAM), Santarém, Pará, Brazil.
- | | | |
|------------|-----------------------------|----------------------------|
| p. year: | 1958 | 1959 |
| age: | 2.7 | 1.7 |
| shade: | 0 | 0 |
| plot size: | 75 trees +
107 replanted | 75 trees +
33 replanted |
| reps: | 1 | 1 |
| spac: | 2.5 x 2.5m | 2.5 x 2.5m |
| height: | 2.9m | 4.1m |
| dbh: | - | - |
| surv: | 5% | 38% |
| ref: | Pitt (1961) | |

7. Station: Service for training and forest research (STPF, CTM-SUDAM)
Curuá-Una, Pará, Brazil

p. year:	1958	1958
age:	2.7	2.7
shade:	0	0
plot size:	100 trees + 123 replanted	96 trees + 86 replanted
reps:	1	1
spac:	2.5 x 2.5m	2.5 x 2.5m
height:	4.5m	6.6m
dbh:	?	7 cm* (dominants & co-dominants only)
surv:	42%	52%
ref:	Pitt (1961), *Pitt in Wadsworth (1960)	
notes:	Km 4	Km 5
	poor sandy soil	better sandy soil
	bare root stock	bare root stock + striplings
		photo Fig.3, page 64, <u>Unasylva</u> 15 (2) 1961

8. Station: Service for training and forest research (STPF, CTM-SUDAM)
Curuá-Una, Pará, Brazil

p. year:	1959	1959	1959
age:	1.7	1.7	18
shade:	0	0	0
plot size:	21 trees + 9 replanted	28 trees + 19 replanted	?
reps:	1	1	1
spac:	2.5 x 2.5m	2.5 x 2.5m	2.5 x 2.5m
height:	4.1m	4.4m	18.9m
dbh:	-	-	11.7cm
surv:	70%	49%	63% if plot M, 40% if M+
ref:	Pitt (1961); 1977 data (18 years old) from Rollet (1980)		
plot:	M	M+	M or M+
notes:	flanco sandy soil	as for M, with added P ₂ O ₅	
	stumps	stumps	

9. Station: Service for training and forest research (STPF, CTM-SUDAM)
Curuá-Una, Pará, Brazil

p. year:	1960	1960	1960
age:	0.7	0.7	18
shade:	0	0	0
plot size:	36 trees	36 trees + 5 replanted	?
reps:	1	1	1
spac:	2.5 x 2.5m	2.5 x 2.5m	2.5 x 2.5m
height:	0.9m	0.9m	14.8m
dbh:	-	-	8.5cm
surv:	97%	78%	81 or 71%
ref:	Pitt (1961); 1977 data (18 years old) from Rollet (1980)		
plot:	M(60)	M(60)	one of the two M(60) plots
	stumps	striplings	
note:	flanco sandy soil		

10. Stations: Service for training and forest research (STPF, CTM-SUDAM)
Curuá-Una, Pará, Brazil

	1959	1960	1960	1960
p. year:	1959	1960	1960	1960
age:	1.7	0.7	0.7	0.7
shade:	0	0	0	0
plot size:	48 trees + 9 replanted	150 trees + 2 replanted	200 trees + 3 replanted	185 trees
reps:	1	1	1	1
spac:	2.5 x 2.5m	2.5 x 2.5m	2.5 x 2.5m	2.5 x 2.5m
height:	4.1m	0.7m	0.6m	0.9m
dbh:	-	-	-	-
surv:	85%	89%	86%	79%
ref:	Pitt (1961)			
notes:	planalto clay soils, plots cleared from felled and burned forest			
	plot E	plot A3	plot A3	plot A3
	stumps	stumps	stumps	60cm striplinge

11. Stations: Service for training and forest research (STPF, CTM-SUDAM)
Curuá-Una, Pará, Brazil

	1959; probably Pitt's plot E (see station 10 above)			
p. year:	1959; probably Pitt's plot E (see station 10 above)			
age:	11	12	13	18 (probably)
shade:	0	0	0	0
plot size:	48 trees + 9 replanted			
reps:	1			
spac:	2.5 x 2.5m			
height:	21.8m	22.1m	23.8m	pmai 1.98m
dbh:	22.6cm	23.8cm	24.4cm	pmai 2.05cm
surv:	?	?	47.4%	?
ref:	Pedroso (1973/74); 1977 data (18 years old) from SUDAM (1979)			
notes:	Pedroso commented that the appearance of the plot was excellent. Growth of the <u>J. copaia</u> was the best of the selection of 17 above-average Amazonian species. SUDAM (1979) also claims periodic mean annual increment in volume of 49.5 m ³ /ha/year.			

12. Station: Reserva Ducke, INPA, Manaus, Amazonas, Brazil
p. year: 1964 1964 ?
age: 14 14 13
shade: 0 100¹ 0
plot size: line of 15 line of 15 ?
reps: 1 1 ?
spac: 2.5 x 5m 2.5 x 5m 3 x 4m
height: 13.7m² 5.6m² 10.8m
dbh: 21.2cm 5.2cm 11.4cm
surv: >80%* ±60%* 89%+
ref: *Alencar & Araujo (in press); †Loureiro, Silva & Alencar (1979)
notes: 1. the line was planted into a 'tunnel' formed by cutting the undergrowth palms and climbers in otherwise virgin tropical rain forest. Both lines have been cleaned twice annually
2. heights and diameters are means of 10 trees drawn at random from each line
3. annual mean height and percentage survival curves cover ages 6-14 years. The curves show a marked change in 1974-75 for all the 20 species reported. This is probably due to changes in measurement procedure and in degree of supervision
4. these plots are now identified as J. paraensis, not J. copaia
13. Station: Estação Experimental de Silvicultura Tropical, Km 45 BR-174, INPA, Manaus, Amazonas, Brazil
p. year: 1973
age: 1.6
shade: 0
plot size: ?
reps: ?
spac: ?
height: 4.7m (12.5% coefficient of variation)
dbh: ?
surv: ?
ref: Loureiro, Silva & Alencar (1979)
14. Station: Maderas y Chapas de Nariño, S.A., Nariño, Colombia
p. year: ? 1973
age: 1.5
shade: 0
plot size: ?; first stage 40.1ha, second stage 41.0ha, third stage 42.0ha
reps: ?; trials on 3 soil types (sandy loam, clay & muck), also replicated in time
spac: 3 x 3m
height: ±3m
dbh: ?; rotation of 15 years suggested
surv: ?
ref: Peck (1976)
notes: forest logged, clear felled and chopped to prepare trial sites; no burning

15. Station: Prueba de especies forestales (tree species trials),
Direccion General Forestal del MAG, Buenos Aires,
Puntarenas, Costa Rica

p. year: ? 1975
age: 4
shade: 0
plot size: 13 x 13
reps: 1
spac: 2 x 2m
height: 9m
dbh: 12cm
surv: ?
ref: Costa Rica (1979)
note: a photograph of the plot is given in the report

16. Station: Puerto Almendra, UNAP, Iquitos, Peru

p. year: 1972
age: 2
shade: 0
plot size: ? 15 trees
reps: 4; randomised complete block species trial
spac: 2 x 2m
height: 8m
dbh: 12cm
surv: ?
ref: Santander, Diaz Reategui & Documet (1974)
note: given as Jacaranda sp. (huamanzamana). However it is likely to be J. copaie. Huamanzamana, or huaman-samane, is Dictyoloma peruviana Planch., Rutaceae, a shrubby tree from upland northeast Peru which also has bipinnate leaves and similar wood (Record & Hess, 1943).

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