MULTIPURPOSE TREE SPECIES TRIALS

DATA COMPILATION

REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

AND

WINROCK INTERNATIONAL FORESTRY/FUELWOOD RESEARCH
&
DEVELOPMENT PROJECT

13 May, 1988

Winrock International

MEMORANDUM

26 May, 1988

TO: THOMAS C. NIBLOCK
PROJECT MANAGER, F/FRED

FROM: C. BUFORD BRISCOE

SUBJECT: REPORT ON F/FRED CONSULTANCY TO DENR, REPUBLIC OF THE PHILIPPINES, APRIL - MAY, 1988

Attached is the report on assembling existing data for multipurpose tree species, prepared in cooperation with the Department of Environment and Natural Resources (DENR).

I felt the consultancy was well worthwhile; a great deal of unpublished information was collected on species now included, and planned for inclusion in the near future, in F/FRED network studies. Data on additional species also demonstrated their potential value for use by landowners in humid and sub-humid Asia.

The results are clearly useful and could have been obtained, I think, in no other way. The U.S. Forest Service tried to obtain similar information throughout the neotropics by mail, questionnaires, and personal contact in the early 1960's. The results were virtually nil until every country was visited following the same basic procedure as used in the Philippines.

The only modification to the Philippine procedure that appears desirable is to include, wherever possible, more sources of field data. Private industry frequently has very good data and sometimes more continuity in keeping records. (And sometimes much less.) Universities and forest research institutes often have data reported only in theses or in publications not generally available. The FAO and other multilateral and bilateral donors have participated in a great many studies over the years, the results of which exist only in project reports of very limited availability. USAID may have a substantial number of such reports. The plantings themselves are frequently still growing, but undocumented since the end of the official project.

Country reviews, to the extent acceptable, would clearly provide information on a greater range of species and age classes than could conceivably be generated during the next ten years of a new network. The results would serve to guide and supplement the more detailed and better-documented Multipurpose Tree Species network studies. It would be useful, therefore, for the F/FRED Project to sponsor additional country data searches such as was conducted in the Philippines.

Republic of the Philippines

Ministry of Natural Resources

Visayas Avenue. Diliman, Quezon City, Metro Manila

13 May 1988

LIRIO T. ABUYUAN
Assistant Secretary
Department of Environment and
Natural Resources
Visayas Avenue
Quezon City, Manila

THRU: JOSE R. GAPAS
Service Chief
Foreign-Assisted & Special Projects

Dear Assistant Secretary Abuyuan:

Attached is a copy of our report on trials of multipurpose tree species in the Republic of the Philippines.

We are greatly indebted to all those who assisted us in locating the information, visiting the field locations, and particularly those who assisted in preparing the report under somewhat rushed conditions.

Sincerely,

DR. E. BUFORD BRISCOE
Project Officer
Winrock International,
F7FRED

Jocelyn M. Alcazar
Social Forester

[illegible]
[illegible] Economist

[illegible]

PREFACE

This report is a compilation of data from past species trials involving multipurpose trees in the Republic of the Philippines. The information was assembled during April May, 1988, from field measurements, office files, and project reports. None of it, to our knowledge, is currently available in the international body of scientific literature.

The contributors were, in chronological order, the Department of Environment and Natural Resources (DENR), particularly the Species Trial & Seed Orchard Development Project, the Reforestation Division-FMB, and the Ecosystem Research & Development Bureau (ERDB); the Manila Seedling Bank Foundation, Inc.; the RP-Japan Reforestation Project; and the ASEAN-New Zealand Afforestation Project (ANZAP). Although no data were collected we also benefited from observing early tree development on small farms of the Rainfed Resources Development Project Visares, Leyte.

As with all forestry field projects, we are indebted to those who planned and implemented plantation establishment, and particularly to the technicians and laborers who carried out the arduous labor of site preparation, planting, and care of the trees.

The Forestry/Fuelwood Research and Development (F/FRED) Project which sponsored this report is an Asian regional forestry research activity financed by the U.S Agency for International Development.

CONTENTS

EXECUTIVE SUMMARY

World opinion has accepted that tropical deforestation is excessive, reforestation is urgently needed, and that smallholder participation is required. An essential step is to provide information on trees that will quickly and reliably provide fuel, fodder, fencing, shelter, on-farm construction materials, food, and beauty, in addition to marketable timber.

One means of prompt provision of such information is to assemble and distribute existing unpublished information. To carry out such a compilation, a technician was assigned by the Multipurpose Tree Species Research Network, sponsored by the F/FRED Project, to work with two counterparts in the Philippine Department of Environment and Natural Resources (DENR), to locate and assemble data generated in the past by DENR and related organizations. The results are summarized briefly in this report. Hard data obtained will be distributed throughout the Asian Multipurpose Tree Species Network.

It is hoped that data from other government and private organizations can be obtained, and that other countries will follow the Philippine lead in making all useful information available as quickly as possible.

Conclusions:

1. Species and provenances vary widely in height and diameter increment, and in survival.

2. Development of a given species or provenance varied considerably between sites.

3. There was a species/site interaction.

4. The species or provenance that began as the fastest-growing tended to continue as the fastest-growing, but this was not invariable.

5. The fastest species on one site was not the fastest on all, but *Acacia auriculiformis*, *Eucalyptus camaldulensis*, and *Gmelina arborea* were included in top rankings almost everywhere they occurred; *Acacia mangium* and *Gliricidia sepium* were consistently near the top.

6. On truly adverse sites, no species tested showed really satisfactory development.

7. Fire is an annual threat throughout the area studied, and may be the critical determinant in choosing species on some sites.

Observations:

1. Inferior trees need to be removed from seed production areas. A permanent program of tree genetics improvement should be initiated as soon as possible for all desirable species and seed orchards established as soon as superior genotypes are available.

2. Existing plantations at the RP-Japan Reforestation Project offer an unusual opportunity for a research team of forester and soils specialist to relate site indices and biomass production to soil and topographic characteristics.

3. Future species trials will provide much more usable information if all species tested are planted at all locations in randomized complete blocks; limited quantities of planting stock should be used in smaller plots, not at fewer locations.

4. There was no indication that a single species is the most desirable on all sites; species/site interaction precludes a single choice among the species tested to date.

5. Coppicing of Acacia auriculiformis and A. mangium is strongly influenced by height of stump and season of cutting; individual genotype probably has an effect also.

6. Adoption of the F/FRED computerization system for data management should facilitate effective and accurate analysis and use of research findings.

I. INTRODUCTION

Throughout the tropics, realization has come that deforestation has exceeded acceptable limits, that reforestation is urgently needed, and that active support and participation by the small landholder is required in order to halt de-forestation and obtain re-forestation. An essential step toward obtaining that support is to provide information on trees that will quickly and reliably provide fuel, fodder, fencing, shelter, on-farm construction materials, food, and beauty, in addition to marketable timber.

In order to accelerate acquisition of such information, a Multi-Purpose Tree Species (MPTS) network of Asian research organizations has been formed. Formal active affiliates are in the Republic of the Philippines, Indonesia, Malaysia, Nepal, Pakistan, Taiwan, and Thailand. Cooperators are also participating, informally to date, in Bangladesh, China, India, and Sri Lanka. Support has been provided by the United States, Australia, and the FAO of the United Nations. The immediate objective of the network is to share research methods and results throughout the region, reducing costs and increasing usefulness. The second, and equally important, objective is to ensure that the knowledge gained is communicated to other researchers, related extension professionals, and to the land managers, the farmers.

One step toward timely accomplishment of these objectives is to assemble and distribute existing unpublished information. All data reported here is taken from replicated plots of statistically adequate experimental designs. Measurement per plot were mostly 15 - 36 plants, and most replications were 4 - 6.

To carry out this compilation, a technician was assigned by the Multipurpose Tree Species Network, sponsored by the F/FRED Project, to work with two counterparts in DENR, RP, to locate and assemble data generated in the past by DENR and related organizations. The results are summarized briefly in this report. Hard data obtained will be distributed throughout the Asian network. It is hoped that additional information can be located and compiled, and that other countries will follow the Philippine lead in making all useful information available as quickly as possible.

II. PROCEDURES

For compilation of this report, data was obtained by reviewing office files and unpublished project reports, and by measuring temporary plots in accessible mixed plantings where data was not available. Presumably more information of all three types could be obtained, when time permits.

Several sites were visited to observe the plantations which served as the bases for project reports: Pampanga and Leyte of the Species Trials and Seed Orchard Development Project (HODAM), Carranglan of the RP-Japan Reforestation Project, and Tarlac of the ASEAN-New Zealand Afforestation Project (ANZAP).

After the data was obtained, plot means were calculated (if tree measurements were supplied), the means were ordered by species and location, replication, treatment or other variable, and analyses of variance were carried out to determine which apparent differences were significant, with a probability of 95% or higher.

Actual calculations were for the most part performed with pocket calculators. Later, when the MPTS network software was available, many of the prior calculations were re-run for verification, and, at the same time, to familiarize the counterpart personnel with the operating procedures of the software package. The complete F/FRED software program was left installed on a DENR computer for future use.

In addition to this report, all plot values will be recorded in the network format and provided as hard copy or on microdiskettes to all network cooperators, for combining with data from other research studies.

III. SUMMARY OF RESULTS

A summary of the results is given below. More details are included in the appendices.

A. Species Trials and Seed Orchard Development (HODAM)

Species trials and seed production areas were established at Solsona, Ilocos Norte and Parac, Pampanga, Babatngon, Leyte, and Murcia, Negros Occidental.

The Ilocos Norte trial is on an upland slope and ridge, clay soils, approximately 300 m elevation, receives 2000 mm of rainfall annually, mostly in May - October. Pampanga is on a rolling upland with steep slopes, clay loam soils, about 500 m above sea level; rainfall is about 1900 mm, and rainy season is May - October.

The Leyte trial is on short steep slopes and sharp ridges, soils are clay loam, 200 - 300 m elevation, rainfall > 2000 mm, fairly well distributed but drier January - April. Negros Occidental is rolling to steep, rocky, 800 m above sea level, soils are clay loam, rainfall 1800 mm, fairly well distributed, heaviest October - December.

As shown in Figure A-1, the height of Gmelina arborea and Acacia auriculiformis are essentially equal throughout the period of measurement, based on the average of the study as a whole. They started rapidly, then tapered off at nearly identical rates. Gliricidia sepium, however, after growing more slowly the first 6 months, grew as rapidly as the top two species for the next year, then tapered off quite rapidly and was overtaken at age 3 by unvarying growth of A. mangium . Thus four species demonstrated three growth patterns. One regrettable conclusion is that species growth potential cannot be evaluated reliably on the basis of very early growth.

Fig. A-1 Tree Height by Species, HODAM

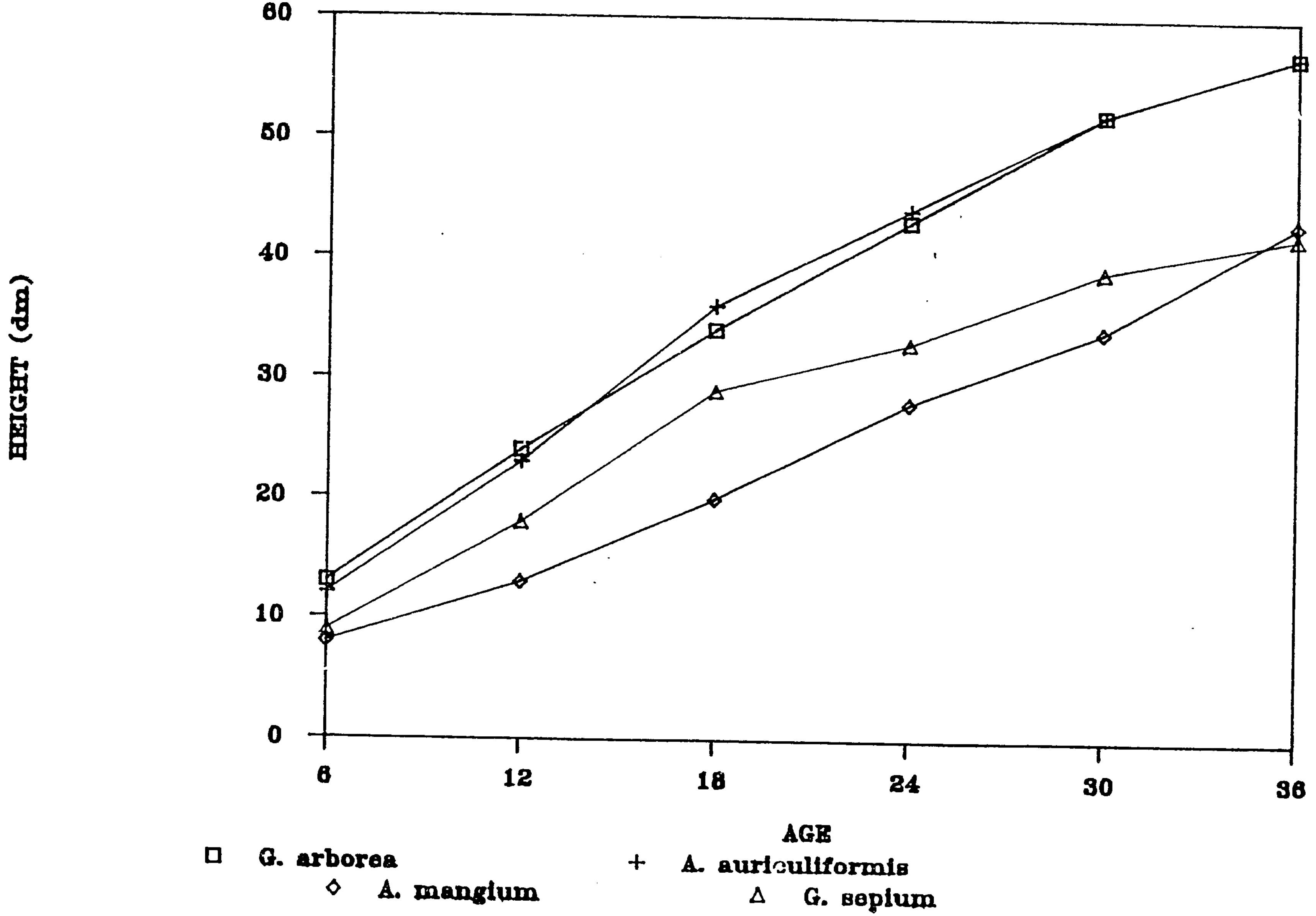


Figure A-2 also shows three patterns, with Leyte and Negros showing similar form, despite the higher absolute values at Leyte, Ilocos showing a steady climb, and Pampanga behaving somewhat erratically. It would be interesting to know the rainfall at Pampanga, especially December 1984 to June 1985, when the trees were 6 - 12 months old.

A further complication is introduced by the height data in table A-1: species/site interaction. Although Gmelina and A. auriculiformis average the same for the project as a whole, Gmelina is, in fact, the taller at Ilocos and Leyte while A. auriculiformis is taller at Pampanga and Negros. More impressive still in table A-1 is Albizia lebbecoides: On Negros, it is ranked 7th of 8 species; on Leyte, it ranked 4th among the same 8 species. In the diameter measurements given in table A-2, Piliostigma malabaricum is ranked 6th of 8 species at Pampanga; on Leyte it is the largest of 11 species.

Although there is a tendency toward consistency in ranking between sites, especially of height, superiority on one site is no guarantee of superiority on another.

Fig. A-2 Tree Height by Site, HODAM

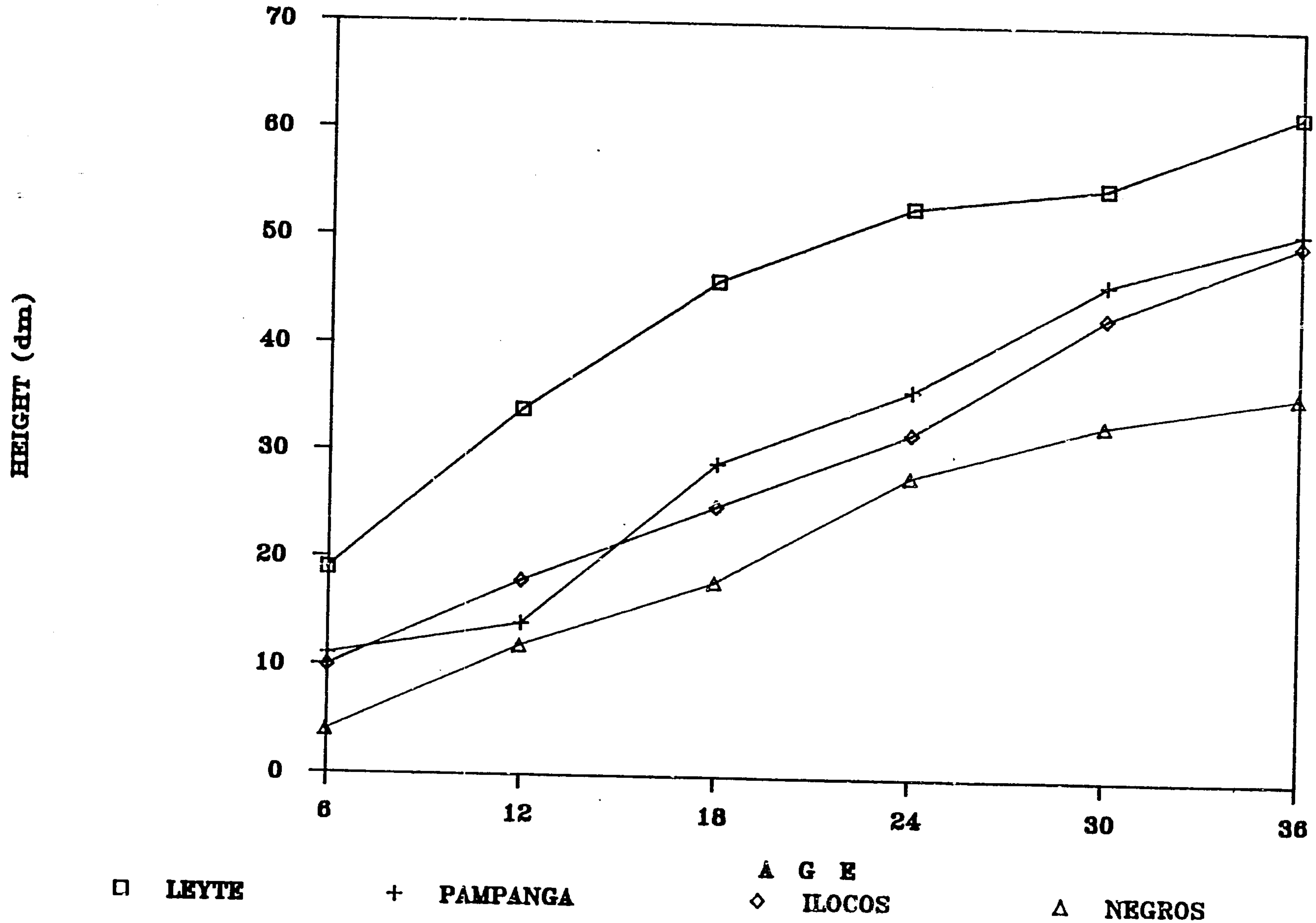


TABLE A-1: HODAM SPECIES TRIALS, mean height at 3 years:

SPECIES	PROJECT	ILOCOS	PAMPANGA	NEGROS	LEYTE*
	- - - - - -	- Total	Height, dm	- - - -	- -
Gmelina arborea	57	64	53	37	74
Acacia auriculiformis	57	56	65	46	62
Acacia mangium	42	29	42	30	69
Gliricidia sepium	42	51	44	29	43
Albizia lebbeck	34		20		48
Albizia lebbecoides	41		14	12	56
Albizia procera	25		12	9	30
Cassia spectabilis	27			20	34
Piliostigma malabaricum	36			25	47
Casuarina equisetifolia					60
Leucaena leucocephala					60

Leyte values extrapolated from 30-month measurements.

TABLE A-2: HODAM SPECIES TRIALS MEAN DIAMETER AT BREAST HEIGHT

	ILOCOS	PAMPANGA	LEYTE
	---DIAMETER BREAST HEIGHT, MM---		
	30 MOS.	42 MOS.	30 MOS.
1. Gmelina arborea	37	46	43
2. Acacia auriculiformis	38	48	108
3. Acacia mangium	30	53	120
4. Gliricidia sepium	26	59	79
5. Albizia lebbeck		25	91
6. Albizia lebbecoides		12	92
7. Albizia procera		15	80
8. Cassia spectabilis			79
9. Casuarina equisetifolia			97
10. Leucaena leucocephala			80
11. Piliostigma malabaricum			134

B. Reforestation Division, FMB, DENR

Field plantings of the Site Classification and Species Suitability Study were established at Carasi, Ilocos Norte; Argao, Cebu; and Baluno, Zamboanga. The following information is abstracted from the study plan.

The Ilocos site is on strongly rolling slopes 100 - 400m elevation, infertile clay loam soils, >2000 mm rain, primarily May - October.

Cebu plantings on a rolling to mountainous area, 500 m, clay loam soils with low fertility, rainfall > 2000 mm, somewhat wetter May to October.

Zamboanga area is relatively gentle slopes, 600 - 800 m, clay loam soils with boulders and outcrops, up to 2800 mm, somewhat more May - October.

The same interaction of species and site found in the Species Trial and Seed Orchard Project occurred in the Reforestation Division study, figures B-1, B-2 and tables B-1, B-2: Acacia mangium did quite well at Zamboanga and Ilocos Norte, but barely grew on Leyte. Even different provenances within a species show site interactions, Figures B-3, B-4 and tables B-3, B-4, Appendix B.

Fig. B.1 Mean Height By Species and Site

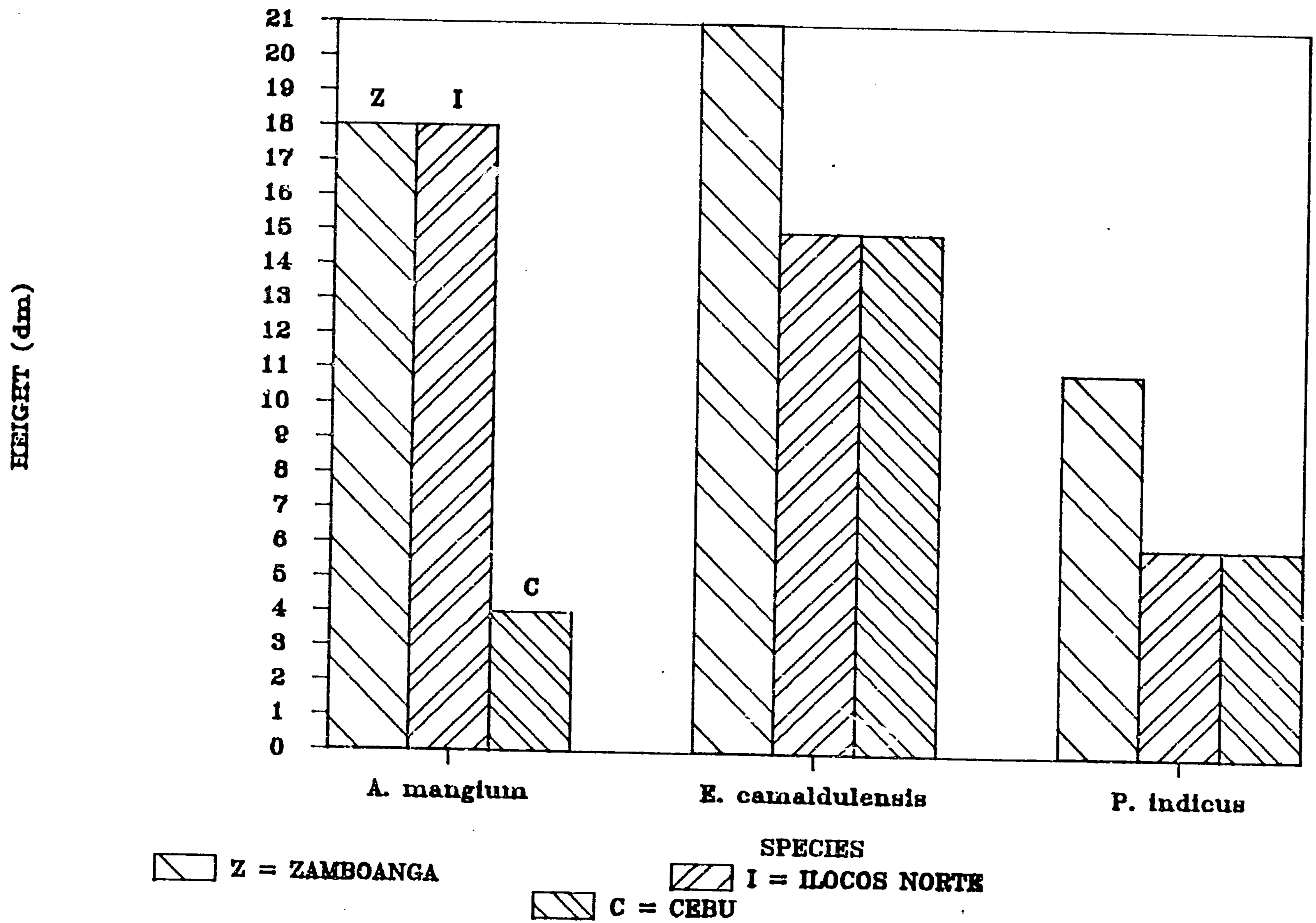


Fig. B.2 Mean DBH By Species and Site

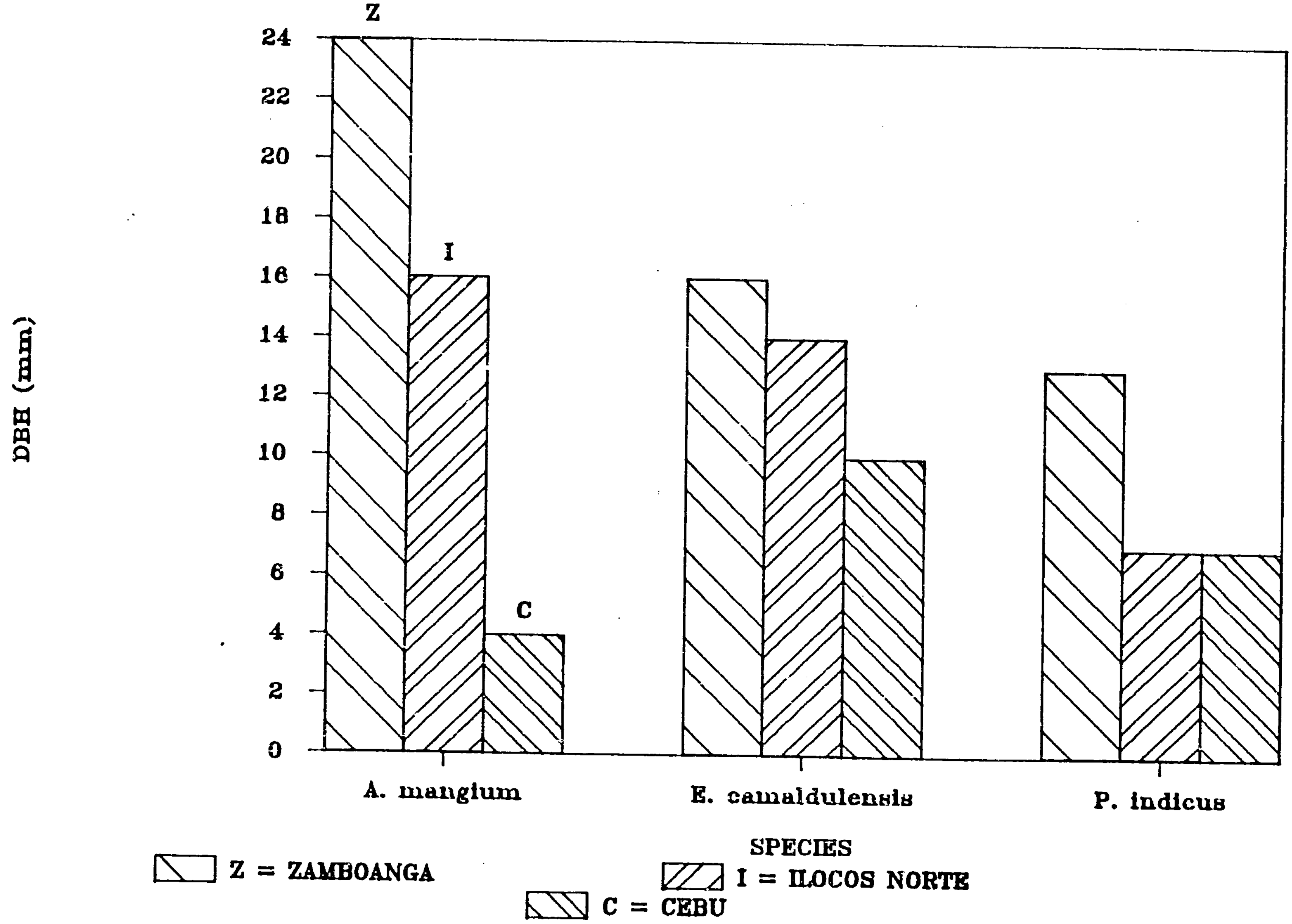


TABLE B-1 : MEAN HEIGHT BY SPECIES AND SITE.
Reforestation Division.

SPECIES	CEBU	ZAMBOANGA	ILOCOS	MEAN
		Height, dm		
Acacia mangium	4	18	18	13
Eucalyptus camaldulensis	15	21	15	17
Pterocarpus indicus	6	11	6	8
Eucalyptus torelliana	8			
Casuarina equisetifolia	12		13	12
Eucalyptus brassiana	17			12
Eucalyptus grandis	9			
Swietenia macrophylla	11	9		10
Eucalyptus pellita	6			
Eucalyptus tereticornis	12		22	17
Gmelina arborea		22	7	14
Pinus kesiya		2		
Acrocarpus fraxinifolius		15		
Dalbergia sissoo		11	10	10
Eucalyptus urophylla		23		
Eucalyptus deglupta		15	10	12
Acacia crassicarpa		21		
Calliandra calothyrsus		42		

TABLE B-2: MEAN DIAMETER BY SPECIES AND SITE, REFORESTATION DIVISION, FMB

	CEBU	ZAMBOANGA	ILOCOS NORTE	$\bar{X}$
	----------IN	MILIMETER	-----------	
1. Acacia mangium	4	24	16	15
2. Eucalyptus camaldulensis	10	16	14	13
3. Pterocarpus indicus	7	13	7	9
4. Eucalyptus torelliana	8			
5. Casuarina equisetifolia	11		7	
6. Eucalyptus brassiana	11		5	
7. Eucalyptus grandis	6			
8. Swietenia macrophylla	15	20		
9. Eucalyptus pellita	6			
10. Eucalyptus tereticornis	6		20	
11. Gmelina arborea	47	8		
12. Pinus kesiya		4		
13. Acrocarpus fraxinifolius		31		
14. Dalbergia sisso		10	8	
15. Eucalyptus urophylla		17		
16. Eucalyptus deglupta		18		
17. Acacia crassicarpa		23		
18. Calliandra calothyrsus		52		

Fig. B.3 Acacia mangium Provenance

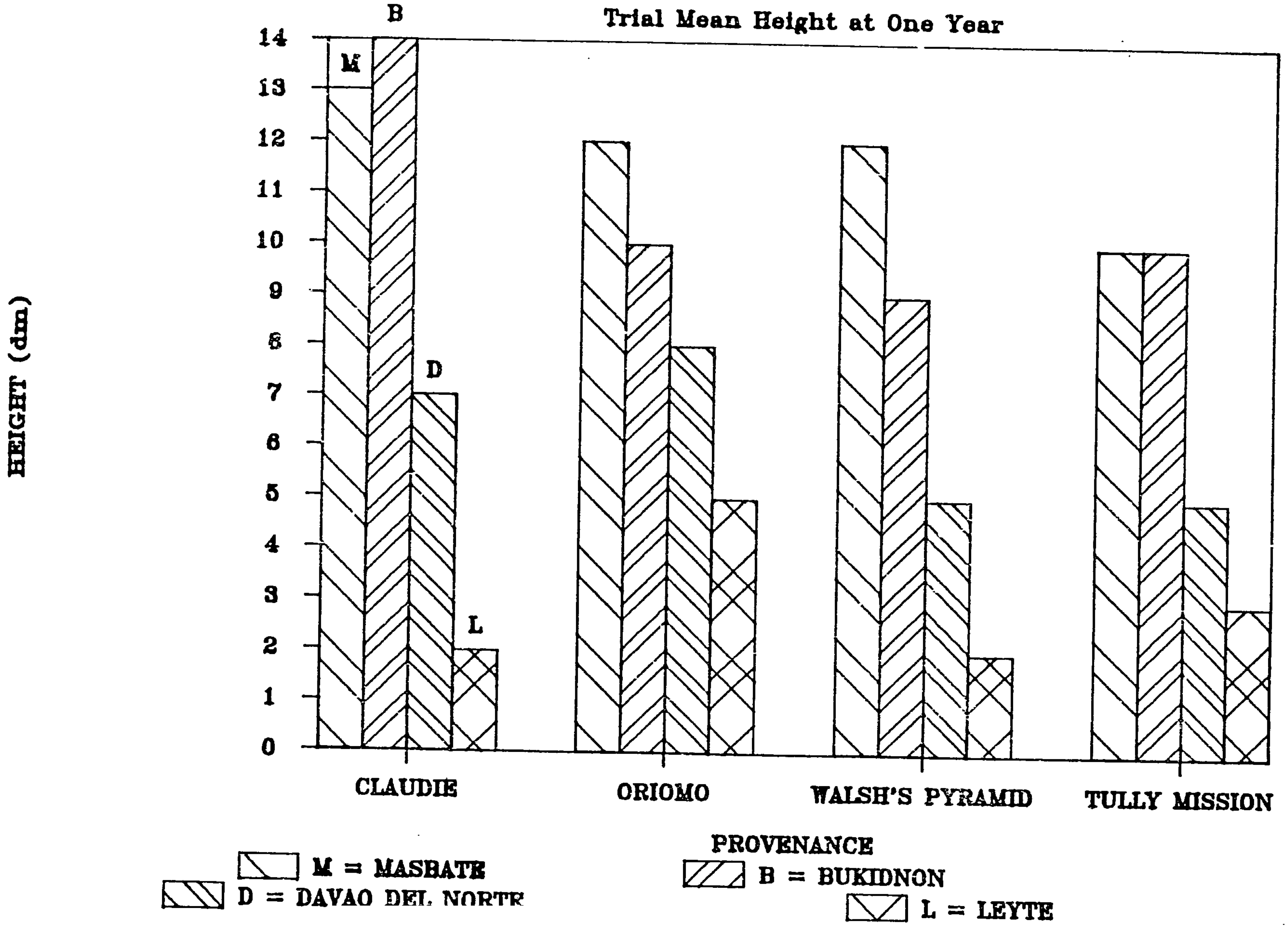
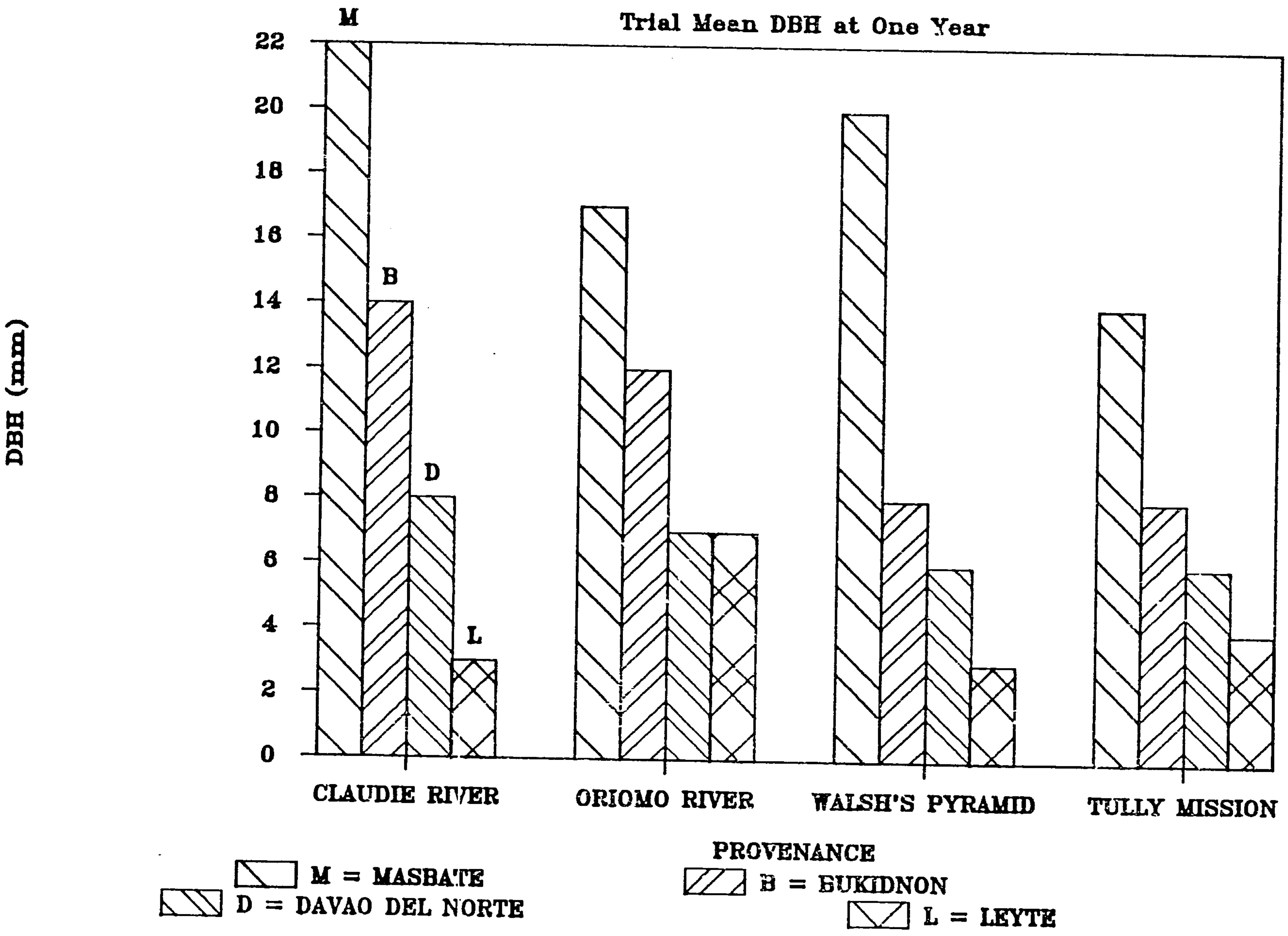


Fig. B.4 Acacia mangium Provenance



C. Manila Seedling Bank Foundation

Two plantation areas established by the Seedling Bank were sampled. La Mesa Dam plantation topography is < 100 m elevation, gently rolling; climate is monsoonal with most of about 2000 mm rainfall between May and October; soils are clay loam.

Bataan Industrial Tree Plantation is at Bagac, Bataan; elevation is 100 - 500 m elevation, slopes are gentle to very steep; an erratic rainfall distribution with a dry season of 3 - 9 months; soils are mostly heavy clay loams, many eroded.

Average tree size at La Mesa Dam is given in table C-1 and Bataan in table C-2, below. Acacia mangium is relatively larger at both locations.

TABLE C-1 : LA MESA DAM SPECIES TRIALS, mean height and diameter at breast height, 8 years.

SPECIES	HEIGHT, DM	DBH, MM
Gmelina arborea	151	161
Acacia mangium	150	154
Acacia auriculiformis	145	122
Anthocephalus chinensis	125	162
Leucaena leucocephala	113	97
Swietenia macrophylla	107	99

TABLE C-2 : BATAAN INDUSTRIAL TREE PLANTATION SPECIES TRIALS, mean height and diameter at breast height, at 6 - 7 years.

SPECIES	HEIGHT, DM	DBH, MM
Acacia mangium	120	152
Gmelina arborea	97	110
Acacia auriculiformis	97	75
Leucaena leucocephala	85	60

D. RP-Japan Reforestation Project

The RP-Japan Reforestation Project is in the Pantabangan watershed in Nueva Ecija, on rolling hills at an elevation of 250 - 300 m.; annual rainfall averaged 1800 mm; 90% falls during the May - October period, mostly leached clay loams.

The species sizes shown in table D-1 should be interpreted while considering the differences in site distribution shown in table D-2; site differences appear to be critical in the project area.

Most projects consider early shading in the nursery to be essential. A study at Carranglan, table D-3, did not show any benefit.

TABLE D-1 : RP-JAPAN SPECIES TRIALS, CARRANGLAN, mean survival, dbh, and height at 5 years.

SPECIES	SURVIVAL %	DBH, MM	HT, DM
Leucaena leucocephala	96	76	53
Casuarina equisetifolia	64	57	41
Acacia auriculiformis	52	70	35
Pinus kesiya	53	91	33
Gmelina arborea	82	72	24
Pinus caribaea	44	56	21
Eucalyptus camaldulensis	49	37	21
Pterocarpus indicus	73	40	20
Tectona grandis	83	54	8
Pinus oocarpa		64	28*
Acacia mangium	73	33	17*
Swietenia macrophylla	78	23	11*

* Age 2 years.

TABLE D-2 : RP-JAPAN SPECIES TRIALS, height by species and site at 5 hears.

TOPOGRAPHIC CLASS	II		III		IV		V	
MICROSITE	a	b	a	b	a	b	a	b
SPECIES	HEIGHT, DM							
Leucaena leucocephala	18		12	38			6	
Casuarina equisetifolia	15						12	15
Acacia auriculiformis	17		29					22
Pinus kesiya				14				10
Gmelina arborea	15	25	12					9
Eucalyptus camaldulensis			17			20	16	
Pterocarpus indicus	14		13		9			11
Swietenia macrophylla							10	12
Tectona grandis	5			12				3

Topographic classes: II - Gentle ridge III - Convex slope
IV - Concave slope V - Gentle slope

Microsite: a - Poor, mostly eroded and droughty
b - Better, mostly with topsoil, retain moisture

TABLE D-3: NURSERY SHADE EFFECTS ON OUTPLANTING SURVIVAL AT ONE MONTH.

Species	Survival %	
	Shaded	Unshaded
Gmelina arborea	98	98
Pinus kesiya	95	98
Acacia auriculiformis (4/86)	95	98
Acacia auriculiformis (3/85)	88	84
Acacia mangium	73	84
Eucalyptus camaldulensis	72	73
Means	87	89

Differences between species are significant, those between treatments are not.

E. ASEAN-New Zealand Afforestation Project

The ASEAN-New Zealand Afforestation Project was begun in Bigbiga, Mayantoc, Tarlac, in 1980. Topography is rolling to very steep, at elevations of 300 - 750 m. Climate is monsoonal, with most of the 2200 mm falling during the May - October period. Soils are sandy clay to sandy clay loams, not very fertile and often eroded.

Tables E-1 to E-7 provide considerable information on variation in growth between provenances of the same species: a great deal in some cases, E. cloeziana, for example, and less in others, E. camaldulensis as cited. The latter probably represents better seed source selection, as a good deal of provenance work has been done elsewhere on E. camaldulensis.

The ANZAP project also carried out a good deal of work on nursery and planting techniques. Some of the results are shown in tables E-8 to E-11. Perhaps most surprising is the lack of difference between planting in a hole versus in T-slits.

Although stumps of Gmelina grew and survived somewhat better than bareroot seedlings, and both grew significantly better than potted plants, ANZAP favored bareroot because they could be produced more cheaply by the methods used. Similar tests elsewhere have shown marked superiority for stump planting, but using a shorter stem and longer root. dry spell after planting also favors stumps.

Table E-1: Eucalyptus camaldulensis provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
06	29	29
05	28	26
04	26	24
03	26	24
01	26	22
02	24	19
10*	26	24

Table E-2: Eucalyptus tereticornis provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
10	26	21
07	19	14
09	18	14
08	18	10
05*	26	24

Table E-3: Eucalyptus cloeziana provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
11	14	7
15	14	7
13	13	6
12	11	5
16	8	6
05*	27	27

Table E-4: Eucalyptus urophylla provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
17	19	12
19	18	16
18	18	12
21	17	18
20	16	11
05*	24	21

Table E-5: Eucalyptus brassiana provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
24	16	10
25	14	8
26	14	8
23	13	8
22	12	7
05*	23	20

Table E-6: Gmelina arborea provenance trial, mean height and diameter at two years.

PROVENANCE	Height dm	DBH mm
07	6	15
02	6	15
06	6	14
08	6	14
04	6	13
09	6	10
03	5	12
01	5	11
05	5	10
11	4	8

Table E-7: Casuarina equisetifolia provenance trial, mean height and diameter at six (6) months, ANZAP

PROVENANCE	Height dm	DBH mm
02	94	96
10	88	97
05	83	69
09	78	72
04	75	84
01	75	56
06	67	46
08	66	62
03	58	43
07	56	36

Table E-8: Planting stock type effects for Gmelina arborea, ANZAP.

Type of Planting Stock	Growth in 24 months d,mm	h,dm	Survival %
Stump	39a	12a	97
Bararoot	37a	12a	88
Potted	16b	9b	73

Growth of stump and bareroot seedlings was significantly superior to that of potted stock, survival was also greater, but the difference was not significant.

Table E-9: Planting stock type effects for Casuarina equisetifolia, ANZAP.

Type of Planting Stock	Size at 36 Months d,mm	h,dm
Potted	18a	165
Rootrainer	15b	157
Bareroot	16b	150

Potted Casuarina grew significantly more in diameter than did rootrainer or bareroot seedlings; Height growth was also greater but not significantly so.

Table E-10: Development of Acacia mangium as affected by type of stock site, and planting system at 24 months.

Planting	Good Sites Bareroot	Good Sites Potted	Bad Sites Bareroot	Bad Sites Potted	$\bar{X}$
		h,dm			
Holes	42	47	18	17	31
T-slit	48	45	18	18	32
$\bar{X}$	45	46	18	17	
		d,mm			
Holes	50	50	24	25	37
T-slit	51	50	19	26	36
$\bar{X}$	50	50	22	25	

Growth of height and diameter were virtually equal for bareroot and potted stock for planting in holes and T-slits, on both good and poor sites. Results for Eucalyptus camaldulensis also showed has significant difference on either sites.

Table E-11: Intensity of cultivation effects on Acacia mangium, at 18 months.

Cultivation	d,mm	h,dm
Clear	21	17
Ring	16	14
None	11	11

Size of tree varied significantly with intensity of cultivation.

F. Species Ranking and Characteristics

A summary of the species ranking based on height increment is given for each location, in Table F-1.

An indication of the characteristics of the principal species is in Table F-2.

Table F-1: Species ranking by location and height*

	RANK							
	ONE		TWO		THREE		FOUR	
STUDY, TABLE, PAGE Location	SP	HT dm	SP	HT dm	SP	HT dm	SP	HT dm
HODAM, A-1, 7								
Ilocos Norte	Ga	64	Aa	56	Gs	51	Am	29
Pampanga	Aa	65	Ga	53	Gs	44	Am	42
Negros Occidental	Aa	46	Ga	37	Am	30	Gs	29
Leyte	Ga	74	Am	69	Aa	62	Ce	60
REFORESTATION, B-1, 11								
Ilocos Norte	Et	22	Am	18	Ec	15	Ce	13
Cebu	Ga	47	Sm	15	Ce	11	Eb	11
Zamboanga	Cc	52	Af	31	Am	24	Ac	23
MANILA SEEDLING BANK FOUNDATION, C-1&C-2, 18								
La Mesa Dam	Ga	151	Am	150	Aa	145	An	125
Bataan	Am	120	Ga	97	Aa	97	Ll	85
RP-JAPAN, D-1, 19								
Carranglan	Aa		Ga		Ce		Gs	
ANZAP, 2ND RPT EUCALYPTS AT ANZAP, TABLE 2**								
Tarlac,								
Height	Am	70	Et	69	Ec	64	Eb	44
Diameter, mm	Am	73	Ec	62	Et	51	Eu	36
Survival, %	Ec	99	Et	95	Am	89	Eb	80
Volume/ha, m3***	Am	15	Ec	12	Et	8	Eb	2

* Trees are of unequal age; values are comparative only within a single horizontal row.

** Values based on trials of 13 Eucalypts and A. mangium.

*** Volume/ha is nominal based on 1000 trees planted times survival percentage times volume as V = h((d squared)/2).

SPECIES CODES

Aa	Acacia auriculiformis	Ac	A. crassicarpa
Af	Acrocarpus fraxinifolius	Am	Acacia mangium
An	Anthocephalus chinensis	Cc	Calliandra calothyrsus
Ce	Casuarina equisetifolia	Eb	Eucalyptus brassiana
Ec	E. camaldulensis	Eg	E. grandis
Et	E. tereticornis	Eu	E. urophylla
Gm	Gmelina arborea	Gs	Gliricidia sepium
Ll	Leucaena leucocephala	Pm	Piliostigma malabaricum
Sm	Swietenia macrophylla		

It can be seen that Acacia auriculiformis, A. mangium, Gmelina arborea, Eucalyptus camaldulensis, and E. tereticornis are among the top rank almost everywhere they occur.

Anthocephalus chinensis, Casuarina equisetifolia, and Gliricidia sepium are near, or even in, the top rankings on at least certain sites.

Table F-2: Species characteristics

Species	Site Tol.	Weed Tol.	Coppice	Fodder	Fire Tol.	Stem Form	Industry Market
Acacia auriculiformis	Yes	Yes	Poor	No	No	Poor	No
Acacia mangium	Med	No	No	No	No	Good	Yes
Eucalyptus camaldulensis	Yes	Yes	Yes	No	Yes	Good	Med.
Eucalyptus tereticornis	Yes	Yes	Yes	No	Yes	Vary	Med.
Gmelina Arborea	Med	Yes	Yes	Yes	Yes	Vary	Yes
Anthocephalus chinensis	No	Med.	Yes	Poor	No	Yes	Yes
Casuarina equisetifolia	No	No	Poor	No	No	Yes	No
Gliricidia sepium	Med.	Yes	Yes	Yes	Med.	No	No

All the above species provide acceptable firewood and are suitable for on-farm construction.

IV. CONCLUSIONS AND OBSERVATIONS

Review of the results, as well as more detailed data in the appendices, offers no surprises but generally quantifies and confirms what was to be expected. Briefly:

A. CONCLUSIONS

1. Species and provenances vary widely in height and diameter increment, and in survival.

2. Development of a given species or provenance varies considerably between sites. Within the limits tested, distribution and reliability of rainfall appeared to have more effect than did total precipitation.

3. The species or provenance that began as the fastest-growing tended to continue as the fastest growing throughout the measurement period; however, this was not invariable. The slowest beginner never caught the fastest, but rankings did change somewhat over time. On most sites, Acacia mangium improved its ranking with age, if cultivation was continued until natural weed suppression occurred.

4. Similarly, the fastest species on one site was not necessarily fastest on all, but Acacia auriculiformis, Eucalyptus camaldulensis, and Gmelina arborea were included in the top rankings almost everywhere they occurred. Acacia mangium and Gliricidia sepium were uniformly near the top rank, and occasionally in it.

5. There was species/site interaction; Piliostigma malabaricum responded noticeably more than other species to conditions on Leyte. Several species that do well on good sites were virtual failures on most of the adverse soils of the RP-Japan Reforestation Project, Tectona grandis most notably.

6. On truly adverse sites, such as those mentioned directly above, no species tested showed really satisfactory development.

7. Fire is an annual threat throughout the area studied, particularly where tall grasses are abundant, and may be the critical determinant in species selection. Although the data available are not adequate for quantitative analysis, it is apparent that Eucalyptus camaldulensis, Gmelina arborea, and Tectona grandis recover well from fire damage when compared to Acacia auriculiformis, A. mangium, Casuarina equisetifolia, and Swietenia macrophylla.

8. Seedlings not shaded in the nursery survived and grew slightly better in the field than those shaded, although the difference was not statistically significant.

9. Some species, Acacia mangium and Gmelina arborea in particular, survived and grew better in the field if produced as barerooted nursery stock than if potted. Stumps of melina were slightly, but non-significantly, superior to barerooted under the conditions tested.

B. OBSERVATIONS

1. During the field trips we had occasion to visit a number of seed production areas, both in trials and projects providing data, and in nearby areas; several of them have been used to supply seed to ongoing plantation programs.

There was no evidence observed that the poorly-formed and low-vigor trees had been removed to guarantee only well-formed and vigorous trees will provide seed for future plantations. Such stand improvement is a cheap, as well as essential, part of providing improved seed.

Beyond simple thinning to favor the better stems, another desirable program is to select the very best existing trees, at an intensity of at least the one best individual in 1000 trees; some organizations select the best in 1 000 000. Form of Acacia auriculiformis and Gmelina arborea, and coppicing capacity of A. auriculiformis and A. mangium are characteristics of obvious importance is they are to be included in continuing planting programs.

Progeny tests can then determine which mother trees produce superior offspring. This should be a permanent program, just as genetic improvement of rice or any other crop is permanent; therefore a) it should be started as soon as possible, b) it should begin on a small scale and c) provision must be made to continue the program indefinitely, preferably incorporated into other continuing programs.

2. In the RP-Japan reforestation project at Carranglan, there is abundant evidence of wide variation in site quality within existing plantations, and of accompanying species/site interaction. This offers an unusual opportunity for a research team of forester and soils specialist to establish forest measurement plots for determining site indices and biomass production, then relating the results to soil and topographic characteristics as a guide for future tree planting and management.

Pending the results of such a study, it seems probable that topsoil is still in position on lower slopes and has not yet eroded away from upper slopes immediately below remaining forest. Such locations are worth trying as priority planting sites.

3. Species trials yield much more usable information if all species are planted at all locations in randomized complete blocks (RCB). If planting stock of one or more species or provenances is in short supply, smaller-than-normal plots in at least two RCBs at every location are far more informative than normal plots at a few locations or in only one block at all locations.

4. Capacity of Acacia auriculiformis and A. mangium to coppice is clearly related to height of stump and season when cut. Research studies are needed to define and quantify the exact relationships.

5. More data almost certainly exist. The Swedish Match Co. is reported to have selected Piliostigma malabaricum as a preferred species, which must have involved a series of species trials. Similarly, PICOP has done considerable work with Albizia falcataria. Universities and other government departments may also be expected to have relevant data still unpublished.

6. The F/FRED computerization system is very user-friendly. It's use for data management should facilitate effective and accurate analysis and use of research measurements.

7. Observations and analyses throughout the consultancy showed no "miracle" tree for all sites and all purposes. Giant Ipil-ipil, which has often been called a miracle tree in the popular press, has recently suffered widespread attacks by psyllid insects, and also had a quite limited range of sites on which good form and high vigor were actually attained.

All known tree species are currently subject to insect and disease problems, one or more of which may become serious sometime in the future. The data reviewed during this consultancy indicate the general high vigor of Acacia auriculiformis, and seed is now readily available. However, it normally has poor form, there are sites where it, too, does not grow well, and it has a number of other actual and potential limitations.

Briefly, any hope of a single answer applicable to all conditions appears illusory. Agroforestry and forestry practitioners must continue to match species with site, practice sound silviculture, and pay constant attention to the objectives of management.

APPENDICES

APPENDIX A

Species Trials and Seed Orchard Development Project

Species trials and seed production areas were established at Solsona, Ilocos Norte and Porac, Pampanga, Babatngon, Leyte, and Murcia, Negros Occidental. Site information from Project reports:

Porac, Pampanga; Floridablanca Tree Farm

Topography: elevation 100 - 600m; steep slopes with nearly flat - rolling uplands; 15degr3'N latitude and 120degr 25'E longitude.

Climate: Typhoon, with 89% of the 1906 mm of rain during the May - October wet season; temperature range 26 - 36, with an average of 27.5 C.

Soil: Soils principally Bolinao clay loam with more sand than normal; fairly deep with 10 - 15 cm of A-horizon; slopes rocky.

Murcia, Negros Occidental; Ceneco Plantation

Topography: 300 - 1100m; rolling to steep, rocky; 10degr32' N and 123degr10' E.

Climate: Rainfall 1800 mm/year, fairly well distributed, with least in February to April and most rain October to December.

Soils: Most soils are Guimbalon clay loam from fine igneous parent rock; rocks and boulders common.

Average growth varies between sites, and --of course-- between species. There is a species/site interaction observable. Piliostigma malabaricum, especially, is noticeably more vigorous in Leyte than in the more seasonal climates.

Summary of HGDAM Species Trials (Height) by Species, Age and Site

Species	Age mons.	LEYTE	NEGROS	PAMPANGA	ILOCOS	$\bar{x}$
		decimeter				
1. Ga Gmelina arborea	6	29	5	7	10	13
	12	47	15	13	20	24
	18	61	22	26	29	35
	24	67	29	34	43	43
	30	68	35	48	57	52
	36	(74) **	37	53	64	57
	42		(46) *			
2. Aa Acacia auriculiformis	6	18	5	14	12	12
	12	32	14	23	23	23
	18	46	22	43	31	36
	24	53	36	50	35	44
	30	56	42	60	50	52
	36	(62)	46	65	56	57
	42		(56)			
3. Am Acacia mangium	6	12	3	7	8	8
	12	26	7	10	10	13
	18	41	10	16	11	20
	24	52	20	24	15	28
	30	56	28	34	22	35
	36	(69)	(38)	42	29	43
	42					
4. Gs Gliricidia sepium	6	18	4	5	8	9
	12	31	11	12	20	19
	18	34	19	32	30	29
	24	39	26	34	34	33
	30	40	29	42	44	39
	36	(43)	29	44	51	42
	42		(32)			
5. Al Albizia lebbeccides	6	10	2	3		5
	12	27	4	5		12
	18	33	6	6		15
	24	39	9	8		19
	30	43	10	10		21
	36	(56)	12	14		27
	42		(14)			
6. Ap Alb[illegible] [illegible]	6	6	2	[illegible]		3
	12	20	4	[illegible]		9
	18	21	5	[illegible]		10
	24	25	8	[illegible]		13
	30	24	[illegible]	[illegible]		14
	36	(30)	5	[illegible]		17
	42		[illegible]			

* 42-month measure included in regression, but not in site mean
** Leyte 36-month is calculated value, not measured.

	Age mons.	LEYTE	NEGROS	PAMPANGA	ILOCOS
		decimeter			
7. Ll Leucaena leucocephala	6	12			
	12	27			
	18	36			
	24	46			
	30	50			
	36	(60)			
	42				
8. Pm Piliostigma malabaricum	6	16	4		10
	12	28	9		19
	18	35	16		26
	24	41	23		32
	30	45	24		35
	36	(47)	25		36
	42		(29)		
9. Ak Albizia lebbeck	6	10		3	7
	12	21		4	13
	18	29		6	18
	24	34		10	22
	30	36		15	24
	36	(48)		20	34
	42				
10. Ce Casuarina equisetifolia	6	18			
	12	29			
	18	42			
	24	48			
	30	54			
	36	(60)			
	42				
11. Cs Cassia spectablis	6	21	4		13
	12	33	14		24
	18	40	21		31
	24	44	22		33
	30	42	24		35
	36	(34)	20		37
	42		(21)		

Analysis of Variance for HODAM Species Trials (Height) by Species

	Source	Ss	dF	MS		F	F95	F99
1. Aa SD = 3.45	Treat	5951.00	5	1190.00	HS	100.00	2.90	4.56
	Site	1096.00	3	366.00	HS	30.76	3.29	5.42
	Residual	179.00	15	11.90				
	R^2 = 0.92							
2. Am SD = 6.13	Treat	3498.00	5	700.00	HS	18.67		
	Site	3882.00	3	965.00	HS	25.73		
	Residual	383.00	15	37.50				
	R^2 = 0.92							
3. Ga SD = 5.05	Treat	5735.00	5	1147.00	HS	44.98		
	Site	3882.00	3	1294.00	HS	50.75		
	Residual	383.00	15	25.50				
	R^2 = 0.96							
4. Gs SD = 4.38	Treat	3172.00	5	634.00	HS	33.06		
	Site	703.00	3	234.00	HS	12.20		
	Residual	286.00	15	19.18				
	R^2 = 0.93							
5. Al SD = 6.82	Treat	891.00	5	178.00	S	3.77	3.33	5.68
	Site	2971.00	2	1486.00	HS	31.48	4.16	7.56
	Residual	472.00	10	47.20				
	R^2 = 0.89							
6. Ap SD = 3.39	Treat	329.00	5	63.80	HS	5.72		
	Site	911.00	2	45.50	HS	39.60		
	Residual	115.00	10	11.50				
	R^2 = 0.92							
7. Ak SD = 5.18	Treat	949.00	5	190.00	S	7.10	5.65	10.97
	Site	1200.00	1	1200.00	HS	45.00	6.61	16.26
	Residual	134.00	5	26.80				
	R^2 = 0.94							
8. Cs SD = 1.87	Treat	611.00	5	122.00	S	7.00		
	Site	990.00	1	990.00	HS	57.00		
	Residual	17.42	5	17.42				
	R^2 = [illegible].99							
[illegible]. Pm SD = 2.48	Treat	1041.00	5	208.00	[illegible]S	34.[illegible]		
	Site	1029.00	[illegible]	1027.00	HS	1[illegible]7.[illegible]		
	Residual	30.75	[illegible]	6.[illegible]				

Summary of HODAM Species Trials (DBH) by Species, Age and Site

Species	Age mons.	LEYTE	NEGROS millimeter	PAMPANGA	ILOCOS
1. Ga Gmelina arborea	6	34			
	12				
	18	41			
	24	44			
	30	43			37
	36	(46)			
	42			46	
2. Aa Acacia auriculiformis	6	23			
	12				
	18	30			
	24	32			
	30	108			38
	36				
	42			48	
3. Am Acacia mangium	6	20			
	12				
	18	30			
	24	35			
	30	120			30
	36				
	42			53	
4. Gs Gliricidia sepium	6	19			
	12				
	18	20			
	24	24			
	30	26			
	36	79			26
	42			59	
5. Al Albizia lebbecoides	6	16			
	12				
	18	24			
	24	26			
	30	92			
	36				
	42			12	
6. Ap Albizia procera	6	19			
	12				
	18	20			
	24	23			
	30	80			
	36				
	42			15	

			Age mons.	LEYTE	NEGROS millimeter	PAMPANGA	ILOCOS
7.	Ll	Leucaena leucocephala	6	16			
			12				
			18	20			
			24	24			
			30	80			
			36				
			42				
8.	Pm	Piliostigma malabaricum	6	25			
			12				
			18	32			
			24	39			
			30	134			
			36				
			42				
9.	Ak	Albizia lebbeck	6	20			
			12				
			18	24			
			24	26			
			30	91			
			36				
			42			25	
10.	Ce	Casuarina equisetifolia	6	19			
			12				
			18	21			
			24	26			
			30	97			
			36				
			42				
11.	Cs	Cassia spectablis	6	19			
			12				
			18	21			
			24	24			
			30	79			
			36				
			42				

APPENDIX B

Reforestation Division, FMB

Field plantings of the Site Classification and Species Suitability Study were established at Carasi, Ilocos Norte, Argao, Cebu, and Baluno, Zamboanga. The following information is abstracted from the study plan.

REGION I, ILOCOS NORTE, PI; Carasi Reforestation Project

Topography: Strongly rolling; 30-40% slope; 100-400m.

Climate: Type 1, with two pronounced seasons, dry Nov - Apr and wet May - Oct. Rainfall averages 2060 mm; Temperature averages 26degr C.

Soils: Good to excessive external & good internal drainage; pH 4.9-6.1; Cervantes clay loam from igneous rock; low fertility.

Vegetative cover: Cogonal & 2nd growth forest.

REGION VII, CEBU, Argao Reforestation Project

Topography: Rolling to mountainous, 40-50% slope; 100-1000m.

Climate: Type 3 without pronounced seasons; relatively dry Nov - Apr. Rainfall varies from 1317 - 3518 mm, av 2130 mm; Temperature is uniformly high.

Soils: Good to excessive drainage; pH 4.7-7.7; Mantalongon clay loam & Faraon clay loam, from metamorphic rocks; low fertility.

Vegetative cover: 3/4 open grassland & 1/4 2nd growth forest.

REGION IX, BALUNO, ZAMBOANGA Reforestation Project

Topography: Rolling to mountainous, 15-40% slope: 600-800m.

Climate: Type 3, relatively dry Nov - Apr. Rainfall minimum is 516 mm: maximum 2800 mm. Temperature averages 26 - 28degr C.

Soils: Good to excessive drainage; pH 5-6; residual Paete clay loam from igneous rocks: exposed basaltic boulders and outcrops; Luisiana clay loam.

Vegetative cover: Cultivated and logged over areas.

Representative growth of species and provenances is shown in the following tables.

TABLE B-5 : AVERAGE HEIGHT (DM) OF DIFFERENT TREE SPECIES PLANTED IN BALUNO, ZAMBOANGA CITY

TREATMENTS	SITES 1	2	3	TOTAL	$\bar{X}$
1 . Calliandra calothyrsus	474	247	555	1,276	425
2 . Eucalyptus urophylla	207	205	286	698	233
3 . Gmelina arborea	172	169	309	650	217
4 . Eucalyptus camaldulensis	201	178	260	639	213
5 . Acacia crassicarpa	198	198	241	637	212
6 . Acacia mangium	201	168	173	542	181
7 . Eucalyptus deglupta	224	73	165	462	154
8 . Anthocephalus fraxinifolius	196	72	170	438	146
9 . Dalbergia sissoo	137	61	137	335	112
10 . Pterocarpus indicus	110	88	134	332	111
11 . Swietenia macrophylla	92	72	107	271	90
12 . Pinus kesiya	23	13	19	55	18
TOTAL	2,233	1,544	2,556	6,333	2,112
$\bar{X}$	186	129	213	528	176

TABLE B-6 : ANALYSIS OF VARIANCE OF DIFFERENT TREE SPECIES AS SHOWN IN TABLE B-5

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	F-.05
Site	49,452	2	24,726	10.02	3.44
Species	168,261	11	15,296	6.20	2.26
Residual	54,028	22	2,456		
Total	271,741	35			

* R^2 = 0.83

TABLE B-7 : AVERAGE DIAMETER (MM) OF DIFFERENT TREE SPECIES PLANTED IN BALUNO, ZAMBOANGA CITY

TREATMENTS	SITES 1	2	3	TOTAL	$\bar{X}$
1. Calliandra calothyrsus	68	37	51	156	52
2. Gmelina arborea	39	46	57	142	47
3. Anthocephalus fraxinifolius	35	16	43	94	31
4. Acacia mangium	25	27	19	71	24
5. Acacia crassicarpa	17	25	26	68	23
6. Swietenia macrophylla	20	15	24	59	20
7. Eucalyptus deglupta	26	10	18	54	18
8. Eucalyptus urophylla	15	17	19	51	17
9. Eucalyptus camaldulensis	14	16	17	47	16
10. Pterocarpus indicus	12	12	15	39	13
11. Dalbergia sisso	11	9	11	31	10
12. Pinus kesiya	3	4	4	11	4
TOTAL	285	234	304	823	274
$\bar{X}$	24	20	25	69	23

TABLE B-8 : ANALYSIS OF VARIANCE OF DIFFERENT TREE SPECIES AS SHOWSN IN TABLE B-7

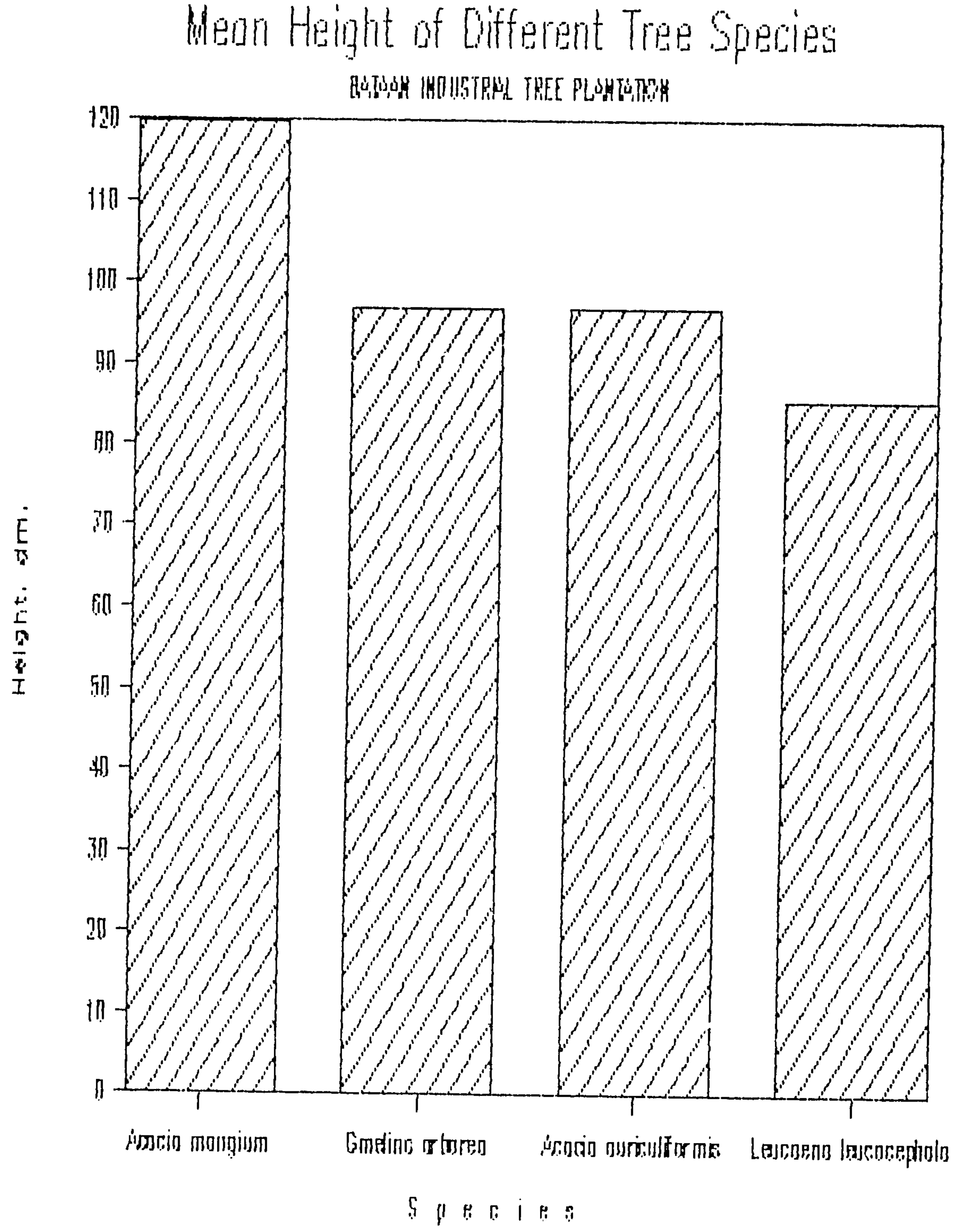
Source	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	F-95
Site	275	2	138	2.94	3.44
Species	6,774	11	616	13.15	1.26
Residual	1,030	22	47		
Total	8,079	35			

APPENDIX C

Manila Seedling Bank Foundation

Two plantation areas established by the Seedling Bank were sampled. La Mesa Dam plantation is just outside Manila; topography is < 100 m elevation, gently rolling; climate is monsoonal with most of about 2000 mm rainfall between May and October; soils are clay loam, waterlogged much of the year in some low areas; some gravel and sand but few surface stones.

Bataan Industrial Tree Plantation is by the seacoast at Bagac, Bataan; elevation is 100 - 500 m elevation slopes are gentle to very steep; climate is quite seasonal, with an erratic rainfall distribution and a dry season of 3 - 9 months; soils are lateritic, pH < 4, mostly heavy clay loams, many eroded; fertilization with a mixture of 16-20-0 and 14-14-14 was standard procedure at planting and for a year or so afterward . There has been substantial fire and wind damage


Mean Height of Different Tree Species
BATAAN INDUSTRIAL TREE PLANTATION
Height, dm.
0
10
20
30
40
50
60
70
80
90
100
110
120
Acacia mangium
Gmelina arborea
Acacia auriculiformis
Leucaena leucocephala
Species

Meon DBH of Different Tree Species

LA MESA DAM PLANTATION

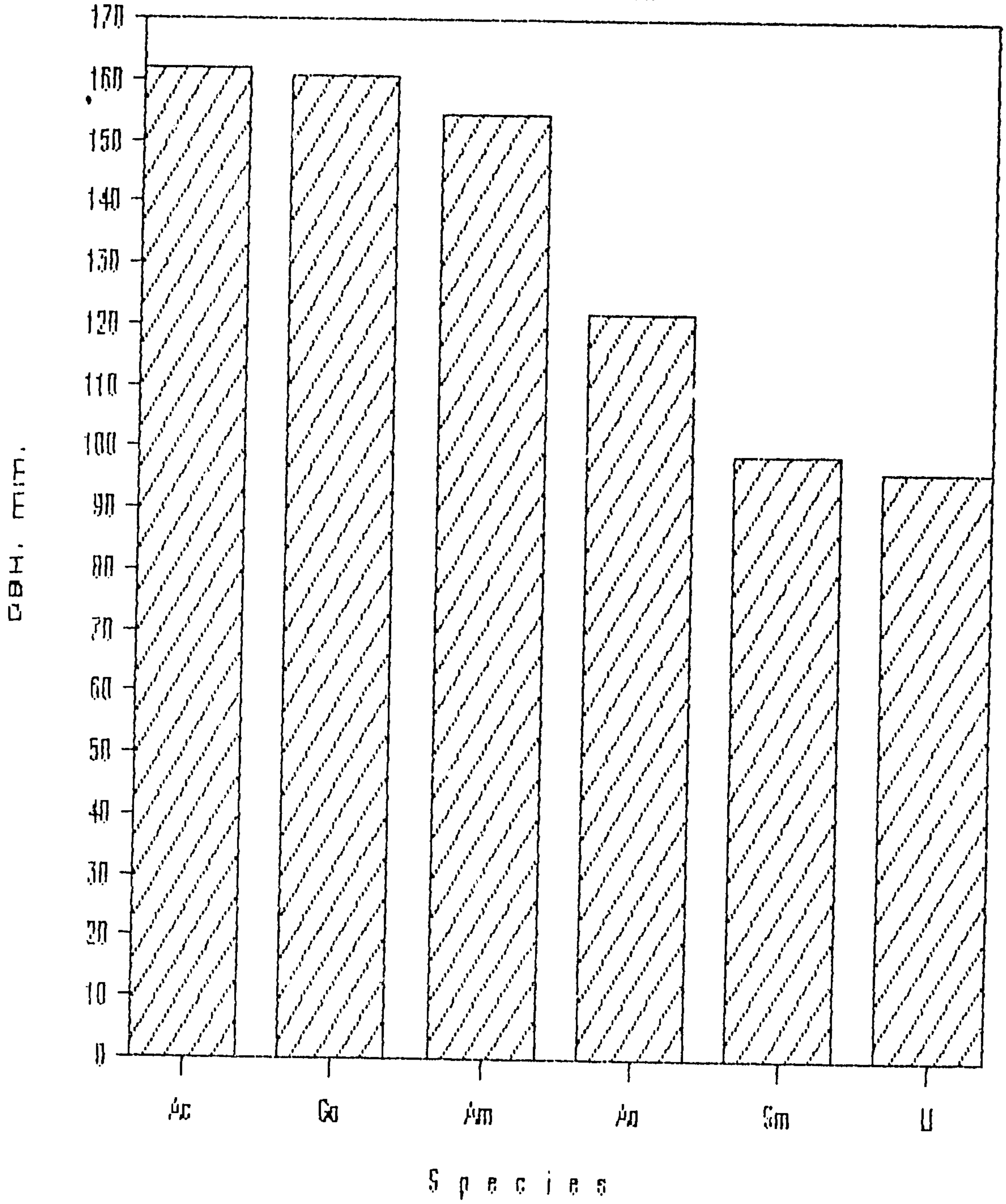


Table C-3: Mean Diameter Breast Height (DBH) of Different Tree Species planted at LA MESA DAM PLANTATION

SPECIES	I	II	III	IV	TOTAL	$\bar{X}$
Anthocephalus chinensis	14.8	17.2	18.7	14.1	64.8	16.2
Gmelina arborea	16.9	15.3	15.1	17.0	64.3	16.1
Acacia mangium	16.2	15.1	15.0	15.5	61.8	15.5
Acacia auriculiformis	9.8	11.2	14.5	13.2	48.7	12.2
Swietenia macrophylla	11.0	10.5	9.9	8.2	39.6	9.9
Leucaena leucocephala	12.5	6.3	13.4	6.4	38.6	9.7

SD = 20.58

Source	Sum of Squares SS	Degrees of Freedom df	Mean of Squares MS	F Value
Species	18,744.00	5	3,748.87	0.0004
Replication	1,575.17	3	525.06	0.3289
Residual	6,332.33	15	422.16	
R	0.7624			

Table C-4: Mean Height (Ht.) of Different Tree Species planted at LA MESA DAM PLANTATION

SPECIES	I	II	III	IV	TOTAL	$\bar{X}$
Gmelina arborea	14	15.7	15	15.7	60.4	15.1
Acacia mangium	12.7	15.7	16.3	15.3	60.0	15.0
Acacia auriculiformis	13.3	14.3	15.7	14.7	58.0	14.5
Anthocephalus chinensis	12	11.7	12.7	13.7	50.1	12.5
Leucaena leucocephala	11.3	12	13.7	8.3	45.3	11.3
Swietenia macrophylla	12	10.3	10.7	9.7	42.7	10.7

SD = 13.12

Source	Sum of Squares SS	Degrees of Freedom df	Mean of Squares MS	F Value
Species	7,554.37	5	1,510.88	0.0005
Replication	711.46	3	237.15	0.1376
Residual	2,580.80	15	172.05	
R	0.7621			

Table C-5 Mean Diameter Breast Height (DBH) in cm. of Different Tree Species planted at
BATAAN INDUSTRIAL TREE PLANTATION

SPECIES	BLOCKS 1	2	3	4	TOTAL	$\bar{X}$
Acacia mangium	17.9	15.6	17.2	9.7	60.4	15.1
Gmelina arborea	11.2	12.4	11.1	10.1	44.8	11.2
Acacia auriculiformis	7.4	8.2	7.3	7.9	30.8	7.7
Leucaena leucocephala	5.8	6.3	6.4	5.9	24.4	6.1
Total	42.3	42.5	42	33.6		
Grand Total					160.4	
Grand Mean						10

Table C-6 Analysis of Variance (ANOVA) of the Different Tree Species as show in Table

Source of Variation	Df	SS	MS	F	Tabular F 5%	1%
Blocks	3	14.1	4.7	1.38	3.86	6.99
Species	3	191.8	63.9	18.79	3.86	6.99
Error	9	31.0	3.4			
Total	15	236.9				

APPENDIX D

RP-Japan Reforestation Project

The RP-Japan Reforestation Project is in the Pantabangan watershed in northern Ecija, latitude 15degr57'N and longitude 121degr4'E, at an elevation of 250 - 300 m. Minimum monthly temperature is lowest in January, 20.2degr; maximum monthly temperature is highest in May, 33.2degr. The area lies in the rainshadow of the Sierra Madres from the northeast trade winds; annual rainfall averaged 1800 mm, but has varied from 950 - 2660 mm during the life of the project; 90% falls during the May - October period, while Dec - March are virtually rainless.

The project covers rolling hills and low mountains. Soils are quite variable, mostly leached clay loams with varying amounts of sand and pockets of laterite nodules. Topsoils are mostly thin or absent. The original vegetation was mixed Dipterocarp forest, of which few remnants occur in the project area; present vegetation is primarily *Imperata cylindrica*, *Saccharum spontaneum* and *Themeda triandra*, with scattered *Piliostigma malabaricum*, *Vitex parviflora*, and other fire resistant bushes and trees.

APPENDIX E

ASEAN-New Zealand Afforestation Project

The ASEAN-New Zealand Afforestation Project was begun in Bigbiga, Mayantoc, Tarlac, in 1980. Topography is rolling to very steep, at elevations of 300 - 750 m. Climate is monsoonal, with most of the 2200 mm falling during the May - October period. Temperatures average 28degr, but reach as high as 35. Soils are sandy clay to sandy clay loams, not very fertile and often eroded. Tall grasses dominate the area, and fires are frequent where not carefully controlled.

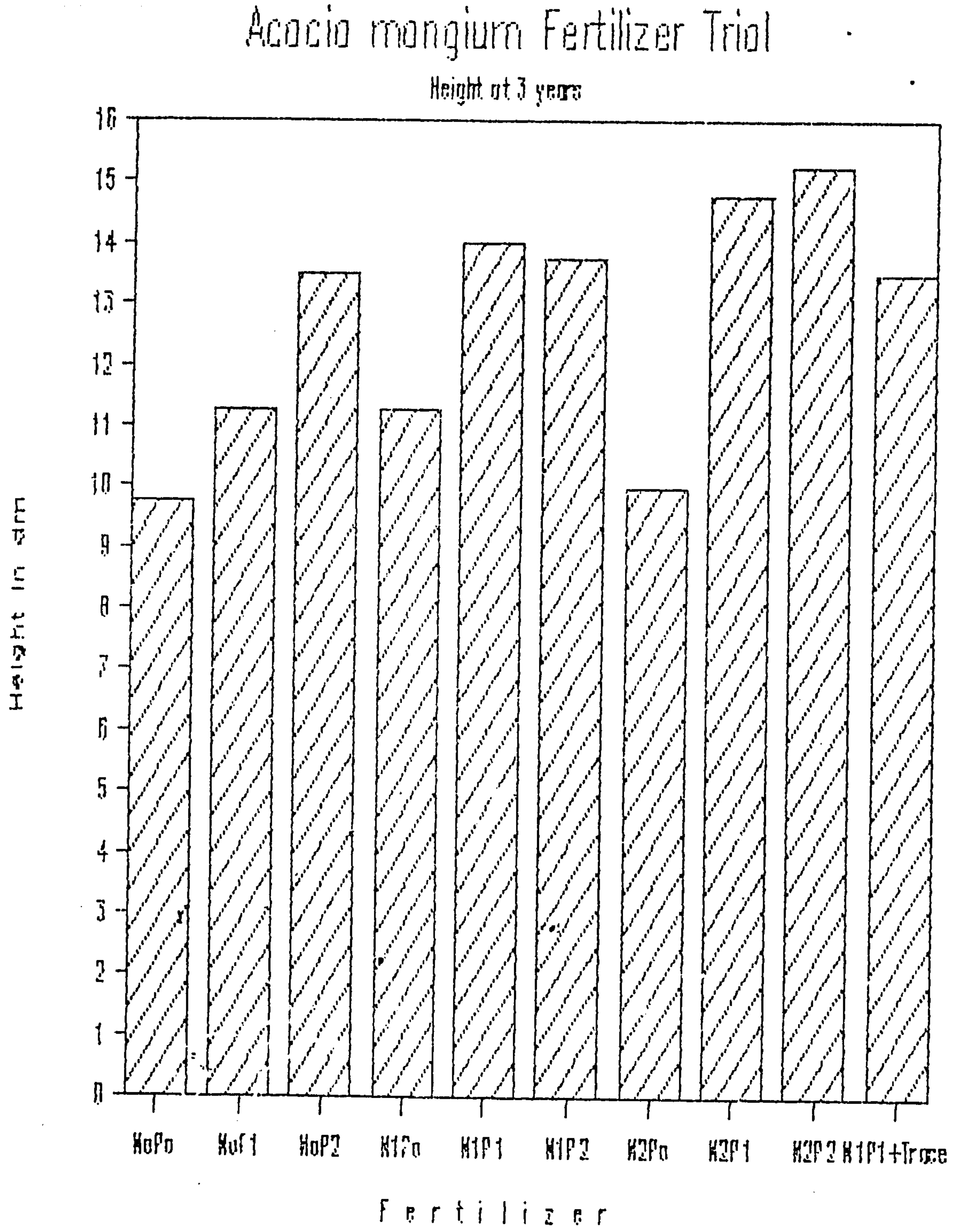
Table E-12: Acacia mangium fertilizer trial, mean height in dm at three years

Treatment	1984	1985	1986	1987	$\bar{X}$
NoPo	6	7	11	15	9.75
NoP1	5	7	13	20	11.25
NoP2	6	8	15	25	13.50
N1Po	6	7	14	18	11.25
N1P1	6	9	16	25	14.00
N1P2	6	9	16	24	13.75
N2Po	5	7	12	16	10.00
N2P1	6	10	17	26	14.75
N2P2	6	10	18	27	15.25
N1P1+Trace	5	9	17	23	13.50

Table E-13: Acacia mangium fertilizer trial,mean diameter at breast height in mm. at three years

Treatment	1984	1985	1986	1987	$\bar{X}$
NoPo	6	6	17	19	12.00
NoP1	5	7	20	25	14.25
NoP2	5	8	24	30	16.75
N1Po	5	7	19	24	13.75
N1P1	5	8	25	30	17.00
N1P2	5	8	24	28	16.25
N2Po	5	7	20	22	13.50
N2P1	5	10	28	31	18.50
N2P2	5	10	28	33	19.00
N1P1+Trace	5	8	26	29	17.00

Figure E - 12



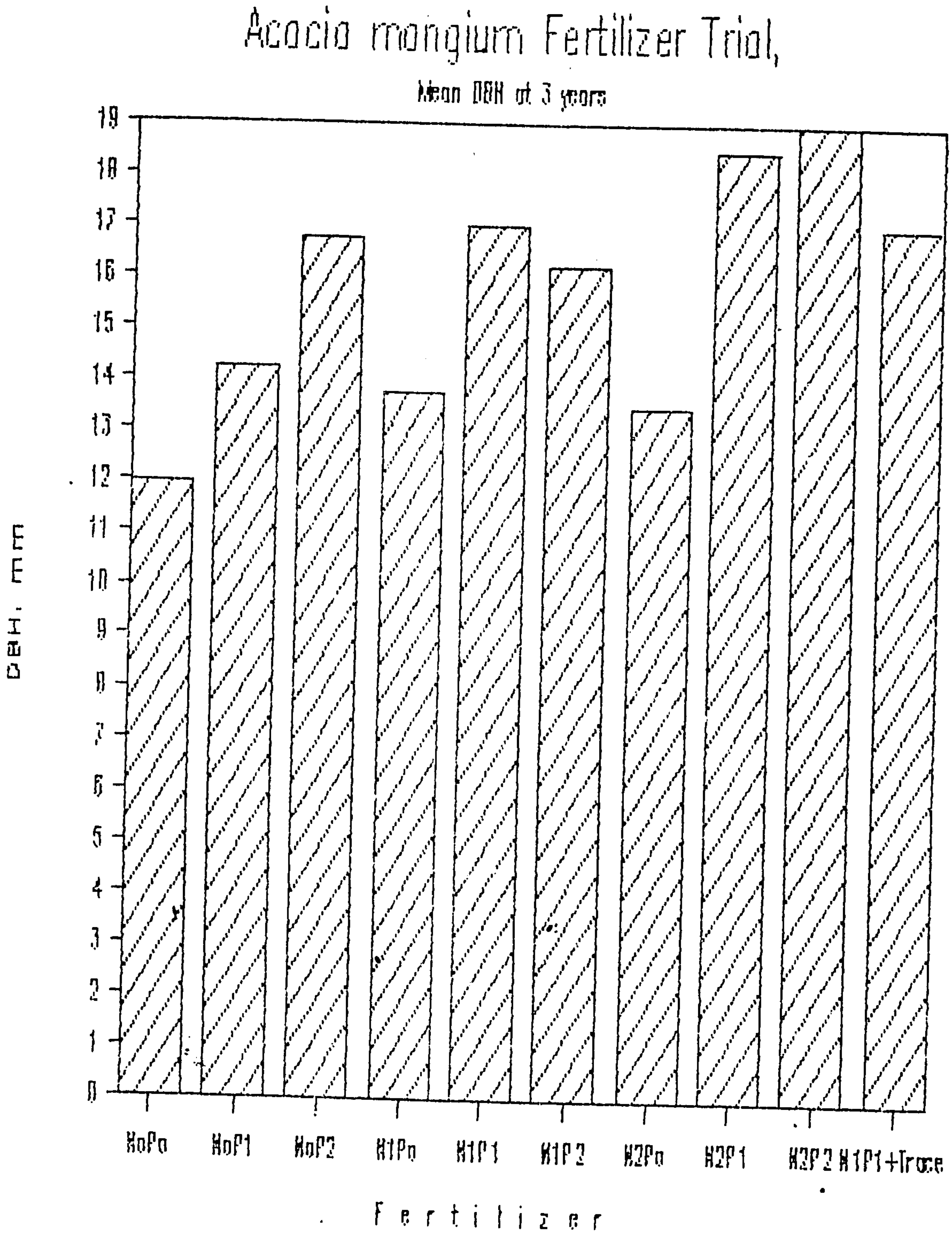
Legend :

N - Nitrogen

P - Phosphorus

0 - Control
1 - 15 grams
2 - 30 grams

Figure E - 13



Legend :

N - Nitrogen

P - Phosphorus

0 - Control
1 - 15 grams
2 - 30 grams

Table E-14: Gmelina arborea fertilizer trial, mean height and diameter at two years

Treatment		Height in dm		Diameter Breast Height	
		Weeds cut	WC + Cult	Weeds cut	WC + Cult
B1	NoPo	6	13	16	32
B2	NoP1	6	11	15	33
B3	NoP2	6	11	15	28
B4	N1Po	7	15	16	44
B5	N1P1	6	14	16	40
B6	N1P2	9	14	26	42
B7	N2Po	9	12	20	36
B8	N2P1	8	13	21	41
B9	N2P2	7	13	17	38
B10	N1P1+Trace	6	14	15	41
B11	N1P1+Boron	5	14	16	39

N1 = 15 g. P1 = 15 g.
N2 = 30 g. P2 = 30 g.

PROVENANCES USED BY ANZAP AND REFORESTATION DIVISION

A. REFORESTATION DIVISION

1. Acacia mangium
   13229 - Claudie River, Qld., Australia
   13230 - Mission Beach, Qld., Austr.
   13231 - NW of Silkwood, Qld., Austr.
   13232 - Cowley Beach Reach Read, Qld., Austr.
   13233 - Walsh's Pyramid, Qld., Austr.
   13234 - Trinity Inlet, Qld., Austr.
   13235 - Mourilyn Bay, Qld., Austr.
   13236 - Kurrimine, Qld., Austr.
   13237 - El Arish, Qld., Austr.
   13238 - Tilly Mission Beach Road, Qld., Austr.
   13239 - Syndicate Road Tully, Qld., Austr.
   13240 - Ellenbeck Road Cardwell, Qld., Austr.
   13241 - Broken Pole Creek, Qld., Austr.
   13242 - Abergowrie SF, Qld., Austr.
   13460 - Oriomo River, PNG
   13621 - Piru, Ceram, Indonesia
   13622 - Sidei, Indonesia
   13446 - 7 km SSE of Mossman, Qld., Austr.

B. ASEAN-NEW ZEALAND AFFORESTATION PROJECT

1. Eucalyptus camaldulensis
   06 - Ord River, W. Austr
   05 - Katherine, N. Territory, Austr.
   04 - Emu Creek, Petford, Qld., Austr.
   03 - Gibb River, Kimberly, W. Austr.
   01 - Irvine Bank, Qld., Austr.
   10 - Kennedy River, Qld., Austr.
   02 - Agnew, W. Austr.

2. Eucalyptus tereticornis
   07 - Holmes Creek, Qld., Austr.
   08 - East of Kupiano, PNG
   09 - Sirinum, Sogeri, PNG
   10 - Kennedy River, Qld., Austr.
   05 - Katherine, N. Terr., Austr.

3. Eucalyptus cloeziana
   15 - Carwell, North Qld., Austr.
   12 - West of Macky, Qld., Austr.
   13 - Fairview Station, Qld., Austr.
   11 - Veteran, N.E. Gympie, Qld., Austr.
   16 - Helenvale, Qld., Austr.
   05 - Kennedy River, N. Austr.

4. Eucalyptus urophylla
   - 17 - Mt. Mandini, Indonesia
   - 18 - Mt. Levo-obi, Indonesia
   - 19 - Mt. Woko Flores Is., Ind.
   - 20 - Mt. boleng, Ind.
   - 21 - Mt. Egon, Ind.
   - 05 - Katherine, N. Terr. Austr.

5. Eucalyptus brassiana
   - 22 - West of Morehead, PNG
   - 23 - Wori to Wipin, PNG
   - 24 - Musgrave Station, Qld., Austr.
   - 25 - Weipa, N. Qld., Austr.
   - 26 - W.E. Banaga, Qld., Austr.
   - 05 - Katherine, N. Terr., Austr.

6. Gmelina arborea
   - 01 - Bintang Huan Forest Reserve, Kuala Lumpur
   - 02 - Gumgum Trial, Sabah, Malaysia
   - 03 - NALCO, Phil.
   - 04 - NALCO, Phil.
   - 05 - Bay Lauang Chieng Mai Prov., Thailand
   - 06 - Pong Namron, Chantaburi, Thailand
   - 07 - Lang Sang Tek Prov., Thailand
   - 08 - Muak Lek Sarabuin, Thailand
   - 09 - Tong Pha Room Kanchanabun Prov., Thailand
   - 11 - Mon Bitter Espiritu Santo

7. Casuarina equisetifolia
   - 01 - NNW Emu Park, Qld., Austr.
   - 02 - NE of Mackay, Qld., Austr.
   - 03 - Maroochydone, Qld., Austr.
   - 04 - Songkala Prov., Thailand
   - 05 - Fujian Prov., China
   - 06 - NW Rolling Stone, Qld., Austr.
   - 07 - Hainan Island, China
   - 08 - Wangeth Beach, Qld., Austr.
   - 09 - Kayong Prov., Thailand
   - 10 - Mayantoc, Tarlac, Phil.

APPENDIX F

ON-FARM RESEARCH METHODS

On-farm research, or research carried out primarily by the private forest land owner, must follow the same rules as professional research; the only difference is that the research is carried out by the landowner, or his employee, to provide the specific information wanted by the farmer himself, to improve production on his own land.

There are three aspects of forestry research to be considered: Research Design, Field Techniques, and Species Selection. They will be discussed in turn.

Research Design

Useful research follows universal guidelines.

1. KEEP TREATMENTS SIMPLE: To study the effects on growth of (a) size of seedling, (b) intensity of cleaning, and (c) level of fertilization, make three separate studies. If the cattle get into one, you only lose one test instead of three. And during the time trees are growing up, it's amazing how many things can happen.

2. RANDOMLY ASSIGN EACH TREATMENT TO ONE PLOT IN EACH BLOCK: Try to lay out a block big enough for all the treatments with as little variation as possible within the block. On a flat, make the block square; on a slope, make the block long along the contour and short up-and-down hill; in a hedgerow study, a block will probably be a series of plots one tree wide and strung out along one contour row. If some soil is sandy and some is not, put some blocks completely on sandy soil and other blocks not at all on sandy soil.

After the plots are laid out in a block, assign the treatments (species, cleaning, whatever) using random numbers, rolling dice, flipping coins. Never, never, NEVER deliberately put the fast-growing species on the good soil during research, because when the study is completed you won't know if the species really is fast-growing, or just seems to be because of the good soil.

3. REPLICATE: use at least two blocks for each condition; two on sand, two on clay, two on the ridge, two on the slope, etc.; if possible, use four blocks for each condition. If you are short of trees, time, or land, four small blocks give more information than two big ones.

Always try to use at least four classes: four diameter classes, four species, four levels of fertilization; four is more efficient and economical than two or three, and usually better than five or more.

4. RECORD EVERYTHING YOU DECIDE, DO, AND OBSERVE: Exactly what do you need to find out? What are site conditions before you start? Going to plant ridge, slope, and valley? Then you need to make trials on ridge, slope, and valley. Going to plant trees in contour hedgerows one tree wide? Then make your study in contour hedgerows one tree wide.

Where did your seeds come from? Not just where purchased, if they were, but where were the trees from which they were collected? If you get good results, can you get more seed from the same mother trees? How long were your seedlings in the nursery? What is average diameter at the root collar (drc) at planting time?

Study size of planting stock? Separate into drc classes: less than 4 mm, 4 - 6, 6 - 8, more than 8 mm. Or whatever you think important, but remember, four classes are better.

Every time you visit the nursery, if you grow your own stock, record what you did and how the trees look. After planting, record at every visit what has been done and how the trees look. Old Chinese proverb: short pencil beat long memory.

For good research design, remember the 4R's:

RESTRICT each study to a simple question.

RANDOMIZE treatments in each block.

REPLICATE blocks.

RECORD everything you do and observe.

Field Techniques

The following suggestions for field techniques are normally economical, simple, and effective. However, they are just one of a large possible number of ways to carry out field work, and if you want to use triangular plots --for example-- your answers should be just as good as square plots, if you follow the guidelines in part 1.

1. PLOT SIZE: The reliability of plot means depends more directly on the number of trees measured than on plot area, so think in terms of number of trees on each plot. Eight is great, so if number of seedlings is adequate, measure at least eight trees per plot. But remember design rule # 3 above; it is better to have four replications with four trees per plot than to have two replications with eight trees each.

Caution: if your study includes removing part of the trees, in thinning or coppicing, for example, remember you want to measure eight trees AFTER thinning. Therefore, you should start by including enough trees so there will still be eight trees at the end of the study. Similarly, if you expect a high mortality, it is better to begin with enough trees so that you can expect to have eight left for final measurement.

But eight is not a sacred number, just a good one. As noted above, four is still OK. Some people habitually use 1-tree plots, and that can also be done very effectively, so don't give up and quit a study just because you get more mortality than originally expected.

There is one exception to the "Eight is great" rule: germination tests, or any test where the measurement is a percentage. Studies using percentages tend to be more erratic than those using dimensional measurements, so you need a larger base for calculations. Therefore, germination percentages are more reliable if based on an original number of 50 seeds; some people insist on 100, but others use as few as 10. Certainly it is better to have four tests of 25 seeds --or even 10 seeds-- each than only two of 50.

2. PLOT SHAPE: Most plots are square, partly because square is convenient, but more because a plot should include as little variation as possible; like a block, but more so. However, the important consideration is "minimum variation," not "square" or "convenient." On a hillside, a rectangular plot along the contour often includes less variation than a square one. When working with hedgerows, a rectangular plot is virtually unavoidable: one tree wide and eight --or more-- trees long.

3. MEASUREMENTS: The classical measurements are diameter breast high (dbh) and dominant, or top, height. Breast high is normally defined as 1.3 m above the ground line on the uphill side of the tree. Dominant height is total height of trees in dominant crown positions, a somewhat ambiguous definition. More objective is top height, which is average total height of the 100 fattest (greatest dbh) trees per hectare.

Other measurements may be needed, depending on the ultimate products of importance; volume of woody stem, weight of woody stem, weight of foliage, etc. may be of importance in specific instances, but most can be related with fair precision and accuracy to dbh and top height.

4. MEASUREMENT INTERVAL: Intervals between measurement must depend on product and growth rate. Production of tomato stakes by coppice will probably be measured by counting stakes only at time of harvest. Additional measurements may be interesting, but benefits are unlikely to be worth the cost unless you consider satisfying curiosity as valuable.

Traditional forest regeneration, for products such as timber or pulpwood, is commonly measured at ages 1 (especially survival), 2, 3, and 5 years. Those are four good times for firewood also, if it will be managed to age 5 or later before first harvest.

There are two important considerations: First, there should be at least four measurements at fairly even intervals. The reason is that tree growth is curvilinear and a curve cannot be defined with less than four points.

Second, measurement must be continued past the expected harvest age. If tree increment rate is still increasing at planned harvest age, harvest should be postponed if possible to maximize return.

5. PURPOSE OF STUDY: Some studies are done as preparation for farm operations. It is logical and desirable to obtain information to permit predicting what results should be obtained from the operations planned. Species trials, for example, commonly precede any planting. Weight of thinning or height of stump in coppicing can only be done when trees of the right age/size are available, but the studies should be initiated as early as possible, before an operation is applied to whole plantings. Most of the discussions above relate more directly to that kind of study.

Another type of study, however, is at least as important, and less frequently performed by individual landowners: studying the actual results obtained. Such studies are equivalent, and may be identical to, inventory; in the tropics, this almost invariably means permanent inventory plots on which the same trees, apart from mortality, are measured throughout the rotation.

Design principles discussed above apply equally to inventory plots. Such plots ideally are located at random; in practice, it is satisfactory to locate them systematically. That is, establish plots at fixed intervals spaced throughout the area to be sampled.

Ocular selection of an "average" area and careful measurement of such pre-selected trees is a convenient and attractive alternative to the laborious process of random or systematic selection. DON'T DO IT! Selecting an average yields useful results only to an observer with a great deal of experience, and only on the days when the weather is nice, he is feeling good, wasn't out too late the night before, etc. How accurate the estimate may be on a specific day is not known and cannot be calculated.

Species Selection

Species selection basically rests on two considerations: (a) products and/or services desired and (b) adaptability of the species to all aspects of the site. A brief description follows for a number of species which offer a variety of products and are adapted to a variety of humid and sub-humid zone sites. All species discussed are vigorous.

ACACIA AURICULIFORMIS: Tolerates many sites. Nitrogen-fixing, persistent mulch. Wood good for crafts, general purpose, fuel. Tree too crooked and branchy for industrial use without intensive genetic improvement. Natural regeneration common on mineral soil with abundant light and rainfall > 1500 mm; coppicing weak to absent, probably best with high stump cut in mid- to late-rainy season. Seeds should be treated with hot water for germination. "Best hot water treatment is usually to boil a volume of water equal to 1 times the volume of the seed; remove from heat, put seed in for 30 seconds, then transfer seeds to water at ambient temperature and leave 24 hours.[8] Seedlings may be barerooted or potted. In either case it is advantageous to have diameter at the root collar equal to or greater than 5 mm at time of planting.

ACACIA MANGIUM: Tolerates many sites, but important to control weed competition until trees are well established. Nitrogen-fixing, persistent mulch. Tree form good. Otherwise similar to A. auriculiformis, but coppicing weaker and growth generally faster.

ANTHOCEPHALUS CHINENSIS: Adapted to fair to good soil, moist but intolerant of prolonged waterlogging. Casts dense shade. Form and wood industrial quality. Natural regeneration scarce from the small seed, but seed abundant with good germination. Planting stock normally potted or bareroot; drc should be > 5 mm, and > 10 mm is preferable.

CALLIANDRA CALOTHYRSUS: Site-tolerant except very compact or with poor drainage, and accepts prolonged dry season. Nitrogen-fixing, very good fuelwood, good fodder and leaf meal. Branchy and crooked, for fuelwood and rustic construction only. Natural regeneration limited but fruits early and abundantly. Treat seed with hot water. Seedlings bareroot or potted. 5 mm drc; can plant stumps if drc 10 mm.

EUCALYPTUS CAMALDULENSIS: Site tolerant, including semi-arid, accepts inundation but not waterlogging. Good fuelwood and pulp, usable lumber and poles, form variable. Natural regeneration limited, fruits abundantly. Store seed in water-tight containers at low moisture content. Shade briefly if transplant small seedlings. With care, can plant bareroot, but potted generally preferred; drc > 5 mm for consistent results.

GLIRICIDIA SEPIUM: Tolerates a wide variety of sites on clay to clay loam. Nitrogen-fixing, good fuelwood, quality fodder although not very palatable at first to livestock, widely used for live fence posts pollarded for fuel and fodder, used also for shade of coffee and cacao. Natural regeneration scarce, but seeds prolifically. Treat with hot water. Can direct seed, set medium to large cuttings, bareroot or potted seedlings, stumps.

GMELINA ARBOREA: Tolerates wide variety of rainfall, but needs deep soils high in clay. Enriches and improves soil by transferring minerals from subsoil into leaves and thence into topsoil. Wood good general purpose, outstanding pulp. Form variable; very important to select well-formed mother trees. Natural regeneration commonly abundant. For good germination, collect fruits freshly fallen, spread under shade in layers less than 10 cm thick to ferment a few days (for large quantities, a coffee de-pulper can be modified easily to clean melina), wash, then sow. To store, dry to about 8% moisture content, then store in sealed containers, preferably at 3 - 5degr C. If not sown fresh, soak 24 hours at ambient temperature before sowing. Direct seed on well prepared sites under regular rainfall. Otherwise plant stumps, especially if rainfall is erratic. Stumps should be > 10 mm drc, stem 5 - 10 cm high, lateral roots cut very short, primary root trimmed to 15 cm.

Dozens of other species have been found satisfactory on some sites. Any of special interest should be included in trials. However, one or more of the above should generally be included to enhance the probability of success and to serve as an indicator of relative growth and survival since a good deal of information is available on their development.