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Multipurpose Tree Species Network Research Series

A Guide for Research Cooperators in the 1991 Humid and Subhumid Zone Network Trials

Manual Number 4

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Preface

Multilocation network trials represent an important step toward coordinated research on MPTS of international interest. This manual describes a multilocation network trial designed by scientists in the Multipurpose Tree Species (MPTS) Research Network at a meeting in Thailand in December 1990.

A first set of network trials for the humid/subhumid environmental zone, begun in 1987, was conducted in Indonesia, Malaysia, Philippines, Republic of China (Taiwan), and Thailand. Both sets of network experiments were conducted with funding support from the USAID-funded Forestry/Fuelwood Research and Development (F/FRED) Project.

Other multilocation experiments conducted by the scientists in the Network include a series of species management trials in the arid and semi-arid environmental zones, and provenance trials of *Acacia auriculiformis* and *Dalbergia sissoo*. The Network has also conducted a six-country survey of farmers' actual land and forest use practices.

The Secretariat of the MPTS Research Network looks forward to continued cooperation with Network scientists on this set of trial experiments, as well as other research that will improve knowledge of the performance of MPTS for the benefit of small-scale farmers in Asia.

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1. Introduction

A group of Asian scientists representing various disciplines of biological and social sciences met in Cha-am, Thailand, December 9-16, 1990 to plan a second set of multilocation network trials for the Humid Zone of the Asian tropics.

The scientists at the Cha-am meeting first reviewed the lessons learned from the 1987 network trials and assessed the results of the regional Farm and Village Forestry survey[1] to help guide the new set of trials. Consensus was reached on the need for all cooperators conducting the trials to adhere to the following features:

* common design and standardized methodology
* common minimum data set to be collected
* common germplasm
* thoroughly described soils and climate at each site
* data exchange and professional interaction among participants
* intersite combined analysis of data

The trials are designed to serve three broad objectives:

1. To increase knowledge of growth, site requirements, management practices of priority multipurpose tree species (MPTS) to meet the needs of small-scale farmers in Asia for fuelwood, fodder and small timber
2. To provide a focus for network cooperation and expansion
3. To help improve and standardize forestry and agroforestry research methodology

This manual provides guidelines for research collaborators participating in the network trials. It outlines the experiment, standard procedures to follow, minimum data set to be collected, and maintenance practices applicable to the trials.

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[1]See Charles B. Mehl, *Trees and Farms in Asia: An analysis of farm and village forest use practices in South and Southeast Asia*. MPTS Research Series Report No. 16. Bangkok: Winrock International.

2. Experiment Description

2.1. Specific objectives

1. To evaluate environment x treatment interactions.

2. To estimate the economic yield of fodder, fuelwood and small timber at farmgate under different farmer-oriented management practices.

3. To formulate recommendations for improved farming practices.

2.2. Experimental design

The experimental design is a randomized complete block with 4 replications, using a factorial arrangement of 2 species x 2 varieties or provenances x 3 management treatments. The three treatment factors are labelled as Factor A (species), Factor B (varieties/provenances) and Factor C (management treatments). Management treatment on each plot is applied to all live trees, including trees in buffer rows. The total number of treatments = 2 x 2 x 3 = 12 treatment combinations (Table 1).

Table 1. Species, genotypes (provenances/varieties) and management treatments for the 1991 network trials.

Factor A Species and Code	Factor B Genotype	Factor C Management Treatments*		
		C	P	Th
Acacia auriculiformis ACACAU	Wenlock, QLD (Seedlot No. 17941)	1**	2	3
	Bensbach, PNG (Seed lot No. 17583)	4	5	6
Leucaena hybrid LEUCHY	KX3B (K156 Dive x K636 Leuc)	7	8	9
Leucaena leucocephala LEUCLE	K636	10	11	12

*Management Treatments: C = Control, receives no special treatment. P = Pruning, removes all live and dead branches with a pruning saw (first stroke is an undercut) at age 12 months, up to 50% of total height; the same trees are pruned again at 24 months to 50% of the new total height. Th = Thinning, removes half the trees, systematically selected, at age 24 months.
**Treatment numbers (T): 1-12.

2.3. Layout

Treatments are randomly assigned in complete blocks of 12 plots each. A sample block layout is shown in Figure 1.

Tree spacing is 2 x 2 m. Each plot is uniquely numbered serially and consists of 6 rows spaced 2 m apart. Figure 2 shows a standard plot layout. Each row contains 6 trees, also 2 m apart; 6 rows x 6 trees = 36 trees/plot x 48 plots = 1,728 trees/site. With 2 species and 2 varieties of each species, there are 4 species-variety combinations. Number of trees of each variety at each site = 1,728 trees/4 = 432 trees of each variety.

Plot size is 12 x 12 m = 144 m^2 per plot x 48 plots = 6,912 m^2 per site.

In Figure 2, trees are numbered beginning at the northwest corner and proceeding east, from 1 to 6. The first tree in the second and succeeding rows is directly below tree number 1 in the plot layout. The outer rows of each plot are buffer trees, the interior 16 trees (interior 4 x 4 rows) are samples measured every 6 months after planting.

T 3 ACACAU QLD THINNING	T 1 ACACAU QLD CONTROL	T 4 ACACAU PNG CONTRAL	T 8 LEUCHY KX1 PRUNING
T 11 LEUCLE K636 PRUNING	T 6 ACACAU PNG THINNING	T 10 LEUCLE K636 CONTROL	T 2 ACACAU QLD PRUNING
T 9 LEUCHY KX1 THINNING	T 5 ACACAU PNG PRUNING	T 7 LEUCHY KX1 CONTROL	T 12 LEUCLE K636 THINNING

Figure 1. Example of block layout (T = Treatment number).

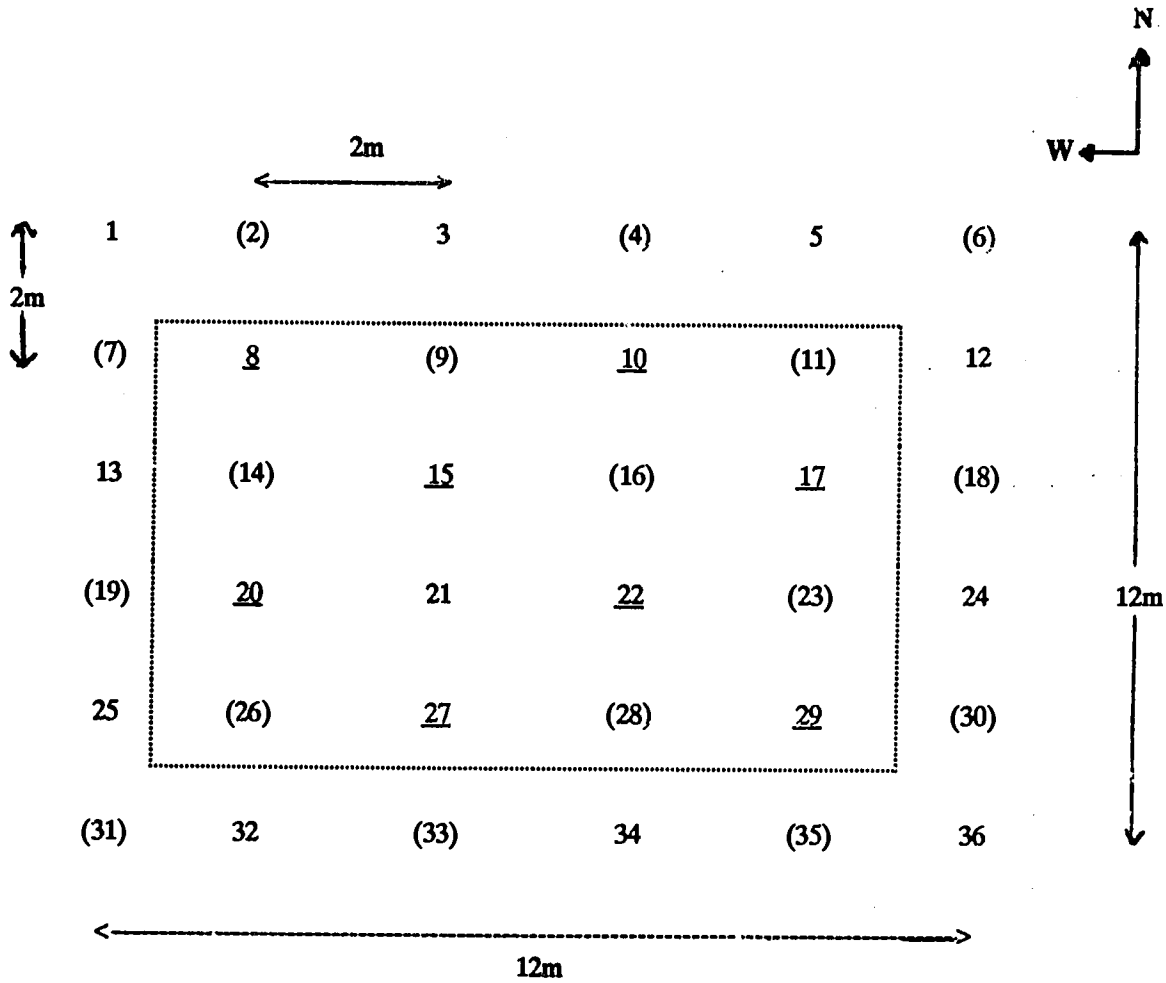


Figure 2. Tree layout within a plot. The 16 trees within the dotted box are for measurement, those outside are buffer rows. Numbers in parentheses indicate trees to be removed at age 24 months on thinning plots. Underlined numbers indicate trees for which permanent measurements should be taken.

3. Nursery Seedling Production

3.1. Seed storage

Although seeds of both *Leucaena* and *A. auriculiformis* have considerable longevity, seeds should be stored in a cold-room (5°C) and moisture free. If such facilities are not available, seeds should be stored in airtight containers in a cool area.

3.2. Presowing treatment

Because of the hard seed coat, seeds of *A. auriculiformis* and *Leucaena* must be treated to make them permeable to water and oxygen to promote germination.

Soak *Leucaena* seed 30 seconds in water at 80°C, then soak 24 hours in water at room temperature. Sow swollen seeds. Treat remaining seeds again; then sow all remaining seeds.

Soak *A. auriculiformis* seed for 30 seconds in water at 80°C, then soak 10 minutes in water at room temperature. Repeat this three times, then air-dry and sow.

Inoculate both species with appropriate local *Rhizobium*.

3.3. Sowing seed

It is recommended that the treated seed of both species and especially *Leucaena* be sown directly in containers. Alternatively, *Acacia* seed can be initially sown in seed flats (beds), then transplanted into containers when hypocotyl is erect before seedcoat is shed.

Sow seeds 3-4 months before the planting date.

3.4. Potting mix

The potting mix should comprise the following mixture.

50% sandy loam (by volume)
40% river sand (by volume)
10% compost (by volume)

Add chemical fertilizer (12:24:12) (N:P:K) at 30-50 g (3-4 table spoons) per 10 liters of potting mixture. Mix fertilizer thoroughly in the potting mixture before filling potting containers. The pH should be maintained between 6.0 and 7.5.

3.5. Potting containers

Use plastic bags (10 cm x 15 cm in size while flat 0.075-0.1 mm in thickness) with 8 to 12 perforations should be used as potting containers. If the bag does not come with holes, punch 8 holes extending to the base of the bag (office paper-puncher will suffice) before filling with potting mixture.

Ideally, all containers should be elevated 10 cm above ground or placed on black plastic sheet to prevent roots from penetrating into the soils below.

3.6. Care of seedlings

Shade

Seedlings should receive about 50% shade. For the last 2-3 weeks prior to planting, seedlings should be exposed to full sunlight.

Watering

Water well in the morning if the upper part of seedling containers is dry. Always water seedlings with fine spray particularly when seedlings are small. As a means of 'hardening off', watering should be reduced a week or so before the plants are transported to site.

Weeding

Keep seedlings free from weed competition at all stages of development. Careful manual weeding is better than the use of herbicides.

Grading of beds

To prevent larger seedlings from shading smaller ones, the beds should be graded by placing the larger seedlings at one end and the smaller seedlings at the other end.

Grading may need to be repeated depending on the length of time the seedlings are kept in the nursery.

Root pruning

If seedling beds are raised above ground or placed on plastic sheets, root pruning should not be necessary. However, if seedlings stand on bare soil it is necessary to prune the roots regularly. Do this by cutting the roots that emerge from drainage holes. Roots may be pruned at the time when you grade the seedlings.

Pest and fungus control

Control damping off and root rot with fungicides if necessary. Similarly, spray pesticides if needed, **but exercise great care.**

4. Field Establishment and Maintenance

4.1. Laying out the trial

Site selection

The trial site should be representative of the area where the species are likely to be planted. The site must be easily accessible in all seasons to facilitate future maintenance and assessments. It is also preferable to select a site for which meteorological data are available.

Site preparation

Clear the site of all vegetation. It should then be tilled adequately. Whenever possible the site should be disc ploughed twice in two directions perpendicular to each other, or otherwise prepare according to local management practices.

Block shape and positioning

The block layout depends on plot shape, soil variability, and practical field considerations. Choose the block shape to minimize the variability within the block. An

obvious site variation should be carefully evaluated when laying out the trial. If the site is uniform, blocks with the shape shown in Figure 1, for example, can be laid freely. Where a dominant soil gradient in a particular direction is known (e.g., sloping land), a 2 x 6 block layout positioned across the slope could be the best choice to minimize variability. Blocks do not have to be contiguous.

Marking out

Three different sizes of marking stakes will be used:

1. Large posts, made of concrete, wood, or PVC pipes will be used as block corners.

2. Large pegs, small posts, or small PVC plastic pipes (but easily visible) will be used as plot corners.

3. Small pegs will be used to mark each planting position.

Mapping trial layout

Prepare map showing trial layout for each trial site. The map should include the following details:

1. Name of the trial

2. Location of the trial site

3. Date of planting

4. Trial design

5. Illustration of field layout

4.2. Planting

Selecting seedlings

From each genotype in the nursery, select 432 healthy seedlings of uniform height. These seedlings should be around 30 cm in height. They should be "hardened off" 1-2

weeks before they are transported to the site. This can be done by gradually reducing the watering and removing shade.

Transport of seedlings

The seedlings should be well watered before transportation. They should be packed in wooden or plastic boxes to avoid damage during transportation. Ensure that the seedlings are not packed loosely. Avoid wind damage during transport by erecting appropriate screens on the truck.

After arriving at the planting site, place the seedlings in a protected, shaded area until planting. Water them thoroughly daily.

Planting seedlings

Planting holes should be 25 x 25 x 25 cm. In addition, cultivate topsoil within 15 cm of the hole. Place 20-30 g of 12:24:12 (N-P-K) fertilizer in bottom of the hole and cover with soil.

Planting should be done in the morning and/or evening, **not** in the heat of the day. Slit the potting bag with a sharp knife or razor blade and carefully remove the plastic bag without breaking the soil or damaging the roots. Set the seedling in the hole with its root collar level with ground surface. Fill in the soil around the roots of the seedling and firm the soil well down around the seedling to avoid large air pockets in the soil. Do not stamp foot and do not use heel. Mulch with dry grass.

Replace dead seedlings with new ones within 2 months after planting.

4.3. Post-planting maintenance

Weeding

The seedlings should be kept free from weed competition during the initial stages of development, until weeds are outgrown. Frequency and method of weed control will depend upon particular site conditions.

Every 2-3 months during the first year, pull all weeds within 50 cm of each seedling, and cut all those in the remainder of the experimental area to prevent competition. For succeeding years, weed as necessary.

If chemicals are used, take care to avoid damaging the tree seedlings and to ensure workers' safety.

Fire protection

Conduct regular weeding and removal to ensure that fuel does not accumulate within the experimental area, especially during the dry season. Prepare a firebreak, 8 - 12m wide, around the experimental area before the beginning of the dry season. Cut and remove vegetation or plow within the firebreak regularly during the dry season.

Fencing

The experimental area should be fenced to prevent damage, particularly damage caused by animals. To help prevent human damage to trees, communicate to all neighbors the study objective and long-term importance of the results to the local population.

Pest and disease control

Monitor pests and diseases, especially the *Leucaena* psyllid (*Heteropsylla cubana*). Appropriate control measures should be taken as necessary up to age 1 year.

Management treatments

Pruning

As part of the treatment design, pruning will be done on 16 plots at age 12 months. Pruning removes all live and dead branches up to 50% of total height of all trees in the pruning plot. The same trees are pruned again at 24 months up to 50% of the new total height. Use a pruning saw, with the first stroke an undercut.

Thinning

The treatment design also requires that 16 plots (not pruning plots) be thinned at age 24 months. Thinning removes every second tree in the entire thinning plot. Pruning saw is again to be used for this operation.

5. Minimum Data Set to be Collected

There are two kinds of data that all cooperators must provide: one-time information and the data measured periodically in the field.

5.1. One-time Information

The following information will be required at the beginning of the trial.

Site description (See examples in Appendices 1 and 3)

Name and address of principal investigator and institution

Site name, state, country

Latitude, longitude, and elevation of experiment site

Climate (maximum and minimum temperatures, precipitation)

Previous vegetation (including existing land use) and method of clearing

General relief: (flat, rolling, hilly, or mountainous)

Site relief: (flat, concave, convex, or ridge)

Position: (upper slope, mid-slope, lower slope, terrace, or valley)

Slope percentage, aspect

Method of soil cultivation

Farmgate prices for fodder, fuelwood, and small size timber

Average daily wage for agricultural labor

Nearest weather station (see example in Appendix 2)

Name, straight-line distance from site

Latitude, longitude, and elevation of weather station

Mean monthly precipitation, maximum and minimum temperatures and relative humidity for the past 10 years.

Soil characterization

Topsoil and subsoil texture, pH, color, drainage

Soil family, moisture regime, temperature regime

Depth to impermeable layer or water table

Parent material, bulk density, stoniness, salinity

Soil fertility

Soil characterization will done by a team of soil scientists to be sent by the MPTS Research Network Secretariat before planting. This will be done for all sites that have not been characterized previously in the 1987 network trials.

5.2. Field measurement and recording procedure

The information described in this section must be recorded periodically during the experiment. Note the frequency of each record where it is described.

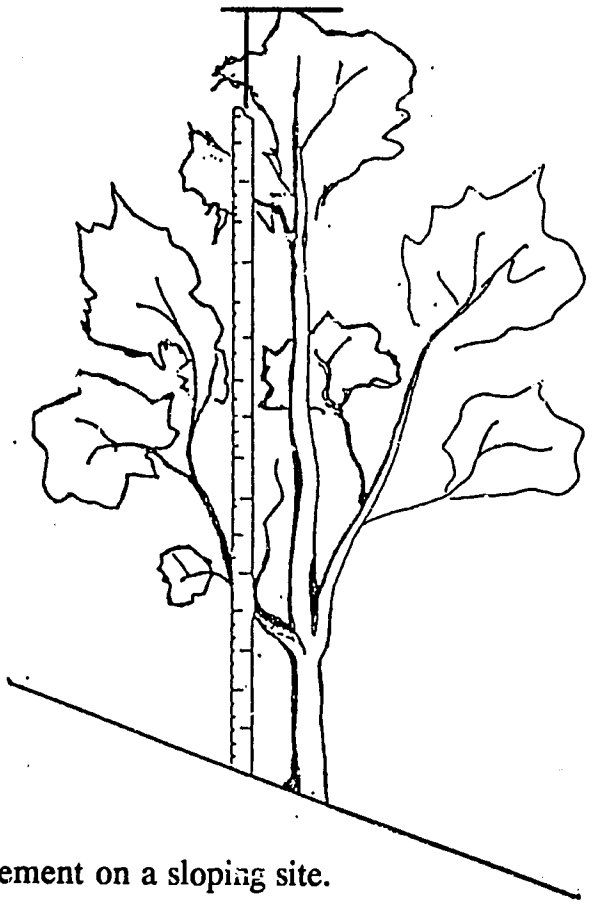
Weather information

This information must be obtained with instruments located at the site. Daily records of maximum and minimum temperatures, precipitation, and relative humidity will be taken for the whole duration of the trials (3 years). If it is not possible to make daily measurement of precipitation, weekly record should be taken. For sites that do not already have a weather station in place, the cooperator must install thermohydrograph and rain gauger. You may request assistance from the Network Secretariat to do this.

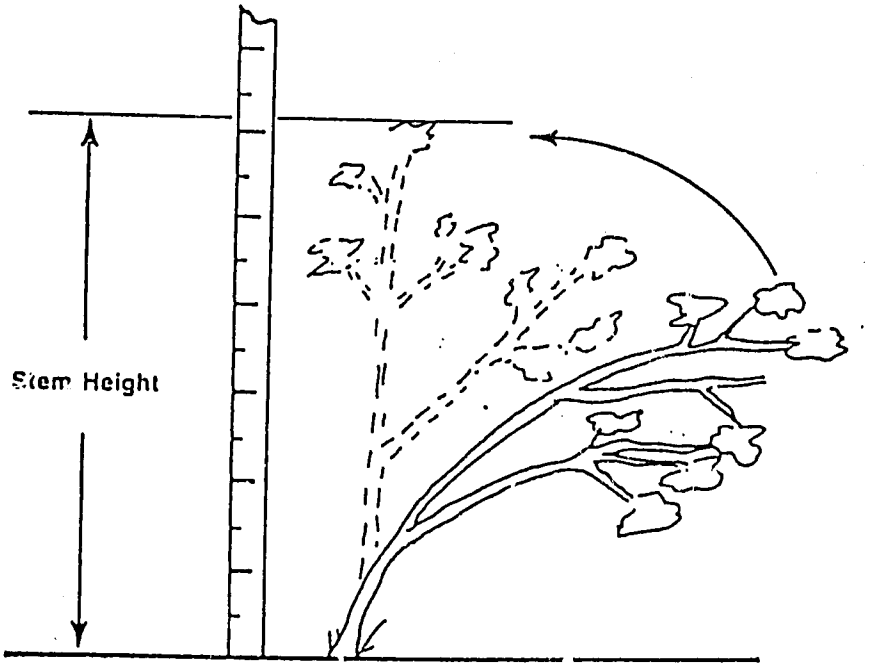
Tree measurements

Height

Measure the total tree height (Figure 3). If there are multiple stems, measure the tree from ground level to the top of its highest apical bud. If the site slopes significantly, measure the principal stem from the uphill side of the tree. If the



(a) Height measurement on a sloping site.



(b) Height measurement of a 'bent' or leaning tree.

Figure 3. Measurement of tree height.

stems are bent over, straighten them if possible, so that the actual length of the stem is measured.

Use a height stick or some type of marked, rigid pole to take this measurement. Measure trees numbered 8, 10, 15, 17, 20, 22, 27 and 29 (Figure 2) at the age of 6, 12, 18, 24, 30 and 36 months. If one of those trees dies or is significantly damaged during the first 24 months, substitute the measurement of an adjacent tree. **For non thinning plots**, this can be selected from the remaining inner 8 trees (number 9, 11, 14, 16, 21, 23, 26 and 28). **For thinning plots**, this should be selected from buffer row trees which are not to be cut during thinning at 24 months.

If trees die after 24 months, no substitution is to be made.

Basal diameter

Basal diameter is defined here as the diameter at 10 cm above ground level (Figure 4). Take measurement on the principal stem (and other stems originating below 10 cm). Mark with paint the point of measurement to ensure that the same point is measured subsequently. The measurement should be made with a metric diameter tape or vernier caliper. For multiple stemmed trees, the average diameter is calculated using the following formula:

$$da = \sqrt{d1^2 + d2^2 + \ldots\ldots dn^2}$$

where da = average diameter and d1, d2.....dn are the diameters of the stems.

A branching bole is considered a stem if its diameter is equal to or greater than 50% of the diameter of the principal bole at the same height.

Measurement should be made on the same sample trees used for height measurements at the ages of 6, 12, 18, 24, 30 and 36 months.

Diameter breast height (dbh)

Take dbh measurement at 1.3 meters above ground level (Figure 4). For forking trees or trees with multiple leaders, take the dbh measurement on all stems if forking or multiple leaders originate less than 50 cm above the ground. Mark with paint all the points of measurement. If there is an abnormality in the tree at 1.3 meters, measure the tree diameter at the point nearest this height which is representative of the stem's diameter.

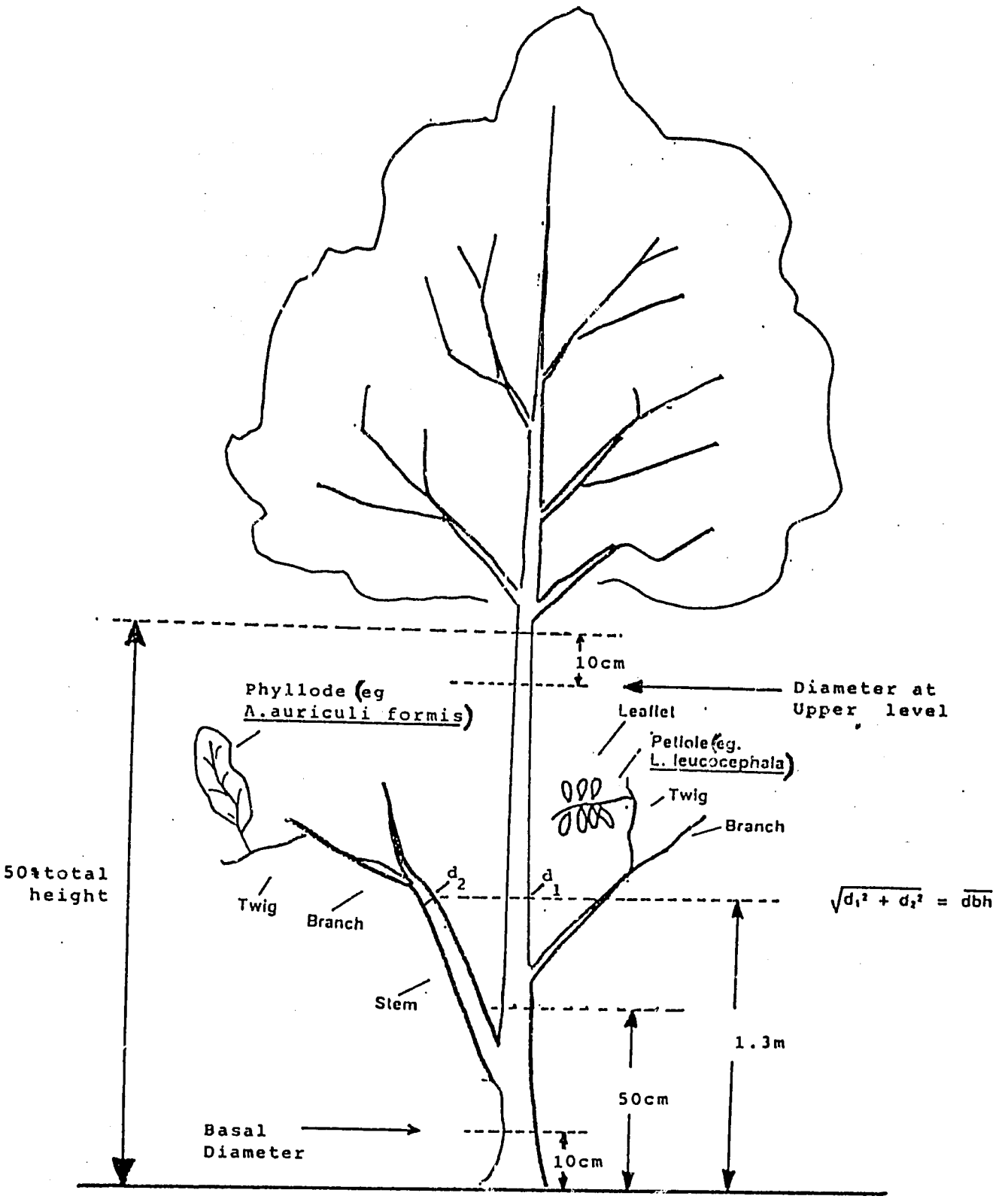


Figure 4. Diameter measurement guidelines.

Take measurement on the same sample trees used for height measurements at the ages of 6, 12, 18, 24, 30, and 36 months.

Diameter at upper levels

This measurement will be made in all plots on 4 trees randomly selected from among the 8 measurement trees (i.e., numbers 8, 10, 15, 17, 20, 22, 27 and 29). At age 12 months, after the pruning treatment, mark a point on the stem 10 cm below the midpoint (50%) of the total height (Figure 4). Measure the diameter (du1) on all 4 trees. Take the measurement (du1) again at 24 and 36 months.

At 24 months, mark another point 10 cm below the new midpoint (50%) of the total height on the same 4 trees measured before. Measure the diameter (du2) at this point. Remeasure the point (du2) at 36 months.

Biomass measurement

Two types of biomass will be taken: pruning biomass and above-ground biomass.

1. Pruning biomass

This will be determined at 12 and 24 months when pruning treatment is imposed. For each pruning plot, select 2 trees among the 16 inner trees with dbh nearest to the plot mean. When the plot is pruned, the biomass cut from these two selected trees is to be determined. For each tree, separate material into two fractions: woody (stem, branches, and twigs) and foliage (leaves, flowers, and fruits). Weigh and record fresh weight of each fraction. Then take a sample of each fraction (about 100 - 200g) and weigh for sample fresh weight. Oven-dry the samples and measure the dry weights.

2. Above-ground biomass

This will be determined:

(a) from 1 border tree from each plot, at 12 months

(b) from 2 thinned trees from each thinned plot at 24 months; and

(c) from 4 trees from a systematic thinning of every plot, at 36 months.

Above-ground biomass will be separated into 3 fractions:

1. stem
2. branches and twigs
3. foliage, flowers, and fruits

For the purpose of (a), (b) and (c) above, select tree(s) with dbh nearest to the plot mean dbh. Measure the height, basal diameter, and dbh of each tree. In addition, measure the diameter at du1 (i.e., 10 cm below the 50%-point of the total height) at 12 months in (a) and du2 (i.e., 10 cm below 50%-point of the new total height at 24 months) in (b).

Determine total fresh weight, sample fresh weight, and sample dry weight of each fraction for each tree.

Specific gravity

Determine specific gravity at 36 months from 4 trees used to determine above-ground biomass for every plot. For each tree, remove: 3-5 cm thick disks from base, midpoint, and tip of the main stem; and one branch disk from one branch. Remove the bark from the disks. Using the water immersion method of determining specific gravity, immerse the disks in water of known volume. Calculate the volume of water displaced by the disks and record this figure. Oven-dry the disks and determine their weight. Calculate specific gravity by dividing the sample dry weight by the weight of the volume of water that was displaced.

Tree form

Take this measurement once on the 8 sample trees (numbers 8,10, 15, 17, 20, 22, 27 and 29) at 36 months just before taking biomass. Score the trees into 3 categories (Figure 5).

Class 1: Tree with one main leading stem up to the tip. Branches are small, having basal diameter less than 50% of the diameter of the principal bole at the same height.

Class 2: Tree with more than one leading stem originating at a height above 50 cm above the ground. The branching bole is considered a stem if its basal diameter is equal to or greater than 50% of the diameter of the principal bole at the same height.

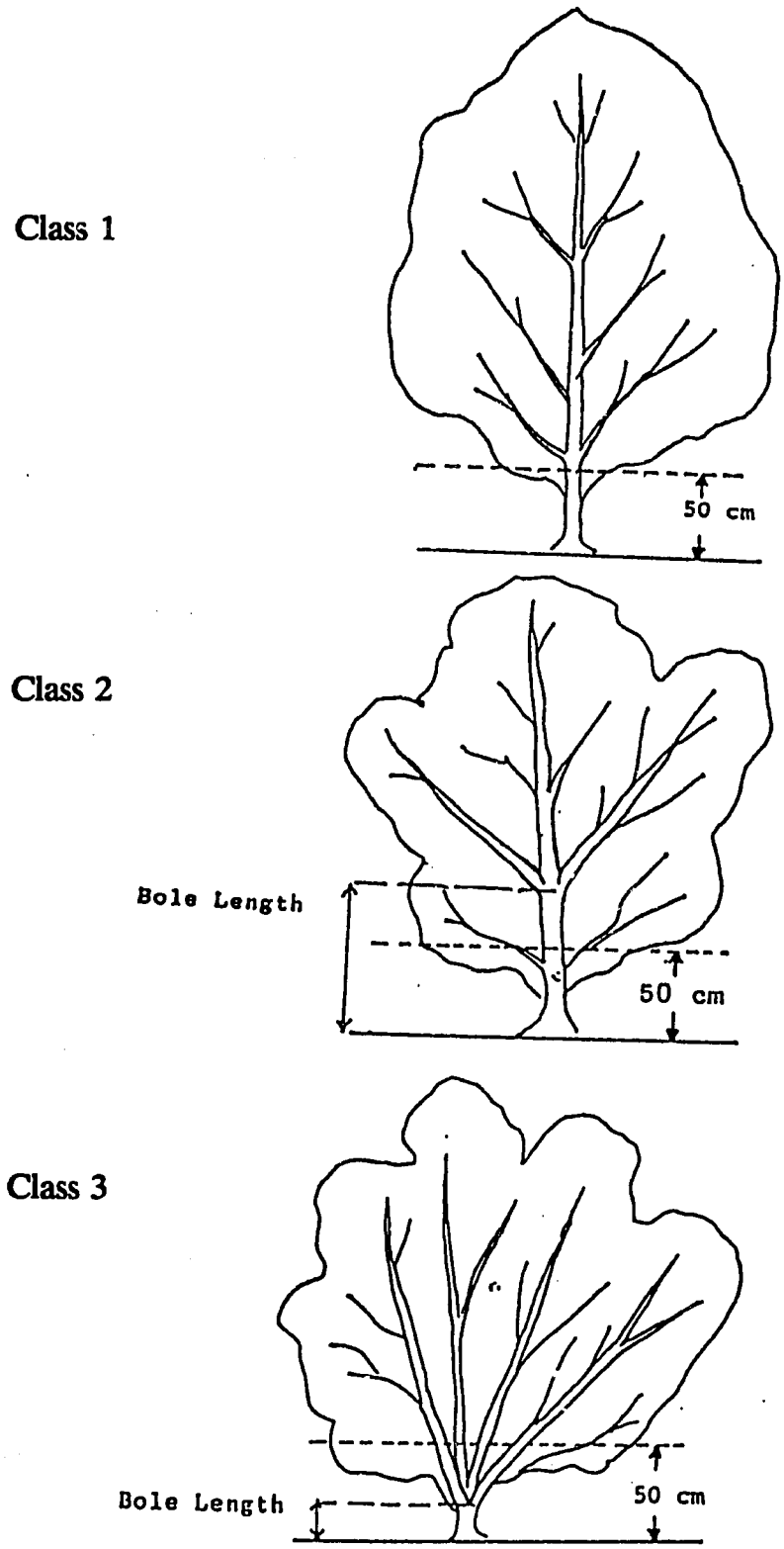


Figure 5. Tree form classes.

Class 3: Tree with more than one leading stem originating below a height of 50 cm above the ground. The definition given above in Class 2 for branching boles considered as stems also applies here.

For Class 1 trees, rate them as (1) straight, (2) fair, or (3) crooked.

For Class 3 trees, record the number of stems.

For trees in Classes 2 and 3, measure the length of the principal bole (i.e., the distance from the ground to the point where multiple stems originate).

Labor input

This is the only economic data that will be recorded as part of the field measurement in the experiment. This will be done at 12 and 24 months, when pruning and thinning treatments are imposed. The data to be recorded are: manhours per plot and the number of trees treated on the plot. Take the measurement for every pruning plot at 12 and 24 months, and every thinning plot at 24 months.

Additional instructions regarding economic data to be collected for analysis will be provided to cooperators by the Network Secretariat.

5.3. Log of experiment operation and monitoring

Keep records of the dates and management operations done. Operations include anything carried out to the trials that may influence growth of the trees (for example, the date of weeding, the type of weeding, or drainage construction).

The trials should also be regularly monitored for other incidences such as wind damage, pest infestation, flooding or diseases.

6. Data Storage and Exchange

One of the main features of these network trials is data exchange for multi site analysis. To facilitate this, the data should be recorded and stored in a standard way. For this purpose, the Experiment Database of the MPTSys computer program will be used by all cooperators. MPTSys is the latest version of IADSS, which was distributed in 1989 by the Network. The program will be distributed to every cooperator by the F/FRED Project.

7. Trial Checklist

Use the following checklist to ensure that you schedule important activities in the trial correctly.

Preplanting Period

1. Receive all seeds from Network Secratariat.
2. Sign and return Professional Service Contract to the Network Secretariat; receive funds for trial establishment.
3. Send information on site and weather station to Network Secretariat.
4. Receive Trial Guidelines from Network Secretariat.
5. Raise sufficient seedlings for the trial. (If insufficient germination is obtained, contact the Network Secretariat for additional seeds).
6. Prepare the site in time for planting during the rainy season.
7. Purchase and install rain gauge and hygrothermograph on sites where there are no weather stations.
8. Arrange with the Network Secretariat for soil characterization by soil scientists (for some sites this may take place after planting).

Post-planting Period

1. When planting, add 20-30 g. of 12:24:12 (N:P:K) fertilizer per hole.
2. Within 2 months after planting, replace dead seedlings with new ones.
3. Weed every 2-3 months during the first year, and as necessary for subsequent years.
4. Record daily weather data.
5. At 6 months of age, measure total height, basal diameter, and diameter at breast height. Send this data to the Network Secretariat.

6. At 12 months of age, measure total height, basal diameter, diameter at breast height, diameter at upper level (du1); do first pruning in all pruning plots; measure the labor input in pruning treatment; measure pruning biomass and above-ground biomass; send data to Network Secretariat.

7. At 18 months of age, measure total height, basal diameter, and diameter at breast height. Send data to the Network Secreatariat.

8. At 24 months of age, measure total height, basal diameter, diameter at upper levels (du1 and du2); do second pruning in the pruning plots, and thinning in all the thinning plots. Measure the labor input in pruning and thinning treatments. Measure pruning biomass and above ground biomass from thinned trees). Send data to the Network Secretariat.

9. At 30 months of age, measure total height, basal diameter, and diameter at breast height. Send data to the Network Secretariat.

10. At 36 months of age, measure total height, basal diameter, diameter breast height, diameter at upper levels (du1 and du2) and tree form; measure final aboveground biomass and specific gravity. Send data to the Network Secretariat.

11. The Network Secretariat will send back to every cooperator the compiled data at plot level for each 6 - month measurement.

12. Make sure you receive MPTSys software for your data management and exchange.

Appendix 1

Sample Site Description

Form C: Trial site Information Experiment ID: TK-01

Trial Site Name: Lad Krating Plantation Site ID: LKT-01

Elevation : 150 m Aspect (degrees from North):
Latitude : 13 degrees 30 minutes N
Longitude : 101 degrees 32 minutes E

Trial Site Topography:

Slope Gradient : 3%
Slope Position : Middle

General Topography:

Slope Gradient : 3%
Length of Slope: 100 m to 500 m

Appendix 2

Sample Site Description - Climate

Form E: Site Descriptor - Climate | Experiment ID: TK-01

Climate Station Name: Sanam Chai Khet | Climate Station ID: 423006

Years of Records : 79
Latitude : 13 degrees 30 minutes N
Longitude : 101 degrees 32 minutes E
Elevation : 150 m

Distance of Experiment Site: 5.0 km

Month	Maximum Temp (C)	Minimum Temp (C)	Precipitation (mm)
January	32.1	21.8	143
Fegruary	33.1	22.3	188
March	33.3	22.6	229
April	33.4	22.2	214
May	33.5	22.5	215
June	33.1	22.1	127
July	32.5	21.6	138
August	32.9	21.6	88
September	32.7	21.4	150
October	32.5	22.1	198
November	32.4	22.1	277
December	32.2	21.8	174
Mean	32.8	22.0	Total: 2141

Appendix 3

Sample Site Description

Form G: Experiment Site Preparation Experiment ID: TK-01

Existing Vegetation:

Plantation of *Melia azedarach* was burned previously and poor growing stock remain.

Method of Clearing:

Cut down big tree with chainsaw, all stumps were removed with bulldozer, land was clear afterward.

Residue: Removed

Percentage of surface free of residues after preparation: 40%

Method of Soil Cultivation:

Ploughing with tractor was done 3 times prior to the planting, to the depth of 50 cm.

Appendix 4

List of Trials Cooperators

		No. of Sites	Site Codes
COSTA RICA			
1.	Dr. Edgar Viques Centro Agronomico Tropical de Investigacion Y Ensefianza (CATIE) 7170 Turrialba	1	AC-21
2.	Mr. Carlos Sandi EARTH (Esc de Agric de La Region Trop Humeda) Apdo 4442-1000 San Jose	2	AE-21 AE-22
INDONESIA			
3.	Mr. Djoko Wahjono Forest Research and Development Centre Jl. Gunung Batu P.O. Box 66, Bogor Tel: (62-251) 325111, 324032 Cable: PUSLITHUT Locality: Carita	1	IF-21
4.	Mr. Markku Temmes Nursery and Reforestation Advisor Mechanized Nursery and Plantation Project in South Kalimantan Jl. Sei Ulin No. 28 B Banjarbaru, Kal-Sel Tel: 511-92197 Locality: Riam Kiwa Trial Site	1	IK-21

		No. of Sites	Site Codes
5.	Mr. Eko C. Hardiyanto Fakultas Kehutanan Universitas Gadjah Mada Bulaksumur, Yogyakarta Tel: (0274) 88688 Ext. 351/352/468/469/622 Tlx: 25135 UGM Locality: Wanagama Education & Experimental Forest, Gunung Kidul, Yogyakarta	1	IG-21
6.	Mr. Soeparno Wirodidjojo Balai Penelitian Kehutanan Ujung Pandang Jalan Perintis Kemerdekaan KM. 16 Jurusan Mandai, Kotak Pos 67 Ujung Pandang Tel: (62-0411) 318-961 (Office) (62-0411) 831-37 (Hse) Locality: Borisallo - Maros, Gowa District, South Sulawesi Province	1	IS-21

MALAYSIA

7.	Mr. Mohd. Lokmal Ngah Forest Research Institute of Malaysia Karung Berkunci 201 52109 Kuala Lumpur Tel: 6342633 ext. 402, or 6262633 Tlx: 27007 FRIM MA Fax: (03) 6367753 Cable: UTAN Locality: Mata Air, Perlis	1	MF-21
8.	Dr. Nor Aini Abd. Shukor/J. Basharuddin Faculty of Forestry Universiti Pertanian Malaysia 43400 Serdang, Selangor Tel: (03) 9487835 or 9486101-11 Ext. 2422 Tlx: 37454 UNIPER MA Fax: (03) 9482507 Locality: UPM campus	1	MP-21

		No. of Sites	Site Codes
9.	Mr. Mohd. Zaki Hamzah Centre of Applied Sciences Universiti Pertanian Malaysia Bintulu Campus, P.O. Box 396 97008 Bintulu, Sarawak Tel: (086) 35911 Fax: (086) 35835 Locality: Bintulu Campus, UPM, Sarawak	1	MS-21
10.	Professor Zakri A. Hamid Faculty of Life Sciences Universiti Kebangsaan Malaysia 43000 UKM Bangi Selangor D.E. Tel: (03) 8250001 Ext. 2953, 8250601, 8250701, 8250296 Tlx: UNIKEB M 31496 Fax: (03) 8256484 Locality: UKM Campus, Bangi, Selangor	1	MK-21

PHILIPPINES

11.	Mr. Justino Quimio Department of Forestry Visayas State College of Agriculture Baybay, Leyte 6521-A Tel: (63-2) 521-2027 588-692 Fax: (63-2) 588-692 c/o Manila Pasay City office. Locality: ViSCA Forest Reservation, Baybay	1	PV-21
12.	Dr. Amado M. Exile, Jr. Dean, College of Forestry Central Mindanao University Musuan, Bukidnon Locality: Inside University Forest Reservation CMU, Uni. Town, Musuan, Bukidnon	1	PM-21

		No. of Sites	Site Codes
13.	Mr. Antonio G. Principe/Eustaquito T. Tandug Regional Executive Director DENR, Region 3 Cleofer's Bldg. Gen. Hizon Ave. San Fernando, Pampanga Tel: 61-28-58 Fax: (45) 61-28-58 Locality: Tarlac in Region III	1	PE-21
14.	Prof. Wilfredo Carandang Dept. of Silviculture & Forest Institute UPLB College of Forestry College, Laguna 4031 Tel: (63-94) 2599 Fax: (63-94) 3206 Locality: Sitio Pangaw. Makiling Forest Reserve, Los Baños	1	PU-21
15.	Dr. Roger Guzman Dean, College of Forestry Isabela State University Cabagan, Isabela 3328 Locality: Garita Slopes, Cabagan, Isabela	1	PI-21
16.	Dr. Amado P. Imper Research Coordinator College of Agriculture and Forestry Don Mariano Marcos Memorial State University Rosario, La Union Locality: Rosario 2506, La Union	1	PD-21

		No. of Sites	Site Codes
REPUBLIC OF CHINA			
17.	Dr. Ming-Jen Lee Professor, Department of Forestry National Chiayi Institute of Agriculture 84 Hon-Mao Bei, Lu Liao Li Chiayi 60083, Taiwan Tel: (886-05) 276-6141 Fax: (886-05) 276-4957 Locality: Sir Ko Experimental Forest at Chung-Pu District of Chiayi Country	1	CA-21
18.	Dr. Fuh-Jiann Pan Silviculture Division Taiwan Forestry Research Institute 53 Nan-Hai Road, Taipei, Taiwan Tel: (886-2) 3116143 or 3718746 Fax: (886-2) 314-2234 Locality: 1. Tai-Ma-Li, Taitung, Eastern Taiwan 2. Hen-Chun, Southern tip of Taiwan	2	CF-21 CF-22
SRI LANKA			
19.	Prof. H.P.M. Gunasena Dean, Faculty of Agriculture University of Peradeniya Peradeniya Tel: (94-8) 88375, 8830, 88041 (Office) (94-8) 25167, 32469 (Home) Fax: (94-8) 32043, 32572 Locality: Dodangolla, Kundasale	1	SA-21

		No. of Sites	Site Codes
20.	Mr. G.D. Bandara Forest Research Centre Kumbalpola, Boyagane Kurunagala Tel: (94-037) 22127 Locality: 1. Mirigama 2. Anuradhapura	2	SF-21 SF-22
21.	Mr. N.D.R. Weerawardene Research Officer Divisional Forest Office Passara Road Badulla Tel: (94-055) 2612	1	SF-23
22.	Dr. M. de S. Liyanage Head, Agronomy Division Coconut Research Institute Bandirippunra Estate Lunnwila Tel: (94-030) 3795, (94-031) 5300 Fax: (94-031) 7195 Locality: Ratmalagara Estate, Madampe NWP	1	SC-21

THAILAND

23.	Dr. Suree Bhumibhamon Department of Silviculture Faculty of Forestry Kasetsart University Bangkhen, Bangkok 10900 Tel: 5790171 Tlx: 21340 WINROCK TH Fax: 561-1041 Locality: 1. Seed Center, Uthaithani 2. Lad Krating Plantation, Chachoengsao	2	TK-21 TK-22

		No. of Sites	Site Codes
24.	Dr. Kovith Yantasath Thailand Institute of Scientific and Technological Research 196 Phahonyothin Road Bangkhen, Bangkok 10900 Tel: 5791121-30 Ext. 1244 Tlx: 21392 TISTR TH Fax: (66-2) 5794940 Locality: 1. Pak Chong Land Development Center, Nakon Ratchasima 2. Hang Dong, District School Hang Dong, Chiang Mai	2	TH-21 TH-22
25.	Mr. Bunyarit Puriyakorn Silviculture Division Royal Forest Department Phahonyothin Road Bangkhen, Bangkok 10900 Tel: 579-0230-4 Fax: (66-2) 579-4730 Locality: Ratchaburi Forest Experiment Station, Ratchaburi Province	1	TS-21
26.	Mr. Boonchoob Boontawee/Verapong Suangtho Silviculture Division Royal Forest Department Phahonyothin Road Bangkhen, Bangkok 10900 Tel: 579-0230-4 Fax: (66-2) 579-4730 (Direct line) Locality: Dong Lan Seed Orchard, Chumpae District, Khon Kaen	1	TS-22

		No. of Sites	Site Codes
27.	Mr. Bopit Kietvuttinon Division of Silviculture Royal Forest Department Phaholyothin Road Bangkok 10900 Tel: 579-0230-4 Fax: 579-4730 Locality: Sai-Thong Forest Experimental Station, Bang Sapan Noi District, Prachuabkirikhan Province	1	TS-23
28.	Mr. Charoon Sukhasem Project Leader Dept. of Soil Science and Conservation Faculty of Agriculture Chiang Mai University Chiang Mai 50002 Tel: (053) 221-699 Ext. 4001 Tlx: 43553 UNICHIM TH Fax: (053) 217-143 Locality: Mae Hia Agricultural Research Station	1	TC-21

Figure 6. Map of 1991 trial sites (Costa Rican sites not pictured).