3-3 Seedlings Production

The two seedlings cultivation methods used in this project are cultivation from seeds and the cultivation of wildings. The following is a description of the standards for the collection and cultivating of seeds and wildings. (Also refer to the various standards that have already been drafted for the cultivation of seedlings of fast-growing species).

1) The Flowering/Fruiting Information Network

Below is a description of the system that has been organized to secure the needed annual supplies of seeds and wildings of the high-quality usable species for this project, particularly dipterocarps.

a. Each month the Forestry Department Peninsular Malaysia collects information on flowering and fruiting from the State Forestry Departments and district forest offices, while the Malaysian Forest Research Institute compiles this information into bulletins that are issued every two or three months. However, by the time these bulletins are received, several months have passed since flowering or fruiting, and by then most fallen seeds have failed to germinate because of insects attack, and other factors. Therefore, in December 1992 an independent information network was established for this project in which information on flowering and fruiting is received directly from State Forestry Departments and district forest offices (Fig. 6).

b. In terms of past flowering and fruiting in Peninsular Malaysia, in 1976 a broad spectrum of species throughout the peninsular flowered between April and May, followed by abundant fruiting in June and July. The flowering and fruiting of this year were the most bountiful than any other. The seed yields for 1981 and 1983, though plentiful did not surpass those of 1976. In Peninsular Malaysia two flowering periods can be expected - once in April and May and another in September and October. One example of this is the fruits (e.g., durian, rambutan and mangosteen) that appears semi-annually - once in June and July and another in December and January - in the markets here. Also, seeds for this project were collected twice in 1993: between March and May and again between August and October.

c. However, it was also said that high-quality indigenous species are always flowering or fruiting somewhere on the Peninsular, making an organized information network vital to the dependable acquisition of seeds and wildings. Consequently, during each flowering season, flowering survey teams are formed and dispatched to nearby natural forests to determine the state of flowering and collecting seeds and wildings (Figs. 6 and 7).

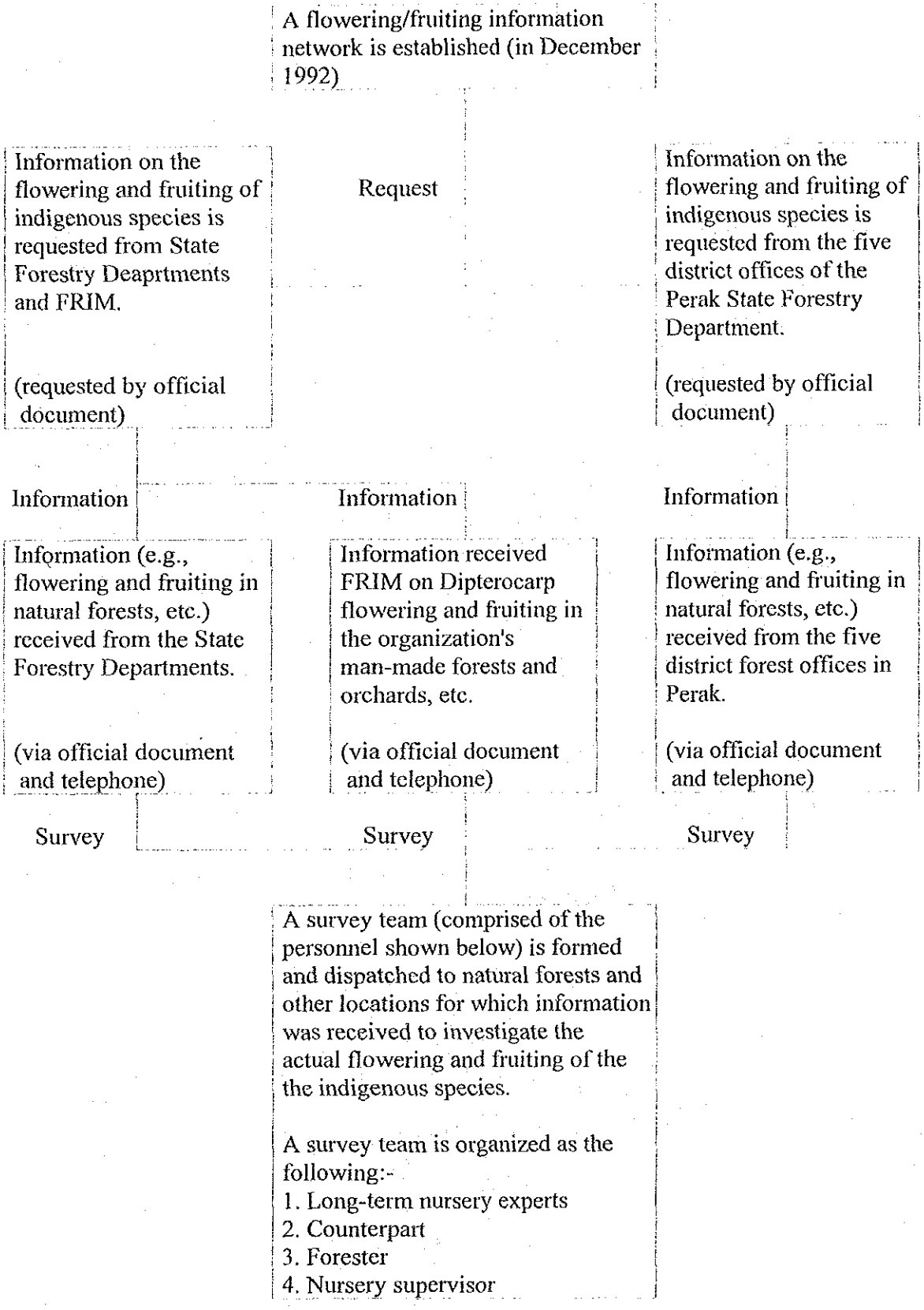


Fig. 6. The flowering/fruiting information network

d. Since establishing the flowering/fruiting information network in December 1992, much information on the flowering and fruiting of indigenous species had been received, in response to which survey teams had been dispatched to investigate the actual state of flowering or fruiting (Table 15).

Table 15. The dispatching of flowering/fruiting survey teams

Date of information received	Name of indigenous species	Source of information	Actual state of flowering/fruiting	Source
1. Jan 1993	*Neobalanocarpus heimii*	FRIM	Flowering was in progress; seed yields one month later were good	Natural forest in Pasoh
2. Feb 1993	*Shorea parvifolia*	Pahang State Forestry Department Bentong District Forest Office	Flowering was in progress; seed yields one month later were good	Nursery under jurisdiction of Lentang
3. Feb 1993	*Shorea macroptera*	Pahang State Forestry Department Bentong District Forest Office	Seeds had already fallen; wildings (18 cm) were collected	Natural forest in Kemasol
4. Mar 1993	*Dipterocarpus crinitus*	South Perak District Forest Office	Seeds had already matured and fallen	Natural forest in Besout
5. Apr 1993	*Calophyllum spp.*	South Perak District Forest Office	Seeds had already fallen; wildings (10 cm) were collected	Natural forest in Besout
6. May 1993	*Dacryodes spp.*	South Perak District Forest Office	Seeds had already fallen; wildings (15 cm) were collected	Natural forest in Bukit Tapah
7. May 1993	*Dipterocarpus cornutus*	Pahang State Forestry Department Bentong District Forest Office	Seeds had already fallen; seeds were collected	Nursery under jurisdiction of Lentang
8. Jun 1993	*Palaquium spp.*	Kinta Manjung District Forest Office	Seeds had already fallen; wildings (20 cm) were collected	Natural forest in Batu Gajah
9. Jul 1993	*Drybalanops aromatica*	Selangor State Forestry Department Rawang District Forest Office	Seeds had already fallen; wildings (25 cm) were collected	Man-made forest in Kanching
10. Aug 1993	*Dipterocarpus cornutus*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Nursery near Gerik

Date of information received	Name of indigenous species	Source of information	Actual state of flowering/fruiting	Source
11. Aug 1993	*Parashorea spp.*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Clear-cut site in Gerik
12. Aug 1993	*Shorea leprosula*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Clear-cut site in Gerik
13. Aug 1993	*Shorea pauciflora*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Clear-cut site in Gerik
14. Sep 1993	*Shorea macroptera*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Along the highwa in Gerik
15. Sep 1993	*Shorea curtisii*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Along the highwa in Gerik
16. Sep 1993	*Sindora spp.*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Along the highwa in Gerik
17. Sep 1993	*Intsia Palembanic*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Along the highwa in Gerik
18. Oct 1993	*Dialium spp.*	Gerik District Forest Office	Seeds were ripe and just right for collecting	Along the highwa in Gerik
19. Nov 1993	*Shorea assamica*	Taiping District Office	Seeds had already fallen; wildings (20 cm) were collected	Natural forest in Taiping
20. Dec 1993	*Shorea assamica*	Taiping District Office	Seeds had already fallen; wildings (20 cm) were collected	Natural forest in Taiping
21. Jan 1994	*Neobalanocarpus heimii*	Taiping District Office	Flowering was in progress; seed yields two months later were good	Natural forest in Taiping

e. Information on flowering and fruiting in Chikus natural forests is used by the South Perak District Forest Office and the Chikus nursery team in their investigations and other operations, such as designating specific trees for observation and collecting wildings.
The flow of flowering and fruiting information on Chikus natural forests are as follows.

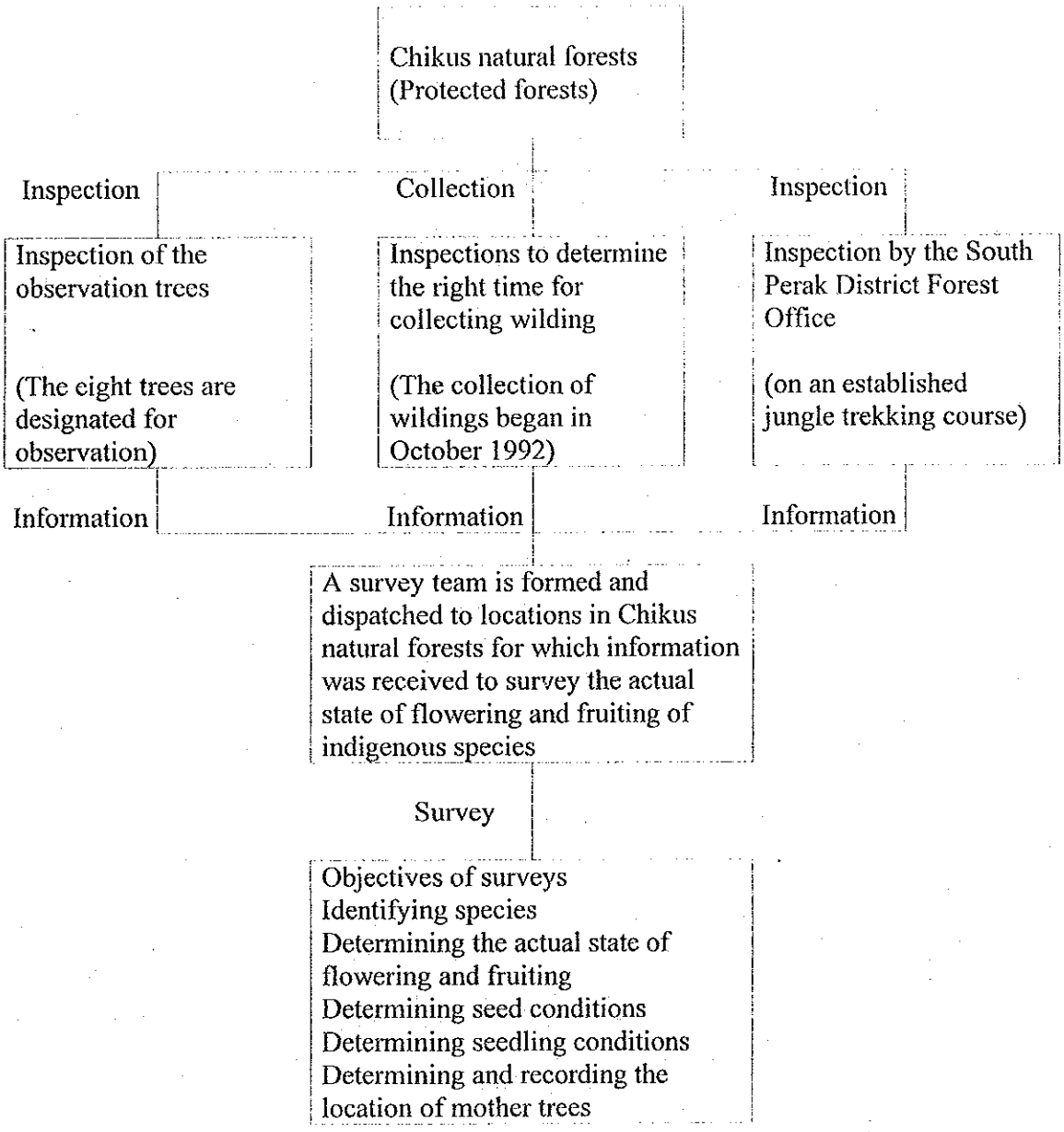


Fig. 7. The flow of information on flowering and fruiting in Chikus natural forests

f. In addition to establishing the flowering and fruiting information network to increase the amount of information received, the necessary survey teams and three mobile collection teams had been formed to facilitate the high-volume collection of seeds and wildings.
Normally, seeds and wildings were collected by dispatched nursery teams. The organization of mobile operations is as shown below:

- Objectives of surveys
- Identifying species
- Determining the actual state of flowering and fruiting
- Determining seed conditions
- Determining wilding conditions
- Determining and recording the location of mother trees

Studying the results of surveys. Decision to dispatch a team

Seed and wilding collection teams are dispatched (Three foresters and 21 workers are divided into three teams)

1. Dispatch	2. Dispatch	3. Dispatch
Team 1 (Nursery team) Forester: 1 Workers: 7 JICA expert: 1 Counterpart: 1	Team 2 (Silviculture team) Forester: 1 Workers: 7 JICA expert: 1 Counterpart: 1	Team 3 (Forest management team) Forester: 1 Workers: 7 JICA expert: 1 Counterpart: 1

Fig. 8. The organisation of mobile team in seed and wildings collection

Note: 1. The results of surveys were studied to determine whether seeds and wildings were ready for collection.
2. Nursery teams ("1. Dispatch") were dispatched one at a time in a fixed order based on the results of the survey team.
3. One team is capable of collecting 500 to 1,000 seeds and seedlings per day.

g. Even within the jurisdiction of the Perak State Forestry Department, the time of flowering differs from district to district. For instance, although trees in the Chikus natural forests flowered in February, those in Gerik flowered as late as July. In addition, some individual trees flower quite readily, while others flower regardless of the time of year. or whether the year in question is an overall bountiful one. Consequently, in the flowering and fruiting of dipterocarps, close observation of a greater number of designated trees is more important than further investigation into the effect of environmental factors.

In accordance with this finding, we had established a flowering/fruiting information network and independently designated trees for the observation of flowering and fruiting. In the jurisdictions of Pahang and Perak State Forestry Departments, twenty dipterocarps previously used in this Project (e.g., to collect seeds or wildings) had already been designated, and we must now work to make our network for relaying information on the flowering and fruiting of the dipterocarps needed in this project more reliable by increasing the number of observations of the designated trees.

Specifically, we feel it should be possible to use information from our existing information network, and from trees designated for observation, in the prediction of dipterocarp flowering and fruiting. For example, after *Shorea parvifolia* and *Hopea odorata* in a single location in Chikus natural forests flowered and fruited in February 1993, neighbouring *Shorea parvifolia* and *Hopea odorata* flowered and fruited in February of the following year. Hence, the flowering/fruiting of dipterocarps is believed to be predictable to a certain extent, and the months of February (and July) have therefore been designated for priority inspection.

Photo - A team inspects a designated tree after receiving flowering/fruiting information.

2) Seedlings Cultivation Plans

The number of seedlings needed is based on the area available for replanting, the number of seedlings per hectare, the rate of supplementary replanting, and survival rates. Seedlings of certain species were purchased from private nurseries because the number of seedlings produced through seeds and wildings collected were below target. See Table 16 for the nursery work schedule for 1993 fiscal year.

3) Seedlings Production

Fig. 19 is the five-year plan for seedling production; Fig. 20 shows actual seedling produced in 1992 and 1993.

These figures show a seedlings production in 1992 of 47,000 -- 3,000 short of the 50,000 seedlings of high-quality species needed. However, the effects of this shortage were diminished by the delay in afforestation up to 1993 fiscal year. In addition, the acquisition of fast-growing trees for this project was helped by the State Forestry Departments' planting operations.

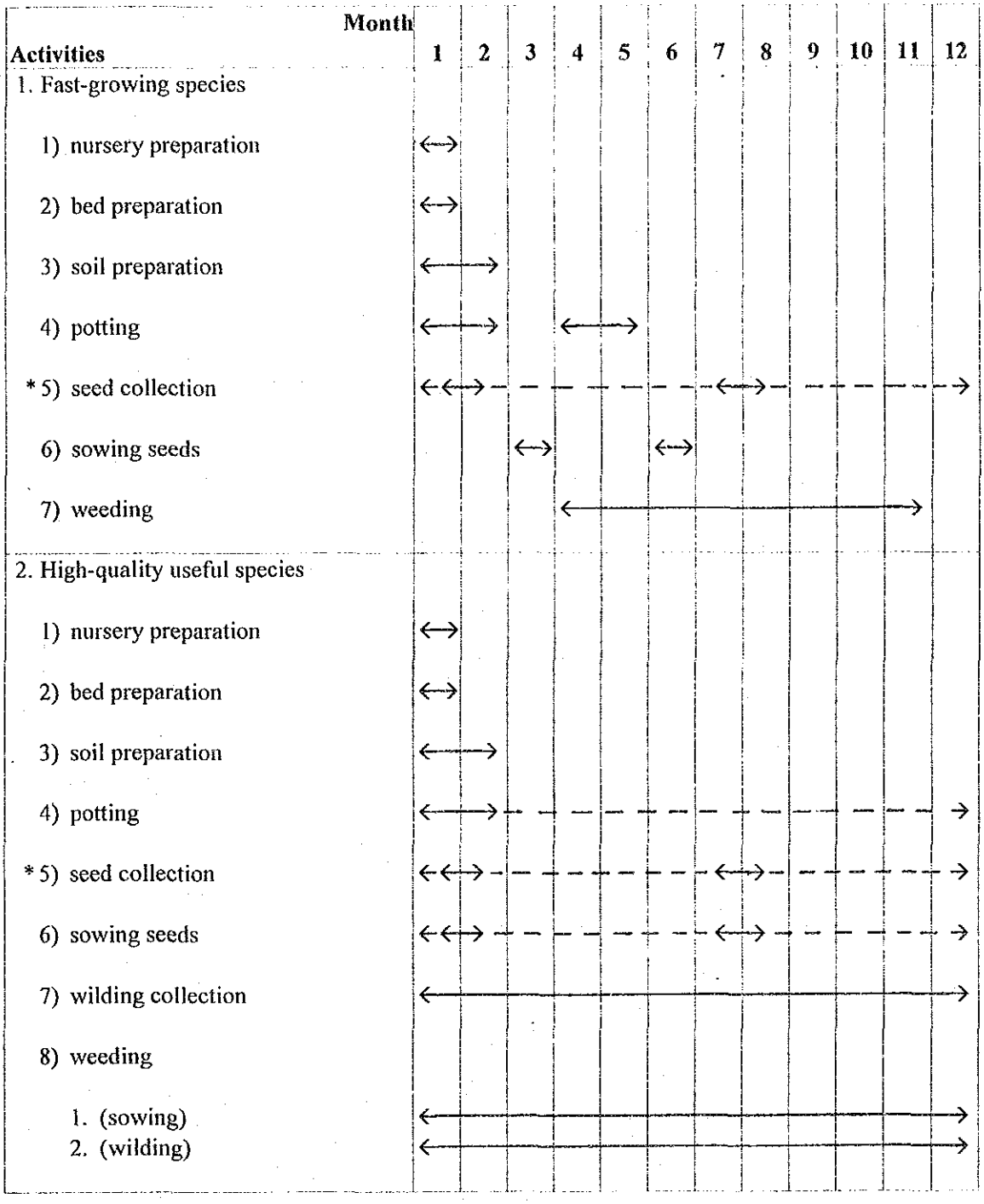
In 1993, information on flowering and fruiting made possible the high-volume collection of seeds and wildings, thus ensuring a stable supply. Seedlings for afforestation production in 1993 fiscal year (the planting of which will begin in February 1994) included many with a production period of more than one year. Combined with those for afforestation in 1994 fiscal year, these numbered roughly 200,000 and are now being kept at the Chikus nursery.

4) Nursery Workers

(1) Number Of Personnel And Work Processes

Table 19 shows the number of nursery workers for each month between September 1992 and December 1993. At first, seedling needs for 1992 replanting were met with wildings collected by workers hired in September 1992. Even though nursery facilities had not yet been completed, five workers and two JICA staff (the chief and a driver) were selected to build a temporary nursery and begin collecting wildings in October. These wildings (11,000 in number) accounted for roughly 23% of the 47,000 seedlings of high-quality species collected in 1992 fiscal year. In 1993 fiscal year the high workloads in operations such as sorting, planting and potting immediately following high-volume seed collection were handled by hiring 11 special temporary female workers and by subcontracting the potting of roughly 90,000 pots in September and October. Seven of these female workers were subsequently hired as nursery workers, and starting in November nursery work was carried-out with 8 male workers and 12 female workers.

Table 16. Nursery work schedule in 1993



Note: * The flowering and fruiting of indigenous local species were very irregular, therefore the seed collection time could not be predicted. The suggested nursery work schedule above is based on the findings of Dr. Teruhiko Kawahara.

Table 17. Five-year plan for seedling production

(1,000) trees

Area \ Year	1992	1993	1994	1995	1996	Total
A. Chikus Block-A site						
Fast growing spp.	28	46	56	28	-	158
High quality spp.	25	40	50	25	-	140
Sub total	53	86	106	53	-	298
B. Chikus Block-B site						
Fast growing spp.	-	-	-	-	-	-
High quality spp.	25	25	25	25	-	100
Sub total	25	25	25	25	-	100
C. Chikus Arboretum site						
Fast growing spp.	-	4	-	-	-	4
High quality spp.	-	6	10	-	-	16
Sub total	-	10	10	-	-	20
D. Bukit Kinta site						
Fast growing spp.	-	-	-	-	-	-
High quality spp.	-	4	9	14	7	34
Sub total	-	4	9	14	7	34
Total						
Fast growing spp.	28	50	56	28	-	162
High quality spp.	50	75	94	64	7	290
Grand total	78	125	150	92	7	452

Table 18. Seedling yields in 1992 and 1993

Seedlings produced in 1992 — Quantity (1,000 seedlings)

Species	No. of seedlings Plan	Result	Remarks
Fast-growing spp.	28	23	from private nursery
* *Acacia mangium*			
High quality spp.	50	47	
* *Shorea leprosula*		10 (2)	
* *Shorea parvifolia*		10 (1)	
* *Shorea acuminata*		4	
* *Neobalanocarpus heimii*		11	from private nursery
* *Hopea odorata*		4	from private nursery
* *Pentaspadon spp.*		8 (8)	
Total	78	70 (11)	

Note: Wildings were collected in Chikus natural forests.

Seedlings produced in 1993 — Quantity (1,000 seedlings)

Species	No. of seedlings Plan	Result	Remarks
Fast-growing spp.	46	41	from private nursery
* *Acacia mangium*			
High quality spp.	94	141 (42)	
* *Shorea parvifolia*		8	
* *Shorea acuminata*		11	from private nursery
* *Hopea odorata*		6 (6)	
* *Pentaspadon motleyi*		8 (8)	
* *Palaquium spp.*		12 (9)	
* *Parashorea spp.*		8 (3)	
* *Drybalanopus aromatica*		16 (6)	
* *Shorea macroptera*		16 (3)	
* *Dipterocarpus cornutus*		7 (3)	
* *Shorea pauciflora*		11	
* *Shorea ovata*		20	
* *Intsia palembanica*		5	
* *Sindora spp.*		3	
* Others spp.		10 (4)	from private nursery
Total	140	182 (42)	

Note: 1. The planned total of 140,000 seedlings is the sum of the 125,000 seedlings called for in the five-year plan for seedlings production, and in 1992 fiscal year, shortage of 15,000 seedlings (for afforestation, etc.)

2. Figures in parentheses indicate the number of wildings collected in natural forests in Chikus, Lentang, Pahang, Rawang and Kemasul.

Table 19. Monthly changes in the number of nursery workers

Year	1992				1993			
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Workers (male)	5	5	5	5	5	5	5	35
Workers (female)							4	4
Temporary workers								0
Total	5	5	5	5	5	5	9	39

Year	1993									
Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Workers (male)	7	7	9	8	11	10	9	8	8	77
Workers (female)	5	5	5	4	5	5	5	12	12	58
Temporary workers						11	11			22
Total	12	12	14	12	16	26	25	20	20	157

Note: All temporary workers were women.

Photo - Nursery work

(2) Working Hours

Working hours are from 7:30 a.m. to 3:30 p.m.; with a 30-minute lunch break from 12:00 to 12:30 p.m. The working week is Monday through Saturday, with half-days on Friday (in which afternoon is for prayers) and Saturday. As seedlings required watering on Friday and Saturday afternoons and Sundays as well, seedlings were watered by six-person shifts, which included project workers. Every Friday, Muslim employees stop work at 12:00 p.m. for their Friday Prayers.

5) Seedlings Production Work

Fig. 9 is the seedlings production work flowchart, and Fig. 10 a graphic representation of the flow of seedlings production work. A specific description of each task is as below.

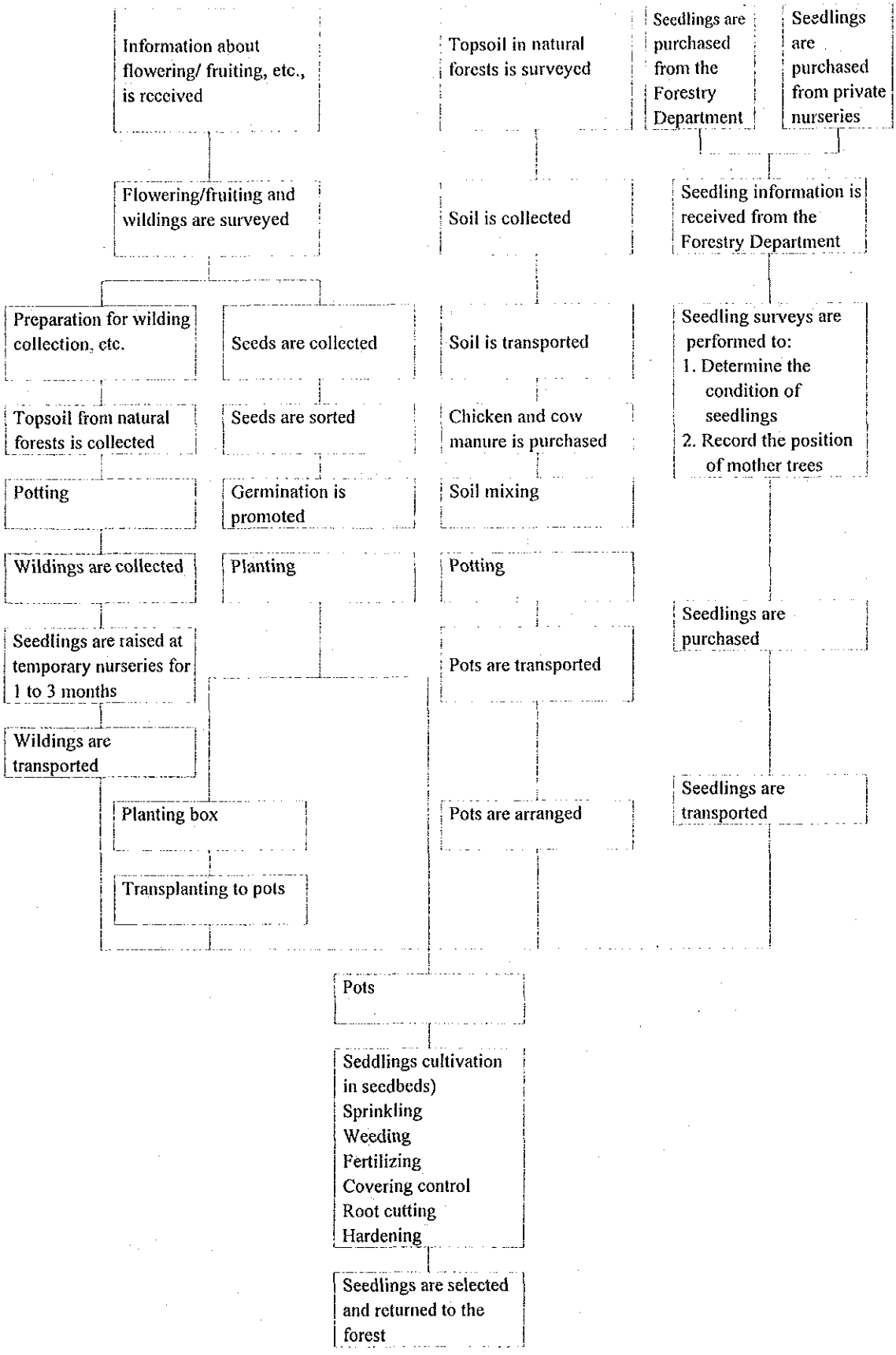


Fig. 9. Seedlings production work

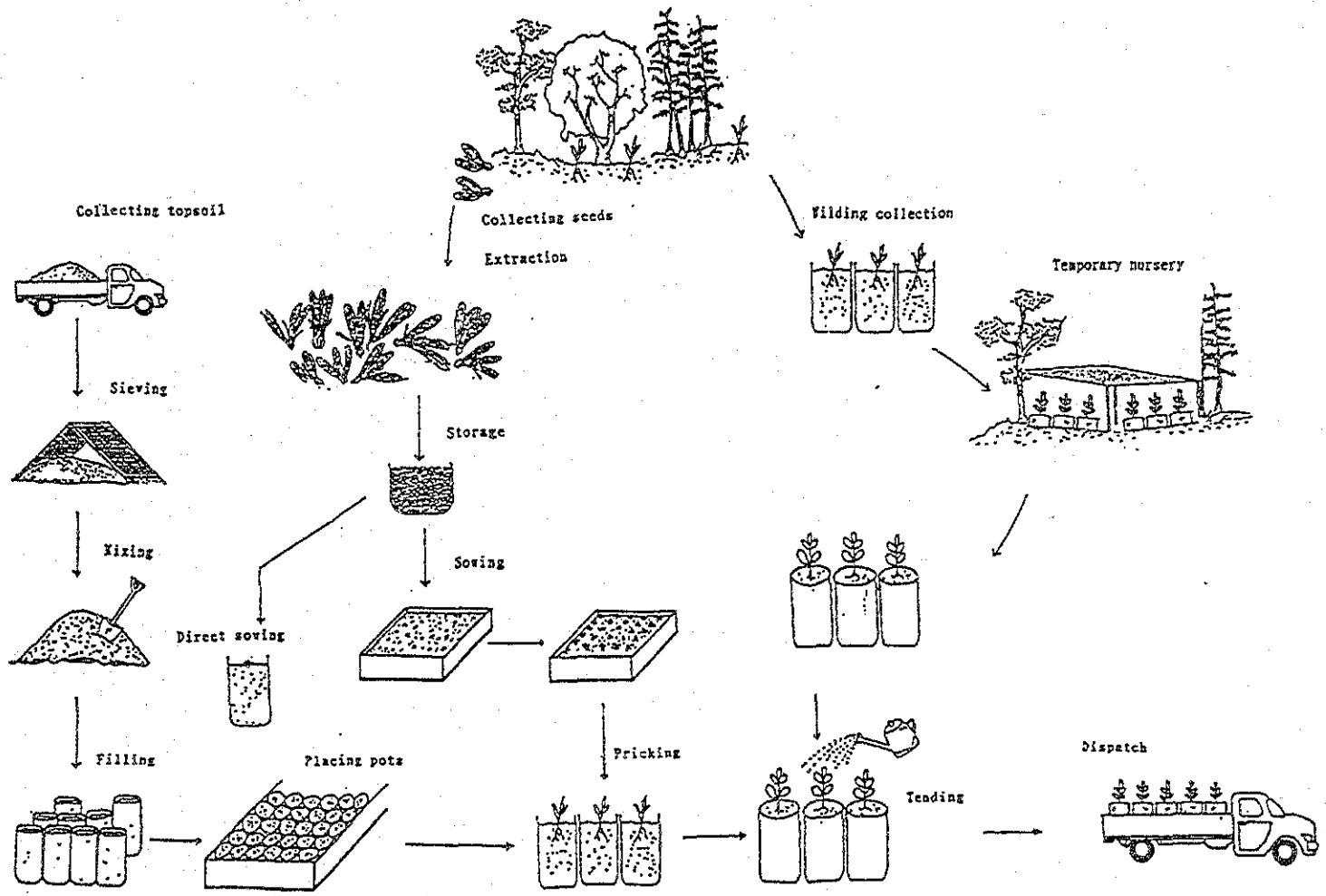


Fig. 10. Graphic representation of seedling cultivation wok

(1) Seedlings Production From Seeds

Dipterocarp seeds were difficult to preserve because of their generally short life-spans and hard to store because of their high water content, which required them to be sealed in polyvinyl bags immediately upon collection to prevent drying. Furthermore, they must be stored at temperatures between 17 °C - 21 °C.

Seedlings production involves either germinating seeds in seedbeds and then transferring them to pots, or germinating them in pots without prior seedbed germination. Pots slightly large in size (6 x 9 inches) were used. Shading, which is necessary at first, must be removed towards the end to prevent turnion which made the seedlings susceptible to damage after they are planted in the field. The size of seedlings before transplanting is 30 to 60 cm. Although seedlings yields of *Shorea* spp. were said to be low, of 12,265 of 13,500 *Shorea leprosula* seeds and 10,350 of 11,100 *Shorea pauciflora* seeds sprouted, yielding 7,000 to 8,000 good seedlings.

a. Seed Collection

Although dipterocarp seeds vary from region to region and even among individual seeds, they mature when their dry weight has become constant, at which time their wings begin to brown This is the optimum time for collection. Only roughly 5% of flowers result in mature seeds, of which, it must be noted, many suffer insect damage after falling from the mother tree. It is said that a single large-diameter *meranti* yields roughly 5,000 seeds.

Table 20 shows the per-tree seed yields between March and October 1993.

① Seeds of a single species of dipterocarps differ greatly in size and shape depending on the individual seed, the location of collection, and whether the year in question was generally a bountiful or bad one. Judging from the small number of cases, the duration between flowering and seed maturation can be as short as one month or as long as six. The optimum time for collection (when the seeds mature) is when dryness is constant and seed browning has progressed from the wings to the seed coat, as previously stated in section 2:3-2, "Seed Collecting Periods". Because of short seed life, the most important prerequisite in seed production and seedling production is to collect seeds during this short period.

② Some *Leguminosae* seeds have hard coats; others relatively thin coats and, consequently, high water absorbency. Seeds collected for this project included *Intsia palembanica* and *Sindora coriacea*, which have hard coats; *Dialium* spp. seeds are dry but have thick coats.

The low water content of these seeds is conducive to storage but not to germination, the rates of which for *Sindora* and *Intsia* seeds collected for this Project (45% and 25% respectively) were considerably lower than those of *Shorea leprosula* (91%) and *Shorea pauciflora* (93%). Mechanical breakage (i.e., using saws, knives, files or sand to break the seed coat) is one way to increase rates of germination, but is time consuming because of small size of seed, and, if the breakage is too deep, can harm the cotyledon and allow bacteria to enter. Because of high-volume seed collection in this project, the direct planting of seeds in pots (without the mechanical breakage of seed coats) is relied on for seedling production.

Table 20. Seeds yields per tree

Species	Source	Date Collected	Number of mother tree	Amount of seed collected	Method of collection
1. *Shorea parvifolia*	Bentong Pahang	Mar - Apr 1993	1	15,000 seeds	Using nets to collect falling seeds
2. *Shorea leprosula*	Gerik Perak	Aug 1993	1	13,500 seeds	Climbing the mother tree to collect seeds
3. *Shorea macroptera*	Gerik Perak	Sep 1993	1	12,900 seeds	Climbing the mother tree to collect seeds
4. *Shorea curtisii*	Gerik Perak	Aug 1993	1	12,400 seeds	Climbing the mother tree to collect seeds
5. *Shorea pauciflora*	Gerik Perak	Aug 1993	1	11,100 seeds	Climbing the mother tree to collect seeds
6. *Shorea ovata*	Gerik Perak	Aug 1993	1	35,100 seeds	Climbing the mother tree to collect seeds
7. *Intsia palembanica*	Gerik Perak	Aug 1993	1	5,100 seeds	Climbing the mother tree to collect seeds
8. *Parashorea densiflora*	Gerik Perak	Aug 1993	1	21,200 seeds	Climbing the mother tree to collect seeds
9. *Sindora spp.*	Gerik Perak	Sep 1993	1	10,600 seeds	Climbing the mother tree to collect seeds
10. *Dialium spp.*	Gerik Perak	Oct 1993	1	23,500 seeds	Climbing the mother tree to collect seeds

b. Soil Mixing

The type of soil used was a mixture of natural forest topsoil (i.e., mixed soil with a 30% sand content) and chicken or cow manure, or chemical fertilizer purchased commercially. Soil was mixed by placing the natural topsoil in a sifter and then mixing in a soil mixer. Topsoil and manure were mixed at a ratio of 8:2; topsoil and chemical fertilizer at a ratio of 9:1.

c. Potting

Potting involved placing soil on the concrete floor of the workroom and then packing it directly into 6 x 9 inch polyvinyl pots. For wildings, only natural forest soil, which was sifted with a simple sifter and then packed into the 6 x 9 inch pot, was used. Table 21 shows the efficiency of potting work: using 6 x 9 inch pots, the direct potting of soil placed on the concrete floor resulted in rates of 150 to 200 pots per worker/day. When subcontracted (at the rate of 5 cents per pot), the rate was 300 to 400 pots per worker/day.

Table 21. The efficiency of potting work

Category	Direct supervision at the nursery workroom	Subcontracted at the nursery workroom	Wildings collected from natural forests	Remarks
Pots per worker	150 - 200	300 - 400	80 - 120	Pot size: 6 x 9 inches

Note: Potting was subcontracted at the rate of 5 cents per 6 x 9 inch pot.

d. Transport And Arrangement Of Pots

After potting was completed, pots were loaded onto tractors, Hilux and lorry and transported to the seedbeds.

At the seedbeds, the pots were arranged on the concrete-covered seedbed surface. Wildings were arranged on a 5-by-10 metres temporary seedbed prepared in the natural forest, kept there for 1 to 3 months and transported by lorry to the Chikus nursery. Here the seedbeds were arranged after verifying that they had taken root and begun to grow in the pots.

e. Planting

Seeds were planted either in planters or pots.

The *Shorea parvifolia* seeds first collected were planted in planters; the *Shorea leprosula* seeds collected in 1993 in seedbeds (a pot bed containing soil).

Shorea seedlings, because of their long roots, were transplanted earlier because the 10 cm.-deep beds would otherwise impede root growth.

There are now over 10,000 seeds planted in seedbeds and pots. At quantities of around 3,000, however, seeds were planted either in planters or pots, of which the former was considered the optimum method of planting because of its conduciveness to observation and, particularly when dealing with small quantities of large seeds like those of dipterocarps, to the verification of germination. And while large numbers of planters taking up large amounts of space were needed when a high volume of seeds had been collected, planters resulted in the highest rates of germination (though this depended on the species). Planting in seedbeds entailed considerable deviation in germination rates; in one case involving *Shorea curtisii*, only 200 of 20,000 seeds planted germinated. In contrast, all methods of planting were deemed suitable for the *Shorea macroptera* seeds collected in September 1993. Hence, we have discovered that some species required gentle handling in planters, while other did not.

In nearly all cases topsoil was used for covering. Seeds germinate in two to three days and grow to a height of roughly 5 cm. in 10 days if watered twice a day.

However, a mixture of saw dust and coconut husk (which was selected on the basis of a successful germination experiment with *Shorea curtisii* seeds in 1993) used as covering for *Shorea ovalis* seeds collected in February 1994 resulted in a germination rate of nearly 100%, which was believed to be because the moisture retaining properties of this mixture helped create a stable germination environment.

f. Transplanting

The method of transplanting used was one in which seedlings were first planted in planters and moved to transplant pots after attaining a height of 5 to 10 cm. Arranging the plants on the bed under covering made it possible to complete transplanting in one day.

No particular problems were encountered with *Shorea leprosula*, *Shorea macroptera* or *Shorea pauciflora* seedlings transplanted in October 1993 (over 90% of which took root), but *Parashorea* seeds germinated badly and had a survival rate after transplanting of only 50% to 60%. Furthermore, between 10% and 20% of the seedlings of species other than *Shorea* (which were planted in pots) suddenly die two months or longer after germination.

g. Sun Shade

In Malaysia, where seedlings were grown mainly in forest nurseries, seedbeds were prepared under the cover of large trees, and so artificial covering was not normally needed. Because this project's nurseries were prepared in open fields on flat sites, therefore, covering was used to protect seedlings from the strong direct sunlight (and daytime temperatures that can reach 40 °C). In dipterocarp seedbeds, netting with sunlight filtering factor of 50% or 70% was used.

See Table 22 for the maximum and minimum temperatures and humidity levels under nursery covering.

Table 22. Temperatures and humidity levels at seedbed relative illuminance

Category	December 1993		11	12	13	14	15	16
Relative illuminance with covering: 25%	Temperature	Maximum	28	32	33	36	35	35
		Minimum	22	22	22	22	22	22
	Humidity	Maximum	98	98	98	98	98	98
		Minimum	78	63	64	53	56	52

Category	December 1993		18	19	20	21	22	23
Relative illuminance with covering: 50%	Temperature	Maximum	29	35	37	37	28	31
		Minimum	23	21	22	22	22	22
	Humidity	Maximum	97	96	97	99	99	98
		Minimum	65	53	47	45	81	68

Category	December 1993		25	26	27	28	29	30
Relative illuminance with covering: 70%	Temperature	Maximum	31	35	36	34	30	36
		Minimum	22	22	22	22	23	21
	Humidity	Maximum	99	98	99	98	98	98
		Minimum	66	54	52	54	60	50

Category	January 1994		5	6	7	8	9	10
Relative illuminance with covering: 100%	Temperature	Maximum	38	39	38	36	37	34
		Minimum	20	20	22	21	21	22
	Humidity	Maximum	98	100	100	98	98	98
		Minimum	47	45	45	50	46	53

Note: 1. Minimum temperature and minimum humidity were measured between 11:00 a.m. and 3:00 p.m.
2. Minimum temperature and maximum humidity were measured between 6:00 p.m. and 6:00 a.m. the following morning.

h. Watering

Watering is performed once in the morning and once in the afternoon. However, it generally rains once a day (rainfall was virtually a daily occurrence in 1993), lasting usually for about an hour starting around 3:00 p.m. Being ideal precipitation conditions for nursery seedlings and the trees used in afforestation, seedlings' growth had been satisfactory. For wildings in temporary nurseries in natural forests, because they take root readily without watering, we felt that watering only once a day will be sufficient.

We intend to base the frequency of watering on the results of experiments now being carried-out.

i. Weeding

In weeding, which began in November 1993, nursery workers rotate (12 at a time, dividing into two teams) in weeding the 60 upper beds of pots and the 60 lower beds of wildings every three months. Until this rotation, the primary task was nursery work, which was carried out by five female nursery workers, who performed weeding of the seedlings (now numbering 70,000) being cultivated.

j. Fertilizer

Seedlings were fertilized with phosphate fertilizer no sooner than four months after transplanting. The amount, determined experimentally, is six grains per pot placed in three spots around the roots.

k. Planting Of Seedlings In The Field

The minimum height for seedlings for planting in the field is 40 cm. Even among seedlings of a single species, differences in growth were considerable: after 4 months, some were higher than 50 cm. while others only about 15 cm. Some seedlings when planting exceeded 1 m. in height.

The efficiency in which seedlings were transplanted to the field was enhanced by placing tables on the lorry bed and stacking the containers of seedlings on and under them.

(2) Cultivating Wildings

a. Soil Mixing

Topsoil taken from actual collection site was used for wildings from natural forests. The mycorrhiza naturally present in the topsoil is believed to promote the growth of dipterocarps.

b. Potting

Potting involved packing topsoil into polyvinyl pots in natural forests. Temporary nurseries required troublesome, time-consuming preparations, such as ground preparation and the hanging of netting to keep seedlings from being covered by falling leaves.

c. Wildings Collection

Wildings were collected between 8:00 and 10:00 a.m., when the temperature is low and humidity is high. Collected seedlings were placed in wet cotton sacks and quickly transported to temporary nursery prepared in the natural forest, and thereafter, placed in pots and watered. This method was selected based on the wildings cultivation experiments (see Table 23). The survey results in Table 23, though representing survival only 30 to 50 days after transplanting (and thus insufficient for predictions of future survival rates), show that the use of temporary nursery described in footnote 2 below tended to result in higher survival rates.

Table 23. Wildings survival rates 30 to 50 days after transplanting

Species	1. Nursery cultivation			2. Temporary nursery		
	Total number of seedlings	Number of surviving seedlings	Survival rate	Total number of seedlings	Number of surviving seedlings	Survival rate
Shorea leprosula	1,775	669	38%	1,734	989	57%
Shorea parvifolia	532	312	59%	428	277	65%
Total	2,307	981	43%	2,162	1,266	59%

Note: The steps in nursery cultivation (No. 1 above) are :-

i) Placing the extracted seedlings in wet cotton sacks.
ii) Transporting them quickly to the Chikus nursery.
iii) Placing the seedlings in pots at the nursery and cultivating them in seedbeds covered with netting, etc.

The steps in temporary nursery (No. 2 above) are :-

i) Placing the extracted seedlings in wet cotton sacks.
ii) Transporting them to a temporary seedbed in a natural forest.
iii) Placing the seedlings in pots for three weeks.
iv) Transporting the pots to the Chikus nursery and cultivating them in seedbeds covered with netting, etc.

d. Transplanting

Collected wildings were placed in pots at the temporary nursery by using a guide bar to make a hole roughly 5 cm. in diameter in the soil, into which the collected wildings were quickly placed and then watered. Most work was finished before 12:00 p.m., and by 1:00 or 2:00 p.m., the hottest time of day, the entire operation was nearly completed. Potting was completed by 3:00 p.m. or so, afterwhich preparations for the next day were made.

e. Seedlings Cultivation In Temporary Nurseries

Seedlings were kept for 1 to 3 months in temporary nurseries with the same natural conditions as the original natural forest (which enhances survival rates and seedlings growth), afterwhich they were transported to the Chikus nursery. The subsequent procedure is as follows: (1) Very delicate seedlings (e.g., *Parashorea*) were sprayed with a transpiration control chemical (brought from Japan) prior to transport. (2) Seedlings that had been in temporary nursery seedbeds for at least 2 months were fertilized in the same manner as that for seedlings raised from seed. (3) Natural precipitation was depended on, in order to recreate the conditions in natural forests. (In 1993, perhaps because of excessive rainfall no difference was perceived between watered seedlings and seedlings that received only natural rainfall). (4) Seedlings were covered with netting (with a sunlight filtration factor of 50% and placed at a height of 2.00 metres) in order to protect them from falling branches and leaves.

f. Transporting

When transporting, containers (each holding twenty-five 6 x 9 inch containers) were stacked on and under tables on the lorry in order to enhance the efficiency of transport.

The distance between collection area of wildings and Chikus nursery was very far, and most of the time we required 2 days to transport the seedlings without inflicting significant damage.

This transport procedure required one lorry driver and three workers.

g. The procedures for weeding and returning seedlings to the forest were the same as those for seedlings raised from seed.

3-4 Seedlings Production Experiments

Production of dipterocarps seedlings and other indigenous species involved many formidable problems, such as the difficulty in seed collection due to irregular fruiting, and the inability to store over long period. We had therefore performed various experiments in order to develop a system for supplying healthy seedlings by making full use of wildings.

These experiments involve the following parameters.

1) Experiments Concerning Species Selection
   (1) Phenological observation and data collection.
   (2) Sunlight conditions and growth.
   (3) Growth and resistance to drying and excessive moisture.

2) Experiments On Seedlings Production From Seeds
   (1) Seeds preservation experiments.
   (2) Germination experiments.
   (3) Seedlings production from seeds.
   (4) Mycorrhiza exposure experiment.

3) Wildings Cultivation Experiment
   (1) Wildings: Size at collection and subsequent growth.
   (2) The process of seedlings mortality in natural forests.
   (3) Pot size and seedlings growth.
   (4) Fertilization experiment.
   (5) Shading experiment.
   (6) Experiment on the efficiency of transpiration control chemical.

4) Experiment On Cuttings

5) Damage From Disease And Insects And Experiments On The Prevention Thereof.

6) Other Seedlings Cultivation Experiments.
   (1) Experiment on methods of promoting flowering.

In spite of plans for these experiments, almost none were performed in the first year because of delays in nursery preparations and other project aspects, and as a result much of the data is from experiments less than one year in duration. However, we plan to continue our experiments, observation and data collection.

1) Experiments Concerning Species Selection

The seedlings production of dipterocarps and other high-quality usable species scheduled for this project required a proper grasp of the phenology of the species in order to determine how many seeds and wildings will be needed each year. The following experiments had been performed to enhance our understanding in this area.

(1) Phenological Observation And Data

Large numbers of natural specimens of species scheduled for planting were selected for the regular observation on the extent of flowering and fruiting and seed falling.

The majority of trees designated for observation (ranging in diameter from 30 to 100 cm. and in height from 20 to 40 m.) were located in Chikus forest where seeds and wildings have been previously collected. These 20 observation trees encompassed 10 different species and located in 7 different locations.

See Table 24 for the species and locations of trees designated for observation.

Table 24. Trees designated for observation

Number of species designated for observation	Species	Place	Remarks
No. 1	*Shorea parviflora*	Lentang, Pahang	Seeds collected Mar. 1993
No. 2	*Dipterocarpus crinitus*	Gunung, Perak	Seeds collected Mar. 1993
No. 3	*Dipterocarpus cornutus*	Lentang, Pahang	Seeds collected Mar. 1993
No. 4	*Calophyllum spp.*	Gunung, Perak	Wildings collected May 1993
No. 5	*Shorea leprosula*	Chikus, Perak	Flower experiment Mar. 1993
No. 6	*Shorea leprosula*	Chikus, Perak	Flower experiment Mar. 1993
No. 7	*Shorea parviflora*	Chikus, Perak	Flower experiment Mar. 1993
No. 8	*Shorea parviflora*	Chikus, Perak	Flower experiment Mar. 1993
No. 9	*Neobalanocarpus heimii*	Chikus, Perak	Flower experiment Mar. 1993
No. 10	*Neobalanocarpus heimii*	Chikus, Perak	Flower experiment Mar. 1993
No. 11	*Neobalanocarpus heimii*	Batu Gajah, Perak	Recommended by the district forest officer
No. 12	*Palaquium gutta*	Papan, Perak	Wildings collected May 1993
No. 13	*Shorea pauciflora*	Gerik, Perak	Seeds collected Aug. 1993
No. 14	*Parashorea densiflora*	Gerik, Perak	Seeds collected Aug. 1993
No. 15	*Dipterocarpus cornutus*	Gerik, Perak	Seeds collected Aug. 1993
No. 16	*Shorea parviflora*	Chikus, Perak	Flower experiment Jul. 1993
No. 17	*Shorea leprosula*	Gerik, Perak	Seeds collected Sep. 1993
No. 18	*Shorea hypychra*	Papan, Perak	Wildings collected Jun. 1993
No. 19	*Shorea assamica*	Taiping, Perak	Wildings collected Dec. 1993
No. 20	*Shorea leprosula*	Chikus, Perak	Flower experiment Jul. 1993

Note: The two methods used in the flowering (induction) experiment were the use of cuts in the trunk to inhibit the flow of sap and the use of hormones to promote flowering.

Photo - A *Dipterocarpus cornutus* (Keruing gombang) designated as an observation tree

Photo - *Dipterocarpus cornutus* seeds

a. Results Obtained From The Observation Trees

Experiments on observation trees in August 1993 and February 1993 revealed no signs of flowering or fruiting. Flowering was observed for spp. *Hopea odorata* in February 1994 nearby Chikus natural forest. The designation of observation trees has thus steadily facilitated the verification of flowering and fruiting.

(2) Sunlight Conditions And Growth

Using wildings cultivated for six months to a certain height, an experiment was performed in which several degrees of shading were used to determine seedlings survival and growth at different levels of illuminance.

Results are shown in Table 25. The experimental conditions are as follows.

① Using netting, relative illuminance was adjusted to 5%, 25%, 50%, 70% and 100%.

② As the experiment was over one year in duration, slightly larger pots (6 x 9 inches) were used.

③ Fifty seedlings of each species were used for each illuminance level.

Table 25. Shading experiment

Species	Date Examined	Relative illuminance				
		5%	25%	50%	70%	100%
1. *Shorea laevis* (Balau kumus)	May 1993	27.4 (70%)	27.4 (100%)	26.5 (100%)	28.1 (100%)	26.8 (100%)
	Dec. 1993	29.3 (18%)	29.5 (98%)	29.1 (100%)	29.7 (94%)	28.5 (74%)
	Growth (cm)	1.9	2.1	2.6	1.6	1.7
2. *Heritiera spp.* (Mengkulang)	May 1993	11.6 (100%)	12.2 (100%)	13.2 (100%)	11.8 (100%)	11.5 (100%)
	Dec. 1993	15.3 (94%)	15.5 (98%)	15.5 (96%)	14.8 (96%)	14.5 (78%)
	Growth (cm)	3.7	3.3	2.3	3.0	3.0
3. *Neobalanocarpus heimi* (Chengal)	May 1993	41.7 (100%)	37.3 (100%)	37.8 (100%)	37.4 (100%)	43.2 (100%)
	Dec. 1993	45.9 (100%)	48.9 (100%)	45.0 (100%)	45.0 (100%)	50.7 (98%)
	Growth (cm)	4.2	11.6	7.2	7.6	7.5
4. *Palaquium spp.* (Nyatoh)	May 1993	27.5 (100%)	31.9 (100%)	30.8 (100%)	32.8 (100%)	32.9 (98%)
	Dec. 1993	29.5 (98%)	33.6 (94%)	32.8 (96%)	33.9 (92%)	34.9 (92%)
	Growth (cm)	2.0	1.7	2.0	1.1	2.0
5. *Drybalanops aromatica* (Kapur)	May 1993	49.0 (10%)	55.8 (98%)	55.1 (100%)	52.4 (98%)	52.1 (96%)
	Dec. 1993	0 (0%)	75.6 (96%)	75.8 (98%)	70.8 (100%)	67.9 (94%)
	Growth (cm)	0.0	19.8	20.7	18.4	15.1

Note: 1. The shading experiment began in March for each species.
2. Figures for seedlings height are in centimetres. Parentheses indicate the percentage of seedlings that took root and begin to grow.

a. Conclusions Drawn From The Results Of Shading Experiments

① After approximately seven months, *Shorea laevis* (Balau kumus) showed good survival rate and growth at 50% illuminance. However, seedlings grown under 100% and 5% illuminance recorded a survival rate of less than 80% and it is expected that the survival rate will be further reduce as the experiment continues.

② Although many of the *Heritiera* spp. (Mengkulang) took root and grew at 25% illuminance, only 78% of those grown at 100% illuminance (uncovered) took root, with survival rates expected to drop further as the experiment continues.

③ Nearly 100% of the *Neobalanocarpus heimii* (Chengal) took root, except those grown in a nearly enclosed state (5% illuminance), growth was good at 8 to 12 cm.

④ In the case of *Palaguium* spp. (Nyatoh), 5 to 50 percent illuminance resulted in more seedlings taking root and almost no differences in growth.

⑤ *Dryobalanops aromatica* (Kapur) grew well at an illuminance of 50%, reaching heights of 20.7 cm. in roughly 7 months; nearly all those grown with an illuminance of 5% died.

While these results show that 25% to 70% illuminance results in favourable rates of survival and growth, the 100% illuminance encountered in open-field plantation necessitates that species suited to such conditions be chosen. These results revealed that the three species *Neobalanocarpus heimii* (Chengal), *Palaquium* spp. (Nyatoh) and *Dryobalanops aromatica* (Kapur) are suited to open-field plantation, while the low survival rates at 100% illuminance of seedlings of the remaining two species suggest that they would be suited to line planting.

(3) Growth And Resistance To Drying And Excessive Moisture

High survival rates and growth will not be possible, no matter how good the seedlings planted are, unless species suited to soil conditions are selected on the basis of their resistance to drying and excessive moisture.

Table 26 shows the survival rates and growth in an experiment performed at the Chikus nursery in which potted seedlings were watered at one of four frequencies: twice a day, once a day, once every two days, or once every three days.

Table 26. Growth under different soil moisture conditions

Species	Date Examined	Frequency of watering: Twice every day	Once every day	Once every 2 days	Once every 3 days
1. *Shorea leprosula* (Meranti tembaga)	Jun. 1993	34.9 (100%)	36.2 (100%)	35.3 (100%)	35.1 (100%)
	Dec. 1993	37.8 (82%)	39.7 (72%)	38.3 (90%)	37.3 (95%)
	Growth (cm)	2.9	3.5	3.0	2.2
2. *Drybalanops aromatica* (Kapur)	Jun. 1993	31.6 (100%)	37.4 (100%)	38.5 (100%)	36.4 (100%)
	Dec. 1993	40.2 (87%)	46.7 (95%)	44.4 (97%)	38.5 (100%)
	Growth (cm)	8.6	9.3	5.9	2.1
3. *Shorea parvifolia* (Meranti sarang punai)	Jun. 1993	27.1 (100%)	25.1 (100%)	19.0 (100%)	23.1 (100%)
	Dec. 1993	30.9 (50%)	30.7 (57%)	21.6 (67%)	26.7 (67%)
	Growth (cm)	3.8	5.6	2.6	3.6
4. *Pentaspadon motleyi* (Pelong)	Jun. 1993	20.1 (100%)	20.2 (100%)	17.8 (100%)	17.7 (100%)
	Dec. 1993	25.2 (92%)	25.0 (87%)	23.0 (67%)	21.7 (62%)
	Growth (cm)	5.1	4.8	5.2	4.0
5. *Neobalanocarpus heimii* (Chengal)	Jun. 1993	41.6 (100%)	52.9 (100%)	41.4 (100%)	41.1 (100%)
	Dec. 1993	44.6 (97%)	56.1 (100%)	42.2 (95%)	42.7 (97%)
	Growth (cm)	3.0	3.2	0.8	1.6
6. *Palaquium spp.* (Nyatoh)	Jun. 1993	27.8 (100%)	24.5 (100%)	26.1 (100%)	28.2 (100%)
	Dec. 1993	32.4 (80%)	31.0 (95%)	31.2 (97%)	31.8 (100%)
	Growth (cm)	4.6	6.5	5.1	3.6

Note: 1. This experiment was carried out in June 1993.
2. Figures for seedlings height are in centimetres. Parentheses indicate the percentage of seedlings that took root and began to grow.
3. Forty specimens of each species were used.
4. Large pots (12 x 20 inches) were used.

a. The Relationship Between Growth And The Frequency Of Watering

① Over 90% of *Shorea leprosula* seedlings watered once every two or three days took root; watering once every day or every two days resulted in greater growth.

② Over 95% of *Dryobalanops aromatica* seedlings watered once every day, 2 days or 3 days took root; watering once daily resulted in the greatest growth.

③ *Shorea parvifolia* had the lowest survival rates of all species at each frequency of watering. Growth was good with once-a-day watering.

④ For *Pentaspadon motleyi* seedlings, watering once or twice a day was conducive to high survival rates and good growth.

⑤ Survival rates of *Neobalanocarpus heimii* seedlings were high regardless of the frequency of watering, although growth was the lowest compared to other species.

⑥ Survival rates of *Palaquium sp.* were over 95% when watered once every day, two days or three days. Growth was greatest when watered once every day.

The above results reveal that for all species other than *Pentaspadon motleyi*, watering once every day, two days or three day; enhanced survival rates better than does watering twice daily. In terms of growth, watering once daily produced good growth for all species, suggesting a general seedlings preference for dry conditions. In contrast, *Pentaspadon motleyi* was found to flourish better under excessively moist conditions rather than dry conditions.

Consequently, these characteristics must be taken into consideration when selecting species for afforestation.

2) Experiments On Cultivating Seedlings From Seeds

Because of the difficulty in securing consistent supplies of seeds of dipterocarps and other species due to the many unknown factors in their flowering and fruiting patterns, the Forestry Department Peninsular Malaysia had relied mainly on wildings in its afforestation operations and, therefore little study was carried out on techniques for cultivating seedlings from seed. The successful collection in 1993 of the seeds of the 16 selected species was offset by rotting and other problems, and experiments designed to urgently develop standards for growing seedlings from seed were begun.

(1) Seed Preservation Experiments

The impracticality of coordinating seeds collection with nursery work schedules necessitated the short-term storage (at the proper temperature) of seeds that had been collected. We therefore performed a seeds preservation experiment to determine the standards and conditions for a seeds storehouse.

The results of this experiment are shown in Tables 27 and 28. The experimental conditions are as follows:-

① Seeds were stored at a fixed temperature of 20 °C.

② Seeds were collected by climbing the mother tree and cutting off seed-bearing branches.

③ Collected seeds were placed in polyvinyl bags for transport.

④ By handling all seeds of a given species in the same manner (steps 1 through 3 above) and cutting open those with mold or rot, the colouring that indicated whether a seed is alive or dead was determined (living seeds have brown seed coats while those of dead seeds have black colouring).

⑤ The number of dead seeds was determined by cutting all seeds to determine which were dead and which were alive.

Table 27. Seeds preservation experiment (at 20 °C)

Species	Date Collecte	Length of storage	Number of seeds used			Remarks
			Number of specimens	Number of living seeds	Number of dead seeds	
1. *Shorea leprosula*	Aug. 21	25 days	95	66	29	
2. *Shorea curtisii*	Aug. 21	25 days	256	150	106	
3. *Shorea macropter*	Aug. 24	22 days	77	48	29	
4. *Shorea pauciflora*	Aug. 19	27 days	175	175	0	
5. *Parashorea spp.*	Aug. 19	27 days	190	0	190	All seeds rotted
6. *Intsia palembanic*	Sep. 10	5 days	210	210	0	
7. *Shorea ovata*	Sep. 9	6 days	100	100	0	

Table 28. Germination after experiment storage at 20 °C

Species	Number of seed planted (Sep. 14)	Date of inspection after planting: Number germinated as of Sep. 17	Number germinated as of Sep. 25	Number germinated as of Sep. 30	Number germinated	Germination rate %
1. *Shorea leprosula*	66 seeds	0	0	All seeds rotted	0	0
2. *Shorea curtisii*	150 seeds	4	9	All remaining seeds had rotted	13	9
3. *Shorea macropter*	48 seeds	0	0	All seeds rotted	0	0
4. *Shorea pauciflora*	50 seeds	10	4	All remaining seeds had rotted	14	28
5. *Intsia palembanic*	32 seeds	4	16	All remaining seeds had rotted	20	63
6. *Shorea ovata*	100 seeds	78	16	All remaining seeds had rotted	94	94
7. *Koompassia spp.*	100 seeds	19	18	All remaining seeds had rotted	37	37
8. *Sindora spp.*	100 seeds	0	8	All remaining seeds had rotted	8	8

Note: 1. Of all species above, the experimental germination of surviving seeds of *Shorea leprosula*, *Shorea curtisii*, *Shorea macroptera*, *Shorea pauciflora*, *Intsia palembanica*, and *Shorea ovata* will be continued.
2. Seeds were stored in polyvinyl bags at a constant temperature of 20 °C and regularly examined.
3. The germination experiment was performed using 50-seed germination plates maintained at proper moisture levels.

a. The Results Of Seeds Preservation Experiments And Subsequent Germination Experiments

① As Table 27 shows, 69% of *Shorea leprosula* seeds survived 25-day storage at 20 °C, but nearly all showed a subsequent lack of germinative capabilities and hence molded or otherwise rotted.

② Table 27 shows that although 59% of *Shorea curtisii* seeds survived 25-day storage, only 1% subsequently germinated, with the remainder rotted due to mold growth, etc.

③ *Shorea macroptera*: 62% survived 22-day storage at 20 °C, but subsequently lacked germinative capabilities, with most dying from rotting, etc. as a result (Table 27).

④ *Shorea pauciflora*: Most survived 27 days of storage at 20 °C, but of these 50 surviving seeds, only 28% successfully germinated, the remainder dying from rotting, etc. (Table 27).

⑤ *Intsia palembanica*: All seeds survived 5-day storage at 20 °C, and 63% successfully germinated.

⑥ *Shorea ovata*: All survived 6-day storage at 20 °C and a full 94% germinated.

⑦ *Parashorea* spp.: All died after 27 days of storage, revealing the species' unsuitability to storage.

⑧ The species *Koompassia* spp. and *Sindora* spp. were subjected only to germination experiments, in which germination rates were 37% and 1%, respectively.

These results suggest that some species could be stored for a long time. It made possible to coordinate seedlings planting and other operations with nursery work schedules. While many seeds were collected between August and October 1993, the limited number (5) of nursery workers was one of the factors in high seeds mortality rate and other problems arising in nursery work control.

Hence, from now on an essential part of nursery work will be the storage for a proper length of time of suitable species and the hiring of temporary workers.

(2) Germination Experiments

2)-1 Germination Experiments

A germination experiment was performed in which seeds were collected using different methods in order to determine how the method of collection affects germination rates, and to apply this knowledge to future seeds collection and seedlings production.

The results of this experiment are shown in Tables 29 through 31. The conditions of the experiment are as follows:-.

① Four species of seeds were collected between March and May 1993. The wings were removed right after collection and the rates of germination were examined.
② Seeds planted on March 15 and 20 and May 18 were those that had been collected from the ground.
③ Seeds planted between March 30 and April 21 were those collected using a net placed under fruiting trees.
④ The survival rate after germination was determined by counting the number of surviving seeds in December 1993.
⑤ These mother trees where seeds had been collected were designated as observation trees.

Table 29. Experiment on germination rates and growth of *Shorea parvifolia* (Meranti sarang punai)

Date planted	Number of seeds planted	Number germinated	Germination rate %	Number of seedling that died after germination	Number of seedling that survived after germination	Remarks
Mar. 15	300	139	46	23	116	Investigated on May 24, 1993
Mar. 20	261	80	31	10	70	
Mar. 30	632	529	84	98	431	
Apr. 9	2,502	1,607	64	370	1,237	
Apr. 10	1,896	1,801	95	374	1,427	
Apr. 11	1,071	976	91	152	824	
Apr. 21	546	481	88	97	384	
May 18	210	114	54	3	111	
Total	7,418	5,727	77	1,127	4,600	

Note: This mother tree, located in the forest under jurisdiction of the Lentang nursery office of the Bentong district forest office (Pahang), was designated as observation tree No. 1.

Table 30. Germination rates and growth of *Dipterocarpus crinitus* and *Hopea odorata*

Species	Date planted	Number of seeds planted	Number germinated	Germination rate %	Number of seedling that died after germination	Number of seedling that survived after germination
1. *Dipterocarpus crinitus* (Keruing mempelas)	Mar. 15	649	95	15	4	91
2. *Hopea odorata* (Merawan siput jantan)	Mar. 15	79	79	100	0	79

Note:
1. Rates of germination were investigated on May 24, 1993.
2. After germination, the number of surviving seedlings were investigated in December 1993.
3. Seeds were collected with netting placed around the mother tree (located in Besout).
4. The *Dipterocarpus crinitus* mother tree was designated as observation tree No. 2.
5. *Hopea odorata* seeds measuring 4 to 6 mm. in thickness were selected.

Table 31. Germination rates and growth of *Dipterocarpus crinitus* (Keruing gombang)

Date planted	Number of seeds planted	Number germinated	Germination rate %	Number of seedling that died after germination	Number of seedling that survived after germination	Remarks
Mar. 20	261	80	31	10	70	The germination rate was investigated on May 24, 1993

Note: 1. After germination, the number of surviving seedlings were investigated in December 1993.
2. Seeds used were those that had already fallen to the ground.
3. This mother tree, located in the forest under jurisdiction of the Lentang nursery office of the Bentong district forest office (Pahang), was designated as observation tree No. 3.

a. The Results Of The Germination Of Species Collected Between March And May 1993

① The germination rates of *Shorea parvifolia* seeds collected with netting placed around mother trees were good. However, the germination rate of seeds that had already fallen to the ground were between 50% - 60% or less.

② As *Dipterocarpus crinitus* seeds had suffered considerable bird- and insect-inflicted damage before falling from their branches, seeds collected with netting showed poor germinative capabilities, thus rendering netting ineffective.

③ Because of their small size, *Hopea odorata* seeds were eaten by birds or insects in small amounts, and fallen seeds had extremely high rates of germination.

④ *Dipterocarpus cornutus* are large in size and frequently eaten by insects and birds. In this experiment only fallen seeds were planted, yielding poor germination rates.

Because of the considerable variation in germination rates depended on method or seed collection, we must determine the right method of collection for each species in order to find one that best facilitates seeds collection and is thus conducive to high germination rates and favourable growth.

2)-2 Germination Experiments

The following is a description of the results (e.g., germination rates) obtained in experimentation in which the seeds of 10 species (collected between July and October 1993 in the jurisdiction of the Gerik district forest office of the Perak State Forestry Department) were planted, before which their wings were removed.

Tables 32 and 33 show the results of the experiment in which seeds were sown after being stored in a moisture-maintained state for six days in the nursery. The results in Tables 34 through 37 are for seeds sown after similarly stored for two weeks. Table 38 shows the results obtained with seeds sown within three days of collection.

Table 32. Germination experiment of *Shorea leprosula* and *Shorea pauciflora*

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
(1) *Shorea leprosula* (Meranti tembaga)	Aug. 28	13,500	12,265	90.9%	These seeds were collected in the jurisdiction of the Gerik district forest office
(2) *Shorea pauciflora* (Meranti nemesu)	Aug. 26	11,100	10,350	93.2%	

Note: 1. Seeds were collected by climbing the mother tree.
2. Germinated seedlings were examined on October 25, 1993.

Table 33. Germination experiment of *Shorea macroptera* and *Shorea ovata*

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
(1) *Shorea macroptera*	Sep. 15	180	180	100%	These seeds were collected in the jurisdiction of the Gerik district forest office
(Meranti merantai)	Sep. 27	180	180	100%	
Total		360	360	100%	
(2) *Shorea ovata*	Sep. 27	561	278	49.6%	
(Meranti sarang punai bukit)	Oct. 10	500	388	77.6%	
Total		1,061	666	62.8%	

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on November 25, 1993.

Table 34. Germination experiment of *Sindora* spp. and *Intsia palembanica*

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
(1) *Sindora spp.*	Sep. 20	650	161	24.8%	These seeds were collected in the jurisdiction of the Gerik district forest office
(Sepetir)	Sep. 25	650	167	25.7%	
Total		1,300	328	25.2%	
(2) *Intsia palembanica*	Sep. 20	500	273	54.6%	
(Merbau	Sep. 25	500	181	36.2%	
Total		1,000	454	45.4%	

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on December 1, 1993.

Table 35. Germination experiment of *Dipterocarpus cornutus*

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
Dipterocarpus curnutus	Sep. 10	1,000	545	54.5%	These seeds were collected in the jurisdiction of the Gerik district forest office
(Keruing gombang)	Sep. 15	1,000	404	40.4%	
Total		2,000	949	47.5%	

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on December 1, 1993.

Table 36. Germination experiment of *Parashorea* spp.

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
Parashorea spp.	Sep. 23	500	79	15.8%	These seeds were collected in the jurisdiction of the Gerik district forest office
(Gerutu pasir)	Sep. 29	500	114	22.8%	
Total		1,000	193	19.3%	

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on December 1, 1993.

Table 37. Germination experiment of *Dialium* spp.

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
Dialium spp.	Oct.20	600	79	13.1%	These seeds were collected in the jurisdiction of the Gerik district forest office
(Keranji)	Nov. 5	600	42	7.0%	
Total		1,200	121	10.0%	

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on December 1, 1993.

Table 38. Germination experiment of *Shorea curtisii* under different planting conditions

Species	Date planted	Number of seeds planted	Number germinated	Germination rate	Remarks
Shorea curitsii (Meranti seraya) Total	Sep. 22	900	213	23.7%	(1) Germination rate obtained with saw husk
	Sep. 25	1,209	555	45.9%	(2) Germination rate obtained with coconut husk
	Sep. 23	10,291	672	6.5%	(3) Germination rate obtained by immediate planting in pots

Note: 1. Seeds were immediately planted in pots and examined roughly 1 month later.
2. Seeds were collected by climbing the mother tree.
3. Germinated seedlings were examined on October 23, 1993.

a. The Results Of The Germination Of 10 Species Of Seeds Collected Between July and October 1993

① Table 32: Germination rates of *Shorea leprosula* and *Shorea pauciflora* were extremely high, most likely due to the timing of seeds collection and the fact that they were collected directly from the mother tree before falling.

② Table 33: The germination rate of *Shorea macroptera* seeds was extremely high, also the result of the timing of seed collection and direct collection. In addition, this species' excellent germinative capabilities made it the easiest to handle among all 10 species.
Seeds of *Shorea ovata* (smaller than those of *Shorea parvifolia*) had lower rates of germination than the other species, due to the fact that direct potting made them vulnerable to rats (roughly 20 cm. long).

③ Table 34: The poor germination rates of *Sindora* spp. and *Intsia palembanica* were due, in the case of the former, to poor handling in view of their double structure and to partial rotting caused by their 2-week storage in the nursery warehouse; and, in the case of the latter, to partial rotting (also caused by storage for more than 2 weeks in the nursery warehouse) and to thick seed coats that hampered proper treatment (i.e., manually cutting) prior to planting. However, these seeds currently continue to germinate.

④ Table 35: The diminished germinative capabilities of *Dipterocarpus cornutus* seeds were believed to be due to their two-week storage in the nursery warehouse and the fact that they were directly potted without manual cutting or other treatment. However, these seeds germinated better than those collected between March and May.

⑤ Table 36: One *Parashorea* tree can yield up to 50,000 seeds, and 23,000 seeds were collected on the first day of the experiment. On the following day, however, the seeds had began to germinate but were then planted in pots in the nursery operation. This resulted in most of the seeds being eaten by rats, and although the seeds were later planted in the nursery seedbed, all but 10% failed to germinate. Almost 100% of those seeds left on the ground around the mother tree germinated. One month later 10,000 of these wildings were collected and cultivated at a temporary nursery in Gerik.

⑥ Table 37: At present only 10% of the *Dialium* seeds planted have germinated. This delayed germination was due to the reason that the seeds were planted without cutting their seed coats first. These seeds (which were capable of surviving prolonged storage) currently continue to germinate.

⑦ Table 38: The extremely poor rate of germination of *Shorea curtisii* seeds reflected the fact that in three days nearly all had died of mold or rot. The first day of collection yielded 23,000 seeds, all of which died of mold or rot prior to sowing. Almost none of the 10,000 seeds collected on the second day germinated despite being sown directly in pots, and the results of Table 38 reflect subsequent changes in the germinative conditions for this species. It was thus determined that the best results were achieved with sowing medium containing coconut husk, the method we have selected for future use.

The investigation described above, which encompassed germination rates and types of seed storage boxes, revealed that many factors must be properly coordinated for successful germination, such as the different germinative conditions of each species, nursery work preparations, seeds treatment prior to sowing, and the proper timing for seeds collection. Learning from this experience, we have hired additional workers, constructed additional seedbeds, re-examined nursery facilities (including the construction of a germination room) and considered which types of storage and treatment would be optimum for seeds collected over a short period of time.

Also, because of the large number of seeds collected during the short period in this experiment, seeds were provided with moisture and sown immediately without any prior treatment.

(3) Production Of Seedlings From Seeds

This involved germinating seeds in nursery seedbeds and transplanting the seedlings into pots of 6 x 9 inches in size. A certain amount of shade must be provided during seedlings production.

See Table 39 for the growth of dipterocarps.

Table 39. Production of seedlings from seeds

Species	Date examined		Height increment	Date planted
	Jun. 1993	Dec. 1993		
Dipterocarpus crinitus (Keruing mempelas)	7.9 cm.	12.6 cm. (100%)	4.7 cm.	Mar. 15
Dipterocarpus cornutus (Keruing gombang)	13.3 cm.	18.2 cm. (97%)	4.9 cm.	Mar. 20
Dipterocarpus crinitus (Keruing mempelas)	11.6 cm.	22.7 cm. (99%)	11.1 cm.	Apr. 11
Dipterocarpus crinitus (Keruing mempelas)	5.0 cm.	9.1 cm. (92%)	4.1 cm.	Mar. 15

Note: 1. Parentheses indicate survival rates.
2. The height increment is between June to December 1993.

Photo - *Dipterocarpus crinitus* seedlings (grown from seeds) used to determine growth

a. Results Of Seedlings Production From Seeds

Despite differences in growth rate among seedlings planted in 6 x 9-inch pots in March and April, subsequent growth was steady, and growth was examined every three months beginning in June 1993, with the 3rd. examination performed in December.

① While all *Dipterocarpus crinitus* seeds took root and grew healthily without damage from disease or insects, their growth over the six-month period was only roughly 5 cm. At this rate it would take over one year to achieve a suitable height for planting.

② *Dipterocarpus cornutus* seeds had a survival rate of 97%, but like the above species grew only about 5 cm. in six months and require over one year before it could be planted.

③ *Shorea parvifolia* responded well, growing approximately 11 cm. in six months from June to December.

④ *Hopea odorata* seeds, despite their small size, grew at extremely slow rates after germination (roughly 4 cm. in six months) and would hence require over one year before they are ready for planting. Fortunately, large number of wildings were collected from the natural forests, enhancing the availability of this species.

The above demonstrates that we must regularly collect data from seedlings produced from seeds. To improve the seedlings production further, studies should be carried out to determine its relationship with application of fertilizer, disease and insect attack and their counter-measures and finally the time required to raise the seedlings into a suitable size before it could be planted in the field.

(4) Mycorrhiza Exposure Experiment

Mycorrhiza, which enhances the growth of dipterocarps, had been examined as one way of improving the growth of seedlings grown from seeds in nurseries. Although wildings already contain mycorrhiza at the time of collection, those grown from seeds in nurseries were not exposed to it. Table 40 is a comparison of data on seedlings provided with mycorrhiza and those not provided with mycorrhiza.

This experiment was performed with the cooperation of a company in Bidor that sells mycorrhiza as well as soil.

a. The Conditions Of The Experiment are as follows:-

① Commercially purchased soil containing mycorrhiza and soil dug up near the Chikus nursery (from a depth of no more than 1 m.) were mixed at a ratio of 1:1.

② One hundred seedlings of each species were planted in pots.

③ These seedlings were planted in pots on October 20, 1993.

b. Results Of The Experiment Using Mycorrhiza

In October 1993, the seedlings were transplanted into pots containing soil into which mycorrhiza had been mixed, after which survival rates and amounts of growth were recorded. The results show that more species had lower rates of survival in the pots containing mycorrhiza.

However, after three months the actual effects of mycorrhiza are still not clear.

Photo - A *Shorea leprosula* seedling with mycorrhiza on its roots

Table 40. Mycorrhiza exposure experiment

Species	Date examined	Seedlings exposed to mychorrhiza (cm.)	Seedlings not exposed to mychorrhiza (cm.)	Remarks
(1) *Shorea macroptera* (Meranti melantai)	Nov. 1993	9.2 (99%)	13.6 (100%)	Transferred to pots on October 20
	Feb. 1994	14.4 (95%)	17.9 (100%)	
	Shoot growth	5.2	4.3	
(2) *Shorea ovata* (Meranti sarang punai bukit)	Nov. 1993	6.7 (96%)	10.3 (100%)	
	Feb. 1994	11.2 (79%)	15.4 (98%)	
	Shoot growth	4.5	5.1	
(3) *Shorea pauciflora* (Meranti nemesu)	Nov. 1993	6.1 (98%)	10.9 (100%)	
	Feb. 1994	10.5 (92%)	14.1 (96%)	
	Shoot growth	4.4	3.2	
(4) *Shorea leprosula* (Meranti tembaga)	Nov. 1993	14.6 (95%)	16.5 (100%)	
	Feb. 1994	17.9 (91%)	21.2 (98%)	
	Shoot growth	3.3	4.7	
(5) *Shorea curtisii* (Meranti seraya)	Nov. 1993	5.2 (80%)	9.5 (100%)	
	Feb. 1994	8.4 (72%)	14.4 (99%)	
	Shoot growth	3.2	4.9	
(6) *Parashorea spp.* (Gerutu pasir)	Nov. 1993	2.9 (72%)	9.5 (100%)	
	Feb. 1994	3.6 (44%)	10.9 (98%)	
	Shoot growth	0.7	1.4	
(7) *Dipterocarpus cornutus* (Keruing gombang)	Nov. 1993	14.9 (100%)	16.1 (100%)	
	Feb. 1994	18.3 (100%)	18.0 (100%)	
	Shoot growth	3.4	1.9	
(8) *Intsia palembanica* (Merbau)	Nov. 1993	33.9 (100%)	33.5 (100%)	
	Feb. 1994	45.4 (100%)	44.4 (99%)	
	Shoot growth	11.5	10.9	
(9) *Sindora spp.* (Sepetir)	Nov. 1993	13.3 (100%)	14.1 (100%)	
	Feb. 1994	20.1 (78%)	18.6 (97%)	
	Shoot growth	6.8	4.5	

Note: 1. Figures for seedlings' height are in centimetres. Parentheses indicate survival rates.

2. Growth shown is for the period between November 1993 and February 1994.

3) Wildings Experiment

Techniques for raising dipterocarps and other indigenous species are not as advanced as those for the many fast-growing species now being planted (such as *Acacia mangium* and *Gmelina arborea* (Yamane), etc.) or those in Chikus. Formidable problems encountered in seeds collection, seeds storage and other operations currently forced us to rely on wildings for our seedlings production. The species of wildings collected in Chikus natural forests and other locations are shown below.

1.	*Shorea leprosula*	(Meranti tembaga)	12.	*Gonystlus spp.*	(Ramin)
2.	*Shorea parvifolia*	(Meranti sarang punai)	13.	*Dacryodes spp.*	(Kedondong)
3.	*Pentaspadon motleyi*	(Pelong)	14.	*Koompasia spp.*	(Kempas)
4.	*Hopea odorata*	(Merawan siput jantan	15.	*Pometia spp.*	(Kasai)
5.	*Palaquium spp.*	(Nyatoh)	16.	*Shorea pauciflora*	(Meranti nemesu)
6.	*Drybalanops aromatica*	(Kapur)	17.	*Endospermum malaccens*	(Sesendok)
7.	*Shorea macroptera*	(Meranti melantai)	18.	*Sindora spp.*	(Sepetir)
8.	*Calophyllum spp.*	(Bitangor)	19.	*Shorea hypochra*	(Meranti temak)
9.	*Heriteria spp.*	(Mengkulang)	20.	*Shorea curtisii*	(Meranti seraya)
10.	*Parashorea spp.*	(Gerutu pasir)	21.	*Shorea assamica*	(Meranti pipit)
11.	*Dipterocarpus cornutus*	(Keruing gombang)	22.	*Shorea bracteolata*	(Meranti pa'ang)

The seeds of many of these species had no dormant period, germinating within several days to several weeks after falling to the forest floor. Seedlings then appear in extremely large numbers, but many died because of insufficient sunlight, disease and insects attack. Although early collection would assure larger quantities of wildings, but because of their generally frail nature and poor survival seedlings reaching a height of 6 to 30 cm. were collected instead.

Experiments were carried out to develop solutions for raising healthy seedlings from wildings.

(1) Wildings: Size At Collection And Subsequent Growth

In this experiment, seedlings in two different size groups were collected in order to determine the size at collection was related to growth during nursery cultivation. Also examined were mortality rates, survival rates and heights of seedlings growing in the wild.

See Table 41 to 46 for the results of this experiment, the conditions of which are as follow.

① Topsoil from natural forests was used.

② Fifty seedlings of each species were used for each size group.

Table 41. Wildings size and subsequent growth (seedlings growing at least one year after germination [30 to 50 cm. in height] and no more than three months after germination [7 to 12 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 30-50 cm		Height: 7-12 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
1. *Hopea odorata* (Merawan siput jantan)	May 1993	39	82	8	100	All pots were 6 x 9 inches in size
	Dec. 1993	47	78	14	96	
	Growth (cm)	8		6		

Table 42. Wildings size and subsequent growth (seedlings growing at least one year after germination [20 to 50 cm. in height] and no more than three months after germination [6 to 15 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 20-50 cm		Height: 6-15 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
2. *Palaquium gutta* (Nyatoh taban merah)	May 1993	32	100	10	100	All pots were 6 x 9 inches in size
	Dec. 1993	33	100	11	100	
	Growth (cm.)	1		1		

Table 43. Wildings size and subsequent growth (seedlings growing at least one year after germination [30 to 65 cm. in height] and no more than three months after germination [5 to 12 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 30-65 cm		Height: 5-12 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
3. *Shorea hypochra* (Meranti temak)	May 1993	43	100	9	100	All pots were 6 x 9 inches in size
	Dec. 1993	45	100	10	100	
	Growth (cm.)	2		1		

Table 44. Wildings size and subsequent growth (seedlings growing at least one year after germination [20 to 35 cm. in height] and no more than three months after germination [8 to 15 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 20-35 cm		Height: 8-15 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
4. *Calophyllum spp.* (Bitangor)	May 1993	22	100	13	100	All pots were 6 x 9 inches in size
	Dec. 1993	23	100	13	100	
	Growth (cm.)	1		0		

Table 45. Wildings size and subsequent growth (seedlings growing at least one year after germination [30 to 50 cm. in height] and no more than three months after germination [7 to 12 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 20-30 cm		Height: 10-15 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
5. *Gonystylus spp.* (Ramin)	May 1993	22	100	14	100	All pots were 6 x 9 inches in size
	Dec. 1993	23	100	16	100	
	Growth (cm.)	1		2		

Table 46. Wildings size and subsequent growth (seedlings growing at least one year after germination [30 to 50 cm. in height] and no more than three months after germination [7 to 12 cm. in height])

Species	Date examined	Seedling size				Remarks
		Height: 20-30 cm		Height: 5-12 cm		
		Height (cm)	Survival rate (%)	Height (cm)	Survival rate (%)	
6. *Calophyllum spp.* (Bitangor)	May 1993	22	100	13	100	All pots were 6 x 9 inches in size
	Dec. 1993	23	100	13	100	
	Growth (cm.)	1		0		

a. Results Of Experiment On Initial Wildings Size And Subsequent Growth

In this experiment two groups of seedlings were collected in order to test different methods of production those that were at least one year old and those that were no more than three months old (i.e.., after germination). Current data (which represents results less than one year into the experiment and therefore requires the continued collection of data) shows that smaller *Hopea odorata* seedlings had better survival rates but grew roughly the same as the larger ones. Regarding the other five species, the short period of this experiment prevented any definite conclusions at present.

For the future we planned to experiment on a greater number of species and continue the collection and analysis of data.

Photo - *Hopea odorata* seedlings used in the experiment on the optimum size of wildings

Photo - *Shorea hypochra* seedlings

(2) The Mortality Rate Of Wildings In The Natural Forest

The dipterocarp seedlings collected in the Chikus natural forests were *Shorea leprosula* (Meranti tembaga), *Shorea parvifolia* (Meranti sarang punai), *Neobalanocarpus heimii* (Chengal), *Hopea odorata* (Merawan), *Pentaspadon* spp. (Pelong), and *Koompassia malaccensis* (Kempas).

In March 1993, six mother trees (*Shorea leprosula, Shorea parvifolia, Hopea odorata,* etc.) were fitted with a quadrant (2 x 2 m.) and designated as experimental plots No. 1 through 6, and an experiment was came out to determine the process by which seedlings die. The results are as shown below.

Experimental plot No. 1

Seedling No.	Date examined Mar. 1993 Height (cm)	Date examined Feb. 1994 Height (cm)
1	10	21
2	80	80
3	90	92
4	25	34
5	60	62
6	15	-
7	100	85
8	100	-
9	240	180
10	30	36
11	20	37
12	100	98
13	120	110
14	120	97
15	20	-
16	10	-
17	30	38
18	20	27
19	10	12
Total	1,200	1,009

Death rate: 21%

Experimental plot No. 2

Seedling No.	Date examined Mar. 1993 Height (cm)	Date examined Feb. 1994 Height (cm)
1	4	-
2	210	300
3	300	100
4	220	102
5	122	250
6	120	91
7	5	-
8	150	170
9	165	122
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
Total	1,296	1,135

Death rate: 22%

Species

1. *Shorea leprosula*
2. *Shorea parvifolia*
3. *Pentaspadon spp.*
4. *Koompassia malaccensis*
5. *Neobalanocarpus heimii*
6. *Pometia spp.*
7. *Hopea odorata*
8. *Cinnamomum spp.*
9. Others

Experimental plot No. 3

Seedling No.	Date examined Mar. 1993 Height (cm.)	Date examined Feb. 1994 Height (cm.)
1	92	92
2	50	78
3	90	77
4	21	35
5	40	-
6	25	28
7	100	49
8	5	-
9	113	125
10		
Total	536	484

Death rate: 22%

Experimental plot No. 4

Seedling No.	Date examined Mar. 1993 Height (cm.)	Date examined Feb. 1994 Height (cm.)
1	135	163
2	83	83
3	143	148
4	40	-
5	85	92
6	75	78
7	13	14
8	15	17
9	5	17
10	93	80
Total	687	692

Death rate: 10%

1. *Shorea leprosula*
2. *Shorea parvifolia*
3. *Pentaspadon spp.*
4. *Koompassia malaccensis*
5. *Neobalanocarpus heimii*
6. *Pometia spp.*
7. *Hopea odorata*
8. *Cinnamomum spp.*
9. Others

Note: 1. The method of examination is described below.

Experimental plot No. 1

A			C
	a	b	c
	d	e	f
	g	h	i
B			D

① The seedlings in each plot were counted by marking with bamboo chopsticks inserted into the ground, at which time the height of each seedling was also recorded.

② The species of the seedlings were identified and confirmed by local foresters.

③ *Calamus manan* (Rotan manau) seedlings were not counted.

Experimental plot No. 5

Seedling No.	Date examined Mar. 1993 Height (cm.)	Date examined Feb. 1994 Height (cm.)
1	23	17
2	23	19
3	23	-
4	40	44
5	23	-
6	20	-
7	16	18
8	30	37
9	30	-
10	105	109
11	20	24
12	16	26
13	21	25
14	20	-
15	100	110
16	14	14
17	18	18
18	17	17
19		
20		
21		
22		
23		
24		
25		
Total	559	478

Death rate: 28%

Experimental plot No. 6

Seedling No.	Date examined Mar. 1993 Height (cm.)	Date examined Feb. 1994 Height (cm.)
1	59	79
2	19	24
3	10	-
4	19	19
5	48	46
6	20	21
7	56	51
8	60	61
9	12	17
10	22	22
11	80	51
12	93	91
13	13	-
14	19	-
15	122	175
16	146	167
17	76	120
18	76	85
19	5	8
20	5	-
21	58	66
22	56	54
23	5	-
24	19	19
25	9	12
Total	1,107	1,188

Death rate: 20%

1. *Shorea leprosula*
2. *Shorea parvifolia*
3. *Pentaspadon spp.*
4. *Koompassia malaccensis*
5. *Neobalanocarpus heimii*
6. *Pometia spp.*
7. *Hopea odorata*
8. *Cinnamomum spp.*
9. Others

Note: Experimental plots Nos. 1 through 5 were located in the natural forests at Chikus project site B; No. 6 in the natural forest at Chikus project site A.

a. The Process Of Seedlings Mortality In Chikus Natural Forests

① Examination of each plot revealed the following:-

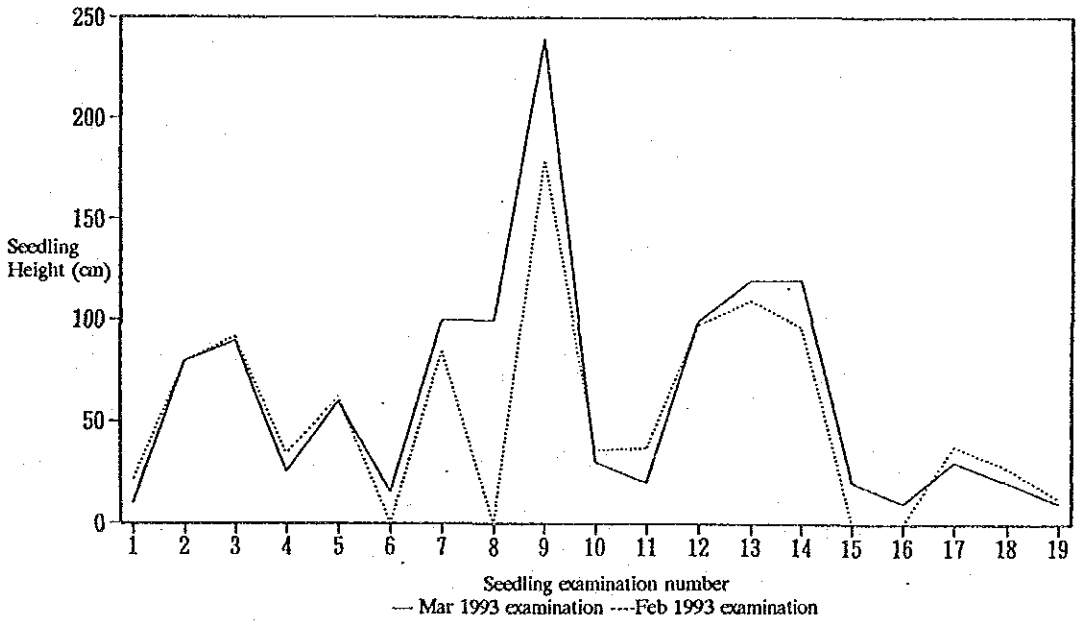
1) As of March 1993 a total of 90 seedlings had grown, of which 52 were growing healthily.
2) Nineteen seedlings had died, of which 16 were under 30 cm. high.
3) Another 19 seedlings had bent at the stalk; 10 were 100 cm. or more in height.

Thus, only 57% of the seedlings were growing healthily; 84% of those that died were under 30 cm. high, while 53% of those that were bent at the stalk were 100 cm. high or more, suggesting that seedlings growth was not unlimited in natural forests, and that most seedlings actually died in such environments. Hence, seedlings growing in natural forests must be collected before growing too high in order to secure larger numbers of viable seedlings and enhance their use in nursery cultivation.

② **Graphic Representation Of The Results Of Examination Of Seedlings Mortality In The Natural Forest In Plot No. 1**

Of the 19 growing seedlings observed in March 1993, seedlings No. 6, 8, 15 and 16 had died by the time of our examination one year later, while most of the seedlings 100 cm. or higher were bent, as the graph below shows.

The Process of Seedlings Mortality in Natural Forests
Experimental Plot No. 1



(3) Pot Size And Seedlings Growth In Cultivation

An experiment was came out to determine the optimum pot size for each species in terms of costs and adequate seedlings growth.

See Table 47 for the results of this experiment, the conditions of which are as follows.

1. Topsoil from natural forests was used for each of the six species.
2. Fifty seedlings of each of the six species were used for each of the five pot sizes.

Table 47. Pot Size and Seedlings Growth in Cultivation

Species	Date examined	Pot size				
		A=10*15	B=10*22	C=13*16	D=15*22	E=18*22
Hopea odorata	May 1993	10.9 (100%)	11.4 (100%)	9.0 (100%)	12.4 (100%)	10.7 (100%)
	Dec. 1993	15.3 (100%)	13.9 (98%)	11.6 (100%)	15.4 (82%)	15.9 (94%)
	Growth (cm.)	4.4	2.5	2.6	3.0	5.2
Pentaspadon Motleyi	Mar. 1993	12.4 (96%)	12.2 (100%)	10.3 (92%)	10.6 (100%)	13.7 (100%)
	Dec. 1993	18.9 (82%)	20.1 (84%)	17.7 (86%)	17.2 (82%)	20.6 (94%)
	Growth (cm.)	6.5	7.9	7.4	6.6	6.9
Shorea leprosula	Jul. 1993	26.2 (100%)	23.3 (98%)	22.4 (100%)	21.7 (100%)	31.0 (100%)
	Dec. 1993	28.2 (66%)	25.9 (42%)	26.2 (86%)	25.2 (58%)	33.6 (76%)
	Growth (cm.)	2.0	2.6	3.8	3.5	2.6
Shorea parvifolia	Jul. 1993	21.1 (100%)	20.9 (98%)	18.1 (100%)	21.8 (100%)	30.2 (100%)
	Dec. 1993	24.4 (70%)	24.3 (84%)	19.5 (52%)	23.7 (86%)	33.2 (94%)
	Growth (cm.)	3.3	3.4	1.4	1.9	3.0
Shorea macroptera	Jul. 1993	15.8 (100%)	17.7 (100%)	14.2 (100%)	12.9 (100%)	14.8 (100%)
	Dec. 1993	16.4 (38%)	23.7 (46%)	15.5 (66%)	16.4 (66%)	21.6 (44%)
	Growth (cm.)	0.6	6.0	1.3	3.5	6.8
Heritiera spp.	Jul. 1993	10.1 (100%)	13.7 (100%)	9.7 (98%)	11.3 (100%)	10.0 (100%)
	Dec. 1993	12.2 (74%)	18.2 (94%)	12.1 (76%)	15.7 (84%)	13.9 (74%)
	Growth (cm)	2.1	4.5	2.4	4.4	3.0

a. Results Of The Experiment On Pot Size And Cultivation Period In The Nursery Cultivation of Seedlings

1. After seven months, seedlings of *Hopea odorata* and *Pentaspadon motleyi* in large-sized pots had consistent survival rates and growth.
   However, size B pots produced the best growth for *Pentaspadon motleyi* - roughly twice the growth of seedlings in other pots.

2. After five months, the survival rate and growth of seedlings of *Shorea leprosula*, *Shorea parvifolia* and *Shorea macroptera* was best in size C. The survival rates and growth of the other two species were also good in sizes D and E.

3. The survival rate and growth of *Heritiera* spp. seedlings in size B pots after five months suggested that this was the optimum size for this species.

The experiment demonstrated that larger pot sizes were more effective for seedlings roughly 10 cm. high (like those of *Hopea odorata* and *Pentaspadon motleyi*), which required at least one year of cultivation after germination.

As *Shorea leprosula* and *Shorea parvifolia* seedlings collected were roughly 20 cm. high and consequently required less than one year of cultivation prior to being planted in the field, size C was effective for the former and the deeper sizes for the latter (i.e., survival rates were higher).

Shorea macroptera cultivated in deeper pots also showed good growth, but had lower survival rates than other species. For *Heritiera* spp. (Mengkulang), pot size B yielded favourable survival rates and good growth.

Nevertheless, current data is inconclusive because of the short duration of this experiment, and consequently it is important to continue collecting data and to include more species in this experiment.

Photo - *Heritiera* spp. seedlings (Mengkulang) used in the experiment to determine optimum pot size

Photo - *Koompassia malaccensis* seedlings used in the experiment for wildings fertilization

(4) Fertilization Experiment

In this experiment we observed the growth of seedlings in pots containing the fertilizer used by the Perak Forestry Department ("Baja", a phosphate fertilizer, N 15%, P205 15%, K205 15%) and compared it with the growth of seedlings cultivated without fertilizer.

See Table 48 for the results of this experiment, the conditions of which were as follows.

① In this experiment two groups of seedlings were given different amounts of fertilizer (6 or 40 grains) and one group no fertilizer.

② Topsoil from natural forests was used.

③ One hundred seedlings of each of the six species were used for each three groups of fertilizer amount

Table 48. Wildings fertilization experiment

Species	Date examined	None	Six grains	Forty grains
Shorea macroptera	Jun. 1993	17.4 (100%)	18.0 (100%)	17.1 (100%)
(Meranti malantai)	Dec. 1993	19.2 (95%)	22.6 (89%)	23.0 (25%)
	Growth (cm.)	1.8	4.6	5.9
Calophyllum spp.	Jun. 1993	11.2 (97%)	12.4 (97%)	11.8 (97%)
(Bitangor)	Dec. 1993	14.2 (92%)	15.6 (58%)	14.7 (59%)
	Growth (cm.)	3.0	3.2	2.9
Hopea odorata	Jun. 1993	11.7 (100%)	12.0 (100%)	12.4 (100%)
(Merawan siput jantan)	Dec. 1993	15.8 (97%)	16.9 (94%)	16.9 (94%)
	Growth (cm.)	4.1	4.9	4.5
Pometia spp.	Jun. 1993	16.8 (100%)	18.0 (100%)	18.1 (100%)
(Kasai)	Dec. 1993	20.6 (89%)	22.1 (96%)	20.9 (96%)
	Growth (cm.)	3.8	4.1	2.8
Koompassia spp.	Jun. 1993	17.3 (100%)	17.0 (100%)	14.8 (100%)
(Kempas)	Dec. 1993	20.6 (89%)	22.1 (96%)	20.9 (96%)
	Growth (cm.)	3.3	5.1	6.1
Pentaspadon motleyi	Jun. 1993	21.8 (100%)	20.4 (100%)	19.9 (100%)
(Pelong)	Dec. 1993	24.9 (95%)	22.5 (98%)	22.5 (99%)
	Growth (cm.)	3.1	2.1	2.6

a. The Results Of Fertilizer Experiments On Wildings

① *Shorea macroptera*: Six grains of fertilizer resulted in good growth and good survival rates, but in terms of survival rate alone, giving no fertilizer produced the best results.

② *Calophyllum* spp.: Seedlings that received no fertilizer grew best and had the highest survival rates. Because of their small size, many seedlings were burned by the fertilizer and subsequently died.

③ *Hopea odorata*: Seedlings that received no fertilizer achieved almost the same growth and survival rates as those that did.

④ *Pometia* spp.: Seedlings that received six grains of fertilizer had good survival rates and showed favourable growth.

⑤ *Koompasia*: Seedlings that received 40 grains had a high survival rate and grew well.

⑥ *Pentaspadon motleyi*: Although survival rates in all three groups were almost the same because of seedling sizes (over 20 cm.), those that received no fertilizer grew more.

The above results reveal the importance of waiting until collected seedlings have grown to a certain height in the nursery before placing chemical fertilizer in the pots. Nevertheless, fertilizer can cause seedlings' death depending on the species and quantity; in this experiment the 40-grain dose was found to be particularly dangerous. At present a dose of six grains of fertilizer is used at the nurseries.

(5) Shading Experiment

In this experiment, we recorded the death rates and growth of wildings transferred to the nursery and provided with varying degrees light intensity immediately after collection.

See Table 49 for results; conditions of the experiment were as follows:-

① Five groups of seedlings were cultivated under different degrees of relative light intensity (using netting as cover) 5%, 25%, 50%, 70% and 100%.

② As this experiment was over one year in duration, large pots (6 x 9 inches) were used.

③ Fifty seedlings of each species were used for each relative light intensity.

Table 49. Experiment on wildings provided with different light intensity after collection

Species	Date examined	Degrees of relative light intensity 5%	25%	50%	70%	100%
1. *Hopea leprosula*	Ma 1993	28.2 (18%)	54.0 (100%)	32.4 (100%)	44.1 (100%)	32.9 (100%)
(Meranti	Dec 1993	0.0 (0%	60.3 (98%)	36.3 (100%)	48.5 (98%)	39.1 (76%)
tembaga)	Growth (cm.	0.0	6.3	3.9	4.4	6.2
2. *Shorea parvifolia*	Mar 1993	19.8 (12%)	22.9 (100%)	21.4 (98%)	24.0 (100%)	21.2 (100%)
(Meranti sarang	Dec 1993	0.0 (0%	26.1 (100%)	25.2 (90%)	27.5 (100%)	25.0 (84%)
punai)	Growth (cm.	0.0	3.2	3.8	3.5	3.8
3. *Shorea macropter*	Jul. 1993	15.5 (100%)	16.1 (100%)	16.1 (100%)	15.5 (100%)	17.8 (100%)
(Meranti	Dec 1993	0.0 (0%	17.1 (90%)	18.2 (86%)	16.2 (100%)	19.8 (82%)
melantai)	Growth (cm.	0.0	1.0	2.1	0.7	2.0
4. *Hopea odorata*	Jul. 1993	10.3 (86%)	10.8 (94%)	11.4 (98%)	11.1 (96%)	11.4 (82%)
(Merawan siput	Dec 1993	0.0 (0%	15.7 (88%)	14.0 (96%)	16.4 (100%)	14.0 (80%)
jantan)	Growth (cm.	0.0	4.9	2.6	5.3	2.6
5. *Pentaspadon*	Jul. 1993	15.8 (10%)	18.2 (94%)	18.9 (100%)	18.2 (100%)	16.9 (98%)
motleyi	Dec 1993	0.0 (0%	25.1 (94%)	25.2 (78%)	24.6 (86%)	23.7 (80%)
(Pelong)	Growth (cm.	0.0	6.9	6.3	6.4	6.8

a. Results Of The Experiment on Wildings Provided with Different Light Intensity After Collection

The seedlings used in this shading experiment, most of which were from the Chikus natural forest, were provided with shading immediately after collection. The conditions were as follows:-

① Topsoil from natural forests was used; the same pot size was used for all species.

② To create a relative light intensity of 5%, a triple layer of netting was used, which blocked out nearly all sunlight and prevented air from flowing, thus creating a steamy environment that killed nearly all seedlings in this group.

③ In the 25% and 50% relative light intensity groups, shade conditions were almost the same as those of seedlings in natural environments, and, consequently, survival rates were near 100% and growth satisfactory.

④ Seedlings cultivated with 100% relative light intensity (i.e.., completely open; identical to conditions of hardening) had poor survival rates but grew almost as much as seedlings with 25% and 50% relative light intensity.

On the basis of these results - which showed that hardening results in survival rates of over 80% in some species and over 40% in others, and that hardening should be performed gradually for certain species - 30 additional beds for hardening were prepared at the Chikus nursery and the resultant seedlings used in afforestation beginning in 1993 fiscal year. Many species of seedlings planted in open fields in 1992 fiscal year had survival rates aver 50%, suggesting the further potential effectiveness of the additional beds prepared for hardening in the Chikus nursery.

(6) Experiment On The Efficiency Of Transpiration Control Chemical

In this experiment, a certain number of wildings collected from the natural forest under jurisdiction of the Gerik district forest office in October 1993 and cultivated for one month at a nearby temporary nursery were sprayed with transpiration control chemical prior to being transferred to the Chikus nursery (it is 220 km. from Gerik to Bidor). The results were compared with those of the remaining seedlings which were not sprayed.

See Table 50 for the results of this experiment, the conditions of which were as follows:-

① The wildings used were those grown in the wild from collected seeds for one month after germination (height: approximately 10 cm.).
② The chemical agent used was "Midorinaru", a plant growth agent made by Japan's Toho Chiba Kagaku Kogyo and diluted with water at a ratio of 1:15 to 1:20.
③ Seedlings were transferred in December 1993 and examined in February 1994.

Table 50. Transpiration control chemical experiment

Category		Species			
		Parashorea spp.	*Dipterocarpus cornutus*	*Shorea pauciflora*	*Shorea leprosula*
Sprayed	Total number of transferred seedlings	670	163	1,041	2,479
	Dead seedlings	28	8	33	69
	Surviving seedlings	642	155	1,008	2,410
	Survival rate	96%	95%	97%	97%
Not sprayed	Total number of transferred seedlings	2,517	24	240	120
	Dead seedlings	256	6	31	13
	Surviving seedlings	2,261	18	209	107
	Survival rate	90%	75%	87%	90%

a. Conclusions Based On The Results Of The Transpiration Control Chemical Experiment

The transpiration control chemical increased survival rates by roughly 10%, and growth was still extremely favourable two months after transfer to the Chikus nursery. It is believed that the chemical reduced evapotranspiration and helped promote root growth.

We intend to continue comparing seedlings sprayed with this chemical prior to transferring from temporary forest nurseries with those not sprayed as part of efforts to develop techniques for enhancing the survival rates of wildings.

4) Experiments On Cutting

In this experiment on cuttings, performed under the guidance of short-term expert Mr.Yamate, cuttings from the Chikus natural forest were sprayed with auxin, a Japanese root stimulant.

See Table 51 for results. The conditions of this experiment were as follows:-

① Nursery workers were instructed on how to collect and cut specimens for cuttings, which were then planted in planters.
② Cuttings were trimmed to a length of 12 to 15 cm.; roughly two thirds of all leaves were removed, leaving only two or three leaves at the tip.
③ Cuttings were taken from still-growing shoots of six-month-old seedlings in the nursery and the branches of naturally grown trees (2 metres in height and 2 cm. in diameter) in the Chikus natural forest.

Table 51. Experiments on cuttings

Species		Number planted	Dead cuttings	Surviving cuttings	Survival rate
1. *Pometia spp.*	(Kasai)	54	53	1	2%
2. *Shorea leprosula*	(Meranti tembaga)	253	218	35	14%
3. *Mesua ferrea*	(Penaga)	98	84	14	14%
4. *Dryobalanops aromatic*	(Kapur)	152	144	8	5%
5. *Cinnamomum spp.*	(Medang teja)	218	117	101	46%
6. *Shorea parvifolia*	(Meranti sarang punai)	78	76	2	3%
7. *Casuarina equisetifolia*	(Ru)	26	24	2	8%
Total		879	716	163	19%

a. Results Of Cutting Experiment

Seven of the 14 species of cuttings planted survived in this experiment (Table 51), the objective of which was to determine the cuttings' viability and also assess their potential for use in large-scale seedlings production. In spite of some instances of success at FRIM and Malaysian State Forestry Departments, afforestation experiments yielded success only with *Hopea odorata* (based on FRIM results and later field investigation). FRIM is also currently experimenting with several species, albeit in small numbers (100 to 200 cuttings per species).

Furthermore, the Malaysian government has stepped up its efforts in the field of cuttings: For example, the Assistant District Forest Officer of the Bentong district forest office of Pahang state (with whom members of this project have had contact in the past) was sent to Edinburgh, England for one month to study techniques for cuttings.

This project taught us the importance of focusing on a smaller number of species and continuing experiments on cuttings with the objective of future applications in large-scale seedlings production.

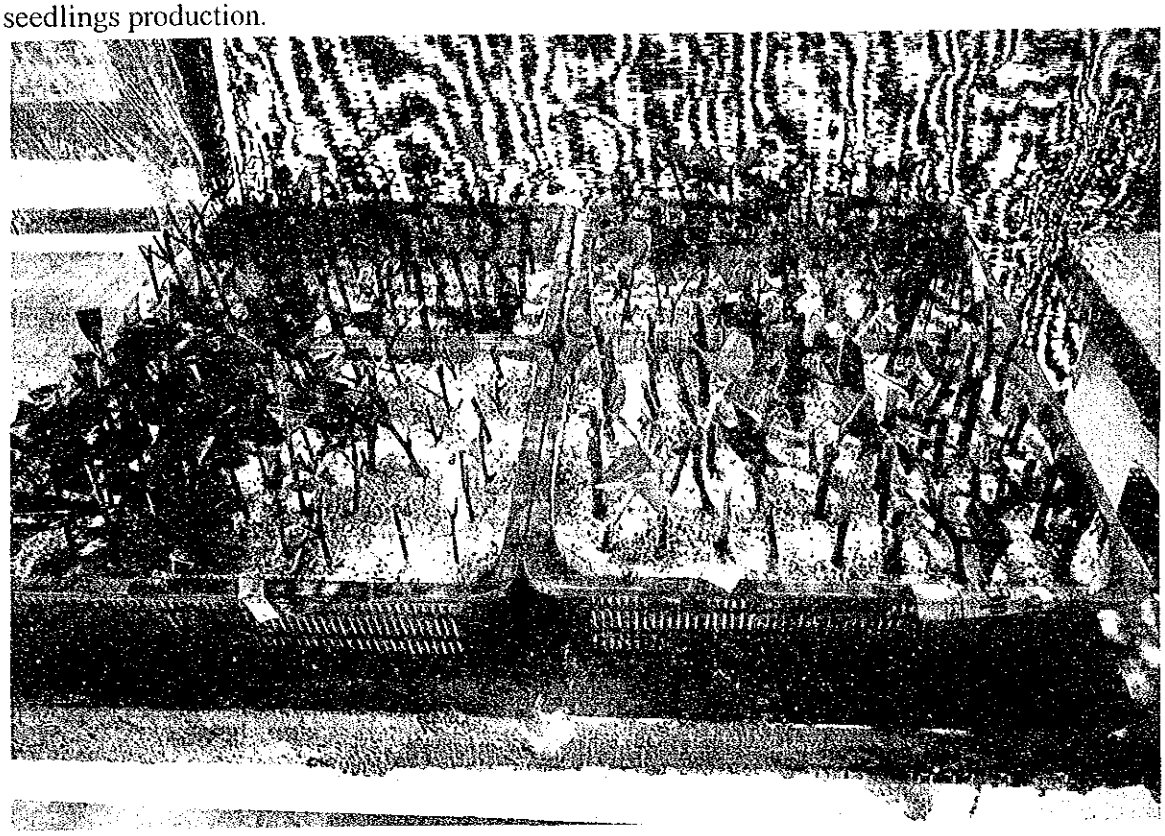


Photo - *Cinnamomum* spp. cuttings used in the experiment

5) Damage From Disease And Insects And Experiments On The Prevention Thereof

The seeds and wildings collected and raised in Chikus nursery were initially subjected to rat and insect attacks. However, the problem of rat had been overcome by the use of domestic rat poison (purchase locally).

Under the guidance of short-term expert on tree diseases Mr. Yamaguchi, the seedlings in the Chikus nursery were examined between November and December. While no major damage from disease or insects was observed, some of the *Shorea macroptera* seedlings were found to have leaf spots. These plants were sprayed with a disinfectant (Ancom Thiram 80) and insecticide (Ch Malathon 1000E) purchased locally. Recently some *Shorea leprosula* seedlings suffered insect damage, but we had not been able to determine the culpable specie of insect as it does not come out during the day.

Although the roughly 200,000 seedlings now being cultivated in our nurseries are sprayed with disinfectant once every two weeks, the occurrence of disease and insect damage is expected to increase. Current nursery conditions also warrant increased caution, and because of the inability of long-term experts to deal with this problem, it is important that short-term experts on disease and insect damage be sent to develop concrete countermeasures.

6) Other Seedlings Cultivation Experiments

(1) Experiments On Methods Of Promoting Flowering

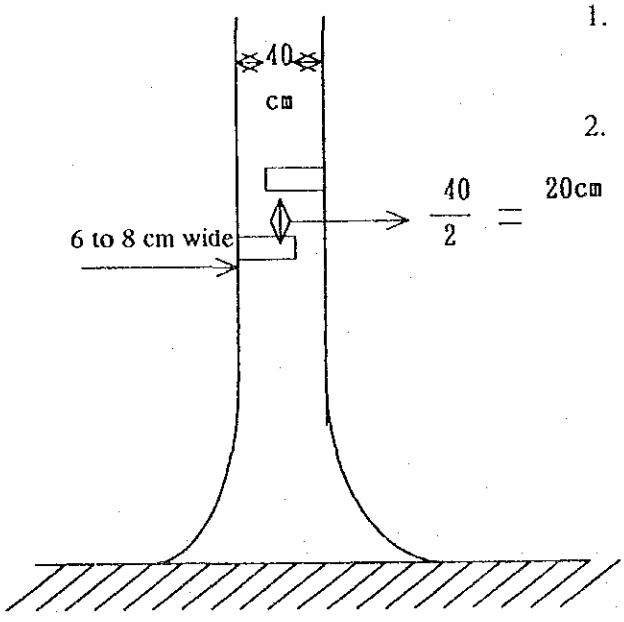
a. Stripping Away Bark To Promote Flowering

In this experiment, carried out under the guidance of short-term expert Mr. Yamate, the bark of observation trees (*Shorea leprosula*, *Shorea parvifolia*, *Neobalanocarpus heimii*) in the Chikus natural forest was stripped away to inflict damage and promote flowering (Table 52 and Fig. 11).

This method was selected for experimentation on *Shorea* species because of past successes in increasing the frequency of flowering/fruiting in Japanese larches from the normal once in seven years to once a year (permitting annual seed collection).

Table 52. Experiment on flowering promotion

Observation tree No.	Species	Trunk diameter	Height	Dead cuttings
No. 5	*Shorea leprosula*	40	28	1. Chikus natural forest
No. 6	*Shorea leprosula*	40	34	
No. 7	*Shorea parvifolia*	42	30	2. Begun in March 1993
No. 8	*Shorea parvifolia*	42	28	
No. 9	*Neobalanocarpus heimii*	66	32	
No. 10	*Neobalanocarpus heimii*	26	18	



1. Strips of bark 6 to 8 cm. wide were stripped away.
2. Strips were spaced at a distance equivalent to one half of the trunk diameter.

Fig. 11. The method of flowering promotion

b. Experiment On Promoting Flowering By Injecting Hormones And Supplying Hormones To The Roots

Carried-out in June 1993, this experiment involved injecting a *Shorea leprosula* tree (50 cm. in diameter and 35 m. high) in the Chikus natural forest with one litre of hormone while simultaneously supplying the roots with an additional litre, and also injecting a *Shorea parvifolia* tree (48 cm. in diameter and 32 m. high) with two litres of hormones (Fig. 12).

A. Simultaneous hormone injection and root infusion

B. 2-litre hormone injection

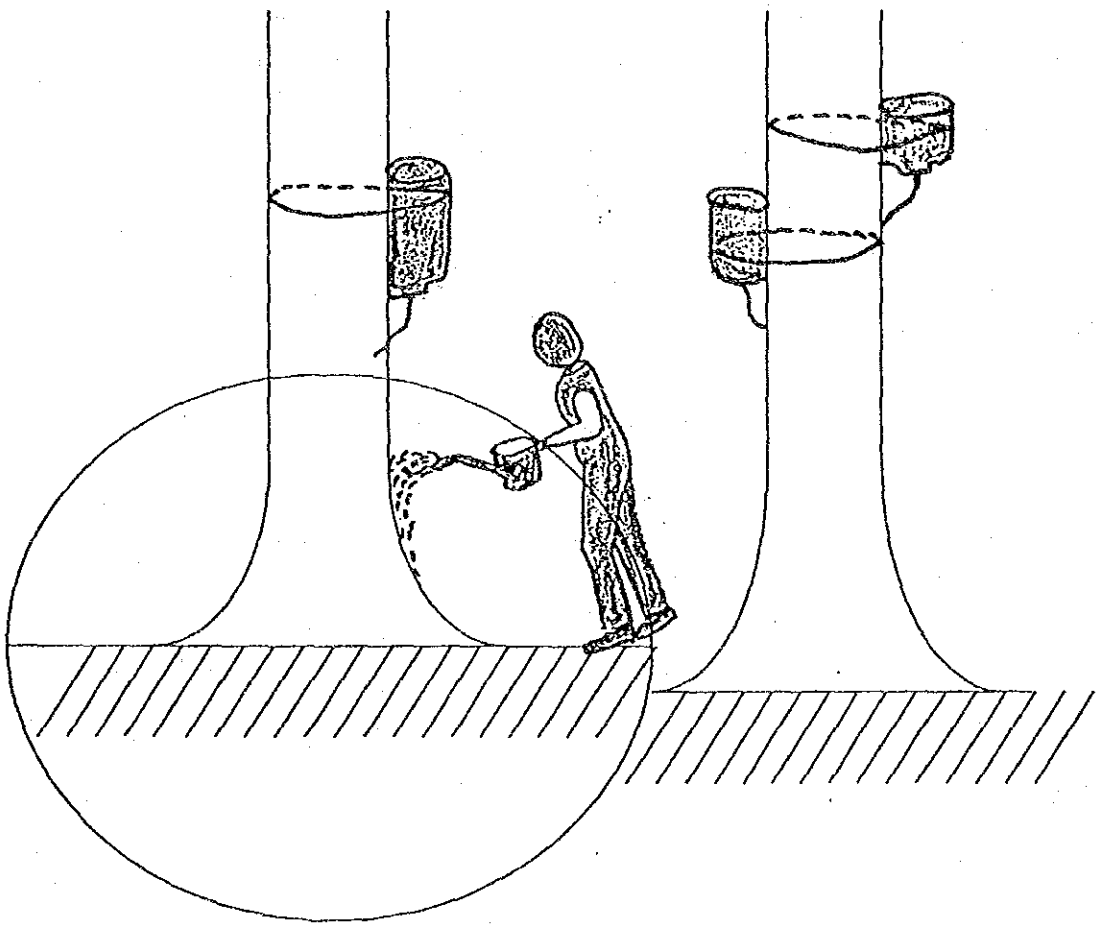


Fig. 12 Experimental promotion of flowering with hormones

c. In this experiment, no signs of flowering have yet to be observed, and so we will continue to observe the above trees as well as increasing the number of observation trees used.