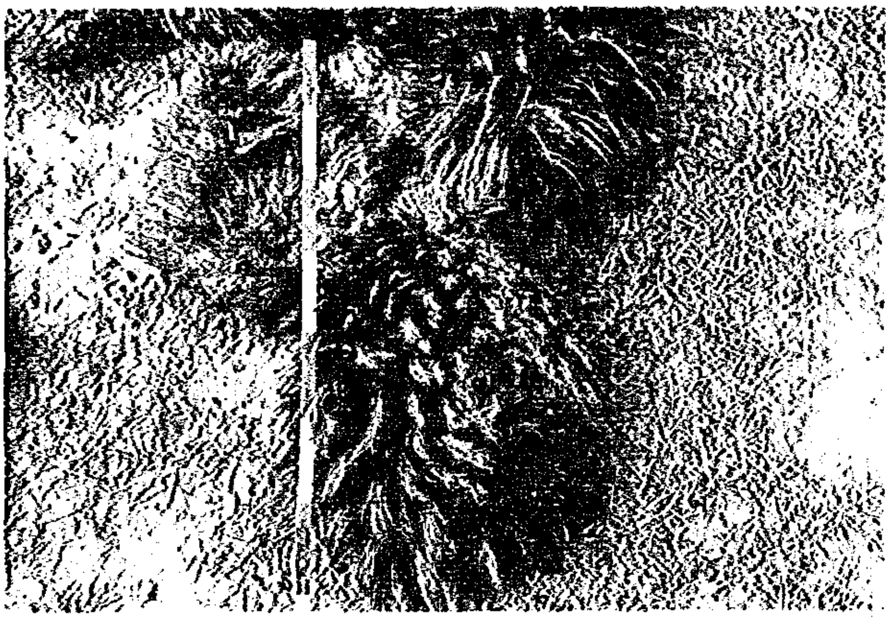


Photo S32 Multing material (Oil Palm Bunches)

4.1.2.6. Pest and diseases

Almost all dipterocarps planted since April 1993 have suffered damage from leaf-eating insects, which have yet to be identified. As same as in Chikus Block-B, there was damage by cattle and water buffalo. They were put to pasture here, and many enter the project site to graze on the plants that grew after weeding. While damage from this grazing was not extensive, some seedlings were trampled, and eaten. Especially *Hevea brasiliensis* which was planted as FGTS in Block-A(1993) suffered seriously by grazing. *Hopea odorata* planted on the pass of cattle and buffalo, suffered from continuous rubbing of top shoots and grew with multiple leaders.

4.1.3. Multi-Storied Forest by Under Planting in Belukar

Multi-Storied Forest by Underplanting in Belukar was established in Chikus Block-A. As this area was planted in 1994, it was named Block-A(1994). The design taken in this area was not planned in the initial five year plan. Belukar was planned to be cleared for the experiments of open planting. However, because of poor result in open planting, a new design was introduced. In this design, Belukar was considered to serve as nurse trees.

4.1.3.1. Demarcation of experimental plots

Experimental plots were set-up to demonstrate different planting design with different species. All plots have been arranged in long strips laying for East - West, with one silvicultural design planted with one species. Arrangement of plots are shown in Fig. S15.

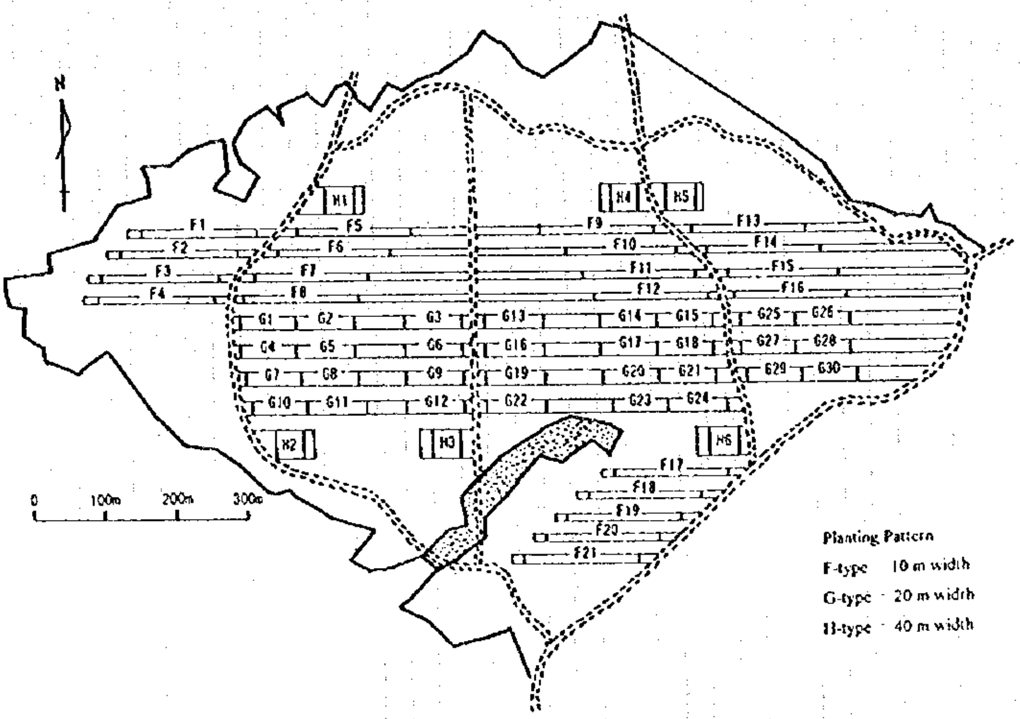


Fig. 15 Arrengements of experimental plots in block A(1994)

4.1.3.2. Site preparation

Belukar was felled in 3 different strip widths in order to manipulate the light condition, and prepare planting strips. Felled rows and retained rows were arranged alternately. Three types of width were set up, namely F-type (10 m width), G-type (20 m width), and H- type (40 m width) (Fig. S16, Photos 33, 34). Width of retained Belukar was set to 20 m. Belukar was felled from December 1994 to January 1995. At that time mean height of Belukar was 8 m.

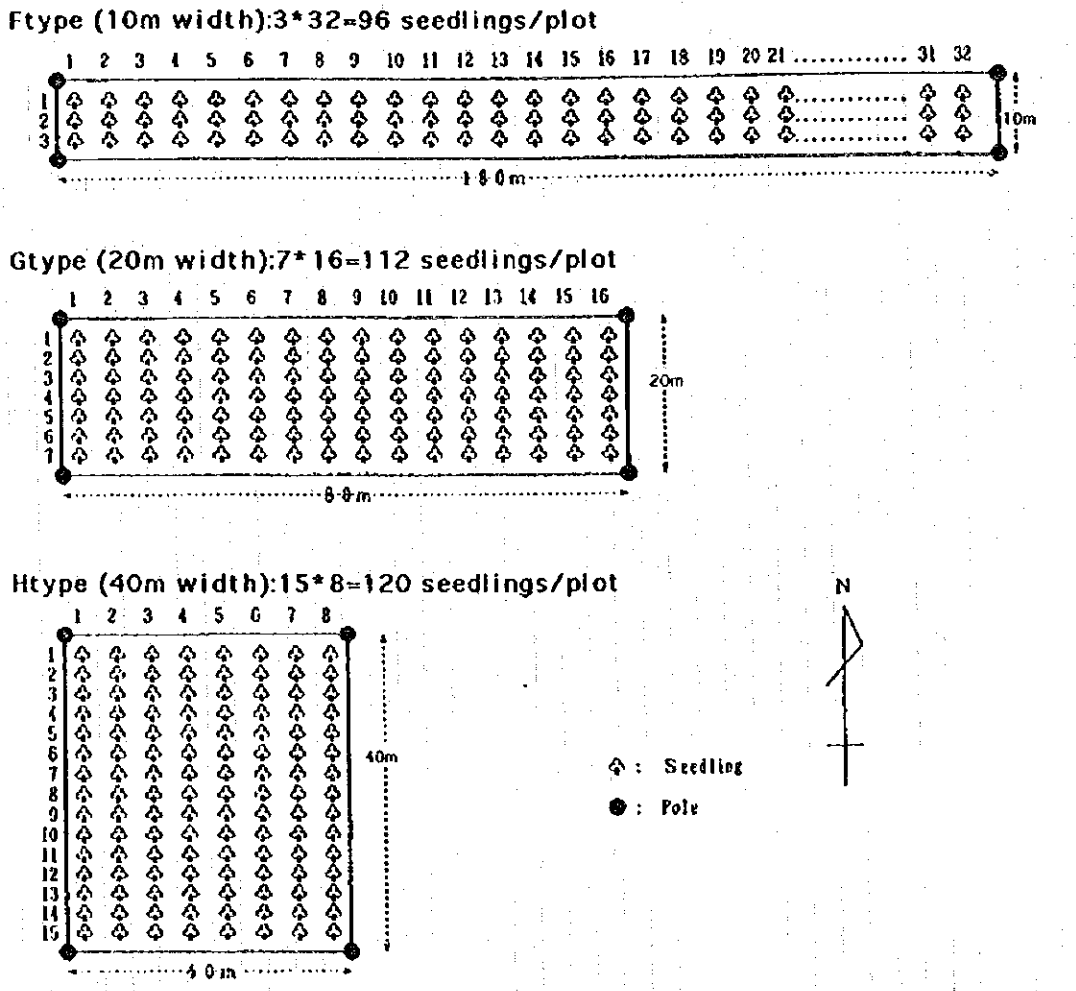


Fig 16 Design of multi-storied forest by underplanting in belukar

Photo S33 Planting strip of F-type (10m width)

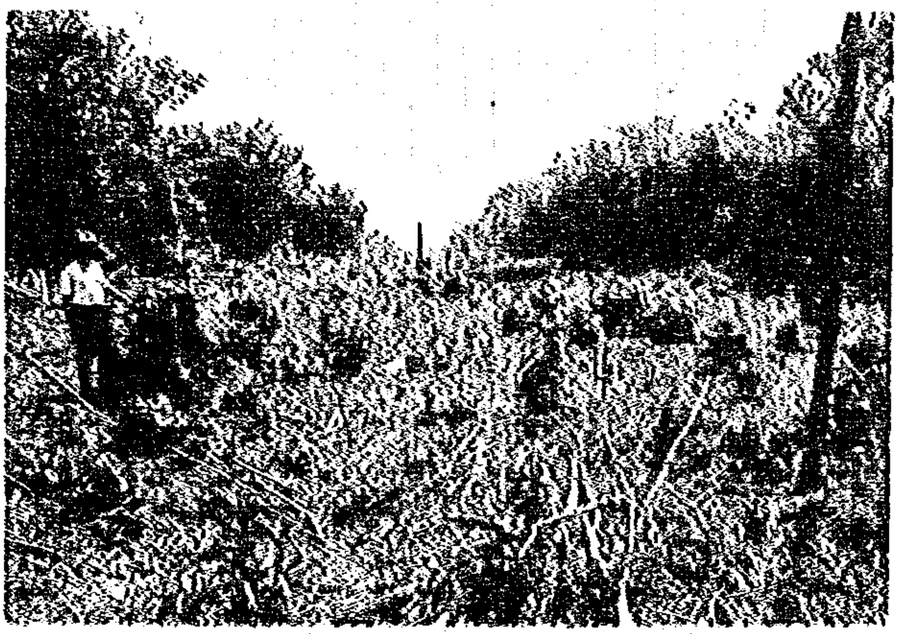


Photo S34 Planting strip of G-type (20m width)

Usually in Malaysia, heavy duty machinery is used to remove Belukar, but in this experiments chainsaws were used to minimize the ground compaction by machinery. Since the felled logs were of no value, they were cut into small sizes randomly on the spot. This process was normally done by one worker. All felled trees were set aside under the retained Belukar to clear the planting strips. A Grapple loader was used for this process. Because of its huge amount, slash could not have been cleared manually. Intensive care was taken to minimize the ground compacting by machinery.

After the removal of Belukar, site preparations, which consists of the clearing of branches from felled trees, the removal and trimming of regenerated plants, and weeding, were carried out. These processes were mainly done manually. Hatchets were used for weeding. Branches were cut and accumulated towards the side of retained Belukar strips. The weeding width was 2 m along the planting line (i.e., 1 meter on each side of the position of planting). The soil was not cultivated. Fertilizer was not applied. The record of site preparation is shown in Table S13.

Table S13 History of Chikus Block-A(1994)

Year	Event in Chikus Block-A(1994)
Originally	Lowland dipterocarp forest
Jun. 1988 - Mar. 1989	Clear cutting for compensatory planting
Apr. 1989	Fired twice for the site preparation of planting *Acacia mangium*
Nov. 1989	Area was left over and Belukar regenerated
Dec. 1994 - Jan. 1995	Belukar was felled in line
Feb.-Mar. 1995	Indigenous species were planted

4.1.3.3. Planting

In this experiment, the same species planted with open planting in block-A was selected as first priority so as to compare the growth with them. Species planted and thier origins are as shown in Table S14 (Photos 35, 36).

Table S14 Planting Species of MSF by Underplanting in Belukar

BLOCK	YEAR	TYPE	DIRECTION	SPP	Date Planted	Seed/Wilding	Name of Place	State	JICA / FD / Private nursery	Date acquired
A	94	F,G	EW	Oralum sp.	Feb.-Mar. 95	Seed	Bauding	Perak	JICA	Aug-93
A	94	F,G	EW	Gonystylus sp.	Feb -Mar. 95	Wilding	Besaut	Perak	JICA	Apr-93
A	94	F,G,H	EW	Neobalanocarpus heimii	Feb -Mar. 95	Seed & Wilding	Kuala Berang	Terengganu	Private (Kuala Berang)	Aug -Sep 92
A	94	F,G	EW	Shorea acuminata	Feb-95	Wilding	Mantin	Sembilan	FD (Mantin)	Aug-93
A	94	F,G	EW	Shorea bracteolata	Feb.-Mar. 95	Seed	Kota Setar	Kedah	Private (Kota Setar)	Oct-93
A	94	F,G	EW	Shorea gibbosa	Feb -Mar. 95	Wilding	Bubu	Perak	JICA	May 94
A	94	F,G	EW	Shorea glauca	Feb-95	Wilding	Kota Setar	Kedah	Private (Kota Setar)	Nov-94
A	94	F,G,H	EW	Shorea leprosula	Feb -Mar. 95	Seed	Bauding	Perak	JICA	Aug-93
A	94	F,G	EW	Shorea multiflora	Feb-95	Wilding	Bukit Larut	Perak	JICA	May-94
A	94	F,G,H	EW	Shorea ovalis	Feb -Mar 95	Seed	Bubu	Perak	JICA	Mar 94
A	94	F,G,H	EW	Shorea ovata	Feb.-Mar 95	Seed	Bauding	Perak	JICA	Sep-93
A	94	F,G,H	EW	Shorea parvifolia	Feb.-Mar. 95	Seed	Lentang	Pahang	JICA	Apr-93
A	94	F,G,H	EW	Shorea pauciflora	Feb.-Mar 95	Seed	Gauda	Perak	JICA	Aug-93
A	94	F,G	EW	Shorea telura	Feb -Mar 95	Wilding	Batu Gajah	Perak	JICA	Jun-93
A	94	F,G	EW	Sindora sp.	Mar-95	Seed	Bauding	Perak	JICA	Sep-93

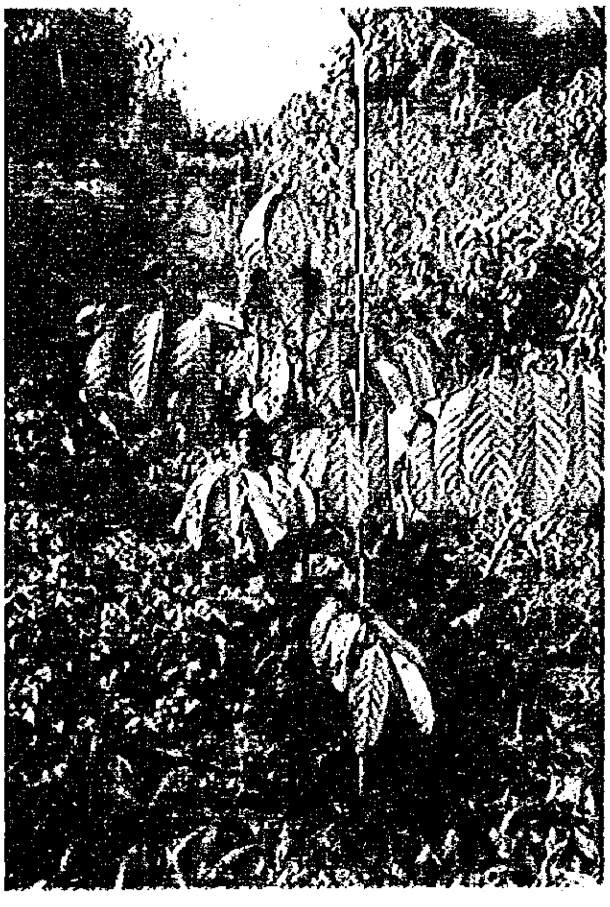


Photo S35 *Shorea multiflora* planted in F-type in Block A(1994)

Photo S36 Dialium sp. planted in F-type in Block A(1994)

Seedlings were planted in 2.5 m x 5.0 m, planting rows were spaced 2.5 m apart and individual seedlings 5.0 m apart (Fig.S17). This results in a density of 800 trees per hectare. Staking were done before planting as in the other plots. Planting methods were the same as those of Multi-Storied Forest by under planting in *Acacia mangium* plantation.

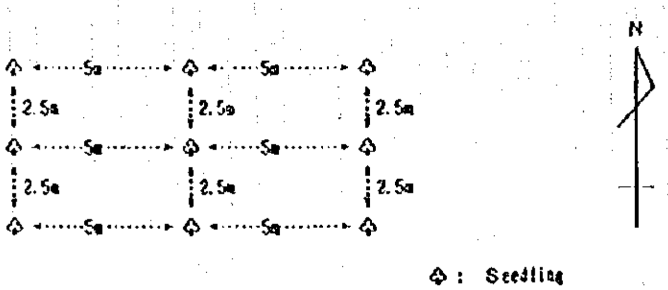


Fig. 17 Spacing of underplanting in belukar

4.1.3.4. Tending

Weeding and climber cutting were carried out at the same time. The first weeding and climber cutting was carried out 2 - 3 months after planting. Afterward they were carried out every 2 - 4 months depending on the growth of undergrowth. This frequency was 1 - 2 times per year more than that in Block-B. Vegetation was weeded in lined by bush cutter with gasoline engine. The line width was 2 m along the planting line.

In this site, regeneration of Belukar consists of *Macaranga* spp., *Mallotus* spp., *Trema* spp., and other pioneer tree species were vigorous. In H-type plots, growth of *Perotis latifolia* (Malay name : Ekor kuching) were quicker than shrub. Climbers were seldom seen.

Pruning was not carried out since seedling planted are still not in the stage of pruning. Any fatal damage to the seedlings by insects or disease was not observed so far.

4.1.4. Arboretum

4.1.4.1. Demarcation of experimental plots

Arboretum was planned to establish in Chikus block-A for demonstrating various species which were to be planted in experimental plots. It was set up near the nursery in order to apply intensive care on seedlings planted there.

In 1992 and 1993, arboretum was established at the same time of establishment of open planting in block-A. The two areas were named arboretum (1992), and arboretum (1993). Experimental plots were set up in the area. Each plot has an area of at least 0.48 hectares (48 m x 99 m). Arrangement of plots are shown in Figs. S8 and S9. Site preparation for Arboretum (1992) was scheduled for completion by November 1992, but the poor performance of contractor resulted in a two-month delay. The record of site preparation is shown in Table S15.

Table S15 History of the Arboretum Site

Year	Arboretum (1992)	Arboretum (1993)
Originally	Lowland dipterocarp forest	
Jun. 1988 - Mar. 1989	Clear cutting for compensatory planting project	
Apr. 1989	Slash burning twice for the site preparation of planting *Acacia mangium*	
	Area was left over without planting *Acacia mangium* and Belukar regenerated	
Oct. 1992 - Jan. 1993	Removal of Belukar and slash burning	
Jan. 1993 - Aug. 1993	Monoculture planting	
Sep. 1993 - Feb. 1994		Removal of Belukar and slash burning
May. 1993 - May 1994		Monoculture planting

4.1.4.2. Site preparation

Site preparation was conducted at the same time and in a same manner with open planting in Chikus Block-A. The soil was cultivated only for four species plots : *Toona sureni*, *Cinnamomum* sp., *Alstonia* sp. and *Endospermum malaccense*.

4.1.4.3. Planting

All the available species at the time of planting were planted in arboretum (Table S16, Photos 37 and 38). Total of 31 species were planted.

One species was planted uniformly in each experimental plot. FGTS was not planted. Seedlings were planted in a spacing of 3.7 m x 3.0 m in accordance with the spacing of *Acacia mangium* plantation. This results in a density of 900 trees per hectare. Contrary to the spacing in Block-B, planting rows were spaced 3.7 m apart and individual seedlings 3 m apart.

Planting methods were the same as those of Multi-Storied Forest by Underplanting in *Acacia mangium* plantation.

Table S16 Planting Species in Arboretum

BLOCK	YEAR	TYPE	DIRECTION	SPP	Date Planted	Seed/Wilding	Name of Place	State	JICA / FD / Private nursery	Date acquired
Arboretum	93	AB	X	Agathis borneensis	May 94	Wilding	Papang	Perak	FD (Papang)	Sep 93
Arboretum	93	AB	X	Alstonia sp	Oct 93	Seed	Sg Buloh	Selangor	Private	Mar 93
Arboretum	93	AB	X	Calophyllum sp	Jul 94	Wilding	Basaur	Perak	JICA	Apr 93
Arboretum	93	AB	X	Cinnamomum sp	Oct 93	Seed	Kota Setar	Kedah	Private	Mar 93
Arboretum	93	AB	X	Dacryodes sp	May 94	Wilding	Chikus	Perak	JICA	Jul 93
Arboretum	93	AB	X	Dipterocarpus cornutus	May 94	Seed	Gaoda	Perak	JICA	Aug 93
Arboretum	92	AB	X	Dryobalanops aromatica	May 93	Seed & Wilding	Kanching	Selangor	Private	Mar 93
Arboretum	92	AB	X	Durio sp	May 93	Seed	Kota Setar	Kedah	Private (Kota Setar)	Mar 93
Arboretum	93	AB	X	Endospermum malaccense	Oct 93	Wilding	Mantin	Sembilan	FD (Mantin)	Aug 93
Arboretum	93	AB	X	Pertiera sp	May 94	Wilding	Mantin	Sembilan	FD (Mantin)	Aug 93
Arboretum	92	AB	X	Hevea brasiliensis (PB260)	May 93	Seed	FRIM, Sg Buloh	Sembilan	FD (Mantin)	Jan 93
Arboretum	92	AB	X	Hopea odorata	May 93	Wilding	Kuala Berang	Terengganu	Private	Aug 92
Arboretum	92	AB	X	Hopea odorata 1 (not Shorea leavis)	Feb 93	Wilding	Mantin	Sembilan	FD (Mantin)	Jan 93
Arboretum	93	AB	X	Hopea odorata 2 (not Shorea hopeifolia)	May 94	Wilding	Manong	Perak	FD (Manong)	Aug 93
Arboretum	93	AB	X	Hopea odorata 3 (not Shorea dolichocarpa)	May 93	Wilding	Jerantut	Pahang	FD (Raub)	Mar 93
Arboretum	92	AB	X	Intsia palembanica	Jun 93	Wilding	Bauding	Perak	FD (Gerik)	May 93
Arboretum	92	AB	X	Intsia palembanica <<Replantes	Mar 94	Seed	Bauding	Perak	JICA	Sep 93
Arboretum	93	AB	X	Koompassia malaccensis	May 94	Wilding	Chikus	Perak	JICA	Jan 93
Arboretum	92	AB	X	Neobalanocarpus heimii	May 93	Seed & Wilding	Kuala Berang	Terengganu	Private (Kuala Berang)	Aug-Sep 92
Arboretum	93	AB	X	Palaquium gutta	May 94	Wilding	Tarunoh	Perak	JICA	Jun 93
Arboretum	92	AB	X	Parkia sp	Jun 93	Seed	Kota Setar	Kedah	Private (Kota Setar)	Mar 93
Arboretum	92	AB	X	Pentaspadon motleyi	May 93	Wilding	Chikus	Perak	JICA	Nov 92
Arboretum	92	AB	X	Scaphium macropodum	Jan 93	Wilding	Pelangai	Sembilan	FD (Mantin)	Jan 93
Arboretum	92	AB	X	Shorea acuminata	May 93	Wilding	Sg Menyala, PD	Sembilan	FD (Mantin)	May 93
Arboretum	92	AB	X	Shorea leprosula	Feb 93	Wilding	Chikus	Perak	JICA	Nov 92
Arboretum	92	AB	X	Shorea leprosula <<Replants>>	Sep 93	Wilding	Manong	Perak	FD (Manong)	Aug 93
Arboretum	93	AB	X	Shorea macroptera	May 94	Wilding	Bauding	Perak	JICA	Sep 93
Arboretum	93	AB	X	Shorea multiflora	May 94	Wilding	Bukit Larut	Perak	JICA	May 94
Arboretum	92	AB	X	Shorea ovalis	May 93	Wilding	Jerantut	Pahang	FD (Raub)	Mar 93
Arboretum	92	AB	X	Shorea parvifolia	Aug 93	Wilding	Manong	Perak	FD (Manong)	Aug 92
Arboretum	93	AB	X	Shorea talura	May 94	Wilding	Batu Gajah	Perak	JICA	Jun 93
Arboretum	92	AB	X	Swietenia macrophylla	May 93	Seed & Wilding	Jelebu	Sembilan	FD (Mantin)	Jan 93
Arboretum	92	AB	X	Tectona grandis	Jun 93	Stump	Gerik	Perak	FD (Gerik)	May 93
Arboretum	93	AB	X	Toona sureni	Oct 93	Seed	Kota Setar	Kedah	Private (Kota Setar)	Mar 93

Photo S37 *Tectona grandis* planted in Arboretum (31 months after planting)

Photo S38 *Parkia speciosa* planted in Arboretum (31 months after planting)

4.1.4.4. Tending

The same as that of Multi-Storied Forest by open planting.

4.1.4.5. Pest and diseases

The same as that of Multi-Storied Forest by open planting.

4.1.4.6. Supplementary planting

The care of the Arboretum expected at initial design was actually not taken. Therefore, survival and growth were very poor and supplementary planting was required. One of the designs of supplementary planting used in the open planting were applied here. Because arboretum was established next to the open planting area, supplementary planting was done at the same time. Arboretum plots were re-arranged as shown in Fig. S12.

Site was weeded in lines from February to March 1996. Retained grass or shrub were expected to provide shade on cleared line. HQTS and *Acacia mangium* were planted in cleared lines in March 1996, and planting line were arranged one by one alternately. Only 10 species available at the time were planted (Table S17). All the seedlings of HQTS were treated with hardening. In arboretum, five different planting methods were applied as follows;

Table S17 Planting Species for Supplementary Planting in Arboretum

BLOCK	YEAR	TYPE	DIRECTION	SPP	Date Planted	Seed/Wilding	Name of Place	State	JICA / FD / Private nursery	Date acquired
Arboretum	95	AB	X	Dipterocarpus kerrii	Feb-96	Seed	Bauding	Perak	JICA	Aug-94
Arboretum	95	AB	X	Dipterocarpus oblongifolius	Feb-96	Seed	Ulu Kenas	Perak	JICA	Feb-95
Arboretum	95	AB	X	Shorea assamica	Feb-96	Wilding	Bubu	Perak	JICA	Apr-94
Arboretum	95	AB	X	Shorea bracteolata	Feb-96	Wilding	Unknown	Perak	FD (Manong)	Aug-93
Arboretum	95	AB	X	Shorea curtisii	Feb-96	Seed	Bukit Larut	Perak	JICA	Feb-95
Arboretum	95	AB	X	Shorea glauca	Feb-96	Wilding	Unknown	Sembilan	FD (Mantin)	Jan-93
Arboretum	95	AB	X	Shorea leprosula	Feb-96	Seed	Ulu Slim	Perak	JICA	Sep-94
Arboretum	95	AB	X	Shorea macroptera	Feb-96	Seed	Bendol	Sembilan	JICA	Jul-94
Arboretum	95	AB	X	Shorea parvifolia	Feb-96	Seed	Bikam	Perak	JICA	Jan-95
Arboretum	95	AB	X	Shorea lepidota	Feb-96	Wilding	Batu Gajah	Perak	JICA	Jun-94

(1) Planting on soil bag

Soil bags, which contains mixture of top soil, organic fertilizer (Product name: Bio-M) and small pieces of charcoal (5 mm x 5 mm x 5 mm, 5% of top soil volume), were placed on the ground. Size of soil bag was 60 cm in width and 90 cm in length. Planting hole was opened on the soil bag, with the size of 20 cm in diameter and 30 cm in depth, and a seedling was planted into it (Photo 39). Mulching was not applied.

Photo S39 Planting on soil bag

(2) Mulching with soil bag

Three soil bags, which contain mixture of top soil, organic fertilizer (Product name: Bio-M) and small pieces of charcoal (5 mm x 5 mm x 5 mm, 5% of top soil volume), was placed on the ground. Size of soil bags were 60 cm in width and 90 cm in length. Planting hole was opened among the three soil bags, with the size of 20 cm in diameter and 30 cm in depth, and a seedling was planted into it. Soil bags were expected to play as mulching (Photo 40).

Photo S40 Multing with soil bag

(3) Big hole planting

Size of planting hole for each indigenous seedling should be more than 50 cm in diameter and more than 50 cm in depth. In each planting hole, mixture of top soil, organic fertilizer (Product name: Bio-M) and small pieces of charcoal (5 mm x 5 mm x 5 mm, 5% of top soil volume), was filled. Half-cut coconuts husks were placed around seedling as mulch (Photo 41).

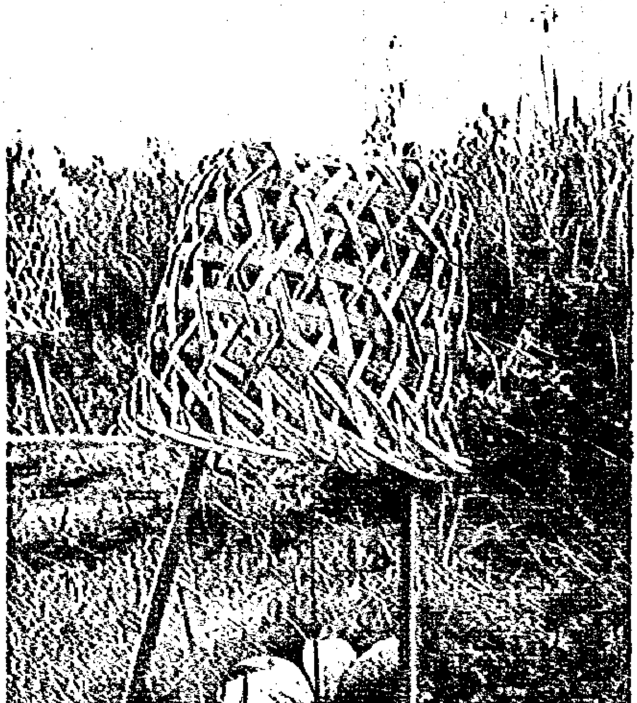


Photo S41 Big hole planting

(4) Group planting

Five seedlings were planted together in one planting spot in order to provide shade for each other. Size of planting hole for each seedling 20 cm in diameter and 30 cm in depth. Oil palm leaves cut in 1 m length were placed around seedlings as mulch (Photo 42).

Photo S42 Group planting

(5) Underplanting in belukar

As the Belukar naturally regenerated again after the site preparation of arboretum(1992) from October 1992 to January 1993, they were used as nurse trees (Photos 43 and 44). Planting method was the same as the big hole planting above.

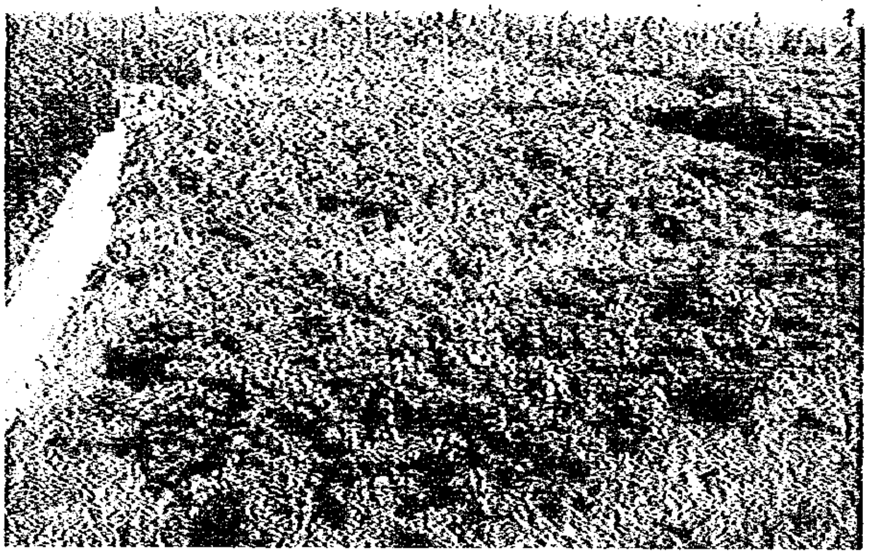


Photo S43 Natural regeneration of belukar
36 month after site preparation

PS44 Underplanting in belukar

4.2. Bukit Kinta site

4.2.1. Demarcation of Experimental Plots

Demarcation of planting area was done based on preliminary survey by referring map and site inspection. A post felling inventory was carried out in compartment 146 by local contractor on Feb. 1993 to know the status and spatial distribution of vegetation, remaining trees,and regenerated saplings within the compartment. The plot demarcation survey was carried out by local contractor. The criteria of maximum closing errors was determined as one percent. Unsuitable areas such as rocky, swampy, stream and steep areas more than 30 degrees were avoided. Experinemtal plots were mainly located along forest road in order to access easily. An amount of area which include one or more plots was named block. Total number of 17 blocks (bloks A-Q) was arranged in the area as shown in Fig. S18.

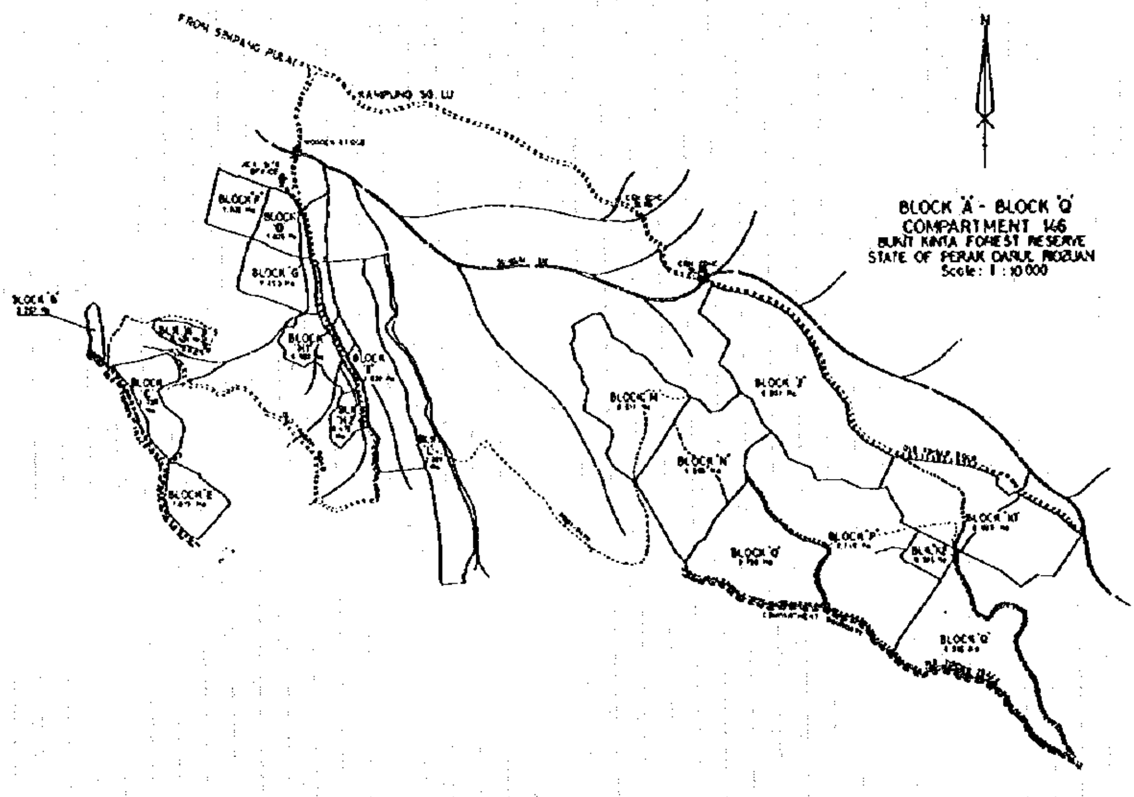


Fig. S18 Arrangements of 17 blocks in Bukit Kinta site

Two types of planting methods have been adopted in Bukit Kinta site. One is gap planting (1990 Ochiai) and another is Line Planting. Furthermore, Gap planting is divided into two types named GP-1 and GP-2.

GP-1 type plots were designed to use pre-existing canopy openings (gaps) which were created naturally or by logging activities, as planting sites. Therefore, each block was demarcated so as to include at least one gap of larger than 30m x 30m. One plot was established in each of the blocks A-G and I, and two plots were established in H block. In K-block, one GP1 plot was established

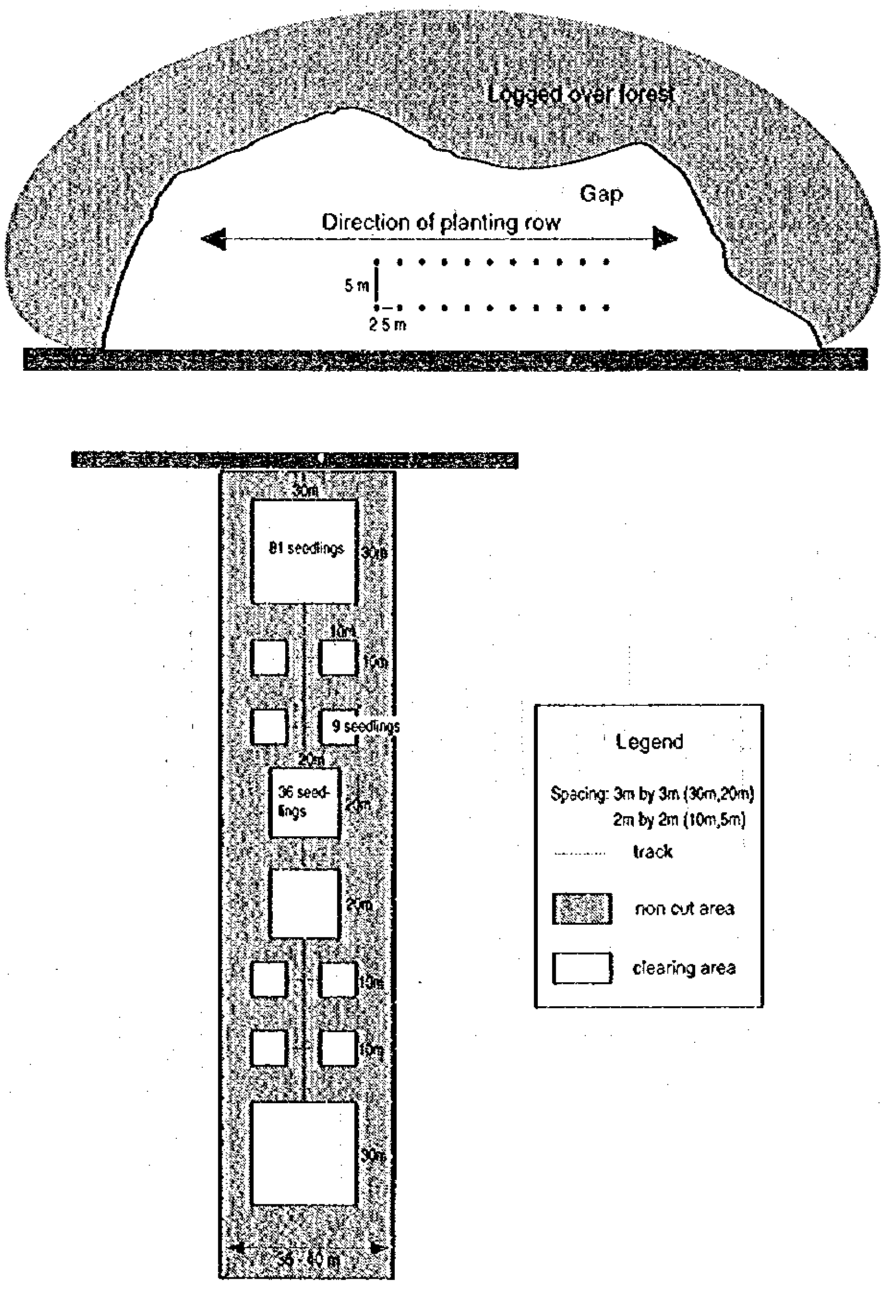


Fig S19 Basic design of GP-1 and GP-2 gap plots

Two types of planting methods have been adopted in Bukit Kinta site. One is gap planting (1990 Ochiai) and another is Line Planting. Furthermore, Gap planting is divided into two types named GP-1 and GP-2.

GP-1 type plots were designed to use pre-existing canopy openings (gaps) which were created naturally or by logging activities, as planting sites. Therefore, each block was demarcated so as to include at least one gap of larger than 30m x 30m. One plot was established in each of the blocks A-G and I, and two plots were established in H block. In K-block, one GP1 plot was established

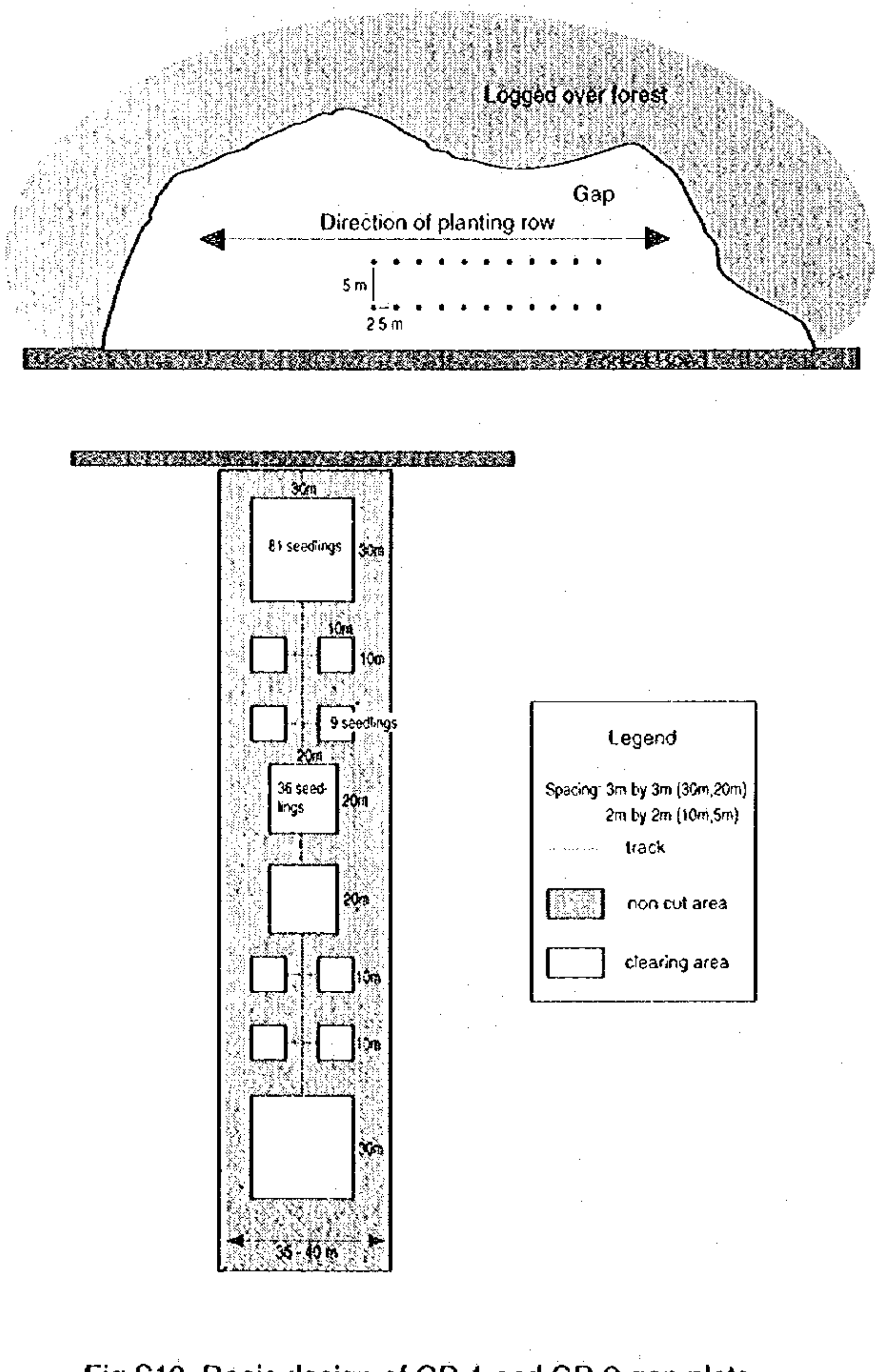


Fig S19 Basic design of GP-1 and GP-2 gap plots besides GP2 and LP type plots mentioned below.

GP-2 type plots and Line planting (LP) plots were designed to compare growth performance of planted seedlings within artificially created various sized canopy openings. Square openings of 5m x 5m, 10x10, 20x20, and 30x30 (Fig. S19), and strip openings of 2m, 10m, and 20m width (Fig. S20) were created. Square gap plots were set so as not to include large trees or palms which have DBHs of 20cm or above. Buffer zone was retained at least 10 m apart each other and from other open area such as forest road, ex-log yard, decking site. Description of plots established in Bukit Kinta site are shown in Table S18.

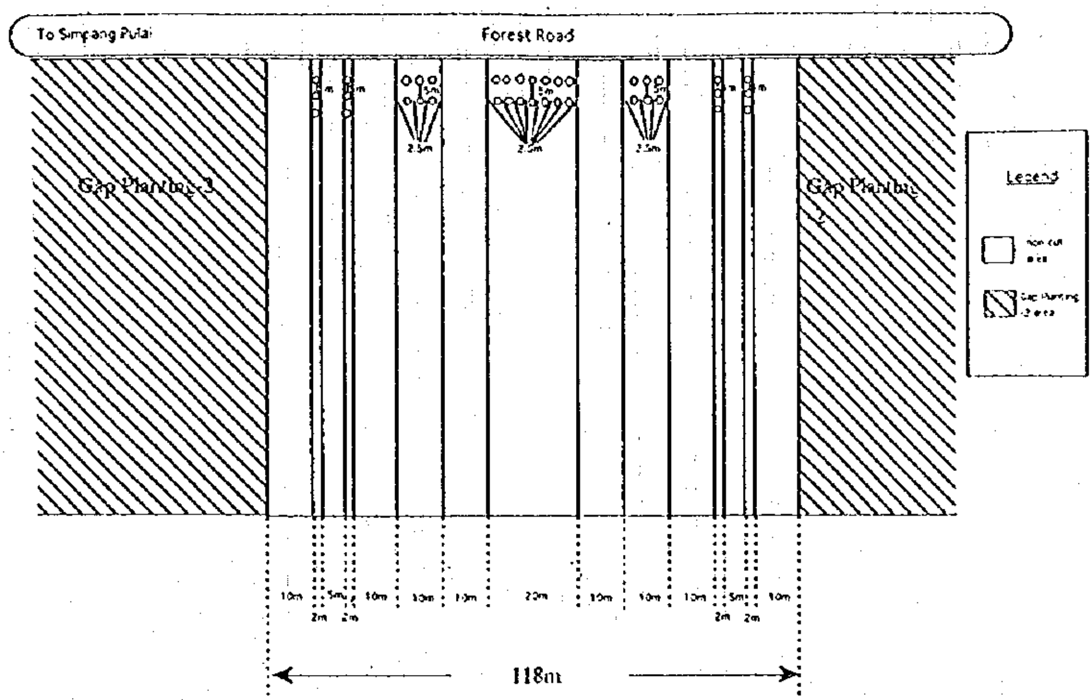


Fig. S20 Design of line planting

Table S18 Areas and number of plots for each planting design

Year	Block	Planting Pattern										Total Area of Gap	Total Area of Block
		GP-1	GP-2					LP					
			(5)	(10)	(20)	(30)	sub-to.	2m	10m	20m	sub to.		
1993	A	0.42 (1)										0.42 (1)	0.42
	B	0.26 (1)										0.26 (1)	0.26
	C	1.36 (1)										1.36 (1)	1.36
	D	1.03 (1)										1.03 (1)	1.03
	E	1.08 (1)										1.08 (1)	1.08
	F	1.00 (1)										1.00 (1)	1.00
	G	1.46 (1)										1.46 (1)	1.46
1994	H	1.37 (2)										1.37 (2)	1.38
	I	3.84 (1)										3.84 (1)	3.84
	J		0.05(19)	0.17(17)	0.20(5)	0.18(2)	0.60(43)	0.11(4)	0.31(2)	0.3(1)	0.71(7)	1.31(50)	6.06
	K	2.61(1)		0.19(19)	0.08(2)	0.18(2)	0.45(23)	0.12(4)	0.32(2)	0.33(1)	0.77(7)	3.83(31)	6.28
1995	L		0.05(21)	0.09(9)	0.08(2)	0.09(1)	0.31(33)					0.31(33)	2.89
	M		0.06(23)	0.08(8)	0.08(2)	0.09(1)	0.31(34)					0.31(34)	3.61
	N		0.04(15)	0.08(8)	0.08(2)	0.09(1)	0.29(26)					0.29(26)	4.50
	O		0.04(17)	0.07(7)	0.16(4)	0.18(2)	0.45(30)					0.45(30)	3.80
	P		0.03(12)	0.09(9)	0.12(3)	0.18(2)	0.42(26)					0.42(26)	7.74
	Q		0.05(18)	0.05(5)	0.12(3)	0.18(2)	0.40(28)					0.40(28)	4.91
Total	17	14.43(11)	0.32(125	0.82(82)	0.92(23)	1.17(13)	3.23(243)	0.23(8)	0.63(4)	0.63(2)	1.48(14)	19.14(268)	51.62

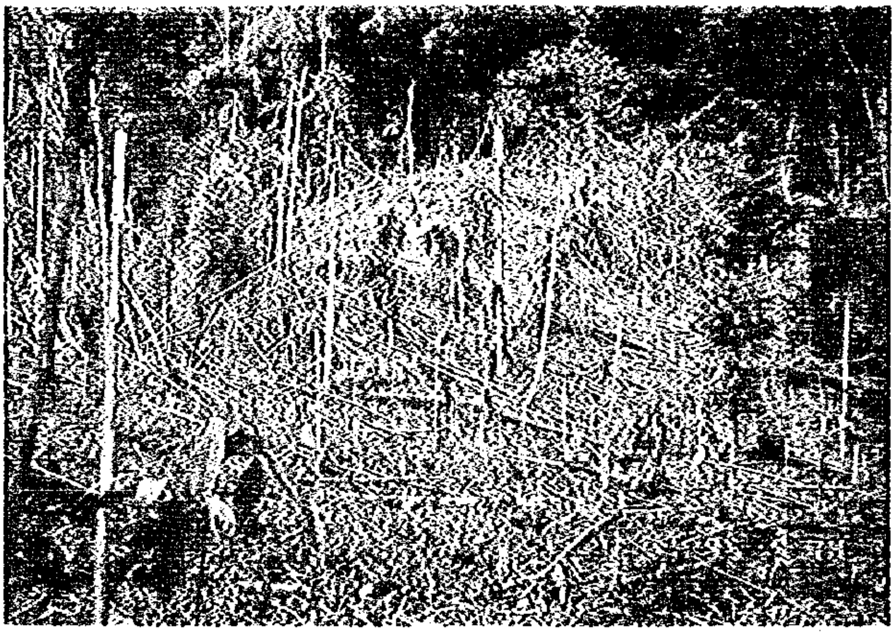


Photo S51
GP-1 plot of
H block

4.2.2. Site Preparation

GP1 plots were set up at pre-existing gaps of unknown ages. All of such kind of gaps were occupied with dense thickets of bamboos, palms, shrubs, and grasses. These thickets were cleared by hatchets or engine bush cutters except for the remaining trees of more than 5 cm (for blocks A-G) or 10 cm (for blocks H, I, and K), or for the species which were listed as useful trees in Pocket chek list of timber trees (Kochummen, 1962). Cut thickets were gatherd along contour lines so as not to hamper planting of seedlings.

Photo S52 Line Planting (2m) in K block

GP2 plots, artificial square gaps of 5mx5m, 10x10, 20x20, and 30x30, were created by felling overstory trees. Trees more than 10 cm in DBH or the useful tree species were retained as in GP1. After felling trees, shrubs were cut and extracted out of the plots. GP2 plots were arranged randomly within J and K blocks.It means that specific gap size should not be gathered on lower slope or upper slope in the area. Two control plots of 20m x 20m, in which saplings were intended to be planted without overstory felling or any other treatments such as climber cutting, were located in block J.

Line planting (LP) plots of 2m, 10m, and 10m widths were established in J and K blocks as the same manner as in GP2. Each line has a length of 120-160 m and direction of NE-SW.

One of the purposes of these treatments in the site preparation is to reduce impact on surrounding conditions such as vegetations, soil and to reduce the costs of establishment of MSF in logged-over forests. The soil was not cultivated, and fertilizer was not applied. Two control plots were located in J-block where no felling or cutting were carried out.

Photo S53 GP-2 (30m) in J Block

4.2.3. Selection of Species

Tree species to plant in Bukit Kinta were selected from the high-quality timber species growing in Bukit Kinta site, and were also planned to plant seedlings collected at B.K site, five or so species with readily available seedlings would be selected according to five year work plan. Actually we were forced to depend on stock quantity in nursery under irregular flowering and fruiting pattern of tropical rain forest.

Finally the 7 species as *D.baudii, S. curtisii, S.leprosura, S. macroptera, S. pauciflora, S. parvifolia, S. ovata*(all dipterocarps) were planted in Bukit Kinta so far (Table S19). All the species except

Table 19 Source of seedlings

Year	Block	Species	Date Planted	seed/wilding	Place	State	Nursery	Date
93	A-G	*Shorea parvifolia*	Feb,Mar,May-94	seed & wilding	Bentong	Pahang	JICA	Mar-93
94	H	*Dipterocarpus baudii*	Mar-95	seed	Bukit Kinta	Perak	JICA	Mar-94
95	L	*Dipterocarpus baudii*	Mar-96	seed	Bukit Kinta	Perak	JICA	Mar-94
94	H	*Shorea curtisii*	Mar-95	seed	Gerik	Perak	JICA	Sep-93
95	L-Q	*Shorea curtisii*	Mar-96	seed	Taiping	Perak	JICA	Feb-95
94	I, K	*Shorea leprosura*	Mar-95	seed	Gerik	Perak	JICA	Aug-93
94	H-K	*Shorea macroptera*	Mar-95	seed	Gerik	Perak	JICA	Sep-93
95	M-O	*Shorea ovata*	Mar-96	seed	Gerik	Perak	JICA	Aug-93
94	J,K	*Shorea pauciflora*	Mar-95	seed & wilding	Gerik	Perak	JICA	Oct-93

Shorea ovata are popular regenerating species in Bukit Kinta according to Post-Felling Inventory and other vegetation surveys. Only *D.baudii* was planted from the seeds collected in Bukit Kinta.

4.2.4. Planting

Seedlings planted in Bukit Kinta site were brought from Chikus nursery, about 70km away from B. K. They were transported by a covered truck usually in the early morning by a contractor . Then seedlings were put under shaded area or put in a temporary nursery made by the contractor near the planting site. Additional 10% to the required number were brought to the site for the reserve.

Differnt spacing were applied for differnt types of openings (Fig. S21). The spacing of 5m x 2.5m was adopted in GP-1 (density of 800 trees per hectare). The spacing of 3m x 3m for larger two types and 2m x 2m for smaller two types were adopted in GP-2. Fundamentally seedlings were planted along contour lines in gap planting plots. Seedlings were planted with a interval of 2.5m in line planting plots of LP10 and LP20, where two and four rows with 5 m apart each other were planted respectively . In LP2 seedlings were planted with a interval of 3m. Planting spots were marked with stakes of bamboos, boards, or PVC pipes of 1m length during the site preparation.

Planting spots were cleaned in circle with diameter of 1.0 m. All the undesirable seedlings were removed with their roots. Grasses and remaining branches and twigs were removed from planting spots. The planting hole is 12cm in diameter and 20cm depth. Polythene bags containing seedlings were removed carefully by sharp instrument so as to make sure the soil in the bag was kept intact. After planting, the holes were covered back and compacted in a proper way. Removed polythene bags were placed on stakes to make it easy to find the planted trees in especially weeding treatment and prevent cutting planted trees. First survey of survival rate was carried out at one month or two months after planting. If 20% or more seedlings have died, supplemental planting was performed by a contractor by 3 months after initial planting (Follows the standard method used by Forestry Department).

Total number and specis of seedlings planted in Bukit Kinta site are shown in Table S20.

4.2.5. Tending

Weeding treatment and climber cutting were done at the same time. Although, weeding treatments were carried out by both man-power and machinery, it was done by man-power near the trees so as not to cut trees. All undesirable plants were cut so as not to exceed 30 cm from the ground level, and all undergrowth within the radius of 45cm around the trees were hoed up with. All climbing plants found on trees were cut and remove manually by hatchets. It is important to cut and remove climbers as soon as possible because they grow so fast in B.K site especially in the area which is located at the lower slope. After hoeing work, soil surface was covered with leaf litter around the trees. These treatment works were carried out in all plots except two control plots in J block which were designated to get comparative data with other plots.

Frequency of weeding treatment varies. It was decided by conditions of each plot. Weeding treatment is done when undergrowth (including climber) come up to tree height. The growth speeds

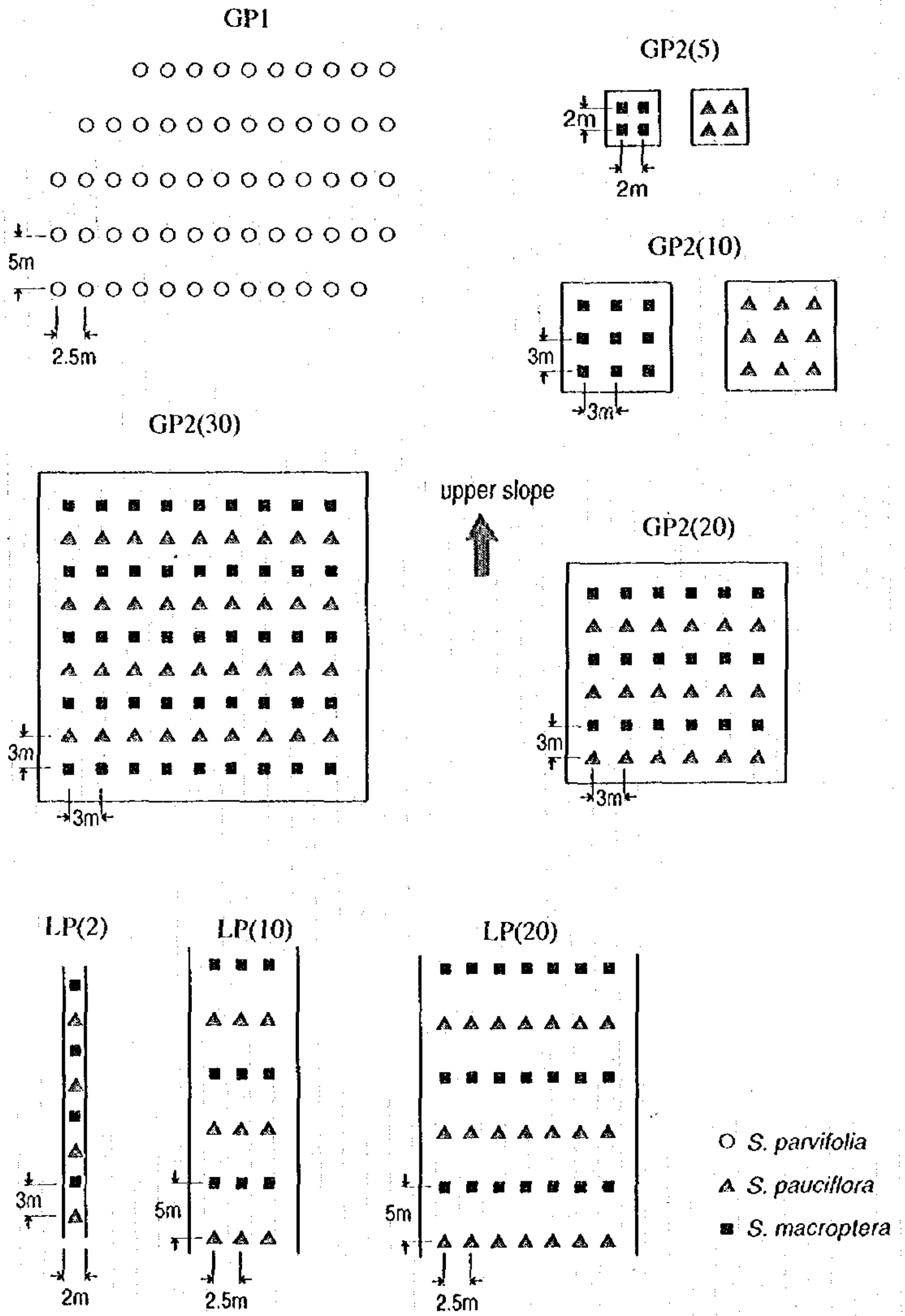


Fig. 21 Examples of spacing for each planting type

Table S20 Species and number of seedlings planted in each planting type in Bukit Kinta Site

BLOCK	Planting Date	Planting type	Species	Plots Number	Area (HA)	Planted Seedlings	Measuring trees	Spacing	Reference
A	May-94	GP-1	*S. parvifolia*	1	0.42	300	173	5mX2.5m	Monoculture
B	May-94	GP-1	*S. parvifolia*	1	0.26	200	115	5mX2.5m	Planting
C	May-94	GP-1	*S. parvifolia*	1	1.36	1,100	130	5mX2.5m	
D	Feb-94	GP-1	*S. parvifolia*	1	1.03	800	102	5mX2.5m	
E	May-94	GP-1	*S. parvifolia*	1	1.08	900	95	5mX2.5m	
F	Mar-94	GP-1	*S. parvifolia*	1	1.00	800	100	5mX2.5m	
G	Mar-94	GP-1	*S. parvifolia*	1	1.46	1,200	140	5mX2.5m	
H-1	Mar-95	GP-1	*D. baudii*	1	0.91	364	50	5mX2.5m	Mix planting
			S. macroptera			364	120		
H-2	Mar-95	GP-1	*D. baudii*	1	0.48	192	60	5mX2.5m	Mix planting
			S. curtisii			192	120		
I	Mar-95	GP-1	*S. macroptera*	1	3.84	1,536	80	5mX2.5m	Mix planting
			S. leprosura			1,536	80		
J	Mar-95	GP-2(5)	*S. macroptera*	19 (8)	0.05	32	32	2mX2m	Mono.Planting
			S. pauciflora	(11)		44	44		
		GP-2(10)	*S. macroptera*	17 (9)	0.17	81	81	3mx3m	Mono.Planting
			S. pauciflora	(8)		72	72		
		GP-2(20)	*S. macroptera*	3	0.12	54	54	3mx3m	Mix planting
			S. pauciflora			54	54		
		GP-2(30)	*S. macroptera*	2	0.18	81	81	3mx3m	Mix planting
			S. pauciflora			81	81		
		CONTROL(20)	*S. macroptera*	2	0.04	33	33	3mx3m	Mix planting
			S. pauciflora			36	36		
		LP2	*S. macroptera*	4	0.13	106	60	12mx3m	Mix planting
			S. pauciflora			106	58		
		LP10	*S. macroptera*	2	0.32	96	60	2.5mx5m	Mix planting
			S. pauciflora			96	60		
		LP20	*S. macroptera*	1	0.32	112	62	2.5mx5m	Mix planting
			S. pauciflora			112	58		
K	Mar-95	GP-1	*S. macroptera*	1	2.61	1044	60	5mx2.5m	Mix planting
			S. pauciflora			1044	59		
		GP-2(10)	*S. macroptera*	19 (9)	0.19	90	90	3mx3m	Mono.Planting
			S. pauciflora	(10)		81	81		
		GP-2(20)	*S. macroptera*	2	0.08	36	36	3mx3m	Mix planting
			S. pauciflora			36	36		
		GP-2(30)	*S. leprosura*	2 *(1)	0.18	40	40	3mx3m	Mix planting
			S. macroptera			81	81		
			S. pauciflora			81	81		
		LP2	*S. macroptera*	4	0.14	120	60	12mx3m	Mix planting
			S. pauciflora			120	58		
		LP10	*S. macroptera*	2	0.36	108	60	2.5mx5m	Mix planting
			S. pauciflora			108	60		
		LP20	*S. macroptera*	1	0.36	126	62	2.5mx5m	Mix planting
			S. pauciflora			126	58		

* 1plot where is planted 3 species

of undergrowth were different among each block. Especially, there are differences between upper blocks and lower blocks; undergrowth comes earlier in lower slope than upper slope in Bukit Kinta. The record of weeding treatment is shown in Table S21. As shown in Table K4, there were plots that need weeding treatment 3-4 times in first year. On the other hand there were plots that do not need weeding treatment for a year.

Main target weed species for weeding treatments are bamboo, ginger, banana, Bertum palm (*Eugeissona tristis*) ,and rattan (*Calamus spp*/Rotan). A grass (*Imperata cylindrica*/Lalang) well known as preventing regeneration of woody species is also a target. The study area can be divided into three types by topography and these correspond to the distribution of weeds. Upper part of the slopes, bertum is one of the typical vegetation evenly found on steep area and ferns also occupied the forest floor. In the middle part of the slope, rattan grows. In lower part of slopes and along the stream,wild ginger and banana occupied the forest floor. A climber (*Mikania scandens spp*/Selaput tunggul) comes up all tree species so frequently in all areas especially lower slope.

4.2.6. Pest and diseases

Although there are some damage on leaf by leaf eating insects, conspicuous damage is not found in Bukit Kinta. Damages by wild pig were seen in I and K blocks where the soil was kept muddy. In those area, footprints of wild pigs and traces of scratches were left on the ground around planted trees, while they were not so serious so far. Only in a plot (30-2) in K block, which is often watterlogged due to small stream run through this area, many footprints of wild pigs were left and staking poles and seedlings were considered to be fallen down by wild pigs. Its damage spread on more than 70 trees while 121 trees were planted.

4.2.7. Supplementary Planting

In B block, replanting was done because forest fire occurred in June 1994. In this block, originally, *S.parvifolia* was planted in May 1994. After assessing survival of trees, the same species *S.parvifolia* were replanted in Nov. 1994. Finally 206 seedlings were planted by the same method as initial planting.

Table S21 Weeding record

	Planted in 93							Planted In 94			
Block	A	B	C	D	E	F	G	H	I	J	K
Planting Date	May.94	May.94	May.94	Feb.94	May.94	Mar.94	Mar.94	Mar.95	Mar.95	Mar.95	Mar.95
May./94		O									
Jul.				O		O	O				
Oct.			O	O	O	O	O				
Dec.				O							
Mar. /95			O	O	O	O	O				
Jun.				O			O	O	O		OGP-1
Jul.										O	OGP2,LP
Aug.								O	O		OGP-1
Sep.					O	O				O	OGP2,LP
Oct.				O			O				
Nov.	O		O					O	O	O	O
Mar./96				O	O	O		O	O	O	O
Jul.		O		O		O	O	O	O	O	O

5. EXPERIMENTS

The objectives of this experiment are divided into two. One is to clarify the optimum silviculture design thorough the comparison of the growth of trees planted among different types (different openness) of Multi-Storied Forest which manipulate the light conditions. The other is to clarify the species character and find out promising species for establishing Multi-Storied Forest thorough the comparison of the growth of different species which were planted both in Multi-Storied Forest and Arboretum .

5.1 Chikus Site

5.1.1. Method

5.1.1.1. Setting up of permanent plots

Permanent plots were set up in each plot for the measurement and monitoring of planted seedlings. Each permanent plot was set up at the central part of the plot to remove border effects. At least 100 seedlings were included in each permanent plot to attain statistical significance.

5.1.1.2. Measurement of survival and growth of planted trees

Survival and growth of trees were measured at each permanent plot. Every planted tree in each permanent plot was marked and numbered, and measured regularly in items of total surviving number, tree height and diameter at ground. Tree height was measured with measuring pole, and diameter was measured with caliper.

Basically, measurement was done at one month after planting for the first time, and after that it was continued every six months. Because of time constraints or manpower constraints, some plots could not have been followed this schedule.

Actual measurement dates for the each plot are shown in Appendix S1, S2, S3, and S4.

5.1.1.3. Measurement of survival and growth of *Acacia mangium*

In Underplanting plots in Block-B(1992), survival and growth of *Acacia mangium* were measured in A - E type of *Shorea leprosula* planted in NS direction. Total surviving number, and diameter at breast height (dbh) were measured. Tree height was estimated with the height of sample trees. Measurements were carried out in June 1993, December 1993, June 1994. They fall on 3 years and 7 months, 4 years and 1 month, and 4 years and 7 months after planting respectively, and 9 months, 1 year and 3 months, and 1 year and 9 months after strip felling respectively.

In Openplanting plots in Block-A(1992), survival and growth of *Acacia mangium* were measured in A - E type of *Hopea odorata, Neobalanocarpus heimii, Shorea leprosula, Shorea parvifolia* plots. Total surviving number, height and diameter at ground height were measured. This measurement was carried out in November 1993, it fall on 5 to 10 months after planting.

5.1.1.4. Measurement of meteorological data

Automatic Meteorological Data Recorder

Automatic meteorological data recorder (OTAC-2000, Ohta Keiki Ltd., Japan) was installed at Chikus Nursery (Photo S45). It records temperature, moisture, rainfall, wind velocity, wind direction, solar radiation, and sunshine duration. Since the trouble with the generator prevented its continuous data recording, solar power supply system was introduced. After installing solar power system in February 1994, meteorological data has been recorded.

Weather Data Logger

Weather data loggers (M-812, Yokogawa Weathac Ltd., Japan) were installed at planting sites to record the micro climate in the forest at November 1995 (Photos S46, S47). Total number of six weather data loggers were installed. Three weather data loggers were installed at EW-A, EW-C, and EW-E in Chikus Block-B(1994) to record light intensity, air temperature (30 cm and 110 cm above the ground) , soil temperature (5 cm and 30 cm beneath the ground), and the one weather data logger was installed at overstory felling experimental plot to record light intensity, and the one weather data logger was installed at Nursery to record light intensity, air temperature (30 cm and 110 cm above the ground), soil temperature (5 cm and 30 cm beneath the ground), and the one weather data logger was installed at Bidor office to record light intensity, air temperature (30 cm and 110 cm above the ground), moisture, soil temperature (5 cm and 30 cm beneath the ground), rainfall, wind velocity, and wind direction.

5.1.1.5. Measurement of light condition

Four kinds of light measurement methods were taken in the Chikus site. Since *Acacia mangium* plantation was considered in homogenous condition, one measurement was taken in one planting strip, and the measured value was regarded as the representative value of the planting design.

Measurement of RAI by diazo method and transient relative light intensity by PPFD meter were conducted by two short term experts; Dr. Y. Matsumoto from October to November 1994, and Dr. K. Kimura from September to November 1995. Refer to their report for the detail of the study.

5.1.1.5.1 Relative Accumulated Illuminance (RAI) by Illuminance Meter

Illuminance Meter (T-1H digital illuminance meter, Minolta Ltd., Japan) was used to measure the average relative accumulated illuminance (RAI) in the planting strip. The measurement was carried out in A to E type of *Shorea leprosula* plots in NS directions in Block-B(1992) and in non-felled *Acacia mangium* forest. The data in the middle of E type was used as a standard for 100 % of RAI. The meter was held at 1.3 meters high above the ground by the man who was walking through the each plots to measure the average illuminance in the plot. Accumulated illuminance

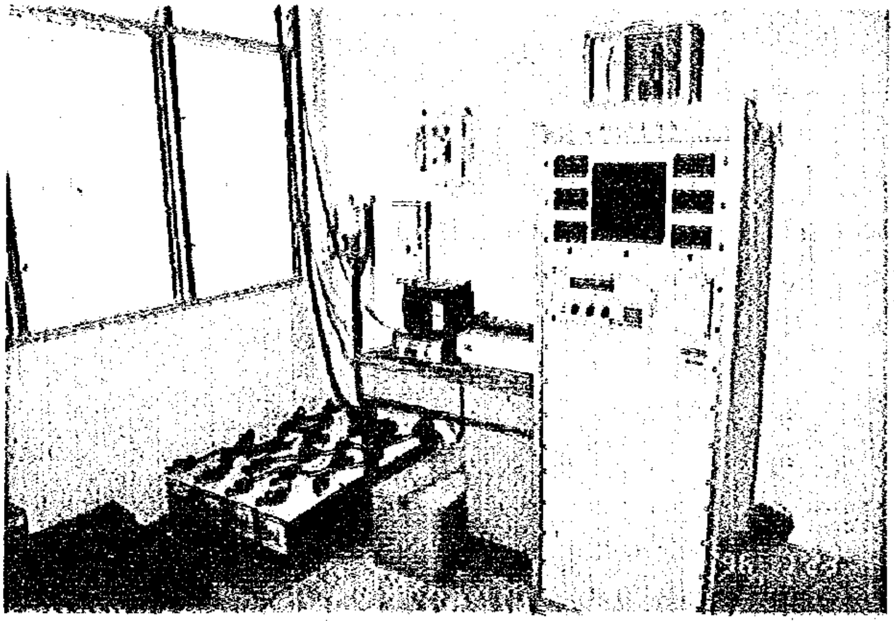


Photo S45 Automatic meteorological data recorder OTAC-2000 installed in nursary office

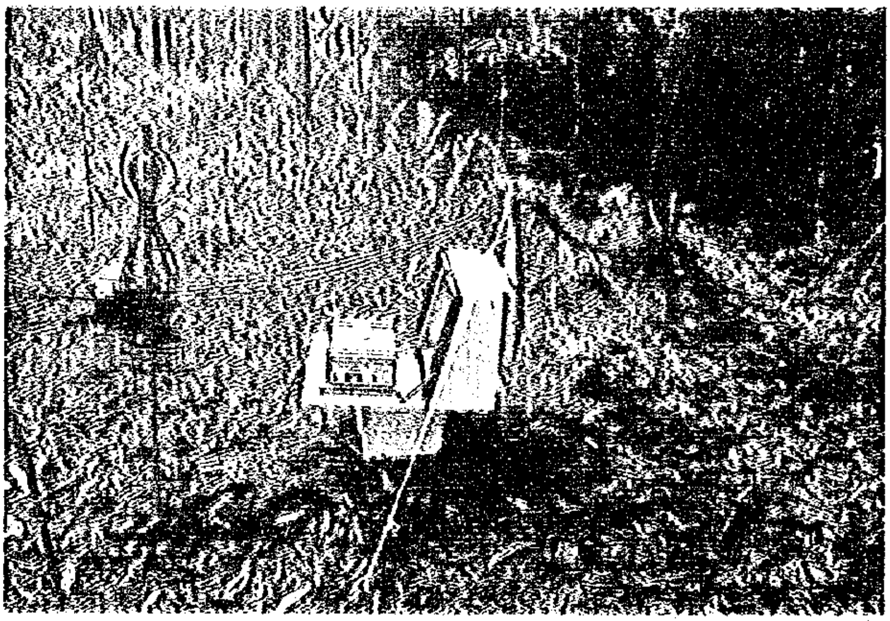


Photo S46 Weather data logger M-812 installed in B-type planting strip

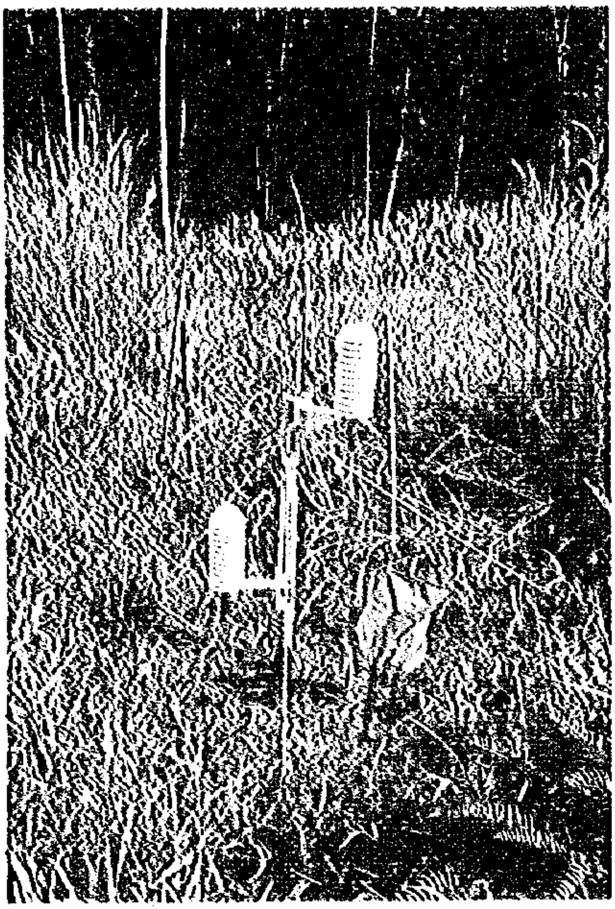


Photo S47 Thermometers and PPFD sensors installed in E-type planting strip

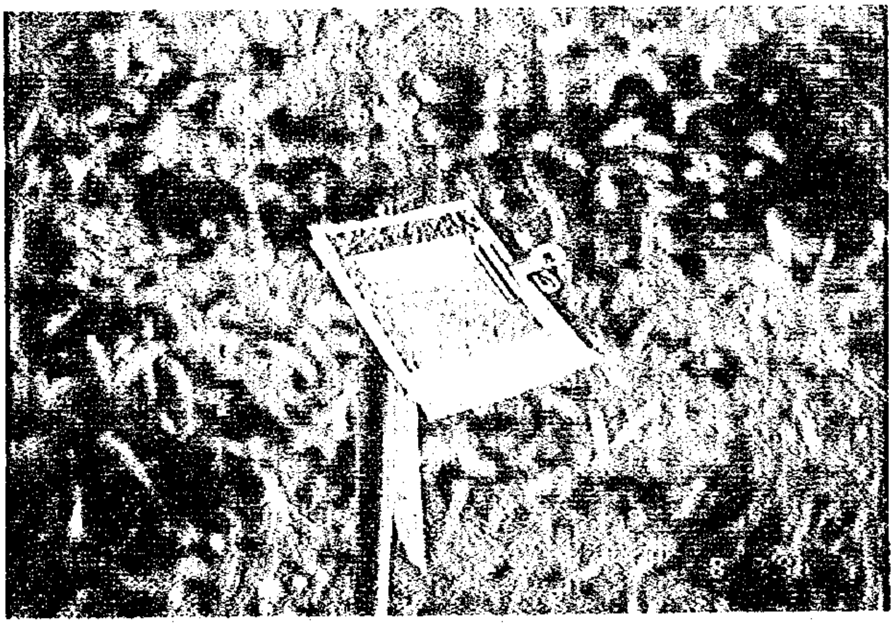


Photo S48 A diazo plate installed in a field was measured for a 10-minute period between 12:30 and 14:30 (one hour before and after the sun crosses the meridian) on slightly overcast days, in October 1992 at the time of planting (1st.), in July 1993 (2nd.) and October 1993 (3rd.).

5.1.1.5.2. Relative Accumulated Illuminance (RAI) by Diazo Method

Diazo photo sensitive paper method (Friend 1961, Ando 1983 and Matsumoto 1995) was taken in order to measure the distribution of RAI within the planting strip. This method uses diazo photo sensitive paper (blue copy paper) with the step wise light absorbing filters. The step wise light absorbing filters makes stepwise exposure pattern on the diazo paper, and these values were calibrated to RAI which was measured by the illuminance meter. This method provided a margin of error within 25 % of actual values.

Measurements were carried out twice in underplanting in *Acacia mangium* sites.

The first measurement was done from the end of October to the beginning of November in 1994. The measurements were done in three sites; firstly in EW-A to EW-E type in Block-B(1992), secondly in EW-A to EW-E in Block-B(1993), and thirdly NS-A to NS-E in Block-B(1993). In Block-B(1992), the measurement time fell on 26 months after strip felling of *Acacia mangium*. In Block-B(1993), it fell on 12 months after strip felling of *Acacia mangium*. *Acacia mangium* was about 18 m in average tree height at that time.

The second measurement was done in October 1995. The measurements were done in three sites; firstly EW-A to EW-E type in Block-B(1992), secondly EW-A to EW-E in Block-B(1993), and thirdly EW-A to EW-E in Block-B(1994). In Block-B(1992), the measurement time fell on 38 months after strip felling of *Acacia mangium*. In Block-B(1993), it fell on 24 months after strip felling of *Acacia mangium*. In Block-B(1994), the measurement time fell on 10 months after strip felling of *Acacia mangium*. *Acacia mangium* was about 20 m in average tree height at that time.

Diazo papers were set on each planting row of seedlings at 1.2 m height above the ground, but not in the shade of seedlings since some seedlings have attained more than 1.2 m in height (Photo S48). Within each plot, two series of diazo papers were set with crossing planting strips, and both ends were on the planting rows of *Acacia mangium* which were the edges of planting strips. In E-type, which was the widest planting strips among all, light condition was measured at each four points from both forest edges of upper storied *Acacia mangium* and the center of the planting strip. The data in the middle of E type was used as a standard for 100 % of RAI.

Another measurement was also taken. RAI before and after the strip felling were measured. This measurement was conducted in conjunction with the over story felling experiment.

The light condition in underplanting in Belukar sites was also measured. F, G, H type in Block-A(1994) were measured in October 1995. It fell on 9 months after strip felling of Belukar. Belukar was about 8 m in average tree height at that time.

5.1.1.5.3 Transient Relative Light Intensity (RLI) by PPFD Sensors

This method was taken for the measurement of vertical distribution of light condition in Multi-Storied Forest by underplanting in *Acacia mangium* plantation. One sensor was fixed at a control open point (the middle of E type) and the another sensor was set on the top of measuring poles and placed at the desired point in the forest. The transient values were measured.

This method evaluated the diffused light from the sky with using two illuminance meters or PPFD sensors. Thus this method should be done under cloudy condition. RLI will fluctuate very strongly under the fine weather, because of the direct sun light.

5.1.1.5.4. Continuous measurement of photon flux density (PPFD) by Data Logger with PPFD Sensors

This method measured the changes of PPFD during the certain period. The Weather Data Logger (M-812) with PPFD sensors were set to record the changes of PPFD every 10 minutes during a day.

5.1.1.6. Other experiments

Other experiments were carried out mainly by the short-term experts. Refer to the short-term expert reports for the details of each study.

(1) Soil Condition

Soil condition in Chikus site was surveyed by the short-term expert, Mr. S. Aizawa, three times; firstly from January to February 1993, secondly from September to November 1993, thirdly from May to June 1995. The physical character of soil was surveyed in first time and second time, and the chemical character of the soil was surveyed in third time. Soil samples for analyzing chemical character were sent for FRIM and the Ministry of Agriculture. The analysis is in progress. Results are awaiting.

(2) Mycorrhiza

Mycorrhiza in Chikus site was surveyed by the short-term expert, Dr. M. Ogawa, two times; firstly from November to December 1994, secondly from May to June 1995. In openplanting site in Chikus Block-A, mycorrhiza formation was poor, and only *Inocybe* sp. was found. In underplanting site in Chikus Block-B, mycorrhiza fungi was also little, only *Laccaria* sp. was found in *Shorea leprosula* plot, *Laccaria* sp. and *Inocybe* sp. were found a little in *Shorea parvifolia* plot. The influence of mycorrhiza on the growth of dipterocarp species was not clarified in Chikus site.

(3) Diseases (Heart Rot of *Acacia mangium*)

Heart rot of *Acacia mangium* was surveyed by two short-term experts, Dr. T. Yamaguchi from October to November 1993, and Dr. S. Ito from November to December 1994. The percentage of damaged tree was 52.6 - 60 %, and the ratios of decayed wood volume to the whole tree volume 0.01 - 6.0 % in 1993 survey. The percentage of damaged tree was increased to 70 % in 1994 survey. Comparing to the similar survey conducted in Sabah state, these damaged rates were remarkably high. Fungus inducing heart rot of Acacia mangium were revealed to invade from wounds and dead branches. Thus it is needed to consider the improvement of procedures not to make wounds on the trunk and of pruning.

(4) Diseases (*Shorea leprosula* stem wound)

Stem wound of*Shorea leprosula* was surveyed by the short-term expert, Dr. S. Ito, from November to December 1994, and from November to December 1995. The damages of stem wound on *Shorea leprosula* planted in Block-B(1992) have been observed since 1993. This wound might be caused by cattle or water buffalo invaded into the site with rubbing their body against the stem. In 1994, canker and rot on stem of *Shorea leprosula* were found on the wound part. The percentage of damaged tree was 55.5 - 55.6 % in March 1995, and 59.4 - 61.4 % in November 1995. While the percentage of damaged tree was increased from March to November, the average severity of the wound did not progress drastically because of the healing. Judging from the infection manner, it is expected that this damage is not a dangerous and highly infectious disease. But xylem in the damaged trees was already rotted, thus the damage itself in this area is a serious problems. The canker and rot of stem was found to be caused by the invasion of decay fungi thorough the wound. *Macrophoma* sp., *Fusarium* sp., etc. were isolated from the wound, and *Macrophoma* sp. caused the lesion in the stem through the inoculation experiment. But *Macrophoma* sp. could not invade from a intact bark of *Shorea leprosula*. Beside this phenomena, other wound on the upper part of the stem was also observed in 1995. This wound might be caused by squirrels. In 1996, some of the wound trees were found to be broken on the point of the wound. Further observation and study is required.

(5) Soil Cultivation and Fertilization Experiment

The effect of soil cultivation and fertilization was studied. While the initial results were reported on "Interim Report, June 1994" of this project, continuous measurement was prevented by high mortality rate of planted seedlings after severe draught in June 1994.

5.1.2. Results and Discussion

5.1.2.1. Stand Environment

5.1.2.1.1. Weather condition

Fig.S22 show the weather condition in Chikus site. According the latest annual record, from August 1995 to July 1996, mean temperature was 27.1 °C, mean maximum temperature was 34.9 °C, mean minimum temperature was 21.4 °C, mean rainfall was 274.3 mm by monthly. Annual rainfall was 3,291 mm.

Fig.S23 shows the daily rainfall at Chikus nursery. Drought periods, which had no rainfall for more than one week were recorded in Feb., Jul., Aug., Sep. In 1995, May, Jun., Jul., Sep. In 1996. Drought period more than one week might affect the survival and growth of planted seed-

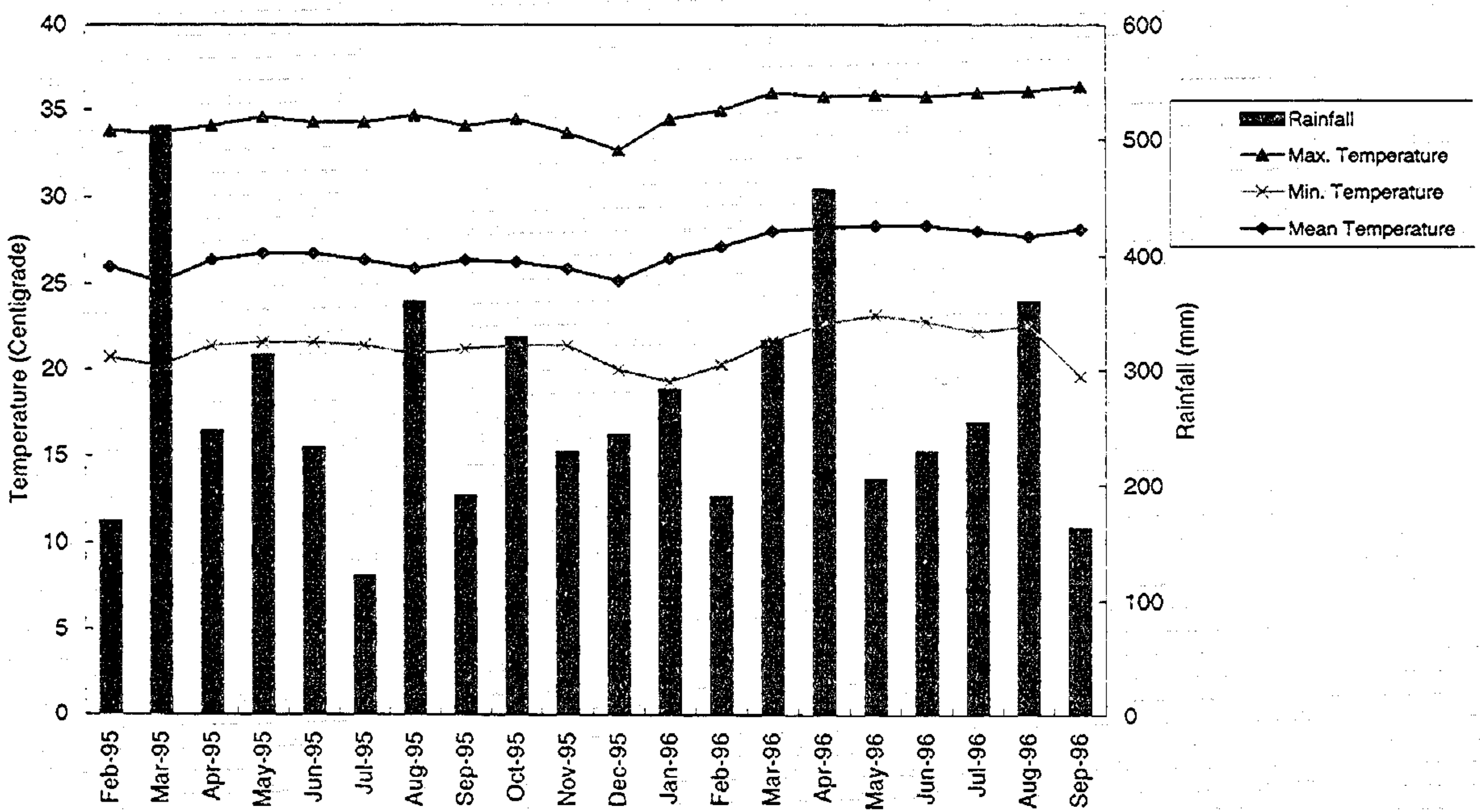


Fig. S22 Monthly temperature and rainfall at Chikus Nursary

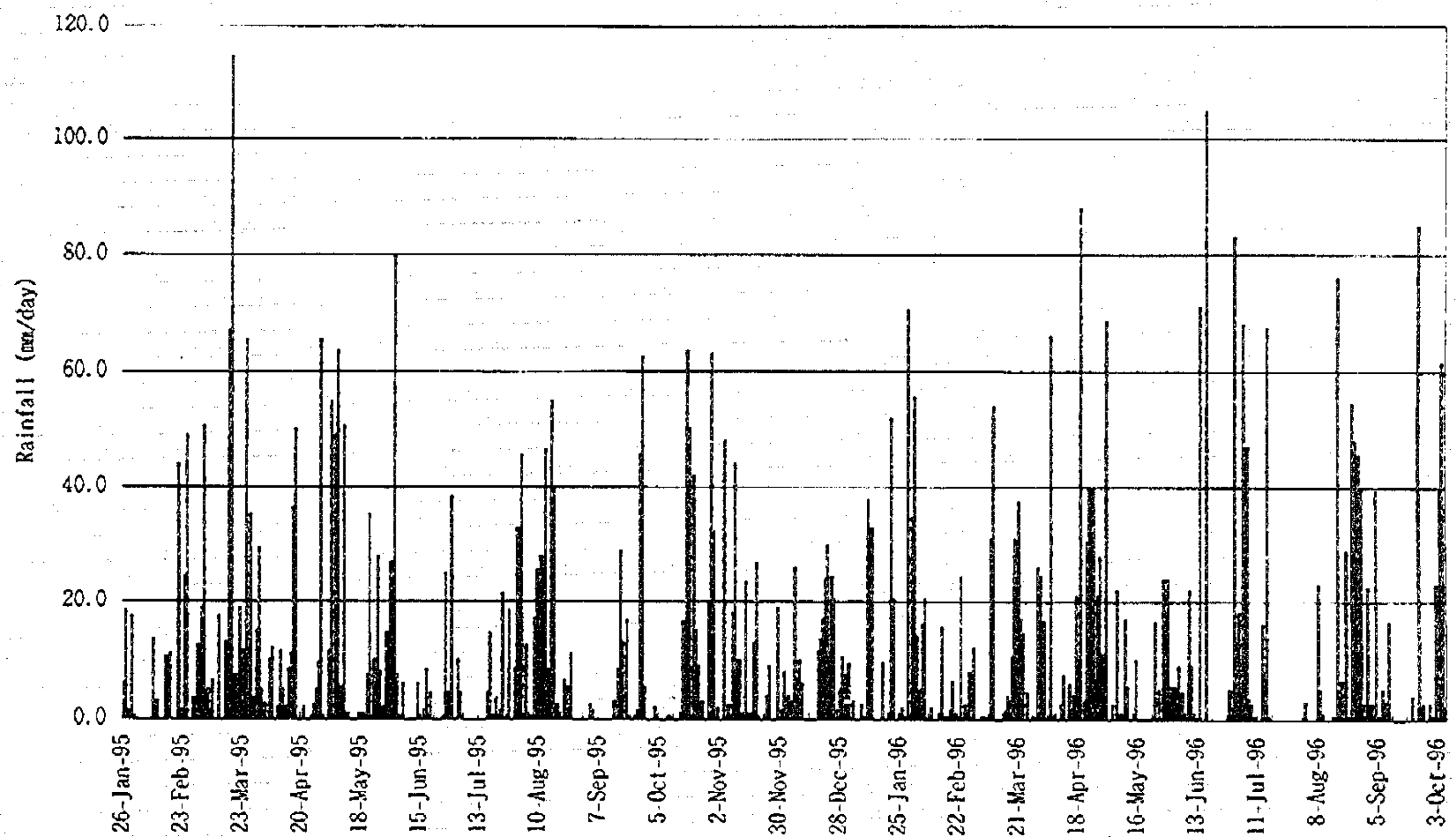


Fig. S23. Daily rainfall at Chikus Nursary lings. It can be recommended that it is important to pay attention to the weather condition, and planting should be avoided in dry period, while there is no clear dry season in this region.

5.1.2.1.2. RAI in each planting strip in underplanting plots in *Acacia mangium*

Relative accumulated illuminances (RAIs) in each planting strip (NS direction) and non-felling *Acacia mangium* plot in Block-B(1992) were measured with the illuminance meter. Table S22 shows the relationship between strip width and RAI. Each strip width and the status of retained *Acacia mangium* (i.e., tree height and canopy closure) gave considerable influence on RAI. In non-felling *Acacia mangium* plots, RAI dropped from 20.1 % at October 1992 (2 year and 11 months after planting) to 18.3 % at July 1993 (3 year and 8 months after planting), and 6.8 % at October 1993 (3 year and 11 months after planting). This drop of RAI is in accordance with the height growth and the canopy closure of *Acacia mangium*..

RAIs were higher in proportion to the width of planting strips; 38.6 % in NS-A, 65.4 % in NS-B, 71.8 % in NS-C, 93.2 % in NS-D, 97.5 % in NS-E in October 1992, when *Acacia mangium* was 2 year and 11 month old after planting, and 2 month after strip felling. After one year, RAI in each strip dropped in accordance with the height growth and the canopy closure of *Acacia mangium*; 14.2 % in NS-A, 22.9 % in NS-B, 42.4 % in NS-C, 68.1 % in NS-D, 94.1 % in NS-E in October 1993, when *Acacia mangium* was 3 year and 11 month old after planting, and 1 year and 2 month after strip felling.

Canopy closures of *Acacia mangium* were observed at about 1 year after strip felling in EW-A with the width of 6 meters, at about one and a half year in EW-B width of 9 m, at about 2 years in NS-B with width of 11.1 m. Due to the growth of underplanted species, RAI could not have been measured by the same method in the same plots after 2 years of planting.

5.1.2.1.3. Spatial distribution of RAI within each planting design in underplanting in *Acacia mangium* plot

Table S23 and Fig.S24 shows the spatial distribution of RAI in each planting design. In every planting design, the RAIs in the edge of the planting strip were lower than those in the middle of the planting strip. This was caused by the shading effect of retained *Acacia mangium* trees. It is said that there is no shading effect on the RAI where the distance from the surrounding forest is beyond corresponding distance to the height of the surrounding forest. In this study, the height of *Acacia mangium* was 18 m in October 1994 and 20 m in October 1995, thus shading effect might be observed in almost all planting strips except for the middle rows of E-type.

The RAIs in northern planting rows in each planting strip with EW direction were higher than those in southern rows. This may be due to the measurement date which was from October to November when the sun track in day time leaned southward from the zenith. The distribution pattern of RAI on planting rows will show symmetrical curve throughout a year, for study site is situated at latitude 4°North.

Comparing to the RAIs in 1994 in the plots in Block-B(1992) and Block-B(1993), the RAIs measured in 1995 did not dropped so much, while *Acacia mangium* grew high. This might have

Table S22 RAI in Each Planting Strip in Underplanting in Acacia mangium Plot (Block-B(1992))

Type	Direction	Width	Measurement Oct-92	Jul-93	Oct-93
Non-Felling	-	-	20.1%	18.3%	6.8%
A	NS	7.4m	38.6%	34.4%	14.2%
B	NS	11.1m	65.4%	62.2%	22.9%
C	NS	18.5m	71.8%	66.8%	42.4%
D	NS	33.3m	93.2%	88.7%	68.1%
E	NS	62.9m	97.5%	94.2%	94.1%

Table S23 Distribution of RAI in Each Planting Design in Underplanting in Acacia mangium Plots

(Unit : %)

Sub Block	Type	Direction	Width	Measurement Oct-94	Oct-95
Block-B(1992)	A	EW	6.0m	10.8	10.8
	B	EW	9.0m	7.1-9.5	11.7-18.8
	C	EW	12.0m	30.7-42.7	18.1-54.9
	D	EW	27.0m	17.0-76.5	19.5-81.3
	E	EW	51.0m	35.8-100.0	14.4-100.0
Block-B(1993)	A	EW	6.0m	19.1	40.5
	B	EW	9.0m	22.7-30.4	27.2-34.3
	C	EW	12.0m	40.0-78.5	37.1-80.1
	D	EW	27.0m	59.8-96.8	26.5-94.6
	E	EW	51.0m	65.4-100.0	75.5-100.0
	A	NS	7.4m	22.1	-
	B	NS	11.1m	43.2-51.2	-
	C	NS	18.5m	48.2-62.3	-
	D	NS	33.3m	57.9-98.7	-
	E	NS	62.9m	54.9-100.0	-
Block-B(1994)	A	EW	6.0m	-	30.1
	B	EW	9.0m	-	50.5-63.2
	C	EW	12.0m	-	52.6-75.0
	D	EW	27.0m	-	45.7-89.5
	E	EW	51.0m	-	67.8-100.0

Table S24 Distribution of RAI in Each Planting Design in Underplanting in Belukar Plots

(Unit : %)

Sub Block	Type	Direction	Width	Measurement Oct-95
Block-A(1994)	F	EW	10m	88.7-96.5
	G	EW	20m	93.6-110.4
	H	EW	40m	98.8-101.1

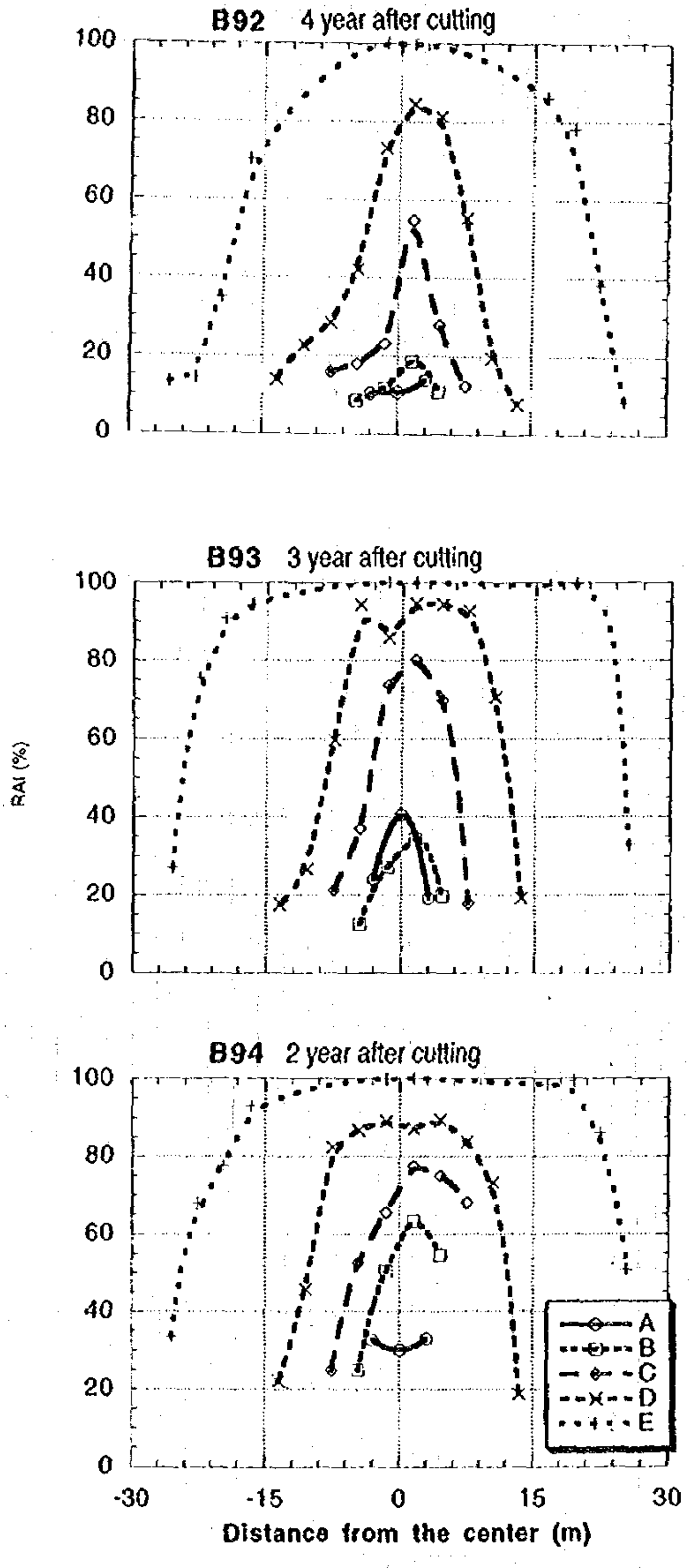


Fig. S24 Distribution of RAI in each planting design in underplanting in Acacia mangium plot been caused by the measurement error of diazo method; which provides a margin of error within 25 % of actual values.

Fig. S25 shows the daily changes of PPFD in EW-A, EW-C, EW-E type of planting strip under in *Acacia mangium* plantation in Block-B(1994) from 12 May 1996 to 14 May 1996. Because of the rainfall, every plots showed lower PPFD on 14 May. Peak value of PPFD was higher in accordance with the strip width; 1,025μE/s/m² in EW-A, 2,071μE/s/m² in EW-C, 2,631μE/s/m² in EW-E. While the difference of peak PPFD values in EW-C type and EW-E type was not so large, total accumulated PPFD was larger in EW-E type than in EW-C type. In EW-E type, PPFD sensors were set also under the retained *Acacia mangium* rows. Daily changes of PPFD under *Acacia mangium* were nearly constant even in fine day or in rainy day, and impulsive direct sun flecks were recorded in fine day. PPFD data is still being recorded. Further analysis is needed.

Fig. S26 shows the vertical distribution of RLI in EW-A type of underplanting in *Acacia mangium* plantation in Block-B(1992) by PPFD meter. RLI was higher in accordance with the height of measurement point up to 10 m above the ground. RLIs at 1 m above the ground where the measurement points were under the both *Acacia mangium* canopy and *Shorea leprosula* canopy were about 8 - 25 %, RLIs at 6 m above the ground where the measurement points were under the *Acacia mangium* canopy and above the *Shorea leprosula* canopy were about 17 - 39 %, RLIs at 10 m above the ground where the highest measurement points under the *Acacia mangium* canopy and above the *Shorea leprosula* canopy were about 13 - 49 %. This means the growth of understory trees may not be interfered by drop of RLI due to the upper canopy closure. Overstory felling may not be necessary at least within a few years in terms of the acceleration of the growth of understory trees.

Fig. S27 shows the changes of RAI before and after the felling of *Acacia mangium* measured by the diazo method. This measurements were conducted in conjunction with the overstory-felling experiment. Overstory-felling experiment was done in three ways; 2 rows felling, 4 rows felling, and 8 rows felling of *Acacia mangium* plantation. Felling directions were East to West. RAI before felling were 3 - 22 % under the *Acacia mangium* canopy, and RAI after felling increased up to 75 % in the 2 rows felling strip, 84 % in the 4 rows felling strips, and 94 % in the 8 rows felling strips. The RAIs in northern rows in each felling strip with EW direction were higher than those in southern rows. This may be due to the measurement date which was in October when the sun track in day time leaned southward from the zenith. The canopy openness made RAI high in the neighboring forest floor up to northward 3 rows from the edge of felling strip. Continuous measurements can make it sure how the RAIs change in accordance with the canopy closures.

5.1.2.1.4. Distribution of RAI in Each Planting Design in Underplanting in Belukar Plot

Table S24 and Fig. S28 shows the distribution of RAI in each planting design in underplanting in Belukar plot. In Belukar plot, even in the narrowest width strip of 10 m; F type, the RAI in the middle of planting strip was nearly 100 %. It might be caused by the wider planting strip in comparing with the surrounding retained tree height . Moreover the canopy of the Belukar might be thinner than that of *Acacia mangium*. Furthermore, the influence of measurement error of diazo

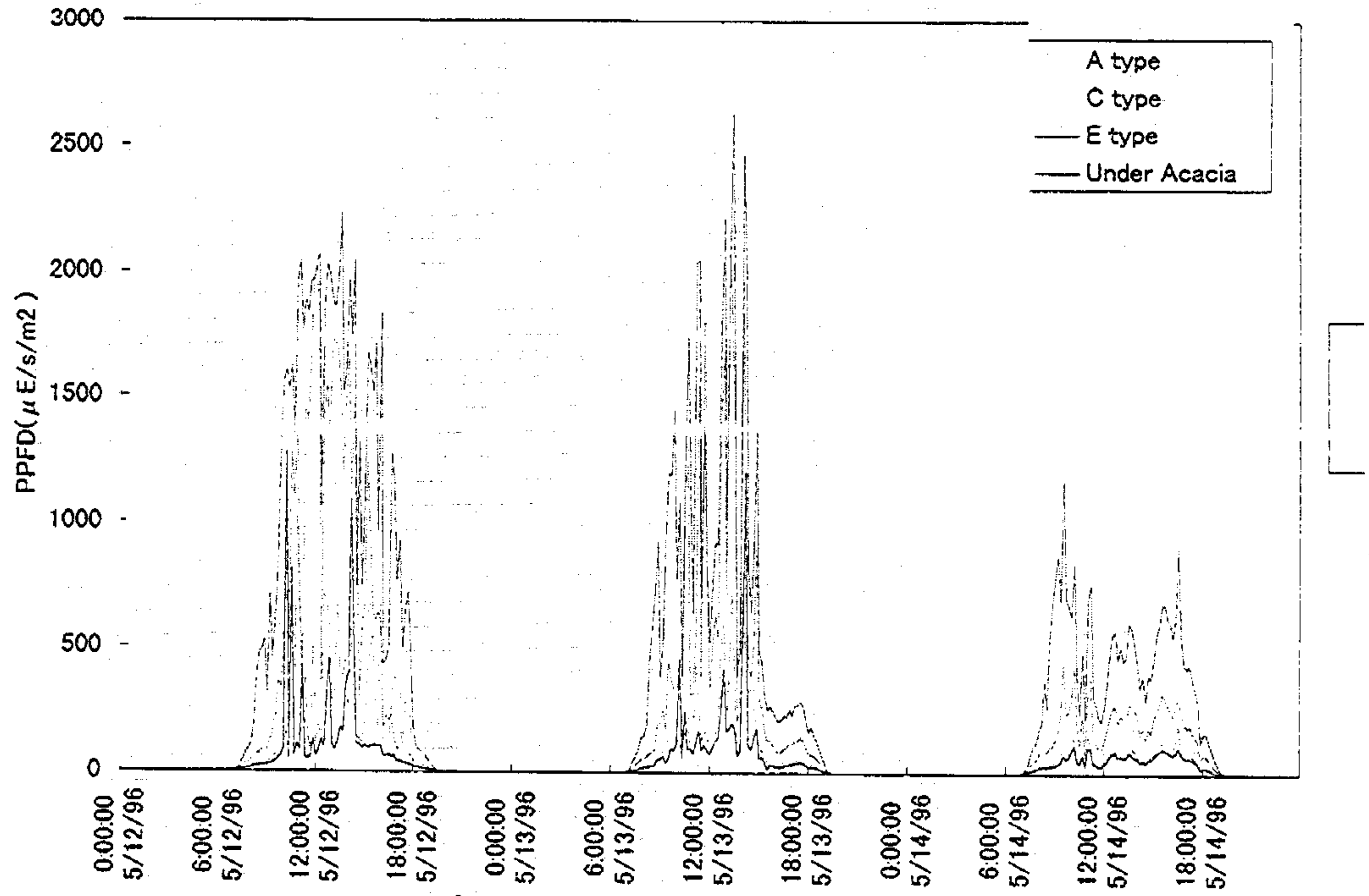


Fig. S25 Daily changes of PPFD in A, C, E types of planting strip under Acacia mangium plots.

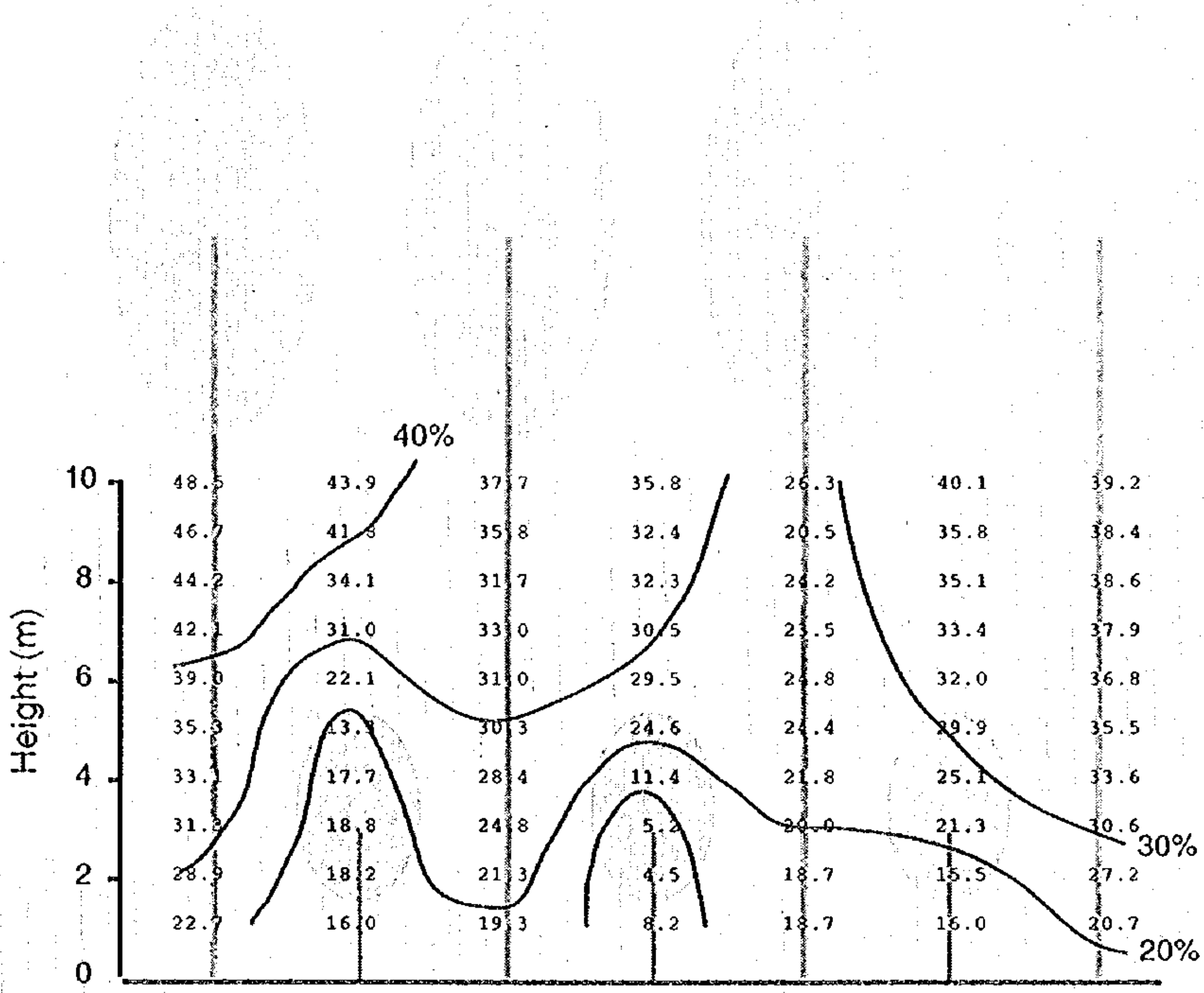


Fig. S26 Vertical distribution of RLI in A-type strip in Chikus B3 (planted in 1992).

Upper story: Acasia mangium Lower story: Shorea leprosula

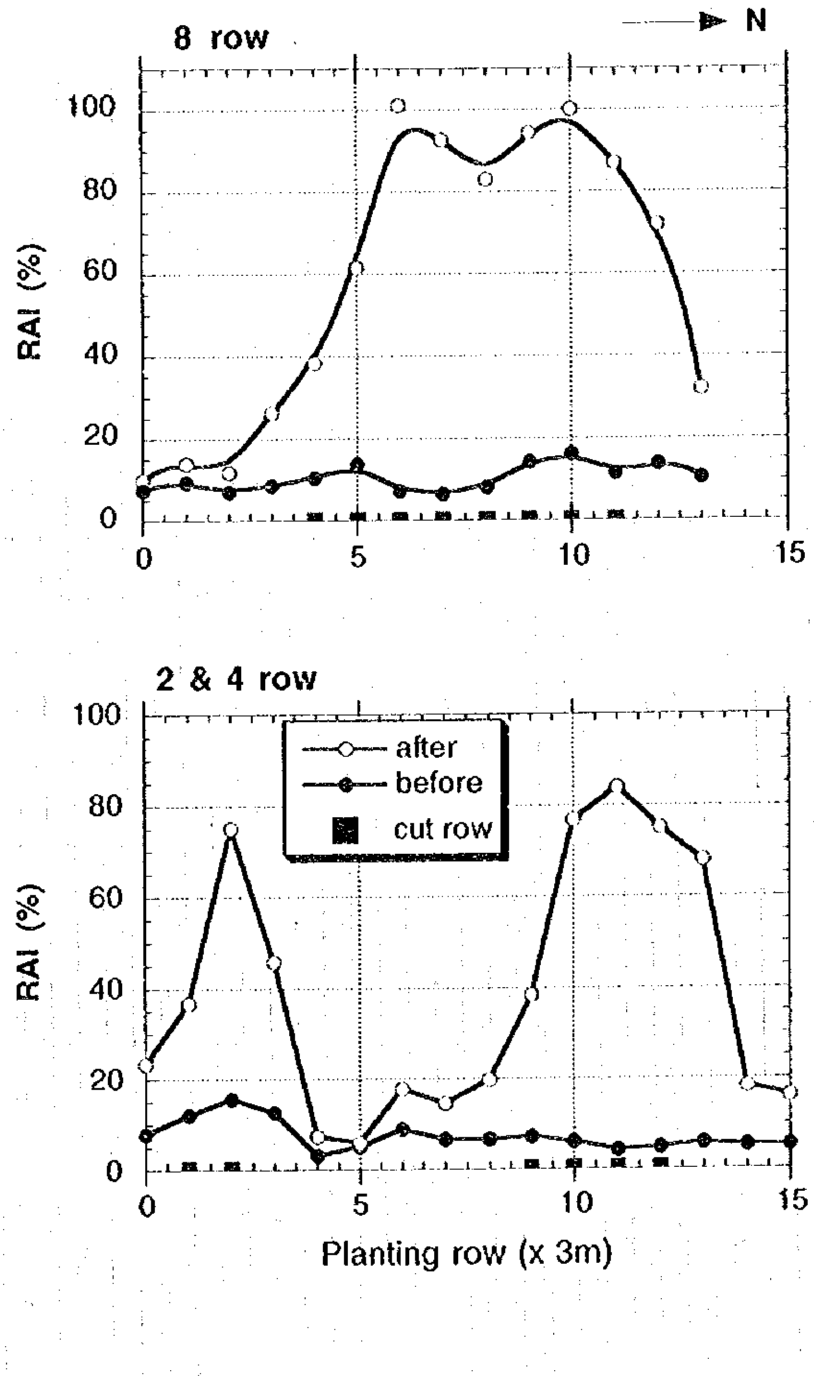
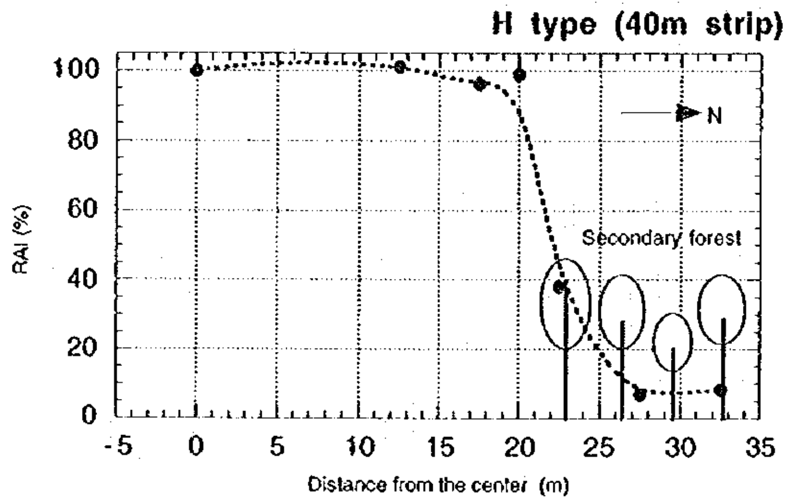


Fig. S27 Changes of RAI before and after the overstory fellin og *Acacia mangium*



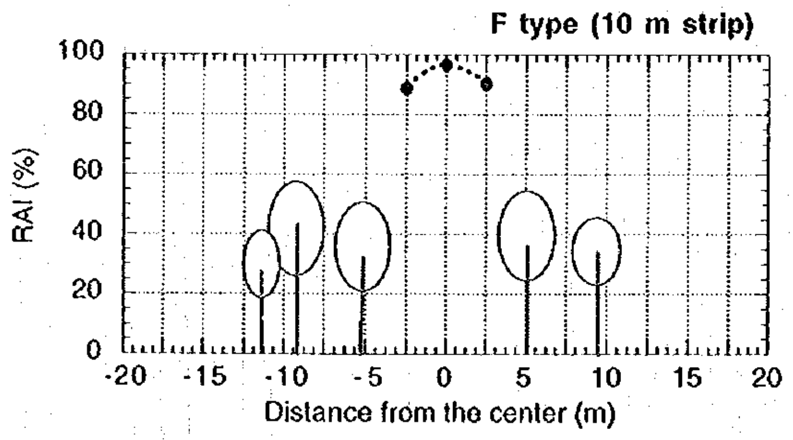


Fig . S28 Distribution of RAI in each planting design in underplanting in belukar plot.

method might be the another reason. Continuous measurements can make it sure how the RAIs change in accordance with the canopy closures.

Fig. S29 shows the frequency distribution of RAI under non-felling *Acacia mangium* canopy and Belukar canopy measured by the diazo method in October 1995. *Acacia mangium* was 5 years and 11 months old with the mean height of 20 m, and the Belukar was 6 and a half years old with the mean height of 8 m. The mean RAI under *Acacia mangium* was 9 %, and that under Belukar was 8 %. Those were relatively higher than that in natural forest; which is less than 5 %. Under these light condition, growth of seedlings can not be suppressed. In other words, light condition can not be a limiting factor on the growth of seedlings.

5.1.2.1.5. Temperature in Underplanting in Acacia mangium Plots

Fig. S30 shows the daily changes of air temperatures (110 cm and 30 cm above the ground) and soil temperatures (5 cm and 30 cm beneath the ground) in EW-A, EW-C, EW-E type of planting strip under *Acacia mangium* plantation in Block-B(1994) from 12 May 1996 to 14 May 1996. Because of the rainfall, every plots showed lower temperature on 14 May. The daily ranges of the air temperatures (110 cm and 30 cm above the ground) and the soil temperatures (5 cm and 30 cm beneath the ground) were larger in accordance with the strip width. The air temperature at 30 cm above the ground and the soil temperature at 5 cm beneath the ground in EW-E plots showed the larger daily range. These were caused by the direct sunshine and its radiation temperature.

It can be concluded that the wider the strips width, the severer the environment in terms of not only light condition but also temperature. In this study, humidity and soil moisture were not measured, but they can be assumed to change in accordance with the strip width.

5.1.2.2. Survival and growth of planted trees

5.1.2.2.1. Survival rates

Table S25 and Table S26 show survival rates of each species in each planting design at one year after planting in blocks B and A. See Appendix S5 and S6 for survival at all the measurement time. Generally, survival rates in underplanting plots were higher than those in openplanting plots. Survival rate in most of the plots showed the rapid decrease within 6 months after planting (Fig. S31). After initial drop of survival rate, the decrease rate became gradual. Especially in openplanting plots, initial decrease of survival rate was outstanding. Several openplanting plots reached less than 20 % of survival rate within 6 months after planting.

Among underplanting plots, narrower planting width plots showed higher survival rate than in wider width plots. The initial drop rates of survival rates were higher in wider width plots than in narrower width plots. After the initial drop of survival rate, the trend of decreases became gradual. In this stage, the decreasing rates of survival rates (it is equal to the mortality rates) were higher in wider width plots than in narrower width plots.

The plots of *Neobalanocarpus heimii* in EW-E, *Shorea leprosula* in EW-E, NS-C, *Shorea parvifolia* in EW-B, EW-D, in Block-B(1992),showed sudden decrease of survival rate again from 18 months to 24 months after planting. This period fell on from April to October in 1994. During

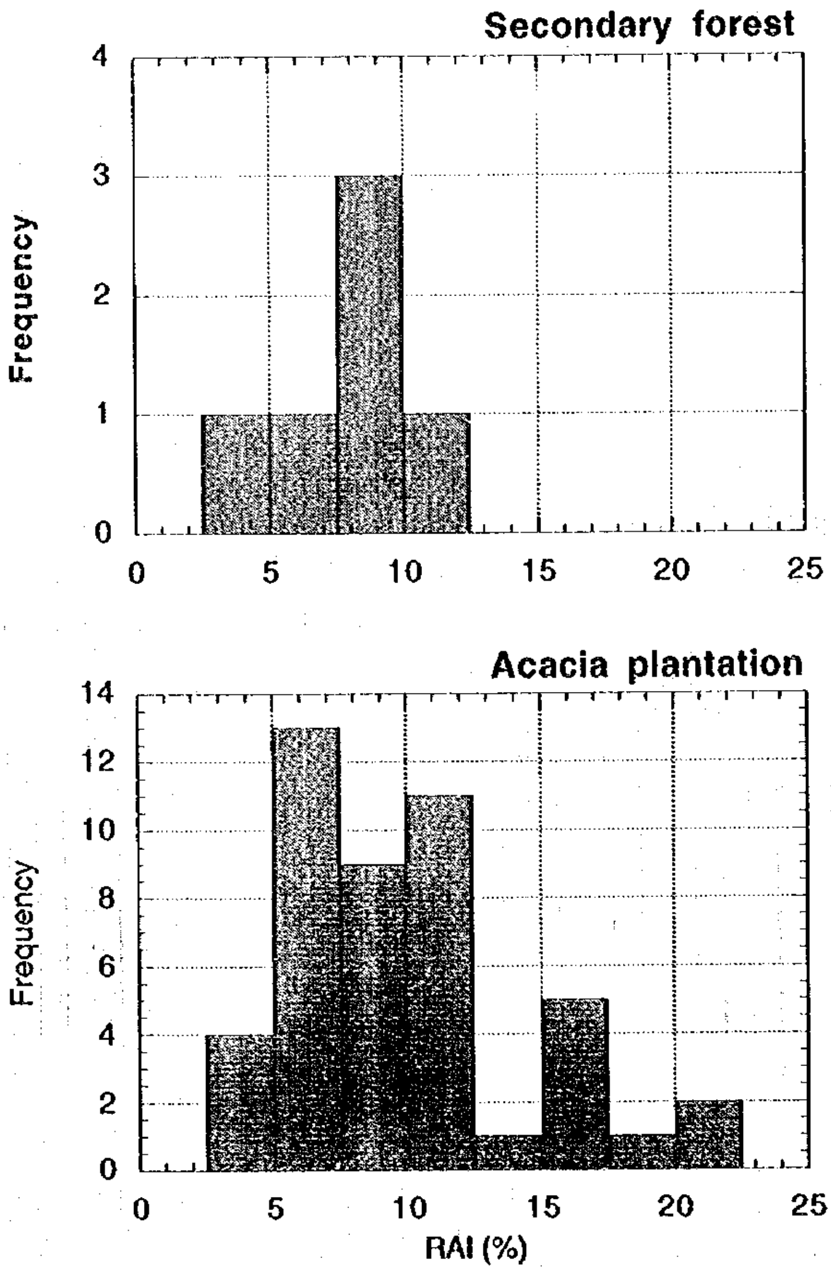


Fig. S29 Frequency distribution of RAI under non-felling Acacia mangium canopy and belukar

Table S25 Survival rates (%) of each species planted in Chikus block B at one year after planting

Species (type / direction)	A EW	A SN	B EW	B SN	C EW	C SN	D EW	D SN	E EW	E SN	aver. A-D
Dipt.cornutus	75.2		58.3		59.4		49.3		56.3		60.6
*Dryobalanops a.**	53.2	37.1	24.1	52.9	32.0	52.7	30.9	28.5	23.9	7.1	38.9
Hopea pubescens	44.4		50.8		23.4		51.1		49.6		42.4
*Hopea odorata**	81.4		76.0		89.6		85.0		76.2		83.0
Intsia palembanica	67.5		79.2		77.3		53.7		50.0		69.4
Neobalanocarpus h.	96.6	79.0	41.3	86.5	71.2	80.7	59.2	64.2	55.3	65.1	72.3
*Palaquium gutta**	77.5		45.0		30.5		23.5		9.6		44.1
*Parashorea d.**	62.0		67.4		47.3		45.6		9.1		55.6
*Pentaspadon m.**	49.5	3.8	67.5	13.0	53.9	30.4	36.0	14.6	9.7		33.6
*S.acuminata**	72.3	19.5	59.2	32.6	58.9	68.8	34.0	27.8	33.1	30.8	46.6
S.assamica	80.3		70.0		62.5		53.7		42.9		66.6
*S.glauca**	52.1				11.5		21.2		14.6		28.3
S.leprosula	87.5	85.4	90.2	99.0	74.5	91.9	70.1	81.8	57.5	52.5	85.1
*S.macroptera**	57.1		63.0		15.4		9.2		17.1		36.2
S.ovalis	74.4		75.4		40.6		44.9		57.9		58.8
S.ovata	45.3		42.4		13.3		19.1		10.8		30.0
S.parvifolia	88.8	86.0	65.3	84.6	75.0	66.0	52.9	51.2	38.3	54.3	71.2
S.pauciflora	71.8		58.3		35.2		24.3		36.3		47.4
Average	64.5		61.0		52.6		43.0		37.3		53.9 62.8**

* species planted in 1994
** average for the 5 common species (see Tab. S26) with open planting site

Table S26. Survival rates (%) of each species planted in Chikus block A at one year after planting

Species	Under planting belukar				Open planting					
type	F	G	H	aver. F,G	A	B	C	D	E	aver. A-E
Calophyllum sp.					3.0	0.0	7.1	0.7	0.0	2.2
Dialium sp.	76.0	79.0		77.5						
Dryobalanops aromatica					5.3	0.0	8.1	0.0	3.8	3.4
Endospermum m.					0.0	11.6	6.3	28.5	0.0	9.3
Gonystylus sp.	81.3	59.8		70.6						
Hopea odorata					77.4	77.2	69.4	78.1	87.2	77.9
Neobalanocarpus heimii	77.1	64.3	70.0	70.7	30.0	13.0	25.0	27.3	35.6	26.2
Pentaspadon motleyi					2.3	0.0	0.0	11.1	8.4	4.4
Pouteria malaccensis					0.0	0.0	1.8	0.0	0.4	0.4
S.acuminata	44.8	27.2		36.0	9.0	0.0	0.0	0.0	6.7	3.1
S.bracteolata	90.6	76.3			8.3	2.2	20.5	27.1	21.7	16.0
S.gibbosa	76.0	67.0								
S.glauca	71.6	55.8								
S.leprosula	57.8	60.7	69.2	59.3	9.4	7.5	25.4	1.5	14.4	11.6
S.mulitiflora	60.4	59.8		60.1						
S.ovalis	72.9	76.3	85.0	74.6						
S.ovata	24.5	17.9	21.7	21.2						
S.parvifolia	65.1	50.9	38.3	58.0	24.0	14.2	12.2	37.7	14.7	20.6
S.pauciflora	67.7	57.6	53.3	62.7						
S.talura	100.0	97.3								
Scaphium macropodum					3.8	11.6	2.7	0.0	16.7	7.0
Sindora sp.	69.8	59.4		64.6						
Average	60.9*	54.6*	56.3*							9.5** 13.0***

* average values for species planted in H-type
** average value excluding *H. odorata*
*** average for 5 common species (*Dryobalanops, Neobalanocarpus, Shorea acuminata, S. leprosula,* and *S.parvifolia*) with Chikus block-B

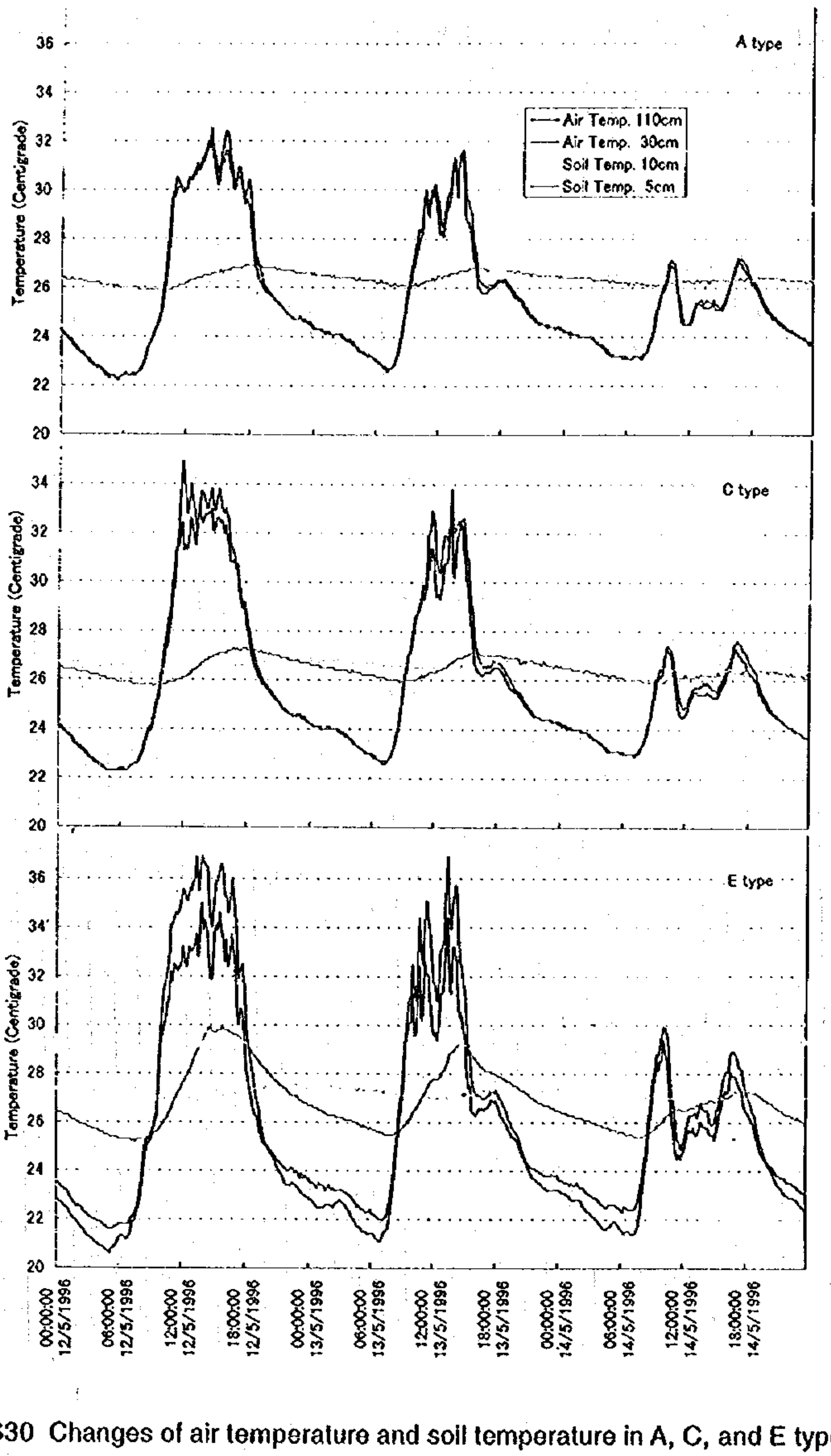


Fig. S30 Changes of air temperature and soil temperature in A, C, and E type planting strip under *Acacia mangium* plantation

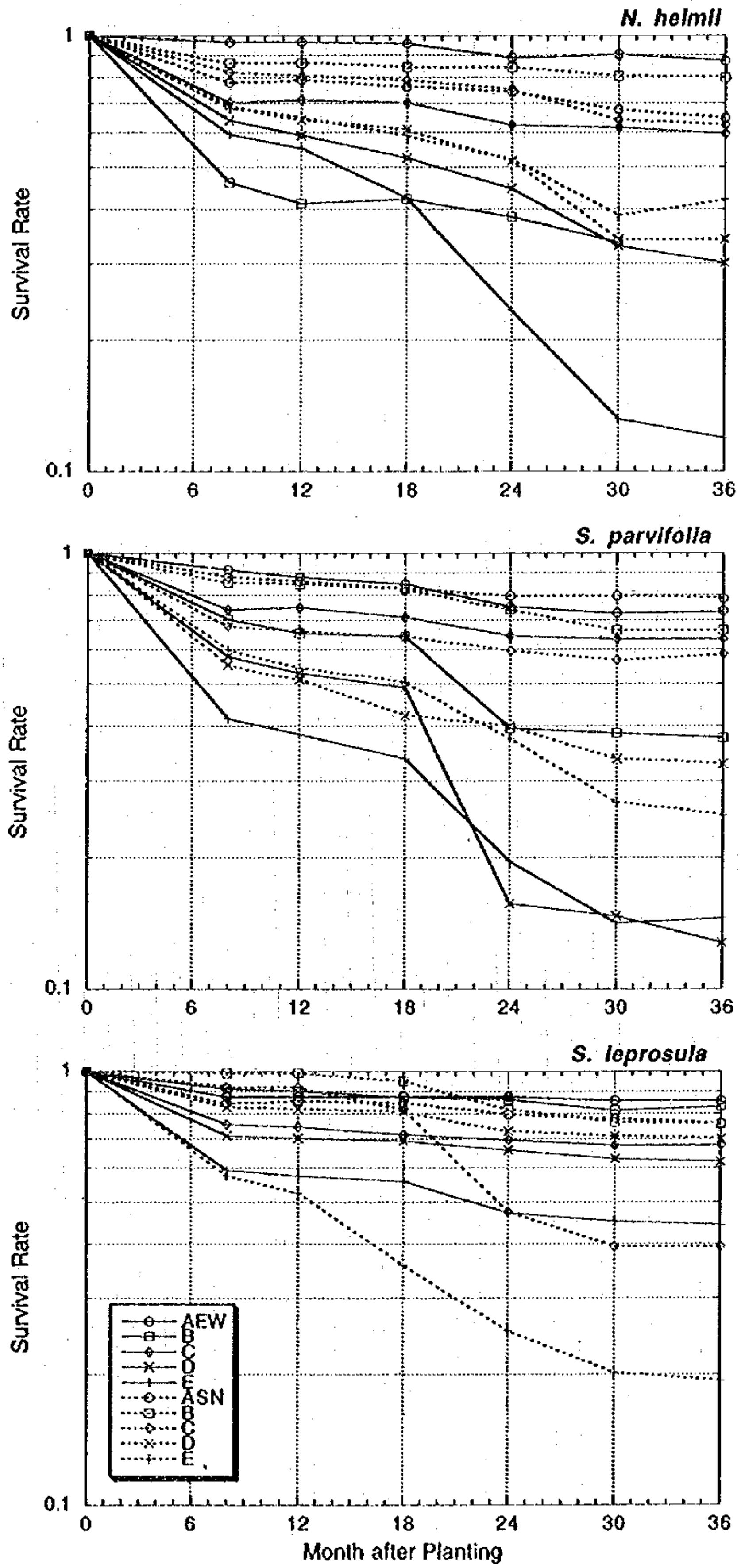


Fig. S31 Changes of survival rates for three species planted in B(1992) this period, especially in June 1994, less rain fall was observed. While there was no rainfall data available in Chikus site, the data in Ipoh showed the less rain from June to July in 1994 (Table S27). Some plots in Block-B(1993), i.e. *Dryobalanops aromatica* in NS-E, *Pentaspadon motleyi* in EW-E, NS-A, NS-B, NS-C, NS-D, NS-E, *Shorea acuminata* in NS-D, *Shorea macroptera* in EW-C, showed drop of survival rate less than 50 % within 1 months after planting. These plots were planted from April to May in 1994. These plots also must have faced the severe draught in June 1994 immediately after planting.

Teble S27 Rainfall Data in Ipoh

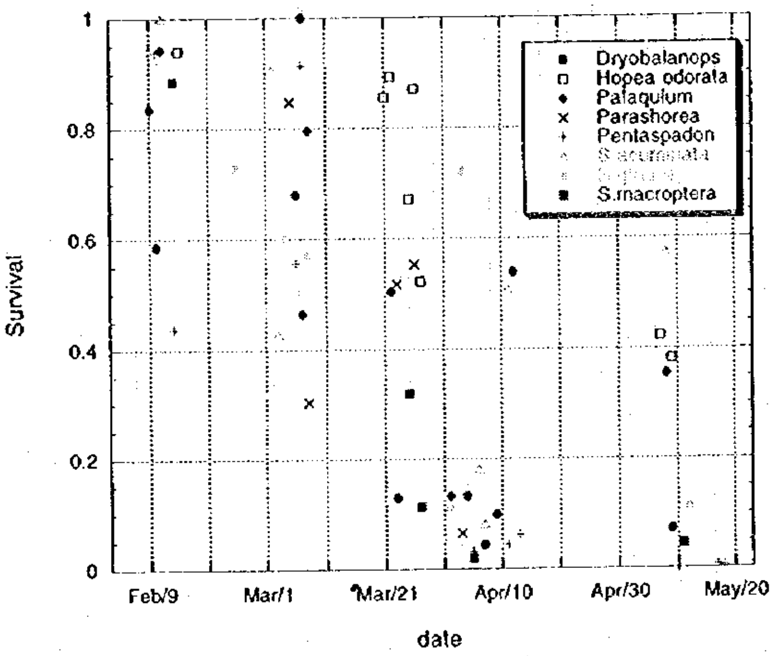
Year	Jan.	Feb.	May	Apr	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1981	140.3	196.9	159.5	297.7	296.0	59.6	99.7	105.0	289.4	314.4	228.3	81.3	2,268.1
1982	39.5	111.8	91.5	601.6	269.5	55.6	248.2	93.2	175.7	290.3	281.2	218.2	2,476.3
1983	52.0	105.0	163.5	184.0	93.8	186.9	81.4	260.0	389.3	203.5	128.3	259.8	2,107.5
1984	206.2	234.1	338.6	158.4	330.4	127.2	241.0	49.6	130.0	219.0	371.1	421.7	2,827.3
1985	67.5	102.4	235.7	189.5	301.1	29.3	121.3	86.7	171.6	386.1	497.0	214.9	2,403.1
1986	150.0	259.4	200.6	338.3	74.6	109.8	179.6	49.5	177.7	341.3	159.9	254.7	2,295.4
1987	94.7	106.7	119.1	332.4	286.8	85.2	152.5	183.9	262.7	581.2	337.6	355.9	2,898.7
1988	190.7	293.8	203.2	192.2	175.5	243.7	213.4	312.7	192.8	96.2	282.4	266.4	2,663.0
1989	146.1	59.5	191.3	292.8	194.5	176.0	157.4	151.5	352.2	260.0	210.3	182.1	2,373.7
1990	139.1	67.5	140.9	301.3	188.7	83.5	216.4	68.5	279.2	405.9	182.1	114.3	2,187.4
1991	103.1	102.2	140.3	350.8	465.2	141.3	194.4	113.0	171.0	305.8	312.4	151.3	2,550.8
1992	125.2	101.7	122.8	141.6	102.8	62.8	114.9	85.7	174.3	207.5	255.5	332.9	1,827.7
1993	90.4	142.6	216.8	329.1	315.7	146.9	290.5	135.1	168.5	291.6	274.8	396.2	2,798.2
1994	63.3	171.3	234.9	150.3	231.0	73.1	82.0	209.5	230.1	239.0	208.6	275.7	2,168.8

Fig. S32 shows relationships between planting dates and initial survival rates for the plots of block B(1993). Clearly, there is a strong tendency of decreasing survival rates with time. Seedlings which were planted later might be affected by the following drought around June to July. No such kind of tendency was found in other planting time.

Depending on the facts above, rainfall should be the greatest factor for the survival of seedlings, especially in their initial stage. It is reported that the initial decreases of survival rates on some dipterocarp species were caused by less rain after planting (Sunyoto et al 1994).

In openplanting plots, *Hopea odorata* and *Tectona grandis* showed outstanding survival rate of more than 80 % at 24 months after planing. These two species are well known as suitable species for openplanting. Next to these two species, *Alstonia* sp. and *Cinnamomum* sp. also showed higher rates in openplanting. They showed more than 70 % of survival at 12 months after planting. Among dipterocarp species, *Shorea talura* showed fair survival of 60 % at 12 months after planting.

In underplanting site, *Neobalanocarpus heimii* in EW-A, *Shorea leprosula* in EW-A, EW-B showed very good survival. They kept more than 80 % of survival after 36 months of planting. *Hopea odorata* in all plots showed outstanding survival rate of more than 80 % at 24 months after planing. Beside these species, *Shorea parvifolia* in EW-A, NS-A, NS-B, *Shorea assamica* in EW-A, *Gonystylus* sp. in F, *Shorea bracteolata* in F, *Shorea talura* in F, G, *Shorea ovalis* in H, showed higher survival rate of more than 80 % at 12 months after planting. Especially the rate of *Shorea*



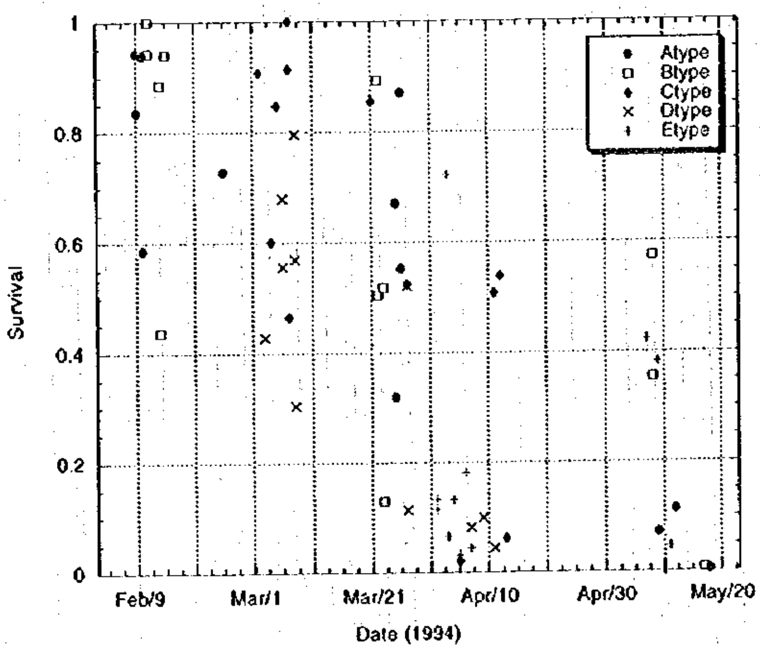


Fig. S32 Relationship between planting dates and initial survival rates for the seedlings planted in Chikus B in1994 *talura* in F was outstanding, which showed 100 % of survival at 12 months after planting.

5.1.2.2.2. Height growth

Tables S28and S29 show mean tree height in each plot at one year after planting, in blocks B and A respectively. See Appendix S7 for detail.

Shorea leprosula showed the fastest growth among dipterocarp species. The mean height of *Shorea leprosula* in EW-B of underplanting in *Acacia mangium* reached 6.88 m, and the highest individual in EW-B of underplanting in *Acacia mangium* reached 10.9 m in height at 36 months after planting (Fig. S33).

Table S28 Average tree height (m) of each species planted in Chikus block B at one year after planting

Species (type / direction)	A		B		C		D		E		aver.
	EW	SN	EW	SN	EW	SN	EW	SN	EW	SN	A-D
Dipt.cornutus	0.81		0.88		0.59		0.73		0.73		0.75
*Dryobalanops a.**	0.99	0.80	0.68	0.83	1.02	0.96	0.84	0.78	0.80	0.75	0.86
Hopea pubescens	0.64		0.69		0.47		0.80		0.80		0.65
*Hopea odorata**	1.01		1.03		1.26		1.08		0.95		1.09
Intsia palembanica	0.79		0.82		0.86		0.65		0.75		0.78
Neobalanocarpus h.	0.6	0.6	0.6	0.7	0.6	0.7	0.5	0.6	0.6	0.6	0.61
*Palaquium gutta**	0.55		0.31		0.44		0.35		0.46		0.41
*Parashorea .d**	0.82		0.77		0.98		0.64		0.38		0.80
*Pentaspadon m.**	0.81	0.41	0.96	0.53	1.14	0.69	0.88	0.77	0.62		0.77
*S.acuminata**	1.23	0.63	1.24	0.76	1.18	0.74	1.14	0.71	0.90	0.77	0.95
S.assamica	0.71		0.69		0.77		0.94		0.81		0.78
*S.glauca**	0.60				0.66		0.42		0.43		0.56
S.leprosula	1.43	1.47	1.68	1.55	1.31	1.14	1.03	1.23	0.92	0.76	1.36
*S.macroptera**	0.67		0.68		0.52		0.52		0.72		0.60
S.ovalis	1.00		1.01		0.99		1.01		0.89		1.00
S.ovata	1.05		0.88		0.71		0.80		0.48		0.86
S.parvifolia	1.17	1.15	1.19	1.21	0.98	1.17	0.89	0.86	0.86	0.84	1.08
S.pauciflora	0.85		1.03		0.71		0.71		0.79		0.82
Average	0.87		0.90		0.86		0.78		0.72		

* species planted in 1994

Table S29 Average tree height (m) of each species planted in Chikus block A at one year after planting

Species	Under planting belukar			aver.	Open planting					aver.
type	F	G	H	F,G	A	B	C	D	E	A-E
Calophyllum sp.					0.3		0.4	0.1		0.26
Dialium sp.	0.69	0.75		0.72						
Dryobalanops aromatica					0.80		0.57		0.55	0.64
Endospermum m.						0.51	0.49	0.68		0.56
Gonystylus sp.	0.85	0.79		0.82						
Hopea odorata					0.59	0.59	0.71	0.45	0.68	0.60
Neobalanocarpus heimii	0.9	0.9	0.9	0.86	0.5	0.4	0.4	0.3	0.4	0.39
Pentaspadon motleyi					0.53			0.50	0.34	0.46
Pouteria malaccensis							0.16		0.25	0.21
S.acuminata	0.88	0.77		0.83	0.45				0.51	0.48
S.bracteolata	0.63	0.54		0.58	0.41	0.57	0.36	0.33	0.36	0.41
S.gibbosa	0.76	0.76		0.76						
S.glauca	1.48	1.24		1.36						
S.leprosula	1.62	1.37	1.44	1.50	0.38	0.38	0.70	0.39	0.38	0.45
S.mulitiflora	1.14	0.87		1.00						
S.ovalis	1.48	1.23	1.34	1.36						
S.ovata	0.94	0.93	0.68	0.94						
S.parvifolia	1.24	1.17	1.06	1.21	0.60	0.44	0.44	0.43	0.37	0.46
S.pauciflora	1.21	1.17	1.07	1.19						
S.talura	1.07	1.34		1.21						
Scaphium macropodum					0.20	0.28	0.34		0.27	0.27
Sindora sp.	0.53	0.59		0.56						
Average	1.23*	1.12*	1.07*		0.47	0.45	0.46	0.40	0.41	0.43

* average values for species planted in H-type

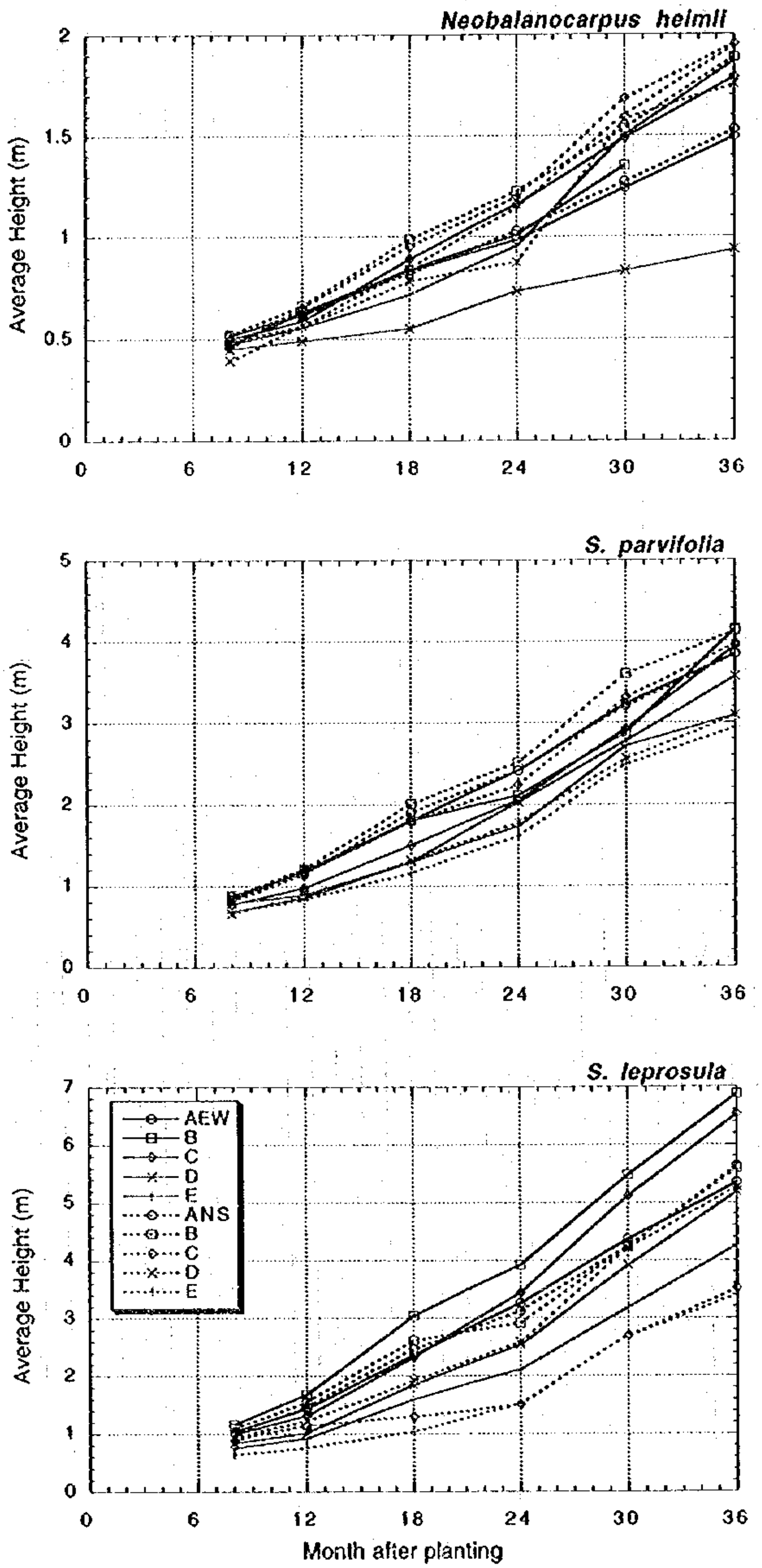


Fig. S33 Height growth for three species planted under Acacia plantation in 1992

Generally the height growth in the underplanting plots were higher than that in the openplanting plots. Several plots in the underplanting reached 1 m of mean height, while no plots in the openplanting reached 1 m of mean height at 12 months after planting.

Species which attained 1 m of mean height at 12 months after planting were as follows;

1) Underplanting in *Acacia mangium* plots

Dryobalanops aromatica in EW-B

Hopea odorata in EW-A, EW-B, EW-C, EW-D

Pentaspadon motleyi in EW-C

Shorea acuminata in EW-A, EW-B, EW-C, EW-D

Shorea leprosula in EW-A, EW-B, EW-C, EW-D, NS-A, NS-B, NS-C, NS-D

Shorea macroptera in EW-C

Shorea ovalis in EW-A, EW-B, EW-D

Shorea ovata in EW-A

Shorea ovalis in EW-A, EW-B, NS-A, NS-B, NS-C

Shorea pauciflora in EW-B

2) Underplanting in Belukar plots

Shorea glauca in F, G

Shorea talura in F, G

Shorea leprosula in F, G, H

Shorea ovalis in F, G, H

Shorea parvifolia in F, G, H

Shorea pauciflora in F, G, H

In terms of competition with surrounding vegetation, height growth is the important indicator especially in their initial stage. Mean height of 1 m is equal to the mean height of other vegetation in A to C type of underplanting in *Acacia mangium* plantation (see Table S8). In other words, planted seedlings can overcome surrounding vegetation after they attain 1 m in height. In this connection species listed above can overcome surrounding vegetation after 12 months of planting.

In D and E type of underplanting in *Acacia mangium* plantation, the grass with mean height of 2 m was dominant (see Table S8). In these plots, planted seedlings can overcome surrounding vegetation after they reach 2 m in mean height. The species and the time when it reached 2 m in mean height are listed below;

Shorea leprosula in EW-D at 24 months after planting

Shorea leprosula in EW-E at 24 months after planting

Shorea leprosula in NS-D at 24 months after planting

Shorea leprosula in EW-D at 30 months after planting

Shorea parvifolia in EW-D at 24 months after planting

Shorea parvifolia in EW-E at 30 months after planting

Shorea parvifolia in NS-D at 30 months after planting

Shorea parvifolia in EW-D at 30 months after planting

The height growths of underplanting seedlings in wider planting strip width were relatively slower than those in narrower planting width, moreover the height of the surrounding vegetation is taller than that in narrower planting width. It means seedlings planted in wider planting width will take longer time to overcome surrounding vegetation. It will cause the increase of weeding cost.

Actual height growth must be affected by initial size of seedlings. In these experiments the standard for the height of planting seedlings was set as 40 - 60 cm. Due to time constraints, seedlings supply, planting work schedule, etc., some seedlings did not meet with this standard, and sometimes mean heights of planting seedlings were different in same species plot, i.e. mean height of *Palaquium gutta* in EW-B of underplanting in *Acacia mangium* was 13 cm, while that in EW-E was 43 cm. This made it difficult to compare the growth to each other.

In order to neglect this influence of initial size, the relative growth rate of height (it is called as RGR-H) was calculated. The relative value of the height at each measurement time was calculated by setting the height of seedling at 1 month after planting as 1. RGR-H was not calculated on the plots without 1 months data.

At 12 months after planting, *Hopea odorata* in EW-A, in EW-C, *Pentaspadon motleyi* in EW-D, in NS-B, *Hopea pubescens* in EW-A, *Shorea ovalis* in EW-A, in EW-B, in EW-C, *Shorea talura* in G, *Shorea ovalis* in F, and *Tectona grandis* in openplanting(Arboretum) showed more than 3.0 of RGR-H.

Beside initial size of seedling, the growth of seedlings may be affected by several factors such as planting time, nurturing history of seedlings, seedling origin, planting method, etc. In this study RGR-H was used as one of the evaluation factors. Further study and data collection is needed to clarify the difference of the growth.

5.1.2.2.3. Diameter growth

Mean diameter at ground height in each plots at each measurement time is shown in Appendix S8. In terms of diameter growth, *Shorea leprosula* showed the fastest growth among dipterocarp species. The mean diameter of *Shorea leprosula* in NS-B of underplanting *Acacia mangium* reached 6.85 cm, and the thickest individual in EW-B of underplanting *Acacia mangium* reached 12.7 cm in diameter at 36 months after planting.

5.1.2.2.4. H/D ratio

H/D ratio is the indicator for the shape of tree. The higher H/D ratio means the slender shape. (see Appendix S9). Species with slender shape, such as *Shorea parvifolia, Dryobalanops aromatica, Pentaspadon motleyi, Shorea acuminata* showed higher H/D rate. Comparing with H/D ratio in underplanting and in openplanting, the former was lower than the latter. Within underplanting H/D ratio was higher in narrower planting strip width. H/D ratio can be the indicator for the treatment. For example, when the ratio get larger than the standard, it means the site is getting dark, then, opening of canopy is required. Due to less information H/D ratio on each species in different condition, conclusion is very difficult. Further study and data collection are needed.

5.1.2.2.5. Biomass

It is very difficult to evaluate the difference among several planting designs and among several species as well. Several indicator should be used for the evaluation. Survival rate is one of the most important indicators in terms of deciding the spacing of seedlings. Height growth is the second important especially in the initial stage in terms of the competition between surrounding vegetation.

It is no doubt that the plot (or the species) which shows good survival rate with good height growth and good diameter growth is the best. How can we evaluate the two plots, the one plot shows the good survival rate but poor height growth, and the other plot shows the poor survival rate but good height growth. Evaluation can be taken depend on the management of the forest. In case of intensive management with high density planting, low survival may be acceptable. In case of extensive management with low density planting, high survival will be preferable. Planting designs and species should be chosen by the management purpose, and the final harvest target of the forest.

One of the main targets of forestry is to harvest timber as much as possible from a certain area. In this study, biomass per unit area (it is called as BPU) was taken for the evaluation especially on the comparison among different planting designs. BPU was used as the third evaluation indicator next to the survival rate and the height growth.

BPU was calculated as follows;

$BPU_t = (\sum D_t^2 \cdot H_t) / N_0$

BPU_t: Biomass per unit at t months after planting

D_t: Diameter of individual tree at t months after planting

H_t: Height individual tree at t months after planting

N_0: Number of trees at initial stage

note: The value of dead tree at t months after planting were set to 0

In the underplanting in *Acacia mangium* plantation plots and the openplanting plots, indigenous species were planted with the spacing of 3.0 m x 3.7 m, so that the BPU means the $\sum D^2H$ value per 11.1 m^2 in the planting strip. In the underplanting in Belukar plots, indigenous species were planted with the spacing of 2.5 m x 5.0 m, so that the BPU means the $\sum D^2H$ value per 12.5 m^2 in the planting strip.

BPU values in each plots at each measurement time are shown in Appendix S10.

Generally the value was higher in underplanting site than in openplanting site because of the high survival and fair growth. In the underplanting site, *Shorea leprosula, Shorea parvifolia, Hopea odorata, Shorea talura, Shorea ovalis* showed larger value. In the openplanting site, *Hopea odorata* and *Tectona grandis* showed larger value.

5.1.2.3. Survival and Growth of *Acacia mangium*

5.1.2.3.1. *Acacia mangium* in Underplanting Plots

Table S30 shows the diameter growth of *Acacia mangium* in underplanting plots. Measurements were taken three times; June 1993, December 1993, and May 1994. They fell on 3 years and

7 months, 4 years and 1 month, and 4 years and 6 months after planting respectively, and 10 months, 1 year and 4 months, and 1 year and 9 months after strip felling. A to E type and non-felling plots were compared. Significant differences among six plots were seen on every measurement time; June 1993 (ANOVA test, DF=5, F=10.9, $P<0.0001$), December 1993 (ANOVA test, DF=5, F=8.5, $P<0.0001$), May 1994 (ANOVA test, DF=5, F=14.8, $P<0.0001$). Non-felling plot showed the thinnest diameter growth among six types, and showed significant difference with every type on each measurement time (Fisher's PLSD test, $p<0.05$). A type showed the thickest diameter growth among six types, and showed significant difference with B, C, and D type (Fisher's PLSD test, $p<0.05$). The differences among B, C, D, and E type were not clear (Fisher's PLSD test, $p<0.05$).

TableS30 Diameter Growth Of Acacia mangium

Measurement Date	Jun. 1993		Dec. 1993		May-94	
after planting	3y 7m		4y 1m		4y 6m	
after felling	0y 10m		1y 4m		1y 9m	
Plot	Count	Mean Diameter(cm)	Count	Mean Diameter(cm)	Count	Mean Diameter(cm)
A	120	18.7 ^{B,C,D,N}	117	19.4 ^{B,C,D,N}	114	21.3 ^{B,C,D,N}
B	127	17.0 ^{A,N}	126	17.8 ^{A,N}	126	19.3 ^{A,N}
C	93	16.6 ^{A,N}	93	17.6 ^{A,N}	92	18.7 ^{A,N}
D	57	16.6 ^{A,N}	55	17.9 ^{A,N}	55	19.5 ^{A,N}
E	47	17.4 ^{N}	47	18.4 ^{N}	43	20.0 ^{N}
Non-Felling	186	15.4 ^{A,B,C,D,E}	183	16.4 ^{A,B,C,D,E}	179	16.9 ^{A,B,C,D,E}

Shared letters indicate the significant differences (Fisher's PLSD test, $p<0.05$)

TableS31 Survival,Height Growth,and Diameter Growth of Acacia mangium in Openplanting Plots

Mix planted HQTS	type	Months after Planting	Total Tree Number	Number of Survivings	Survival Rate	Mean Height(m)	Mean Diameter(cm)
N. heimii	A	7	138	78	57%	0.86	0.9
	B	7	138	82	59%	0.88	0.9
	C	7	224	164	73%	0.58	0.8
	D	7	129	90	70%	0.65	0.9
	E	10	151	130	86%	1.64	1.7
H. odorata	A	6	146	92	63%	0.75	0.8
	B	6	149	96	64%	0.62	0.8
	C	6	218	137	63%	0.93	1.2
	D	6	128	80	63%	0.41	0.7
	E	6	123	112	91%	1.40	1.3
S. leprosula	A	7	137	83	61%	0.80	0.8
	B	7	143	107	75%	0.70	0.8
	C	7	216	123	57%	1.17	1.3
	D	7	135	93	69%	0.57	0.9
	E	9	149	126	85%	2.26	2.5
S. parvifolia	A	8	138	120	87%	2.18	2.2
	B	8	154	129	84%	1.78	1.7
	C	8	228	207	91%	1.89	1.7
	D	8	128	110	86%	1.91	1.8
	E	9	160	133	83%	2.38	2.5

These results clarified the effect of strip felling of *Acacia mangium* on acceleration of its diameter growth. In A type, which means the alternate row felling by one row, individual tree might get enough openness after strip felling, and might enhance its diameter growth.

5.1.2.3.2. *Acacia mangium* in Openplanting Plots

Table S31 shows the survival, height growth, and diameter growth of *Acacia mangium* in Openplanting Plots. Measurement was taken once after planting. The planting times were different on the plots, thus the measurement time fell on 6 to 10 months after planting. The lowest survival rate of 57 % was recorded at 7 months after planting. It was quite low figure for *Acacia mangium*. This may suggest the influence of severe site condition. Mean height of 2 m and mean diameter of 2 cm were attained 8 months after planting. The data for survival, height and diameter varied widely. This may suggest that the site condition varied widely.

5.1.2.4. Comparison between Underplanting and Openplanting

Two methods of openplanting were taken, one was the mix and coexistent planting both with fast growing species and indigenous species for establishing Multi-Storied Forest, the another was the monoculture planting with one species for establishing Arboretum. The former method expected that the fast growing species grow faster than indigenous one, then provide shade over them. Unfortunately, the growth of fast growing species was very poor, consequently they could not grow enough to provide shade. Therefore the upper story influence did not exist, while five different planting designs were taken. Hence the former design and the latter design can be discussed as the same planting design as openplanting. The five different planting designs in the former method were regarded as the replications.

5.1.2.4.1. Comparison with the Underplanting in *Acacia mangium* Plantation Plots

In order to clarify the difference between the openplanting and the underplanting in *Acacia mangium* plantation, same species planted both in the openplanting and in the underplanting in *Acacia mangium* plantation were compared. *Dipterocarpus cornutus, Dryobalanops aromatica, Hopea odorata, Intsia palembanica, Neobalanocarpus heimii, Palaquium gutta, Pentaspadon motleyi, Shorea acuminata, Shorea leprosula, Shorea macroptera, Shorea ovalis,* and *Shorea pauciflora* were compared.

Survival rate and height growth are shown in Table S32, and Table S33, respectively. Each table consists of two parts. Left side shows the actual value at each measurement time, and right side shows the relative value at each measurement time with setting the standard value of EW-E type as 1. Relative value more than 1.2 or less than 0.8 were regarded as the significant difference with the standard (EW-E type).

- Survival Rate

Table S32 shows the survival rate in each planting design. Most of the species except *Hopea odorata* showed lower survival in openplanting than in EW-E type in underplanting. *Hopea odorata*, which showed quite good survival even in openland, showed less difference between in openplanting and in underplanting. *Shorea acuminata* and *Shorea leprosula* showed larger difference between in openplanting and in underplanting. All the plots of them showed less than 0.5 of relative value to the EW-E type.

- Height Growth

Table S33 shows the mean height in each planting design. All the species in openplanting showed lower height growth than that in underplanting. *Hopea odorata* showed lower height growth in openplanting than in underplanting, while they showed less difference in survival rate between in the openplanting and in the underplanting.

5.1.2.4.2. Comparison with the Underplanting in Belukar Plots

Because of the poor result in openplanting, the planting design in Block-A was changed from the openplanting into the underplanting in Belukar. In order to clarify the difference between the openplanting and the underplanting in Belukar, same species planted both in the openplanting and in the underplanting in Belukar were compared. *Neobalanocarpus heimii, Shorea acuminata, Shorea bracteolata, Shorea leprosula, Shorea multiflora, Shorea ovalis*, and *Shorea parvifolia* were compared.

Survival rate and height growth are shown in Table S34 and Table S35, respectively. Each table consists of two parts. Left side shows the actual value at each measurement time, and right side shows the relative value at each measurement time with setting the standard value of F type of underplanting in Belukar as 1. Relative value more than 1.2 or less than 0.8 were regarded as the significant difference with the standard (F type).

- Survival Rate

Table S34 shows the survival rate in each planting design. All the plots in openplanting showed lower survival than in underplanting. While no plots in underplanting showed less than 20 % of survival after 12 months of planting, several plots in openplanting showed less than 20 % of survival.

Table S32 Survival of Trees in Underplanting in Acacia mangium Plots and in the Openplanting Plots

			Actual Value							Relative Value						
			Acacia	Open						Acacia	Open					
Species	Month	Direction	E	A	B	C	D	E	x	E	A	B	C	D	E	X
Dipterocarpus cornutus	6	EW	70.0%						29.3%	1.00						0.42
	12	EW	56.3%						6.0%	1.00						0.11
Dryobalanops aromatica	6	EW	32.4%	10.5%	2.2%	33.3%	9.0%	16.3%	35.2%	1.00	0.33	0.07	1.03	0.28	0.50	1.09
		NS	31.3%							0.96						
	12	EW	23.9%	5.3%	x	8.1%	x	3.8%	13.0%	1.00	0.22	x	0.34	x	0.16	0.54
		NS	7.1%							0.30						
	18	EW	15.3%	x	x	x	x	x	4.6%	1.00	x	x	x	x	x	0.30
		NS	4.2%							0.27						
Hopea odrata	6	EW	80.3%	78.2%	76.3%	69.4%	85.9%	87.2%	75.7%	1.00	0.97	0.95	0.86	1.07	1.09	0.94
	12	EW	76.2%	77.4%	77.2%	69.4%	78.1%	87.2%	70.1%	1.00	1.02	1.01	0.91	1.03	1.15	0.92
	18	EW	68.3%	69.4%	74.6%	67.6%	64.8%	85.2%	70.1%	1.00	1.02	1.09	0.99	0.95	1.25	1.03
Intsia palembanica	6	EW	54.6%						42.9%	1.00						0.79
	12	EW	50.0%						20.2%	1.00						0.40
Neobalanocarpus heimii	12	EW	55.3%	30.0%	13.0%	25.0%	27.3%	35.6%	46.3%	1.00	0.54	0.24	0.45	0.49	0.64	0.84
		NS	65.1%							1.18						
	18	EW	42.6%	22.5%	7.8%	8.9%	14.1%	28.5%	25.0%	1.00	0.53	0.18	0.21	0.33	0.67	0.59
		NS	59.0%							1.39						
	24	EW	23.4%	15.8%	7.0%	8.0%	7.8%	25.1%	13.0%	1.00	0.68	0.30	0.34	0.33	1.07	0.55
		NS	52.2%							2.23						
	30	EW	13.2%	13.3%	7.0%	6.3%	7.0%	19.7%	x	1.00	1.01	0.53	0.47	0.53	1.49	x
		NS	39.0%							2.95						
Palaquium gutta	6	EW	35.0%						7.5%	1.00						0.21
	12	EW	9.6%						4.5%	1.00						0.47
Pentaspadon motleyi	6	EW	20.5%	5.3%	3.1%	27.7%	40.3%	23.8%	24.5%	1.00	0.26	0.15	1.35	1.97	1.17	1.20
		NS	8.3%							0.41						
	12	EW	9.7%	2.3%	x	x	11.1%	8.4%	10.4%	1.00	0.23	x	x	1.15	0.87	1.07
		NS	0.0%							0.00						
	18	EW	6.8%	x	x	x	12.5%	x	6.6%	1.00	x	x	x	1.83	x	0.97
		NS	0.0%							0.00						
Shorea acuminata	6	EW	43.9%	17.3%	2.9%	1.8%	13.9%	20.8%	21.3%	1.00	0.39	0.07	0.04	0.32	0.47	0.48
		NS	43.8%							1.00						
	12	EW	33.1%	9.0%	x	x	x	6.7%	8.3%	1.00	0.27	x	x	x	0.20	0.25
		NS	30.8%							0.93						
Shorea leprosula	8	EW	59.2%	x	x	x	x	18.0%	x	1.00	x	x	x	x	0.30	x
		NS	57.6%							0.97						
	12	EW	57.5%	9.4%	7.5%	25.4%	1.5%	14.4%	13.1%	1.00	0.16	0.13	0.44	0.03	0.25	0.23
		NS	52.5%							0.91						
	18	EW	55.8%	4.3%	2.8%	19.3%	0.7%	9.6%	4.7%	1.00	0.08	0.05	0.35	0.01	0.17	0.08
		NS	35.7%							0.64						
	24	EW	47.2%	x	x	11.4%	x	8.0%	x	1.00	x	x	0.24	x	0.17	x
		NS	25.2%							0.53						
Shorea macroptera	6	EW	28.8%						45.9%	1.00						1.60
	12	EW	17.1%						37.6%	1.00						2.20
Shorea ovalis	6	EW	63.6%						38.9%	1.00						0.61
	12	EW	57.9%						17.6%	1.00						0.30
Shorea parvifolia	8	EW	41.7%	no dat	no dat	no dat	no dat	16.7%	no dat	1.00	x	x	x	x	0.40	x
		NS	59.9%							1.44						
	12	EW	38.3%	24.0%	14.2%	12.2%	37.7%	14.7%	4.0%	1.00	0.63	0.37	0.32	0.98	0.38	0.10
		NS	54.3%							1.42						
	18	EW	33.8%	18.2%	7.1%	3.5%	20.0%	6.9%	x	1.00	0.54	0.21	0.10	0.59	0.21	x
		NS	50.4%							1.49						
	24	EW	19.6%	15.7%	7.1%	2.6%	14.6%	6.1%	x	1.00	0.80	0.36	0.13	0.75	0.31	x
		NS	37.5%							1.91						

Table S33 Height Growth of Trees in the Underplanting in Acacia mangium Plots and in the Openplanting Plots

			Actual Value							Relative Value						
			Acacia	Open						Acacia	Open					
Species	Month	Direction	E	A	B	C	D	E	Arbo	E	A	B	C	D	E	X
Dipterocarpus cornutus	6	EW	0.40						0.29	1.00						0.71
	12	EW	0.73						0.22	1.00						0.30
Dryobalanops aromatica	6	EW	0.56	0.48	0.41	0.48	0.51	0.48	0.41	1.00	0.86	0.73	0.85	0.91	0.86	0.74
		NS	0.61							1.09						
	12	EW	0.80	0.80	x	0.57	x	0.55	0.54	1.00	0.99	x	0.71	x	0.69	0.68
		NS	0.75							0.94						
	18	EW	1.02	x	x	x	x		0.51	1.00	x	x	x	x	x	0.50
		NS	1.21							1.18						
Hopea odrata	6	EW	0.45	0.48	0.48	0.44	0.42	0.52	0.34	1.00	1.09	1.08	0.98	0.95	1.17	0.76
	12	EW	0.94	0.59	0.59	0.71	0.45	0.68	0.62	1.00	0.63	0.63	0.76	0.48	0.72	0.66
	18	EW	1.63	0.74	0.71	0.86	0.48	0.81	0.78	1.00	0.45	0.43	0.53	0.29	0.50	0.48
Intsia palembanica	6	EW	0.61						0.58	1.00						0.96
	12	EW	0.75						0.70	1.00						0.94
Neobalanocarpus heimii	12	EW	0.56	0.45	0.37	0.40	0.34	0.37	0.50	1.00	0.81	0.66	0.71	0.60	0.67	0.90
		NS	0.56							1.01						
	18	EW	0.72	0.51	0.47	0.45	0.32	0.55	0.57	1.00	0.71	0.65	0.63	0.45	0.76	0.79
		NS	0.85							1.18						
	24	EW	0.96	0.49	0.57	0.49	0.37	0.55	0.62	1.00	0.51	0.59	0.52	0.38	0.57	0.64
		NS	1.14							1.19						
	30	EW	1.50	0.60	0.70	0.63	0.47	0.68	x	1.00	0.40	0.46	0.42	0.31	0.45	x
		NS	1.61							1.07						
Palaquium gutta	6	EW	0.44						0.24	1.00						0.54
	12	EW	0.46						0.33	1.00						0.72
Pentaspadon motleyi	6	EW	0.34	0.34	0.29	0.27	0.26	0.22	0.24	1.00	1.02	0.85	0.80	0.76	0.66	0.72
		NS	0.28							0.83						
	12	EW	0.62	0.53	x	x	0.50	0.34	0.45	1.00	0.85	x	x	0.81	0.55	0.72
		NS	0.00							0.00						
	18	EW	1.43	x	x	x	0.79	x	0.53	1.00	x	x	x	0.55	x	0.37
		NS	0.00							0.00						
Shorea acuminata	6	EW	0.68	0.41	0.34	0.31	0.41	0.45	0.53	1.00	0.61	0.49	0.45	0.60	0.66	0.78
		NS	0.47							0.69						
	12	EW	0.90	0.45	x	x	x	0.51	0.54	1.00	0.51	x	x	x	0.57	0.61
		NS	0.77							0.86						
Shorea leprosula	8	EW	0.75	no dat	no dat	no dat	no dat	0.36	no dat	1.00	x	x	x	x	0.47	x
		NS	0.65							0.86						
	12	EW	0.92	0.38	0.38	0.70	0.39	0.38	0.31	1.00	0.41	0.41	0.76	0.42	0.42	0.34
		NS	0.76							0.83						
	18	EW	1.60	0.49	0.63	0.87	0.35	0.48	0.58	1.00	0.31	0.39	0.55	0.22	0.30	0.36
		NS	1.04							0.65						
	24	EW	2.11	x	x	1.40	x	0.83	x	1.00	x	x	0.66	x	0.39	x
		NS	1.52							0.72						
Shorea macroptera	6	EW	0.50						0.49	1.00						0.98
	12	EW	0.72						0.66	1.00						0.92
Shorea ovalis	6	EW	0.47						0.60	1.00						1.28
	12	EW	0.89						0.54	1.00						0.61
Shorea parvifolia	8	EW	0.68	x	x	x	x	0.38	x	1.00	x	x	x	x	0.55	x
		NS	0.67							0.98						
	12	EW	0.86	0.60	0.44	0.44	0.43	0.37	0.41	1.00	0.70	0.51	0.51	0.50	0.43	0.48
		NS	0.84							0.98						
	18	EW	1.30	0.73	0.60	0.32	0.59	0.51	x	1.00	0.56	0.46	0.25	0.46	0.39	x
		NS	1.16							0.89						
	24	EW	1.74	0.73	0.55	0.52	0.95	0.61	x	1.00	0.42	0.31	0.30	0.55	0.35	x
		NS	1.61							0.93						

- Height Growth

Table S35 shows the mean height in each planting design. Almost all the plots in openplanting showed lower height growth than in underplanting. While *Shorea leprosula*, *Shorea ovalis*, and *Shorea parvifolia* even in widest planting strip of H type in underplanting showed more than 1 m of height growth at 12 months after planting, no plots in open planting attained the mean height of 1 m.

5.1.2.4.3. Reason for insufficient growth in block A

Survival and growth in Block-A was very poor. The reasons for this might be concluded as follows;

a) Harsh weather condition (e.g., full sunlight, high air temperature, high soil temperature, low humidity, dryness of the soil, etc.)
b) Degraded soil condition (e.g., compacting, loss of nutrient)
c) Insufficient hardening process for seedling before planting
d) Trampling by cattle and water buffalo
e) Damage by leaf-eating insects

It is mentioned specially in this site, excess slash burning and usage of heavy duty machinery made deterioration of soil condition.

One of the practical solutions on this site was to leave the site for another 2 - 3 years waiting for regeneration of shrub, and then plant some seedlings under the shade of shrub. But because of the limited project period, such an option could not be taken. Then we put priority to reforestation of the site with any kind of species.

5.1.2.4.4. Conclusion

The openplanting method, generally, might be concluded that it is inferior to the underplanting method in terms of both survival and height growth. Due to the scarcity of replication plots, precise comparisons could not have been done in this study. The various condition, such as the provenance of the seedlings, the nurturing history of the seedlings, the planting method, the planting time, etc., might have been affected the difference of the growth of trees. Further studies are required.

Chikus Block-A was left over for a long time after clear cut of natural forest, heavy duty machinery was used for site preparation, slash burning was repeated several times during short period. These conditions must have caused the degradation of soil, i.e. compacting and flashing out of nutrient. More over the area was suffered from the damage by cattle and water buffalo, and planted seedlings were not well treated hardening process. Further more, it was notably less rain in June - August 1994. These were the reasons for poor results in openplanting in Chikus Block-A.

On the contrary, openplanting conducted by FD in Chikus Block-B prior to the beginning of this project showed rather good results in survival and growth. It is difficult to conclude that openplanting is not suitable for indigenous species especially dipterocarp species.

Table S34 Survival of Trees in the Underplanting in Belukar Plots and in the Openplanting Plots

			Actula Value									Relative Value								
			Belukar			Open						Type			Open					
Species	Month	Direction	F	G	H	A	B	C	D	E	X	F	G	H	A	B	C	D	E	x
Neobalanocarpus	6	EW	85.4%	74.1%	80.0%	40.8%	33.0%	42.9%	53.1%	no data	58.3%	1.00	0.87	0.94	0.48	0.39	0.50	0.62	x	0.68
	12	EW	77.1%	64.3%	70.0%	30.0%	13.0%	25.0%	27.3%	35.6%	46.3%	1.00	0.83	0.91	0.39	0.17	0.32	0.35	0.46	0.60
Shorea acuminat	6	EW	62.5%	44.6%	-	17.3%	2.9%	1.8%	13.9%	20.8%	21.3%	1.00	0.71	x	0.28	0.05	0.03	0.22	0.33	0.34
	12	EW	44.8%	27.2%	-	9.0%	0.0%	0.0%	0.0%	6.7%	8.3%	1.00	0.61	x	0.20	0.00	0.00	0.00	0.15	0.19
Shorea bracteola	6	EW	93.8%	88.8%	-	34.6%	42.8%	33.9%	44.4%	32.1%	-	1.00	0.95	x	0.37	0.46	0.36	0.47	0.34	x
	12	EW	90.6%	76.3%	-	8.3%	2.2%	20.5%	27.1%	21.7%	-	1.00	0.84	x	0.09	0.02	0.23	0.30	0.24	x
Shorea leprosula	6	EW	71.9%	70.1%	74.2%	20.5%	12.1%	25.4%	6.7%	27.2%	no data	1.00	0.98	1.03	0.29	0.17	0.35	0.09	0.38	x
	12	EW	57.8%	60.7%	69.2%	9.4%	7.5%	25.4%	1.5%	14.4%	13.1%	1.00	1.05	1.20	0.16	0.13	0.44	0.03	0.25	0.23
Shorea mulitiflor	6	EW	68.8%	68.8%	-	-	-	-	-	-	4.5%	1.00	1.00	x	x	x	x	x	x	0.07
	12	EW	60.4%	59.8%	-	-	-	-	-	-	1.5%	1.00	0.99	x	x	x	x	x	x	0.02
Shorea ovalis	6	EW	83.3%	83.5%	87.5%	-	-	-	-	-	38.9%	1.00	1.00	1.05	x	x	x	x	x	0.47
	12	EW	72.9%	76.3%	85.0%	-	-	-	-	-	17.6%	1.00	1.05	1.17	x	x	x	x	x	0.24
Shorea parvifolia	6	EW	83.9%	68.3%	60.0%	33.9%	21.2%	14.8%	50.0%	32.2%	35.7%	1.00	0.81	0.72	0.40	0.25	0.18	0.60	0.38	0.43
	12	EW	65.1%	50.9%	38.3%	24.0%	14.2%	12.2%	37.7%	14.7%	4.0%	1.00	0.78	0.59	0.37	0.22	0.19	0.58	0.23	0.06

Table S35 Height Growth of Trees in the Underplanting in Belukar Plots and in the Openplanting Plots

			Actula Value									Relative Value								
			Belukar			Open						Type			Open					
Species	Month	Direction	F	G	H	A	B	C	D	E	x	F	G	H	A	B	C	D	E	x
Neobalanocarpus	6	EW	0.55	0.62	0.63	0.44	0.29	0.40	0.31	no data	0.47	1.00	1.14	1.16	0.80	0.53	0.74	0.58	x	0.86
	12	EW	0.86	0.86	0.85	0.45	0.37	0.40	0.34	0.37	0.50	1.00	0.99	0.99	0.52	0.43	0.46	0.39	0.43	0.58
Shorea acuminat	6	EW	0.49	0.46	-	0.41	0.34	0.31	0.41	0.45	0.53	1.00	0.93	x	0.84	0.68	0.62	0.84	0.91	1.08
	12	EW	0.88	0.78	-	0.45	x	x	x	0.51	0.54	1.00	0.89	x	0.52	x	x	x	0.58	0.62
Shorea bracteola	6	EW	0.51	0.40	-	0.33	0.33	0.29	0.30	0.37	-	1.00	0.77	x	0.64	0.64	0.57	0.59	0.73	x
	12	EW	0.63	0.54	-	0.41	0.57	0.36	0.33	0.36	-	1.00	0.86	x	0.66	0.91	0.58	0.52	0.57	x
Shorea leprosula	6	EW	0.81	0.74	0.76	0.50	0.42	0.48	0.35	0.41	no data	1.00	0.91	0.93	0.62	0.52	0.59	0.43	0.51	x
	12	EW	1.62	1.37	1.44	0.38	0.38	0.70	0.39	0.38	0.31	1.00	0.84	0.89	0.23	0.23	0.43	0.24	0.24	0.19
Shorea mulitiflor	6	EW	0.69	0.47	-	-	-	-	-	-	0.21	1.00	0.67	x	x	x	x	x	x	0.31
	12	EW	1.14	0.87	-	-	-	-	-	-	0.24	1.00	0.76	x	x	x	x	x	x	0.21
Shorea ovalis	6	EW	0.66	0.56	0.68	-	-	-	-	-	0.60	1.00	0.85	1.04	x	x	x	x	x	0.91
	12	EW	1.48	1.23	1.34	-	-	-	-	-	0.54	1.00	0.83	0.90	x	x	x	x	x	0.36
Shorea parvifolia	6	EW	0.59	0.59	0.42	0.40	0.42	0.45	0.51	0.37	0.41	1.00	1.01	0.71	0.68	0.72	0.77	0.86	0.63	0.71
	12	EW	1.24	1.17	1.06	0.60	0.44	0.44	0.43	0.37	0.41	1.00	0.94	0.85	0.48	0.35	0.36	0.35	0.30	0.33

Mr. Aizawa, the short term expert on soil survey, suggested that compacting of soil by heavy duty machinery might be the main reason for the poor survival growth of the seedling in Block-A. Chemical analysis is in progress now, the result is awaited.

The plots with insufficient growth and survival of planted seedling was re-planted from Dec. 1995 to Mar. 1996. As counter methods, hardening of seedling, and mulching on foot of seedlings were taken.

We can temporarily conclude through the result in this five years, as follows;

1) The planting site must be regenerated immediately after clear cutting,
2) The site preparation by heavy duty machinery should be avoided,
3) In case of planting in bare land, fast growing species should be planted prior to the planting of indigenous species rather than mix and coexistent planting both with fast growing species and indigenous species. After the fast growing species grow big enough to provide shade, underplanting method should be taken.

These must be avoid the risk for the poor result of planting indigenous species in bare land.

5.1.2.5. Relationship between the Planting Design and the Growth of Trees in Underplanting Plots

5.1.2.5.1. Underplanting in *Acacia mangium* plantation

5.1.2.5.1.1. Planting Design (A-E type) and Growth of Trees

Survival rate, height growth, RGR-H, diameter growth, BPU, H/D ratio are shown in Tables S36, S37, S38, S39, and S40, respectively. Each table consists of two parts. Left side shows the actual value at each measurement time, and right side shows the relative value at each measurement time with setting the standard value of EW-E type as 1.

Relative value more than 1.2 or less than 0.8 were regarded as the significant difference with the standard (EW-E type).

Species in Block-B(1992) and B(1994), *Neobalanocarpus heimii, Shorea leprosula, Shorea parvifolia, Dipterocarpus cornutus, Hopea pubescens, Intsia palembanica, Shorea assamica, Shorea ovalis, Shorea ovata, Shorea pauciflora,* were planted in almost at the same time, thus the each species and the each planting designs can be compared.

Species in Block-B(1993), *Dryobalanops aromatica, Hopea odorata, Palaquium gutta, Parashorea densiflora, Pentaspadon motleyi, Shorea acuminata, Shorea glauca, Shorea macroptera,* were planted within utmost 3 months difference, thus the comparison among species and designs were difficult.

In this study, basically, one plot were established with one species on one planting design.

This was intended to plant as many species as possible. This, at the same time, caused no replication of the plot. At the beginning of this study, the Chikus site was considered as in homogeneous site condition, because of its flat terrain and monoculture plantation of *Acacia mangium*. As the time going on, this homogeneity became doubtful. Because of micro terrain, and micro distribution of soil type, some plot was suffered from water logging, and some plot showed the difference of undergrowth vegetation. The condition of the each plots were not homogeneous in the view of micro scale. The study with replication is needed in the future.

Survival of Trees

Table S36 shows the survival rate in each planting design. Generally, survival rates in narrower planting width plots were higher than those in wider width plots. The plots which showed more than 80 % of survival were observed mainly A and B type, while the plots showing less than 20 % of survival were mainly observed in D and E type.

Among 18 species planted with this design, *Hopea odorata* showed the highest survival in all planting widths. This species showed good survival even in openplanting site. As this species showed good survival even in E-type, there was not so much difference of relative value among A to E type. On the other hand, *Neobalanocarpus heimii, Palaquium gutta, Parashorea densiflora, Pentaspadon motleyi, Shorea glauca, Shorea macroptera*, and *Shorea parvifolia* showed higher relative value in narrower planting widths than in EW-E type.

Height Growth

Table S37 shows the mean height in each planting design. *Shorea leprosula* showed the highest growth among 18 species planted with this design. Judging from the relative value, it showed optimum height growth in A and B type by 24 months after planting, then optimum growth in B and C type 30 months after planting. *Shorea parvifolia* showed the second highest growth next to *Shorea leprosula*. A, B and C type may be suitable for the height growth of this species by 36 months after planting. *Neobalanocarpus heimii* showed the optimum growth in B and C type from 18 to 24 months after planting. After 30 months, differences among planting types were not so clear. It had resulted from the higher growth in wider width plots (D and E type). This species showed low survival in D and E type, but the surviving trees in D and E type showed outstanding height growth superior to the A, B and C type.

The species planted in Block-B(1993) were difficult to clarify the response to the planting design. Because of the difference in planting dates, the difference of initial seedling size, and the severe draught immediately after planting. For example, *Pentaspadon motleyi* in EW-A type was planted on 10 February, and the same species in NS-A type was planted on 18 May. *Palaquium gutta* planted in EW-B type was 13 cm in mean height at 1 month after planting while the same species in EW-E type was 43 cm in mean height. As discussed in former section (See 5.1.2.2.1.), there was much less rain in 1994, especially from June to August. These conditions made it very difficult for the comparison of each planting design and species.

Table S36 Survival Rate of Each Planting Design in Underplanting in Acacia mangium Plots

Species	Month	Direction	Actual Value Type					Relative Value Type				
			A	B	C	D	E	A	B	C	D	E
Dipterocarpus cornutus	1	EW	90.6%	78.3%	89.1%	74.3%	79.2%	1.14	0.99	1.13	0.94	1.00
	6	EW	82.9%	86.7%	88.4%	72.8%	70.0%	1.18	0.95	0.95	1.04	1.00
	12	EW	75.2%	58.3%	59.4%	49.3%	56.3%	1.34	1.04	1.06	0.88	1.00
Dryobalanops aromatica	1	EW	92.7%	86.4%	100.0%	95.6%	56.6%	1.63	1.52	1.76	1.68	1.00
		NS	59.6%	81.9%	84.8%	52.6%	40.8%	1.05	1.44	1.49	0.93	0.72
	6	EW	75.0%	47.3%	35.9%	35.3%	32.4%	2.32	1.46	1.11	1.09	1.00
		NS	45.5%	83.0%	68.6%	40.3%	31.3%	1.40	1.95	2.12	1.24	0.95
	12	EW	53.2%	24.1%	32.0%	30.5%	23.9%	2.23	1.01	1.34	1.29	1.00
		NS	37.1%	52.9%	52.7%	26.5%	7.1%	1.56	2.22	2.21	1.19	0.30
	18	EW	41.6%	13.0%	27.3%	22.4%	15.3%	2.73	1.24	1.78	1.44	1.00
		NS	33.3%	39.9%	47.3%	17.4%	4.2%	2.17	2.60	3.08	1.13	0.27
Hopea odorata	1	EW	98.6%	99.2%	96.6%	95.0%	86.6%	1.14	1.15	1.12	1.10	1.00
	6	EW	87.8%	88.6%	91.0%	90.8%	80.3%	1.09	1.08	1.13	1.13	1.00
	12	EW	81.4%	76.0%	89.6%	85.0%	76.2%	1.07	1.00	1.18	1.12	1.00
	18	EW	81.4%	78.5%	88.8%	82.5%	68.3%	1.19	1.15	1.30	1.21	1.00
Hopea pubescens	1	EW	100.0%	99.2%	78.1%	77.4%	72.0%	1.37	1.38	1.07	1.06	1.00
	6	EW	77.8%	79.2%	87.2%	68.2%	69.6%	1.12	1.14	0.97	0.95	1.00
	12	EW	44.4%	50.8%	23.4%	51.1%	49.6%	0.90	1.03	0.47	1.03	1.00
Intsia palembanica	1	EW	95.7%	99.2%	95.3%	78.7%	59.2%	1.62	1.68	1.61	1.33	1.00
	6	EW	78.6%	79.2%	85.2%	72.8%	54.6%	1.44	1.45	1.56	1.33	1.00
	12	EW	87.5%	79.2%	77.3%	53.7%	50.0%	1.35	1.58	1.55	1.07	1.00
Neobalanocarpus heimii	6	EW	96.6%	46.2%	70.2%	64.1%	59.6%	1.62	0.77	1.18	1.08	1.00
		NS	78.1%	86.5%	82.5%	89.2%	68.3%	1.31	1.45	1.38	1.18	1.15
	12	EW	96.6%	41.3%	71.2%	59.2%	55.3%	1.75	0.75	1.29	1.07	1.00
		NS	79.0%	86.5%	80.7%	64.2%	65.1%	1.43	1.56	1.46	1.16	1.18
	18	EW	95.7%	42.3%	70.2%	52.4%	42.6%	2.25	0.99	1.65	1.23	1.00
		NS	76.2%	84.6%	78.9%	60.8%	59.0%	1.79	1.99	1.86	1.43	1.39
	24	EW	88.9%	38.5%	62.5%	44.7%	23.4%	3.80	1.64	2.67	1.91	1.00
		NS	74.3%	84.6%	75.4%	51.7%	52.2%	3.17	3.62	3.22	2.21	2.23
	30	EW	90.6%	33.7%	61.5%	33.0%	13.2%	6.87	2.55	4.67	2.50	1.00
		NS	67.6%	80.8%	64.0%	34.2%	39.0%	5.13	6.12	4.85	2.59	2.95
	36	EW	87.2%	x	59.6%	30.1%	11.9%	7.32	x	5.00	2.53	1.00
		NS	64.6%	78.8%	62.3%	34.2%	42.2%	5.44	6.70	5.23	2.67	3.54
Palaquium gutta	1	EW	97.5%	99.2%	93.8%	97.8%	55.0%	1.77	1.80	1.70	1.78	1.00
	6	EW	85.0%	65.8%	43.0%	30.1%	35.0%	2.43	1.88	1.23	0.86	1.00
	12	EW	77.5%	45.0%	30.5%	23.5%	9.6%	8.09	4.70	3.18	2.45	1.00
	18	EW	68.3%	31.7%	23.4%	16.2%	1.7%	41.00	19.00	14.06	9.71	1.00
Parashorea densiflora	1	EW	97.5%	92.6%	98.5%	82.4%	57.6%	1.69	1.61	1.71	1.43	1.00
	6	EW	72.7%	74.1%	68.7%	59.6%	32.7%	2.22	2.26	2.10	1.82	1.00
	12	EW	62.0%	67.4%	47.3%	45.6%	9.1%	6.82	7.41	5.21	5.01	1.00
	18	EW	47.5%	58.5%	42.0%	36.0%	4.8%	9.89	12.07	8.66	7.43	1.00
Pentaspadon motleyi	1	EW	99.1%	89.2%	99.2%	93.4%	38.1%	2.60	2.34	2.61	2.45	1.00
		NS	38.3%	41.3%	48.2%	42.4%	21.3%	1.01	1.09	1.27	1.11	0.56
	6	EW	73.0%	74.2%	62.5%	45.6%	20.5%	3.57	3.63	3.06	2.23	1.00
		NS	21.1%	19.6%	39.3%	31.9%	8.3%	1.03	0.96	1.92	1.56	0.41
	12	EW	49.5%	67.5%	53.9%	38.0%	9.7%	5.13	6.99	5.58	3.73	1.00
		NS	3.8%	13.0%	30.4%	14.6%	0.0%	0.39	1.35	3.14	1.51	0.00
	18	EW	36.9%	60.0%	49.2%	27.9%	6.6%	5.42	8.80	7.22	4.10	1.00
		NS	6.0%	0.0%	25.0%	7.6%	0.0%	0.88	0.00	3.67	1.12	0.00
Shorea acuminata	1	EW	98.3%	100.0%	99.1%	91.0%	52.3%	1.88	1.91	1.89	1.74	1.00
		NS	66.9%	83.9%	83.0%	48.6%	60.8%	1.26	1.72	1.59	0.93	1.10
	6	EW	81.6%	83.3%	81.3%	38.2%	43.9%	2.08	1.90	1.85	0.87	1.00
		NS	50.4%	80.4%	75.0%	31.3%	43.8%	1.15	1.83	1.71	0.71	1.00
	12	EW	72.3%	59.2%	58.9%	34.0%	33.1%	2.19	1.79	1.78	1.03	1.00
		NS	19.5%	32.6%	68.8%	27.8%	30.8%	0.59	0.99	2.08	0.84	0.93
	18	EW	72.3%	53.3%	58.9%	31.9%	20.1%	3.60	2.66	2.93	1.59	1.00
		NS	16.5%	34.1%	51.8%	15.3%	24.2%	0.82	1.70	2.58	0.76	1.20
Shorea assamica	1	EW	99.1%	94.2%	87.5%	64.0%	76.3%	1.30	1.23	1.15	0.84	1.00
	6	EW	88.9%	75.8%	71.1%	59.6%	62.5%	1.42	1.21	1.14	0.95	1.00
	12	EW	80.3%	70.0%	62.5%	53.7%	42.9%	1.87	1.63	1.46	1.25	1.00
Shorea glauca	1	EW	96.6%	x	94.7%	94.2%	84.2%	1.15	x	1.12	1.12	1.00
	6	EW	69.7%	x	44.3%	30.7%	53.6%	1.30	x	0.82	0.57	1.00
	12	EW	52.1%	x	11.5%	21.2%	14.6%	3.57	x	0.79	1.45	1.00
	18	EW	38.7%	x	10.7%	2.2%	6.7%	5.80	x	1.60	0.33	1.00
Shorea leprosula	6	EW	87.5%	91.2%	75.5%	71.1%	59.2%	1.48	1.54	1.27	1.20	1.00
		NS	84.5%	99.0%	91.8%	82.7%	57.6%	1.43	1.67	1.55	1.40	0.97
	12	EW	87.5%	90.2%	74.5%	70.1%	57.5%	1.52	1.57	1.30	1.22	1.00
		NS	85.4%	99.0%	91.6%	81.8%	52.5%	1.49	1.72	1.60	1.42	0.91
	18	EW	87.5%	87.3%	71.6%	69.1%	55.8%	1.57	1.56	1.28	1.24	1.00
		NS	84.5%	94.8%	81.8%	80.9%	35.7%	1.51	1.70	1.47	1.45	0.64
	24	EW	87.5%	86.3%	69.6%	66.0%	47.2%	1.85	1.83	1.47	1.40	1.00
		NS	79.6%	81.6%	47.5%	72.7%	25.2%	1.69	1.73	1.01	1.54	0.53
	30	EW	85.7%	81.4%	67.6%	62.9%	45.1%	1.90	1.81	1.50	1.40	1.00
		NS	77.7%	76.5%	39.4%	70.9%	20.2%	1.72	1.70	0.87	1.57	0.45
	36	EW	85.7%	83.3%	67.6%	61.9%	44.2%	1.94	1.89	1.53	1.40	1.00
		NS	75.7%	75.5%	39.4%	70.0%	19.3%	1.71	1.71	0.89	1.56	0.44
Shorea macroptera	1	EW	94.0%	98.3%	33.7%	84.2%	56.3%	1.67	1.75	0.60	1.50	1.00
	6	EW	71.4%	73.9%	24.0%	11.2%	28.8%	2.48	2.57	0.84	0.39	1.00
	12	EW	57.1%	63.0%	15.4%	9.2%	17.1%	3.34	3.69	0.90	0.54	1.00
	18	EW	48.8%	57.1%	8.7%	4.6%	4.2%	11.73	13.71	2.08	1.11	1.00
Shorea ovalis	1	EW	97.4%	92.6%	78.1%	57.4%	82.9%	1.18	1.12	0.94	0.69	1.00
	6	EW	93.2%	90.2%	83.3%	55.1%	83.8%	1.48	1.41	0.99	0.67	1.00
	12	EW	74.4%	75.4%	40.6%	44.5%	57.9%	1.28	1.30	0.70	0.77	1.00
Shorea ovata	1	EW	94.9%	88.1%	76.6%	75.0%	45.8%	2.07	1.92	1.67	1.64	1.00
	6	EW	76.9%	69.5%	47.7%	61.6%	17.9%	4.29	3.88	2.66	3.45	1.00
	12	EW	45.3%	42.4%	13.3%	19.1%	10.8%	4.18	3.91	1.23	1.76	1.00
Shorea parvifolia	6	EW	91.5%	70.3%	74.0%	57.8%	41.7%	2.19	1.69	1.78	1.39	1.00
		NS	88.2%	85.6%	67.9%	55.2%	59.9%	2.12	2.05	1.63	1.32	1.44
	12	EW	86.0%	65.3%	75.0%	52.9%	38.3%	2.30	1.70	1.96	1.38	1.00
		NS	85.0%	84.6%	66.0%	51.2%	54.3%	2.24	2.21	1.72	1.34	1.42
	18	EW	84.6%	84.4%	71.2%	49.0%	33.6%	2.51	1.91	2.11	1.45	1.00
		NS	82.8%	82.7%	64.2%	42.4%	50.4%	2.45	2.45	1.90	1.26	1.49
	24	EW	75.2%	39.6%	64.4%	15.7%	19.6%	3.84	2.02	3.29	0.80	1.00
		NS	79.6%	74.0%	59.4%	40.0%	37.5%	4.06	3.78	3.03	2.04	1.91
	30	EW	72.6%	38.6%	63.5%	14.7%	14.2%	5.13	2.73	4.48	1.04	1.00
		NS	79.6%	68.3%	56.6%	33.6%	26.7%	5.62	4.68	4.00	2.37	1.89
	36	EW	73.5%	37.6%	63.5%	12.7%	14.6%	5.04	2.58	4.35	0.87	1.00
		NS	78.5%	66.3%	58.5%	32.8%	25.0%	5.38	4.55	4.01	2.25	1.71
Shorea pauciflora	1	EW	96.3%	93.3%	83.6%	76.5%	73.8%	1.33	1.27	1.13	1.04	1.00
	6	EW	81.2%	84.2%	66.4%	46.3%	57.9%	1.40	1.45	1.15	0.80	1.00
	12	EW	71.6%	58.3%	35.2%	24.3%	36.3%	1.98	1.61	0.97	0.67	1.00

Table S37 Height Growth of Each Planting Design in Underplanting in Acacia mangium Plots

			Actual Value Type					Relative Value Type				
Species	Month	Direction	A	B	C	D	E	A	B	C	D	E
Dipterocarpus cornutus	1	EW	0.41	0.45	0.27	0.30	0.30	1.37	1.47	0.88	1.00	1.00
	6	EW	0.51	0.49	0.39	0.39	0.40	1.27	1.23	0.96	0.98	1.00
	12	EW	0.81	0.88	0.59	0.73	0.73	1.11	1.21	0.81	1.00	1.00
Dryobalanops aromatica	1	EW	0.46	0.32	0.43	0.43	0.47	0.98	0.69	0.91	0.91	1.00
		NS	0.45	0.52	0.50	0.51	0.46	0.94	1.11	1.08	1.08	0.98
	6	EW	0.58	0.41	0.59	0.58	0.56	1.04	0.73	1.04	1.03	1.00
		NS	0.54	0.59	0.57	0.60	0.61	0.97	1.06	1.01	1.08	1.09
	12	EW	0.99	0.68	1.02	0.84	0.80	1.23	0.84	1.27	1.05	1.00
		NS	0.80	0.83	0.96	0.78	0.75	1.00	1.04	1.19	0.97	0.94
	18	EW	1.56	0.99	1.60	1.67	1.02	1.52	0.97	1.56	1.64	1.00
		NS	1.37	1.38	1.63	1.26	1.21	1.34	1.35	1.60	1.24	1.18
Hopea odrata	1	EW	0.31	0.35	0.40	0.61	0.35	0.90	1.01	1.15	1.77	1.00
	6	EW	0.45	0.51	0.57	0.67	0.45	1.01	1.15	1.29	1.50	1.00
	12	EW	1.01	1.03	1.26	1.08	0.94	1.07	1.09	1.34	1.15	1.00
	18	EW	1.62	1.57	2.19	1.30	1.63	1.00	0.95	1.35	0.80	1.00
Hopea pubescens	1	EW	0.20	0.45	0.23	0.33	0.38	0.54	1.20	0.61	0.88	1.00
	6	EW	0.29	0.49	0.25	0.45	0.49	0.60	1.01	0.52	0.92	1.00
	12	EW	0.64	0.69	0.47	0.80	0.80	0.79	0.86	0.58	1.00	1.00
Intsia palembanica	1	EW	0.48	0.44	0.50	0.50	0.53	0.90	0.83	0.93	0.93	1.00
	6	EW	0.57	0.57	0.56	0.53	0.61	0.94	0.94	0.93	0.87	1.00
	12	EW	0.79	0.82	0.86	0.65	0.75	1.06	1.09	1.15	0.87	1.00
Neobalanocarpus heimii	8	EW	0.52	0.47	0.50	0.45	0.48	1.09	0.99	1.05	0.95	1.00
		NS	0.51	0.52	0.46	0.39	0.48	1.08	1.09	0.96	0.83	1.01
	12	EW	0.62	0.63	0.59	0.49	0.56	1.11	1.13	1.06	0.88	1.00
		NS	0.64	0.67	0.65	0.57	0.56	1.14	1.19	1.17	1.01	1.01
	18	EW	0.84	0.84	0.89	0.55	0.72	1.16	1.17	1.24	0.77	1.00
		NS	0.82	0.99	0.95	0.78	0.85	1.14	1.38	1.33	1.09	1.18
	24	EW	0.93	1.01	1.16	0.74	0.96	1.03	1.06	1.21	0.77	1.00
		NS	1.03	1.23	1.20	0.87	1.14	1.08	1.28	1.25	0.91	1.19
	30	EW	1.24	1.35	1.49	0.83	1.50	0.83	0.90	0.99	0.55	1.00
		NS	1.27	1.54	1.69	1.58	1.61	0.85	1.02	1.12	1.05	1.07
	36	EW	1.50	x	1.79	0.94	1.87	0.80	x	0.96	0.50	1.00
		NS	1.53	1.89	1.96	1.76	1.55	0.82	1.01	1.04	0.94	1.04
Palaquium gutta	1	EW	0.22	0.13	0.16	0.14	0.43	0.52	0.30	0.39	0.34	1.00
	6	EW	0.33	0.18	0.21	0.21	0.44	0.74	0.40	0.48	0.48	1.00
	12	EW	0.55	0.31	0.44	0.35	0.46	1.19	0.66	0.96	0.76	1.00
	18	EW	0.85	0.62	0.74	0.58	0.83	1.02	0.75	0.89	0.69	1.00
Parashorea densiflora	1	EW	0.29	0.35	0.49	0.44	0.16	1.81	2.18	3.10	2.75	1.00
	6	EW	0.41	0.46	0.59	0.43	0.22	1.87	2.09	2.69	1.96	1.00
	12	EW	0.82	0.77	0.98	0.64	0.38	2.18	2.06	2.60	1.70	1.00
	18	EW	1.31	1.17	1.45	1.16	0.92	1.42	1.28	1.58	1.26	1.00
Pentaspadon motleyi	1	EW	0.30	0.34	0.39	0.28	0.26	1.12	1.27	1.47	1.05	1.00
		NS	0.20	0.16	0.36	0.31	0.27	0.76	0.61	1.34	1.16	1.00
	6	EW	0.44	0.47	0.55	0.44	0.34	1.31	1.41	1.64	1.29	1.00
		NS	0.25	0.21	0.36	0.39	0.28	0.73	0.63	1.06	1.15	0.83
	12	EW	0.81	0.96	1.14	0.88	0.62	1.30	1.55	1.83	1.41	1.00
		NS	0.41	0.53	0.69	0.77	0.00	0.66	0.85	1.10	1.24	0.00
	18	EW	1.46	2.07	2.05	1.78	1.43	1.02	1.45	1.44	1.25	1.00
		NS	0.93	0.00	1.32	1.48	0.00	0.65	0.00	0.93	1.04	0.00
Shorea acuminata	1	EW	0.61	0.62	0.69	0.64	0.62	0.99	1.00	1.12	1.04	1.00
		NS	0.44	0.42	0.44	0.40	0.39	0.71	0.68	0.72	0.65	0.63
	6	EW	0.75	0.71	0.76	0.65	0.68	1.10	1.04	1.12	0.95	1.00
		NS	0.53	0.57	0.53	0.46	0.47	0.78	0.84	0.77	0.68	0.69
	12	EW	1.23	1.24	1.18	1.14	0.90	1.37	1.38	1.31	1.28	1.00
		NS	0.63	0.78	0.74	0.71	0.77	0.70	0.85	0.83	0.79	0.86
	18	EW	1.95	2.17	1.66	1.88	1.55	1.26	1.40	1.07	1.20	1.00
		NS	0.98	1.29	1.24	1.27	1.27	0.63	0.83	0.80	0.81	0.82
Shorea assamica	1	EW	0.42	0.47	0.39	0.51	0.50	0.83	0.92	0.77	1.00	1.00
	6	EW	0.51	0.51	0.57	0.57	0.59	0.86	0.86	0.96	0.96	1.00
	12	EW	0.71	0.69	0.77	0.94	0.81	0.88	0.85	0.95	1.16	1.00
Shorea glauca	1	EW	0.28	x	0.33	0.27	0.34	0.84	x	0.98	0.80	1.00
	6	EW	0.35	x	0.38	0.32	0.35	1.02	x	1.11	0.93	1.00
	12	EW	0.60	x	0.66	0.42	0.43	1.42	x	1.56	0.98	1.00
	18	EW	0.78	x	0.95	1.00	0.65	1.19	x	1.45	1.53	1.00
Shorea leprosula	8	EW	1.04	1.16	1.01	0.84	0.75	1.38	1.54	1.33	1.11	1.00
		NS	1.03	1.10	0.89	0.93	0.65	1.37	1.46	1.18	1.24	0.86
	12	EW	1.43	1.68	1.31	1.03	0.92	1.55	1.82	1.42	1.11	1.00
		NS	1.47	1.55	1.14	1.23	0.76	1.59	1.67	1.24	1.33	0.83
	18	EW	2.37	3.04	2.33	1.85	1.60	1.48	1.91	1.46	1.16	1.00
		NS	2.47	2.61	1.30	1.92	1.04	1.55	1.63	0.81	1.20	0.65
	24	EW	3.26	3.92	3.44	2.54	2.11	1.54	1.86	1.63	1.20	1.00
		NS	3.13	2.93	1.52	2.59	1.52	1.48	1.38	0.72	1.23	0.72
	30	EW	4.36	5.48	5.13	3.91	3.19	1.37	1.72	1.61	1.23	1.00
		NS	4.24	4.26	2.71	4.22	2.70	1.33	1.34	0.85	1.32	0.85
	36	EW	5.35	8.88	6.53	5.18	4.27	1.25	1.61	1.53	1.22	1.00
		NS	5.63	5.59	3.51	5.26	3.41	1.32	1.31	0.82	1.23	0.80
Shorea macroptera	1	EW	0.24	0.30	0.30	0.19	0.37	0.65	0.80	0.81	0.50	1.00
	6	EW	0.34	0.41	0.38	0.36	0.50	0.69	0.83	0.76	0.71	1.00
	12	EW	0.67	0.68	0.52	0.52	0.72	0.93	0.94	0.72	0.72	1.00
	18	EW	0.98	1.10	0.82	1.12	1.42	0.69	0.78	0.58	0.79	1.00
Shorea ovalis	1	EW	0.29	0.34	0.31	0.39	0.35	0.82	0.95	0.88	1.11	1.00
	6	EW	0.48	0.54	0.51	0.52	0.47	1.03	1.15	1.07	1.10	1.00
	12	EW	1.00	1.01	0.99	1.01	0.89	1.13	1.14	1.11	1.14	1.00
Shorea ovata	1	EW	0.55	0.44	0.49	0.46	0.41	1.33	1.06	1.18	1.12	1.00
	6	EW	0.63	0.44	0.43	0.47	0.44	1.44	1.01	0.99	1.07	1.00
	12	EW	1.05	0.88	0.71	0.80	0.49	2.19	1.84	1.47	1.67	1.00
Shorea parvifolia	8	EW	0.87	0.84	0.78	0.79	0.68	1.28	1.23	1.14	1.16	1.00
		NS	0.82	0.88	0.82	0.66	0.67	1.21	1.30	1.20	0.98	0.98
	12	EW	1.17	1.19	0.98	0.89	0.86	1.36	1.39	1.14	1.04	1.00
		NS	1.15	1.21	1.17	0.86	0.84	1.34	1.41	1.36	1.00	0.98
	18	EW	1.80	1.81	1.51	1.30	1.30	1.39	1.40	1.16	1.00	1.00
		NS	1.91	2.02	1.79	1.32	1.16	1.47	1.55	1.38	1.01	0.83
	24	EW	2.41	2.12	2.05	2.03	1.74	1.39	1.22	1.18	1.17	1.00
		NS	2.41	2.52	2.24	1.78	1.61	1.39	1.45	1.29	1.02	0.93
	30	EW	3.24	2.89	2.93	2.78	2.72	1.19	1.06	1.08	1.02	1.00
		NS	3.21	3.60	3.31	2.57	2.49	1.18	1.32	1.22	0.94	0.92
	36	EW	3.85	4.15	3.94	3.57	3.10	1.24	1.34	1.27	1.15	1.00
		NS	3.84	4.13	3.97	3.09	2.95	1.24	1.33	1.28	1.00	0.95
Shorea pauciflora	1	EW	0.37	0.39	0.32	0.37	0.34	1.07	1.15	0.94	1.08	1.00
	6	EW	0.54	0.53	0.43	0.44	0.45	1.20	1.18	0.95	0.98	1.00
	12	EW	0.85	1.03	0.71	0.71	0.79	1.07	1.31	0.90	0.90	1.00

Diameter Growth

Table S38 shows the mean diameter in each planting design. Comparing the response to the planting design with the relative value to EW-E type plots, most of the species showed almost same trend with the height. Some species showed the fair diameter growth in wider planting width, for example, *Neobalanocarpus heimii* in EW-E, *Shorea parvifolia* in NS-E, *Dryobalanops aromatica* in NS-E, *Shorea macroptera* in EW-E, etc.. These species showed quite low survival rate in wider planting strips. This may suggest that only thicker seedlings could survive well in wider planting strips.

H/D Ratio

Table S39 shows H/D ratio in each planting design. Species with slender shape, such as *Shorea parvifolia, Dryobalanops aromatica, Pentaspadon motleyi, Shorea acuminata* showed higher H/D rate. Generally, H/D ratio was higher in narrower planting strip width. *Dipterocarpus cornutus, Hopea pubescens, Intsia palembanica, Shorea assamica, Shorea glauca, Shorea macroptera, Shorea ovalis*, and *Shorea pauciflora*, did not show much difference of H/D ratio between A to E type.

Biomass

Table S40 shows BPU in each planting design. *Shorea leprosula* showed the highest BPU value. B type showed the highest value at each measurement time, because of its high survival and fair height and diameter growth. *Hopea odorata* showed the second highest BPU next to *Shorea leprosula*. At 18 months after planting, B type showed the highest value between A to E type. *Shorea parvifolia* showed the third highest value next to *Shorea leprosula* and *Hopea odorata*. It showed highest value of BPU in C type. Most of the species showed the highest BPU value in B or C type, while *Hopea pubescens* showed the highest value in E type, *Palaquium gutta, Shorea glauca* and *Shorea ovata* showed the highest value in A type.

5.1.2.5.1.2. Planting Direction (EW and NS type) and Growth of Trees

In order to clarify the difference of growth of trees underplanted between EW planting direction and NS direction in *Acacia mangium* plantation, same species planted in both EW and NS direction plots were compared. *Dryobalanops aromatica, Neobalanocarpus heimii, Pentaspadon*

Table S38 Diameter Growth of Each Planting Design in Underplanting in Acacia mangium Plots

Species	Month	Direction	Actual Value Type A	B	C	D	E	Relative Value Type A	B	C	D	E
Dipterocarpus cornutus	1	EW	0.66	0.71	0.52	0.59	0.54	1.22	1.31	0.96	1.09	1.00
	6	EW	0.70	0.74	0.57	0.58	0.58	1.21	1.27	0.99	1.00	1.00
	12	EW	0.93	1.02	0.78	0.83	0.80	1.16	1.28	0.98	1.04	1.00
Dryobalanops aromatica	1	EW	0.43	0.38	0.39	0.41	0.48	0.90	0.80	0.80	0.86	1.00
		NS	0.40	0.38	0.45	0.46	0.45	0.83	0.79	0.94	0.96	0.94
	6	EW	0.49	0.45	0.57	0.55	0.66	0.74	0.68	0.97	0.83	1.00
		NS	0.47	0.45	0.49	0.55	0.54	0.71	0.68	0.74	0.83	0.82
	12	EW	0.70	0.63	0.79	0.73	0.68	1.03	0.92	1.16	1.08	1.00
		NS	0.55	0.50	0.68	0.66	0.72	0.81	0.73	0.99	0.97	1.06
	18	EW	1.03	0.73	1.14	1.23	0.96	1.08	0.77	1.20	1.29	1.00
		NS	0.89	0.82	1.03	0.91	1.22	0.93	0.85	1.08	0.95	1.28
Hopea odrata	1	EW	0.39	0.53	0.54	0.78	0.51	0.76	1.05	1.06	1.55	1.00
	6	EW	0.66	0.73	0.93	0.86	0.71	0.93	1.03	1.31	1.21	1.00
	12	EW	1.20	1.23	1.77	1.19	1.33	0.91	0.92	1.33	0.89	1.00
	18	EW	2.11	1.80	2.90	1.56	2.33	0.91	0.77	1.25	0.68	1.00
Hopea pubescens	1	EW	0.21	0.44	0.28	0.37	0.42	0.50	1.04	0.66	0.88	1.00
	6	EW	0.35	0.54	0.35	0.46	0.48	0.74	1.13	0.73	0.96	1.00
	12	EW	0.53	0.66	0.41	0.63	0.73	0.72	0.90	0.56	0.86	1.00
Intsia palembanica	1	EW	0.71	0.60	0.80	0.80	0.75	0.94	0.79	1.06	1.06	1.00
	6	EW	0.77	0.68	0.84	0.83	0.88	0.87	0.77	0.95	0.94	1.00
	12	EW	0.99	0.92	1.09	0.95	0.96	1.03	0.96	1.13	0.99	1.00
Neobalanocarpus heimii	6	EW	0.61	0.52	0.61	0.64	0.66	0.92	0.78	0.93	0.97	1.00
		NS	0.61	0.64	0.62	0.61	0.65	0.93	0.98	0.94	0.93	0.98
	12	EW	0.74	0.74	0.75	0.73	0.77	0.96	0.96	0.98	0.94	1.00
		NS	0.78	0.77	0.81	0.76	0.77	1.01	1.01	1.05	0.99	1.01
	18	EW	0.90	0.90	0.98	0.85	0.99	0.90	0.91	0.99	0.86	1.00
		NS	0.95	1.09	1.17	1.14	1.10	0.96	1.11	1.19	1.16	1.11
	24	EW	1.01	1.01	1.23	0.98	1.22	0.83	0.83	1.01	0.80	1.00
		NS	1.08	1.27	1.35	1.40	1.36	0.88	1.04	1.11	1.15	1.12
	30	EW	1.17	1.22	1.63	1.19	1.71	0.69	0.71	0.95	0.69	1.00
		NS	1.23	1.61	1.65	1.97	1.94	0.72	0.94	1.08	1.15	1.13
	36	EW	1.37	x	1.77	1.34	2.03	0.68	x	0.87	0.66	1.00
		NS	1.50	1.88	2.14	2.46	2.39	0.74	0.93	1.06	1.21	1.18
Palaquium gutta	1	EW	0.33	0.22	0.25	0.23	0.67	0.50	0.33	0.37	0.34	1.00
	6	EW	0.35	0.28	0.31	0.37	0.73	0.48	0.39	0.43	0.51	1.00
	12	EW	0.46	0.43	0.44	0.43	0.76	0.61	0.57	0.58	0.57	1.00
	18	EW	0.62	0.50	0.62	0.58	0.93	0.67	0.54	0.67	0.63	1.00
Parashorea densiflora	1	EW	0.33	0.39	0.51	0.54	0.26	1.23	1.46	1.92	2.05	1.00
	6	EW	0.46	0.51	0.67	0.63	0.33	1.40	1.56	2.03	1.91	1.00
	12	EW	0.67	0.76	1.02	0.83	0.49	1.35	1.55	2.06	1.68	1.00
	18	EW	1.15	1.05	1.32	1.27	0.86	1.34	1.22	1.53	1.47	1.00
Pentaspadon motleyi	1	EW	0.36	0.35	0.37	0.30	0.28	1.27	1.24	1.29	1.06	1.00
		NS	0.13	0.12	0.29	0.30	0.19	0.47	0.43	1.04	1.06	0.67
	6	EW	0.43	0.45	0.57	0.47	0.38	1.14	1.23	1.51	1.25	1.00
		NS	0.23	0.19	0.40	0.39	0.25	0.61	0.49	1.05	1.04	0.67
	12	EW	0.67	0.81	1.01	0.79	0.58	1.16	1.40	1.75	1.37	1.00
		NS	0.30	0.26	0.56	0.66	x	0.52	0.44	0.98	1.15	x
	18	EW	1.19	1.46	1.71	1.51	1.19	0.99	1.22	1.43	1.27	1.00
		NS	0.73	x	1.02	1.30	x	0.61	x	0.85	1.09	x
Shorea acuminata	1	EW	0.62	0.52	0.54	0.57	0.63	0.99	0.82	0.86	0.90	1.00
		NS	0.45	0.42	0.47	0.41	0.42	0.71	0.67	0.75	0.65	0.67
	6	EW	0.71	0.66	0.64	0.71	0.68	1.04	0.97	0.95	1.04	1.00
		NS	0.60	0.55	0.52	0.54	0.50	0.88	0.80	0.76	0.80	0.73
	12	EW	1.00	0.99	1.04	1.13	0.91	1.10	1.08	1.14	1.24	1.00
		NS	0.60	0.61	0.73	0.69	0.70	0.66	0.67	0.80	0.75	0.77
	18	EW	1.45	1.67	1.52	1.54	1.38	1.05	1.21	1.10	1.12	1.00
		NS	0.84	0.98	1.12	1.18	1.15	0.61	0.71	0.81	0.86	0.84
Shorea assamica	1	EW	0.48	0.54	0.45	0.63	0.65	0.74	0.84	0.69	0.97	1.00
	6	EW	0.77	0.76	0.63	0.72	0.68	1.13	1.11	0.92	1.06	1.00
	12	EW	1.08	1.08	1.06	1.11	0.91	1.19	1.18	1.17	1.22	1.00
Shorea glauca	1	EW	0.40	x	0.34	0.31	0.34	1.17	x	1.00	0.90	1.00
	6	EW	0.46	x	0.39	0.43	0.44	1.04	x	0.88	0.98	1.00
	12	EW	0.58	x	0.59	0.53	0.50	1.17	x	1.19	1.07	1.00
	18	EW	0.81	x	0.87	1.23	0.61	1.32	x	1.42	2.01	1.00
Shorea leprosula	6	EW	0.92	0.94	1.01	0.93	0.87	1.06	1.08	1.17	1.08	1.00
		NS	0.88	1.00	0.97	0.97	0.78	1.02	1.16	1.11	1.12	0.90
	12	EW	1.32	1.53	1.54	1.25	1.19	1.11	1.29	1.30	1.05	1.00
		NS	1.43	1.57	1.44	1.49	1.06	1.20	1.32	1.21	1.25	0.89
	18	EW	2.18	2.79	2.82	2.29	2.18	1.00	1.28	1.30	1.05	1.00
		NS	2.31	2.79	2.19	2.62	1.66	1.06	1.28	1.01	1.21	0.77
	24	EW	2.92	3.80	3.91	3.15	2.85	1.03	1.33	1.37	1.11	1.00
		NS	3.28	3.77	2.78	3.75	2.33	1.15	1.32	0.98	1.32	0.82
	30	EW	3.80	5.25	5.54	4.80	4.34	0.88	1.21	1.28	1.11	1.00
		NS	4.43	4.77	3.65	5.31	3.65	1.02	1.10	0.84	1.22	0.84
	36	EW	4.80	6.30	6.72	6.50	6.19	0.78	1.02	1.09	1.05	1.00
		NS	5.56	5.96	4.42	6.85	5.17	0.90	0.96	0.71	1.11	0.83
Shorea macroptera	1	EW	0.35	0.37	0.35	0.32	0.38	0.92	0.98	0.93	0.84	1.00
	6	EW	0.46	0.59	0.46	0.44	0.53	0.87	1.11	0.86	0.83	1.00
	12	EW	0.64	0.68	0.59	0.65	0.68	0.93	1.00	0.87	0.95	1.00
	18	EW	0.84	0.95	0.64	0.94	1.23	0.68	0.77	0.52	0.77	1.00
Shorea ovalis	1	EW	0.43	0.43	0.39	0.53	0.55	0.78	0.78	0.70	0.96	1.00
	6	EW	0.59	0.66	0.68	0.71	0.66	0.90	1.00	1.03	1.08	1.00
	12	EW	0.99	1.08	1.17	1.26	1.03	0.97	1.06	1.14	1.22	1.00
Shorea ovata	1	EW	0.56	0.48	0.43	0.48	0.57	0.99	0.85	0.76	0.84	1.00
	6	EW	0.63	0.52	0.57	0.56	0.61	1.04	0.86	0.94	0.91	1.00
	12	EW	0.99	0.80	0.84	0.79	0.63	1.59	1.28	1.34	1.26	1.00
Shorea parvifolia	6	EW	0.73	0.67	0.73	0.76	0.68	1.07	0.99	1.07	1.11	1.00
		NS	0.72	0.79	0.83	0.70	0.64	1.06	1.16	1.21	1.04	0.94
	12	EW	1.01	0.99	0.87	0.98	0.90	1.13	1.10	0.97	1.09	1.00
		NS	0.94	1.04	1.14	0.92	0.99	1.04	1.16	1.27	1.02	1.10
	18	EW	1.68	1.59	1.47	1.39	1.52	1.10	1.05	0.97	0.91	1.00
		NS	1.56	1.73	2.05	1.43	1.53	1.03	1.14	1.35	0.98	1.01
	24	EW	2.36	1.94	2.07	2.09	1.97	1.20	0.98	1.05	1.06	1.00
		NS	2.14	2.36	2.72	1.91	2.09	1.09	1.20	1.38	0.97	1.06
	30	EW	3.06	2.66	2.79	2.84	3.13	0.98	0.85	0.89	0.91	1.00
		NS	2.77	3.32	3.53	2.83	3.31	0.89	1.06	1.13	0.91	1.06
	36	EW	3.70	3.25	3.82	4.12	4.08	0.91	0.80	0.94	1.01	1.00
		NS	3.44	3.98	4.53	4.10	4.81	0.84	0.98	1.11	1.00	1.18
Shorea pauciflora	1	EW	0.56	0.60	0.50	0.50	0.52	1.07	1.14	0.94	0.95	1.00
	6	EW	0.65	0.70	0.63	0.62	0.66	1.00	1.06	0.96	0.95	1.00
	12	EW	0.86	1.06	0.96	0.86	0.88	0.98	1.21	1.09	0.98	1.00

Table S39 H/D Ratio of Each Planting Design in Underplanting in Acacia mangium Plots

Species	Month	Direction	Actual Value Type A	B	C	D	E	Relative Value Type A	B	C	D	E
Dipterocarpus cornutus	1	EW	63.1	62.5	50.1	50.9	55.7	1.13	1.12	0.90	0.91	1.00
	6	EW	72.3	67.4	65.2	66.0	70.1	1.03	0.96	0.93	0.94	1.00
	12	EW	85.1	83.7	72.7	84.8	90.2	0.94	0.93	0.81	0.94	1.00
Dryobalanops aromatica	1	EW	109.9	85.8	113.0	105.8	109.1	1.01	0.79	1.04	0.97	1.00
		NS	114.4	140.1	112.4	113.8	104.5	1.05	1.29	1.03	1.04	0.96
	6	EW	122.5	92.8	102.9	107.0	98.5	1.24	0.94	1.05	1.09	1.00
		NS	117.3	134.3	118.5	110.7	112.6	1.19	1.36	1.20	1.12	1.14
	12	EW	142.3	108.3	128.5	117.9	120.6	1.18	0.90	1.07	0.98	1.00
		NS	149.9	159.6	141.5	118.3	104.8	1.24	1.41	1.17	0.99	0.87
	18	EW	156.2	136.6	141.9	140.0	109.8	1.42	1.24	1.29	1.29	1.00
		NS	154.3	172.2	162.0	140.2	101.5	1.41	1.57	1.48	1.28	0.92
Hopea odrata	1	EW	81.7	65.0	75.5	78.6	69.8	1.17	0.93	1.09	1.13	1.00
	6	EW	69.6	71.4	62.9	78.9	63.1	1.10	1.13	1.00	1.25	1.00
	12	EW	86.9	85.6	72.3	93.0	70.7	1.23	1.21	1.02	1.32	1.00
	18	EW	77.1	84.5	75.2	81.1	70.5	1.09	1.20	1.07	1.15	1.00
Hopea pubescens	1	EW	110.4	101.2	83.4	88.6	88.3	1.25	1.15	0.94	1.00	1.00
	6	EW	82.8	91.7	70.5	96.5	101.2	0.82	0.91	0.70	0.95	1.00
	12	EW	114.8	106.6	111.0	123.9	111.4	1.03	0.95	1.00	1.11	1.00
Intsia palembanica	1	EW	68.6	75.0	63.9	63.5	72.9	0.94	1.03	0.88	0.87	1.00
	6	EW	75.0	83.9	67.9	63.9	69.8	1.07	1.20	0.97	0.91	1.00
	12	EW	77.7	86.1	78.3	68.0	77.1	1.01	1.12	1.01	0.88	1.00
Neobalanocarpus heimii	6	EW	87.1	88.8	81.4	69.1	73.1	1.19	1.21	1.11	0.94	1.00
		NS	83.5	82.7	73.4	61.9	75.1	1.14	1.13	1.00	0.85	1.03
	12	EW	83.2	83.7	77.9	66.1	71.9	1.16	1.16	1.08	0.92	1.00
		NS	82.8	86.6	79.6	73.2	73.0	1.15	1.20	1.11	1.02	1.02
	18	EW	91.6	90.7	90.1	62.4	71.3	1.28	1.27	1.26	0.87	1.00
		NS	87.4	90.3	80.6	66.5	77.4	1.23	1.27	1.13	0.93	1.09
	24	EW	97.2	98.5	94.0	74.5	77.3	1.26	1.27	1.22	0.96	1.00
		NS	95.2	97.6	88.5	61.7	85.4	1.23	1.26	1.14	0.80	1.10
	30	EW	105.0	110.4	94.9	68.0	85.2	1.23	1.30	1.11	0.80	1.00
		NS	103.4	96.2	91.2	79.1	84.8	1.21	1.13	1.07	0.93	1.00
	36	EW	108.4	x	100.4	64.9	92.3	1.17	x	1.09	0.70	1.00
		NS	100.0	102.6	92.2	71.0	82.3	1.08	1.11	1.00	0.77	0.89
Palaquium gutta	1	EW	66.5	61.0	67.8	65.0	64.3	1.03	0.95	1.05	1.01	1.00
	6	EW	93.8	64.9	69.9	58.7	61.7	1.52	1.05	1.13	0.95	1.00
	12	EW	118.8	71.2	101.6	78.5	61.6	1.93	1.16	1.65	1.28	1.00
	18	EW	135.8	123.3	113.7	98.4	90.0	1.51	1.37	1.26	1.09	1.00
Parashorea densiflora	1	EW	91.4	95.5	98.4	83.1	59.3	1.54	1.61	1.66	1.40	1.00
	6	EW	93.1	93.2	88.3	69.8	64.9	1.43	1.44	1.36	1.08	1.00
	12	EW	121.7	100.9	95.7	77.4	75.0	1.62	1.35	1.28	1.03	1.00
	18	EW	107.9	109.3	106.7	89.5	102.3	1.05	1.07	1.04	0.87	1.00
Pentaspadon motleyi	1	EW	83.5	97.1	107.8	93.3	96.5	0.87	1.01	1.12	0.97	1.00
		NS	160.2	139.5	126.2	107.1	149.3	1.66	1.45	1.31	1.11	1.55
	6	EW	103.9	102.2	98.7	94.8	89.7	1.16	1.14	1.10	1.06	1.00
		NS	126.7	123.6	91.3	103.9	122.0	1.41	1.38	1.02	1.16	1.36
	12	EW	117.9	118.1	115.7	114.0	104.7	1.13	1.13	1.11	1.09	1.00
		NS	137.2	199.6	126.3	118.8	x	1.31	1.91	1.21	1.12	x
	18	EW	118.1	143.6	121.7	117.7	118.8	1.00	1.21	1.03	0.99	1.00
		NS	124.8	x	130.8	115.4	x	1.05	x	1.10	0.97	x
Shorea acuminata	1	EW	98.9	120.9	128.2	114.1	95.9	1.03	1.26	1.34	1.19	1.00
		NS	99.7	101.0	95.8	99.2	96.4	1.04	1.05	1.00	1.03	1.01
	6	EW	106.9	107.7	118.6	91.9	98.5	1.09	1.09	1.20	0.93	1.00
		NS	89.4	104.2	102.6	65.8	95.8	0.91	1.06	1.04	0.87	0.97
	12	EW	123.8	124.1	113.7	104.0	97.6	1.27	1.27	1.16	1.07	1.00
		NS	108.3	125.1	102.3	102.1	108.8	1.11	1.28	1.05	1.05	1.11
	18	EW	133.0	131.4	107.3	122.1	116.0	1.15	1.13	0.93	1.05	1.00
		NS	115.8	131.9	113.1	108.0	118.3	1.00	1.14	0.98	0.93	1.02
Shorea assamica	1	EW	90.7	88.5	89.8	82.1	80.9	1.12	1.09	1.11	1.01	1.00
	6	EW	68.3	69.9	91.6	61.5	90.7	0.75	0.77	1.01	0.90	1.00
	12	EW	67.5	64.9	74.2	87.0	89.8	0.75	0.72	0.83	0.97	1.00
Shorea glauca	1	EW	76.4	x	97.0	88.6	100.4	0.76	x	0.97	0.88	1.00
	6	EW	77.2	x	100.0	74.9	79.6	0.97	x	1.26	0.94	1.00
	12	EW	104.6	x	113.8	78.9	88.6	1.18	x	1.28	0.89	1.00
	18	EW	96.4	x	108.5	83.2	104.2	0.93	x	1.04	0.80	1.00
Shorea leprosula	6	EW	112.9	126.0	100.7	91.0	91.3	1.24	1.38	1.10	1.00	1.00
		NS	118.5	111.3	94.3	100.3	86.2	1.30	1.22	1.03	1.10	0.94
	12	EW	110.2	110.8	88.6	83.6	79.1	1.39	1.40	1.12	1.06	1.00
		NS	102.8	99.6	80.4	86.2	75.6	1.30	1.26	1.02	1.09	0.96
	18	EW	110.5	110.4	86.0	81.0	74.4	1.48	1.48	1.15	1.09	1.00
		NS	108.1	94.8	60.0	76.8	66.9	1.45	1.27	0.81	1.03	0.90
	24	EW	112.9	104.6	91.4	81.7	77.3	1.46	1.35	1.18	1.06	1.00
		NS	95.9	77.7	52.4	73.2	71.3	1.24	1.01	0.68	0.95	0.92
	30	EW	116.9	106.1	95.8	83.4	75.9	1.54	1.40	1.28	1.10	1.00
		NS	95.5	89.1	72.3	82.4	80.5	1.26	1.17	0.95	1.09	1.06
	36	EW	113.7	110.7	101.5	81.6	71.5	1.59	1.55	1.42	1.14	1.00
		NS	101.6	93.5	77.5	79.8	71.7	1.42	1.31	1.08	1.12	1.00
Shorea macroptera	1	EW	68.9	81.1	81.4	59.5	100.1	0.69	0.81	0.81	0.59	1.00
	6	EW	79.4	83.7	79.8	80.7	94.1	0.84	0.89	0.85	0.86	1.00
	12	EW	104.6	97.7	86.2	77.6	105.2	0.99	0.93	0.82	0.74	1.00
	18	EW	113.3	112.8	124.1	120.7	117.4	0.97	0.96	1.06	1.03	1.00
Shorea ovalis	1	EW	70.1	83.4	81.5	74.9	63.5	1.10	1.31	1.28	1.18	1.00
	6	EW	80.4	80.8	73.8	71.1	73.9	1.09	1.09	1.00	0.95	1.00
	12	EW	97.9	90.3	82.6	79.7	85.5	1.15	1.06	0.97	0.93	1.00
Shorea ovata	1	EW	99.7	91.5	122.0	96.9	74.4	1.34	1.23	1.64	1.30	1.00
	6	EW	100.1	88.2	75.3	83.3	75.8	1.32	1.17	1.00	1.10	1.00
	12	EW	105.0	108.9	83.0	98.5	79.6	1.32	1.37	1.04	1.24	1.00
Shorea parvifolia	6	EW	117.2	126.4	108.1	104.5	99.6	1.18	1.27	1.09	1.05	1.00
		NS	115.0	112.4	100.7	97.7	109.2	1.15	1.13	1.01	0.98	1.10
	12	EW	113.9	119.2	111.8	88.2	94.5	1.20	1.26	1.18	0.93	1.00
		NS	120.4	113.6	103.4	95.4	85.3	1.27	1.20	1.09	1.01	0.90
	18	EW	106.2	113.1	102.4	88.4	83.4	1.27	1.36	1.23	1.06	1.00
		NS	122.1	117.2	89.6	88.8	74.5	1.46	1.41	1.06	1.07	0.89
	24	EW	103.3	106.3	104.2	100.7	89.0	1.16	1.22	1.17	1.13	1.00
		NS	114.2	105.8	84.5	98.0	77.7	1.28	1.19	0.95	1.10	0.87
	30	EW	106.3	109.0	109.5	102.0	88.8	1.20	1.23	1.23	1.15	1.00
		NS	117.9	107.3	97.4	95.5	78.3	1.33	1.21	1.10	1.07	0.88
	36	EW	107.7	131.9	106.9	91.7	75.7	1.42	1.74	1.41	1.21	1.00
		NS	113.7	102.0	88.4	75.7	63.9	1.50	1.35	1.17	1.01	0.84
Shorea pauciflora	1	EW	66.3	66.9	66.5	75.0	66.8	0.99	1.00	1.00	1.12	1.00
	6	EW	82.9	76.4	67.3	71.3	70.0	1.18	1.09	0.96	1.02	1.00
	12	EW	96.6	93.0	73.3	82.9	88.6	1.09	1.05	0.83	0.94	1.00

Table S40 BPU of Each Planting Design in Underplanting in Acacia mangium Plots

			Actual Value					Relative Value				
			Type					Type				
Species	Month	Direction	A	B	C	D	E	A	B	C	D	E
Dipterocarpus cornutus	1	EW	0.19	0.20	0.08	0.09	0.09	2.17	2.37	0.90	1.08	1.00
	6	EW	0.24	0.20	0.11	0.12	0.12	2.07	1.71	0.91	0.99	1.00
	12	EW	0.67	0.68	0.32	0.35	0.35	1.88	1.91	0.90	0.98	1.00
Dryobalanops aromatica	1	EW	0.09	0.06	0.07	0.08	0.15	0.58	0.37	0.47	0.50	1.00
		NS	0.06	0.07	0.09	0.06	0.04	0.33	0.45	0.62	0.40	0.29
	6	EW	0.11	0.05	0.07	0.07	0.18	0.62	0.25	0.41	0.36	1.00
		NS	0.06	0.08	0.10	0.08	0.06	0.34	0.45	0.57	0.42	0.35
	12	EW	0.30	0.08	0.25	0.17	0.11	2.88	0.71	2.33	1.64	1.00
		NS	0.11	0.13	0.30	0.12	0.03	1.07	1.28	2.86	1.14	0.31
	18	EW	0.87	0.13	0.65	0.72	0.20	4.42	0.63	3.31	3.65	1.00
		NS	0.46	0.47	1.19	0.27	0.11	2.35	2.41	6.06	1.35	0.56
Hopea odrata	1	EW	0.07	0.13	0.14	0.39	0.09	0.77	1.37	1.54	4.23	1.00
	6	EW	0.23	0.29	0.54	0.49	0.22	1.07	1.33	2.49	2.24	1.00
	12	EW	1.60	1.42	4.32	1.52	1.76	0.91	0.81	2.46	0.86	1.00
	18	EW	7.97	5.77	21.19	3.74	9.44	0.84	0.61	2.24	0.40	1.00
Hopea pubescens	1	EW	0.01	0.13	0.02	0.04	0.06	0.18	2.10	0.27	0.71	1.00
	6	EW	0.03	0.16	0.02	0.08	0.10	0.33	1.55	0.23	0.76	1.00
	12	EW	0.11	0.21	0.03	0.22	0.28	0.40	0.75	0.09	0.77	1.00
Intsia palembanica	1	EW	0.29	0.17	0.33	0.28	0.20	1.51	0.86	1.69	1.45	1.00
	6	EW	0.31	0.24	0.37	0.31	0.29	1.08	0.84	1.30	1.07	1.00
	12	EW	0.67	0.72	1.01	0.39	0.41	1.61	1.75	2.46	0.93	1.00
Neobalanocarpus heimii	8	EW	0.22	0.09	0.15	0.14	0.16	1.33	0.53	0.90	0.88	1.00
		NS	0.17	0.23	0.18	0.13	0.17	1.02	1.44	1.11	0.80	1.06
	12	EW	0.37	0.18	0.29	0.18	0.23	1.65	0.80	1.28	0.81	1.00
		NS	0.34	0.41	0.46	0.29	0.28	1.49	1.81	2.01	1.26	1.22
	18	EW	0.76	0.42	0.78	0.29	0.43	1.75	0.96	1.80	0.67	1.00
		NS	0.64	1.16	1.36	0.87	0.80	1.46	2.68	3.12	2.00	1.84
	24	EW	1.04	0.55	1.39	0.42	0.53	1.97	1.04	2.63	0.80	1.00
		NS	1.02	1.91	2.09	1.18	1.45	1.92	3.62	3.95	2.24	2.75
	30	EW	1.86	0.92	3.09	0.58	0.85	2.20	1.08	3.66	0.68	1.00
		NS	1.50	3.61	4.54	2.69	2.90	1.77	4.27	5.37	3.18	3.43
	36	EW	2.89	no data	4.40	1.01	1.27	2.27	no data	3.46	0.79	1.00
		NS	2.87	6.34	6.91	4.59	5.98	2.10	4.99	5.43	3.61	4.70
Palaquium gutta	1	EW	0.03	0.01	0.01	0.01	0.12	0.23	0.05	0.10	0.07	1.00
	6	EW	0.04	0.01	0.01	0.01	0.09	0.41	0.11	0.12	0.11	1.00
	12	EW	0.10	0.03	0.03	0.02	0.03	3.52	1.10	1.10	0.66	1.00
	18	EW	0.26	0.07	0.09	0.04	0.01	18.64	4.79	6.64	2.79	1.00
Parashorea densiflora	1	EW	0.04	0.07	0.16	0.12	0.01	4.56	7.22	17.22	13.44	1.00
	6	EW	0.08	0.11	0.21	0.12	0.01	8.00	11.10	20.70	11.50	1.00
	12	EW	0.33	0.38	0.54	0.24	0.01	30.00	34.45	49.45	22.00	1.00
	18	EW	1.21	1.06	1.49	0.97	0.06	22.37	19.57	27.61	17.91	1.00
Pentaspadon motleyi	1	EW	0.04	0.05	0.07	0.03	0.01	4.20	4.70	6.60	2.90	1.00
		NS	0.00	0.00	0.02	0.02	0.00	0.10	0.10	1.90	1.60	0.30
	6	EW	0.07	0.10	0.14	0.05	0.01	5.75	7.92	12.00	4.50	1.00
		NS	0.00	0.00	0.03	0.03	0.00	0.25	0.17	2.08	2.08	0.17
	12	EW	0.24	0.57	0.86	0.27	0.03	9.23	22.04	32.88	10.38	1.00
		NS	0.00	0.01	0.08	0.07	0.00	0.08	0.31	3.15	2.50	0.00
	18	EW	1.13	3.26	4.03	1.54	0.18	6.11	17.71	21.92	8.34	1.00
		NS	0.04	0.00	0.45	0.25	0.00	0.20	0.00	2.45	1.33	0.00
Shorea acuminata	1	EW	0.25	0.19	0.23	0.21	0.15	1.64	1.22	1.49	1.37	1.00
		NS	0.07	0.08	0.09	0.04	0.05	0.45	0.50	0.62	0.25	0.32
	6	EW	0.37	0.29	0.29	0.14	0.16	2.29	1.80	1.77	0.83	1.00
		NS	0.11	0.16	0.12	0.05	0.06	0.67	0.98	0.72	0.28	0.36
	12	EW	0.98	0.90	0.88	0.54	0.33	2.95	2.71	2.66	1.63	1.00
		NS	0.05	0.11	0.32	0.13	0.15	0.15	0.33	0.95	0.39	0.45
	18	EW	3.52	3.84	2.90	1.63	0.91	3.87	4.23	3.19	1.79	1.00
		NS	0.15	0.57	1.03	0.42	0.65	0.16	0.63	1.14	0.46	0.72
Shorea assamica	1	EW	0.11	0.15	0.09	0.15	0.20	0.57	0.76	0.44	0.74	1.00
	6	EW	0.30	0.26	0.21	0.21	0.23	1.33	1.14	0.91	0.90	1.00
	12	EW	0.73	0.66	0.80	0.84	0.37	1.94	1.77	2.15	2.24	1.00
Shorea glauca	1	EW	0.06	x	0.04	0.03	0.04	1.36	x	0.98	0.67	1.00
	6	EW	0.06	x	0.03	0.02	0.04	1.45	x	0.75	0.50	1.00
	12	EW	0.12	x	0.03	0.03	0.02	6.67	x	1.67	1.61	1.00
	18	EW	0.24	x	0.09	0.04	0.02	10.26	x	3.74	1.57	1.00
Shorea leprosula	8	EW	0.89	1.08	0.97	0.63	0.46	1.96	2.36	2.13	1.39	1.00
		NS	0.83	1.22	0.89	0.95	0.33	1.82	2.68	1.95	2.07	0.72
	12	EW	2.66	4.06	3.14	1.59	1.07	2.48	3.80	2.93	1.49	1.00
		NS	3.11	4.25	2.72	3.08	0.75	2.91	3.97	2.55	2.88	0.70
	18	EW	12.41	23.90	18.10	9.32	6.75	1.84	3.54	2.68	1.38	1.00
		NS	13.97	21.74	7.34	16.67	2.11	2.07	3.22	1.09	2.47	0.31
	24	EW	30.33	56.44	46.78	24.37	11.09	2.73	5.09	4.22	2.20	1.00
		NS	34.94	38.59	11.20	41.53	4.05	3.15	3.51	1.01	3.74	0.37
	30	EW	64.71	140.38	130.16	74.25	35.16	1.84	3.99	3.70	2.11	1.00
		NS	85.61	92.22	28.68	123.90	12.19	2.43	2.62	0.82	3.52	0.35
	36	EW	127.26	275.01	242.03	173.47	93.19	1.37	2.95	2.60	1.86	1.00
		NS	169.33	175.55	54.12	239.64	27.84	1.82	1.88	0.58	2.57	0.30
Shorea macroptera	1	EW	0.04	0.05	0.02	0.02	0.03	1.09	1.42	0.52	0.61	1.00
	6	EW	0.12	0.41	0.02	0.01	0.05	2.57	8.81	0.51	0.19	1.00
	12	EW	0.19	0.25	0.03	0.03	0.08	2.33	3.00	0.40	0.30	1.00
	18	EW	0.47	0.73	0.04	0.05	0.10	4.60	7.23	0.38	0.53	1.00
Shorea ovalis	1	EW	0.07	0.07	0.04	0.07	0.11	0.60	0.63	0.38	0.65	1.00
	6	EW	0.20	0.27	0.19	0.19	0.17	1.19	1.58	1.11	1.14	1.00
	12	EW	1.01	1.30	0.76	1.08	0.89	1.13	1.45	0.85	1.21	1.00
Shorea ovata	1	EW	0.19	0.10	0.09	0.09	0.07	2.63	1.42	1.26	1.29	1.00
	6	EW	0.24	0.14	0.09	0.12	0.03	7.00	4.03	2.50	3.53	1.00
	12	EW	0.73	0.42	0.08	0.15	0.03	26.00	15.04	2.75	5.29	1.00
Shorea parvifolia	8	EW	0.57	0.33	0.36	0.37	0.17	3.35	1.90	2.11	2.14	1.00
		NS	0.48	0.59	0.44	0.22	0.22	2.79	3.44	2.57	1.29	1.30
	12	EW	1.49	1.03	0.76	0.71	0.35	4.26	2.94	2.17	2.03	1.00
		NS	1.10	1.40	1.23	0.50	0.61	3.16	4.01	3.53	1.44	1.75
	18	EW	6.23	4.72	3.41	2.31	1.51	4.13	3.13	2.26	1.53	1.00
		NS	5.42	6.68	6.66	1.89	2.17	3.60	4.43	4.42	1.25	1.44
	24	EW	13.71	5.11	8.12	2.27	1.73	7.93	2.96	4.70	1.32	1.00
		NS	11.43	14.42	13.38	4.00	4.04	6.62	8.34	7.74	2.31	2.34
	30	EW	30.11	13.55	23.21	5.53	4.79	6.29	2.83	4.84	1.16	1.00
		NS	27.23	34.96	32.40	10.03	9.89	5.69	7.30	6.76	2.09	2.07
	36	EW	52.62	26.51	54.95	10.51	10.24	5.14	2.59	5.37	1.03	1.00
		NS	49.00	65.04	69.20	24.77	24.73	4.79	6.35	6.76	2.42	2.41
Shorea pauciflora	1	EW	0.13	0.15	0.10	0.08	0.08	1.62	1.92	1.22	0.96	1.00
	6	EW	0.21	0.30	0.18	0.09	0.15	1.44	2.05	1.25	0.62	1.00
	12	EW	0.55	1.08	0.59	0.15	0.38	1.43	2.83	1.56	0.39	1.00