REPORT ON THE EXPERIMENT FOR LARGE-SCALE REFORESTATION TECHNIQUES

MARCH, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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FOREWORD

Some 17 million ha of forests (FAO Report, 1990) are lost every year in the tropics due to the expansion of shifting cultivation, excessive stock raising, collection of firewood and intensive commercial felling, all of which are the result of an ever increasing population. The stands which remain are also deteriorating. Despite such critical conditions, many developing countries are able to reforest less than 10% of the forest area which is lost every year. This low level of reforestation has many causes, i.e. shortage of skilled forestry workers, lack of a reforestation system, absence of such reforestation-related infrastructure as nurseries and forest roads and severe financial constraints. Against this background, the implementation of "environmental reforestation", a concept of reforestation to recover the water conservation function of forests, to prevent desertification and to control global warming, etc., is urgently required and much attention is being paid to the promising aerial reforestation method which aims at achieving fast, large-scale and low cost reforestation.

A series of fact-finding surveys were conducted on aerial reforestation practices in Canada, the US, Australia, Indonesia and China between fiscal 1988 and fiscal 1990. In addition, direct seeding experiments using aerial seeding commenced in South Kalimantan, Indonesia in fiscal 1990 on flat and sloping land to verify ① the effects of land preparation on the germination and growth of seeds and ② the effects of seed coating on the germination and growth of seeds, etc.

The results of the above direct seeding experiments completed in December, 1992 and of other tests are compiled in the present report. It is hoped that the findings reported here will prove useful for the systematisation of large-scale reforestation techniques using the aerial reforestation method.

CONTENTS

Attached Tables

I BASIC TESTS

1. Germination Tests

Germination tests on uncoated seeds and seeds coated with a coating agent, fertilizer, fungicide and repellent were conducted to obtain information on ① whether or not the coating method in use is suitable to stimulate germination and ② whether or not specific seeds are suitable for coating. These tests were designed to enable the effective and efficient use of seeds for aerial reforestation. Refer to the Report on Experiment Results of Large-Scale Reforestation Techniques (JICA, March, 1990).

(1) Germination Test on Uncoated Seeds

a) Germination Test Method

The germination test method used and other relevant information are outlined in Table I-1.

Table I-1 Outline of Germination Test on Uncoated Seeds

1. Species Tested		
① Acacia auriculiformis	Australian origin	purchased from CSIRO
② Acacia mangium	Australian origin	purchased from CSIRO
③ Pinus radiata	Australian origin	purchased from CSIRO
④ Pinus merkusii	Indonesian origin	-
⑤ Eucalyptus camaldulensis	Australian origin	purchased from CSIRO
⑥ Eucalyptus globulus	Australian origin	purchased from CSIRO
⑦ Eucalyptus grandis	Australian origin	purchased from CSIRO
⑧ Leucaena leucocephala	Indonesian origin	-

Note: CSIRO (Commonwealth Scientific and Industrial Research Organization)

2. Test Method
In accordance with the seed testing procedure recommended by the International Seed Testing Association (ISTA).

3. Seed Cleaning
- Eucalyptus: The seeds were screened to achieve a weight ratio of 1 (large seeds) to 3 (small seeds).
- Leucaena leucocephala: The seeds were selected based on colour, i.e. light brown, brown and dark brown.

4. Pre-Treatment to Stimulate Germination
Use of warm water, hot water or no treatment (see Table I-2 for the actual re-treatment method by species).

5. Germination Bed
Petri dish and filter paper: just enough water supplied to prevent the germination bed from drying out.

6. Amount of Seeds Tested
The amount of seeds tests for each species is given in Table I-2.

7. Temperature
30°C (pyrostat used)

8. Decision on Germination
Germination was recognized when the roots broke through the seed coat.

b) Germination Test Results

The germination test results are given in Table I-2. Based on these results, the following observations can be made in regard to the necessity of the pre-treatment of seeds.

① The seeds of Acacia mangium and Acacia auriculiformis show a high germination rate when dipped in boiling water (100°C) for one minute as recommended by the seed certificate issued by the CSIRO.

② In the case of the seeds of Leucaena leucocephala, further examination is necessary in regard to the germination stimulation method and cleaning method.

③ Coating is unsuitable for the seeds of Pinus merkusii regardless of the pre-treatment method employed.

④ The seeds of Pinus radiata show a high germination rate without pre-treatment.

⑤ The seeds of Eucalyptus globulus show a high germination rate without pre-treatment.

⑥ The seeds of Eucalyptus grandis and Eucalyptus camaldulensis require screening using a sieve.

Table I-2 Germination Test Results for Uncoated Seeds

Species	Tested Seed Quantity	Pre-Treatment [2] Temperature (°C)	Time Duration		Required Days for Germination	Number of Germinated Seeds	Germination Rate (%)	Number of Rotten Seeds	Remarks
Acacia auriculiformis 676 seeds/10g (76%)[1]	100 seeds	100	10 sec	natural cooling (N/C)	15	89	89	11	
				continuous heating (C/H)	12	74	74	26	
			30 sec	N/C	16	84	84	16	
				C/H	12	79	79	13	
			60 sec	N/C	15	87	87	9	as recommended by CSIRO seed certificate
				C/H	14	76	76	24	
		80	10 min	C/H	12	81	81	15	
			6 hrs	C/H	16	60	60	40	
		No treatment			21	12	12	7	
Acacia mangium 979 seeds/10g (88%)	100 seeds	100	10 sec	N/C	9	87	87	12	
				C/H	6	92	92	5	
			30 sec	N/C	7	94	94	2	
				C/H	7	89	89	5	
			60 sec	N/C	10	90	90	6	
				C/H	8	78	78	6	
		80	10 min	C/H	7	86	86	9	
			6 hrs	C/H	10	48	48	24	
		No treatment			12	5	5	6	
Leucaena leucocephala 14,476 seeds/kg	100 seeds	80	1 hr	N/C	11	5	5	95	
			6 hrs	N/C	14	34	34	66	80°C-20°C (after 4 hrs)
				C/H	9	0	0	100	
			18 hrs	N/C	9	34	34	-	80°C-20°C (after 2.5 hrs)
		60	18 hrs	N/C	8	29	29	-	60°C-20°C (after 2.5 hrs)
			24 hrs	N/C	5	16	16	-	as above
		No treatment			11	15	15	42	
Leucaena leucocephala 14,476 seeds/kg	147 58 seeds 53 36	40	6 hrs	N/C	8	10	17	-	40°C-20°C(after 2 hrs) (light brown seeds)
					10	0	0	-	as above (brown seeds)
					9	1	3	3	as above (dark brown seeds)

(Table 1-2 continued)

Pinus merkusii 51,151 seeds/kg	100 seeds	40	1 hr	C/H	18	0	0	0	
		60	1 min	C/H	18	0	0	4	
			6 hrs	N/C	9	0	0	-	40°C-20°C (after 2 hrs)
			18 hrs	N/C	9	0	0	-	as above
		No treatment			24	0	0	3	
Pinus radiata 34,014 seeds/kg	100 seeds	No treatment			21	77	77	2	(75%)[1]
Eucalyptus globulus (74.2 seeds/g)[1]	1g of seeds	No treatment			16	78	78	-	
Eucalyptus grandis	0.19g 0.04g (182 0.15g seeds)[1]	No treatment (large seeds)			10	191	133	-	0.19 grammes of seeds screened
		No treatment (small seeds)			10	52		-	
	0.29 (192 seeds[1]	No treatment			11	242		-	
Eucalyptus camaldulensis	0.28 0.05g (156 0.15g seeds)[1]	No treatment (large seeds)			7	123	118		0.2 grammes of seeds screened
		No treatment (small seeds)			7	61			
	0.2g (156 seeds)[1]	No treatment			6	150	96	-	

Notes
1) These figures indicate the expected germination rate or the number of germinated seeds as suggested by the CSIRO.
2) N/C denotes natural cooling whereby the seeds are initially dropped into boiling water (100°C) and then left to cool naturally. C/H denotes continuous heating whereby the seeds are kept heated at 100°C.

(2) Germination Test on Coated Seeds

Based on the germination test results for uncoated seeds described in (1) above, the germination test on coated seeds (cracking-type coating and breaking-type coating) was conducted to determine the effects of coating on the germination rate and the initial growth of seeds. The test conditions, i.e. pre-treatment conditions used, were exactly the same as those used in the germination test on uncoated seeds to obtain the necessary data for comparison between uncoated and coated seeds in terms of the germination rate. The test conditions for seeds with a cracking-type coating and seeds with a breaking-type coating are outlined in Table I-3 and Table I-4 respectively.

a) Tested Species

The seeds of all species (7 in all), except Pinus merkusii, tested in (1) above were also tested with a cracking-type coating. Tested seeds with a breaking-type coating were those of 4 species, i.e. Acacia auriculiformis, Acacia mangium, Eucalyptus grandis and Eucalyptus camaldulensis.

b) Coating

In the case of the cracking-type coating which cracks into 2 parts at the centre, germination commences after the occurrence of the crack, making root exposure above the ground likely to occur with the possible death of the roots due to drought. Consequently, the breaking-type coating which evenly breaks when absorbing water was also tested. The actual conditions of both types of coating are given in Table I-5 and Table I-6.

c) Germination Test Results for Seeds with Cracking-Type Coating

① Germination Test Results for Uncoated Seeds

The germination test on uncoated seeds was conducted in accordance with the test procedure recommended by the International Seed Testing Association (ISTA) for the purpose of comparing the test results with those of the germination test on coated seeds and the germination test results for uncoated seeds are given in Table I-7.

Table 1-3 Outline of Germination Test on Seeds with Cracking-Type Coating

1. Species Tested
① Acacia auriculiformis
② Acacia mangium
③ Pinus radiata
④ Eucalyptus camaldulensis
⑤ Eucalyptus globulus
⑥ Eucalyptus grandis
⑦ Leucaena leucocephala

2. Test Method
In accordance with seed testing procedure recommended by the ISTA.

3. Seed Cleaning
- Eucalyptus camaldulensis: coating of seeds of 0.5mm or more in size.
- Eucalyptus globulus: as above
- Eucalyptus grandis: as above
- Leucaena leucocephala: coating of seeds of 3.6mm or more in size, black seeds removed, light brown seeds being the best.

4. Pre-Treatment to Stimulate Germination

① Dipping in Boiling Water (Acacia auriculiformis, Acacia mangium)
The seeds were dipped in boiling water (100°C) for one minute and then transferred to normal temperature service water for approximately one hour. The seeds were coated after one hour of ventilated drying at room temperature.
② Scarification (Acacia mangium, Leucaena leucocephala)
Seed coat scarification using sandpaper (AA-40).

5. Coating

① Coating Materials
Fertilizer: (N:P=18.46) .... 10g/10,000 seeds
Fungicide: 1 ai. g .... per 10,000 seeds
Repellent: 0.5 ai. g .... per 10,000 seeds
(ai: active ingredient)
② Firebreak
See Table I-5 for the coating weight and Thickness
③ Coating Method
Stratified Coating: just before the completion of coating by the coating agent, fertilizer, fungicide and repellent are added in this order.
Mixed Coating: coating of admixture containing coating agent, fertilizer, fungicide and repellent.
④ Miscellaneous
The coated seeds first went through one hour of ventilated drying at room temperature and were then dried for 16 hours at 35°C.

	Laboratory Dish	Wagner Pot
6. Germination Bed	Petri dish, culture medium (Japanese gelatin: 0.9%), filter paper	Wagner pot, medium or small size, red soil (ball shaped soil used in pots for raising flowers)
7. Seeding Quantity	100 seeds/dish	100 seeds/dish
8. Temperature and daytime length	30°C for 8 hours and 20°C for 16 hours, natural daytime length	30°C and 20°C for 12 hours each, natural daytime length
9. Decision on Germination	28th day after seeding	28th day after seeding

Table I-4 Outline of Germination Test on Seeds with Breaking-Type Coating

1. Species Tested
① Acacia auriculiformis
② Acacia mangium
③ Eucalyptus grandis
④ Eucalyptus camaldulensis

2. Test Method
In accordance with the seed testing procedure recommended by the ISTA.

3. Seed Cleaning
- Eucalyptus grandis: coating of seeds of 0.5mm or more in size.
- Eucalyptus camaldulensis: as above

4. Pre-Treatment to Stimulate Germination

① Dipping in Boiling Water (Acacia auriculiformis, Acacia mangium)
The seeds were dipped in boiling water (100°C) for one minute and then transferred to normal temperature service water for approximately one hour. The seeds were coated after one hour of ventilated drying at room temperature.

5. Coating

① Coating Materials
Fungicide: 1 ai. g ..... per 10,000 seeds
Repellent: 0.5 ai. g ..... per 10,000 seeds
② Firebreak
Acacia: 8-13.2 times of the seed weight
Eucalyptus: 170-195 times of the seed weight
③ Coating Method
Mixed Coating: coating of admixture containing coating agent, fungicide and repellent.
④ Miscellaneous
The coated seeds first went through one hour of ventilated drying at room temperature and were then dried for 16 hours at 35°C.

6. Germination Bed
Petri dish, culture medium (Japanese gelatin: 0.9%), filter paper

7. Seeding Quantity
100 seeds of each species per dish.

8. Temperature
30°C for 8 hours: use of a 750-1,250 lux incandescent lamp
20°C for 16 hours: no light

9. Decision on Germination
28th day after seeding. Germination was recognized when the root length became approximately 3 times longer than the seed diameter.

Table I-5 Seeds Treated by Cracking-Type Coating

Species	Coating Type No.	Pre-Treatment	Fertilizer	Fungicide and Repellent	Coating Method [1]	Coating Weight (no. of times the seed weight)	Coating Thickness (mm)	Uncoated Seeds (g/100 seeds)	Coated Seeds (g/100 seeds)
Acacia auriculiformis	1	dipping in boiling water (100°C) for one minute		O	S	6.86	4.0-6.76	1.456	9.99
	2		O	O	S	7.20	"	"	10.49
	3			O	M	6.92	"	"	10.08
	4		O	O	M	6.67	"	"	9.71
Acacia mangium	1	dipping in boiling water (100°C) for one minute		O	S	7.75	4.0-6.0	0.923	7.157
	2		O	O	S	8.22	"	"	7.583
	3			O	M	7.89	"	"	7.285
	4		O	O	M	8.39	"	"	7.743
Acacia mangium	1	scarification of seed coat (using AA-40 sandpaper)		O	S	7.69	4.0<	0.96	7.38
	2		O	O	S	7.69	"	"	7.38
	3			O	M	7.78	"	"	7.47
	4		O	O	M	8.11	"	"	7.79
Pinus radiata	1	no treatment		O	S	4.88	5.0<	2.8	13.65
	2		O	O	S	5.29	"	"	14.82
	3			O	M	5.08	"	"	14.22
	4		O	O	M	5.14	"	"	14.38
Eucalyptus camaldulensis	1	no treatment		O	S	77.3	2.0-3.36	0.015	1.16
	2		O	O	S	100.7	"	"	1.51
	3			O	M	75.0	"	"	1.125
	4		O	O	M	79.3	"	"	1.190
Eucalyptus globulus	1	no treatment		O	S	13.5	3.36-4.35	0.277	3.73
	2		O	O	S	14.5	"	"	4.02
	3			O	M	13.7	"	"	3.80
	4		O	O	M	13.0	"	"	3.61
Eucalyptus grandis	1	no treatment		O	S	85.6	2.0-3.36	0.012	1.027
	2		O	O	S	97.5	"	"	1.170
	3			O	M	90.3	"	"	1.084
	4		O	O	M	94.8	"	"	1.138
Leucaena leucocephala	1	scarification of seed coat (using AA-40 sandpaper)		O	S	10.4	6.67<	69.7	69.7
	2		O	O	S	"	"	69.7	69.7
	3			O	M	"	"	69.2	69.2
	4		O	O	M	"	"	69.2	69.2

1) S: stratified, M: mixed

Table I-6 Seeds Treated by Breaking-Type Coating

Species	Pre-Treatment	Fungicide and Repellent	Coating Method	Coating Weight (no. of times the seed weight)	Coating Thickness (mm)	Uncoated Seeds (g/100 seeds)	Coated Seeds (g/100 seeds)
Acacia auriculiformis	dipping in boiling water (100°C) for 1 minute	yes	mixed	8	4.0-6.0	1.85	14.8
Acacia mangium	dipping in boiling water (100°C) for 1 minute	yes	mixed	13.2	4.0-6.0	1.28	16.9
Eucalyptus grandis	no treatment	yes	mixed	195	2.5-3.6	0.017	3.31
Eucalyptus camaldulensis	no treatment	yes	mixed	170	2.5-3.6	0.018	3.07

Table I-7 Germination Test Results for Uncoated Seeds

Species	Pre-Treatment	Test Period (days)	Germination Rate (%)
Acacia auriculiformis	dipping in boiling water (100°C) for one minute	28	91
Acacia mangium	"	28	92
Acacia mangium	scarification of seed coat (using AA-40 sandpaper)	21	87
Pinus radiata	no treatment	28	87
Eucalyptus camaldulensis	"	14	100 seeds/0.1g
Eucalyptus globulus	"	14	95 seeds/0.1g
Eucalyptus grandis	"	18	113 seeds/0.1g
Leucaena leucocephala	scarification of seed coat (using AA-40 sandpaper)	10	82

② Germination Test Results for Coated Seeds

As the ISTA does not recommend a specific procedure for the germination test of coated seeds, the test procedure for uncoated seeds was employed using a petri dish and Wagner pot.

i) Germination Test Results Using Petri Dish

The germination test results using a petri dish are given in Table I-8 and the following general observations can be made.

o Acacia auriculiformis
The germination rate was unaffected by the types of coating agent or coating method.

o Acacia mangium
The germination rate of the seeds coated after dipping in boiling water or scarification was lower than that of uncoated seeds. In particular, those seeds having undergone the scarification treatment (No.2) recorded a lower germination rate than other seeds. The cause of this is unknown.

o Pinus radiata
The seeds which were not pre-treated recorded the lowest germination rate.

o Eucalyptus
The germination rate of Eucalyptus globulus was unaffected by the coating method. Both Eucalyptus camaldulensis and Eucalyptus grandis showed an extremely low germination rate when coated, probably because of the incorrect selection of the coating weight (see Table I-5). As Eucalyptus seeds are known to like light, the high coating weight (thickness) must have prevented the penetration of light into the seeds.

ii) Germination Test Results Using Wagner Pot

The germination test results using the Wagner pot are given in Table I-9 and the following general observations can be made.

o Acacia auriculiformis
The germination rate was hardly affected by the coating method.

o Acacia mangium
While the germination rate of the coated seeds was unaffected by the coating method, it was lower than that of the uncoated seeds. Some uncoated seeds suffered from damping-off while the coated seeds managed to avoid damping-off due to the use of a fungicide. As in the case of using a petri dish, those seeds having undergone the scarification treatment (No.2) recorded a lower germination rate than other seeds due to an unknown cause.

o Pinus radiata
The seeds which were not pre-treated recorded the lowest germination rate, possibly because of the eventual death of the roots which were exposed above the ground at the time of germination and the occurrence of damping-off on the 8th day and thereon. No damping-off was observed in the case of the coated seeds due to the use of a fungicide.

o Eucalyptus camaldulensis
The seeds which were not pre-treated recorded a germination rate of 34% while the coated seeds hardly germinated, possibly because of the incorrect selection

of the coating weight (75-100 times of the seed weight) as in the case of the petri dish.

- Eucalyptus globulus
  The high recorded germination rate was possibly the result of a lower coating weight (approximately 13 times of the seed weight) than Eucalyptus camaldulensis. The uncoated seeds recorded a conspicuously low germination rate because of the occurrence of damping-off. The coating seeds were unaffected by damping-off due to the use of a fungicide.

- Eucalyptus grandis
  While the uncoated seeds recorded a germination rate of 45%, the coated seeds recorded a much lower germination rate, possibly because of the high coating weight (approximately 75 times of the seed weight).

- Leucaena leucocephala
  A high germination rate was recorded by all groups of seeds regardless of the coating method.

Table I-8 Germination Test Results for Coated Seeds (Petri Dish)

Species (Type of Pre-Treatment)	Coating Type No.	Fertilizer	Fungicide	Repellent	Coating Method	Germination Rate (%) From the Sowing Day						
						Day 7	Day 9	Day 11	Day 15	Day 20	Day 24	Day 28
Acacia auriculiformis (dipping in boiling water (100°C) for one minute)	1		O	O	S	3	12	22	54	78	83	85
	2	O	O	O	S	9	23	33	55	67	72	73
	3		O	O	M	4	12	21	49	67	77	78
	4	O	O	O	M	6	15	24	52	74	79	80
	5				none	10	20	30	51	72	79	79
Acacia mangium (dipping in boiling water (100°C) for one minute)	1		O	O	S	31	49	63	73	74	79	80
	2	O	O	O	S	42	64	74	78	79	80	80
	3		O	O	M	33	52	61	68	70	71	75
	4	O	O	O	M	25	56	72	80	83	84	85
	5				none	36	57	69	82	85	88	88
Acacia mangium (scarification)	1		O	O	S	93	69	76	82	84	84	84
	2	O	O	O	S	29	56	58	60	60	60	60
	3		O	O	M	26	61	67	76	80	82	83
	4	O	O	O	M	55	72	75	77	79	80	80
	5				none	66	86	91	94	94	94	38
Pinus radiata (no treatment)	1		O	O	S	38	61	69	78	80	82	83
	2	O	O	O	S	17	50	60	72	74	76	80
	3		O	O	M	27	49	55	67	70	71	72
	4	O	O	O	M	14	37	47	61	65	67	69
	5				none	16	39	46	56	60	61	61
Eucalyptus camaldulensis (no treatment)	1		O	O	S	4	5	6	7	8	8	9
	2	O	O	O	S	0	0	1	2	3	5	5
	3		O	O	M	0	0	0	0	0	0	0
	4	O	O	O	M	0	0	0	0	0	0	0
	5				none	83	91	94	97	97	97	97
Eucalyptus globulus (no treatment)	1		O	O	S	58	77	79	82	83	83	84
	2	O	O	O	S	63	75	78	82	82	82	82
	3		O	O	M	67	80	82	86	87	87	87
	4	O	O	O	M	64	77	81	86	86	88	88
	5				none	69	77	78	79	80	80	80
Eucalyptus grandis (no treatment)	1		O	O	S	1	2	4	7	10	12	12
	2	O	O	O	S	1	5	10	16	31	37	38
	3		O	O	M	1	3	4	85	8	11	13
	4	O	O	O	M	1	2	4	7	12	22	24
	5				none	36	52	59	66	74	79	83
Leucaena leucocephala (scarification)	1		O	O	S	29	59	65	72	75	76	79
	2	O	O	O	S	55	68	71	75	75	76	77
	3		O	O	M	47	66	69	73	75	78	78
	4	O	O	O	M	54	66	68	71	73	76	78
	5				none	49	73	77	82	82	82	82

Coating Method : S: stratified, M: mixed
Test Temperature : 30°C and 20°C (dual temperature for 8 hours and 12 hours respectively)
Culture Medium : Japanese gelatin (0.9%)

Table I-9 Germination Test Results for Coated Seeds (Wagner Pot)

Species (Type of Pre-Treatment)	Coating Type No.	Fertilizer	Fungicide	Repellent	Coating Method	Germination Rate (%) From the Sowing Day						
						Day 4	Day 6	Day 8	Day 10	Day 12	Day 18	Day 28
Acacia auriculiformis (dipping in boiling water (100°C) for one minute)	1		O	O	S	24	33	51	64	68	72	72
	2	O	O	O	S	22	35	52	64	67	71	71
	3		O	O	M	23	31	47	64	70	76	76
	4	O	O	O	M	18	27	43	58	61	67	69
	5				none	21	30	45	56	61	69	70
Acacia mangium (dipping in boiling water (100°C) for one minute)	1		O	O	S	58	61	64	64	65	65	66
	2	O	O	O	S	58	65	68	69	69	70	70
	3		O	O	M	58	62	68	69	70	72	72
	4	O	O	O	M	52	59	64	65	65	65	65
	5				none	63	75	81	82	82*	82	82
Acacia mangium (scarification)	1		O	O	S	0	38	57	72	72	74	75
	2	O	O	O	S	0	19	28	46	46	48	48
	3		O	O	M	0	19	34	60	60	62	63
	4	O	O	O	M	0	31	50	59	59	60	60
	5				none	0	57	67	70	70	70	70
Pinus radiata (no treatment)	1		O	O	S	0	61	74	80	82	83	83
	2	O	O	O	S	0	33	55	68	69	71	72
	3		O	O	M	2	53	63	69	73	76	76
	4	O	O	O	M	7	38	52	59	62	64	65
	5				none	14	37	47	50*	50	52	52
Eucalyptus camaldulensis (no treatment)	1		O	O	S	0	1	1	1	1	1	1
	2	O	O	O	S	0	0	0	0	0	0	0
	3		O	O	M	0	1	1	1	1	1	1
	4	O	O	O	M	0	0	0	0	0	0	0
	5				none	19	24	25	29*	31	33	34
Eucalyptus globulus (no treatment)	1		O	O	S	51	58	60	66	67	67	67
	2	O	O	O	S	52	58	59	60	60	60	60
	3		O	O	M	47	54	58	65	65	65	65
	4	O	O	O	M	44	50	52	53	53	53	53
	5				none	5*	10	10	10	10	10	10
Eucalyptus grandis (no treatment)	1		O	O	S	3	3	3	5	7	9	10
	2	O	O	O	S	0	0	1	2	2	5	6
	3		O	O	M	0	0	1	2	2	2	3
	4	O	O	O	M	0	0	0	1	2	2	2
	5				none	27	32	38	39*	41	44	45
Leucaena leucocephala (scarification)	1		O	O	S	55	67	69	70	71	72	74
	2	O	O	O	S	58	67	68	69	70	72	73
	3		O	O	M	51	60	64	67	68	71	73
	4	O	O	O	M	54	65	71	72	72	74	78
	5				none	61	80	82	83	83	83	83

Coating Method : S; stratified, M: mixed
Test Temperature : 30°C and 20°C (*dual temperature for 12 hours each*)
Light : natural daytime length
Culture Medium : red soil (ball shaped soil used in pots for raising flowers & garden trees)

d) Germination Test Results for Seeds with Breaking-Type Coating

The germination test on uncoated seeds was conducted in accordance with the test procedure recommended by the ISTA for the purpose of comparing the test results with those of the germination test on seeds with a breaking-type coating, the test procedure of which was similar to that recommended by the ISTA. The test results are given in Table I-10 and the following general observations can be made.

o Acacia
The germination rates of Acacia mangium and Acacia auriculiformis were slightly more than 70% and approximately 50% respectively for both the coated and uncoated seeds. Compared to the test results for the seeds with a cracking-type coating, the rate was almost identical for Acacia mangium but some 15% lower for Acacia auriculiformis. As the germination rate of the uncoated seeds declined for both species compared to the previous results recorded for the germination test on seeds with a cracking-type coating, the decline of the germination rate in the present test may have been caused by a deteriorated germination prospect of the subject seeds due to storage.

o Eucalyptus
In the case of the germination test on seeds with a cracking-type coating, the uncoated seeds of both Eucalyptus camaldulensis and Eucalyptus grandis showed better results than the coated seeds, presumably because of the heavy coating. The reverse results recorded in the present test appear to indicate a deteriorated germination prospect of the subject seeds due to storage and a poor seed cleaning process.

Table I-10 Germination Test Results for Coated (Breaking-Type) and Uncoated Seeds

Species	Coated Seeds (%)	Uncoated Seeds (%)
Acacia auriculiformis	56.3	49.0
Acacia mangium	71.7	76.0
Eucalyptus grandis	39.3	11.0
Eucalyptus camaldulensis	59.3	11.0

(3) Storage Test on Coated Seeds

In order to clarify the effects of the storage period on the germination rate, a germination test was conducted using 2 groups of coated seeds which were stored for 6 months and 12 months respectively. As the ISTA does not specify the germination test procedure for coated seeds, the procedure for uncoated seeds was employed. Refer to the Report on Seed Coating Experiment and Direct Seeding Experiment Results to Develop Large-Scale Reforestation Techniques (JICA, March, 1991) for details.

a) Germination Test on Coated Seeds Stored for 6 Months

The germination test method for stored seeds and other details of the test are outlined in Table I-11.

① Species Tested

7 types of seeds of the following 5 species were tested.

o Acacia auriculiformis
o Acacia mangium (2 groups of seeds subject to different pre-treatment methods)

o Pinus radiata
o Eucalyptus globulus
o Leucaena leucocephala (one group of seeds stored under a normal temperature)

② Temperature Conditions

30°C and 20°C (30°C for 8 hours in the light and 20°C for 16 hours in darkness).

③ Test Results

The germination test results for coated seeds stored for 6 months are given in Table I-12 and the following general observations can be made.

o Acacia auriculiformis
While the germination rate was unaffected by the different coating methods, seeds coated with a fertilizer recorded a low germination rate, possibly because of the greater mould observed in the case of fertilizer-coated seeds than other types of seeds.

o Acacia mangium
No difference was observed in the germination rate of the seeds of the No. 1, No. 2 and No. 3 coating types having undergone pre-treatment by boiling water while the seeds of the No. 4 coating type showed a relatively higher germination rate. Mould was observed for all types of seeds from the 5th - 8th day after seeding but was not as obvious as in the case of scarified seeds. A high germination rate was recorded for the scarified seeds of the No. 1 and No. 3 coating types. The lower germination rate of the fertilizer-coated seeds of the No. 2 and No. 4 coating types was presumably caused by mould.

o *Pinus radiata*
The germination rate was hardly affected by the different pre-treatments. Little mould was observed.

o Eucalyptus globulus
The highest germination rate was recorded by the seeds of the No. 3 coating type. There was practically little different in the germination rates of the seeds of the other 3 coating types. Little mould was observed.

o Leucaena leucocephala
The seeds having undergone dual temperature (30°C–20°C) storage showed a slightly lower germination rate than the seeds stored at a normal temperature. Of the seeds subject to dual temperature storage, those of the No. 1 coating type showed a lower germination rate than the seeds of the other 3 types, all of which returned a similar germination rate. Mould was observed for all types of seeds from the 4th day after seeding. However, the mould appears to have little affected germination as strong germination activity took place for all types of seeds. The germination rate was unaffected by the different coating types under a normal temperature. The appearance of mould did not have any impact on the germination rate as in the case of the seeds subject to dual temperature storage.

For all species, no difference in the germination rate was observed between those seeds stored for 6 months and those seeds which were seeded immediately after coating.

b) Germination Test on Coated Seeds Stored for 12 Months

The germination test method for stored seeds and other details of the test are outlined in Table I-11.

① Species Tested

The species tested were the same as those tested after 6 months storage.

② Temperature Conditions

The temperature conditions were the same as those for seeds stored for 6 months.

③ Test Results

The germination test results for coated seeds stored for 12 months are given in Table I-13 and the following general observations can be made.

- o Acacia auriculiformis
  The germination rate was hardly affected by the different coating types. While mould was observed for all types of seeds, it did not affect the germination rate. Consequently, it can be inferred that storage for 12 months does not affect the germination rate of seeds but poses a small problem of mould.

- o Acacia mangium
  The seeds of the No. 1 coating type having undergone boiling water pre-treatment recorded the highest germination rate while the seeds of the No. 2 coating type recorded the lowest, possibly because of much observed mould. In the case of the scarified seeds, no significant difference in the germination rate was observed among all types of seeds but mould appeared on many types of seeds as in the case of those seeds pre-treated with boiling water.

- o Pinus radiata
  The seeds of the No. 4 coating type recorded a slightly lower germination rate than other types of seeds.

- o Eucalyptus globulus
  The germination rate was unaffected by the different coating types.

- o Leucaena leucocephala
  The seeds subject to dual temperature storage recorded a lower germination rate than those seeds stored at normal temperature. The different types of coating did not affect the germination rate.

For all species, no significant difference in the germination rate was observed between those seeds stored for 12 months and those seeds which were seeded immediately after coating.

Table I-11 Outline of Germination Test on Stored Seeds with Cracking-Type Coating

Storage Periods of 6 Months and 12 Months

1. Species Tested
① Acacia auriculiformis
② Acacia mangium
③ Pinus radiata
④ Eucalyptus globulus
⑤ Leucaena leucocephala

2. Test Method
In accordance with seed testing procedure recommended by the ISTA.

3. Seed Cleaning
- Eucalyptus globulus: coating of seeds of 0.5mm or more in size.
- Leucaena leucocephala: coating of seeds of 3.62mm or more in size, black seeds removed, light brown seeds being the best.

4. Pre-Treatment to Stimulate Germination

① Dipping in Boiling Water (Acacia auriculiformis, Acacia mangium, Leucaena leucocephala)
The seeds were dipped in boiling water (100°C) for one minute and then transferred to normal temperature service water for approximately one hour. The seeds were coated after one hour of ventilated drying at room temperature.
② *Scarification (Acacia mangium)*
Scarification of seed coats using sandpaper (AA-40).
③ No pre-treatment (Pinus radiata, Eucalyptus globulus)

5. Coating

① Coating Materials
Fertilizer: (N:P=18.46) .... 10g/10,000 seeds
Fungicide: 1 ai. g .... per 10,000 seeds
Repellent: 0.5 ai. g .... per 10,000 seeds
② Coating Weight and Thickness
See Table I-5 for the coating weight and thickness
③ Firebreak
Stratified Coating: just before the completion of coating by the coating agent, fertilizer, fungicide and repellent are added in this order.
Mixed Coating: coating of admixture containing coating agent, fertilizer, germicide and repellent.
④ Miscellaneous
The coated seeds first went through one hour of ventilated drying at room temperature and were then dried for 16 hours at 35°C.

6. Storage
Low temperature storage except for one group of Leucaena leucocephala seeds.

7. Germination Bed
Petri dish, culture medium (Japanese gelatin: 0.9%), filter paper

8. Seeding Quantity
100 seeds of each species per dish but 50 seeds for Leucaena leucocephala, repeated 3 times.

9. Temperature
30°C for 8 hours in the light and 20°C for 16 hours in darkness.

10. Decision on Germination
Germination was recognized 28th day after seeding.

Table I-12 Germination Test Results for Coated Seeds (Stored for 6 Months)

Species (Type of Pre-Treatment)	Coating Type No.	Fertilizer	Fungicide	Repellent	Coating Method	Germination Rate (%) From the Sowing Day						
						Day 7	Day 9	Day 13	Day 17	Day 21	Day 25	Day 28
Acacia auriculiformis (dipping in boiling water (100°C) for one minute)	1		O	O	S	0	9.7	28.7	53.0	77.3	86.3	91.3
	2	O	O	O	S	0	3.7	20.0	46.7	70.3	76.0	79.0
	3		O	O	M	0	6.3	21.0	40.3	65.7	78.3	86.7
	4	O	O	O	M	0	4.3	21.7	44.3	67.0	73.7	75.3
Acacia mangium (dipping in boiling water (100°C) for one minute)	1		O	O	S	3.7	19.3	42.3	59.0	65.3	70.3	74.0
	2	O	O	O	S	0	17.3	45.3	60.0	65.7	69.0	71.7
	3		O	O	M	0	15.7	39.0	55.3	62.7	65.0	69.3
	4	O	O	O	M	0	12.3	58.7	73.7	79.3	81.7	83.7
Acacia mangium (scarification)	1		O	O	S	5.7	36.7	66.7	76.7	78.7	79.3	79.7
	2	O	O	O	S	2.0	15.0	44.0	61.7	63.3	64.0	64.3
	3		O	O	M	19.3	41.0	68.3	76.7	79.0	80.0	80.3
	4	O	O	O	M	7.7	22.7	51.3	65.3	68.0	69.0	69.0
Pinus radiata (no treatment)	1		O	O	S	0	47.7	76.0	81.0	81.7	82.0	82.0
	2	O	O	O	S	0	29.3	67.3	78.0	81.7	82.3	82.7
	3		O	O	M	0	34.7	65.3	73.3	76.7	78.3	78.7
	4	O	O	O	M	0	16.3	54.0	69.0	74.3	77.0	78.7
Eucalyptus globulus (no treatment)	1		O	O	S	21.7	48.3	69.4	74.3	74.3	76.6	76.6
	2	O	O	O	S	17.7	43.3	73.3	76.7	78.3	78.3	78.3
	3		O	O	M	32.0	65.7	84.3	88.7	91.0	91.0	91.0
	4	O	O	O	M	15.3	52.7	78.0	80.7	82.0	82.0	82.0
Leucaena leucocephala (boiling water)	1		O	O	S	39.3	61.3	68.0	69.3	69.3	72.0	74.0
	2	O	O	O	S	51.3	72.7	77.3	78.0	78.0	82.0	82.7
	3		O	O	M	44.0	64.0	70.7	72.7	72.7	76.0	78.7
	4	O	O	O	M	46.0	73.3	76.0	76.0	76.0	80.0	82.0
Leucaena leucocephala (boiling water) stored at normal temperature	1		O	O	S	74.0	84.7	87.3	88.0	88.0	88.0	88.0
	2	O	O	O	S	38.0	78.7	82.7	82.7	82.7	83.3	83.3
	3		O	O	M	56.7	84.0	88.0	88.0	88.0	88.0	88.0
	4	O	O	O	M	67.3	86.7	89.3	89.3	89.3	89.3	89.3

Coating Method : S: stratified, M: mixed
Test Temperature : dual temperature at 30°C for 8 hours in the light and 20°C for 16 hours in darkness
Culture Medium : Japanese gelatin (0.9%)
Container : 50 or 100 seeds/Petri dish, repeated 3 times

Table I-13 Germination Test Results for Coated Seeds (Stored for 12 Months)

Species (Type of Pre-Treatment)	Coating Type No.	Fertilizer	Fungicide	Repellent	Coating Method	Germination Rate (%) From the Sowing Day					
						Day 5	Day 10	Day 14	Day 19	Day 24	Day 28
Acacia auriculiformis (dipping in boiling water (100°C) for one minute)	1		O	O	S	0	14.3	34.7	60.0	72.0	76.0
	2	O	O	O	S	0	14.3	33.3	62.3	74.3	79.3
	3		O	O	M	0	14.0	31.3	55.0	77.0	84.0
	4	O	O	O	M	0	11.0	22.0	47.0	66.3	75.0
Acacia mangium (dipping in boiling water (100°C) for one minute)	1		O	O	S	0	24.3	71.0	79.3	82.0	83.7
	2	O	O	O	S	0	16.0	56.0	61.3	64.0	68.0
	3		O	O	M	0	16.0	61.3	68.0	73.7	74.0
	4	O	O	O	M	0	16.0	68.0	75.0	76.0	76.3
Acacia mangium (scarification)	1		O	O	S	0	9.7	38.7	60.0	71.3	74.7
	2	O	O	O	S	0	11.7	54.0	63.3	72.0	78.7
	3		O	O	M	0	12.5	46.0	55.0	66.0	69.0
	4	O	O	O	M	0	10.3	54.0	64.0	75.3	77.3
Pinus radiata (no treatment)	1		O	O	S	0	41.3	76.3	80.0	81.3	81.3
	2	O	O	O	S	0	42.3	82.3	86.0	87.0	88.3
	3		O	O	M	0	42.7	75.3	80.7	82.0	88.3
	4	O	O	O	M	0	25.3	63.3	72.7	73.7	75.3
Eucalyptus globulus (no treatment)	1		O	O	S	0	53.3	77.3	81.0	81.0	81.0
	2	O	O	O	S	0	54.7	79.0	81.0	81.0	81.0
	3		O	O	M	0	56.3	76.3	79.7	79.7	79.7
	4	O	O	O	M	0	59.3	80.0	82.3	82.3	82.3
Leucaena leucocephala (boiling water)	1		O	O	S	10	72.0	75.3	77.3	78.0	78.7
	2	O	O	O	S	9.3	61.3	67.3	68.0	70.0	72.7
	3		O	O	M	0	70.0	73.3	74.7	75.3	76.7
	4	O	O	O	M	0	64.0	71.3	74.7	76.0	77.3
Leucaena leucocephala (boiling water) stored at normal temperature	1		O	O	S	6.0	88.0	89.3	89.3	89.3	89.3
	2	O	O	O	S	6.0	85.3	87.3	88.0	88.0	88.0
	3		O	O	M	10.6	88.7	88.7	88.7	88.7	88.7
	4	O	O	O	M	10.4	88.7	89.3	90.0	90.0	90.0

Coating Method : S: stratified, M: mixed
Test Temperature : dual temperature at 30°C for 8 hours in the light and 20°C for 16 hours in darkness
Culture Medium : Japanese gelatin (0.9%)
Container : 50 or 100 seeds/Petri dish, repeated 3 times

(4) Test on Mechanical Germination Stimulation Method

Boiling water is generally used to stimulate the germination of hard seeds of the Leguminosae species. As aerial reforestation demands a pre-treatment method to quickly stimulate germination in view of its requirement of a large quantity of seeds in a short period of time, a test was conducted on the mechanical scarification of the seed coats to stimulate germination. Refer to the Report on Seed Coating Experiment and Direct Seeding Test Results to Develop Large-Scale Reforestation Techniques (JICA, March, 1991) for details.

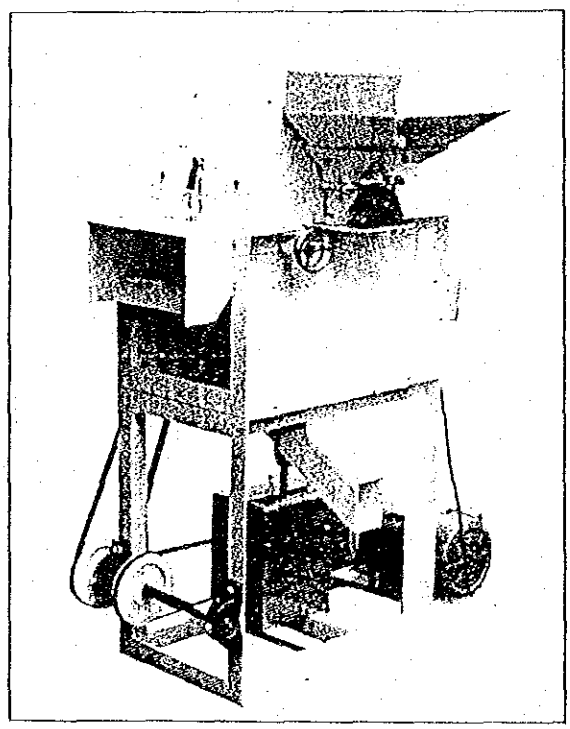
a) Species Tested

The seeds of the following 2 species were tested.

o Acacia auriculiformis
o Acacia mangium

b) Machine Used

The machine used was the Iwata-type small (MF) skin peeler (Photograph I-1).



Dimensions: 805mm (L)
575mm (W)
1,055mm (H)
Motor: 750W (200V) with automatic transmission
Performance: 100-200kg/hr (approx.)

Photograph I-1 Iwata-Type Small (MF) Skin Peeler

c) Seed Treatment Methods

The 3 seed treatment methods shown in Table I-14 were used.

Table I-14 Seed Treatment Methods

	Revolutions (rpm)	Number of Repetitions
a	2,500	1
b	2,200	2
c	2,000	3

Note: The number of revolutions means the revolutions/min of the propeller located inside the drum.

d) Test Results

The germination test was conducted on seeds treated with boiling water for comparison with the germination rate of those seeds which were mechanically treated. The test results are given in Table I-15 and Fig. I-1.

o *Acacia auriculiformis*
The highest germination rate of 80.6% was recorded by those seeds which were mechanically treated at 2,500 rpm. In short, all the mechanically treated seeds recorded a better germination rate than the seeds treated with boiling water.

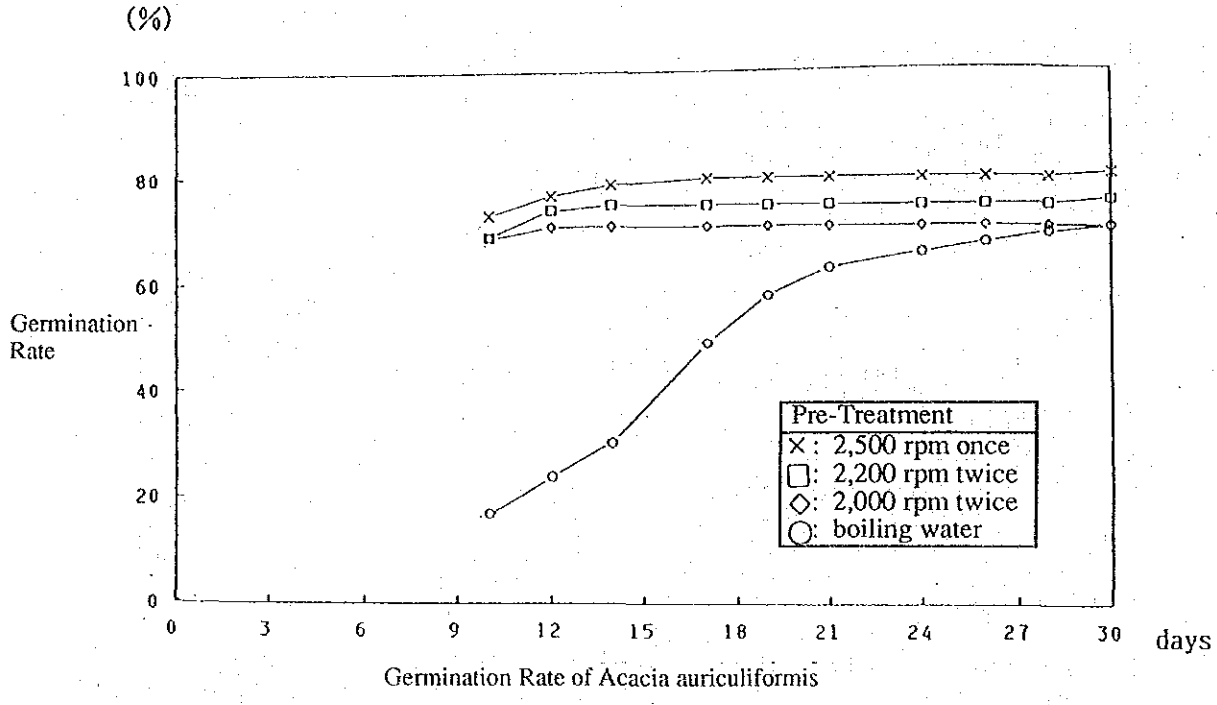
o Acacia mangium
The highest germination rate of 84.0% was recorded by those seeds which were treated with boiling water. The mechanically treated seeds also recorded a relatively high germination rate of 70%.

Table I-15 Germination Rate of Mechanically Treated Seeds

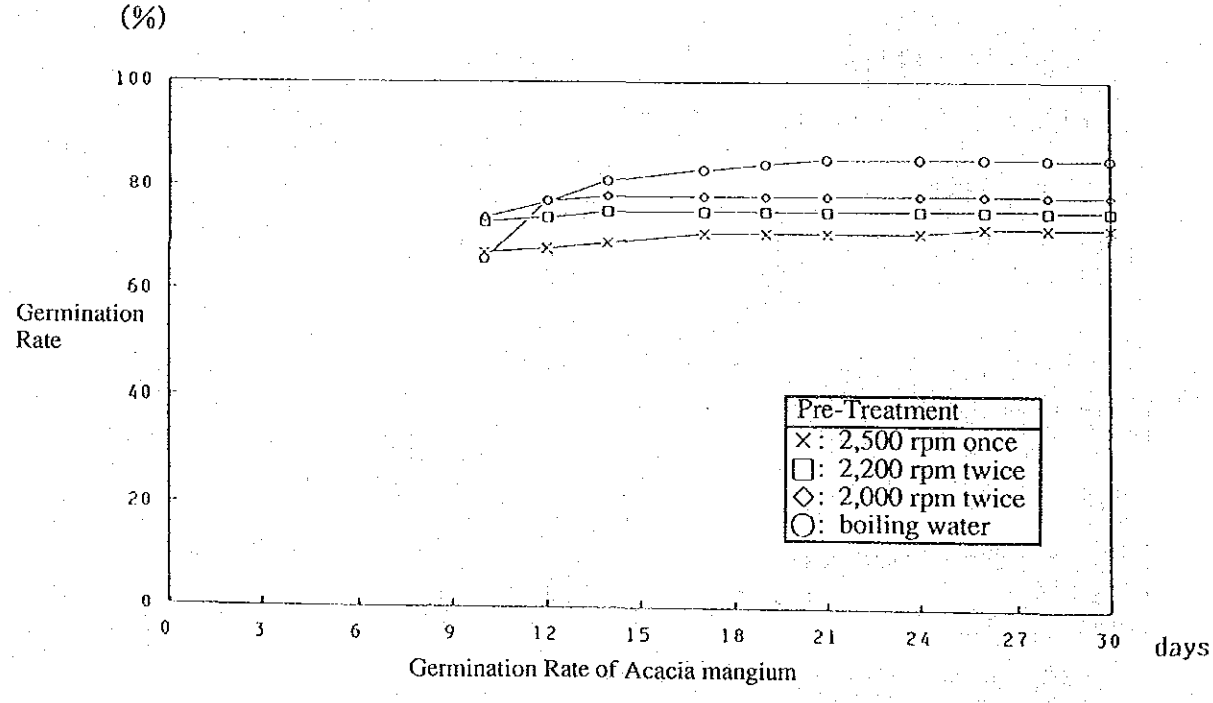
(Unit: %)

Pre-Treatment / Species	2,500 rpm* Once	2,200 rpm* Twice	2,000 rpm* Twice	Boiling Water (100°C for one minute)
Acacia auriculiformis	80.6	75.6	71.3	70.6
Acacia mangium	72.0	75.3	78.3	84.0

* Revolutions/minute of the propeller inside the drum.



Germination Rate of Acacia auriculiformis



Germination Rate of Acacia mangium

Fig. I-1 Germination Rate of Mechanically Treated Seeds

2. Initial Growth Test

The seeds used in the initial growth test were the same 7 types of uncoated and coated seeds of the 5 species used for the germination test. Refer to the Report on Direct Seeding Experiment Results to Develop Large-Scale Reforestation Techniques (JICA, March, 1991) for details.

(1) Initial Growth Test Results

The initial growth test results are given in Table I-16 and the following general observations can be made.

o Acacia
Hardly any difference in growth due to the different pre-treatment methods or coating methods was observed for both Acacia auriculiformis and Acacia mangium. The large seeds of these species had stored a good level of nutrients and their initial growth does not vary from species to species because of the use of the stored nutrients. The different nutrient conditions used for the different coating types for the test did not result in any significant difference in initial growth.

o An established fact regarding the relationship between the growth and environmental conditions (temperature, nutrients, pH and rhizobia, etc.) of Leguminosae species is that the addition of rhizobia has a positive impact on plant growth in a temperature range of between 23°C and 30°C, a relatively high nitrogen density (50 ppm) and a pH value range between 6 and 8 (malgrowth occurs with a pH of 4 or less). This impact is also observed even under poor nutrient conditions. It is also reported that the use of charcoal stimulates the multiplication of rhizobia. These past findings suggest that the possible use of lime, charcoal and rhizobia should be considered when deciding additives for seed coating purposes.

o Eucalyptus
Different initial growth affected by the coating method was observed in the case of Eucalyptus camaldulensis, Eucalyptus globulus and Eucalyptus grandis. The provision of fertilizer (N:4, P:2 and K:3 ppm/seed) was found to be effective to stimulate the growth of particularly small seeds of Eucalyptus camaldulensis and Eucalyptus grandis because of the very low level of nutrients stored in the seeds.

Based on the above observations, it appears necessary to consider the use of quick effect-type fertilizer to assist the initial growth of seeds and the use of slow effect-type fertilizer to assist subsequent growth.

Table I-16 Initial Growth Test Results for Coated Seeds

Species (Type of Pre-Treatment)	Coating Type No.	Fertilizer	Fungicide	Repellent	Coating Method	Initial Growth Results (cm)						
						Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13
Acacia auriculiformis (dipping in boiling water (100°C) for one minute)	1		O	O	S	1.5	2.3	3.5	4.0	4.2	4.6	5.3
	2	O	O	O	S	1.5	2.0	3.3	3.9	4.1	4.5	5.2
	3		O	O	M	1.5	2.4	3.6	3.9	4.2	4.5	5.2
	4	O	O	O	M	1.5	2.2	3.4	3.8	4.2	4.7	5.4
	5				none	1.5	2.4	3.7	4.3	4.4	4.8	5.3
Acacia mangium (dipping in boiling water (100°C) for one minute)	1		O	O	S	1.5	2.1	2.7	3.3	3.5	3.7	4.5
	2	O	O	O	S	1.5	2.0	3.0	3.6	4.2	4.2	4.9
	3		O	O	M	1.5	2.0	2.8	3.3	3.6	3.8	4.5
	4	O	O	O	M	1.5	2.3	3.3	3.8	4.3	4.6	5.4
	5				none	1.5	1.9	2.8	3.0	3.5	3.5	4.4
Acacia mangium (scarification)	1		O	O	S	1.5	2.2	2.9	3.2	3.6	4.0	4.5
	2	O	O	O	S	1.5	2.1	2.9	3.2	3.6	4.2	4.8
	3		O	O	M	1.5	2.1	2.3	2.7	3.2	3.6	4.1
	4	O	O	O	M	1.5	2.0	2.9	3.3	3.7	4.1	5.0
	5				none	1.5	2.1	3.3	3.6	4.0	4.3	4.5
Pinus radiata (no treatment)	1		O	O	S	2.0	2.9	4.3	6.1	6.8	7.3	8.0
	2	O	O	O	S	2.0	2.7	4.2	5.6	6.3	6.7	7.5
	3		O	O	M	2.0	3.1	4.7	6.0	6.6	6.9	7.2
	4	O	O	O	M	2.0	2.8	4.1	5.4	6.3	6.7	7.2
	5				none	2.0	2.5	4.0	5.2	6.3	6.8	7.2
Eucalyptus camaldulensis (no treatment)	1		O	O	S	-	0.5	1.1	1.5	1.6	1.7	1.9
	2	O	O	O	S	-	1.0	2.1	5.2	11.7	16.9	24.0
	3		O	O	M	-	0.5	1.3	1.3	1.4	1.6	1.9
	4	O	O	O	M	-	0.8	1.7	3.0	5.7	7.1	9.0
	5				none	-	1.0	1.9	2.5	2.8	2.9	3.2
Eucalyptus globulus (no treatment)	1		O	O	S	2.0	3.3	5.7	7.3	8.3	8.8	9.1
	2	O	O	O	S	2.0	3.3	6.0	9.0	11.0	12.5	16.0
	3		O	O	M	1.7	2.9	5.2	6.2	7.0	7.3	7.6
	4	O	O	O	M	2.0	3.3	5.7	8.2	11.3	13.8	18.0
	5				none	2.1	3.5	5.9	7.6	8.4	8.8	9.1
Eucalyptus grandis (no treatment)	1		O	O	S	-	0.5	1.1	1.6	1.6	2.2	2.4
	2	O	O	O	S	-	1.2	2.2	3.9	5.3	7.1	8.3
	3		O	O	M	-	0.5	1.2	1.3	1.4	1.7	1.9
	4	O	O	O	M	-	0.5	1.4	2.0	3.2	4.8	7.0
	5				none	-	0.5	1.8	1.8	1.9	2.1	2.3
Leucaena leucocephala (scarification)	1		O	O	S	2.5	3.6	6.1	9.1	9.9	10.4	11.4
	2	O	O	O	S	2.5	3.7	6.0	8.3	9.2	9.6	10.5
	3		O	O	M	2.5	3.7	6.1	8.5	9.3	9.7	10.6
	4	O	O	O	M	2.5	3.6	5.8	8.3	9.3	9.7	10.6
	5				none	2.5	4.7	6.8	9.4	10.0	10.5	11.5

Coating Type : S: stratified, M: mixed
Test Temperature : 30°C and 25°C (dual temperature for 12 hours each)
Light : natural daytime length
Culture Medium : red soil (ball shaped soil used in pots for raising flowers & garden trees)
Container : 2-4 seeds/10,000 area Wagner pot, repeated 3-6 times

o The growth of leaves was observed in the case of Acacia auriculiformis from the fifth week.
o The cotyledon of Leucaena leucocephala began to yellow and started to drop in the seventh week.
o Seed growth marked (-) was too small to measure.

II DIRECT SEEDING EXPERIMENTS

1. Direct Seeding Experiment (I)

The direct seeding experiment (I) was conducted in South Kalimantan, Indonesia based on the germination tests on both coated and uncoated seeds. Refer to the Report on Seed Coating Experiment and Direct Seeding Experiment Results to Develop Large-Scale Reforestation Techniques (JICA, March, 1991) and the Report on Direct Seeding Experiment Results to Develop Large-Scale Reforestation Techniques (JICA, March, 1991) for details.

(1) Outline of Experiment Site

a) Location

The direct seeding experiment site (I) is located some 10km southwest of Banjarbaru with good road access and Bandjarmasin Airport is not far from the site (Fig. II-1).

Shifting cultivation has been conducted at the site and in its surrounding area since the commencement of settlements in 1961 and the soil has lost its fertility due to repeated burning, becoming Alang-alang grassland in 1975.

The site is neighboured by the Reforestation Technology Centre (BTR) which was established by Finnish technical cooperation in 1985 to mechanise nursery work and handed over to the Directorate General of Reforestation of Indonesia's Ministry of Forestry.

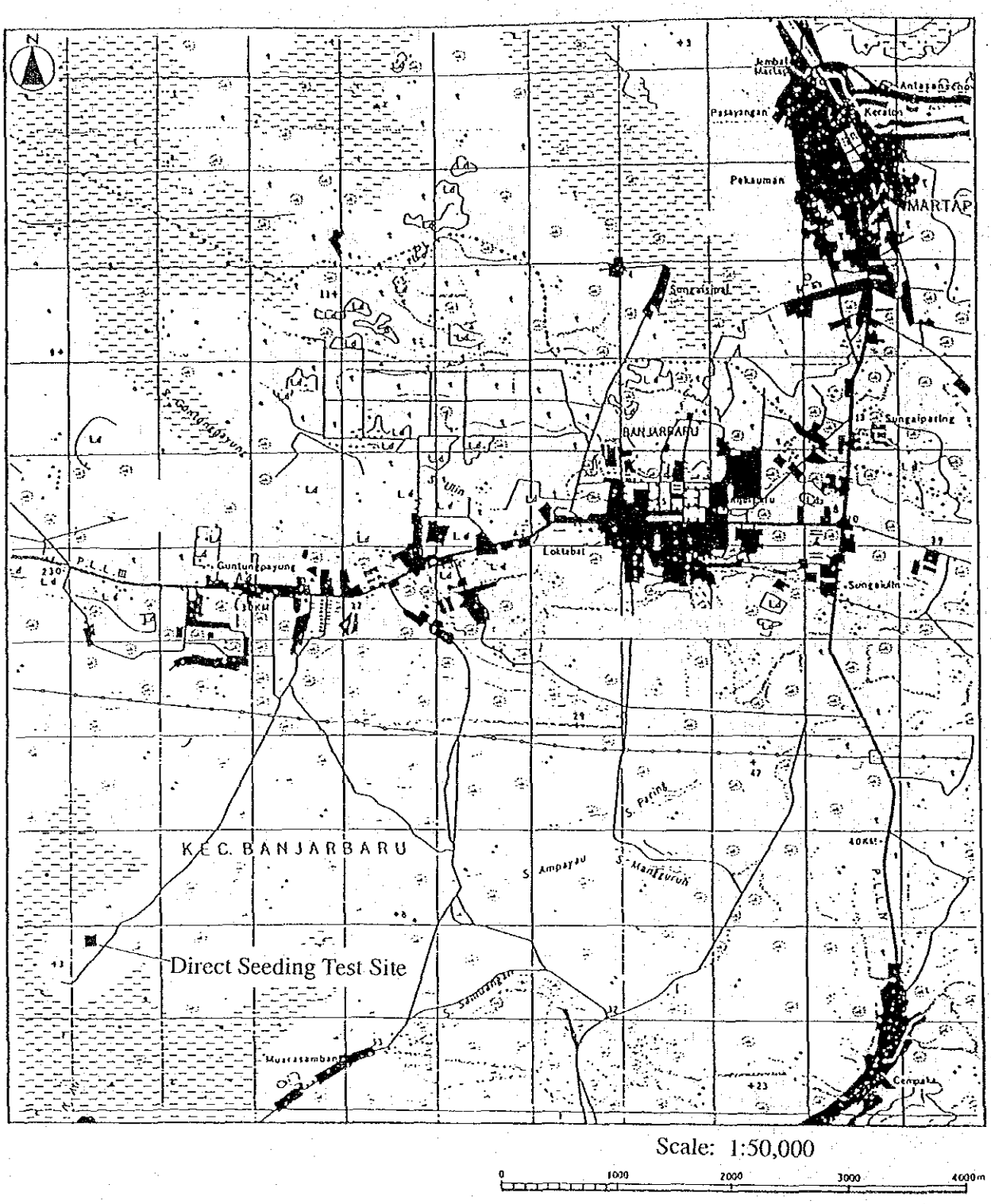


Fig. II-1 Location of Direct Seeding Experiment Site (I)

b) Climate

The annual rainfall and number of annual rainy days at Banjarbaru for the period between 1979 and 1987 ranged between 1,527 and 3,012mm and 98 and 192 days respectively. There are 2 seasons, i.e. a dry season from May to October and a rainy season from November to April. The mean monthly rainfall during the dry season varies from 60mm in August to 189mm in May. However, the rainfall pattern greatly differs from year to year, as illustrated by the recorded monthly rainfall of 1mm in August, 1986 and 329mm in May, 1984 (Table II-1 and Fig. II-2).

The minimum and maximum temperatures are 22.4°C and 32.8°C respectively while the mean annual temperature is 26°C. The relative humidity ranges from 41% to 100%.

Rainfall data recorded at the BTR which neighbours the direct seeding experiment site (I) are given in Table II-2 and Fig. II-3. The highest monthly rainfall recorded during the observation period was 422mm in April, 1992 while the lowest monthly rainfall of 0mm was recorded in September, 1991. The highest daily rainfall of 99mm was recorded in April, 1992. The largest number of rainy days/month of 26 days was recorded in December, 1990 while the lowest of 0 days was recorded in September, 1991.

Table II-1 Rainfall and Rainy Days at Banjarbaru

Year / Month	1979		1980		1981		1982		1983	
	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days
1	415	22	431	16	200	10	470	17	326	13
2	492	22	270	11	254	12	257	11	189	8
3	297	17	135	9	161	8	351	13	126	5
4	214	22	191	10	235	10	265	10	118	6
5	186	11	160	9	167	9	148	8	212	11
6	133	17	114	8	33	6	96	5	188	8
7	35	5	62	6	204	10	27	2	155	8
8	24	4	20	2	35	2	37	3	99	6
9	96	9	40	3	130	9	31	3	35	6
10	25	6	153	8	123	8	44	4	142	10
11	236	21	131	7	314	14	239	9	295	15
12	243	26	439	17	456	17	278	13	290	14
Total	2,396	182	2,146	106	2,312	115	2,243	98	2,175	110

Year / Month	1984		1985		1986		1987		Average	
	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days	Rainfall (mm)	Rainy Days
1	454	23	454	24	276	24	394	27	380	20
2	241	19	178	18	202	24	361	21	272	16
3	289	19	212	21	266	22	290	21	236	15
4	392	24	175	17	318	30	360	18	252	16
5	329	17	190	18	30	13	282	18	189	13
6	86	13	99	10	76	14	136	11	107	10
7	227	15	95	15	34	11	37	3	97	8
8	128	11	154	8	1	2	45	7	60	5
9	110	12	32	7	31	9	61	6	63	7
10	147	10	151	7	38	10	95	5	102	7
11	218	12	163	16	200	20	180	17	220	15
12	391	12	182	19	55	13	440	27	308	18
Total	3,012	187	2,085	180	1,527	192	2,681	181	2,286	150

Sources: 1981, 1982 and 1983 - dari Kantor Data Statistik Propinsi I Kalimantan Selatan 1985.
1979, 1980, 1984, 1985, 1986 and 1987 - dari Statistik dan Beofisika, Stasion Klimatologi Banjarbaru 1988.

Table II-2 Rainfall and Rainy Days at Experiment Site (I)

Year/ Month	Experiment Site (I)		
	Rainfall (mm)	Highest Daily Rainfall (mm)	Number of Rainy Days
Nov. 1990	381	55	21
Dec.	420	46	26
Jan. 1991	349	75	24
Feb.	197	67	14
Mar.	283	66	12
Apr.	154	24	15
May	213	46	15
Jun.	55	16	9
Jul.	18	11	2
Aug.	65	21	4
Sep.	0	0	0
Oct.	13	10	3

Year/ Month	Experiment Site (I)		
	Rainfall (mm)	Highest Daily Rainfall (mm)	Number of Rainy Days
Nov. 1991	269	49	17
Dec.	336	54	21
Jan. 1992	313	65	20
Feb.	176	30	16
Mar.	345	95	15
Apr.	422	99	16
May	157	45	9
Jun.	151	27	10
Jul.	87	22	9
Aug.	109	37	4
Sep.	204	91	10
Oct.	93	48	6

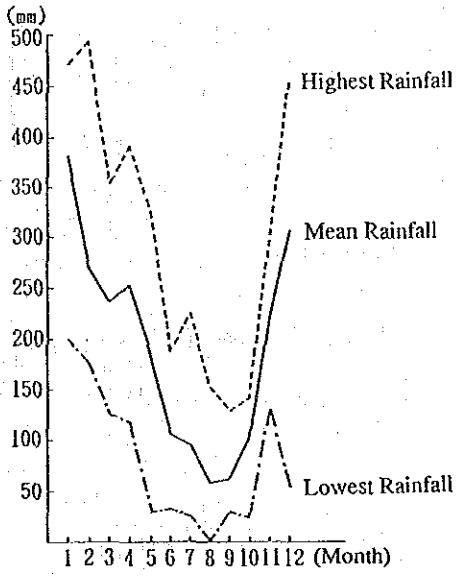


Fig. II-2 Rainfall at Banjarbaru
(Data: 1979 – 1987)

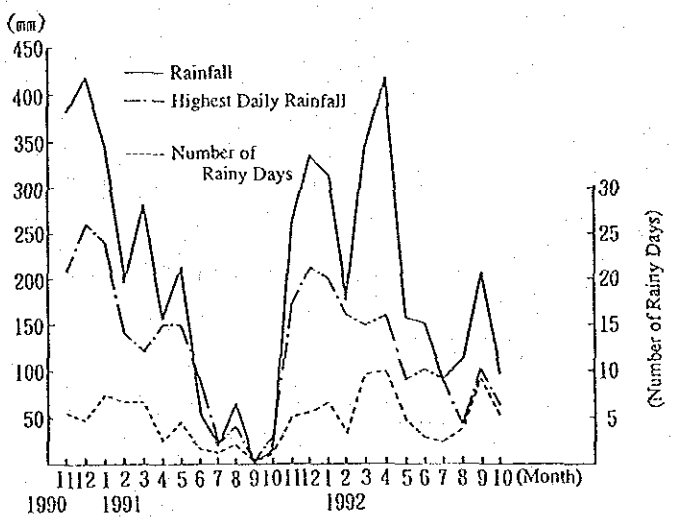


Fig. II-3 Rainfall and Rainy Days at Experiment Site(I)

c) Topography

The experiment site (I) is almost flat land with an average gradient of approximately 2°.

d) Soil

The most prominent soil at the site is reddish yellow podzol containing much gravel but hardly any humus. The pH value of 5.2 - 5.6 is slightly acid. The soil is hard as shown by the hardness value of 26 - 29mm but the root system of Alang-alang reaches as deep as some 15cm below the ground.

e) Vegetation

While the experiment site (I) is classified as Alang-alang grassland, the Alang-alang vegetation is rather sparce due to repeated burning. Such bushes as Ambin, Puspa, Komoloko and Vitex are also observed at the site.

The vegetation survey found the live weight of Alang-alang/m^2 to be 500g with an average height of 65cm. Alang-alang observed on hills is generally sparce and has a low height.

(2) Method

a) Species Tested

The following 2 species were tested.

- Acacia auriculiformis
- Acacia mangium

b) Pre-Treatment to Stimulate Germination

The following pre-treatment was conducted to stimulate the germination of the subject seeds.

- Seeds with breaking-type coating: mechanical scarification of the seed coat before coating
- Uncoated seeds: the heating was switched off when the boiling water reached 100°C and the seeds were kept dipped for 24 hours in naturally cooling hot water

c) Land Preparation

As the experiment site (I) is entirely Alang-alang grassland, the following land preparation was conducted (Fig. II-4).

Plot 1: Burned Grassland - Alang-alang above the ground surface was cut and burned after drying
Plot 2: Harrowed Grassland - a harrow was used
Plot 3: Grassland - the existing state of Alang-alang grassland was left untouched
Plot 4: Harrowed Bare Land - Alang-alang and the surface soil were removed to create bare land which was then harrowed
Plot 5: Bare Land - Alang-alang and the surface soil were removed to create bare land

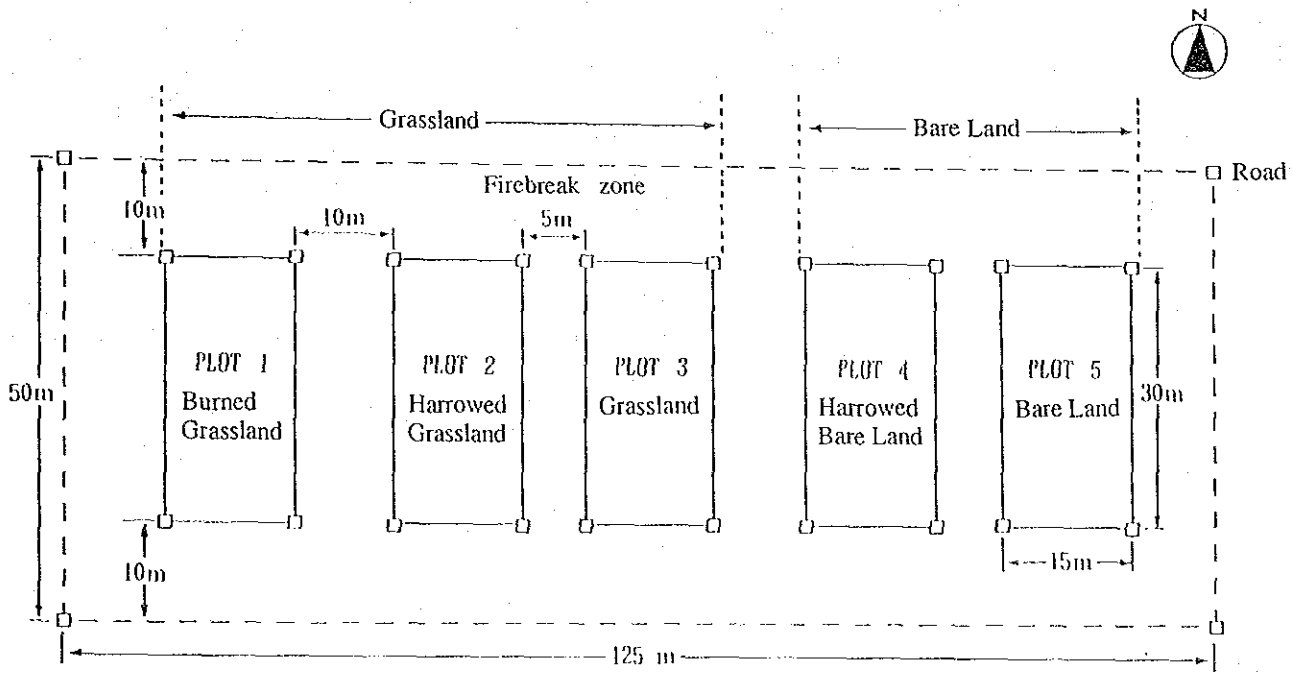
d) Design of Experiment Site (I)

The overall design of the experiment site (I) is shown in Fig. II-4 while details of its compartmentation and sub-plots are given in Fig. II-5 and Table II-3 respectively.

The experiment area data are as follows.

- Area of experiment site (I) : 50m x 125m = 6,250m²
- Area of each plot : 15m x 30m = 450m²
- Area of each sub-plot : 5m x 5m = 25m²
- Area of each quadrat : 1m x 1m = 1m²

(3 quadrats were randomly selected for data collection purposes.)

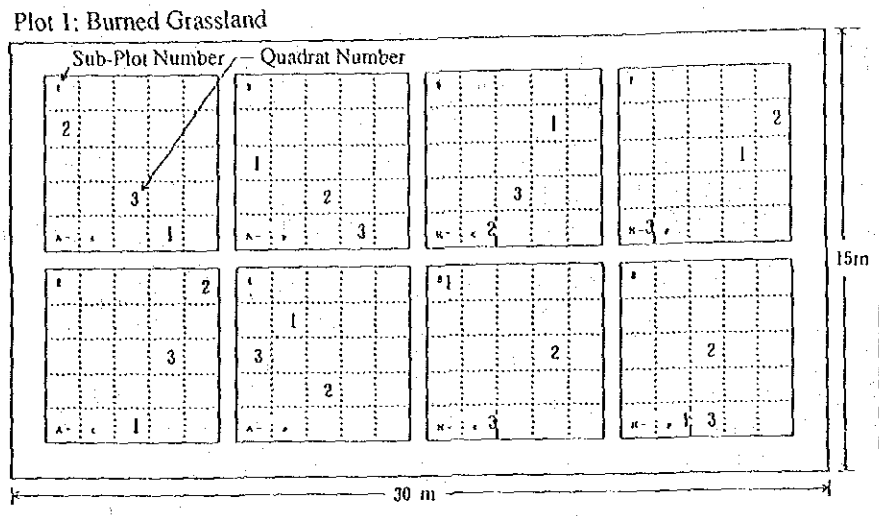


Nursery Site of BTR

Note: Bare land was mechanically created from the original grassland.

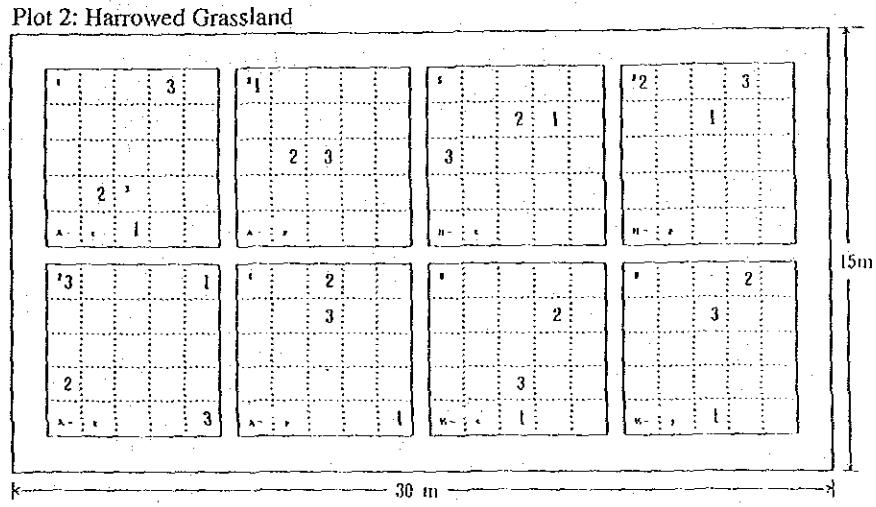
Fig. II-4 Plot Distribution

Plot 1: Burned Grassland



Legend		
Sub-Plot	Species	Coating
1	Acacia auriculiformis	yes
2	"	yes
3	"	no
4	"	no
5	Acacia mangium	yes
6	"	yes
7	"	no
8	"	no

Plot 2: Harrowed Grassland



Plot 3: Grassland

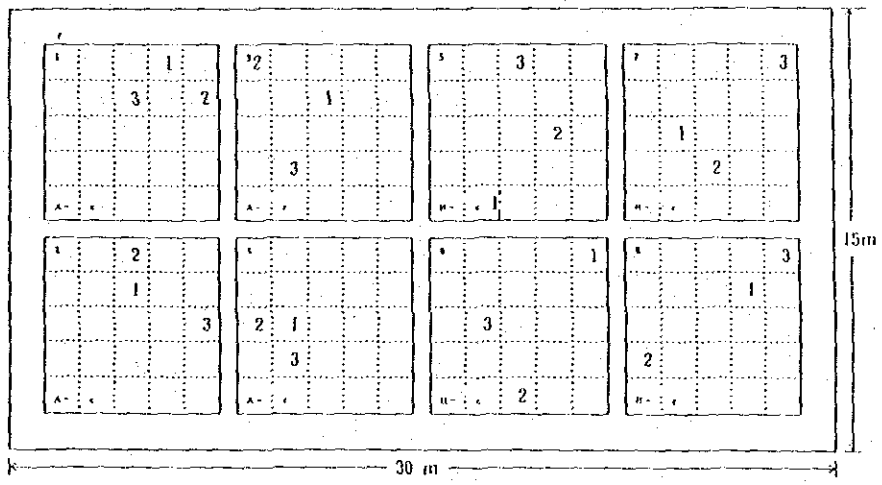
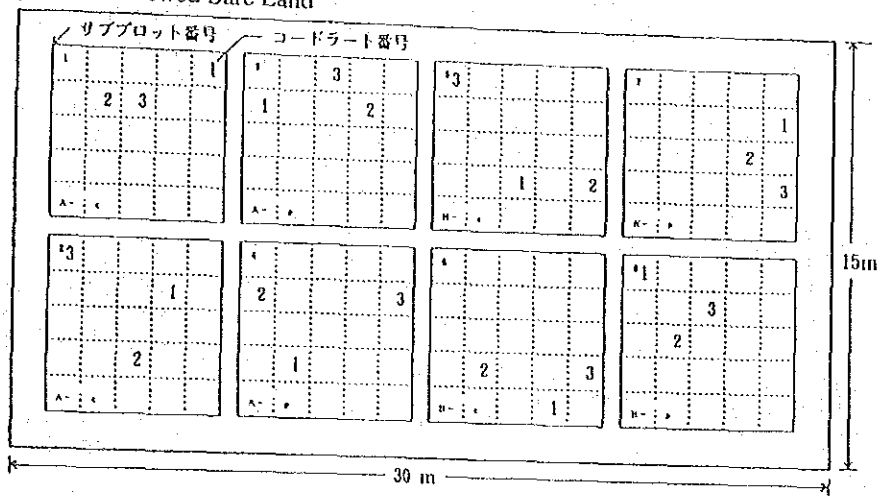


Fig. II-5 Locations of Sub-Plots and Quadrats in Each Plot

(Fig. II-5 continued)

Plot 4: Harrowed Bare Land



Plot 5: Bare Land

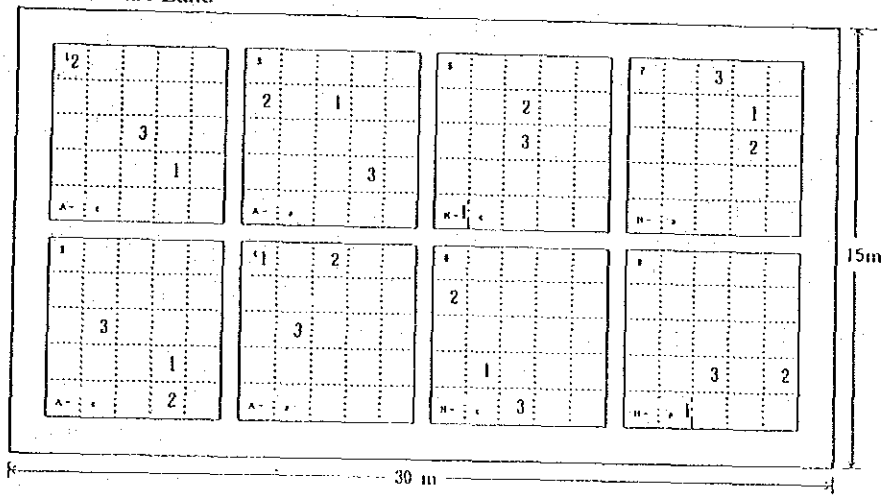


Table II-3 Details of Sub-Plots

(Unit: Number of Sub-Plots)

Land / Species / Preparation	Acacia auriculiformis		Acacia mangium		Total
	Coated Seeds	Uncoated Seeds	Coated Seeds	Uncoated Seeds	
Burned Grassland	2	2	2	2	8
Harrowed Grassland	2	2	2	2	8
Grassland	2	2	2	2	8
Harrowed Bare Land	2	2	2	2	8
Bare Land	2	2	2	2	8
Total	10	10	10	10	40

e) Seeding Quantity

The seeding quantity/m² was 50 seeds for both coated and uncoated seeds. The details of the seeding quantity for each species are given in Table II-4.

Table II-4 Details of Seeding Quantity

(Unit: Number of Seeds)

Species	Acacia auriculiformis	Acacia mangium	Total
Coated Seeds	12,500	12,500	25,000
Uncoated Seeds	12,500	12,500	25,000
Total	25,000	25,000	50,000

f) Seeding Method

In the seeding of the 3 quadrats established for data collection purposes in each sub-plot, meshes were created using ropes so that each seed could be carefully placed by hand. Seeding in all other quadrats was also conducted to make the seed distribution as uniform as possible.

g) Survey Items

The actual survey was conducted in the 3 quadrats randomly established in each sub-plot (Fig. II-5) on the following items.

① Germination Rate

- Time of Observation: weekly after initial seeding
- Survey Items: germination rate, growth after germination and number of surviving seedlings using the field note shown in Table II-5

② Number of Surviving Seedlings and Seedling Height

- Time of Observation: in principle, the 15th of each month
- Survey Items: number of surviving seedlings and seedling height, etc. using the field note shown in Table II-6

Table II-5 Field note for Intensive Germination Experiment

FUNDAMENTAL. SURVEY ON LARGE-SCALE REFORESTATION TECHNIQUE

FIELD DATA SHEET ON INTENSIVE GERMINATION EXPERIMENT

Plot No._____. Sub-plot No._____. Quadrate No._____. Date of mesurement_____. Name of the data collector_____.

Please put a circle (○) in the column identified!!

	Seed-ling No.	Germi-nation	Causes of mortality				Survival	Budding	Remarks
			insect & pest	Disease	Physical damage	Others			
1									
2									
3									
4									

(3) Results

a) Germination

① Germination at Experiment Site (I)

- o Most of the seeds in each plot germinated during Week 3 (Table II-7)
- o While the germination rate varied depending on the species, the general rate was 2-15% one month after seeding followed by a slight increase during the next month. No new germination occurred after 2 months (Fig. II-6). The germination rate of 2% is equivalent to one germinated seedling/m^2 (based on a seeding quantity of 50 seeds/m^2) or 10,000 seedlings/ha.
- o No significant difference was observed between the coated and uncoated seeds in terms of germination.
- o Table II-8 shows the species with a high germination rate in each plot one month after the initial seeding. The bare land plots tend to show a higher germination rate than the other types of plots. It appears that the germination rate was little affected by either the Alang-alang coverage or land preparation.

② Germination in Planters

The results of the germination test using planters which was conducted simultaneously with the main test are given in Table II-9. The germination rates approximately one month after seeding indicate that the performance of those seeds having undergone only boiling water pre-treatment was better than that of the coated seeds in the case of both Acacia auriculiformis and Acacia mangium.

Table II-6 Field note for Survival and Height Measurements

FUNDAMENTAL SURVEY ON LARGE-SCALE REFORESTATION TECHNIQUE

FIELD DATA SHEET ON SURVIVAL AND HEIGHT MEASUREMENTS

Name of data collector _____.

Plot No.	Sub-Plot No.	Qua-drate No.	Date of sowing	Date of measurment	Number of seedlings survived	Average height (cm)	Causes of mortality				Remarks
							Insect & pest	Disease	Physical damage	Others	

Table II-7 Germination Rates (Nov. 24, 1990–Dec. 15, 1990)

Plot 1: Burned Grassland (Unit: %)

Plot No.	Sub-Plot No.	Species	Date			
			Nov. 24	Dec. 1	Dec. 8	Dec. 15
1	1	A.a (C)	-	-	1	5
	2	A.a (C)	-	-	-	1
	3	A.a (P)	-	-	-	-
	4	A.a (P)	-	-	-	1
	5	A.m (C)	-	-	-	-
	6	A.m (C)	-	-	1	1
	7	A.m (P)	-	-	-	-
	8	A.m (P)	-	-	-	2

Plot 2: Harrowed Grassland (Unit: %)

Plot No.	Sub-Plot No.	Species	Date			
			Nov. 24	Dec. 1	Dec. 8	Dec. 15
2	1	A.a (C)	-	-	-	-
	2	A.a (C)	-	-	1	1
	3	A.a (P)	-	-	-	1
	4	A.a (P)	-	-	-	2
	5	A.m (C)	-	-	-	-
	6	A.m (C)	-	-	-	1
	7	A.m (P)	-	-	1	9
	8	A.m (P)	-	-	1	4

Plot 3: Grassland (Unit: %)

Plot No.	Sub-Plot No.	Species	Date			
			Nov. 24	Dec. 1	Dec. 8	Dec. 15
3	1	A.a (C)	-	-	-	3
	2	A.a (C)	-	-	1	4
	3	A.a (P)	-	-	3	9
	4	A.a (P)	-	-	-	3
	5	A.m (C)	-	-	2	3
	6	A.m (C)	-	-	-	3
	7	A.m (P)	-	-	-	2
	8	A.m (P)	-	-	-	5

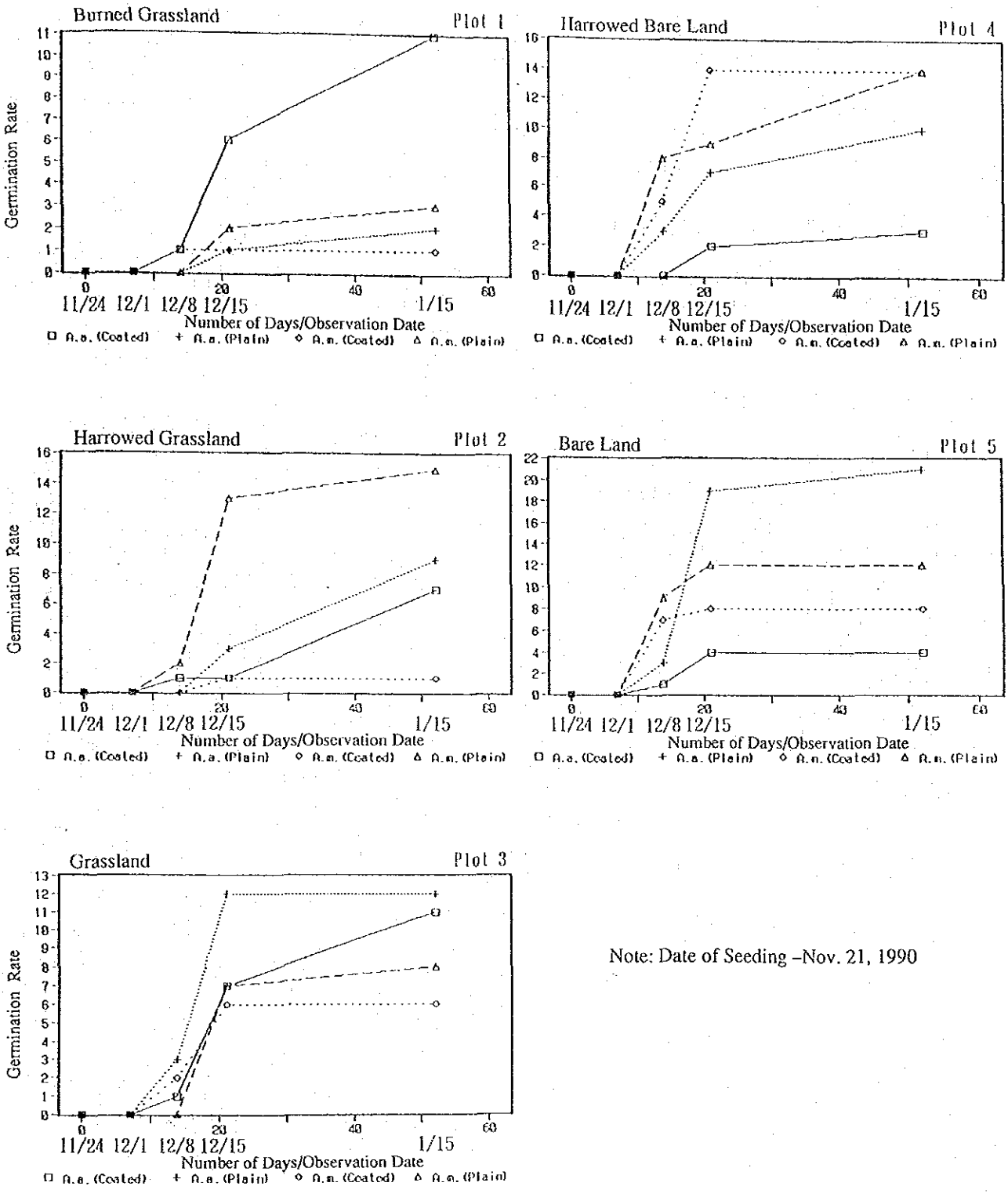
Plot 4: Harrowed Bare Land (Unit: %)

Plot No.	Sub-Plot No.	Species	Date			
			Nov. 24	Dec. 1	Dec. 8	Dec. 15
4	1	A.a (C)	-	-	-	1
	2	A.a (C)	-	-	-	1
	3	A.a (P)	-	-	-	2
	4	A.a (P)	-	-	3	5
	5	A.m (C)	-	-	2	7
	6	A.m (C)	-	-	3	7
	7	A.m (P)	-	-	3	4
	8	A.m (P)	-	-	5	5

Plot 5: Bare Land (Unit: %)

Plot No.	Sub-Plot No.	Species	Date			
			Nov. 24	Dec. 1	Dec. 8	Dec. 15
5	1	A.a (C)	-	-	-	3
	2	A.a (C)	-	-	1	1
	3	A.a (P)	-	-	-	1
	4	A.a (P)	-	-	3	18
	5	A.m (C)	-	-	7	7
	6	A.m (C)	-	-	-	1
	7	A.m (P)	-	-	-	-
	8	A.m (P)	-	-	9	12

Notes
1. A.a: Acacia auriculiformis
   A.m: Acacia mangium
2. (C): coated seeds
   (P): plain (uncoated) seeds
3. Date of Land Preparation: Nov. 19, 1990
4. Date of Seeding: Nov. 21, 1990



Note: Date of Seeding –Nov. 21, 1990

Fig. II-6 Germination Rate

Table II-8 Species Showing High Germination Rate

	Plot	Species	Average Germination Rate (%)
1	Burned Grassland	Acacia auriculiformis (C)	11
2	Harrowed Grassland	Acacia mangium (P)	15
3	Grassland	Acacia auriculiformis (P)	12
4	Harrowed Bare Land	Acacia mangium (C) Acacia mangium (P)	14
5	Bare Land	Acacia auriculiformis (P)	21

(C) Coated Seeds, (P) Plain (Uncoated) Seeds

Table II-9 Germination Test Using Planters

(Unit: %)

Observation Date	Acacia mangium			Acacia auriculiformis		
	Uncoated (Plain) Seeds (dipped in 100°C boiling water for one minute)	Uncoated (Plain) Seeds (heating off on reaching 100°C and seeds kept dipped for 24 hours)	Coated Seeds	Uncoated (Plain) Seeds (dipped in 100°C boiling water for one minute)	Uncoated (Plain) Seeds (heating off on reaching 100°C and seeds kept dipped for 24 hours)	Coated Seeds
Nov.21 (Seeding)	-	-	-	-	-	-
Nov.22-Nov.27	-	-	-	-	-	-
Nov.28	13	15	5	0	4	-
Dec.3	55	68	38	12	23	-
Dec.6	55	71	47	19	35	4
Dec.8	55	71	52	19	35	8
Dec.15	55	71	58	41	43	12

b) Number of Surviving Seedlings

Number of surviving seedlings are shown in Fig. II-7, Fig. II-8 and Attached Tables 1 - 6. In general, it is very difficult to clearly identify the types of seeds, i.e. coated or uncoated, and the types of species which show a high survival rate.

In Fig. II-7, Fig. II-8 and Table II-10, the number of surviving seedlings are shown by species and by type of land preparation for the combined total of coated and uncoated seeds. Both Acacia auriculiformis and Acacia mangium showed a decline and an increase of the seedling counts during the period between Day 150 and Day 400 of the initial germination. The causes of these fluctuations are not clearly known although ① an error in the initial counting of germinated seeds and ② the germination of seeds in later days, are suspected.

While the decline of the seedling number in Plot 3 (Grassland) upto Day 400 was sharper than other types of plots for both Acacia auriculiformis and Acacia mangium, it then almost stabilized as in the case of the other plots. The lowest survival level by land preparation type was recorded in Plot 3 (Grassland) for both species. However, the survival rate in this plot could be improved if some kind of land preparation is

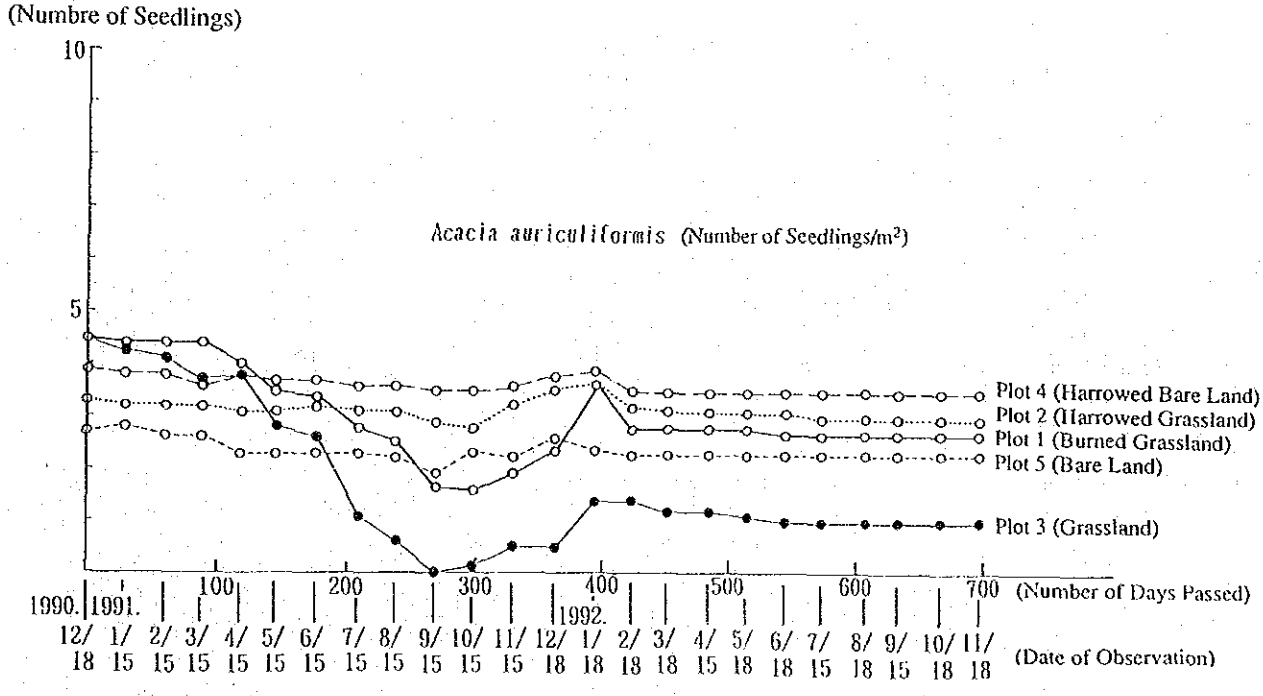


Fig. II-7 Number of Surviving Acacia auriculiformis Seedlings/m² (Experiment Site I)

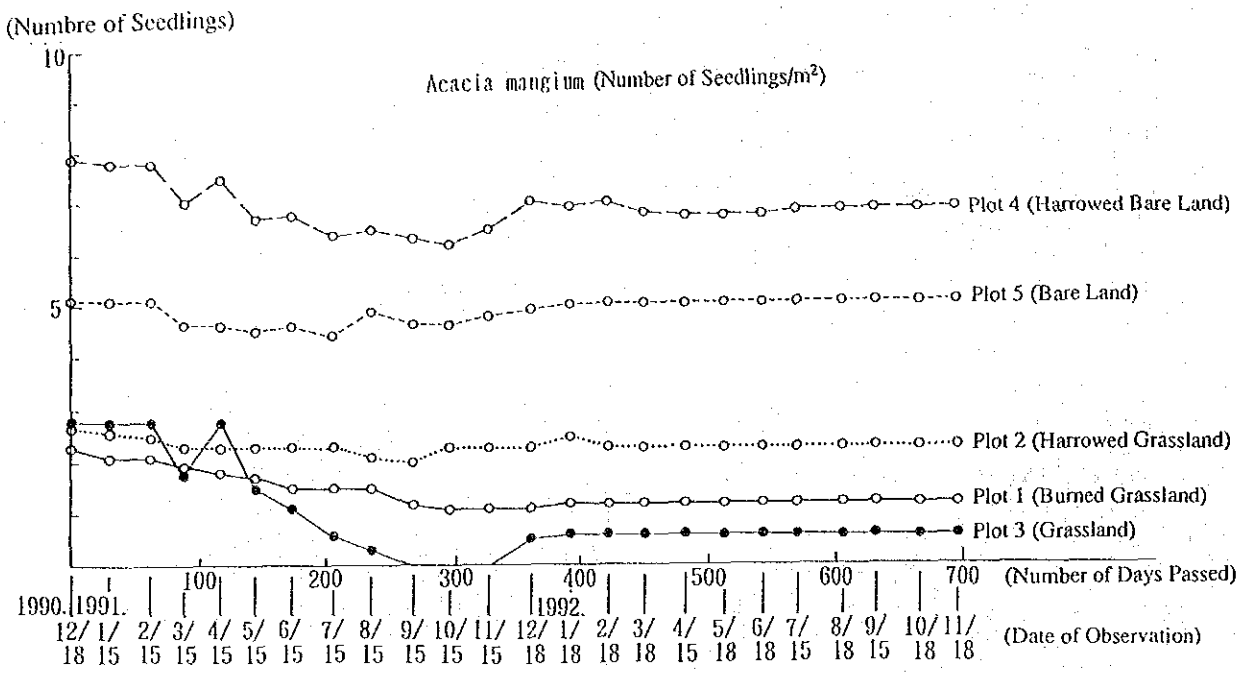


Fig. II-8 Number of Surviving Acacia mangium Seedlings/m² (Experiment Site I)

c) Height Growth

Height growth is shown in Fig. II-9, Fig. II-10 and Attached Tables 7 - 12. Fig. II-9 and Fig. II-10 in particular illustrate the height growth observed in a sub-plot which is believed to represent the typical height growth for the specific type of plot to which it belongs.

The numerical values given in these figures and tables are average values and the seedling height is generally low upto Day 400 or partially unrecorded for Plot 3. Taking the suspicion of ① an error in the initial counting of the germinated seeds and ② the germination of seeds in later days into consideration, the average value is low upto this stage. In general, the height growth appears not to have been affected by the type of seed, i.e. coated or uncoated, as in the case of seedling survival. The height growth of Acacia auriculiformis by the type of land preparation showed the best growth in Plot 4 (Harrowed Bare Land), followed by Plot 2 (Harrowed Grassland), Plot 5 (Bare Land), Plot 1 (Burned Grassland) and Plot 3 (Grassland) in that order. In the case of Acacia mangium, the best growth was recorded in Plot 4 (Harrowed Bare Land), followed by Plot 5 (Bare Lad), Plot 2 (Harrowed Grassland), Plot 1 (Burned Grassland) and Plot 3 (Grassland). The overall height growth performance seems to indicate the positive effect of land preparation on height growth. Table II-10 shows the state of survival and seedling height on Day 698.

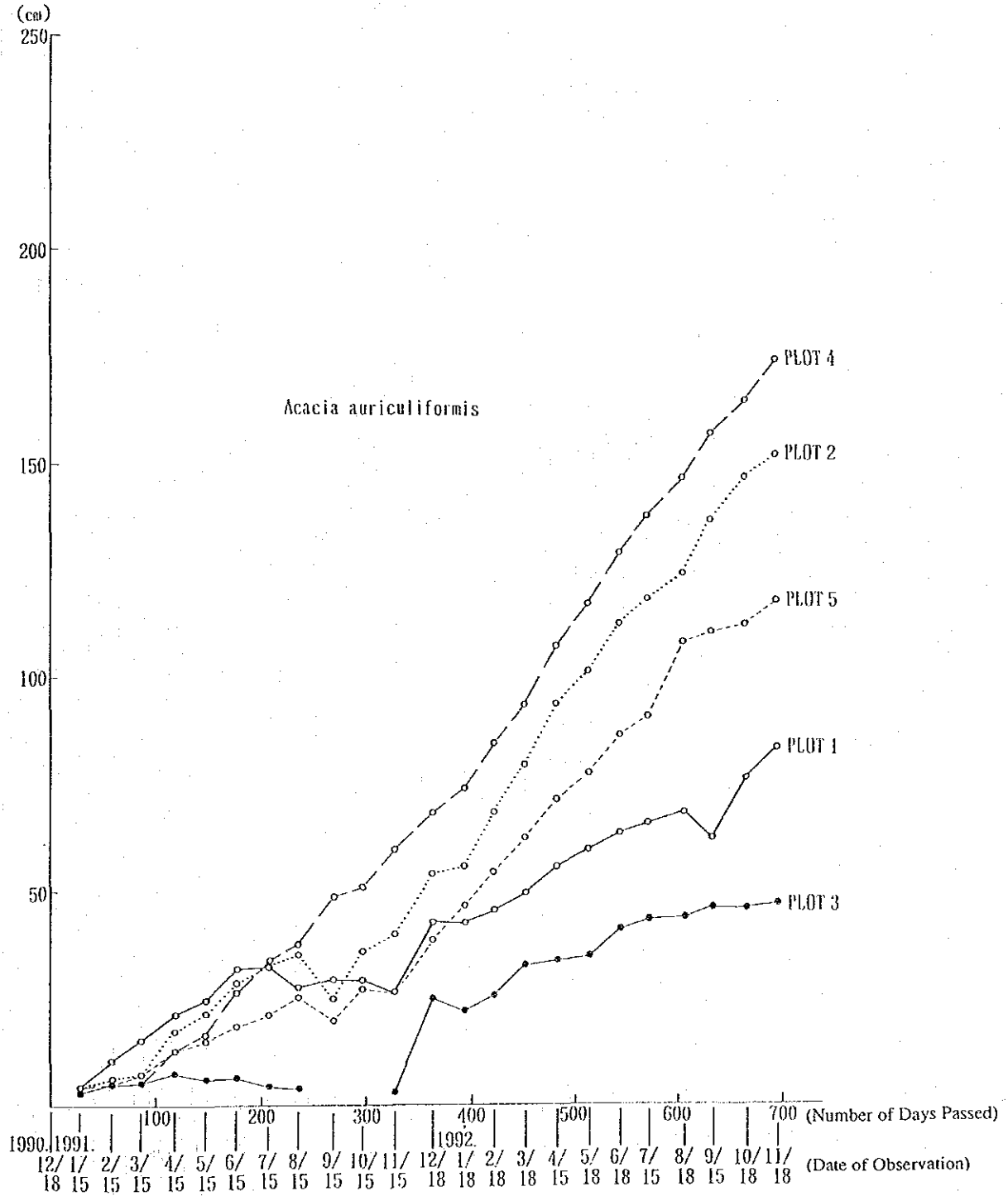


Fig. II-9 Height Growth of Acacia auriculiformis (Experiment Site I)

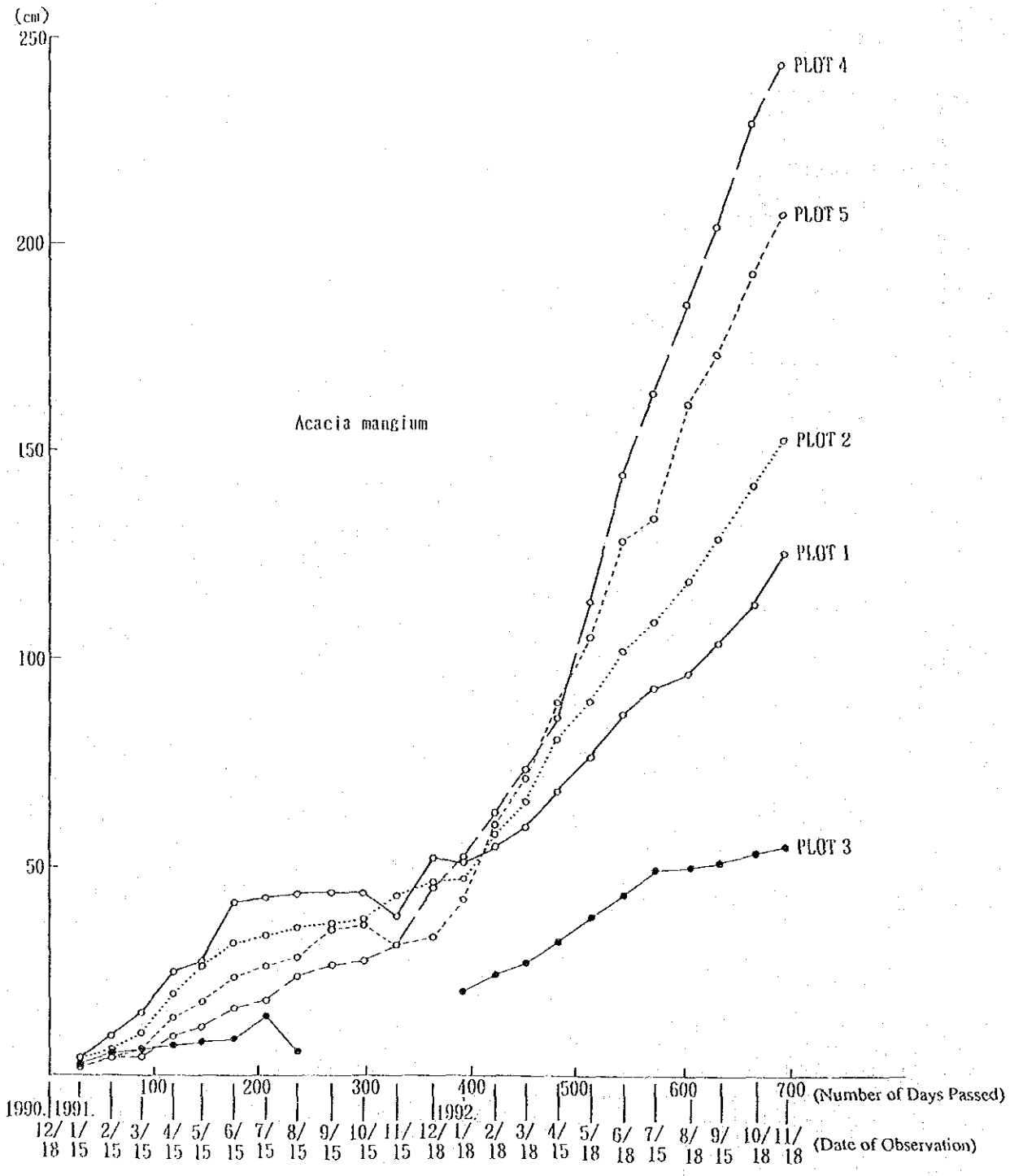


Fig. II-10 Height Growth of Acacia mangium (Experiment Site I)

Table II-10 State of Survival and Tree Height

(Date of Observation: November 18, 1992)

Plot No.	Species		Acacia auriculiformis				Acacia mangium				Remarks
	Sub-Plot		(C)		(P)		(C)		(P)		
	Item	No.	1	2	3	4	5	6	7	8	
1 Burned Grassland	Seedling Height (cm)	Highest	145	130	113	140	300	170	88	132	1. Date of Seeding: Nov. 21, 1990 2. Seeding Quantity: 50 seeds/m^2 3. Sub-Plot Size: 5m x 5m = 25m^2 4. (C) Coated Seeds (P) Plain (Uncoated) Seeds
		Lowest	45	32	69	24	160	42		75	
		Average	89	84	90	69	205	124	88	99	
	No. of Surviving Seedlings	Total	15	8	4	5	5	5	1	3	
		per m^2	0.6	0.3	0.2	0.2	0.2	0.2	0.0	0.1	
		Average	0.4		0.2		0.2		0.1		
2 Harrowed Grassland	Seedling Height (cm)	Highest	230	245	172	250	240	131	308	250	
		Lowest	45	120	83	30	50		55	97	
		Average	153	196	129	137	130	131	151	156	
	No. of Surviving Seedlings	Total	9	4	12	11	6	1	16	5	
		per m^2	0.4	0.2	0.5	0.4	0.2	0.0	0.6	0.2	
		Average	0.3		0.5		0.1		0.4		
3 Grassland	Seedling Height (cm)	Highest	58	58	116			62	33	88	
		Lowest	35	34	35					32	
		Average	47	42	75			62	33	55	
	No. of Surviving Seedlings	Total	2	3	7	0	0	1	1	4	
		per m^2	0.1	0.1	0.3			0.0	0.0	0.2	
		Average	0.1		0.3		0.0		0.1		
4 Harrowed Bare Land	Seedling Height (cm)	Highest	300	290	320	230	370	320	440	325	
		Lowest	140	82	35	50	100	80	140	100	
		Average	203	180	176	145	238	240	304	224	
	No. of Surviving Seedlings	Total	5	9	16	12	14	26	16	25	
		per m^2	0.2	0.4	0.6	0.5	0.6	1.0	0.6	1.0	
		Average	0.3		0.6		0.8		0.8		
5 Bare Land	Seedling Height (cm)	Highest	210	180	105	220	275	245	250	380	
		Lowest	110	122	70	20	70	40	65	50	
		Average	164	155	88	119	205	154	152	223	
	No. of Surviving Seedlings	Total	5	2	2	18	11	12	19	18	
		per m^2	0.2	0.1	0.1	0.7	0.4	0.5	0.8	0.7	
		Average	0.1		0.4		0.5		0.7		

PLOT 1. (Burned Grassland) A. auriculiformis

PLOT 2. (Harrowed Grassland) A. auriculiformis

PLOT 3. (Grassland) A. auriculiformis

PLOT 4. (Harrowed Bare Land) A. auriculiformis

PLOT 5. (Bare Land) A. auriculiformis

A. mangium

A. mangium

A. mangium

A. mangium

A. mangium

Photographs

① Day 728 (28/11/1992) after seeding (21/11/1990)

② Alang-alang growth is sparse at both the harrowed bare land and bare land.

③ See Fig. II-7, Fig. II-8, Fig. II-9, Fig. 2-10 and Table II-10 for data by species and Fig. II-18 for data on Alang-alang.

(4) Growth of Alang-alang

Fig. II-11 and Attached Table 13 show the average height of Alang-alang for a period of 2 years after November, 1990 when the land preparation was conducted.

o Burned Grassland (Plot 1)

The growth of Alang-alang was the fastest in this plot, recovering the original height before burning in 3 months and reaching a height of 80 - 100cm in approximately 18 months. The density was also higher than that of Plot 3 (Grassland).

o Harrowed Grassland (Plot 2)

The height of Alang-alang was some 20cm in the 3 month period after harrowing, recovering the original height in 9 months and reaching a height of 70 - 80cm with subsequent growth. The density was lower than that of Plot 1 and Plot 3.

o Harrowed Bare Land (Plot 4)

The growth of Alang-alang was extremely sparce.

o Bare Land (Plot 5)

The growth of Alang-alang was sparce.

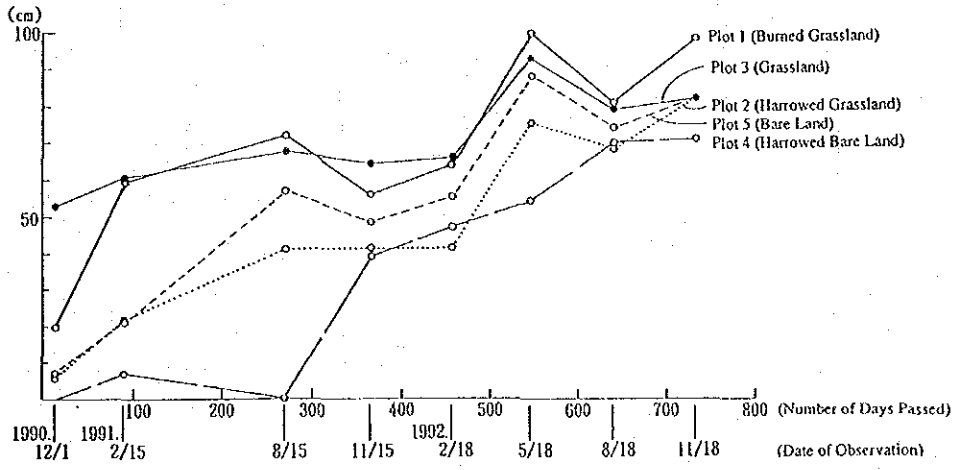


Fig. II-11 Growth of Alang-alang (Experiment Site I)

(5) Effects of Land Preparation

a) Burning

While burning appeared effective for initial growth, the Alang-alang recovered its original height in 3 months with a higher density than before. The decline in the number of seedlings is assumed to have been caused by the height of the Alang-alang.

b) Harrowing

In general, harrowing appeared effective for the survival and growth of seedlings in the case of both grassland and bare land. The harrowing of bare land appeared particularly effective.

(6) Effects of Coating on Seeds

The coating of seeds did not appear effective for germination, seedling survival and growth (Fig. II-6, Table II-7 and Table II-8).

- In general, the uncoated seeds recorded a better germination rate than the coated seeds.
- The stratified or mixed coating of seeds involving fertilizer, germicide and repellent did not achieve the intended effects in terms of germination and growth.

(7) Various Types of Damage to Seeds and Seedlings

Table II-11 and Table II-12 show the various types of damage to seedlings during the some 23 month period after germination. Much damage occurred to young seedlings. During the initial seeding and germination stages, the loss of seeds due to rain or their being eaten by ants and birds was observed in addition to damage to roots exposed by rain or drought. The causes of damage are not differentiated between in these 2 tables although suppression from Alang-alang and competition between the root systems of the seeded species and Alang-alang are suspected but not clearly substantiated.

Table II-11 Damage to Acacia auriculiformis (Experiment I)

Date of Observation	No. of Days Passed	Plot 1 (Burned Grassland)				Plot 1 (Harrowed Grassland)				Plot 1 (Grassland)				Plot 1 (Harrowed Bare Land)				Plot 1 (Bare Land)			
		No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)
			Others	Total			Others	Total			Others	Total			Others	Total			Others	Total	
18/12/1990	1	54				39				54				47				32			
15/1/1991	29	53	1	1	2	38	1	1	3	51	3	3	6	45	2	2	4	33			0
15/2/1991	60	53	1	1	2	38	1	1	3	49	5	5	9	45	2	2	4	31	2	2	6
15/3/1991	88	53	1	1	2	38	1	1	3	44	10	10	19	43	4	4	9	31	2	2	6
15/4/1991	119	48	6	6	11	37	2	2	5	45	10	10	18	44	4	4	8	28	5	5	15
15/5/1991	145	42	12	12	22	37	2	2	5	34	21	21	38	44	4	4	8	27	6	6	18
15/6/1991	176	41	13	13	24	38	2	2	5	31	24	24	44	44	4	4	8	27	6	6	18
15/7/1991	206	33	21	21	39	37	3	3	8	13	42	42	76	43	5	5	10	27	6	6	18
15/8/1991	237	30	24	24	44	37	3	3	8	7	48	48	87	43	5	5	10	26	7	7	21
15/9/1991	268	20	34	34	63	35	5	5	13	2	52	52	95	42	6	6	13	23	10	10	30
15/10/1991	298	17	37	37	69	34	6	6	15	1	51	51	93	42	6	6	13	23	10	10	30
15/11/1991	329	24	37	37	61	39	6	6	13	6	54	54	90	43	6	6	12	26	10	10	28
18/12/1991	362	29	37	37	56	43	6	6	12	5	55	55	92	45	6	6	12	31	10	10	24
18/1/1992	393	32	37	37	54	44	6	6	12	17	55	55	76	47	6	6	11	29	12	12	29
18/2/1992	424	33	37	37	53	38	12	12	24	17	55	55	76	42	11	11	21	28	13	13	32
18/3/1992	453	33	37	37	53	37	13	13	26	14	58	58	81	42	11	11	21	27	14	14	34
18/4/1992	484	33	37	37	53	37	13	13	26	14	58	58	81	42	11	11	21	28	14	14	33
18/5/1992	514	33	37	37	53	37	13	13	26	13	59	59	82	42	11	11	21	27	15	15	36
18/6/1992	545	32	38	38	54	37	13	13	26	12	60	60	83	42	11	11	21	27	15	15	36
18/7/1992	572	32	38	38	54	36	14	14	28	12	60	60	83	42	11	11	21	27	15	15	36
18/8/1992	606	32	38	38	54	36	14	14	28	12	60	60	83	42	11	11	21	27	15	15	36
15/9/1992	634	32	38	38	54	36	14	14	28	12	60	60	83	42	11	11	21	27	15	15	36
18/10/1992	667	32	38	38	54	36	14	14	28	12	60	60	83	42	11	11	21	27	15	15	36
18/11/1992	698	32	38	38	54	36	14	14	28	12	60	60	83	42	11	11	21	27	15	15	36
Final Count of Germinated Seeds		70				50				72				53				42			

NotesNotes
1. The number of surviving seedlings on December 18, 1990 was the initial number of germinated seeds.
2. The damage rate is the percentage of damaged seedlings vis-a-vis the initially germinated seeds or subsequently increased germinated seeds.
3. All figures are per 100m^2.
4. The seeding quantity is 50 seeds/m^2.

Table II-12 Damage to Acacia mangium (Experiment I)

Date of Observation	No. of Days Passed	Plot 1 (Burned Grassland)				Plot 1 (Harrowed Grassland)				Plot 1 (Grassland)				Plot 1 (Harrowed Bare Land)				Plot 1 (Bare Land)			
		No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)	No. of Surviving Seedlings	Total Damaged Seedlings		Damage Rate (%)
			Others	Total			Others	Total			Others	Total			Others	Total			Others	Total	
18/12/1990	1	27				32				34				95				61			
15/1/1991	29	25	2	2	7	31	1	1	3	33	1	1	3	93	2	2	2	61			
15/2/1991	60	25	2	2	7	30	2	2	6	34	1	1	3	93	2	2	2	61			
15/3/1991	88	23	4	4	15	27	5	5	16	22	13	13	37	94	11	11	12	55	6	6	10
15/4/1991	119	22	5	5	19	28	5	5	15	34	13	13	28	90	11	11	11	55	6	6	10
15/5/1991	145	20	6	6	26	27	6	6	18	18	29	29	62	80	21	21	21	54	7	7	11
15/6/1991	176	18	9	9	33	27	6	6	18	13	34	34	72	82	21	21	20	55	7	7	11
15/7/1991	206	18	9	9	33	27	6	6	18	7	40	40	85	77	26	26	25	53	9	9	15
15/8/1991	237	18	9	9	33	25	8	8	24	4	43	43	91	78	26	26	25	59	9	9	13
15/9/1991	268	14	13	13	33	24	9	9	27	0	47	47	100	75	29	29	28	55	13	13	19
15/10/1991	298	13	14	14	48	28	9	9	24	0				74	30	30	29	55	13	13	19
15/11/1991	329	13	14	14	52	28	9	9	24	0				78	30	30	28	58	13	13	18
18/12/1991	362	13	14	14	52	27	10	10	27	0				84	30	30	26	59	13	13	18
18/1/1992	393	14	14	14	52	30	10	10	25	6			0	83	31	31	27	60	13	13	18
18/2/1992	424	14	14	14	50	28	12	12	30	7			0	84	31	31	27	60	13	13	18
18/3/1992	453	14	14	14	50	28	12	12	30	7			0	81	34	34	30	60	13	13	18
18/4/1992	484	14	14	14	50	28	12	12	30	7			0	80	35	35	30	60	13	13	18
18/5/1992	514	14	14	14	50	28	12	12	30	6	1	1	14	80	35	35	30	60	13	13	18
18/6/1992	545	14	14	14	50	28	12	12	30	6	1	1	14	80	35	35	30	60	13	13	18
18/7/1992	572	14	14	14	50	28	12	12	30	6	1	1	14	81	35	35	30	60	13	13	18
18/8/1992	606	14	14	14	50	28	12	12	30	6	1	1	14	81	35	35	30	60	13	13	18
15/9/1992	634	14	14	14	50	28	12	12	30	6	1	1	14	81	35	35	30	60	13	13	18
18/10/1992	667	14	14	14	50	28	12	12	30	6	1	1	14	81	35	35	30	60	13	13	18
18/11/1992	698	14	14	14	50	28	12	12	30	6	1	1	14	81	35	35	30	60	13	13	18
Final Count of Germinated Seeds		28				40				54				116				73			

NotesNotes

1. The number of surviving seedlings on December 18, 1990 was the initial number of germinated seeds.
2. The damage rate is the percentage of damaged seedlings vis-a-vis the initially germinated seeds or subsequently increased germinated seeds.
3. All figures are per $100m^2$.
4. The seeding quantity is 50 seeds/m^2.

2. Direct Seeding Experiment (II)

(1) Outline of Experiment Site

a) Location

The experiment site (II) is located next to the experimental forest site of the BTR some 70km east of Banjarbaru (Fig. II-12).

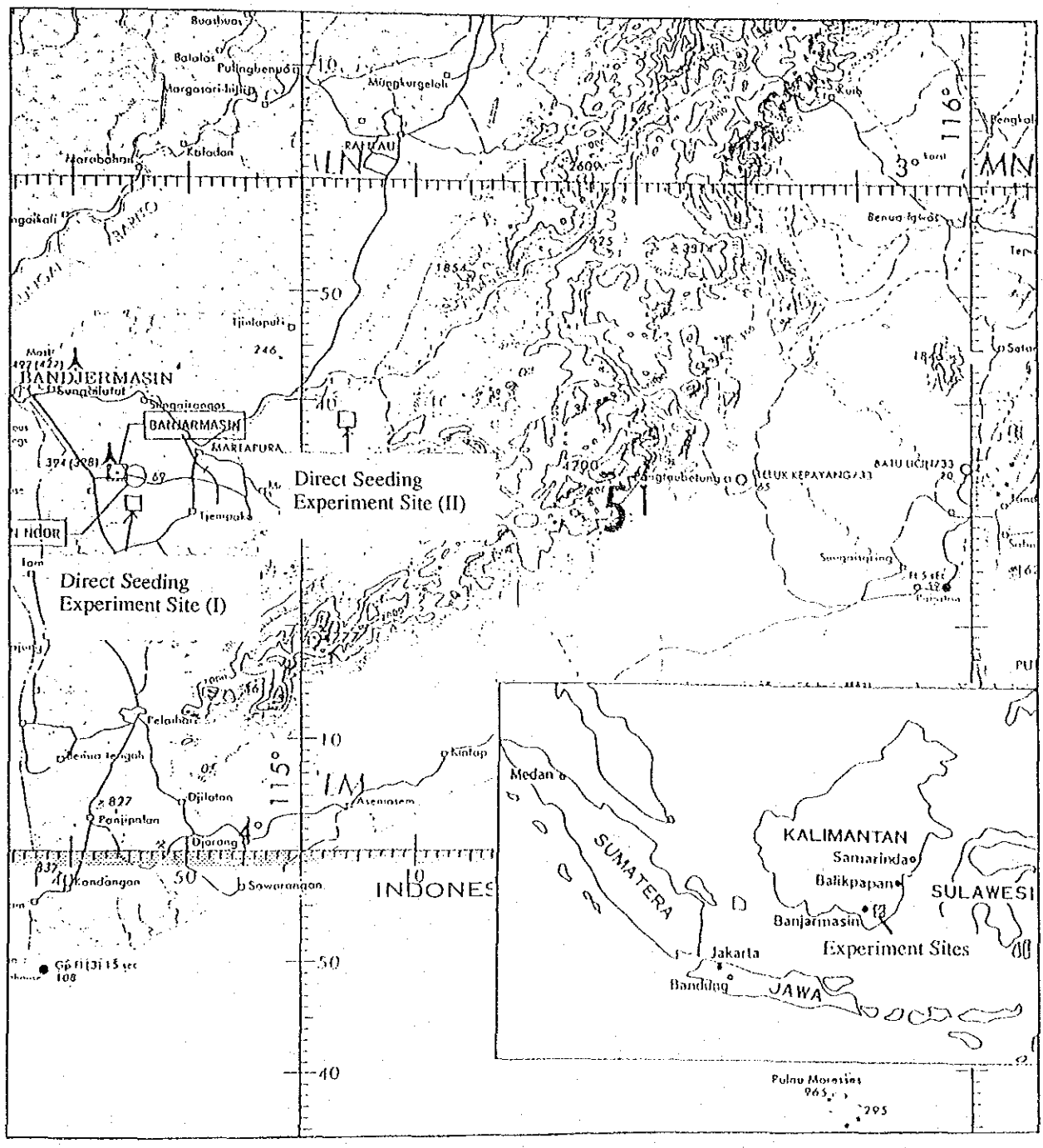


Fig. II-12 Location of Experiment Site (II)

b) Climate

The general climate at Banjarbaru is explained in II-1-(1)-b) while rainfall data for the experiment site (II) are given in Table II-13 and Fig. II-13. Due to the short observation period, it is impossible to indicate a reliable trend of rainfall, etc. although it appears safe to assume that the meteorological conditions at the experiment site (II) are similar to those at the experiment site (I).

Table II-13 Rainfall and Rainy Days at Experiment Site (II) For the year 1992

Month	Experiment Site (II)		
	Rainfall (mm)	Highest Daily Rainfall (mm)	Number of Rainy Days
1	303	85	18
2	180	33	10
3	287	40	17
4	321	61	17
5	304	122	11
6	89	27	9
7	68	31	12
8	65	33	6
9	81	35	8
10	135	69	7
11	290	76	19

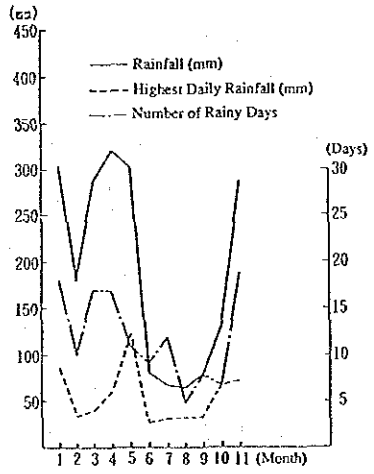


Fig. II-13 Rainfall and Rainy Days at Experiment Site (II)

c) Topography and Geology

According to the geological map of South Kalimantan (scale: 1/500,000), the geology around Riam Kiwa where the experiment site (II) is located is characterised by the distribution of sedimentary rocks of mainly the pre-Tertiary period and sedimentary rocks of the Palaeogene are found in the high mountain areas.

The Meratus mountains run from the southeast to the east of Riam Kiwa and the experiment site (II) is located on the left bank of Riam Kiwa river which originates in the Meratus mountains.
The experiment site (II) has a gently undulating topography which is common in areas from the Meratus mountains to the west of Riam Kiwa. Apart from certain areas along the valley, the gradient of the land surrounding the experiment site (II) is less than 20% and this land is mainly Alang-alang grassland.

d) Soil

According to the soil map prepared in 1984 by the South Kalimantan Forestry Bureau and the Directorate General of Forestry Resources Surveys, the prominent soil in the Riam Kiwa area is yellowish red podsol (Kompleks Podosolik Merah Kuning dan laritik).

As shown by the soil test results (Table II-14), the pH value is in the range of between 5.2 and 5.4, i.e. it is not strongly acid, and poses no particular problem in regard to plant growth. The fact that the soil is not sandy also gives a better plant growth prospect.

Table II-14 Outline of Experiment Site (II) Soil

Plot No.	Horizon	Depth (cm)	Soil Colour	Soil Type	Hardness (mm)	pH	Remarks
1	AO	15	7.5 YR 4/4	clay		5.4	Topography: upper slope
	B1	15	5 YR 4/4	clay	22	5.4	Vegetation: Alang-alang
	B2	-	5 YR 4/6	(with gravel)	20	5.2	
3	A1		7.5 YR 4/6	sandy clay		5.4	Topography: lower slope
	B1	15	5 YR 4/4	sandy clay	22	5.4	Vegetation: Alang-alang
	B2	15-	5 YR 4/6		20		
5	A1		7.5 YR 5/6	sandy clay		5.4	Topography: lower slope
	B1	14	5 YR 3/4	sandy clay	23	5.4	Vegetation: Alang-alang
	B2	15-	5 YR 4/4		22	5.4	

e) Vegetation

While woody plants with a height of 5-10m are observed in parts of the valleys, the predominant landscape in and around the experiment site (II) is Alang-alang grassland due to the deterioration of the soil's fertility, assumed to have been caused by repeated burning for stock raising or shifting cultivation purposes and forest fires, etc.

The density of Alang-alang at the time of establishing the experiment site (II) was a live weight of 500g - 800g/m^2 with a height of 50cm - 90cm (average: 65cm).

(2) Method

Compared to the direct seeding experiment using coated and uncoated seeds at the experiment site (I), the following uncoated seeds were used for the direct seeding experiment at the experiment site (II).

a) Species Tested

The species experimented with were the following 2 species of Indonesian origin.

- Acacia auriculiformis
- Acacia mangium

b) Pre-Treatment to Stimulate Germination

The heating of the water was switched off when the temperature reached 100°C. The seeds were then dipped in the boiling water for 24 hours while the boiling water naturally cooled and were then immediately planted.

c) Seeding Quantity

The seeding quantity was 50 seeds/m² as in the case of the direct seeding experiment (I).

d) Seeding Method

The seeds were placed to achieve uniform distribution in each plot.

e) Design of Experiment Site (II)

The overall design of the experiment site (II) is shown in Fig. II-14 while details of its compartmentation and quadrats are given in Fig. II-15 and Table II-15 respectively. The area of one plot was 500m² (20m x 25m) and 6 plots were established. 15 quadrats (25m² each, i.e. 5m x 5m) were introduced in each plot and 3 quadrats were randomly selected to obtain experiment data.

f) Land Preparation

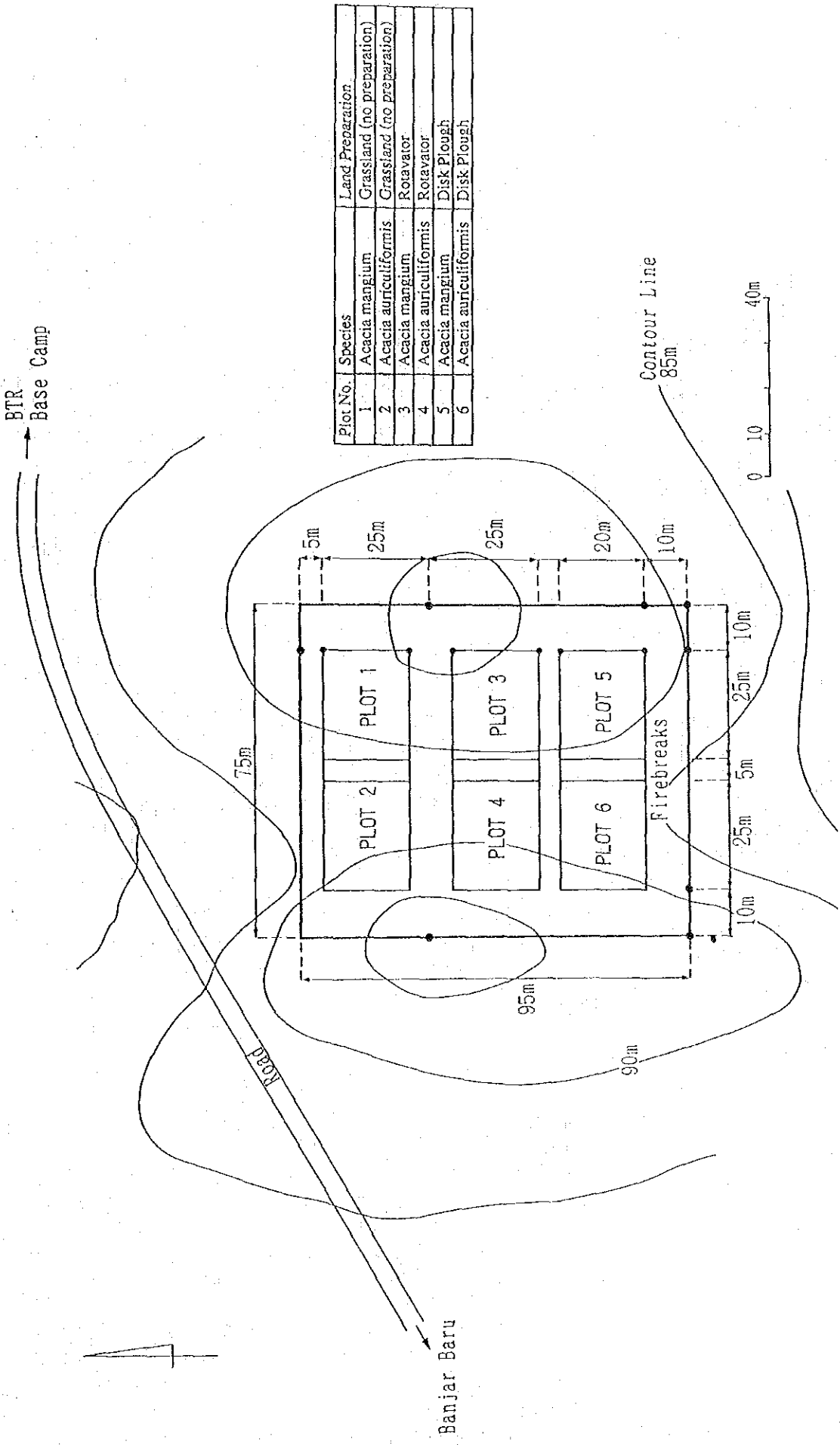
The following types of land preparation were conducted (Table II-15).

- Type 1: for a depth of 10 - 15cm using a rotavator
- Type 2: for a depth of 25 - 30cm using a disk plough

Firebreaks were established around the test site (II) to prevent the spread of forest fires to the site.

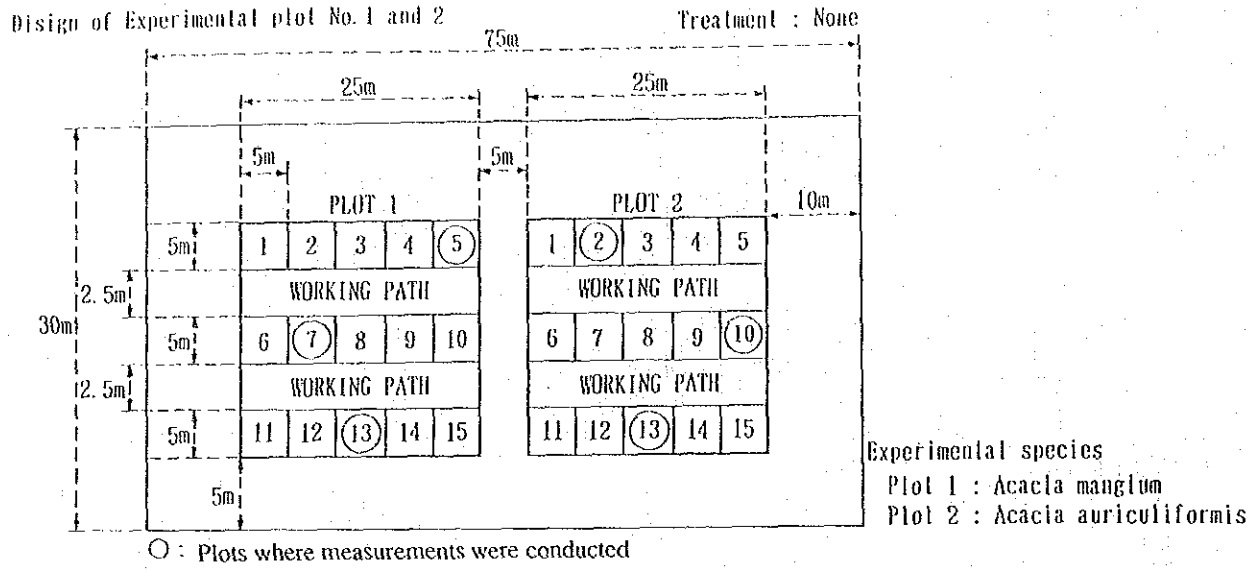
Table II-15 Description of Experiment Plots

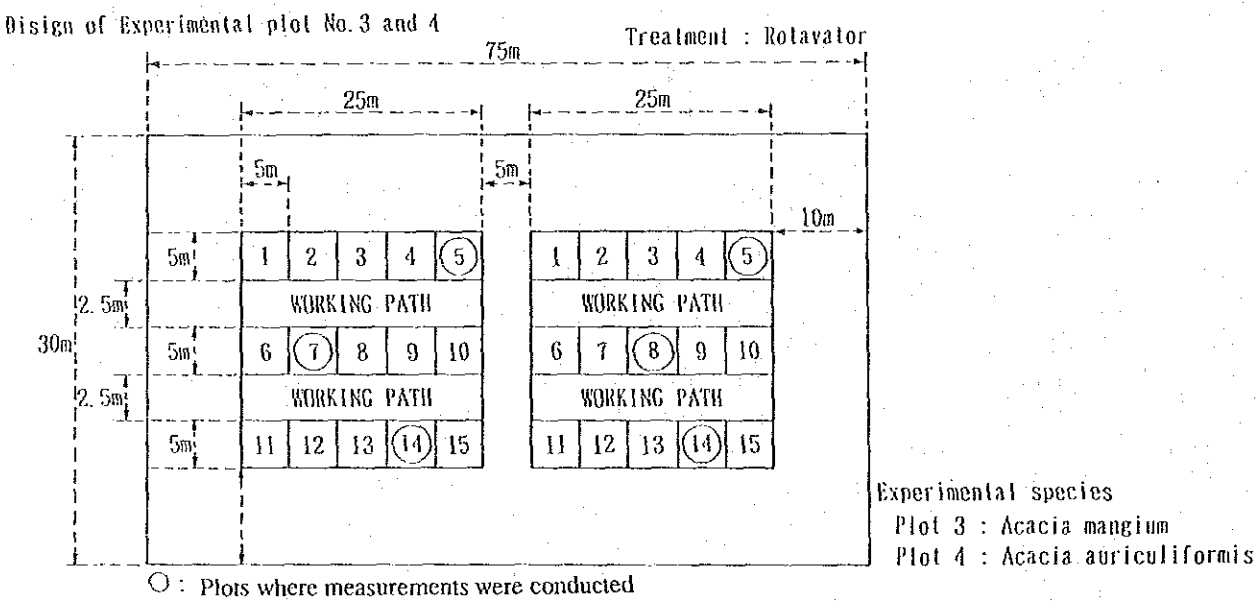
Land Preparation	Species	Plot No.
Grassland Plot	Acacia mangium	1
Grassland Plot	Acacia auriculiformis	2
Rotavator Plot	Acacia mangium	3
Rotavator Plot	Acacia auriculiformis	4
Disk Plough Plot	Acacia mangium	5
Disk Plough Plot	Acacia auriculiformis	6



Plot No.	Species	Land Preparation
1	Acacia mangium	Grassland (no preparation)
2	Acacia auriculiformis	Grassland (no preparation)
3	Acacia mangium	Rotavator
4	Acacia auriculiformis	Rotavator
5	Acacia mangium	Disk Plough
6	Acacia auriculiformis	Disk Plough

Fig. II-14 Layout of Direct Seeding Experiment Site (II)





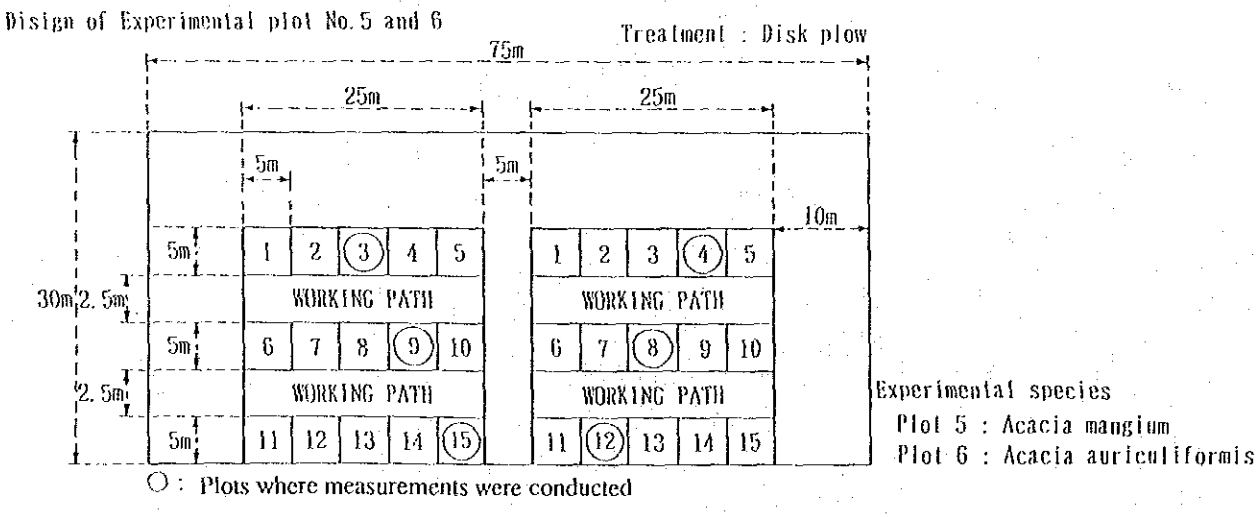


Fig. II-15 Locations of Plots and Quadrats

g) Survey Items

3 quadrats were randomly selected from the 15 quadrats established for each plot for data collection purposes. The survey items in these selected quadrats were as follows.

① Germination

- Time of Observation: weekly after initial seeding
- Survey Items: germination rate, growth after germination and number of surviving seedlings using the field note shown in Table II-5

② Number of Surviving Trees and Tree Height

- Time of Observation: first observation on the 29th day of initial seeding, followed by approximately one monthly intervals
- Survey Items: number of surviving trees and tree height, etc. using the field note shown in Table II-6

(3) Results

a) Germination Rate

Germination appears to have been completed on Day 22 after seeding (Table II-16). The recorded germination rates are given in Table II-17.

o Acacia mangium
The highest germination rate for Acacia mangium of 20% was recorded by the rotavator plots, followed by the grassland plots (9.4%) and the disk plough plots (9.2%). Compared to the corresponding results for the experiment site (I), the germination rate of the grassland plots at the experiment site (II) were slightly higher. The rotavator plots recorded a some 10% higher germination rate than the harrowed grassland at the experiment site (I) while the disk plough plots recorded similar results to the latter.

o Acacia auriculiformis
The highest germination rate for Acacia auriculiformis was recorded by the disk plough plots (1.9%), followed by the rotavator plots (1.4%) and the grassland plots (0.5%). Compared to the corresponding results for the experiment site (I), the germination rate of the grassland at the test site (II) declined by just over 10% and the rate of the mechanically prepared plots also declined by approximately 7%.

Table II-16 Number of Germinated Seeds (Experiment Site (II))

Plot No.		1 (A.m.)				2 (A.a.)				3 (A.a.)				4 (A.a.)				5 (A.m.)				6 (A.a.)				Remarks
Quadrat No.		1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	
Date of Observation	Number of Days Passed																									Date of Seeding: Dec. 17, 1991
17/12/1991	1																									A.m: Acacia mangium
24/12/1991	8	22	22	11	53					100	40	63	203					28	31	26	85	1		2	3	A.a: Acacia auriculiformis
31/12/1991	15	30	24	15	69			1	1	108	55	70	233	3	1	2	6	105	98	109	312	6	3	4	13	Quadrat Size: 5m x 5m
7/1/1992	22	132	90	130	352	6	8	14	18	221	230	300	751	26	15	10	51	125	100	120	345	35	22	16	73	
14/1/1992	29	132	90	130	352	6	8	14	18	221	230	300	751	26	15	10	51	125	100	120	345	35	22	16	73	

Table II-17 Germination Rate

(Unit: %)

Species / Quadrat No.	Acacia mangium			Acacia auriculiformis		
	1. Grassland Plot	3. Rotavator Plot	5. Disk Plough Plot	2. Grassland Plot	4. Rotavator Plot	6. Disk Plough Plot
1	10.6	17.7	10.0	0.5	2.1	2.8
2	7.2	18.4	8.0	0.6	1.2	1.8
3	10.4	24.0	9.6	0.3	0.8	1.3
Average	9.4	20.0	9.2	0.5	1.4	1.9

b) Number of Surviving Seedlings

Number of surviving Acacia mangium and Acacia auriculiformis seedlings are shown in Fig. II-16, Fig. II-17 and Attached Tables 14 and 15. Recorded data on the latest state of seedling height and number of surviving seedlings are given in Table II-18.

① Acacia mangium

The survival performance of Acacia mangium seedlings varied from one land preparation method to another but, in general, showed a noticeable decline in the first 6 months after germination and continued to slightly decline for the next 3 months. The large decline in the number of surviving seedlings in both the rotavator and disk plough plots can be partially explained by the adverse effects of the vigorous growth of Saccharum sp. as described later.

The relationship between the number of surviving seedlings and the height growth (Fig. II-16) indicates that a seedling has an excellent prospect of survival once its height reaches 10 - 15cm. The relationship between the height growth of Alang-alang (Fig. II-18) and the survival of Acacia mangium seedlings is illustrated by the fact that the number of surviving seedlings noticeably declined during the first 5 months during which Alang-alang attained its initial height prior to land preparation in approximately one month, growing another 50% in the remaining period. It appears that the survival of Acacia mangium seedlings is not only affected by the Alang-alang height but also by the density of the latter and the way in which it grows. In short, the survival of Acacia mangium seedlings has a strong relationship with the suppression and shade created by Alang-alang.

Moreover, vigorous growth of Saccharum sp. was observed from August or September onwards at both the rotavator and disk plough plots, reaching as high as 150 - 300cm which definitely affected the growth and survival of Acacia mangium.

② Acacia auriculiformis

In addition to the low germination rate, the survival rate of Acacia auriculiformis after approximately 340 days from the time of germination was 33% for the grassland plots (2 seedlings/25m^2), 41% for the rotavator plots (7 seedlings/25m^2) and 21% for the disk plough plots (5 seedlings/25m^2). As in the case of Acacia mangium, the survival of Acacia auriculiformis largely depends on the successful avoidance of suppression and/or shade created by Saccharum sp.

c) Height Growth

Height growth of both tested species are shown in Fig. II-16, Fig. II-17 and Attached Table 16.

① Acacia mangium

The height growth of Acacia mangium was generally slow at all the plots. At the disk plough plots, however, the growth accelerated after 8 months when the seedling height reached approximately 15cm (Fig. II-16), possibly because of the favourable light conditions and the avoidance of competition with Alang-alang.

② Acacia auriculiformis

The height growth of Acacia auriculiformis was slow in the initial 8 months during which the seedlings grew by approximately 15cm and then became slightly faster. The overall picture is that the height growth of Acacia auriculiformis was slightly superior to that of Acacia mangium (Fig. II-17).

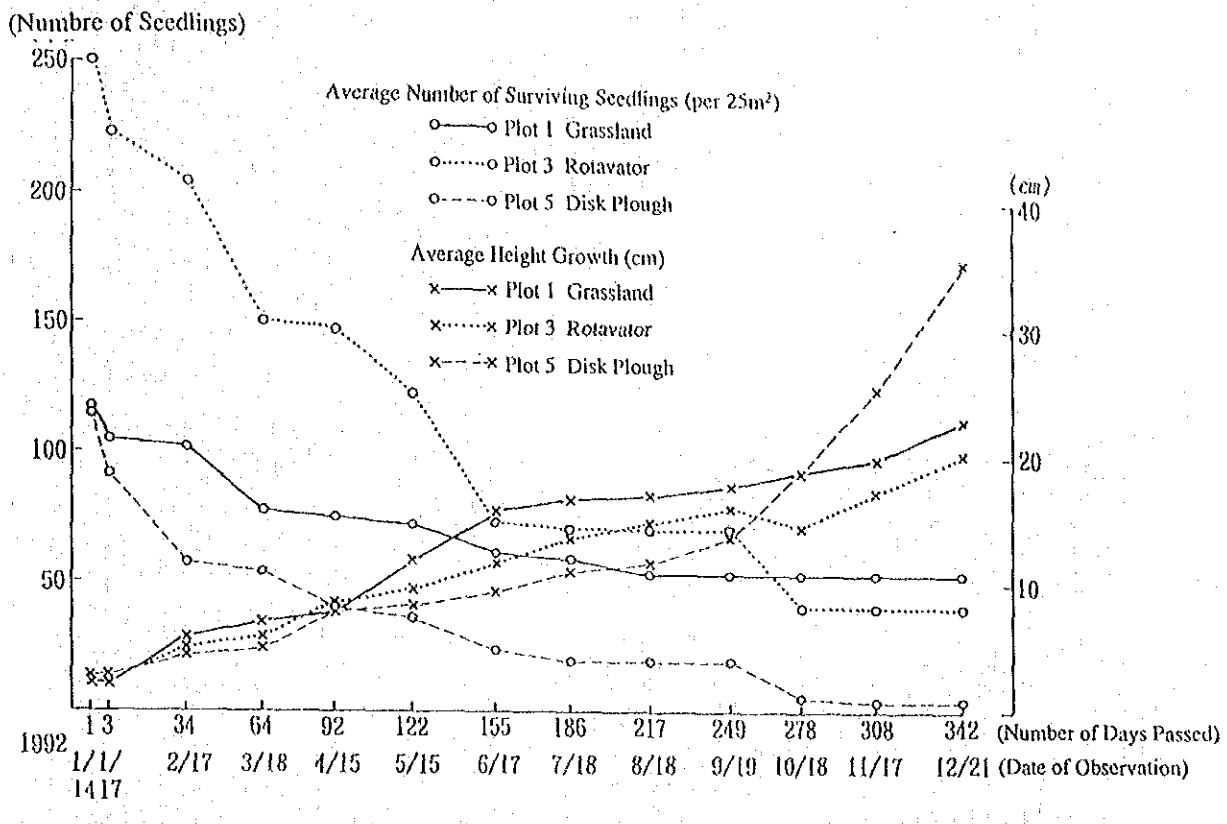


Fig. II-16 Number of Surviving Acacia mangium Seedlings and Height Growth: Experiment Site (II)

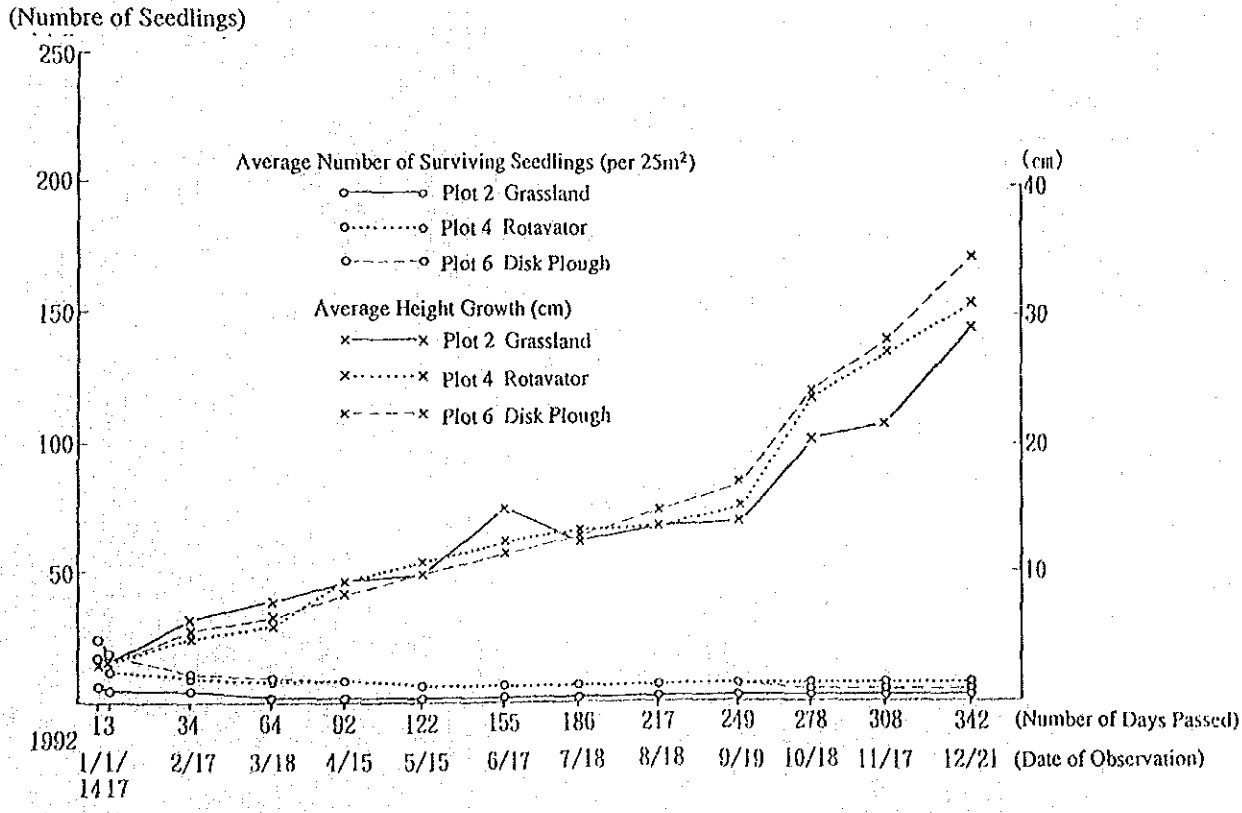


Fig. II-17 Number of Surviving Acacia auriculiformis Seedlings and Height Growth: Test Site (II)

Table II-18 State of Survival and Tree Height (Experiment Site II)

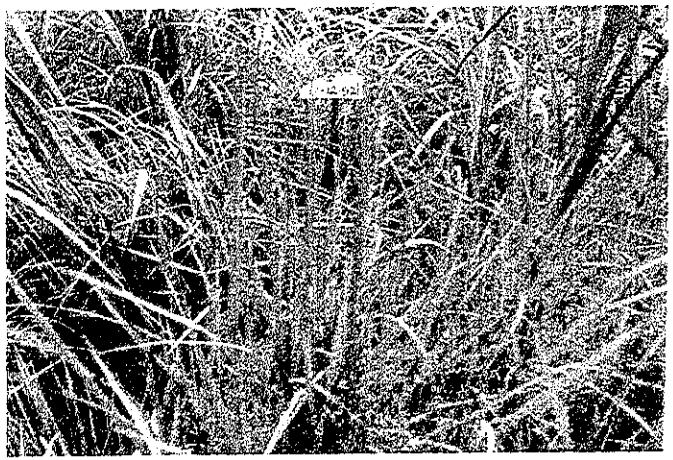
Date of Observation: December 21, 1992

Plot No.	Item		Quadrat No. 1	2	3	Remarks
1 (Grassland) Acacia mangium	Seedling Height (cm)	Highest	35	37	36	1. Date of Seeding: Dec. 17, 1991
		Lowest	11	14	13	2. Seeding Quantity: 50 seeds/m^2
		Average	22	26	23	3. Quadrat Size: 5m x 5m ($25m^2$)
	No. of Observed Seedlings		3	2	3	
	Number of Surviving Seedlings	Total	37	49	75	4. Seedling height was only measured for those where appeared.
		per m^2	1.5	2.0	3.0	
		Average	2.1			
2 (Grassland) Acacia auriculiformis	Seedling Height (cm)	Highest	-	24	38	
		Lowest	-	17	-	
		Average	-	20	38	
	No. of Observed Seedlings		-	4	1	
	Number of Surviving Seedlings	Total	-	4	1	
		per m^2	-	0.2	0.0	
		Average	0.1			
3 (Rotavator) Acacia mangium	Seedling Height (cm)	Highest	31	30	45	
		Lowest	9	6	5	
		Average	24	15	22	
	No. of Observed Seedlings		9	7	9	
	Number of Surviving Seedlings	Total	42	40	41	
		per m^2	1.7	1.6	1.6	
		Average	1.6			
4 (Rotavator) Acacia auriculiformis	Seedling Height (cm)	Highest	43	54	35	
		Lowest	13	8	24	
		Average	29	33	30	
	No. of Observed Seedlings		7	7	2	
	Number of Surviving Seedlings	Total	10	7	3	
		per m^2	0.4	0.3	0.1	
		Average	0.3			
5 (Disk Plough) Acacia mangium	Seedling Height (cm)	Highest	80	16	50	
		Lowest	49	-	15	
		Average	65	16	25	
	No. of Observed Seedlings		2	1	9	
	Number of Surviving Seedlings	Total	2	1	9	
		per m^2	0.1	0.0	0.4	
		Average	0.2			
6 (Disk Plough) Acacia auriculiformis	Seedling Height (cm)	Highest	102	35	57	
		Lowest	28	8	15	
		Average	52	20	32	
	No. of Observed Seedlings		4	9	3	
	Number of Surviving Seedlings	Total	4	9	3	
		per m^2	0.2	0.4	0.1	
		Average	0.2			

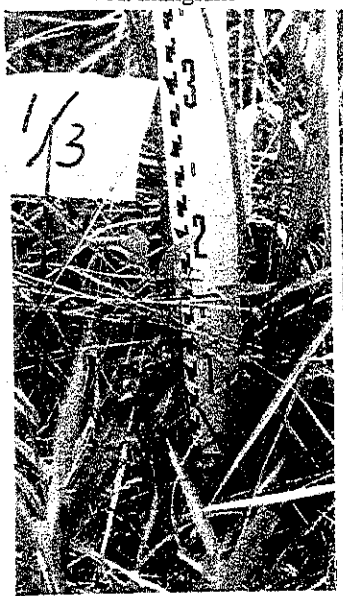
Vegetation at Grassland Plot
(no ground surface preparation)

Vegetation at Rotavator Plot

Vegetation at Disk Plough Plot



A. mangium



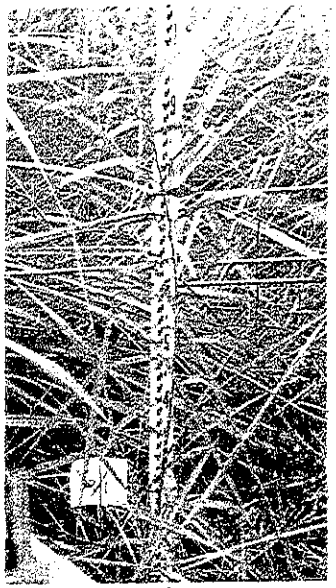
A.auriculiformis

A. mangium

A.auriculiformis

A. mangium

A.auriculiformis



PLOT No.:	1	2	3	4	5	6
Quadrate No.:	3	3	2	2	1	

Photographs
① One year after initial seeding (data of seeding: 17/12/1991, data of observation: 17/12/1991)
② Most of the tall plants seen in the photographs are Saccharum sp. and the others are Alang-alang.
③ See Fig. II-16, Fig. II-17 and Table II-18 for data by species and Fig. II-18 for data on Alang-alang.

(4) Growth of Alang-alang

Data on the growth of Alang-alang at the experiment site (II) are given in Fig. II-18 and Attached Table 17. Prior to the land preparation, the density of Alang-alang at the experiment site (II) was generally higher than that at the experiment site (I). The grass height at the experiment site (II) was also higher. Because of the different method used, the data on Alang-alang restoration at both experiment sites are not fully compatible. The general observation result is that Alang-alang at the experiment site (II) was restored to the previous state of growth faster than at the experiment site (I). The main reason for this is probably the higher soil fertility at the experiment site (ii) as illustrated by the denser and higher growth of the original Alang-alang and the vigorous growth of Saccharum sp. 8 - 9 months after the mechanical land preparation.

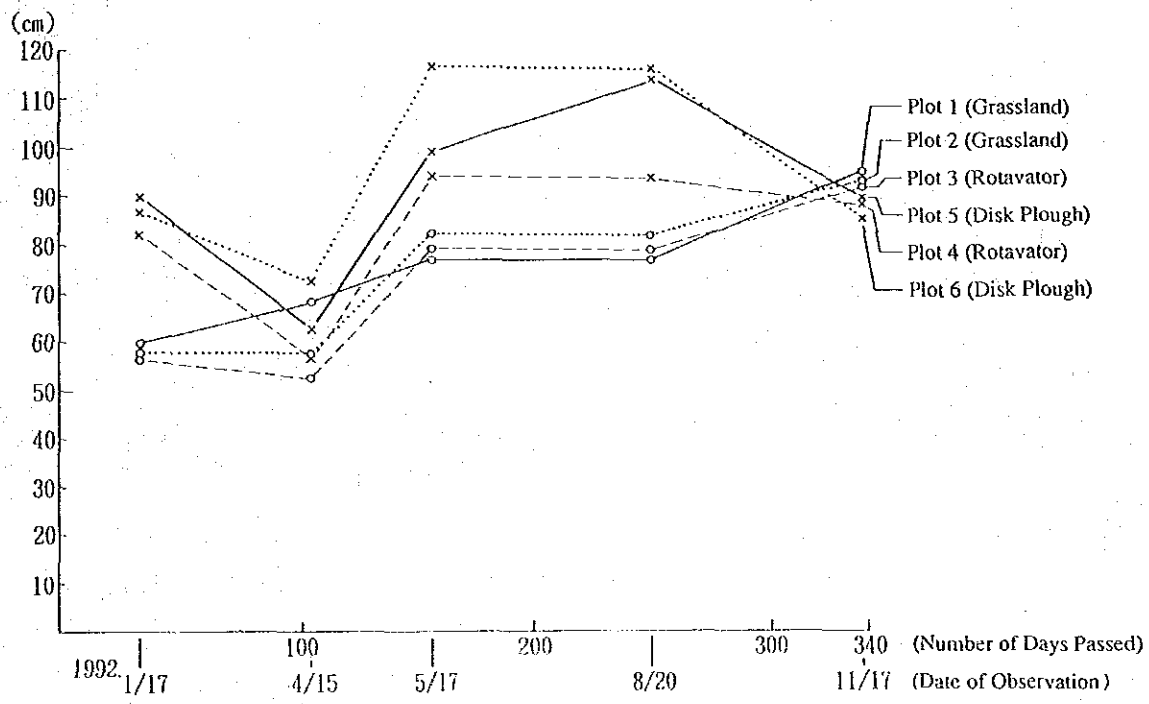


Fig. II-18 Height Growth of Alang-alang: Experiment Site (II)

(5) Effects of Land Preparation

The highest germination rate of 20.0% was recorded by the Acacia mangium rotavator plot as shown in Table II-17, followed by the Acacia mangium grassland plot (9.4%) and the Acacia mangium disk plough plot (9.2%). In the case of Acacia auriculiformis, the germination rate was approximately 1%.

In short, the land preparation using a rotavator or disk plough at the experiment site (II) was not particularly effective given the experiment results shown in Table II-16 (Number of Germinated Seeds), Fig. II-16, Fig. II-17 and Attached Tables 14 and 15 (Number of Surviving Seedlings) and Fig. II-16, Fig. II-17 and Attached Table 16 (Average Height Growth).

The factor strongly affecting the effects of land preparation are the growth density and height of Alang-alang and the new growth of Saccharum sp. after mechanical land preparation.