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F.A.O. PILOT PLANTATIONS OF QUICK-GROWING INDUSTRIAL TREE SPECIES

M A L A Y S I A

EFFECT OF FERTILIZER ON EARLY GROWTH OF PINUS CARIBAEA VAR. HONDURENSIS ON THE RANTAU PANJANG FOREST RESERVE, (EXPERIMENT SS7Q1)

By

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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1. OBJECT

The object of this preliminary test is to study the effect of superphosphate and Japanese pelleted fertilizer on the growth of Pinus caribaea when applied at the time of planting.

2. LOCATION

The test is located on the Rantau Panjang Forest Reserve, Compartment 38, Block C (see Figure 1).

The general landform of this forest reserve is rolling to hilly with the steepest slopes not exceeding 30 per cent. The actual experimental area covers the crest of a low ridge (+200 feet A.S.L.) where micro-topography is uniform and slopes range from 0 to 5 per cent approximately.

The soils which are derived from sandstones and quartzites, are deep, well drained and of a fine sandy clay loam texture. They are identified as the Serdang Series and are rather low in plant nutrients.

3. DESIGN

Two types of fertilizer were tested:-

(i) Superphosphate (40% P_2O_5)

(ii) Kokei Ball Fertilizer: This is a product of Mitsui & Co. of Japan and is a N.P.K. fertilizer. The individual balls weigh approximately 1/2 oz. each. The percentage of N.P & K in this fertilizer, as stated by Mitsui & Co. are as follows:-

NH_4-N	Available P_2O_5	Water Soluble K_2O
6.0	4.0	3.0

Treatments:

(a) Superphosphate 4 oz. per tree
(b) Superphosphate 8 oz. per tree
(c) Pellets approximately 4 oz. per tree
(d) Pellets approximately 8 oz. per tree
(e) Control

The amounts (gm) of the three elements applied per tree under the treatments are as follows:-

Treatment	N	P_2O5	K_2O
(a)	0	45	0
(b)	0	90	0
(c)	6.8	4.5	3.4
(d)	13.6	9.0	6.8
(e)	0	0	0

Lay Out: Randomized blocks (Figure 2)

Unit Plot: One tree

Replications: 20

4. WORK DONE

Block C in Compartment 38 was planted on 4th August, 1969 with 8-month-old potted plants from the Batu Arang nursery, Selangor.

A block of 100 trees on an apparently uniform site was selected before the experiment was laid down. The 100 trees were divided into 20 blocks (20 rows) of five trees each. The treatments were assigned to the blocks at random. The fertilizer was applied in a circle around the tree, five inches away from the trees on 20th October, 1969. Weeds within a radius of 2 feet of the trees were first removed. A shallow trench, 1 inch deep and 1 inch wide was dug around the tree with a small trowel. The appropriate amount of fertilizer was then placed in the trench and covered with soil.

The height of each tree was measured and recorded when the experiment was established and at 3,6,9 and 14 months afterwards.

Pegs with the experiment number were placed in front of the first tree in each row and between every five rows or replications.

5. RESULTS

Table I

Mean Height Increment (ins.) (20 blocks)

	Superphosphate 4 oz.	Superphosphate 8 oz.	Pellets 4 oz.	Pellets 8 oz.	Control
After 3 mths	13.4	13.6	12.6	11.1	9.1
After 6 mths	26.6	28.5	23.0	21.8	17.5
After 9 mths	46.0	48.1	37.1	37.1	29.1

Table II

Health Score, 14 Months After Treatment

	Superphosphate 4 oz.	Superphosphate 8 oz.	Pellets 4 oz.	Pellets 8 oz.	Control
Dead	1	-	-	-	3
Almost dead	2	-	-	1	-
Very unhealthy	-	-	-	1	-
Unhealthy	2	2	2	2	1

The "brown needle" disease has been prevalent in the Rantau Panjang Forest Reserve in recent years. It occurs on the experimental trees and is interfering with the results of this fertilizer test. The effects of the different treatments on the disease is not clear although the highest frequency of dead pines occurs with the control.

Table III

Height Increment After 14 Months (17 Blocks*)

Blocks	Superphosphate 4 oz.	Superphosphate 8 oz.	Pellets 4 oz.	Pellets 8 oz.	Control
2	52.50	34.00	50.00	85.50	41.00
3	60.00	44.00	40.00	15.00	74.00
4	126.00	110.00	34.50	85.50	66.50
6	66.00	72.00	47.50	65.00	72.00
7	92.50	85.25	69.25	90.25	67.00
8	108.00	50.50	41.50	72.00	54.00
10	66.00	113.25	84.00	73.25	36.00
11	106.00	75.50	60.00	53.00	50.00
12	54.00	50.00	93.50	65.50	37.00
13	79.00	83.00	44.50	48.50	29.75
14	96.00	117.50	51.00	48.50	80.50
15	61.00	116.00	62.75	68.00	69.50
16	80.75	91.00	32.50	32.00	[illegible]
17	69.00	48.00	60.50	75.50	[illegible]
18	77.00	102.00	42.00	98.00	[illegible]
19	38.00	67.00	55.50	[illegible]	[illegible]
20	76.00	[illegible]	56.00	[illegible]	[illegible]
Total	1307.75	[illegible]	[illegible]	[illegible]	976.50
Mean	76.93	[illegible]	[illegible]	63.69	57.44

*Excluding Blocks 1,5 & 9 [illegible] trees

An analysis of variance of the above height increments over 14 months is as follows:-

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F	F.T. P=0.05
Blocks	16	10,860.7	678.8		
Treatments	4	7,146.6	1,786.6	4.14	2.51
Error	64	27,629.2	431.7		
Total	84	45,636.5			

Since 4.14 exceeds 2.51, there is a significant difference between the effects of the treatments. Furthermore, the viariability between the blocks is very low (F = 1.57) which confirm the homogeneity of the soil over the site selected for the fertilizer test.

To discover which of the several treatments differences were significant may be done by comparing the treatment means or 't' test.

Standard deviation = $\sqrt{\text{error mean square}} = \sqrt{431.7} = 20.78$

Standard error of treatment means = $\frac{20.78}{\sqrt{17}} = 5.04$

Standard error of differences between two means = $5.04 \times \sqrt{2}$
$= 7.13$

From tables the values of t for 64 degrees of freedom and a probability of 0.05 is approximately 2.00. Therefore, a difference of 7.13 x 2.00 = 14.26 will only be exceeded 1 in 20 times if there is really no differences between the treatment means and differences greater than this between two means can be considered to be significant.

Thus superphosphate significantly increased the height of the trees. Japanese pellets did not.

For a probability of 0.01 the test is only very slightly significant (t = 2.66)

7.13 x 2.66 = 18.97

57.09 (control mean) + 18.97 = 76.06

76.06 < 77.69 (8 oz superphosphate)

76.06 < 76.93 (4 oz superphosphate)

6. CONCLUSION

The response of the young pine trees to superphosphate is not negligible (see Figure 3). After 14 months, the trees which received superphosphate show a total height on an average 35 per cent higher than the controls. The biggest response of the trees, 60 - 65 per cent as compared with the controls, is obtained after 6-9 months. Then it starts to decrease gradually, the highly soluble superphosphate probably being gradually washed away by rain water.

The trees did not response to an increase in superphosphate from 4 ounces to 8 ounces per tree.

The Japanese pellets did not statistically increase the height of the tree. This is most likely due to the low level of P_2O_5 in the pellets (1/10 of the amount in the superphosphate).

The effects of the N and K contained in the pellets are impossible to separate in such a preliminary test.

7. FOLLOW-UP WORK ON THE EXPERIMENT

Height will be measured after another 6 months and every year thereafter (20 June, 1971; June, 1972; June, 1973 etc.)

To avoid competition, tending will be done when necessary, and at least whenever the heights of the trees are measured.

8. REFERENCES

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Fisher and Yates 1963 Statistical tables for biological, agricultural and medical research. Oliver and Boyd, London.

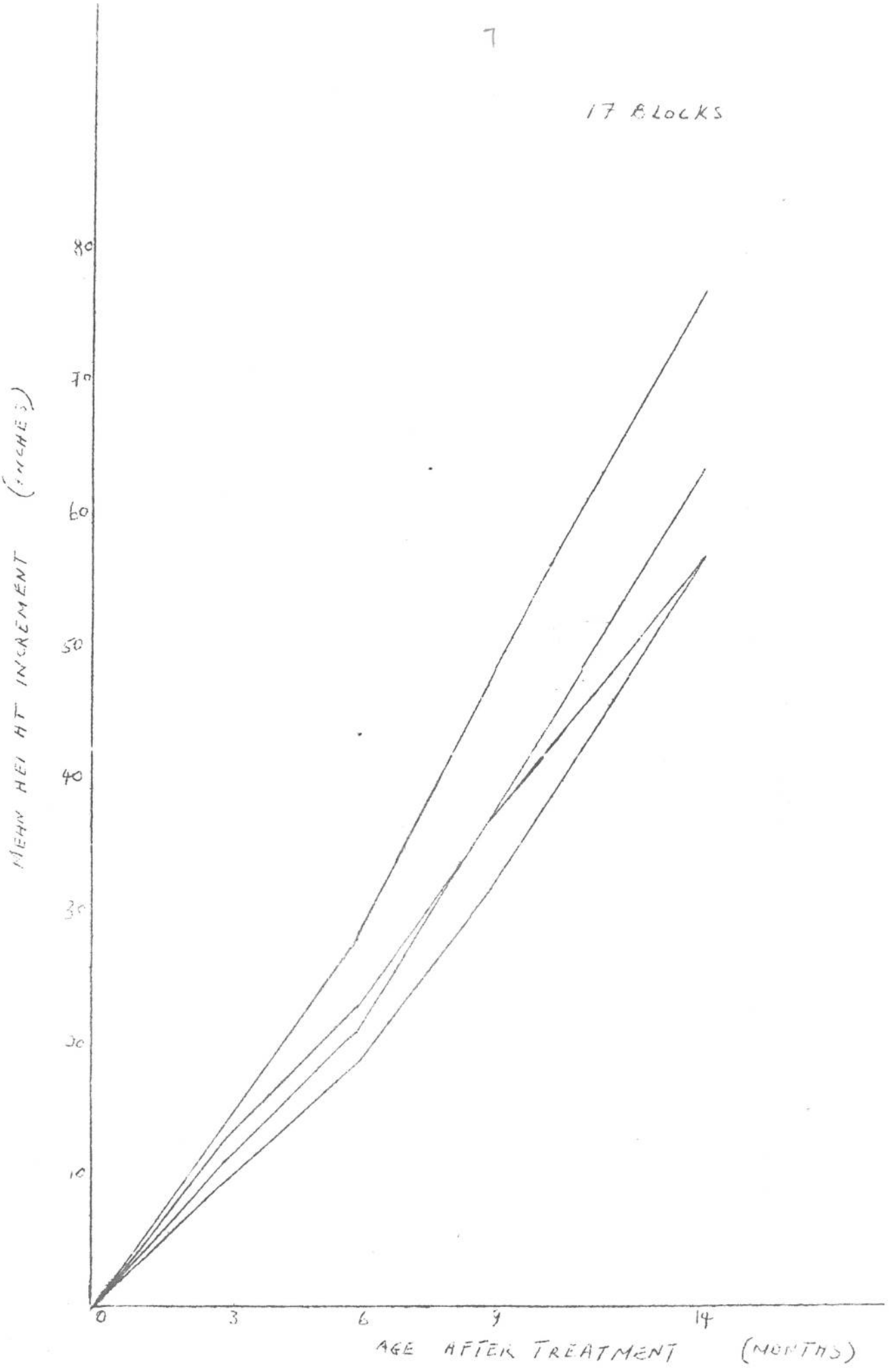
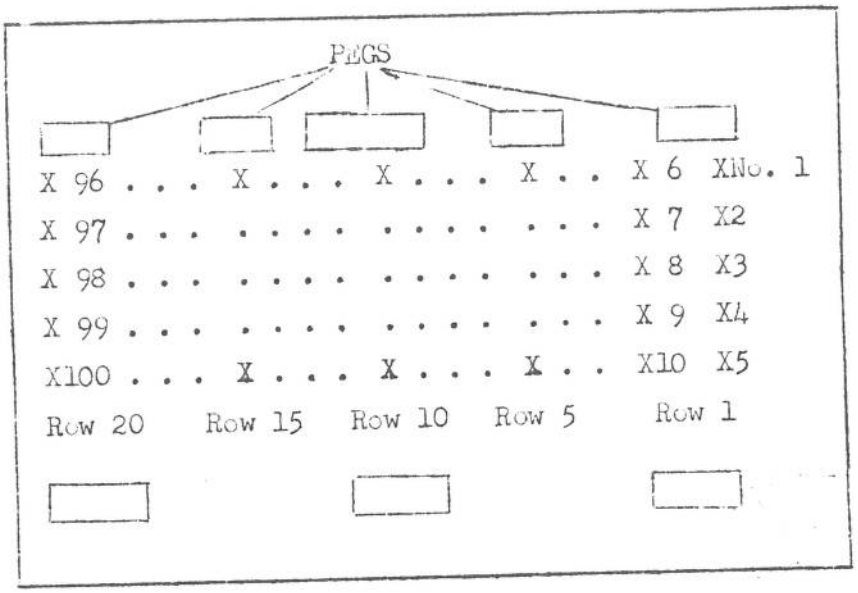


Figure 3

Height increments at 3, 6, 9 and 14 months after treatment

Figure 2

Location: Compartment 38, Block C
Rantau Panjang Forest Reserve



Layout of Experiment (No.SS4.Q.1)

Row	Treatments				
	Tree No. 1	2	3	4	5
1	c	Q	d	e	b
	6	7	8	9	10
2	e	c	b	a	d
3	c	a	b	d	e
4	e	d	c	a	b
5	a	d	c	b	e
6	e	c	b	a	d
7	c	a	b	d	e
8	d	c	a	e	b
9	b	d	c	e	a
10	a	b	d	c	e
11	e	c	d	a	b
12	b	e	c	d	a
13	b	d	e	c	a
14	d	a	c	b	e
15	a	e	b	d	c
16	e	d	c	b	a
17	a	c	b	e	d
18	a	d	e	c	b
19	e	b	a	d	c
20	96	97	98	99	100
	d	b	e	a	c

Randomized Blocks

a---4 ozs. Superphosphate
b---8 ozs. Superphosphate
c---4 ozs. Pallets (Complete)
d---8 ozs. Pallets (complete)
e---Control

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M A L A Y S I A

THE RESULTS OF AN EXPERIMENT ON THE NUTRIENT STATUS OF THE SURFACE SOIL OF THE RANTAU PANJANG FOREST PLANTATION IN SELANGOR, MALAYSIA.

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1. Introduction

The pine plantations on the Rantau Panjang Forest Reserve, near Batu Arang, Selangor show widespread symptoms of illhealth. The soils of these plantations have good physical properties. They are derived from sandstone and are deep, well drained, friable and of a fine sandy clay loam texture, but they are low in nutrients. Analysis of soil samples taken from five profiles dug in Compartment 35 show the following average contents in N, P, & K:-

Contents expressed in kg. per ha. for a depth of 200 cm.

Nitrogen	6,500	(low)
Available phosphorus	25	(very low)
Available potassium	90	(low)

The symptoms of illhealth which include dead tops and branches, thin crowns, poor colour of foliage, leafless shoots and excessive foxtailing, suggest nutrient deficiency.

It was therefore decided to lay down a pot trial using surface soil from a freshly cleared and burned site on the forest. The Project number of the experiment is No. SS402.

There was no glasshouse at the Forest Research Institute at Kepong, and a temporary plant house was designed and built in the Kepong nursery for the experiment. This plant house has a wooden frame and is roofed with transparent polythene. It is 25ft. long, 14 ft. wide and 7ft. high. (Fig. 2).

After the experiment was concluded, a more permanent type of plant house was built. It is 37ft. long, 14ft. wide and has a corrugated plastic roof.

The nursery and laboratory facilities of the Forest Research Institute at Kepong were used for the experiment.

The Rantau Panjang plantations are comprised almost entirely of Pinus caribaea var. hondurensis. Annual plantings were started in 1962 and at the end of 1970 approximately 1,000 acres had been planted.

2. Object

The object of the experiment was to determine which elements, if any, are deficient with regard to the growth of *Pinus caribaea* var. *hondurensis* in the surface soil of a freshly cleared planting site on the Bantau Panjang Forest Reserve in Selangor. This is a preliminary experiment which was laid down with the aim of obtaining information for use in planning future field fertilizer trials.

3. Design.

Omission type.

3.1 Treatments.

1. Minus nitrogen
2. Minus phosphorus
3. Minus potassium
4. Minus sulphur
5. Minus calcium
6. Minus magnesium
7. Minus iron, manganese, zinc
8. minus boron
9. Minus copper
10. Minus molybdenum
11. Minus nickel
12. Nil
13. All on *
14. All on
15. All on
16. Plus phosphorus (minus 12 elements)
17. Plus nitrogen, phosphorus, potassium, sulphur
18. Plus nitrogen, phosphorus, potassium sulphur, boron, nikel, copper (minus 6 elements)

********** **********

* "All on" = N,P,K,S,Ca,Mg,Fe,Mn,Zn,B,Cu,Mo & Ni.

3.2 Randomization

Rep. 1		Rep. 2		Rep. 3		Rep. 4		Rep. 5		Rep. 6	
Pot No.	Treat-ment	Pot No.	Treat-ment	Pot No.	Treat-ment	Pot No.	Treat-ment	Pot No.	Treat-ment	Pot No.	Treat-ment
1	17	19	17	37	2	55	3	73	6	91	7
2	7	20	1	38	9	56	4	74	17	92	13
3	3	21	12	39	16	57	10	75	13	93	17
4	13	22	3	40	4	58	13	76	12	94	11
5	12	23	2	41	6	59	16	77	15	95	1
6	16	24	13	42	3	60	14	78	18	96	4
7	15	25	10	43	5	61	18	79	9	97	14
8	1	26	14	44	13	62	5	80	3	98	6
9	10	27	15	45	10	63	9	81	14	99	8
10	14	28	16	46	17	64	17	82	2	100	5
11	2	29	5	47	18	65	15	83	1	101	2
12	8	30	6	48	8	66	12	84	7	102	16
13	4	31	7	49	7	67	11	85	4	103	18
14	5	32	9	50	12	68	6	86	10	104	12
15	9	33	18	51	1	69	7	87	16	105	10
16	11	34	11	52	15	70	1	88	5	106	15
17	6	35	8	53	11	71	2	89	8	107	3
18	18	36	4	54	14	72	8	90	11	108	9

3.3 Replications: Six

3.4 Pots

3,500 gr. tins of 3179 cc (dia., 15.3cm; ht., 17.3cm) capacity. The tins were sprayed with varnish (ICI, Duco, Wood Finish, glossy water white) and fitted with drainage holes and placed on dishes which acted as "saucers".

3.5 Rate of Application of Nutrients.

Element	Compound	Rate per acre
Nitrogen	NH_4 NO_3	6 cwt
Phosphorus	NaH_2PO_4	5 cwt
Potassium	KCl	1 cwt
Sulphur	Na_2SO_4	1 cwt
Calcium	$CaCl_2$	$\frac{3}{4}$ cwt
Magnesium	$MgCl_2$	$\frac{1}{2}$ cwt
Iron	$FeCl_2$	$\frac{1}{2}$ cwt
Zinc	$ZnCl_2$	$\frac{1}{4}$ cwt
Copper	$CuCl_2$	7 lbs
Manganese	$MnCl_2$	14 lbs
Molybdenum	Na_2MoO_4	$\frac{1}{2}$ lb
Boron	$Na_2B_4O_7$	2 lbs
Nickel	NiCl	$\frac{1}{2}$ lb

The following solutions were made up in order to deliver the above rate in a 10 ml. aliquot. One third of each treatment was added before sowing, one third after two months and the final third after another two months.

Compound	Nutrient Element	Weight (gr.) Dissolved in 2 litres of water	Desired rate/acre in gr. per tin, delivered by 10 ml. aliqu
NH_4HO_3	N	274.80	1.374
NaH_2PO_4 (2H20)	P	229.00	1.145
KCl	K	45.80	0.229
Na_2SO_4 (10 H20)	S	45.80	0.229
$CaCl_2$ (6 H20)	Ca	34.34	0.1717
$MgCl_2$ (6 H20)	Mg	22.90	0.1145
$ZnCl_2$	Zn	11.44	0.0572
$FeCl_2$ (4 H20)	Fe	22.90	0.1145
$MnCl_2$ (4 H20)	Mn	5.72	0.02862
$CuCl_2$ (2 H20)	Cu	2.86	0.0143
$Na_2B_4O_7$ (10 H20)	B	0.818	0.00409
Na_2MoO_4 (2H20)	Mo	0.204	0.00102
NiCl (6 H20)	Ni	0.204	0.00102

The above quantities were calculated as follows:-

Tin diameter : 6.0 inches
Top area : 28.27 sq. ins.
Area of an acre : 6272640 sq. ins.
1 lb. = 453.5924 grammes
N rate = 6 cwt per acre

$$\text{Gr. per tin} = \frac{28.27}{6272640} \times 672 \times 453.5924 = 1.374$$

The quantity was dissolved in 2 litres to yield the full application in aliquot of 10 mls. ..... 1.374 x 200 = 274.80 gr.

4. Location

The glasshouse is located at the Forest Research Institute nursery at Kepong, Selangor.

5. Work performed.

5.1 Soil.

The soil, a sandy loam, is from the crest of a low ridge (200ft. a.s.l.) with uniform microtopography in Compartment 38 D, Rantau Panjang Forest Reserve, Selangor.

The soil was sampled on 12/11/1969, from the 0-10 cm top horizon, 2 months after clear felling and burning of the secondary forest. Soil over 5 different 1 m^2 areas was collected, mixed together, sifted and airdried.

Analysis from an average sample (F.R.I. Laboratory) shows:

pH	4.7	
C	1.78%	
P	10.9 p.p.m.	(available P)
K	27.0 p.p.m.	(available K)
N	.15%	

5.2 Tins

The tins are 15.3 cm (6 ins.) in diameter and 17.3 cm in height (3179 cc capacity) and weigh 275 grs. Gravel for drainage plus the tin weighed 580 grs; weight after filling to within 2.5 cm of top with air-dry soil was 3,500 grs. Ten grs. of soil was added during the process of sowing.

5.3 Nutrients and pre-germinated seeds.

Nutrients at one third of the full rate were applied on 13-15/12/1969 and pre-germinated seeds were sown on 22/12/69 under light shade. Each pot received 10 pre-germinated seeds; the 10 plants were thinned to 5 on the 29/1/1970.

During the first month after sowing, losses due to insects (crickets) occurred; the damaged plants were replaced by plants from spare tins which had been sown without fertilizer treatment

All watering was done using demineralized water.

Shade was removed from the glasshouse on 3/2/70.

6. Observations and measurements.

A few months after the experiment was established abnormalities showed up in some pots of replications 4, 5 and 6, sited on one side of the glasshouse; these abnormalities, as compared with the three other replications, strongly suggested that some treatments were accidently mixed up. Therefore it was decided that replications 4, 5 and 6 should be neglected in the results and conclusions of the experiment.

Heights of three tallest seedlings per pot were measured in March, April, May, June and September. Fig. 1 shows the resulting height/age relationship up to 9 months of age (for the 3 replications only).

For the first 2-3 months after sowing, the seedlings of all treatments were growing well and uniformly. However, after 3 months of age the following differences occurred:-

Treatments including phosphorus. All the seedlings were healthy, fast growing and of a uniform dark green colour. No deficiency symptoms were observed. Apart from the +P treatment which up to 6 months of age was well ahead of the other treatments, no marked differences were observed among the treatments.

All the seedlings were free from the "brown needle disease" which seriously infested the surrounding nursery; this was probably due to the fact that in this glasshouse experiment the needles were never wet.

The treatment without phosphorus showed striking deficiency effects. At 3 months of age, growth appeared to cease almost completely on treatments -P and Nil (see Fig. 1); the seedlings were by that time 5 inches high. The colour changed gradually to a yellow green; necrosis, in the form of a change from green to purple brown colour, appeared on the tips of the bottom needles, then the necrosis spread to the whole needle and from the bottom of the seedling up. One month later, the seedlings were stunted, 5-6 inches high, with short yellow-green needles restricted to the upper 1/3 of the seedling; the bottom needles were all dried up and dead. By the time the experiment was completed, only a few seedlings were alive.

Fig. 3 taken on 7/5/70, illustrates the symptoms of P deficiency.

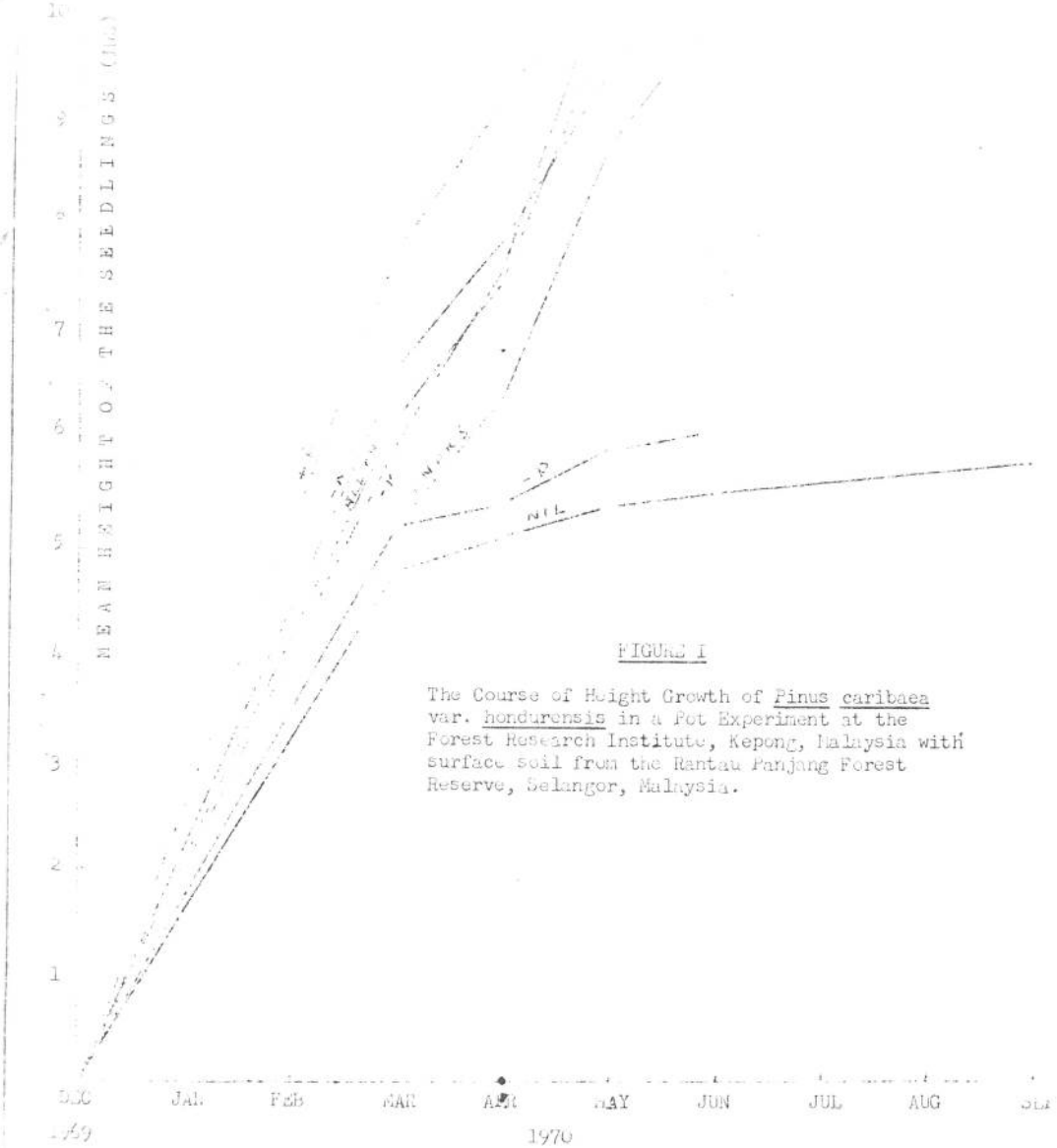
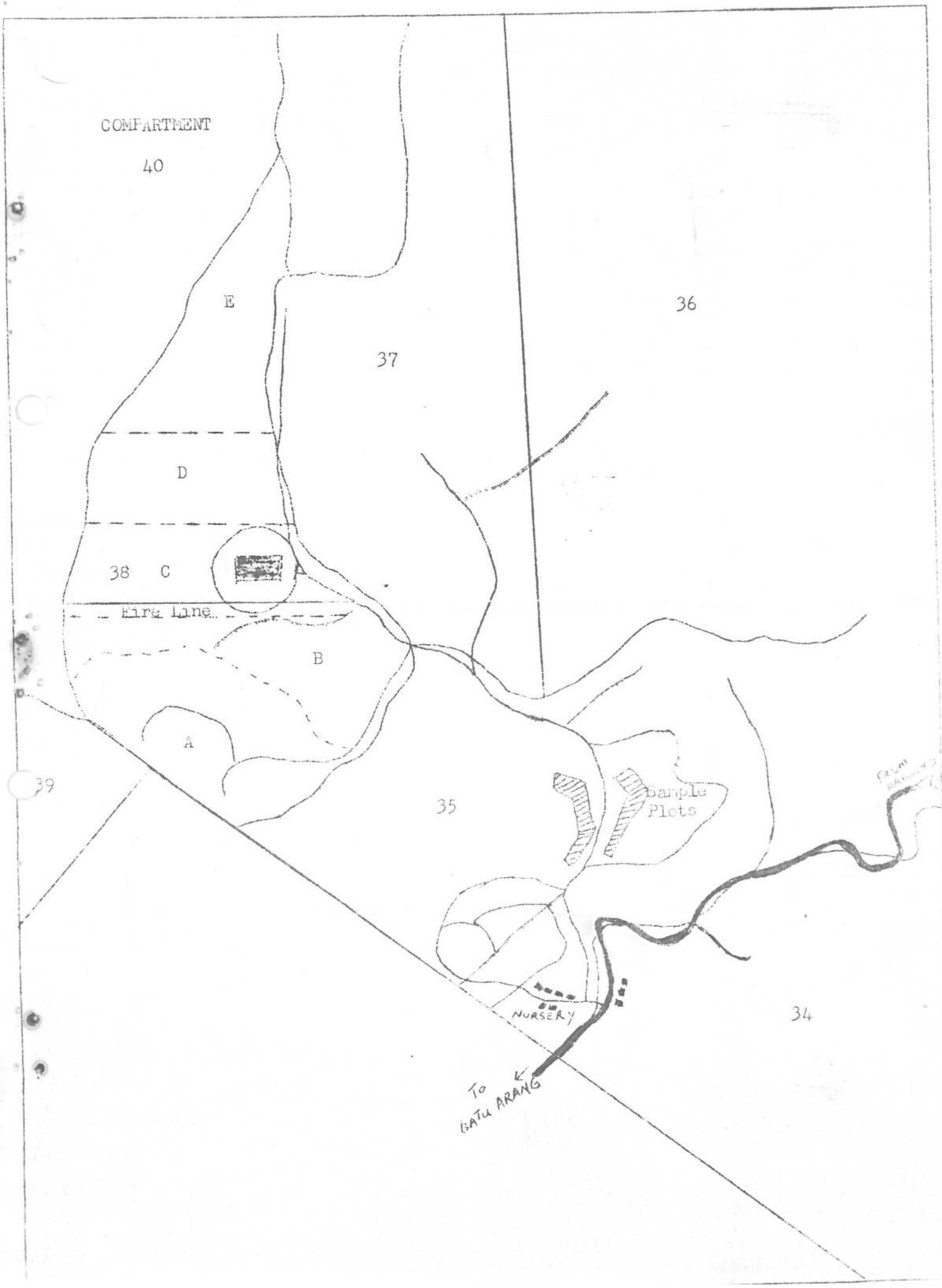


FIGURE I

The Course of Height Growth of Pinus caribaea var. hondurensis in a Pot Experiment at the Forest Research Institute, Kepong, Malaysia with surface soil from the Rantau Panjang Forest Reserve, Selangor, Malaysia.

Figure 1
Location of the Experiment (SS4.Q.1) on the
Rantau Panjang Forest Reserve



7. Results at the end of one year.

On 19/12/70, heights and weights were recorded for the 3 replications (1,2 & 3; 54 pots).

For the heights, all the living plants were measured and dead plants were ignored (the dead plants occurred mostly in treatments without P.)

Unfortunately the plants were accidently burned in the oven during the process of drying. Therefore only fresh weight data can be used.

Table 1. Fresh Weight of Tops (grammes)

Treatment	Replications			Total	Mean
	1	2	3		
1	105.3	132.2	122.9	360.4	120.1
2	3.0	4.0	1.0	8.0	2.7
3	83.2	123.9	138.2	345.3	115.1
4	109.2	145.8	116.8	371.8	123.9
5	110.1	122.9	127.8	360.8	120.3
6	116.5	111.5	128.0	356.0	118.7
7	124.8	115.9	152.6	393.3	131.1
8	139.4	107.3	134.0	380.7	126.9
9	110.2	99.5	125.6	335.3	111.8
10	108.2	147.0	115.5	370.7	123.6
11	135.8	143.8	116.6	396.2	132.1
12	2.2	3.5	9.7	15.4	5.1
13	100.2	151.4	128.3	379.9	126.6
14	124.8	113.2	129.0	367.0	122.3
15	121.8	131.3	137.3	390.4	130.1
16	112.8	145.0	139.0	396.8	132.3
17	151.2	127.2	142.8	421.2	140.4
18	110.9	130.2	146.8	387.9	129.3

Table 2. Fresh Weight of Roots (grammes)

Treatments	Replications			Total	Mean
	1	2	3		
1	22.0	26.0	29.0	77.0	25.7
2	1.0	1.5	0.5	3.0	1.0
3	23.5	46.0	20.0	89.5	29.8
4	29.0	37.0	29.5	95.5	31.8
5	21.5	28.0	31.0	80.5	26.8
6	36.5	20.0	27.5	84.0	28.0
7	52.5	30.0	29.0	111.5	37.2
8	21.0	22.5	35.5	79.0	26.3
9	24.0	16.5	23.0	63.5	21.2
10	28.0	43.5	26.0	97.5	32.5
11	47.0	38.5	27.0	112.5	37.5
12	1.0	1.0	3.0	5.0	1.7
13	24.5	33.0	29.0	86.5	28.8
14	37.0	28.0	39.0	104.0	34.7
15	24.0	24.0	28.0	76.0	25.3
16	36.0	26.5	22.0	84.5	28.2
17	32.0	20.5	27.0	79.0	26.5
18	31.2	24.2	27.3	82.5	27.5

Table 3. Total Fresh Weight of Tops and Root. (grammes)

Treatments	Replications			Total	Mean
	1	2	3		
1	127.3	158.2	151.9	437.3	145.8
2	4.0	5.5	1.5	11.0	3.7
3	106.7	169.9	158.2	434.8	144.9
4	138.2	182.8	146.3	467.3	155.8
5	131.6	150.9	158.8	441.3	147.1
6	153.0	131.5	155.5	440.0	146.7
7	177.3	145.9	181.6	504.8	168.3
8	160.4	129.8	169.5	459.7	153.2
9	134.2	116.0	148.6	398.8	132.9
10	136.2	190.5	141.5	468.2	156.1
11	182.8	182.3	143.6	508.7	169.6
12	3.2	4.5	12.7	20.4	6.8
13	124.7	184.4	157.3	466.4	155.5
14	161.8	141.2	168.0	471.0	157.0
15	145.8	155.3	165.3	466.4	155.5
16	148.8	171.5	161.0	481.3	160.4
17	183.2	147.7	169.8	500.7	166.9
18	141.9	154.4	174.1	470.4	156.8

Table 4. Average Height (ins)

Treatment	Replications			Total	Mean
	1	2	3		
1	13.0	14.6	14.7	42.3	14.1
2	5.5	7.1	-	12.6	6.3
3	10.6	14.9	14.6	40.1	13.4
4	11.7	14.0	15.2	40.9	13.6
5	12.3	13.5	14.6	40.4	13.5
6	11.1	13.3	11.6	36.0	12.0
7	10.9	14.4	15.0	40.3	13.4
8	13.7	13.5	13.9	41.1	13.7
9	11.3	13.1	14.2	38.6	12.9
10	11.7	13.6	11.4	36.7	12.2
11	13.5	15.4	11.1	40.0	13.3
12	5.7	6.9	9.6	22.2	7.4
13	10.9	13.4	13.0	37.3	12.4
14	12.8	13.6	12.7	39.1	13.0
15	12.8	14.0	14.1	40.9	13.6
16	11.0	16.5	15.2	42.7	14.2
17	11.6	10.8	13.9	36.3	12.1
18	11.5	15.2	11.8	38.5	12.8

8. Statistical Analysis

8.1 Omission of treatments 2 and 12 in the analyses

In both sets of data, there is no purpose in including the above two treatments, since these are very obviously extremely poorly developed relative to the others.

8.2 Analysis of Variance of Total Fresh Weight

Source	S.S.	D.F.	M.S.	V.R.
16 Treatments	3526	15	235	0.56
(3) Residual	13478	32	421	-
	17004	47		

S.E. of difference between two treatment means is therefore approximately 17 and hence the critical difference exceeds 35. Most of the means ranged between 150 and 160. Only treatment No. 9 (value 133) and No. 11 (value 170) stand out, but neither of these is statistically significant.

8.3 Analysis of Variance of Mean Height

Source	S.S.	D.F.	M.S.	V.R.
16 Treatments	19.8	15	1.3	0.5
(3) Residual	82.7	32	2.6	-
	102.5	47		

The analysis of variance of mean height also shows no significant differences, even treatments 9 and 11 are entirely unremarkable. (Table 4).

8.4 Conclusions

It can be seen in Tables 1, 2, 3 & 4 that phosphorus is a very serious limiting element and that absence of additional phosphorus resulted in extreme stunting and even starvation of the plants.

The tables do not show any obvious effect on growth of the other elements tested.

A field experiment was conducted on a newly planted area, in Compartment 38, Block C in the Rantau Panjang Forest Reserve. Fertilization with superphosphate has had a striking effect on the rate of height growth of Pinus caribaea var. hondurensis during the first year in the plantation. (Platteborze, 1971)

A study carried on in old plantations indicates the existence of a correlation between the phosphorus content of the soil and the growth rate of Pinus caribaea (Platteborze, 1971)

9. Acknowledgements

The author is greatly indebted to Mr. H.D. Waring, Consultant in Soil and Nutrition, who gave the full details of the design of this experiment.

Thanks are also due to the following members of the Forest Research Institute: Mr. Ee Chong Sen, former Forest Soil Survey Officer, who was responsible for the applications of the nutrients; Mr. Joseph Anthony, Nursery Officer who very kindly collected the final data; and Mr. K.Nandrasegaran, Forest Statistician, who did the statistical analyses.

The author is also grateful to Dr. Fielding, Project Manager, for his advice and guidance.

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Fig. 2. The Glasshouse experiment at the Forest Research Institute Nursery at Kepong, Selangor.

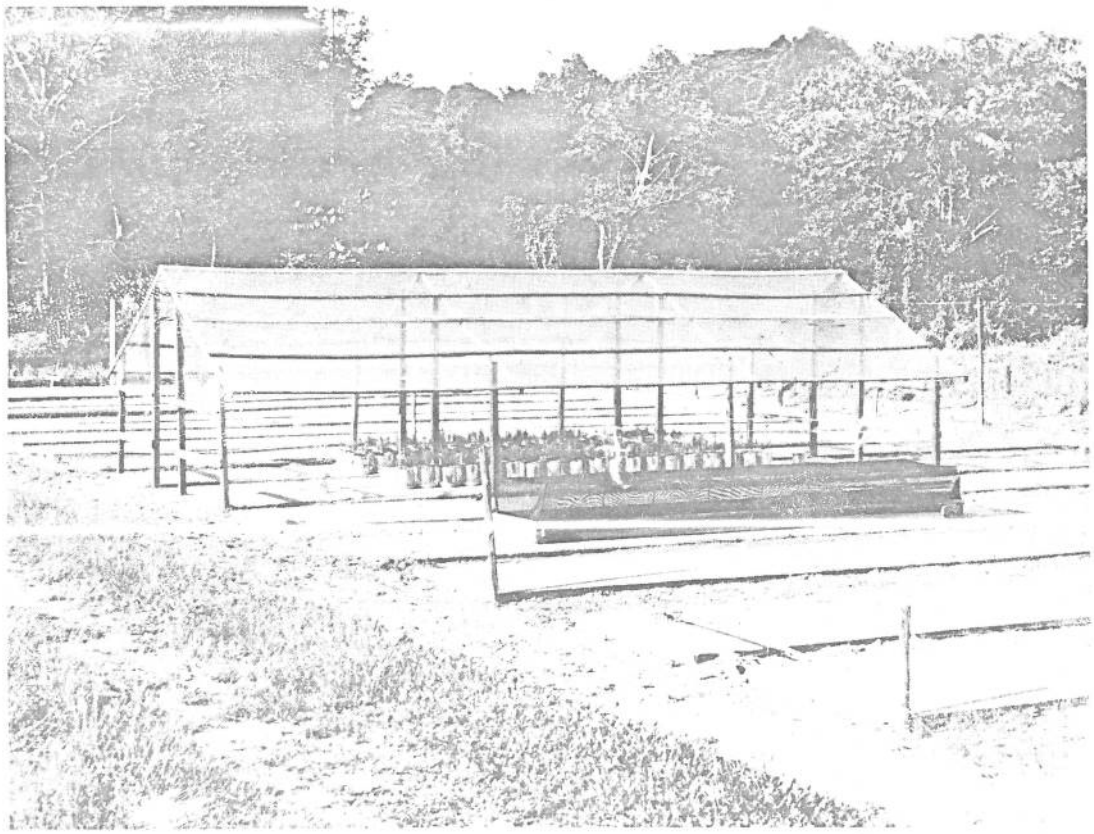


Photo by J. M. Fielding.

Fig. 2. The Glasshouse Experiment at the Forest Research Institute Nursery at Kepong, Selangor.

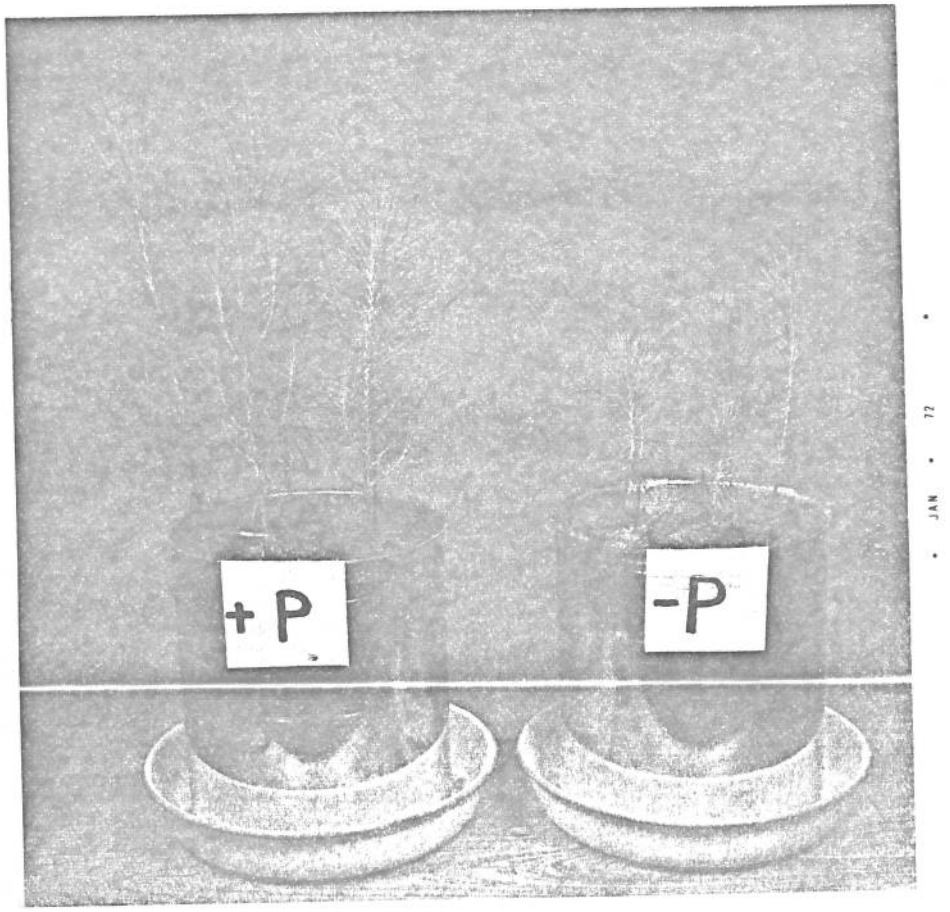
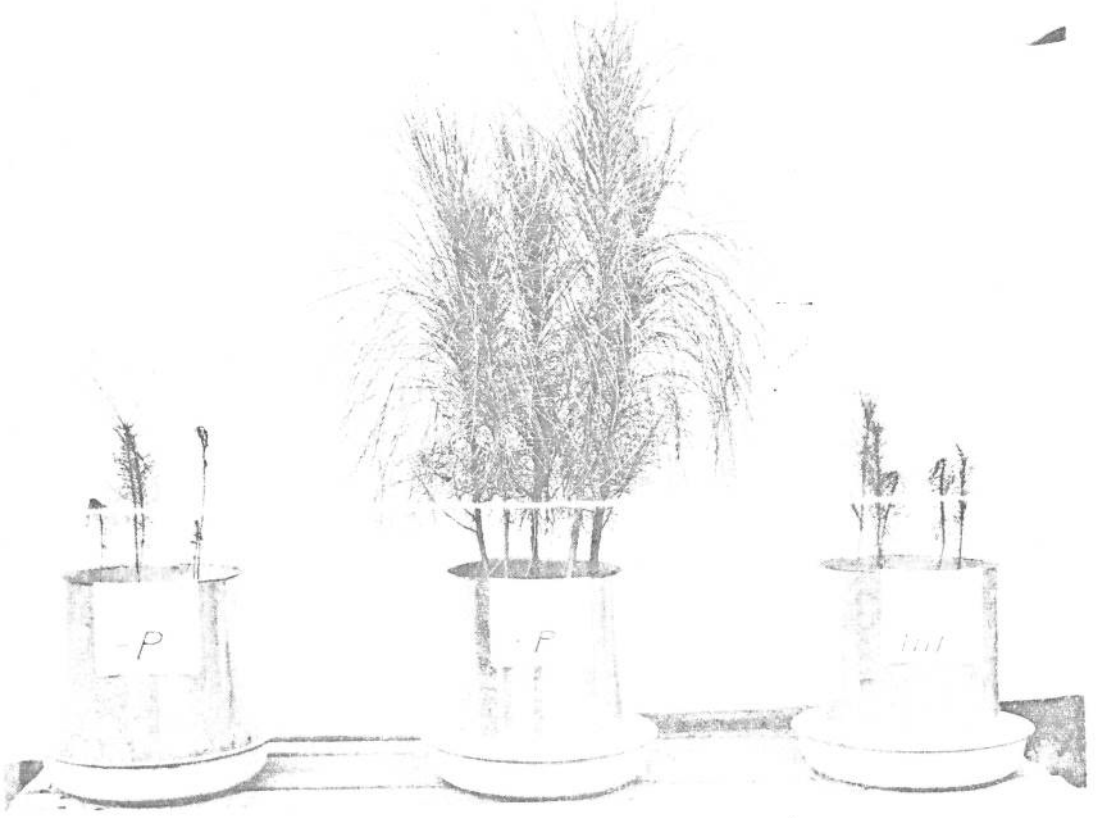


Fig. 3. Pinus caribaea var. hondurensis.
After 4½ months, the plants of treatments without phosphorus are stunted, with short yellow green needles restricted to the upper part of the stem.
Symptoms of phosphorus deficiency are clearly visible on treatment -P.



F.R.I. Photo by Ho Sai-Yuen

Fig. 4. *Pinus caribaea* var. *hondurensis*. Result at the end of the experiment.

F.R.I. Photo by Ho Sai-Yuen

Fig. 5. Figure shows that the addition of phosphorus alone has resulted in growth equivalent to the addition of all the thirteen elements used in the experiment.

FO: SF/MAL 67/512
Technical Report 5

PILOT PLANTATIONS OF QUICK-GROWING INDUSTRIAL TREE SPECIES

M A L A Y S I A

SOILS AND NUTRITION IN RELATION TO THE ESTABLISHMENT OF PINE PLANTATIONS IN WEST MALAYSIA

Report prepared for
the Government of Malaysia
by
the Food and Agriculture Organization of the United Nations
acting as executing agency for
the United Nations Development Programme

based on the work of

A. Platteborze
Soils Expert

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Kuala Lumpur, 1972.

This technical report is one of a series of reports prepared during the course of the UNDP/SF project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

The designations employed and the presentation of the material in this report do not imply the expression of any opinion whatsoever on the part of the United Nations or the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Soils and Nutrition in Relation to the Establishment of Pine Plantations in West Malaysia based on the work of A. Platteborze, Kuala Lumpur, 1972.
FO: SF/MAL 67/512. Technical Report 5.

ABSTRACT

This report summarizes soil surveys of potential pine plantation areas and established plantations in West Malaysia, and aspects of the nutrition of these plantations.

Reconnaissance surveys were made of forest areas which had been proposed as potential plantation sites, and four plantation areas. A soil suitability classification for pine plantations was drawn up, under which West Malaysian soils are arranged in four classes- from very suitable (Class A) to unsuitable (Class D).

A correlation was established between the phosphorus content of the soil and the growth rate of P. caribaea var. hondurensis in West Malaysian plantations. Nutrition and fertilizer experiments showed that the application of phosphate to certain soils resulted in marked increases in the growth rate and health of P. caribaea var. hondurensis. A number of long-term fertilizer trials were established.

ACKNOWLEDGEMENTS

The Food and Agriculture Organization of the United Nations is greatly indebted to the many people who provided the expert with information, advice and facilities. In particular it is desired to acknowledge the help given by the University of Malaya and the Rubber Research Institute at Kuala Lumpur.

CONTENTS PAGE

1. INTRODUCTION

In November, 1967, the Government of Malaysia, assisted by the Food and Agriculture Organization of the United Nations (FAO) under the United Nations Development Programme (Special Fund) (UNDP), started a five year project titled "Pilot Plantations of Quick-Growing Industrial Tree Species" to carry out investigations connected with a proposal to establish a pulp and paper industry. This report describes work done under the project on soil surveys, and on nutrition and fertilizer investigations in West Malaysian pine plantations.

BACKGROUND

The first experimental plot of conifers was planted in Malaysia in 1932 when a plot of Pinus kesiya was established in the Cameron Highlands. However, systematic trials with exotic conifers started only in 1950 when an Afforestation Branch was developed in the Forest Research Institute at Kepong.

Initially the Afforestation Branch was established in order to conduct afforestation research on degraded mined areas. Later it was decided to investigate the use of introduced conifers in areas poor or deficient in natural regeneration and to look into the feasibility of a pulp and paper industry based on locally grown long-fibre materials.

In 1964, United Nations aid was sought in connection with conifer afforestation research. The Government's view then was that the large-scale planting of pines could be safely undertaken in Malaysia and that it was considered "neither premature nor inherently risky that steps be taken to establish plantations of these quick-growing industrial species on a more extensive scale to initiate industrialization".

PURPOSE OF THE PROJECT

The project was approved in November, 1967. The Food and Agriculture Organization of the United Nations is acting as executing agency for the United Nations Development Programme.

The main purpose of the UNDP/SF project "Pilot Plantations for Quick-Growing Industrial Tree

Species, as described in the Plan of Operation was to consist in establishing pilot plantations on which to demonstrate techniques for establishing large-scale plantations of quick-growing long-fibred tree species as a continuous supply of cellulose material. Selection of potential plantation areas from the point of view of proximity to the proposed mill sites, accessibility and erodibility of the soil for sustained tree growth was the aspect of the project's work.

PURPOSE AND SCOPE OF THE SOILS ACTIVITIES

As part of the project, Mr. A. Platteborze was appointed by FAO as a Soil Survey Expert for three years from November, 1967. His terms of reference as outlined in the employment contract were:-

"Under the general supervision of the Project Manager and in close collaboration with the national counterparts, the Soil Surveyor will:

1. assemble all existing information on soils of project area and make quick reconnaissances in order to assist in the selection of potential plantation areas;

2. carry out a semi-detailed soil survey and land capability classification of selected areas and make investigations on characteristics and management of representative soils;

3. carry out a detailed survey of selected sites for nurseries and pilot plantations;

4. produce maps and reports;

5. train the national counterparts in the above survey techniques".

However, it became obvious in 1969 that the emphasis of the project would have to be shifted from establishing pilot plantations to investigations. Such a change was needed because of a number of problems which were found to be associated with establishing conifer plantations in Malaysia. Two of the most important of these problems were associated with soils. The first problem is the rather widespread occurrence of ill-health in Malaysian pine plantings due probably to soil nutrient deficiencies complicated in some cases

by inter-action with competing weeds. The second problem was that virtually all the pine plantings in West Malaysia were found to be located on the best (Class 1 & Class 2) soils - which are in high demand for agriculture.

A new programme of work was subsequently adopted for the project. Under this new programme the main soils activities were changed from soil surveys to investigations into the nutrition of conifers and the use of fertilizers and into the relationship between soil fertility and the growth rate of pines. The study of the soil / growth rate relationship was needed in order to gain a better knowledge of the growth of the pines under Malaysian conditions and to enable a soil suitability classification for pine plantations to be drawn up. Because Malaysian conifer plantations were found to be concentrated on the best (Class 1) soils, it was necessary to establish trial plots (in association with fertilizing) on the poorer soil series.

4 WORK ON SOILS BY THE SOIL SCIENCE DIVISION OF THE DEPARTMENT OF AGRICULTURE AND THE RUBBER INDUSTRIES

The Soil Science Division of the Department of Agriculture completed a reconnaissance soil survey of West Malaysia in 1967 and a generalized soil map of West Malaysia was made available at the end of 1968. These soil maps are useful not only for agriculture but also for forestry, and they are a valuable aid in the selection of sites for pine plantations. The Department of Agriculture has also drawn up a "Soil Suitability Classification" mainly for the use of rubber and oil palm planters (Leamy and Panton, 1966). This classification, which has relevance also for pine planting, is referred to in Section 3. The Rubber Research Institute of Malaya has done excellent work on soil nutrition and the use of fertilizers - work which is also valuable for Malaysian foresters.

2. SOILS OF WEST MALAYSIA

The soils are characterized by intense weathering and in general have very good physical properties. They are fairly deep and generally well drained and they

show adequate clay content and good water holding capacity, porosity and structure. Except for the A horizon, which is the level of maximum biological activities, the horizons are usually weakly developed. Granite, sandstone and shale are the most common parent rocks.

The soils acid (pH 4.5-5), very leached and possess low nutrient reserves. Chemical analyses show that most of the available nutrients are retained in the surface soil (A horizon) Nutrient contents fall very abruptly in the horizons below the surface soil. There are usually no weatherable minerals within the reach of the roots except in the shallow soils of the "steeplands".

In the tropical rainforest there is a constant circulation of mineral nutrients and organic matter between soil and plant which acts against leaching and helps to maintain the level of soil fertility. When the forest is disturbed the equilibrium is interrupted and the soil fertility can quickly degenerate. Clearing and burning of the natural forest is a common and probably unavoidable practice in any plantation scheme and involves considerable nutrient losses from a system inherently low in nutrients. Erosion is accelerated, leaching losses are increased and the fertile surface soil can quickly deteriorate.

3. SOIL SUITABILITY CLASSIFICATION FOR PINE PLANTATIONS

The successful introduction of an exotic forest tree involves long-term planting trials and research. Such a research programme is essential in order to obtain a satisfactory knowledge of the performance of the species under local conditions and to allow sound decisions to be made on the economics of large-scale plantations. A study of the relationship between pine and soil is an important part of a research programme but it requires the establishment of experimental plantings on a wide range of representative soils.

Experimental pine plantations were started in Malaysia in 1950. Most of these experimental plantings were established on the better soils. The few plantings on soils of lower value (with physical limitations)are

general[illegible] limited in area to be of great help in determ[illegible] the effects of these limitations on the grow[illegible] the pines. The project has therefore started to est[illegible]sh trial plantings on the poorer soils.

The soil suitability classification for pines which is given in this report has been developed from in[illegible]tions made in the pine plantations throughout W[illegible]laysia, combined with information available from ex[illegible]ence with pines in other countries. The soil suitability classification available from the Malaysian Department of Agriculture, and which has been developed mainly for rubber and oil palm, was also found very useful in formulating the classification. This soil suitability for pines should be regarded as tentative, especially in the lower classes. It is probable that amendments to the classification will be required when more information becomes available from experimental plantings now being made.

The classification is based on two main assumptions, one of the most important of which is that the plant nutrient deficiencies which characterize Malaysian soils can be corrected by fertilizers. Fertilizer requirements are not mentioned because the necessary information is not yet available for the wide range of soils considered. However, in Section 6, guidelines are given on the critical level of phosphorus. Another important assumption concerns the soil internal drainage. It is considered that extensive artificial drainage is neither feasible nor economical for pine plantations in Malaysia. The major difference between the pine soil suitability classification proposed in this report and the Malaysian Agriculture Department classification (Leamy and Panton, 1966) is therefore in the importance placed on internal drainage.

In the proposed classification for pines, four classes have been established. In order to avoid confusion with the Agriculture Department classification, letters A, B, C, D are used instead of numbers.

3.1 A KEY TO THE SUITABILITY CLASSES

Classes	Description
Class A Very suitable	Soils with no limitations These are deep (over 3 feet), well drained, friable, well aerated and structured soils. Texture is not of prime importance provided it is not sand, and provided the other conditions are satisfied.
Class B Suitable	Soils with minor limitations These are deep (over 3 feet) soils with one or more of the following limitations:- (a) moderate drainage (b) weak structure (c) weak or moderate compaction (d) frequent (up to 50% of volume) stones or concretions.
Class C Marginal	Soils with at least one serious limitation The limitations are:- (a) effective depth of only 2-3 feet (b) imperfect or excessive drainage (c) very frequent (50-80% of volume) stones or concretions (d) strong compaction (e) peat layer (above 4,000 feet a.s.l. - not associated with poor drainage conditions (f) sand texture throughout (g) slopes steeper than 40% but less than 60%
Class D Unsuitable	Soils with at least one very serious limitation The limitations are :- (a) effective depth less than 2 feet. (b) poor drainage and associated conditions (peat, acid sulphate clays, salinity) (c) dominant (over 80% of volume stones or concretions (d) slopes steeper than 60%

3.2 CLASSIFICATION OF REPRESENTATIVE SOIL SERIES ACCORDING TO THEIR SUITABILITY FOR PINES

3.2.1 Lowlands

On the basis outlined above, the most representative soils occurring in West Malaysia are classified in Table I according to their estimated suitability for pine plantations. The soils of the steeplands are not included in Table I. They are dealt with in Section 3.2.2. Some soil series vary considerably in their suitability for pine plantations and consequently fall into two different suitability classes. In Table I, the second suitability class of these particular soils, is indicated by the class letter (in brackets) of the second class.

The alluvial soils are of limited value for pine plantations due to their generally poor drainage conditions. They are more suited to agriculture. They are included in Table I only because small extents of some of them probably be found in any future large-scale pine plantations.

3.2.2 Steeplands

To estimate the suitability of the soils of the steeplands is a more complex task as it depends not only on the soil morphology but also and to a greater extent on other factors such as erosion hazards, internal access difficulties and high costs of establishing plantations. Furthermore, the soils of the steeplands, being considered unsuitable for agriculture have not been surveyed or differentiated. On Malaysian soil maps they are shown merely as "steepland soil association".

Generally speaking, the hilly terrains in West Malaysia show a very dissected topography and difficult internal access. The steepness of the slopes increases very abruptly from the lowlands to the hilly terrains. Erosion is severe because of the association of steep slopes, heavy rainfall and erodable soils.

TABLE I

SUITABILITY FOR PINE PLANTATIONS OF REPRESENTATIVE SOIL SERIES ON 0 TO 40% SLOPES IN WEST MALAYSIA

PARENT ROCK/ RATERIAL	VERY SUITABLE CLASS A	SUITABLE CLASS B	MARGINAL CLASS C	UNSUITABLE CLASS D
[illegible]	Rongam Sogamat Jerangau Kampong Kolam Tampin	Kulai		
[illegible] and [illegible]	Munchong Bungor Serdang Batang Merbau	Seremban Durian (C) Tavy (C) Batu Anam (C) Kuala Brang (C) Po Hoi	Malacca (D) Kedah Chenian Marang Apek Gajah Mati Pokok Sena	
Old alluvium		Harimau Tampoi Ulu Tiram		
Subrecent alluvium		Sitiawan	Holyrood Rasau Sogomana	
Recent riverine alluvium		Telemong	Akob Briah	
Recent marine alluvium			Rudua Jambu	Kranji Selangor Linau Rusila
Organic soils				Peat Organic clays and mucks

"(C) and "(D)" indicate that these particular series occur also in Classes C and D respectively.

Except on the upper slopes where skelettic soils are not uncommon, the soils over the steeplands are generally deep (especially in the granite mountains) and would be suitable for pine plantations if it were not for the steepness of the topography. The pilot plantation which covered very steep slopes in the Lenggeng Forest Reserve, has demonstrated the difficulties and the high costs of establishing pine plantations on steep slopes. A Consultant in Forest Engineering recommended strongly against the use of the Malaysian steeplands for conifer plantations (Rudmann, 1971). It is recommended at the present stage of conifer planting in Malaysia that the "steeplands" be avoided. Possibly in the future, when there has been greater experience with the establishment of conifer plantations or when there may be a general or local shortage of land, consideration could be given to planting conifers on limited areas of the steeplands. It is strongly recommended, however, that slopes greater than 60% be left under rainforest.

4. RECONNAISSANCE SOIL SURVEYS OF POTENTIAL PLANTATION SITES

4.1 INITIAL SOIL SURVEYS OF THE PROPOSED SITES

In 1967, Malaysian State Forest Officers, in response to a project questionnaire, submitted lists of possible sites for large-scale plantations. During 1968, reconnaissance soil surveys of these sites were made in order to determine their relative suitability (Platteborze and Ee, 1970(b)). The work done in association with an investigation of the sites by a Forest Engineer Consultant (Rudmann, 1971).

Table II lists the sites which were surveyed and Figure I shows their locations. Table III summarizes the results of the work.

TABLE II

LIST OF THE PROPOSED SITES

State	Site
Selangor	Ulu Langat Forest Reserve
Pahang	Bukit Tinggi Forest Reserve
Negri Sembilan	Mantin Area
Perlis	Mata-Ayer Forest Reserve
Perlis	Rimba Mas Mas Forest Reserve
Kedah	Bukit Kaya Hitam F.R.
Kedah	Bukit Tangga Forest Reserve
Kedah	Tampoi Forest Reserve
Kedah	Sungei Muda Area
Kedah	Pedu Forest Reserve
Kedah	Trenas Forest Reserve

The reconnaissance soil surveys, combined with the findings of the Forest Engineer Consultant, showed that none of the proposed sites, even a regional basis, had all the features desired in a large-scale plantation scheme - sufficient area, proximity to a suitable pulp mill site, reasonable topography and satisfactory soils.

TABLE III

S Y N O P S I S : Acreage for Soil Suitability Classes

Groups and Sites	Lowland (0 – 40%)				Steepland		Total
	very suitable	suitable	marginal	unsuitable	40 – 60% marginal	over 60% unsuitable	
GROUP I							
Ulu Langat	5,900	–	–	–	5,900	6,700	18,500
Bukit Tinggi	9,500	–	–	–	8,100	4,900	22,500
Mantin	17,100	–	–	–	11,700	3,800	32,600
Total	32,500	–	–	–	25,700	15,400	73,600
Dom. Soil Series	Rengam	–	–	–	Rengam (red variant) Bt. Temiang Bt. Lunchu	Bt. Temiang Bt. Lunchu	
Soil Fertility Status (Phosphours)	Moderately deficient or not deficient	–	–	–	Moderately deficient	Moderately deficient	
GROUP II							
Mata Ayer	–	500	2,500	–	4,000	–	7,000
Rimba Kas Kas	500	6,000	3,000	–	500	–	10,000
Kayu Hitam	–	3,000	4,500	–	1,500	–	9,000
Bukit Tangga	4,500	–	2,000	–	1,000	–	7,500
Genting Tampoi	–	–	1,500	–	1,500	–	3,000
Total	5,000	9,500	13,500	–	8,500	–	36,500
Dom. Soil Series	Langkawi Serdang	Tavy Holyrood	Gajah Mati Pokok Sena	–	Kedah, Serdang Kuala Brang	–	
Limitations	None	Compact subsoil or sandy texture	Dense lateritic concretions and compact subsoil				
Soil Fertility	Very deficient	Very deficient	Very deficient	–	Very deficient		
GROUP III							
Muda-Pedu	36,600		–	–	37,500		74,100
Trenas	11,000		–	–	5,000		16,000
Total	47,600		–	–	42,500		90,100
Dom. Soil Series	Nami, Lunchong, Rengam, Kuala Nerang, Kedah, Kuala Brang, Serdang						
Soil Fertility Status (Phosphorus)	Deficient				Deficient		

4.2 RECONNAISSANCE SOIL SURVEY OF THE BAHAU FOREST RESERVE

In 1970, a reconnaissance soil survey was made of the Bahau Forest Reserve in Negri Sembilan (Platteborze and Ee, 1970(b)).

The major soils of the Bahau Forest Reserve belong to the Durian, Batu Anam (ultisols) and Malacca (concretionary oxisols) series. The soil physical limitations are a strong compactness of the subsoil in the case of the Durian and Batu Anam series and very frequent lateritic concretions and boulders in the case of the Malacca series. Furthermore, as shown by the analysis of soil samples collected during the survey, these soil series are deficient in plant nutrients especially phosphorus. The soils are of special interest for pine plantations because, first, they are in less demand for agriculture, second, they occur on gentle topography which is favourable for large-scale plantations and third, they occur in very extensive areas, especially in the central part of West Malaysia. On the basis of the soil survey, sites for trial plots on the Bahau F.R. were recommended and these plots are being established.

5. SELECTION AND SOIL SURVEY OF THE EXPERIMENTAL PLANTATION ON THE LENGGENG FOREST RESERVE IN NEGERI SEMBILAN

An experimental plantation scheme, covering approximately 250 acres was established on the Lenggeng State Forest in the Mantin District of Negeri Sembilan in 1969-70. The main reasons for selecting this particular area were first, that it is representative of a large area of hilly terrain in West Malaysia, second, it provides opportunities to gain experience and study problems on both moderate and steep slopes and third, it is relatively close to the Project headquarters.

The soil survey of the area showed the soils to be derived from granite, to be fairly deep and to be morphologically suitable for growing pines (Platteborze, 1971(d)). However, the experience gained in this experimental plantation has demonstrated the seriousness of erosion problems, and the difficulties and high costs of establishing pine plantations on these steep slopes. Forest plantations on such steep terrain cannot be recommended

Investigations were also made of two plantations in the State of Johore (Platteborze, 1970(a)).

6. SOIL NUTRITION

In some Malaysian plantations the pines are growing very fast indeed. However, the plantings show great variation in growth rate from one locality to another and even within a given locality. Some plantations are very patchy in development with large differences in the size and health of the trees. Furthermore, symptoms of illhealth are widespread and include dead tops and branches, thin crowns, poor foliage colour, leafless shoots and foxtailing. There is evidence that certain stands which were healthy when young have developed symptoms of illhealth as they aged. The great variation in growth rate and health occurring in the pine plantations on soils which morphologically are similar, strongly suggests soil nutrient deficiencies.

There is obviously great need for research into the role of soil nutrients in Malaysian conifer plantations and into the possibility of improving health and growth rate on certain sites by the use of fertilizers. The project therefore carried out investigations with the following aims:

(a) to obtain information on the relationship between soil fertility (as shown by chemical analysis) and growth rates of conifers in West Malaysia in order to determine nutritional levels at which fertilizing is economic;

(b) to determine whether illhealth or slow growth on certain sites is caused by nutrient deficiency and if so the nature of the deficiency;

(c) to determine methods of overcoming illhealth and increasing growth rate by the use of fertilizers.

This programme involves long-term research which can only be initiated during the limited time of the project.

The most important nutritional component affecting the pine plantations will most likely centre

around the deficiency or imbalance of major elements. In Malaysian rubber plantations, the occurrence of nitrogen and phosphorus deficiencies was demonstrated many years ago and the use of fertilizers with emphasis on these two elements is now standard practice. The application of phosphate fertilizer is essential for the successful growth of pines in Malaysian nurseries. Nitrogen and potassium were also found deficient but not to the same extent as phosphorus.

6.1 SHORT-TERM INVESTIGATIONS

6.1.1 The Relationship between Soil Fertility and Growth Rates of Pines in West Malaysia.

This work covered ten 0.25-acre plots of Pinus caribaea var. hondurensis, 5 to 13 years of age (Platteborze et. al (1971)). Eight plots are located in the State of Selangor and one each in Kedah and Perlis. The total available contents of nitrogen, phosphorus and potassium in the soils were estimated from soil analyses and correlated with the average height of ten tallest trees in each plot. The mean height for each plot was adjusted to a standard age of ten years by using age/height relationship of three Forest Research Institute sample plots.

The results, which are shown in Table IV, indicate a significant correlation between available phosphorus in the soil and growth rate. The correlations in the case of nitrogen and potassium are not significant. The relationship growth/phosphate, as shown in Figure 2, is hyperbolic in form.

The correlation provides the basis for a tentative classification of the fertility status of the soils in terms of their measured content of available phosphorus. The soil can be regarded as being very deficient in phosphorus, when the total amount of available phosphorus within the effective depth (up to a maximum depth of 200 cm.) and calculated on the basis of a soil density of 1.0 is less than 20 kg/ha, and as having sufficient phosphorus, when the total amount exceeds 60 kg/ha.

TABLE IV

ESTIMATED HEIGHT AT 10 YEARS OF AGE AND ESTIMATED CONTENTS OF N, P AND K IN THE SOIL

Plot No.(Ranked in Order of Height)	Estimated Height at 10 Years of Age (ft.)	Kg/Ha		
		N	P	K
6	74	13,500	105	210
1	73	12,000	115	220
7	71	9,500	60	180
2	69	12,500	95	165
3	67	13,000	35	600
5	66	6,500	45	680
9	64	17,000	20	245
4	58	12,000	30	310
8	54	6,500	25	90
10	52	10,000	20	650

Further evidence of the important role played by soil nutrition in the growth rate and health of pine plantations in Malaysia was revealed by an investigation of two adjacent plots of P.caribaea var. hondurensis which differed widely in growth rate and health (Platteborze, 1970(b)). The estimated phosphorus, potassium and nitrogen contents of the soil of the faster growing plot were 43%, 31% and 11% respectively greater than those of the slow growing plot. It was concluded on the basis of the above relation between soil phosphorus content and height growth, and the results of fertilizer trials, that the difference in phosphorus content was the factor mainly responsible for the difference between the growth of the two plots.

6.1.2 The Effects of Major and Minor Elements on the Early Growth of Pines

An experiment was carried out on the surface soil of the Rantau Panjang plantation in Selangor with the aim of obtaining information to guide future experimentation and to give a preliminary indication on fertilizer requirements (Platteborze, 1971(c)). The plantation of Pinus caribaea var. hondurensis on

the Rantau Panjang forest suffers widespread symptoms of illhealth. It was an omission type pot experiment using 13 elements and it was carried out in a plant house designed and built by the project in the research nursery of the Forest Research Institute at Kepong.

There was a striking response to phosphorus but no obvious response to any of the other elements. The course of height growth is given in Figure 3. The absence of phosphorus resulted in severe stunting and in the death of some of the pines within 12 months after the start of the experiment (Figure 4).

4.1.3 The Effects of P and NPK Fertilizers on the Early Growth of Pines

This experiment, which was carried out in the Rantau Panjang plantation, tested the use of two fertilizers (P and NPK) at two rates of application (4 oz. and 8 oz. per tree). The fertilizers were applied shortly after the trees were planted. The experimental design used 5 treatments and 20 replications with individual trees as unit plots (Platteborze, 1971(a)).

The phosphate treatment was associated with a significant and 35 per cent increase in the height growth of the pines over the first 14 months following fertilization. The NPK fertilizer did not give a significant growth response, probably because of its low level of phosphorus.

4.2 LONG-TERM EXPERIMENTS

Based largely on the results of the above short-term investigations, long-term experiments were designed and established in order to extend the work to other soils, to provide more detailed data on fertilizer requirements and responses, to determine the effects of fertilizers on rates of yield and to provide a basis for estimating the economic gains to be expected from the use of fertilizers. Boron was included in some of the experiments following the recommendations of the Tree Nutrition Consultant.

The following long-term experiments have been established:

(a) Fertilization of an 8-year-old Pinus caribaea var. hondurensis stand on the Rantau Panjang Forest Reserve

Response to phosphorus on this forest was found in two previous experiments (Platteborze, 1971(a); 1971(c)). The aim of the experiment is to determine whether the health and growth rate of the older plantations in the forest can be improved by the application of rock phosphate. The experiment covers 3.7 acres and comprises 5 treatments and 5 replications.

(b) Fertilization of Pinus caribaea var. hondurensis on the Rantau Panjang Forest Reserve at the time of planting

The aim of this experiment is to test the effects of nitrogen, phosphorus and boron fertilizers on the early growth. The experiment covers 3.7 acres and comprises 4 treatments and 5 replications.

(c) Fertilization of a 6-year-old Pinus caribaea var. hondurensis stand on the Kampong Gajah plantation

The Kampong Gajah plantation shows very poor growth and widespread symptoms of illhealth. It was established on abandoned farmland and on probably very degraded soils. The aim of the experiment is to determine whether the health and growth rate in the plantation can be improved by the application of fertilizers (nitrogen, phosphorus and boron). The experiment covers 4 acres and comprises 4 treatments and 5 replications.

7. ASSISTANCE TO PRIVATE FORESTRY COMPANIES IN THEIR SOIL AND NUTRITION PROBLEMS

Advice and assistance was given to two Japanese paper companies which are establishing experimental plantations in Malaysia. Help has been given in the identification of the soil series on their land and advice has been given on nursery and plantation fertilizing.

8. TRAINING

The training of counterpart staff has been an important part of the activities of the project's soil section. In particular, training was given to professional and technical staff in the field work of soil surveys and fertilizer experimentation.

9. THE SOIL LABORATORY AT THE FOREST RESEARCH INSTITUTE, KEPONG

The soil laboratory, which has been in operation since January 1967, makes the following routine soil analyses: particle size, pH, moisture content , loss on ignition and estimates of the content of carbon, phosphorus, potassium and nitrogen. The facilities have been extensively used by the project, which has provided the laboratory with a considerable amount of equipment such as high speed stirrers, centrifuges, shakers, particle size apparatus stand, pH meter, electric oven, balances and water distillation apparatus.

10. CONCLUSIONS

10.1 THE POTENTIAL FOR LARGE-SCALE CONIFER PLANTATIONS

The prospects for large-scale pine plantations in Malaysia are good. There are large areas of land not yet used for agriculture which can possibly be made available for pine plantations. Rates of growth on suitable soils are very fast. Malaysian soils, in general, are characterized by good physical properties, and although most soils are heavily leached and have a low content of nutrients, the experience of the rubber industry, in particular, has shown that plant nutrient deficiencies can be corrected by fertilizing.

10.2 PLANT NUTRIENT DEFICIENCIES

Growth abnormalities are widespread in Malaysian pine plantations. These abnormalities, which are symptoms of illhealth and which include dead tops and branches, thin crown, poor foliage colour, leafless shoots and foxtailing, are probably a result of nutritional deficiencies. The project consequently started a programme of nutritional investigations.

It has been found in two experiments that the application of phosphorus results in a marked increase in growth rate on one particular forest and a study of the growth rate of Pinus caribaea var. hondurensis on various Malaysian sites in relation to their contents of N, P and K showed that growth rate was correlated with the phosphorus content of the soil.

No growth responses to the application of nitrogen have yet been obtained. However, it is not unlikely that future research will show such responses and that on some sites, other elements such as possibly boron may be found to be deficient.

10.3 THE NEED FOR FERTILIZERS

In pulpwood plantations, fast growth and high yields are required over short rotations. Most Malaysian soils have low nutritional status. Under such conditions, the need for fertilizer application is particularly important and should be accepted. In the past there has been a reluctance throughout the world to use fertilizers in extensive forestry but the importance and value of fertilizing is becoming more and more recognized by foresters.

In rubber plantations it is accepted that fertilizing is required to ensure continued high productivity.

Records on growth rates in pine plantations established on Malaysian soils derived from shale and/or sandstone indicate that fertilizers will be needed to develop vigorous growth on such sites; on granite-derived soils fertilizers may not be indispensable; however, it will probably be found that even granite soils will require fertilizing in order to maintain healthy and rapid growth into the second rotation or even perhaps towards the end of the first rotation.

At this stage it is not possible to draw definite conclusions as to the kinds of fertilizer and fertilizer regimes for Malaysian pine plantations; fertilizer requirement may be quite different from site to site: more research is needed in this field. However, it is felt that emphasis will have to be placed on phosphate in any future fertilizing programme.

It is advisable to apply the fertilizer at the time of, or shortly after planting in order to ensure maximum early growth and rapid capture of the site. It is also the easiest and cheapest time for applying fertilizer.

10.4 EROSION CONTROL

After the removal of the rainforest, virtually the whole nutrient capital is in the surface soil. It is therefore of great importance, in order to maintain the soil fertility, to reduce the risk of erosion to a minimum. One of the best ways to control erosion is to encourage a rapid soil cover, either by regeneration of natural regrowth or by sowing leguminous plants or other suitable cover crops. Fertilizing a pine plantation at the time of planting may also aid in reducing erosion by ensuring rapid canopy closure and early capture of the site.

Serious erosion on steep slopes is almost impossible to control effectively and therefore such slopes should be avoided for plantation establishment.

10.5 WEED COMPETITION

Strict attention must be given to weed control. A careful balance should be the aim, with some cover to prevent erosion and excessive leaching, but with the weeds kept sufficiently under control to reduce competition for nutrients and water.

The weeds compete with the pines for nutrients as well as space. An untended plantation in Malaysia will develop an extremely dense stand of weeds which will dominate many of the pines. Weed competition in some of the plantations has probably been partly responsible for the illhealth of the pines.

10.6 THE NEED FOR RESEARCH

The future prospects for growing long-fibre plantations in Malaysia are promising and several States are already actively engaged in planting programmes. A continuous research programme is therefore essential. Soil nutrition is one of the most important problems faced in Malaysian pine plantations and unless the soil nutrient deficiencies are clarified and overcome, it will not be possible to move confidently into large-scale plantations establishment.

Research on tree nutrition has been initiated by the project and basic long-term experiments laid down in several localities. It is vital that the research programme be continued and further developed. A soils and nutrition section is needed within the Afforestation Branch of the Forest Research Institute and with at least two professional researchers, one on chemical analysis and the other on field trials.

11. RECOMMENDATIONS

The following are recommended:

(a) Continuation of nutritional research. This includes further glasshouse pot trials, field experiments and the continuation of the current experiments. Detailed recommendations are given in Technical Report No. 1.

(b) Strict control of weeds.

(c) Testing effective methods of controlling erosion, and testing the relative value of various cover crops for holding and building up the nutrient reserve of the soil.

(d) Advising and assisting private companies on methods and problems of pine establishment.

(e) Training in modern methods of soil and leaf analysis for the officer in charge of the soil laboratory of the Forest Research Institute at Kepong.

(f) Acceptance by the Malaysian Government that the future large-scale conifer plantations should be

established on reasonable topography and on soils which may be suitable for agriculture.

(g) Maintaining a systematic exchange of information among researchers, including an exchange of information with other tropical regions.

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Platteborze, A., Ee, C.S., and Sundralingam, P. (1971)- A preliminary study of the correlation between the N, P & K contents of the soils and growth of Pinus caribaea var. hondurensis in West Malaysia. Malayan Forester XXXIV (2): 113-132.

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13. ABSTRACTS OF WORKING PAPERS AND SCIENTIFIC REPORTS PRODUCED BY THE SOIL SECTION OF THE PROJECT

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Initial Site Survey of Potential Forest Plantation Sites in West Malaysia based on the work of A. Platteborze and C.S. Ee, Counterpart. FO: SF/MAL 12. Working Paper No. 3.

Reconnaissance soil surveys of forest areas proposed by the Malaysian State Forest Officers as possible sites for large-scale conifer plantations were made in order to determine their suitability for large-scale conifer plantations.

For each site, the representative soils are described in general terms and approximate acreages are given for each suitability class.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Assessment of the Suitability of the Soils of the Bahau Forest Reserve for Pine Plantations based on the work of A. Platteborze and C.S. Ee, Counterpart. FO: SF/MAL 12. Working Paper No. 4.

The soils of the Bahau Forest Reserve in Negri Sembilan are characterized by heavy texture and low nutrient content. They are therefore in lesser demand for agriculture than are most other soils in the lowlands of West Malaysia. Because they happen to be associated with easy topography and cover large areas, they are of particular interest for forest plantations. The work discussed in this paper describes the more extensive of these soils and indicates the locations for the trial plantations which were later established by the project.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Soils of the Kampong Gajah and Labis Pine Plantations in Johore based on the work of A. Platteborze. FO: SF/MAL 12. Working Paper No. 5.

The trial plantation of P. caribaea var. hondurensis at Kampong Gajah shows severe symptoms of illhealth which is probably due basically to nutrient deficiency. The study discussed in this paper was made with the object of describing the soils and locating an area for a fertilizer experiment.

The soil of the Labis plantation belongs to the "Rengam" series and it is probably alluvial in origin. It is a fertile soil on which the pines are growing exceptionally fast.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Effect of Fertilizer on Early Growth of Pinus caribaea var. hondurensis on the Rantau Panjang Forest Reserve, Selangor based on the work of A. Platteborze. FO: SF/MAL 12. Working Paper No. 6.

This preliminary experiment, which was carried out in the Rantau Panjang plantation in the State of Selangor, tested the use of two fertilizers (P and NPK) at two rates of application.

The phosphate treatment was associated with a 35 per cent increase in the height growth of the pines over the 14 months following fertilization. The NPK fertilizer did not give a significant growth response, probably because of its low level of phosphorus.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. An Assessment of the Most Important Soils for Pine Plantations and their Approximate Acreage and Distribution in West Malaysia, with Recommendations for Additional Trial Plots based on the work of A. Platteborze. FO: SF/MAL 12. Working Paper No. 7.

The most important soils for pine plantations in West Malaysia were determined on the basis of soil data of the Department of Agriculture of West Malaysia. Locations for trial plantations to cover representative soils not previously tested for conifers are recommended.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. The Results of an Experiment on the Nutrient Status of the Surface Soil of the Rantau Panjang Forest Plantation in Selangor, Malaysia based on the work of A. Platteborze. FO:SF/MAL 12. Working Paper No. 9.

Substantial areas of the Rantau Panjang

pine plantation show serious symptoms of illhealth which is probably due to nutrient deficiency. The object of this experiment was to obtain data on which to base further detailed experimentation : surface soil was tested in an omission type pot experiment with P.caribaea var. hondurensis using 13 elements. A plant house was built by the project for the experiment.

There was a striking response of P.caribaea var. hondurensis to phosphorus but no obvious response to any of the other elements. The absence of phosphorus resulted in severe stunting and in the death of some of the pines within 12 months after the start of the experiment.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. Soils of the Project's Plantation on the Lenggeng Forest Reserve, Negri Sembilan based on the work of A. Platteborze. FO: SF/MAL 12. Working Paper No. 13.

This paper describes the soils of the project's plantation on the Lenggeng Forest Reserve in Negeri Sembilan.

The soils are all of the "Rengam" family. They are deep and suitable for pines. The soils were differentiated on topography. Juvenile soils occur on the upper, steep slopes while colluvial soils are dominant along the lower slopes. Mature soils occur over the lowland terrains.

FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. A Soil and Vegetation Study under a Pinus caribaea Plantation in West Malaysia based on the work of A. Platteborze. FO: SF/MAL 12. Scientific Report No. 8.

This paper discusses a difference in height of 12 feet, at 6 years of age, between the eastern and western parts (sub plots) of a 0.2 acre plot situated

in a Pinus caribaea plantation close to the Forest Research Institute at Kepong in the State of Selangor in West Malaysia.

The two sub-plots are almost identical in aspect, relief, shape and soil morphology. The estimated phosphorus, potassium and nitrogen contents of the taller sub-plot are 43%, 31% and 11% respectively greater and the carbon content 9% less than those of the shorter sub-plots.

It is concluded, on the basis of fertilizer trials and a previously determined relationship between phosphorus content and height growth of Pinus caribaea in West Malaysia, that the difference in phosphorus content of the soil is the factor basically responsible for the difference in pine growth.

The ground covers of the two sub-plots differ markedly. The fern, Dicranopteris linearis, almost completely covers the poorer sub-plot and is much less abundant in the other, but the difference in ground cover is regarded as a secondary effect.

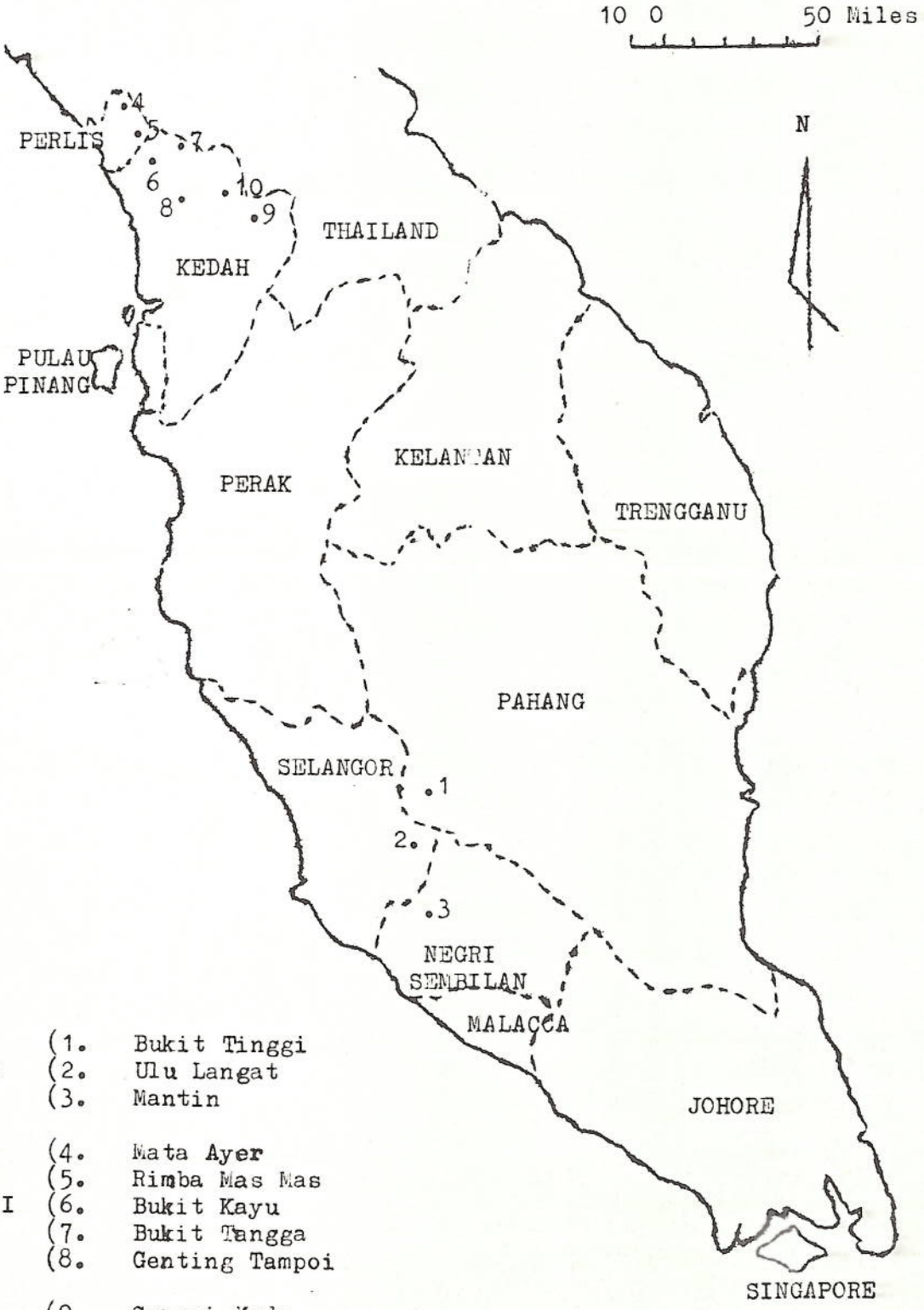
FAO. Pilot Plantations of Quick-Growing Industrial Tree Species, Malaysia. A Preliminary Study of the Correlation between the N, P and K contents of the Soil and Growth of Pinus caribaea var. hondurensis in West Malaysia based on the work of A. Platteborze. FO: SF/MAL 12. Scientific Report No. 11.

This paper discusses the nutrient status of the soil in ten plots of Pinus caribaea var. hondurensis, aged 5 to 18 years, in West Malaysia in relation to growth rate.

A significant correlation was found between growth rate and the amount of available phosphorus in the profile. No such correlation was found in the case of nitrogen or potassium.

FIGURE 1

Locations of the Potential Plantation Sites in West Malaysia which were Surveyed in 1968



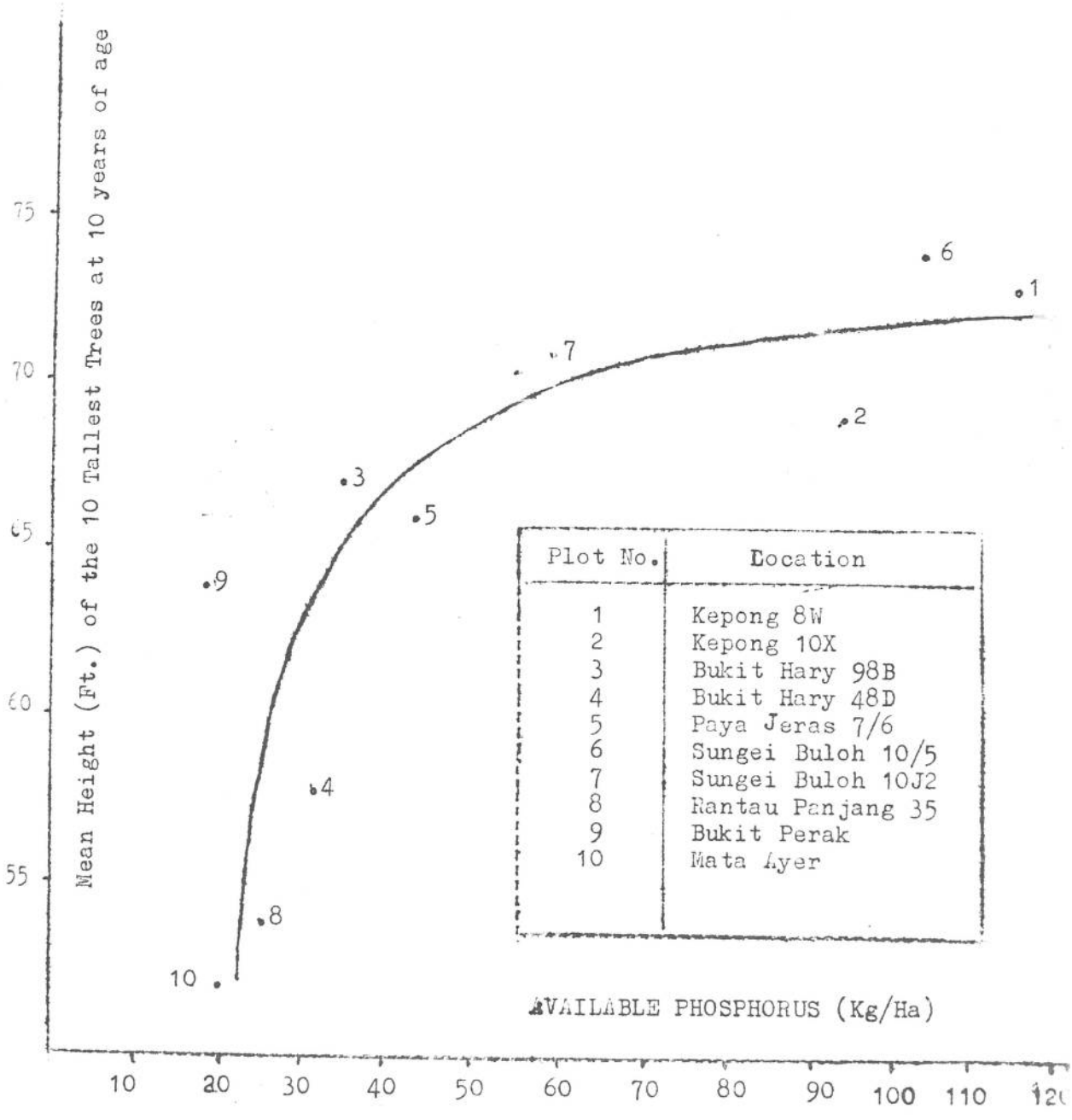
GROUP I
(1. Bukit Tinggi
(2. Ulu Langat
(3. Mantin

GROUP II
(4. Mata Ayer
(5. Rimba Mas Mas
(6. Bukit Kayu
(7. Bukit Tangga
(8. Genting Tampoi

GROUP III
(9. Sungei Muda
(10. Sungei Pedu
(11. Trenas

FIGURE 2

The Relation between the Growth of P.caribaea var. hondurensis and the Amount of Available Phosphorus in the Soil of West Malaysian Plantations



Plot No.	Location
1	Kepong 8W
2	Kepong 10X
3	Bukit Hary 98B
4	Bukit Hary 48D
5	Paya Jeras 7/6
6	Sungei Buloh 10/5
7	Sungei Buloh 10J2
8	Rantau Panjang 35
9	Bukit Perak
10	Mata Ayer

FIGURE 3

The Course of Height Growth of Pinus caribaea var. hondurensis in a Pot Experiment at the Forest Research Institute, Kepong, Malaysia with Surface Soil from the Rantau Panjang Forest Reserve, Selangor, Malaysia.