Plantation Trials on Bris Soils and Tin Tailings in Peninsular Malaysia

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Abstract

Plantation trials of some selected species in Peninsular Malaysia on BRIS and tin tailing soils are presented. *Acacia mangium* has been the single species widely established as plantation crop. Peninsular Malaysia has planned to establish 188,255ha of fast-growing species based on a 15-year rotation period. It was estimated that a yield of 39.64 million m^3 of wood materials could be obtained. To date 42,500ha have been planted with this species, where the oldest stand is already 10 years old. Besides *Acacia*, some selected tropical hardwood species have been identified for plantation establishment.

BRIS soils which form an almost continuous belt along the east coast of Malaysia cover 162,000ha or 1.23% of the total land mass. Tin tailing soil includes residues of tin mining activities and this soil type is estimated to cover around 113,700ha or nearly 1% of the total land mass of Peninsular Malaysia. It is mainly found in the central part of the country. Both BRIS and tin tailing soils are inherently low in fertility and are considered as problem soils. As a result, FRIM has devised a strategy to utilize these problem soils for the afforestation program for timber production.

In addition, FRIM plans to explore the possibility of stabilizing the micro-environment under BRIS and tin tailing soils for future agroforestry use. These soils have been successfully planted with *Acacia mangium, A. aulocarpa, A. aucuriculiformis, Casuarina equisetifolia, Pinus caribaea* and *Pinus ellotii*. Some success has also been recorded in the production of bamboo shoots using a combination of organic and compound fertilizers. In addition, FRIM also plans to initiate studies on nutrient cycling, litter decomposition, introduction of rattan as intercropping with *Acacia mangium*, and establishment of commercial plantations of *Cinnamomum* spp. on these soils.

This paper outlines the fertility status of the BRIS and tin tailing soils compared with some prominent Malaysian soils derived from widely distributed parent rocks. Such studies may enable a better assessment of these two problem soils. In addition, the foliar nutrient status of *Acacia mangium* grown on BRIS soils will be also presented in comparison with other soils.

Height, diameter and basal area of *Acacia mangium* grown on various geological formations will be presented in comparison with BRIS and tin tailing soils. In addition, the MAI (dbh) and total height of selected species planted on both BRIS and tin tailing soils are also presented for comparative purposes. It was observed that *Acacia mangium, A. auriculiformis, A. richii, Pinus caribaea, Paraserienthesis falcataria* and *Casuarina equisetifolia* offered a definite potential for reafforestation of these problem soils. *Bambusa vulgaris* also showed a potential for culm production provided that certain levels of organic and compound fertilizers were applied.

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Introduction

The term BRIS means 'Beach Ridges Interspersed with Swales'. These formations are characterized by parallel sand ridges with depression areas in between the ridges and swamps at one lower end of the elevation. They form an almost continuous belt along the east coast of Peninsular Malaysia varying from 10 to 200m in width (Fig. 1). This soil type covers 162,000ha or 1.23% of the land mass of Peninsular Malaysia (Lim, 1986). The extent of distribution in the states of Peninsular Malaysia is shown in Table 1.

Tin tailing soil is the waste product of tin mining, where tin was once the main supporting activity of the Malaysian economy. The extent of this soil type was estimated to be around 113,700ha or nearly 1% of the Peninsular land mass (Chan, 1990). Most of the soils are located in the state of Perak, the leading tin mining industrial area. The extent of tin tailing soil distribution in the states of Peninsular Malaysia is tabulated in Table 1. The soil composition is mainly sand, even though a mixture of silt and clay has been found, but the hectarage is limited.

In geneal, BRIS and tin tailing soils have equal agriculture potentials. However, the latter may be more productive compared to the former when silt and clay dominate the site. Generally, these two soils are classified as problem soils.

Against this background, the Forest Research Institute Malaysia (FRIM) has embarked on a strategy to utilize these problem soils by an afforestation program for timber production. In addition, FRIM would like to explore the possibility of stabilizing the micro-environment under BRIS conditions for future agroforestry use. These soils have been successfully planted with *Acacia mangium, A. aulocarpa, A. auriculiformis, Casuarina equisetifolia, Pinus caribaea* and *P. elliotii*. Some success has also been recorded in the production of bamboo shoots using a mixture of compound fertilizer and organic matter. In addition, FRIM intends to undertake nutrient cycling trials, litter decomposition studies, introduce rattan as intercrop and planting of *Cinnamomum* spp. on these soils. A fair amount of mulching materials which include palm oil mill effluent (POME), coconut husks, empty fresh fruit bunches of oil palm and dried leafy materials has been used in these trials.

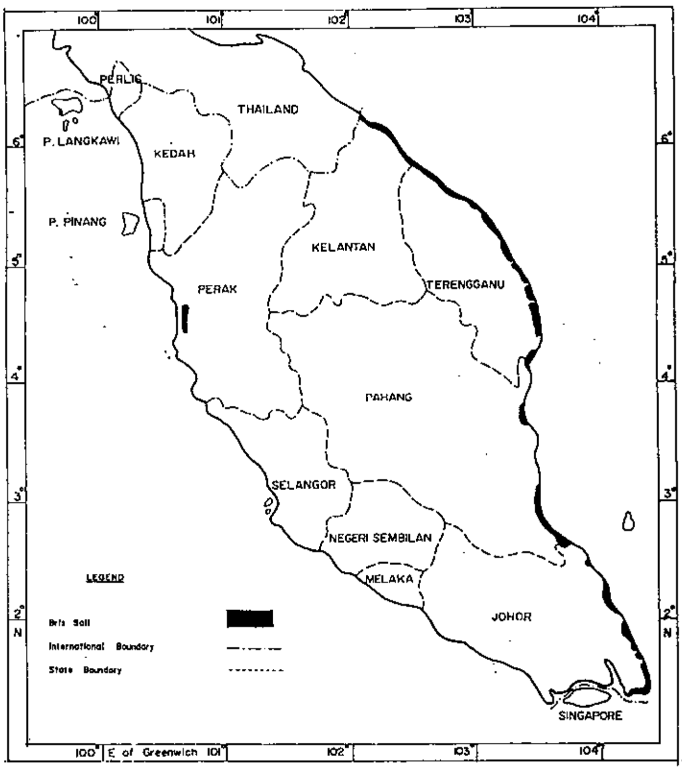

Fig. 1 Distribution of BRIS soils in Peninsular Malaysia
Source : Cho Seh Boh (1991).

Table 1 Distribution of BRIS and tin tailing soils in Peninsular Malaysia

States of Peninsular Malaysia	Extent (ha)	
	* BRIS soils	* * Tin tailing soils
Terengganu	71,000	400
Pahang	47,000	2,910
Johor	20,000	5,600
Kelantan	17,000	—
Perak	4,000	71,850
Kedah	2,500	2,510
Malacca	400	380
Perlis	—	(800)
Penang	—	10
Selangor/K. Lumpur	—	28,250
Others	10	—
	161,910	112,770

Source: * Choo (1991), * * Chan (1990), while the figure in parenthesis denotes underground mining.

Current status of plantation forestry in Peninsular Malaysia

The total area of forested land in Peninsular Malaysia amounts to approximately 6.28 million ha or 47% of the total land mass, of which 2.85 million ha and 1.90 million ha were classified as productive and protective forest estates, respectively (Ministry of Primary Industries, 1989). The remaining are either reserves for National Parks and Wildlife sanctuaries and stateland forests (Table 2). From 1981 to 1987, a total of approximately 1.6 million ha of forest land had been logged-over, and to date the remaining figure is expected to decline further (Table 2). Furthermore, Freezaillah (1980) predicted that by 1995 Malaysia could face imminent timber shortage for domestic consumption.

Table 2 Distribution of forested land in Peninsular Malaysia

Type of land use	Extent (million ha)
Permanent forest estates	4.75
— Productive forests	2.85
— Protective forests	1.90
National parks and wildlife sanctuaries	0.59
Stateland forests	0.94
Logged-over forests (1981-1987)	1.57
Total land mass of P. Malaysia	13.20

Source: Ministry of Primary Industries, (1989).

In view of this trend and the slow recovery of natural forests after logging, the Malaysian Government launched the 'Compensatory Forest Plantation Project' under the 4th Malaysian plan. The task was initiated by the Forestry Department, under which 188,225ha of forest plantation was to be materialized. A 15-year rotation period was planned and planting commenced in 1982. To date, 42,500ha have been established, mainly with *Acacia mangium* (Zakaria, 1992), which was estimated to yield 39.64 million m^3 of wood at the end of the rotation period (Amir, 1982). These planned plantation estates are derived mainly from the conversion of poorly stocked inland logged-over forests of the productive forest land. Recently, more emphasis has been placed on the exploitation of the BRIS and tin tailing soils for afforestation program, which had by far been the least utilized soils, even by the agriculture sector, except for the planting of tobacco and cash crops.

Besides *Acacia mangium*, other species for example, *Khaya ivorensis*, some selected Shoreas, *Swietenia macrophylla, Dryobalanops aromatica* and *Tectona grandis* are being evaluated for plantation trials.

Formation of beach ridges and depressions

A beach is a ridge of beach materials formed along the shores by waves, current and tides. A beach barrier (offshore bar) is an offshore ridge of unconsolidated material (not necessarily attached to a headland), emerging (at least partly) at high tide (Kooistra, 1983). Hypothesis on barrier formation in Malaysian waters includes encroachment, bar emergence and shore drift (Teh, 1983). The east coast of Peninsular Malaysia is a high energy coast due to open seas and it is battered yearly by the northeast monsoon. Hence, materials forming the ridges are maily marine sands.

However, at river mouths, sediments with a heavier texture may occur. An analysis of selected barriers in Peninsular Malaysia showed that the origin of the inner barriers cannot be determined as these structures are not formed *in situ*. The materials have been driven landwards by seas, which rose to and slightly above the present level to transgress over the marshes of former terrestrial surface. The outer barrier originated from emerged offshore bars related to a sea level fall, or from along-shore split extension (Teh, 1983). These findings support the concept of a multiple origin of barriers and imply that barriers can be formed in different ways along different parts of the coastline. Furthermore, along a particular stretch of coastline different barriers may have different modes of origin. Lagoon which was originally an expanse of water separating an offshore bar from the shore will now form the depression (swale) between the consolidated ridges. The lithology or texture of the sediments in these depressions is extremely variable, ranging from peat through clays to sands. The formation sequence of BRIS soils is illustrated in Fig. 2.

Formation of tin tailing soils

Tin tailing soils tend to be dominated by a high percentage of sand. They are excessively drained, exhibit a low nutrient status, inferior water and nutrient-holding capacity, and poor aggregation between the particle fractions. In addition, they can be rich in silt and clay fractions, thus leading to poor drainage and when dry, susceptible to compaction. However, these forms of tin tailing soils are capable of retaining nutrients even though the status is low.

Tin tailing soils can be generally classified into three types depending on the mechanical fractions of the soil as follows: sand, sandy slime and slime, where the latter can also occur in waterlogged form. However to date no proper soil classification system has been drawn-up for tin tailing soils which are considered to be disturbed land.

It is common to observe a variable landscape formation resulting from tin mining activities. The soil (after tin extraction) is being removed and heaped into small mounds, resulting in the observed phenomenon.

Physical and chemical data of selected BRIS, tin tailing and other selected soils of Peninsular Malaysia

The authors would like to describe the fertility status of some typical BRIS and tin tailing soils of Peninsular Malaysia. In addition, some fertility data of other soil types dominating the geological body in Peninsular Malaysia are also included for comparison. The data presented in Table 3 show the mean values of topsoil (0-30cm) reported after Law and Tan (1975), unless otherwise stated.

BRIS soils are dominated by over 99% sand fraction with a negligible amount of silt and clay. The soils are normally acidic with pH values slightly over 5. Amir *et al.* (1991) however, reported a much lower figure (3.7-4.1). The difference could be attributed to the vegetation cover, where the former was

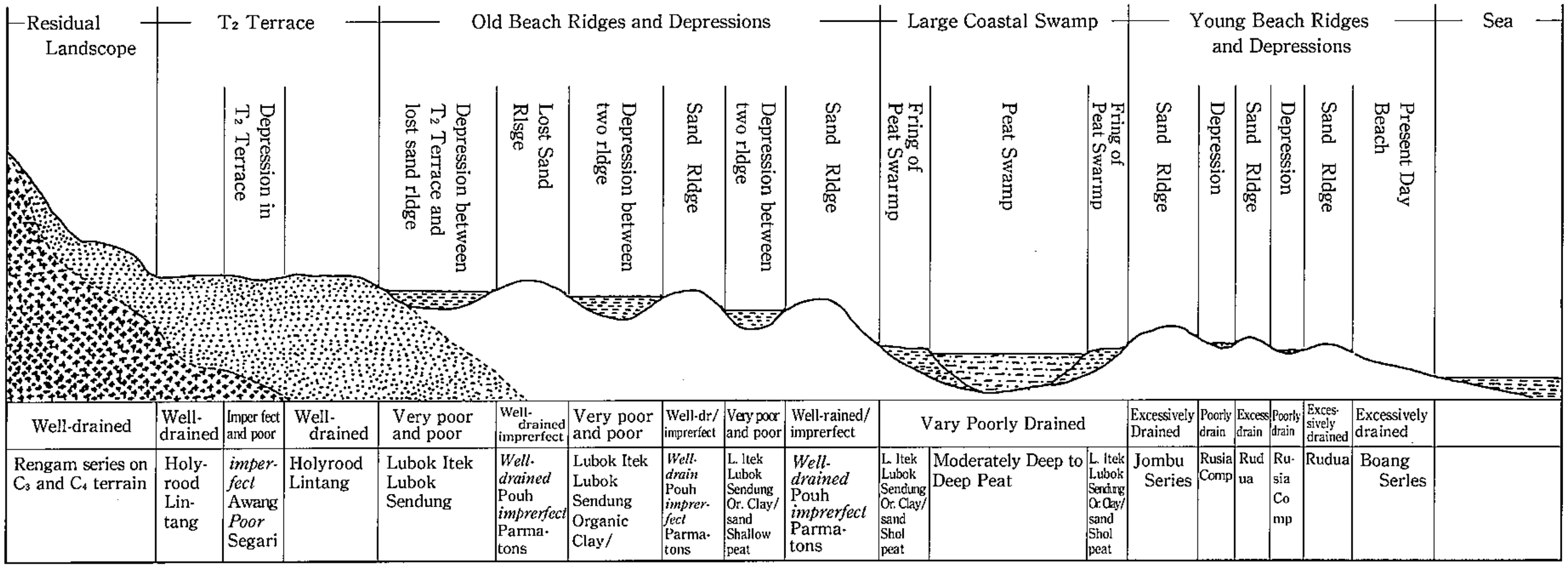

Fig. 2 Cross-section showing the formation sequence of BRIS soils in Peninsular Malaysia.
Source: Lim Jit Sai (1986).

Table 3 Mean soil nutrient concentrations and mechanical composition of BRIS soils in comparison to other soil types of dominating geological body of Peninsular Malaysia

Soil parameter	SOIL PARENT MATERIALS											
	Igneous rock	An-desite Basalt	Sand stone	Shale	Lime-stone	Older Allu-vium	Subre-cent Al-luvium	Riverine	Marine Clay	Marine sand (BRIS)	*Tin tailing	**BRIS
Clay+	59	69	35	49	80	46	44	55	66	4	2	2
Sand+	37	20	56	35	12	50	47	21	13	97	91	97
pH	4.6	5.2	4.4	4.5	5.0	4.3	4.5	4.8	4.8	5.0	5 - 6	4.4
Carbon+	0.85	0.92	0.43	0.49	0.75	0.56	0.58	0.49	1.72	0.53	–	3.44
Nitrogen+	0.08	0.09	0.06	0.06	0.12	0.06	0.07	0.12	0.14	0.03	0.02	0.26
NaOH P++	28	34	29	26	5	39	42	55	50	25	0.4	7
CEC	8.5	10.6	6.8	7.8	14.3	6.8	6.6	12.4	26.8	3.2	–	0.9
Ca (Ex.)–	0.1	0.48	0.38	0.12	2.80	0.15	0.26	0.86	5.04	0.86	–	0.15
Mg (Ex.)–	0.22	0.41	0.18	0.15	1.50	0.17	0.31	0.89	18.79	0.17	–	0.10
K (Ex.)–	0.07	0.09	0.06	0.03	0.10	0.44	0.07	0.17	0.51	0.03	0.03	0.03
B. S.–	5.22	9.17	5.75	3.14	28.00	5.40	7.80	16.80	60.45	16.83	–	37.93
Tot. Fe–	7.61	14.00	2.05	2.51	12.8	2.87	1.06	3.68	4.88	0.57	–	–
Tot. P++	126	463	68	87	850	337	90	203	284	55	–	113
Tot. Ca–	1.51	2.50	2.70	2.56	6.50	2.10	1.10	3.36	10.64	1.70	–	0.68
Tot. Mg–	4.35	2.93	3.18	4.21	20.00	2.13	1.36	1.36	27.95	2.60	–	0.87

Note: +, ++ and – are expressed in %, ppm and meq/100g soil, respectively.
Source: *Ang (1991), **Amir *et al*., (1991), whilst others are data of Law and Tan (1975).

under vegetative scrubs and the latter under *Acacia magium* stand. The decomposed litter of the latter may have given rise to humic and fulvic acids, thus lowering the soil pH. Based on Table 3 it is generally obvious that BRIS (marine sand) and tin tailing soils are poor in exchangeable and reserve cations compared to other Malaysian soils. The nitrogen content of BRIS soils (marine sand) is very low (0.03%) compared to other listed soils of variable parent rocks. The same applies to the content of carbon, CEC and reserved P with the exception of carbon in BRIS soils as reported by Amir *et al*. (1991). These findings are attributed to the large amounts of decomposed litterfall of *Acacia mangium* on the forest floor.

It is less surprising to note a high level of exchangeable Ca in these soils since they have a marine origin, with a large amount of sea shells and coral. However, the base saturation of over 16meq/100g soil (Law and Tan, 1975) and over 37meq/100g soil (figure quoted by Amir *et al*., 1991) is high compared to some of the soils derived from sedentary materials. This phenomenon is attributed to the flooding of the soils by exchangeable cations, which tend to become fixed to the limited exchange sites in the soil as indicated by their respective low CEC values (3.2 and 0.87meq/100g soil). However Ang (1991), showed that tin tailing soils are the poorest, even though sandy slime and slime types could be more fertile but their occurrence is of small magnitude.

Acacia mangium plantation for micro-site stabilization on BRIS and tin tailing soils

Acacia mangium is renowned for its ability to establish itself on highly degraded sites. It has been successfully planted along the beach front in the states of Pahang and Terengganu since 1983 and 1985 by the Forestry and Agriculture Departments, respectively. According to the Agriculture Department, the aim of planting *Acacia mangium* is to ameliorate the physical and chemical soil properties, improve the micro-environment and later to be utilized for agroforestry purposes.

FRIM was requested by the Agriculture Department to study the amount of nutrients returned to the forest floor and rate of leaf litter decomposition. This study is underway. Some data on *Acacia mangium* growth on BRIS soils are available for presentation which can be compared to those of inland soils.

Based on Table 4, it is interesting to note that, the height achievement of 6-year-old *Acacia mangium* is somewhat parallel to its 2-year-old counterpart grown on sedentary soils (shale/sandstone parent materials). In terms of diameter growth, it is comparable to its 4-year-old counterpart of alluvial-derived soil. However in terms of basal area attainment, it performed better than its 4-year-old counterpart but significantly less than its age class. A similar pattern was observed in the 4-year-old *Acacia mangium* grown on tin tailing soils.

Table 4 Accumulated mean diameter, height and basal area growth of 100 dominant *Acacia mangium* trees of selected ages grown on different geological bodies in Peninsular Malaysia

Age (yrs)	P. Material	Soil Series	Height (m)	Diameter (cm)	B. Area (m^2)
2	Shale	Chat	8.08	8.83	0.006
2	Shale/Sandstone	Bungor	10.35	13.10	0.014
4	Old Alluvium	Harimau	14.65	17.18	0.023
4	Shale	Chat	14.26	14.69	0.017
4	* Mining land	Disturbed soil	11.80	11.48	0.010
6	Shale	Chat	22.99	21.28	0.036
6	Beach ridges	BRIS	10.48	16.44	0.029
8	Laterised shale	Bt. Lapan	24.76	22.52	0.040
8	Shale	Chat	27.09	23.83	0.045
8	* Beach ridges	BRIS	14.88	20.80	0.034

Sources : * Zakaria and Ang (1992), whilst others are from Amir (unpublished data)

It must be considered that both tin tailing and BRIS soils are inherently poor in nutrient reserves, which has been the basis of tree growth. The same was observed by Huston, (1980), Proctor *et al*. (1983), Ho *et al*. (1987) and Amir and Miller (1991) under natural forest stands. These problem soils are totally dependent on the recycling of nutrients (litterfall) within the tight ecosystem which can be subjected to a remarkable loss of available nutrients due to the low degree of surface soil aggregation (high level of sand fractions), unlike the sedentary soils where the surface texture contains considerable amounts of clay. Therefore, the released nutrients can be available to the plant in a much longer period of time, not to mention the soil reserve nutrients.

It is interesting to note that since *Acacia mangium* is a legume, it is capable of fixing N from the atmosphere. This has been observed by Amir and Miller (1990) and Amir *et al*. (1991) with *Koompassia malaccensis* (also a legume) and *Acacia mangium*, respectively, showing somewhat independent N uptake from the soils. Under BRIS soils, *Acacia mangium* has been found to nodulate (Amir *et al*., in press). This phenomenon may explain why the N concentration in its foliar parts is somewhat comparable to the levels found in other Acacia trees. However, these findings do not apply when the P and K levels of Acacia trees are compared with those of rubber and oil palm trees (Table 5).

Based on the review of Leaf (1968), Miller (1981 and 1984) and Amir (1991) on the nutrient-deficient levels in forestry crops, it appears that *Acacia mangium* grown on BRIS soils in Peninsular Malaysia tends to be deficient, particularly in P and K. This has been observed by the first author in the field. Furthermore he also observed some degree of N deficiency in plants where the leaves tend to be light green in color which some exhibit a yellowish green color.

In addition, it is also interesting to note the low levels of N in *Shorea* of the natural stand and teak plantations on alluvial soils. A similar trend was observed for the P nutrient level in *Shorea* and *Koompassia* but not in teak.

Table 5 Mean nutrient concentrations in *Acacia mangium*, teak, oil palm and rubber trees and also *Shorea* and legume spp. in Peninsular Malaysia under various soil types/parent rocks

Foliar Nutrients	O. Palm	*Dipt. spp. (N. Forest)	**ruber	+Legume spp. (N. Fprest)	++*A.mangium*~ (Allvial)	*A.mangium*~~ (Lat. Shale)	-*A.mangium*^ (Shale)	*A.mangium*^^ (Bris)	Teak # (Alluvial)
N	2.76	1.36	3.60	2.68	2.85	2.83	2.86	2.16	1.13
P	0.17	0.07	0.22	0.08	0.11	0.10	0.10	0.08	0.10
K	1.09	0.61	1.40	0.72	1.29	1.04	1.29	0.47	0.92
Ca	0.70	0.44	0.70	0.60	—	—	—	0.65	2.08
Mg	0.27	0.19	0.23	0.24	—	—	—	0.23	0.60

Sources: * 8-yr-old (Foster *et al*., 1987), ** and ++ Emergent tree (Amir and Mona, 1990), + Mature rubber tre e (Sivanadyan Rubber Research Institute Malaysia, personal communication), ^^ Amir *et al*. (1991), whilst ~, ~~ ^, and # are of Amir (unpublished data), all of 6-8yr-old-trees.

More studies should be concentrated on nutrient deficiencies, especially in the plantations and the understanding of optimum nutrient requirements of a particular species. This will in turn improve the plantation management. Currently, FRIM has drawn up plans to determine the growth-limiting nutrients of *Acacia mangium, Tectona grandis* and *Calamus manan* since these trees are widely planted and of economic importance.

BRIS and tin tailing soils for use for other forest trees

In addition to *Acacia mangium* FRIM has also gained some experience on trial plots of trees like *Acacia aulocarpa, A. auriculiformis, Pinus caribaea, P. elliotii, P. merkusii, P. oocarpa, Araucaria cunninghamii, Casuarina equisetifolia, Hopea odorata* and *Melaleuca leucadendron* on BRIS and tin tailing soils. In addition, several bamboo species were also tested for culm production. Following are the results that have been obtained to date. The pioneer work of Mitchell (1957) and subsequently those of Ang (1991) and Razak (1991) will be highlighted in this paper.

According to Ang (1986), it is important to determine the age of the tin tailing soil as it exerts on important effect on the growth performance of the planted trees. For example, *Pinus caribaea* planted on a six-and-one-year-old sandy tin tailing soil is capable of attaining a diameter MAI of 0.76cm/yr and 0.58 cm/yr, respectively. This could be due to the lower heavy metal toxicity and acidity which are in agreement with the findings of Mitchell (1959), further supported by Down and Stocks (1977).

It is interesting to note that there was no significant difference in the diameter increment of *Melaleuca leucadendron* planted in one-year-old and two-year-old waterlogged slime of tin tailing soils. Likewise, there was no difference in MAI of the same tree between one and five-year-old sites. These findings to some extent showed that waterlogged slime of different ages does not affect significantly the diameter growth of this particular species. Further research into this area is required before conclusions can be drawn.

Table 5 shows some selected forest tree species and their suitability for the various microsites of tin tailing and BRIS soils in Peninsular Malaysia. In addition, the individual tree MAIs at dbh and top height are presented for comparison.

All these species can be considered to be marketable and their rotation period depends on the objective end use. For timber production, the requirement period can range from 30 to 40 years, with the exception of *Hopea odorata*, since the growth attained after 6 1/2 years is less than 5cm and 5m in terms of dbh and top height, respectively.

In terms of pulpwood production, the rotation period can only range between 7 and 10 years for almost all the listed species. For example, *Acacia mangium* planted on BRIS soils was estimated to reach a MAI of $10m^3/ha/yr$ (Ang and Yusof, 1991). Assuming that all the 162,000ha of BRIS soils are planted with this species, after 7 years as much as 1.62 million m³ of pulpwood materials should be available. This will to some extent enable to overcome the expected shortfall of 2.69 million m³ of pulpwood by the year 1995.

The seeds of all the trial species are easily available. The nursery and forest plantation techniques have been developed (Benard, 1959, Mitchell, 1957 and Ang, 1991). No pests and diseases were observed in the research plots of both tin and BRIS soils, even though some degree of heart-rot has been reported by Zakaria (1992), but is expected to have little impact on the pulp production.

Table 6 Performance of some tree species planted in degraded sites in Peninsular Malaysia

Degraded Species site	Stand age	MAI dbh (cm)	MAI top height (m)
Tin tailing			
1 Sandy			
Acacia aulocarpa	27	0.85	0.64
A. auriculiformis	32	0.78	0.67
A. mangium	4	2.87	2.95
Pinus caribaea	26	0.76	0.74
P. elliotii	33	0.59	0.50
Casuarina equisetifolia	30	0.78	1.00
2 Sandy slime			
A. auriculiformis	30	1.24	0.80
A. richii	28	1.02	0.68
P. merkusii	32	0.87	0.98
P. caribaea	30	1.22	1.00
3 Slime			
A. auriculiformis	32	0.99	0.83
Paraserianthes falcataria	30	1.63	0.91
Fagraea fragrans	30	0.47	0.41
Bris soils			
Acacia mangium	8	2.60	1.86
Hopea odorata	6.5	0.72	0.54
Araucaria cunninghamii	29	0.65	0.45
Pinus caribaea	30	0.92	0.71
Pinus merkusii	24	0.92	0.56
P. oocarpa	24	0.91	0.71
Casuarina equisetifolia	8	2.74	2.45

Source : cited by Zakaria and Ang (1992).

Trials were also conducted by FRIM on tin tailing soils to assess the potential of some selected bamboo species for culm production. Three species, *Bambusa vulgaris, Dendrocalamus asper* and *Gigantochloa levis* were tested by branch cuttings. It was concluded that tin tailing soils can be used for culm production by using a combination of organic fertilizer with compound fertilizer. *Bambusa vulgaris* is the most promising species for culm production among the three species tested (Abdul Razak, 1991).

This study, initiated for the past three years was confined mainly to sedentary soils but is currently dealing with BRIS soils. The data on degraded soils are still at the preliminary stage and further studies are required before concrete evidence can be drawn.

Conclusion

The BRIS and tin tailing soils as problem soils in Peninsular Malaysia are distributed over an area of slightly over 2% of the country's total land mass, which can be considered to be insignificant. However the problem is that these types tend to be localized and dominate a particular state in Peninsular Malaysia. With a view to distributing wealth and securing environmental protection, the Government of Malaysia is promoting the use of these soils for agriculture and forestry.

It is obvious from this paper that both BRIS and tin tailing soils are inherently low in nutrient fertility. These soils are high in sand fractions, excessively drained, show a low nutrient content and water-holding capacity, and the temperature of the surface soil may reach 60°C. The agricultural sector has successfully used BRIS soils for tobacco planting and to a lesser extent for some cash crops, for example, vegetables and melons. The local farmers have successfully utilized sandy slime and slime tin tailing soils for planting star and guava fruits, except for the sandy type.

These soils have a potential for afforestation, provided proper management and mulching materials, organic and inorganic fertilizers are applied at the initial establishment phases. It was observed that *Acacia mangium, A. auriculiformis, A. richii, Pinus caribaea, Paraserienthes falcataria, Casuarina equisetifolia* showed a potential for afforestation on these soils. Furthermore, *Bambusa vulgaris* can also be planted for culm production on these soils provided organic and compound fertilizers are added.

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