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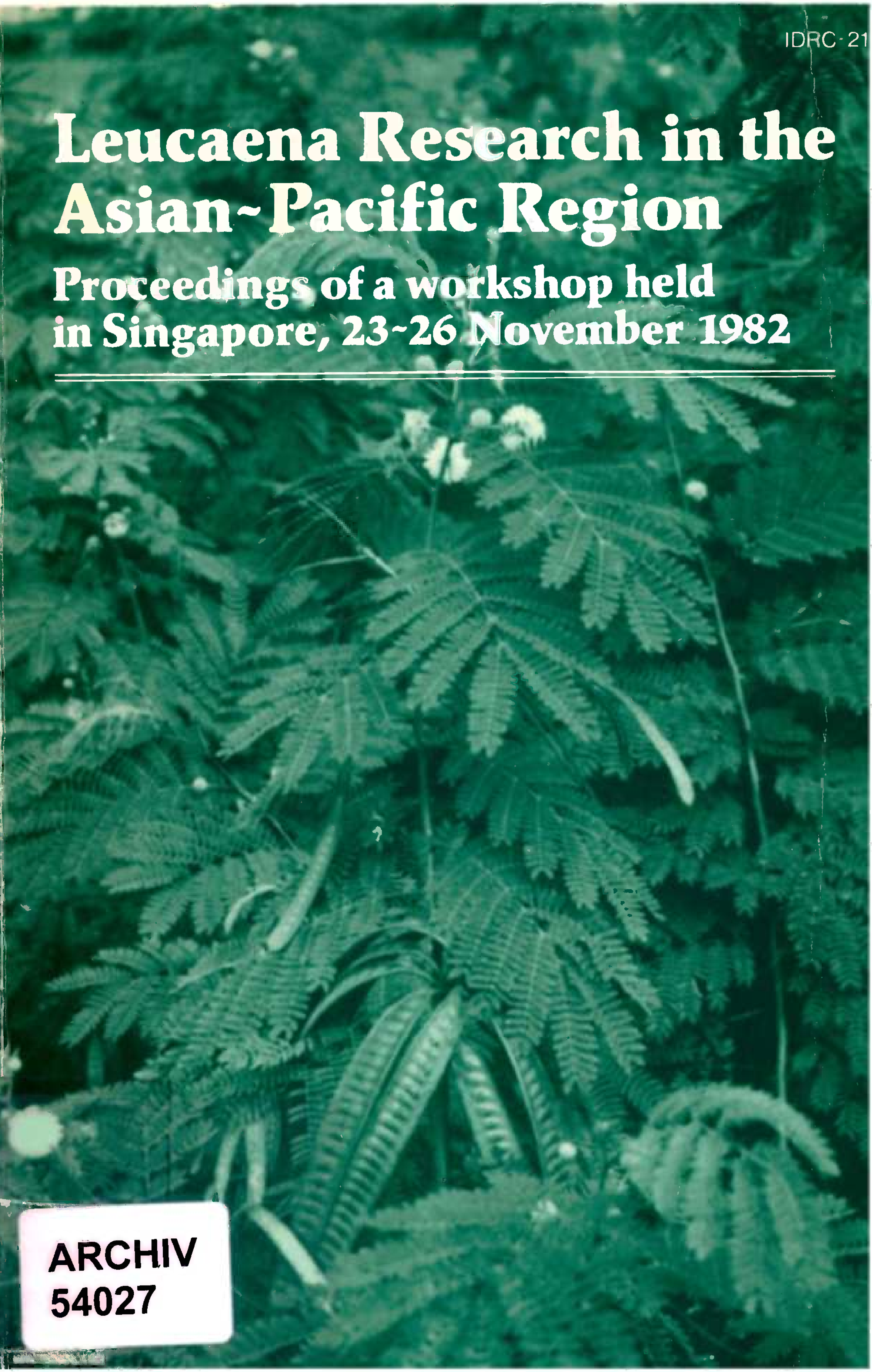
Leucaena Research in the Asian-Pacific Region

Proceedings of a workshop held in Singapore, 23-26 November 1982



Leucaena Research in the Asian-Pacific Region IDRC-211e

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Leucaena Research in the Asian–Pacific Region

Proceedings of a Workshop Held in Singapore, 23–26 November 1982

Organized by the Nitrogen Fixing Tree Association and the International Development Research Centre

Abstract

Because of *Leucaena leucocephala*'s multiple uses as forage, fuelwood, poles, green manure, etc., this fast-growing, nitrogen-fixing tree has been the subject of much research in the last decade. The results have clarified the capabilities of the plant as well as its limitations. One main constraint to cultivation in vast areas of Latin America and Southeast Asia has been leucaena's inability to survive on acidic, aluminum-saturated soils. At low pH, the aluminum complexes with calcium, which is essential for good growth. Trials have shown that some varieties of *L. diversifolia* can make use of the calcium from the complexes and that crosses between these varieties and *L. leucocephala* perform well on acidic soils. The main constraint to use of leucaena as a forage derives from the plant's content of mimosine, a toxic, nonprotein amino acid. Although leucaena has proved to be a highly nutritious animal feed, the mimosine and its breakdown product, DHP (3-hydroxy-4[1H]pyridone), have caused toxicity among animals fed high levels of leaf meal. Scientists now have evidence that the mimosine is converted into DHP when brought into contact with an enzyme contained in some of the plant's cells harbouring mimosine. This finding needs follow up; it suggests that simple processing, such as chopping fresh leaves, will convert all the mimosine into the less-toxic DHP. Elsewhere, researchers have found that DHP can be metabolized by anaerobic microorganisms that have been found in the guts of ruminants in countries like Indonesia. They have successfully transferred the microorganisms to animals in Australia where toxicity from DHP has deterred graziers from using leucaena as forage. Other research has defined optimal approaches to breeding and genetic improvement of leucaena; characteristics of rhizobia that effectively provide the plant with nitrogen-fixing ability; biomass production under widely different soil conditions; effects on fish, poultry, cattle, goats, and sheep fed leucaena leaf meal; management and cultural practices for both large-scale and smallholder operations; etc. The results are the subject of this publication, which comprises 30 papers from researchers in the Asian–Pacific Region.

Résumé

Leucaena leucocephala a fait l'objet de nombreuses recherches au cours de la dernière décennie, cet arbre légumineux fixateur d'azote et de croissance rapide ayant de nombreux usages comme fourrage, combustible, poteau, engrais vert, etc. Ces études ont permis d'en délimiter les fonctions. L'un des facteurs limitants de sa culture dans de vastes régions de l'Amérique latine et de l'Asie du Sud-Est est l'incapacité de *Leucaena* de survivre dans des sols acides, saturés d'aluminium. Dans le cas d'un faible pH l'aluminium complexe le calcium, essentiel à une croissance régulière. Des essais ont démontré que certaines variétés de *L. diversifolia* peuvent utiliser le calcium présent dans les complexes et que les croisements entre ces variétés et *L. leucocephala* prospèrent dans des sols acides. Le principal obstacle à l'utilisation de *Leucaena* comme fourrage est sa teneur en mimosine, acide aminé non protéique toxique. Bien que ce fourrage soit hautement nutritif, la mimosine et DHP (3-hydroxy-4[1H]pyridone) ont provoqué des cas de toxicité chez les animaux consommant de grandes quantités de farine de feuilles. Les scientifiques ont découvert que la mimosine se décompose en DHP lorsqu'elle entre en contact avec une enzyme contenue dans certaines cellules où elle est présente. Cette découverte a permis de déterminer des moyens simples de neutraliser cette substance toxique, tel que le hachage des feuilles vertes qui décompose la mimosine en DHP moins toxique. Ailleurs, des chercheurs ont trouvé que le DHP peut être métabolisé par des microorganismes anaérobiques présents dans l'intestin des ruminants dans certains pays comme l'Indonésie. Ils ont réussi à transférer ces microorganismes à des animaux en Australie où les pasteurs refusent l'emploi du fourrage de *Leucaena* à cause de la toxicité de DHP. D'autres recherches préconisent une approche optimale: de la sélection et de l'amélioration génétique de *Leucaena*; des caractères des rhizobiums qui assurent la fonction de la fixation d'azote chez la plante-hôte; de la production de bio-masse dans diverses conditions de sols très variés; des effets des rations de farine de feuilles sur les poissons, les volailles, le bétail, les chèvres et les moutons; de la gestion et des pratiques culturales des opérations des petites et des grandes exploitations, etc. Tous ces résultats sont détaillés dans la présente brochure qui contient trente communications exposées par des chercheurs de la région du Pacifique asiatique.

Resumen

Debido a los múltiples usos de la *Leucaena leucocephala* como forraje, combustible, madera, abono, etc., este árbol, de rápido crecimiento y habilidad para fijar el nitrógeno, ha sido objeto de abundante investigación en la última década. Los resultados han aclarado las capacidades de la planta, así como sus limitaciones. Uno de los problemas para su cultivo en vastas áreas de Latinoamérica y el Sudeste Asiático ha sido su incapacidad para sobrevivir en suelos ácidos, saturados de aluminio. A niveles bajos de pH, el aluminio forma complejos con el calcio que es esencial para un buen crecimiento. Las pruebas han mostrado que algunas variedades de *L. diversifolia* pueden usar el calcio de los complejos y que los cruces entre estas variedades y la *L. leucocephala* se desempeñan bien en suelos ácidos. El principal inconveniente para usar la leucaena como forraje proviene de su contenido de mimosina, un aminoácido tóxico no proteínico. Aunque la leucaena ha probado ser un alimento animal altamente nutritivo, la mimosina y su producto de descomposición, el DHP (3-hydroxy-4[1H]pyridone), han causado toxicidad entre los animales alimentados con altos niveles de harina de follaje. Los científicos tienen ahora evidencia de que la mimosina se convierte en DHP cuando entra en contacto con una enzima que se encuentra en algunas células de la planta que contienen mimosina. Este hallazgo necesita seguimiento, pero sugiere que un simple procesamiento, como picar las hojas frescas, convierte toda la mimosina en el menos tóxico DHP. En otras partes, los investigadores han encontrado que el DHP puede ser metabolizado por microorganismos anaeróbicos que han sido hallados en el intestino de rumiantes en países como Indonesia. Ellos han traspasado con éxito los microorganismos a animales en Australia donde la toxicidad del DHP ha impedido que los ganaderos empleen la leucaena como forraje. Otras investigaciones han definido los enfoques óptimos para el fitomejoramiento de la leucaena, las características de la rizobia que efectivamente dotará a la planta de la habilidad de fijar nitrógeno, la producción de biomasa bajo condiciones edáficas ampliamente distintas, los efectos sobre los peces, las aves, el ganado, las cabras y las ovejas alimentadas con harina de hoja de leucaena, las prácticas culturales y de manejo para las actividades a gran escala o del pequeño agricultor, etc. Los resultados son el tema de esta publicación que abarca 30 trabajos de investigadores en la región Asiopacífica.

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Contents

Fast-Growing Leguminous Trees in Sabah

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The importance of high growth rates of trees in the tropics is highlighted, particularly in relation to the future demands for wood products in Asia. In Sabah, Malaysia, the need for high volumes of wood and for tree legumes in reclamation of land degraded by excessive cultivation has prompted tree planting and trials with two major species: Acacia mangium *and* Albizia falcataria. *Two other species,* Acacia auriculiformis *and* Gliricidia sepium *are mentioned, the latter grown primarily for its value as cocoa shade in the state. Special attention is drawn to the importance of seed origin and the dangers of overexpanding populations of limited genetic base. The biological ease with which some species can be generatively or vegetatively propagated makes overexpansion a real possibility.*

On souligne ici l'importance des arbres à croissance rapide pour les Tropiques, en considération, surtout, de la demande prévisible des produits du bois, en Asie. Dans le Sabah (Malaisie) cette nécessité a stimulé le recours à des arbres de la famille des légumineuses pour la régénération des terres ruinées par une exploitation agricole excessive, et notamment les essais de deux espèces principales : Acacia mangium *et* Albizia falcataria. *On mentionne également deux autres espèces :* Acacia auriculiformis *et* Gliricidia sepium, *cette dernière précieuse surtout pour ombrager les plants de cacao dans l'État. On attache une attention spéciale à l'origine des semences et aux dangers d'une expansion excessive de populations n'ayant qu'une base génétique limitée. La facilité biologique avec laquelle certaines espèces peuvent se propager par voie végétative ou générative rend très réelle la possibilité d'expansion exagérée.*

Se subraya la importancia de las altas tasas de crecimiento arbóreo en los trópicos, particularmente en relación con las demandas futuras por productos madereros en Asia. En Sabah, Malasia, la necesidad de mayores volúmenes de madera y de árboles leguminosos para recuperar la tierra degradada por exceso de cultivo ha promovido la siembra de árboles y los ensayos con dos especies mayores: la Acacia mangium *y la* Albizia falcataria. *Se mencionan otras dos especies,* Acacia auriculiformis *y* Gliricidia sepium, *la última nombrada principalmente por su valor como sombrío del cacao en la provincia. Se llama la atención sobre la importancia del origen de la semilla y sobre los peligros de la sobreexpansión de poblaciones con base genética limitada. La facilidad biológica con que algunas especies pueden ser propagadas generativa o vegetativamente hace de la sobreexpansión una posibilidad real.*

Tree legumes have a dual role in tropical farming and plantations in Malaysia: reclamation of degraded land and wood production, both of which are becoming increasingly important in Sabah.

Initial studies on tree planting were aimed at finding species and developing silvicultural techniques to reclaim the derived grasslands abandoned after shifting cultivation or, on the Sook plain, probably resulting from a massive natural fire (Cockbum 1974). The Forest Department commenced trials in the mid-1950s. These were intensified a decade later when it was recognized that species were also needed for some logged-over forest areas that did not respond to natural-regeneration management. At this time, the popular species for tropical tree planting, especially on grassland sites, was *Pinus caribbaea*, whereas fast-growing hardwoods such as *A. falcataria, Gmelina arborea,* the eucalypts, etc. were acknowledged as productive species on better sites.

The pines were regularly set back by fires, inevitable in grasslands. Hardwood firebreaks were planted, and the most common species used was the ubiquitous, but poorly formed, *Acacia auriculiformis*. A second acacia *A. mangium*, a species having a distinct bole, was introduced. A small quantity of seed, collected from a single tree, was imported from Queensland, Australia, in 1966 and planted in 1967. Seeds produced in 1971 were used for further firebreaks and Tham (1980) observed: "... by 1975 it was apparent that the species ... was outgrowing the pines on these degraded sites."

Albizia falcataria featured in planting trials from 1960. It occurs in many parts of Sabah, planted mainly as an amenity tree but probably introduced as a shade tree. J.A. Hepburn (personal communication) suggested that the species is native to Sabah. When tobacco was grown in the northwest, *A. falcataria* was used as shade and as fuel for curing the leaves. Like *A. auriculiformis*, it has a notoriously poor form, attractive to landscape planners but problematic for utilization.

The natural distribution of *A. mangium* in Australia is described by Nicholson (1981), and Pedley (1978) recorded it in southern Papua New Guinea and the Moluccas Islands. Tham (1980) placed the northern limit of distribution at 0°50'S at Monokwari in Irian Jaya; the southern limit recorded by Nicholson (1981) is Herbert River Valley, Queensland, Australia, 18°31'S. The natural habitat of *A. mangium* appears to be low-lying land liable to inundation. It occurs with *Melaleuca* spp. in Queensland on the landward fringes of the mangrove forests. Land clearing, especially by fire, influences the local distribution, and *A. mangium* appears to be a pioneer species. It can also be considered a riverine species, occurring abundantly in the riverside forests between Ingham and Mossman on the eastern side of the dividing range. In fact, though normally a lowland species, it may have encroached on the hills through valleys and is found at 720 m altitude in Gadgarra Forest Reserve, Queensland.

Taxonomically, *A. mangium* belongs to the Mimosoideae and is in the section Juliflorae of the subgenus *Heterophyllum*. It is a phyllode-bearing acacia. Upon germination, a single compound leaf (pinnae), usually bearing six pinnules, develops above the cotyledon. At the next 2–4 nodes, a bipinnate leaf is formed. Double bipinnate leaves form on successive nodes and transform into phyllodes. Under nursery conditions, phyllodes are being formed by the 5th or 6th week. The characteristic nodules begin to form on the roots at about the same time. Seedlings tolerate shade or full sun, although observation suggests that light shade for up to 2 weeks is beneficial and full sunlight is preferred thereafter.

Flowers are milky white, borne on a loosely packed spike (53 flowers/cm — Bowen 1981). The corolla is very small, and the androecium gives the flower colour and form. Inflorescences are borne in clusters of 2–6 in the axil of phyllodes, and, at peak flowering, the tree is a mass of blooms. Flowering is precocious, frequently occurring at age 18 months. Most acacias are outbreeding by preference (Moffett and Nixon 1974); therefore, controlled pollination can be effected without emasculation. There is some evidence in Sabah that self-fertilization is possible, but cross-pollination is most common.

Narrow pods (3–5 mm wide) develop and intertwine into characteristically tight ball-like structures. The seeds are oriented along the pods. In Sabah, it has been found that first-generation trees have well-synchronized flowering, and there is always a single annual peak, although synchronization is less in subsequent generations. Pod ripening is indicated by a change from green through brown to black. On ripening, pods dehisce along one margin, and the seeds, also black when ripe, hang outside on the colourful orange funicles, another characteristic of many acacias. Harvesting takes place between late April and mid-August, pods ripening approximately a month earlier on the west coast than on the east.

The potential of this species has been recognized by the United States National Academy of Sciences, which sent a panel of scientists to Sabah in May 1981. Their visit has resulted in the preparation of a document on the species (NAS, in press).

Many albizias are grown as shade trees for cash crops, and they are especially favoured for tea shade in widely separated countries such as Fiji, Sri Lanka, and Kenya. According to Fenton et al. (1977), *A. falcataria* has been planted in forestry trials or plantations in at least 14 countries. Tropical foresters appear to "blow hot and cold" over the species, probably because of its outstanding performance at establishment and growth, which are offset later by its poor form and inability to withstand winds. However, Streets (1962) pointed out that the species, indigenous to Moluccas, has been distributed throughout the Far East since the 1870s, describing it as "A very large, fast growing tree, with light crown and clean straight bole." The wide distribution in the tropics is artificial, and records quoted by Fenton et al. (1977) suggest that it regenerates readily on disturbed land.

The tree belongs to the subfamily Mimosoideae. It has compound leaves, and flowers are borne on fairly large panicles. Like *A. mangium*, the androecium is the attractive part. Flowering appears to be synchronous in Sabah, and, during 2–3 weeks, the crowns of mature trees are covered with flowers. It is unusual for trees to flower before they are 6 years old, and full flowering is unlikely to occur before 10 years.

The flat woody pods are about 10 cm long and 2 cm wide, with the 11 or 12 seeds arranged laterally. The ripening period is extremely short, and, because the pods dehisce along both margins, harvesting must be carefully planned. Seeds are normally collected in May; a few trees flower again in October, but little or no seed can be harvested.

Although *A. mangium* and *A. falcataria* are the only species planted commercially in Sabah, there are two other species worthy of note, i.e., *A. auriculiformis* and *Gliricidia sepium*. Both are planted throughout the state, the former mainly as an amenity species, the latter for cocoa shade.

Acacia auriculiformis grows naturally from northern Queensland and the coast of western Australia into Papua New Guinea where it overlaps with *A. mangium*. It is also found in the Solomons. Like *A. falcataria*, it has been planted in many tropical countries. Generally, it has a very poor form, but its high wood density (0.60–0.75) makes it a useful fuelwood. In the natural forest, some well-formed trees can be found with straight boles of 15 m or more.

Flowers are yellow and, otherwise, are similar to those of *A. mangium*. The species flowers precociously, setting large quantities of seed. The fruits are twisted pods shaped like a human ear, hence the specific name; they often develop close to one another but do not intertwine. Seeds are arranged laterally across the pod and hang outside on yellow funicles after the pod dehisces along one side.

It is difficult to describe the natural distribution of *G. sepium* because it has been introduced into many countries in Asia, Africa, Central and South America. It produces an attractive flower, is easily set from root cuttings, and is, therefore, popular among gardeners throughout the tropics. It can be planted as a live fence, repeatedly pollarded for fuel, and is a valued fodder and a green manure. These attributes have led to its indiscriminate and wide distribution.

The species is also widely used for shade in cocoa plantations, and, as cocoa has become the most popular cash crop in Sabah (before 1970 only 2.5×10^3 ha were planted but by 1981 the figure was more than 50×10^3 ha), *G. sepium* is the most extensively planted tree legume in Sabah. It is seldom raised from seed, cocoa planters preferring hardwood cuttings, about 0.5 m long and 2–3 cm in diameter. On cleared forest sites, mortality is low but, on badly disturbed areas, the cuttings fail unless the planting hole is carefully prepared and a low concentration of rooting hormone is applied (M. McMyn, personal communication).

Field Trials and Growth Rates

In Sabah, research on species introduction and silviculture is carried out by the state forest department, whereas all plantings are entrusted to other agencies such as the Sabah Forest Development Authority (SAFODA), which is a government-controlled body responsible for afforestation. Sabah Foundation, a self-funding government organization established to ensure education facilities and other social improvements for Sabahans, has entered two joint ventures involving major forest tree planting. One, called Sabah Softwoods Sdn Bhd, is with the North Borneo Timber Company and the other, Pacific Hardwoods Sdn Bhd, is with Weyerhaeuser Company. The former plans to plant just over 6×10^4 ha of forest trees, and the latter 1.2×10^4 ha. Since it was formed in 1974, Sabah Softwoods has planted about 2.5×10^4 ha, and Pacific Hardwoods is at the trials stage. SAFODA has established 1.5×10^4 ha, mainly *A. mangium*.

Although *A. mangium* was first planted in 1967, relatively few trials were undertaken before 1980. A spacing trial was established at the Sook research station in 1974, and a further seed importation was planted, also at Sook, in 1978. Meantime, Sabah Softwoods and Pacific Hardwoods planted trials in 1976. UNDP (United Nations Development Programme) sponsored the FAO (Food and Agriculture Organization of the United Nations) Seed Sources Establishment and Tree Improvement Project (MAL/78/009), which was started at the request of the state forest department in 1980 and has since organized many trials.

During 1980, an assessment of form variability, which included growth measurements, was carried out in the older plantings. More seed was imported from individual, though not select, trees from the easily accessible acacia forests of Queensland, Australia. At the same time, arrangements were made for contracts to harvest seed from the remote Iron Range area of Queensland and in the Western Province of Papua New Guinea. These efforts have resulted in a gradual accumulation in Sabah of seed from widely separated sources. A progeny–provenance trial was established on three sites in 1980 and includes a total of 29 progeny and 6 provenances (including the Sabah race).

In 1982, a provenance trial to compare sources south of Mossman in Queensland with the Papua New Guinea provenances was planted by Sabah Softwoods and Pacific Hardwoods, and the Forestry Department established a provenance-resource stand with Papua New Guinea stock. Nursery variation between progeny and provenances is being observed in the successive Sabah generations. Sabah Softwoods planted some of these trials in the field in 1982.

The first recorded trial planting of *A. falcataria* was at Sibuga, near Sandakan, on the east coast in 1960. Seeds were collected locally from amenity trees. This trial has since been felled. Between 1965 and 1969, 14 additional trials were planted on various sites, but only 4 of these have sufficient stocking to be considered as interim seed sources. Sabah Softwoods established *A. falcataria* in its first plantings in 1974 and has planted areas in each succeeding year using seed imported from Sri Lanka. Seeds from selected trees from the Philippines Pulp and Paper Industry (PICOP) Bislig plantations were imported in 1979, and a small plot was planted in 1980 as a provenance-resource trial. This was browsed heavily by deer but was observed to be recovering in 1982. Half-sib progeny seeds from selected PICOP trees were imported in 1981, and a trial was established by Sabah Softwoods in 1982.

The major research field stations are at Sook, Ulu Kukut, and Gum Gum (Fig. 1). Tham (1977) described the Gum Gum site as being a logged-over forest with alluvial soil and the Sibuga site as *I. cylindrica* over degraded red–yellow acrisol (Tham 1980). Data from these sites are complemented by those from

Fig. 1. Map showing research areas in Sabah, Malaysia.

two firebreaks (Jalan Madu and Jalan Lee) at Ulu Kukut, which both traverse a catenary formation on which *I. cylindrica* has become established. The catenary strata are only identified for Jalan Lee. In the Sook area, the spacing trial and the avenue trees are on poor sites but Kampung Bunang is a relatively good site. Data supplied by Sabah Softwoods are from logged-over forest sites that are not really typical of sites within this definition. The Pacific Hardwoods site is compacted ultisol over granodiorite to ultrabasic rock with a pH 6.0.

The plots of *A. mangium* indicate either cessation or marked reduction in height increment with increasing age (Table 1). Height growth at Jalan Madu and Jalan Lee was less than 2 m/year at the time of measurement. Diameter increment appears to fall off with age also but in 8.7-year-old trees, at Jalan Madu, is still 2.4 cm/year.

The influence of age on increment is clear from a comparison of measurements made at Gum Gum. A 9-year-old *A. mangium* tree, 23.0 m high with a DBH (diameter, breast

Table 1. Top height and diameter, breast height (DBH) of *A. mangium*.

Location	Age (years)	Top height (m)	DBH (cm)
Pacific Hardwoods	2.0	7.5	7.9
Kampung Bunang	2.9	13.4	14.4
Sabah Softwoods	5.0	21.6[a]	16.0
Sook	5.1	17.1	13.3
Jalan Lee	8.7	16.3	20.7
Sibuga	10.0	23.0	20.0
Gum Gum	11.9	24.8	26.8
Jalan Madu	12.8	20.1	30.2

[a] Mean height of 100 trees with largest DBH/ha.

Table 2. Variation in growth of *A. mangium* (8.7 years) on different soil catenas along Jalan Lee (Low, in preparation).

Catena	Mean height (m)	Mean DBH (cm)
Skeletal	11.0	14.6
Hill creep	14.6	18.8
Sedentary	15.9	19.9
Hill wash	19.5	23.9
Alluvium	20.7	26.5

height) of 22.9 cm, exhibited an annual increment of 2.6 m in height and 2.5 cm in DBH, whereas the respective figures for an 11.9-year-old tree (24.8 m tall and 26.8 cm DBH) were 2.1 m and 2.3 cm. Nevertheless, the growth rates are still good, and, as the wood density is approximately 0.6 (NAS, in press), the production is satisfactory. A 10% sample of the Jalan Lee population (made up of more than 2000 trees) was measured. This firebreak extends nearly 5 km across five catenary strata (Table 2).

The development of soil catenas is important to plant growth throughout the world but is especially significant in the tropics. Soil texture varies little from catena to catena, but soil depth usually increases from the top to the bottom of the slope; in this case, the difference in altitude is less than 100 m and only the alluvial catena is much deeper than the others. Tree growth on the alluvial catena is almost double that on the skeletal catena of the hilltop — a difference that could be extremely important to *A. mangium* wood production.

The effects of three spacings (4.6, 3.7, and 3.1 m) were measured at Sook, and the findings at 5.1 years indicated that the closest spacing increased height growth considerably (mean heights 14.9, 14.3, and 17.1 m respectively) but had little influence on diameter growth (mean DBH 13.8, 13.4, and 13.3 cm).

There are only two reliable estimates of volume production for this species in Sabah: the first, supplied by Sabah Softwoods, is 145 m^3/ha (at 5 years), which translates into a mean annual increment (MAI) of 29 m^3/ha. The second was recorded by Tham (1980) when the Sibuga plantation was felled at 10 years, yielding 439 m^3/ha (MAI 44 m^3/ha). Both figures were to 10 cm top diameter.

The growth of *A. falcataria* is being carefully monitored by Sabah Softwoods, and Tan and I (1982) have reported the data elsewhere. Mean data from soils more than 50 cm deep with more than 20% clay provide some basis for growth comparisons for the species from ages 2–7 years, and other data are available for older trees from the Forestry Department trial plots (Table 3).

The only volume data available (Tan and Jones 1982) for the species in Sabah indicate 225 m^3/ha at age 5 years (MAI 45 m^3/ha). Plots on better sites annually yield 66 m^3/ha.

Wood density of *A. falcataria* at Gum Gum has been recorded by Ong and Tham (1980) as varying between 0.24 and 0.41. Correlations between density and growth rates indicate higher density with better growth rates; however, the correlations are weak.

Seed Supplies

At the beginning of a planting program, seeds often are obtained from the most convenient sources, although research over the last 2 decades has indicated that the origin (provenance) of a particular species may be critical to its success. If the genetic base is limited, a

Table 3. Growth data for *A. falcataria* in Sabah.

Location	Age (years)	Height (m)		Mean DBH (cm)
		Dominant[a]	Mean	
Sabah Softwoods	2	11.5	—	—
Sabah Softwoods	3	19.1	—	—
Sabah Softwoods	4	25.2	—	—
Sabah Softwoods	5	29.4	—	—
Sabah Softwoods	6	32.7	—	—
Sabah Softwoods	7	35.2	—	—
Kolapis	10.4	31.0	26.5	32.5
Gum Gum	11.4	34.0	30.1	35.5
Apas Road	14.4	35.0	24.0	37.1
Lungmanis	14.8	34.0	30.5	47.9

[a] Mean height of the 100 trees/ha with the largest DBH.

precocious, flowering species that is easily propagated can be overextended.

Acacia mangium is an example. A small amount of seed was imported from a single tree to establish the first Sabah generation (fewer than 500 trees in 1967 on three sites) and served as the source for seed for second and third generations. Fourth and fifth generations will have developed by now, and examination of the first, second, and third generations indicated a deterioration in form (Williams et al., in preparation). This degradation was both masked and complicated by the development of an *A. auriculiformis* hybrid (FAO, in press, a).

A new two-pronged breeding policy, therefore, was developed for *A. mangium*, requiring vegetative expansion of selected trees of the original imports and imports of more sources to expand the genetic base. At present, the first generation in Sabah seed is harvested from Jalan Madu, 221 trees, and from Gum Gum, 37 trees; the second generation comes from Jalan Lee, Penuntut, and Siba also at Lungmanis, approximately 4500 trees. It is estimated that the mean annual harvest if properly timed and carefully handled will be 0.5 kg seeds from each tree (Bowen and Eusebio 1981a). During the 1982 harvest season, every effort was made to maximize the first-generation harvest (Bowen and Eusebio, in press); however, shortage of staff and a poor crop combined to reduce the forecast 126 kg to an actual harvest of only 44.5 kg. Likewise, only 101 kg of second-generation seed was harvested because of a shortage of staff. A new seed source is being developed from a second importation, which has been culled to 10% of its original size (3600 trees). The stand is now 4 years old so should be in full production in the late 1980s.

Sabah Softwoods has about 18 ha of culled stands, harvesting more than 80 kg seed in 1981. It has potential for a much larger production, well in excess of its requirements.

Albizia falcataria presents a different problem: reasonable quantities of seed are only available within Sabah from amenity trees. Sabah Softwoods imports all its seed from Sri Lanka. Studies at the Tree Improvement Section of the state research centre and by the Sabah Softwoods tree breeder indicate a generally poor form of trees both from local seed sources and from exporters. However, excellent trees occur in the Philippines (Jones 1981), and there is evidence that selection will improve form. Attempts are being made to establish seed sources in Sabah from outstanding individuals and also from seed imported from the Philippines. Unfortunately, the species will take 10 years to become productive. Efforts are being made to propagate flowering individuals vegetatively, but this is difficult. There is a possibility that vegetative propagation of juvenile material for commercial planting will be an answer to these problems (FAO, in press, b).

Acacia auriculiformis seed is readily available from amenity trees, but the form is very poor. Like *A. mangium*, this species probably has suffered from an overexpansion of a limited genetic base. Seed has now been imported from western Australia and ordered from Papua New Guinea.

Gliricidia sepium develops into a shrub of up to 10 m on good, often volcanic, sites in the south. However, it is normally smaller than this. Its wide, artificial range, coupled with its easy propagation, especially by cuttings, suggests the need for survey of its natural habitat to ascertain its potential beyond that of shade or fuelwood.

Conclusions

Tree legumes are important in Sabah both for the rehabilitation of land degraded by overintensive agriculture and for the production of wood raw material. *Acacia mangium* has shown itself capable of growing, and growing quite well, on degraded and disturbed sites. However, the current population of this species in Malaysia is from a limited genetic base. The quality and health of this population need careful monitoring while efforts are being made to expand the gene base. Ample seed of improved quality for the state needs is available at present, and other sources are being developed. The need and the means for improvement of the form of *A. falcataria* have been identified, and efforts are being made to develop within-state sources. Both *A. auriculiformis* and *G. sepium* have potential, and the latter is widely planted as shade for cocoa. No research is planned for either species, although potentially better-quality seed of *A. auriculiformis* has been and is being imported. Sabah is fortunate in having an expanding plantation program, as rapid forest-exploitation continues. There is every possibility that a continued raw-material resource will be available for either export or local processing.