Acacia auriculiformis A. Cunn. ex Benth. Northern black wattle

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Leguminosae (Mimosoideae) Legume family

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Acacia auriculiformis A. Cunn. ex Benth., commonly known as northern black wattle in Australia, Papua wattle in Papua New Guinea, and kasia in Indonesia, is a small to medium-sized tree native to northern Australia and islands off the southern coast of Papua New Guinea (*34, 36*). During the past 60 years, it has been introduced to many tropical countries in Asia, Africa, and Latin America, where it is planted for fuelwood, erosion control, shade, and ornamental purposes. Tolerant of extremely poor soils, this nitrogen-fixing tree is a promising species for pulpwood production. It is also particularly useful for rehabilitating severely degraded sites, such as mined lands and grasslands resulting from human disturbance. It has been successfully used to rehabilitate *Imperata* grasslands in Southeast Asia.

HABITAT

Native and Introduced Ranges

Northern black wattle occurs in natural stands between latitudes 5° and 14° S. in northern Australia (Queensland and Northern Territory), southern New Guinea, and eastern Indonesia on the Kei Islands and Thursday Island (fig. 1). Due to its ability to grow well on difficult sites and ameliorate poor soils, it has been introduced into several countries in Asia, Africa, and Latin America since the 1930's. In Puerto Rico, the first plantation trials were established in 1989 at a coastal site in Toa Baja from seeds of Australian origin. Northern black wattle is a very common ornamental and shade tree in Florida.

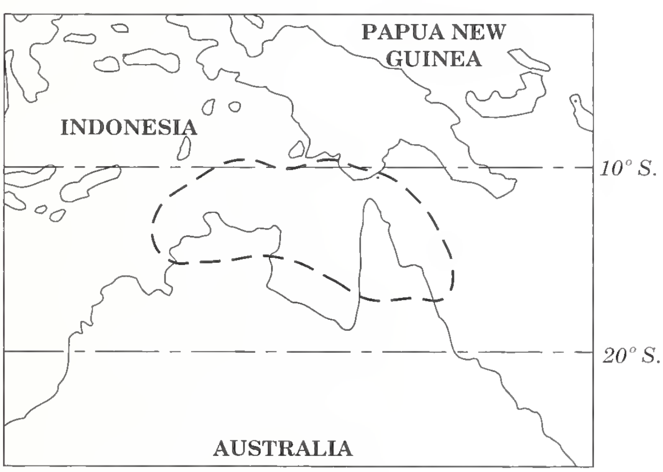

Figure 1.—*Native range of northern black wattle (*Acacia auriculiformis *A. Cunn. ex Benth.) enclosed by a dashed line.*

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Climate

The native range of northern black wattle lies within the hot humid and hot subhumid climatic zones that have summer rainfall of 1300 to 1700 mm and a dry season of 4 to 6 months (*34, 36*). In its native range, temperatures are high throughout the year, with a mean annual temperature from 24 to 26 °C and mean maximum and minimum temperatures during the warmest and coolest months, respectively, of 32 to 34 °C and 17 to 22 °C (*35*). In the northern part of its range, the mean annual rainfall is approximately 2000 mm. Rainfall throughout the range has a monsoonal pattern, with a dry season occurring between May and October.

Although it survives in areas receiving less than 1500 mm of annual rainfall, it is best suited to climates with an annual rainfall of at least 2000 mm and with a dry season lasting several months (*24*). Due perhaps to its superficial root system, it is not as drought resistant as other species commonly used for reforestation of degraded sites, such as *Eucalyptus* spp. (*23*).

Soils and Topography

Northern black wattle is a lowland species that grows mainly on sites from sea level to about 100 m in elevation, although it sometimes occurs naturally on sites up to 500 m in elevation (*35, 36*). In northern Australia, it grows mainly on dissected, lateritic, lowland soils and alluvial coastal plains. These soils vary from dune sands and sandy loams to alluvial soils with a high clay and humus content. The species can tolerate highly alkaline and saline soils. In coastal areas of the Northern Territory, it occurs naturally just above the tidal range on the edges of sand dunes, behind mangrove forests, and along river levees. In Queensland it occurs naturally mainly on river banks and drainage lines (*35*). In Papua New Guinea and Irian Jaya, Indonesia, it occurs mainly on the Oriomo Plateau, a relict alluvial plain with well-drained acidic soils in which a shallow, sandy loam is over a heavy clay. It also occurs on poorly drained, strongly acidic, nutrient-poor Ultisols that are subject to flooding during the wet season.

This species tolerates a wide range of soil types from light sands to heavy clays, including lateritic soils, Vertisols developed on marl, and on various eroded soils (*4, 36*). In northern Australia it has been grown on acidic uranium mine spoils with a pH of 3.0 as well as on alkaline dune sands with a pH of 9.0 (*23*). Studies have shown that potted seedlings grow equally well over a range of pH's from 4.3 to 8.0 (*15*). Because of this species' tolerance of oxygen deficiencies, it will survive prolonged flooding (*35*).

It performs well on extremely poor, nitrogen-deficient soils and is commonly planted to stabilize eroded hillsides and to improve soil fertility (*10, 23, 34*). It has been planted successfully on tin mine spoils and nutrient-deficient sands in Malaysia (*22, 34*); on degraded lands in Sabah; on sand dunes and infertile coastal sites in India, Zanzibar, Malaysia, and Puerto Rico; and on poorly drained grasslands on Spodosols in Papua New Guinea. In Southeast Asia, it is considered a very useful species for suppression of *Imperata* grass, although it is less resistant to fire than species such as *Eucalyptus* (*4, 34, 36*).

Associated Forest Cover

In northern Australian savanna forests, northern black wattle is an early successional species, forming narrow belts in which it may be a dominant or codominant species. In coastal grasslands on the Cobourg Peninsula, Northern Territory, it is associated with *Alstonia actinophylla, Casuarina equisetifolia* L. ex J.R. & G. Forst., *Pandanus spiralis,* and *Timonius timon* (*6*). Elsewhere in northern Australia, it grows in depressions or along drainage channels in low, open forests dominated by *E. miniata* A. Cunn. ex Schau. and *E. tetrodonta* F. Muell., with *Acacia holosericea* A. Cunn. ex G. Don. and *A. simsii* A. Cunn. ex Benth. as understory associates (*35*). It is also found in littoral rain forests adjacent to either mangrove forests or coastal dunes in association with *A. aulacocarpa* A. Cunn. ex Benth., *A. mangium* Willd., *Canarium australianum* F. Muell., *Casuarina equisetifolia, Hibiscus tiliacous* L., and *Melaleuca leucadendra* (L.) L. (*35*).

On the Oriomo Plateau in Papua New Guinea, northern black wattle occurs at low population densities in savanna woodlands with *A. mangium, Lophostemon suaveolens*, and *M. cajaputi* Powell, and in open, monsoon forests with *A. aulacocarpa* and species of *Halfordia, Lophostemon, Mangifera, Parinari,* and *Syzygium*. In swamp forests, it usually occurs on better drained sites dominated by *Melaleuca cajaputi* and other *Melaleuca* spp. It is common in littoral forests in association with *Alstonia spectabilis* R. Br., *Canarium* sp., *Instia* sp., and *M. cajaputi* (*35*).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.— Flowers are borne in paired axillary spikes up to 8 cm long. Individual flowers are stalkless, tiny, and 3 mm long. They are composed of a cuplike, five-toothed, hairless calyx; a corolla of five narrow, pointed petals 2 mm long; many threadlike stamens 3 mm long; and a pistil with a hairy ovary and threadlike style (*21*).

The fruits are flat, twisted, rather woody pods approximately 1.5 cm wide and 6.5 cm long. In its native range, flowering occurs from June to July, and pods ripen between August and October (*35*). On Java, trees flower throughout the year, with peak seed production from July to November (*36*). In Puerto Rico, flowering occurs between February and April, and the dehiscent fruits contain up to 15 seeds each (author, personal observation).

Seed Production and Dissemination.— The black, beanlike, elliptical seeds are approximately 5 mm long. They are attached to the pods by a long, encircling, yellow-orange to red stalk, or funicle. On maturity, the pods split along a single margin, exposing the seeds that fall to the ground after decomposition of the attached funicle. The seeds are typically dispersed either by wind while still attached to the pods or by birds that consume the edible funicle. Depending on individual seed weights, the number of seeds per kilogram can vary from 30,000 to 62,000 (*35, 36*). In Puerto Rico, there were 48,000 seeds per kilogram for samples collected from 4-year-old trees (author, personal observation).

Seeds sown 2 months after ripening reportedly have the highest germinative capacity (*36*). Stored in air-tight containers, seeds remain viable for at least 18 months (*36*).

Seedling Development.—The germination of northern black wattle seeds is epigeous and takes place 6 to 28 days after sowing. For best results, seeds should be scarified by hot water treatment before sowing. One of two methods is recommended: immersing in boiling water for 30 seconds followed by soaking in water at ambient temperature for 24 hours (*8*), or soaking in warm water for 24 hours (*36*). In tests conducted in Puerto Rico, the germination rate for fresh seeds without pretreatment was 4 percent, whereas hot water pretreatment enhanced germination to between 47 and 65 percent (author, personal observation). Seeds should be sown under full light in loose, well-drained soil at a depth of 0.6 to 1.2 cm.

Newly germinated seedlings produce two or three bipinnate leaves, but thereafter develop long, narrow phyllodes (modified leafstalks) 1.5 to 2.5 cm wide and 10 to 16 cm long. Seedlings generally begin to reach plantable size (15 to 30 cm tall) at approximately 3 months of age, although taller seedlings are recommended for plantings in *Imperata* grasslands (*26*).

Plantations are normally established using containerized seedlings, although bare-root planting stock is also recommended (*8*). In either case, the root collar diameter should be at least 0.5 cm (*8*). Direct sowing has met with only limited success due to weed competition (*4, 36*). Seedlings are very hardy and will usually survive without site preparation, although intensive site preparation, cultivation, and fertilization in the early establishment phase was found to greatly improve growth on poorly drained, degraded grasslands in Papua New Guinea (*20*).

Natural regeneration is profuse after fire or on disturbed sites in the absence of heavy weed competition. Natural regeneration after clearcutting of plantations in Java has been found to be an acceptable means for obtaining a well-stocked second rotation crop (*36*).

Vegetative Reproduction. Coppice regeneration is possible, but only if the stumps remain moist and shaded. A successful technique developed in Indonesia involves cutting the trees during the wet season at a height of 50 cm, leaving one of the basal branches (*33*). This species can be readily propagated from cuttings treated with indolacetic acid (IAA) (*16*).

Sapling and Pole Stage to Maturity

Growth and Yield.—Mature trees usually attain heights of between 8 and 20 m and are usually heavily branched with a short, crooked stem up to 50 cm in diameter at breast height (d.b.h.). Under favorable conditions in its native habitat, northern black wattle can occasionally grow to 30 m in height with a single, straight stem up to 80 cm in d.b.h. (*36*). On *Imperata* grasslands in Southeast Asia and on very infertile soils, its growth is usually better than that of other fast-growing species of *Albizia, Eucalyptus, Leucaena*, and *Pinus* (*35*).

Under optimal conditions, early growth is very rapid, with heights of 15 to 18 m and d.b.h.'s of 15 to 20 cm attained at 10 to 12 years. On degraded sites where this species is most commonly planted, growth rates are highly variable, with reported average stem diameter and height increments ranging from 1.0 to 4.5 cm/yr and 0.6 to 4.1 m/yr, respectively, in stands up to 6 years of age, and from 0.8 to 1.6 cm/yr and 0.6 to 1.8 m/yr in stands from 7 to 20 years of age (*4, 8,* 22, 25, *35*).

In adaptability trials in Puerto Rico on a coastal site with sandy soils receiving 1600 mm of annual rainfall, mean tree heights with 2- by 2-m spacings were 2.3 ± 0.1 m, 5.8 ± 0.1 m, and 9.2 ± 0.2 m at 12, 28, and 48 months, respectively. Mean tree d.b.h. at 48 months in this study was 10.2 ± 0.3 cm (author, unpublished data).

On relatively fertile soils in Sabah and Java receiving over 2000 mm of annual rainfall, mean annual wood increments of 15 to 20 m^3/ha have been reported (*26, 31, 36*). On the island of Madura, Indonesia, mean annual increments of 7.6

to 9.0 m^3/ha were obtained in 7- to 12-year-old plantations on sites receiving 1700 to 1900 mm of annual rainfall (*36*). On less fertile or highly eroded sites, the increments are generally reduced to 8 to 12 m^3/ha (*36*). Further yield reductions are to be expected on drier sites or those subject to a prolonged dry season. In West Bengal, India, for example, expected mean annual increments of 2 to 6 m^3/ha were estimated for 10- to 20-year-old plantations on sites with red lateritic soils receiving 1000 to 1400 mm of annual rainfall (*8*).

Litter production constitutes a very high proportion of net primary production in northern black wattle plantations, contributing to the species' value for rehabilitating degraded soils. Studies of 4- and 7.5-year-old plantations in Java (*36*) and the Congo (*5*) indicated that litter production comprised between 37 and 40 percent of total net aboveground production, or 9.2 to 10.7 t/ha/yr. Leaf litter decomposition rates for this species are similar to those of *Dalbergia latifolia* Roxb. and *Swietenia mahogoni* Jacq., but much slower than those of fine-leaved leguminous trees such as *L. leucocephala* (Lam.) de Wit and *Paraserianthes falcataria* (L.) I. Nielsen, which have higher foliar nitrogen concentrations and a much thinner cuticle (*36*).

Rooting Habit.— Northern black wattle forms a wide-spreading, densely matted, superficial root system, enabling it to grow on very shallow soils and favoring its use in reforestation programs for erosion control. Root biomass comprised 9.4 percent of total tree biomass in 7.5-year-old plantations in the Congo (*5*).

Like other members of the genus *Acacia*, northern black wattle forms a symbiotic association with nitrogen-fixing bacteria. Nursery studies have shown that the roots of seedlings inoculated with *Bradyrhizobium* and *Rhizobium* bacterial strains form nodules, although only *Bradyrhizobium* strains are known to fix nitrogen (*12*). Both vesicular-arbuscular mycorrhizal fungi and ectomycorrhizal fungi are typically associated with the roots of this species (*11*).

Reaction to Competition.— Plantations are normally established at densities ranging from 1,600 to 3,000 trees per hectare. In Indonesia, where plantations are on a 10-year rotation, a single thinning is recommended to maintain a relative spacing (tree distance to tree height) of 0.35 (*31*). Studies in Papua New Guinea have shown that higher production is obtained in heavily thinned than in lightly thinned plots (*20*).

Mixed-species plantations with *D. latifolia* have shown good results in Indonesia (*36*). In this system, northern black wattle seedlings were planted at an initial density of 2,475 trees per hectare and *D. latifolia* at 825 trees per hectare. The northern black wattle was thinned to one-third of its initial density at 6 years, and the remainder was harvested at 10 years, leaving the *D. latifolia* for a later harvest. Mixed-species plantings of northern black wattle with *Albizia lebbek* (L.) Benth., *Calliandra calothyrsus* Meissn., and L. *leucocephala* at a coastal site in Taiwan reportedly showed good survival and growth (*18*). Due to heavy shading and possible allelopathic effects of leaf litter, northern black wattle is not considered an ideal tree for taungya or other agroforestry systems involving interplanting with food crops (*32, 36*)

Damaging Agents.— To date, no major pests and diseases of northern black wattle have been reported. In nurseries and young plantations in Indonesia, a rust fungus (*Uromyces digitatus* Winter) is known to impair growth, and root rot caused by *Ganoderma lucidum* (Leyss.) Karst. and *G. applanatum* (Pers.) Pat. has been reported in India (*30, 35, 36*). Powdery mildew disease caused by *Sphaerotheca* sp. has been reported in nursery-grown seedlings in Indonesia (*17*).

In Malaysia, shoots and transplants of northern black wattle are reportedly susceptible to serious infestations by *Hypothenemus dimorphus*, and attacks by the weevil, *Hypomeces squamosus*, have been reported in both Malaysia and India (*2*). In southern India, the larvae of the coleopteran *Myllocerus viridanus* Fab. has been reported to cause some defoliation in plantations (*2*). In northern Australia, the wood is often attacked by borers and termites, and scale insects are common on young trees (*14, 35*).

SPECIAL USES

Northern black wattle produces fine-grained, often attractively fissured timber that finishes well (*19*). The light-brown to dark-red heartwood is hard and durable, while the yellow sapwood is susceptible to termite and borer attacks and requires preservative treatment when in contact with the soil. The wood has a high specific gravity (0.60-0.75 g/cm), a calorific value of 4.8 to 5.0 kcal/g, and burning characteristics that make it an excellent source of firewood and charcoal, for which it is extensively planted in China, India, and Indonesia, and elsewhere in Asia (*23, 35, 36*). In many countries, the abundant leaf and branch litter produced in plantations is also used for fuel (*24*).

Plantation-grown northern black wattle is a promising source of raw material for the production of high-quality sulphate and neutral sulphite semichemical pulp, though it is less suitable for high-yield mechanical pulp (*23, 28*). The bark yields a natural dye used in the batik textile industry. The bark contains a water-soluble tannin (13 percent) that produces a good quality leather, but tends to redden on exposure to sunlight (*1, 23*).

The species has been used in many countries for revegetating mined lands and mine spoils, and is sometimes planted for shade and ornamental purposes in cities where it is valued for its hardiness, dense foliage, and bright yellow flowers (*35*). In India, the tree is used in the production of shellac as a host for the lac insect, *Kerria lacca*.

GENETICS

Northern black wattle (formerly known as *Acacia auriculaeformis* A. Cunn) is closely related to A. *aulacocarpa* and *A. crassicarpa* A. Cunn. ex Benth. but differs from both by having narrower pods and having seeds encircled by a bright orange or red funicle (*35*). It is sometimes confused with *A. leptocarpa* A. Cunn. ex Benth. and *A. polystachya* A. Cunn. ex Benth. These latter species can be distinguished by their pod characteristics and phyllode venation (*29*). A recently proposed reclassification of the genus *Acacia* includes the transfer of the majority of Australian *Acacia* spp., including northern black wattle, to the genus *Racosperma* (*27*).

Genetic variation among provenances of this species is thought to be very high, and there may be considerable scope for genetic improvement, with stem form as the major selection criterion (*13*). An international trial of 25 provenances from northern Australia and Papua New Guinea was recently initiated at 7 sites in 4 countries in Southeast Asia (*3*). Hybrids of northern black wattle and *A. mangium* occur in both natural stands and in plantations (*29, 35*). Northern black wattle is a diploid species with 26 chromosomes (*7*).

LITERATURE CITED

1. Abdul Razak, M.A.; Low, C.K.; Abu Said, A. 1981. Determination of relative tannin contents of the barks of some Malaysian plants. Malaysian Forester. 44: 87-92.
2. Ahmed, Mukhtar. 1989. Feeding diversity of *Myllocerus viridanus* Fab. (Coleoptera: Curculioidae) from south India. Indian Forester. 115(1): 832-838.
3. Awang, Kamis; Venkateswarlu, Perugupalli; Aini, Abd. Shukor Nor [and others]. 1994. Three year performance of international provenance trials of *Acacia auriculiformis*. Forest Ecology and Management. 70: 147-158.
4. Banerjee, A.K 1973. Plantations of *Acacia auriculaeformis* (Berth.) A. Cunn. in West Bengal. Indian Forester. 99(9): 533-540.
5. Bernhard-Reversat, France; Diangana, Daniel; Tsatsa, Martin. 1993. Biomasse, minéralomass et productivité en plantation d'*Acacia mangium* et *A. auriculiformis* au Congo. Bois et Forêts des Tropiques. 238: 35-44.
6. Bowman, D.M.J.S.; Panton, W.J.; McDonough, L. 1990. Dynamics of forest clumps on Chenier Plains, Cobourg Peninsula, Northern Territory. Australian Journal of Botany. 38(6): 593-601.
7. Brewbaker, James L.; Halliday, Jake; Lyman, Judy. 1983. Economically important nitrogen fixing trees. Nitrogen Fixing Tree Research Reports. 1: 35-40.
8. Briscoe, C. Buford; Alcazar, Jocelyn M.; Votación, Paciencia A. 1988. Multipurpose tree species trials data compilation, Republic of the Philippines. F/FRED Project, Multipurpose Tree Species Network Research Series Rep. 3. Arlington, VA: Winrock International. 62 p.
9. Browne, F.G. 1968. Pests and diseases of forest plantation trees. Oxford: Clarendon Press.
10. Chakraborty, R.N.; Chakraborty, D. 1989. Changes in soil properties under *Acacia auriculiformis* plantations in Tripura. Indian Forester. 115(4): 272-273.
11. Chong, L. 1987. Occurrence of mycorrhizae in seedlings of some tree species in Sarawak. Forest Research Report FP5. Kuching, Sarawak, Malaysia: Forest Department. 12 p.
12. Galiana, A.; Chaumont, J.; Diem, H.G.; Dommergues, Y.R. 1990. Nitrogen-fixing potential of *Acacia mangium* and *Acacia auriculiformis* seedings innoculated with *Bradvrhizobium* and *Rhizobium* spp. Biology and Fertility of Soils. 68(4): 263-272.
13. Gavinlertvatana, Paiboolya; Matheson, A. Colin; Sim, Eng Peng. 1987. Feasibility study on tissue culture for multipurpose tree species. F/FRED Project, Multipurpose Tree Species Network Research Series Rep. 1. Arlington, VA: Winrock International. 78 p.
14. Hearne, D.A. 1975. Trees for Darwin and Northern Australia. Canberra: Australian Government Publishing Service.
15. Hu, P.W.; Cheng, W.E.; Shen, T.A. 1983. Growth of seedlings of four leguminous tree species in relation to soil pH in a pot test. Nitrogen Fixing Tree Research Reports. 1: 24-25.
16. Huang, L.S. 1989. Study on the inoculation and cultural techniques of *Acacia auriculiformis*. Forest Science and Technology (China). 5: 10-11.
17. Ibnu, Z.; Supriana, N. The use of the fungicide copper oxychloride 85% to control mildew diseases on *Acacia auriculiformis*. Buletin Penelitian Kehutanan. 3(1): 63-72.
18. Kan, W.H.; Hu, T.W. 1987. Regeneration of deforested sites of coastal windbreaks by underplanting. Bulletin of the Taiwan Forestry Research institute. 2(1): 1-15.
19. Keeting, W.G.; Bolza, E. 1982. Characteristics, properties and uses of timbers. Vol 1. Southeast Asia, Northern Australia and the Pacific. Melbourne: Inkata Press. 362 p.
20. Lamb, D. 1975. Kunjingini plantations 1965-1975. Tropical Forestry Research Note SR. 24. Boroka, Papua New Guinea: Department of Forests. 14 p.
21. Little, Elbert L., Jr.; 1983. Common fuelwood crops. Morgantown, WV: Communi-Tech. Associates. 354 p.
22. Mitchell, B.A. 1957. Malayan tin tailings - prospects for rehabilitation. Malayan Forester. 20(4): 181-186.
23. National Research Council. 1980. Firewood crops: shrub and tree species for energy production. BOSTID Rep. 27. Washington, DC: National Academy of Sciences. 237 p.
24. National Research Council. 1983. Mangium and other acacias of the humid Tropics. BOSTID Rep. 41. Washington, DC: National Academy of Sciences. 63 p.
25. Neil, P.E. 1986. Early results from *Acacia* species research. Forest Res. Rep. 7/86. Port Vila, Vanuatu: Vanuatu Forest Service. 10 p.
26. Nicholson, D.I. 1965. A note on *Acacia auriculiformis* A. Cunn. ex Benth. in Sabah. Malaysian Forester. 28: 243-244.
27. Pedley, L. 1986. Derivation and dispersal of *Acacia* (Leguminosae), with particular reference to Australia, and the recognition of *Senegalia* and *Racosperma*. Botanical Journal of the Linnean Society. 92: 219-254.
28. Phillips, F.H.; Logan, A.F.; Balodis, V. 1979. Suitability of tropical forests for pulpwood: mixed hardwoods, residues and reforestation species. Tappi. 62: 77-81.
29. Pinyopusarerk, K. 1990. *Acacia auriculiformis:* an annotated bibliography. Canberra, Australia: Australian Centre for International Agricultural Research; Morilton, AR: Winrock International Institute for Agricultural Development. 154 p.
30. Santosa, E.; Suharti, M. 1984. Morphological and anatomical studies of rust diseases attacking *Acacia auriculiformis*. No. 441. Hutan, Indonesia: Laporan, Pusat Penelitian den Pengembangan 15 p.
31. Sastroamidjojo, J.S. 1964. *Acacia auriculiformis* A. Cunn. Rimba Indonesia. 9(3): 214-225.
32. Setiadi, D.S.; Samingan, T. 1978. Allelopathic effects of *Acacia auriculiformis, Acacia villosa* and *Albizia falcataria* on seedlings of *Tamarindus indicus*. Kehutanan Indonesia. 5(6): 6-20.
33. Soedibja, R.S.; Ardikusumah, R.I. 1953. A consideration about the coppice system experiment with *Acacia auriculiformis* A. Cunn. at Maribaja (Djasinga). Rimba Indonesia. 2: 279-288.
34. Streets, R.J. 1962. Exotic forest trees in the British Commonwealth. Oxford: Clarendon Press. 750 p.
35. Turnbull, John W., ed. 1986. Multipurpose Australian trees and shrubs: lesser-known species for fuelwood and agroforestry. AGIAR Monograph 1. Canberra: Australian Centre for International Agricultural Research. 316 p.
36. Wiersum, K.F.; Ramlan, A. 1982. Cultivation of *Acacia auriculiformis* on Jaya, Indonesia. Commonwealth Forestry Review. 61(2): 135-144.