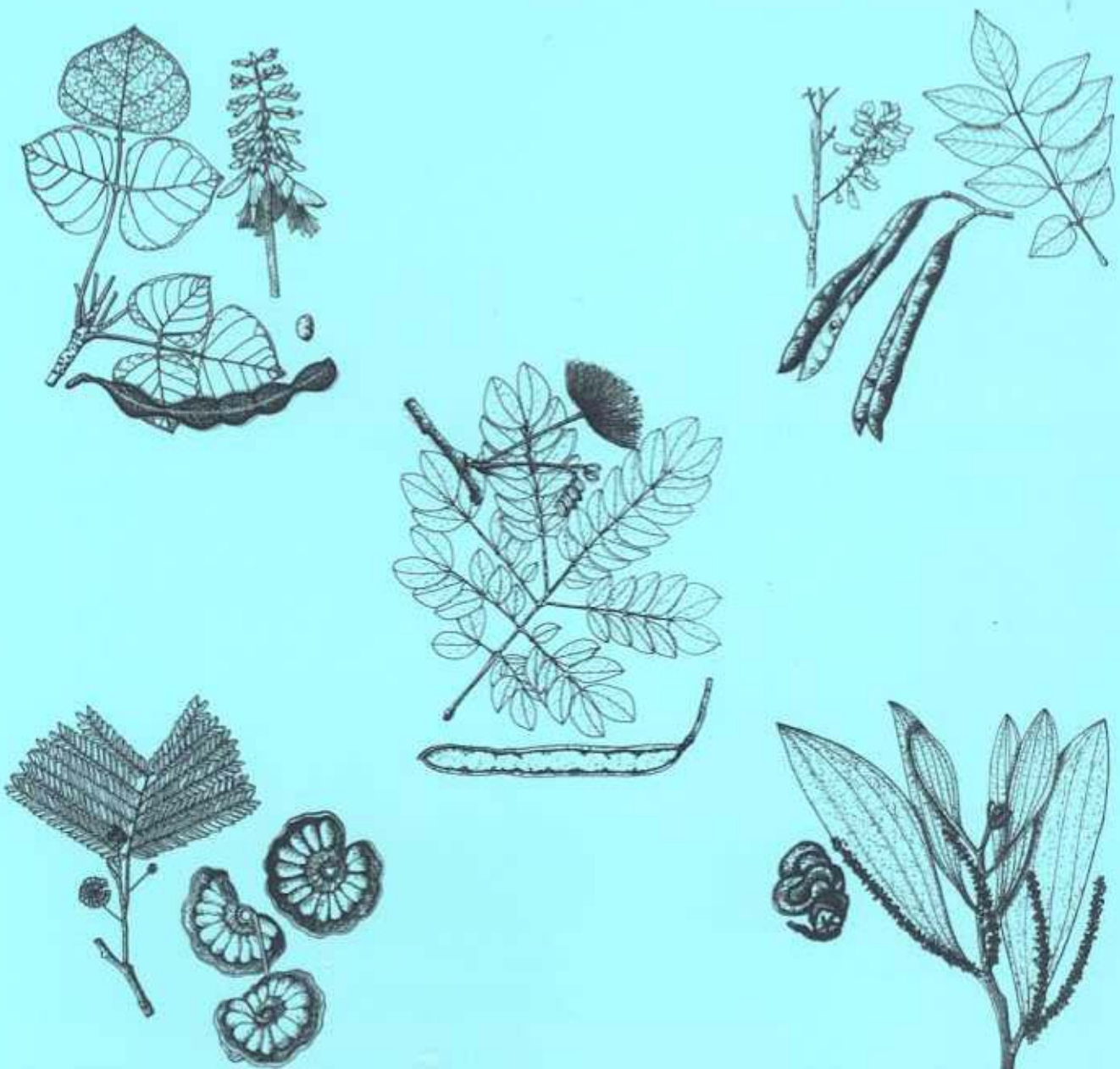
Agroforestry Species and Technologies

A compilation of the highlights and factsheets published by NFTA and FACT Net 1985-1999

A Publication of Winrock International

TFRI Extension Series No. 138



Agroforestry Species and Technologies

A compilation of the highlights and factsheets published by

NFTA and FACT Net 1985-1999

Winrock International
Taiwan Forestry Research Institute

James M. Roshetko, Editor

October 2001

A Publication of Winrock International

Roshetko, J.M. (ed). 2001. Agroforestry species and technologies: a compilation of the highlights and factsheets published by NFTA and FACT Net 1985-1999. Taiwan Forestry Research Institute and Council of Agriculture, Taiwan, Republic of China; Winrock International, Morrilton, Arkansas, USA.

Published by Winrock International and the Taiwan Forestry Research Institute, with financial support from the Council of Agriculture, Taiwan, Republic of China.

ISBN 1-57360-032-6
TFRI Extension Series No. 138

Winrock International
38 Winrock Drive
Morrilton, AR 72110-9370, USA
Telephone: 1 (501) 727-5435
Fax: 1 (501) 727-5417
Email: forestry@winrock.org
Website: www.winrock.org/forestry.htm

Taiwan Forestry Research Institute
53 Nan-Hai Road, Taipei, Taiwan, Republic of China
Telephone: 886-22-23039978
Fax: 886-22-23076220

Council of Agriculture, Executive Yuan
37 Nan-Hai Road, Taipei, Taiwan, Republic of China

Cover drawings adapted from highlights and factsheets NFTA 90-05, NFTA 94-02, NFTA 95-02, FACT 96-03, and FACT 98-04.

Table of Contents

Preface

This booklet assembles under one cover the 97 factsheets and highlights published by the *Forest, Farm, and Community Tree Network (FACT Net)* and its predecessor the *Nitrogen Fixing Tree Association (NFTA)* between 1985 and 1999. These 2 to 4 page bulletins are concise summaries of important information on tree species and agroforestry technologies suitable for many environmental and socioeconomic conditions. We hope this booklet is a practical and useful reference tool for former network members and others.

Background of FACT Net and NFTA

The NFTA was started in 1981 to promote the wise-use of nitrogen fixing trees (NFTs) for rehabilitating degraded lands and enhancing the livelihoods of the world's rural poor. The Association worked with a diverse array of researchers, extension agents, development workers, professors, students, and government officers as well as community groups, non-government organizations, universities and colleges, government agencies, and international organizations. Many of these individuals and institutions were located in remote areas of developing countries and actively involved in agricultural or forestry activities at the community level. These individuals and institutions had little or no access to reliable technical support. NFTA's global extension network effectively bridged the gap that often existed between the formal research community and remote, field-oriented institutions in developing countries.

In 1994, NFTA become part of Winrock International. In 1996, NFTA changed its name to the Forest, Farm, and Community Tree Network (FACT Net) in recognition of its expanded mandate to spotlight all tree species and agroforestry systems of relevance to smallholder farm families. FACT Net closed at the end of 1999 due to a shortage of financial resources to cover general operating costs. Well over half of FACT Net's associates lived in developing countries and received a waiver of annual fees. The Network annually provided hundreds of documents and many hours of free technical consultation to individuals and organizations that had limited financial resources, but an enthusiastic desire to grow trees. A shifting of donors' priorities away from technical services—even cost-effective ones such as FACT Net's— toward other interests placed a severe strain on the Network's core resources and restricted the staff's ability to maintain services.

A review of programs and accomplishments

For twenty years FACT Net operated as an international extension service providing reliable information and resources to individuals and organizations interested in growing trees. The Network provided services through three basic programs: research, training and communications. These programs were characterized by dynamic flexible activities and services that adjusted to the changing global environmental priorities and the specific biophysical and socioeconomic conditions of associates and other clients. From its inception, over 5000 individuals and organizations participated in the Network. Tens of thousands of others benefited from its publications, services and activities.

The Network's key accomplishments include:

- conducted more than 65 training courses on tree propagation, management and utilization;
- co-sponsored 20 international workshops on important tree species and agroforestry topics;
- awarded 150 small grants to community groups to establish agroforestry projects;
- supported 600 collaborative tree species evaluation trials with associates;
- distributed over 5000 kilograms of quality tree seed;
- published over 160 technical documents;
- translated documents into 7 languages (Chinese, French, Indonesian, Khmer, Spanish, Portuguese and Vietnamese); and
- provided thousands of hours of technical consultation through letters, faxes, email and field visits.

Operations and staffing

The Network was always a small, cost-effective organization that ran on a lean budget. This was made possible because associates and partner organizations often provided matching support, both financial and in-kind, for network activities. Community groups often provided support in the form of food and local resources. The Network's staff rarely exceeded 4-5 full-time people. During the last 10 years, staff members spent 3-6 months per year implementing activities in the field.

The hardworking people who made the Association and Network a great success included: board members Jim Brewbaker, John Musser, Bill Bentley, Jeff Burley, David Challinor, Narayan Hegde, Ta-Wei Hu, Bill Hueg, and Lynn-Day Weyerhaeuser; and Rodrigo Arias, Bertha Boom, Sonja Bowden, Eric Brennan, Jim Chamberlain, Narong Chomchalow, Doris Cook, Karl Dalla Rosa, Joshua Daniel, Dale Evans, Nancy Glover, Y.S. Huang, Ken MacDicken, Bill Macklin, Erin Moore, Linda Nelson, Mark Powell, James Roshetko, Charles Sorensson, Carol Stoney, Greg Sullivan, Rick van den Beldt, Sidney Westley, Kate Willers, Donna Willson, Dale Withington, Y.J. Yuang, Fuh-Jiunn Pan, and Hsiang-Hua Wang, to name some. In addition, there are many other associates and friends who supported the Association and Network by authoring factsheets or highlights, contributing articles for the newsletter or researcher reports, collaborating on activities or making financial contributions. These hundreds of individuals and organizations are too numerous to list here. Their involvement and collaboration helped develop the Association and Network into a global family that will persist long beyond the end of the formal organization.

Adieu to the Network!!!

NFTA and FACT Net succeeded beyond expectations in providing practical information and services to thousands of organizations and individuals around the world. These efforts contributed to an increased awareness and appreciation of multipurpose tree species and their uses in agroforestry systems. The Network's departure from the international environmental community creates an information gap that is difficult to fill. We encourage all former staff, associates, friends, collaborators and clients to communicate and share information with each other to further advance our mutual cause—the production, management and utilization of trees to help protect the environment and alleviate poverty.

James M. Roshetko
Mark H. Powell

Acknowledgements

The Forest, Farm, and Community Tree Network thanks the authors who wrote the highlights and factsheets that appear in this booklet; Marcella Christina of ICRAF (International Center for Research in Agroforestry, Southeast Asia Regional Office) for scanning the original documents and developing the format of this document; and Sonja Bowden and Miriam Boroski of Winrock International and Madah Saskia of ICRAF for assisting with the scanning of documents.

The network owes a special thanks to the Council of Agriculture, Taiwan, and the Taiwan Forestry Research Institute for financially supporting the production of this booklet, and for coordinating its production and distribution.

Introduction

The highlights and factsheets assembled in this booklet were originally published as separate bulletins by NFTA and FACT Net between 1985 and 1999. The contents of the bulletins appear here in their original form. Some changes have been made to provide a uniform format. The booklet is organized in two sections. The first compiles the bulletins published by NFTA and FACT Net through its communications program. The section starts with bulletins summarizing the importance and uses of nitrogen fixing trees (NFTs) and actinorhizal trees. These are followed by bulletins featuring specific taxa arranged in alphabetical order by genus and species. The first section is concluded with a bulletin on marketing tree products. Early editions of bulletins that were later replaced with updated versions are not included in this document.

The second section is comprised of the bulletins published through the *Agroforestry Information Service for the Pacific (AIS),* a project operated by NFTA with funding from the USDA Forest Service's Tropical Forestry Program between 1992 and 1995. The AIS bulletins are arranged in chronological order by the publishing date. The two species bulletins published through AIS appear at the end of the section.

Appendix 1 provides a list of all bulletins arranged chronologically by publishing date. There also are indices of authors and species.

Section 1.

NFTA Highlights
and
FACT Net Factsheets

NFT Highlights

NFTA 89-93
A quick guide to multipurpose trees from around the world September 1989

WHY NITROGEN FIXING TREES?

Why Nitrogen Fixing Trees?
Nitrogen fixing plants are key constituents in many natural ecosystems in the world. They are the major source of all nitrogen that enters the nitrogen cycle in these ecosystems. Many nitrogen fixing plants are woody perennials, or nitrogen fixing trees (NFTs), most of these being found in the tropics. In temperate areas, the nitrogen fixers tend to be herbaceous.

NFTs have been removed or reduced in most man-made ecosystems, such as agricultural and forest lands and urban environments. These lands require expensive chemical fertilizer inputs in order to maintain their productivity. Manmade systems can be improved by learning and adopting from natural ecosystems. For example, the reintroduction of NFTs, with appropriate management, can increase and sustain productivity. Agroforestry land-use practices do this.

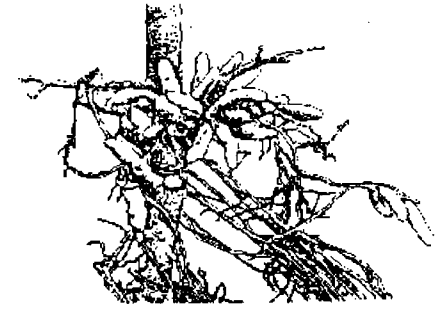
No plant grows without nitrogen, and many tropical soils have low supplies of this nutrient. NFTs do not depend solely on soil nitrogen, but "fix" nitrogen through symbiotic microorganisms that live in root nodules and convert atmospheric nitrogen into a usable form.

Botany: There are two basic types of N-fixing systems found in trees, based on two different symbiotic microorganisms. Bacteria of the genus *Rhizobium* inoculate trees in the families Leguminosae and Ulmaceae, while an actinomycete of the genus *Frankia* inoculates several other families:

Family	Genera
Betuleceae	*Alnus*
Casuarinaceae	*Allocasuarina, Casuarina, Gymnostoma*
Coriariaceae	*Coriaria*
Elaeagnaceae	*Elaeagnus, Hippophae, Shepherdia*
Myricaceae	*Comptonia, Myrica*
Rhamnaceae	*Ceanothus, Colletia, Descaria, Kentrothamnus, Retanilla, Talguena, Trevoa*
Rosaceae	*Cercocarpus, Chamaebatia, Cowania, Dryas, Purshia*

The Leguminosae, however, make up a vast majority of the 650 known NFT species. This family is broken into three distinct sub-families:

Sub-family	# Species	% Fixers	Representative NFT Genera
Caesalpinioideae	1.900	23	*Chamaecrista, Cordeauxia*
Mimosoideae	2.800	90	*Acacia, Albizia, Calliandra, Enterolobium, Leucaena, Mimosa, Paraserianthes, Pithecellobium*
Papilionoideae	12.300	97	*Cajanus, Dalbergia, Erythrina, Flemingia, Gliricidia, Pterocarpus, Robinia, Sesbania, Tephrosia*



Nitrogen fixing trees "fix" nitrogen with symbiotic microorganisms. These legume tree roots have nodulated through an association with Rhizobium.

Uses: Many NFTs are important to rural households throughout the tropics providing a variety of products and services:

Firewood and charcoal are the primary energy sources for almost one half the world's population. Fast-growing, high density NFTs make excellent fuelwood and charcoal. Many re-sprout, or coppice, vigorously after cutting, allowing repeated harvests without replanting.

Fodder to feed animals is a constant concern to many farmers in developing countries. The highly nutritious and digestible leaves of some NFTs make them excellent feed for annuals. The deeply penetrating roots of NFTs can reach retreating moisture and provide fresh feed during dry seasons.

Soil fertility is critical to crop production, but many resource-poor farmers cannot afford chemical fertilizers. Leaves of many NFTs are high in nitrogen and other plant nutrients and can be a renewable, free source of fertilizer.

Timber and poles are needed all over the world for house and other general construction. NFTs include both fast growing trees for rough wood, and some of the most valuable luxury timbers in the world.

Human food is harvested from several species of NFT in various parts of the world, in some instances supplying important seasonal staples.

Planting Systems: Depending on local needs and preferences, a variety of different planting schemes with NFTs can be utilized yielding a wide variety of products and staples.

Living fences and hedges protect crops from large pests such as wildlife, domestic animals, and man, and are often managed for fuelwood and fodder production. Trees are arranged densely, or planted as fence posts, and trimmed frequently to attain the desired form. *Pithecellobium dulce* is a favored hedge species in coastal East Africa.

Windbreaks are single or multiple rows of trees planted on windward field boundaries. Windbreaks help prevent soil desiccation and yield secondary tree products. Consistent

Written by NFTA staff

foliage closure is achieved by choosing trees with dense canopies and by managing the canopy to encourage lateral branching. *Erythrina variegata* is commonly planted as a windbreak in Hawaii and other Pacific Islands.

Alley farming, or intercropping, is a labor intensive management system which leads to major crop yield increases through alternating rows of tree hedges and crops. Cut leaves and green twigs are incorporated into or laid on top of the soil for multiple benefits of green manuring, soil and water conservation, and weed control. This practice is successfully being introduced on steep sloped hillsides in the Philippines using several NFT species, including *Flemingia macrphylla.*

Shade and support are attained quickly from fast-growing NFTs. Shade is an important benefit in hot climates for some crops, such as cacao, coffee, and tea, as well as for humans and animals. Living, soil-enriching support is quickly established for vining crops such as yarns, vanilla, and black pepper. *Gliricidia sepium* has been used for all these purposes.

Fodder banks are intensive plantings of fodder plants, spaced to maximize production, and provide a source of "cut and carry" fodder. Many NFTs have leaves or pods that are very high in protein. *Leucaena leucocephala* is called the "alfalfa of the tropics" because of its extensive use as fodder.

Pasture improvement is achieved through increased grass production, tree fodder browsed directly by animals, and shade; livestock digest more efficiently when shade is available. *Acacia* species are found throughout the African savanna grazing lands.

Home gardens utilize NFTs for soil fertility, as well as for edible fruits, leaves, or flowers, and as medicinals. *Parkia* species are important seasonal food sources in both Southeast Asia and West Africa.

Woodlots planted with fast growing NFTs can yield quick returns, especially in less productive areas of the farm. Coppicing (sprouting) trees are the species of choice, particularly for stands of fuelwood. *Calliandra calothyrsus* is an important woodlot tree in Indonesia.

Improved fallow is most useful in areas where slash and burn agriculture is practiced. When a field is exhausted of its nutrients from intensive cultivation, NFTs can be planted for soil enrichment, and hasten the return of fertility. *Sesbania sesban* is utilized for this in western Kenya.

Land reclamation using NFTs is commonly practiced on eroded mountainsides, exhausted grazing areas, unproductive mined areas, and for dune stabilization. *Casuarina* has been planted for dune stabilization in over 1,000,000 hectares in China.

Silviculture: Most NFTs can be grown readily from seed. Many have seeds with thick coats, allowing long storage, but require scarification for moisture uptake. Some NFTs are easily propagated vegetatively. NFTs are fast-growing, many coppice readily, and can be managed for multiple products.

Genetic Improvement: Many NFT species have unique potential amongst trees for genetic improvement because of their short seed-to-seed cycles, often less than one year. Many are also highly variable in the wild, offering unique opportunities for selection.

Why Not NFTs: There are alternatives to NFTs for people who need tree products, soil improvement, or other services. Some non-fixing trees are easily established, grow rapidly, coppice readily, and produce desirable products and services. The lack of nitrogen fixation capability may be a drawback, but may not be needed in rich soils or uses which do not require rapid growth, such as watershed protection. Trees that are not harvested can establish a nutrient cycle in which little nitrogen is lost.

Weediness is another potential problem with NFTs. Since some NFTs are aggressive pioneer species adapted to rapid colonization, they may become pests. Species that cannot be controlled by grazing because of thorns or noxious plant chemicals can become especially weedy.

Chemical fertilizers may not necessarily be replaced by NFTs. The role of herbaceous N-fixing plants in soil management is also distinct, and may be a viable alternative to tree species. Local traditions, farmers' preference, and site conditions will dictate the choice of species, which may not include N-fixers.

Additional Reading

Allen, O.N. and E.K. Allen. 1981. The Leguminosae: A Source Book of Characteristics, Uses, and Nodulation. The University of Wisconsin Press.

Ayanaba, A.N. and P.J. Dart (Eds.). 1977. Biological Nitrogen Fixation in Farming Systems of the Tropics. Wiley, New York, N.Y.

Dawson, J.O. 1986. Actinorhizal Plants: Their use ia forestry and agriculture. Outlook on Agriculture vol. 15, no. 4.

Duke, JA. 1981. Handbook of Legumes of World Economic Importance. Plenum Press, New York.

Evans, Julian (ed.) 1984. Plaotation Forests in the Tropics. Clarendon Press. Oxford England.

Gordon, J.C. and C.T. Wheeler (Eds.). 1983. Biological Nitrogen Fixation in Forest Ecosystems: Foundations and Applications.Martinus Nijhoff/Dr. W. Juak Publisher.

Graham, P.H. and S.C. Harris (Eds.). 1982. Biological Nitrogen Fixatioa for Tropical Agriculture. CIAT, AA 67-13, Cali, Colombia.

Huxley, PA. (ed). 1983. Plant Research and Agroforestry. ICRAF. Nairobi, Kenya.

Kang, B.T., G.F. Wilson, T.L. Lawson. 1986. Alley Cropping: A stable Alternative to Shifling Cultivation. IlTA.

National Academy of Sciences. 1979. Tropical Legumes: Resources for the Future. National Academy Press, Washington, D.C. USA.

National Academy of Sciences. 1980. Firewood Crops: Shrub and Tree Species for Energy Production. Volumes 1 and 2. National Academy Press, Washington, D.C. USA.

NFTA. 1983-88. Nitrogen Fixing Tree Highlights Series. Nitrogen Fixing Tree Association, P.O. Box 680, Waimanalo, Hawaii, USA 96795

Sprent. J.I. 1987. The Ecology of the Nitrogen Cycle. Cambridge University Press, Cambridge, England.

Sprent, J.I., et al. 1989. Occurence of nodulaton in the Leguminosae. New Phytol. 111:607-619

Turnbull, J.W. 1986. Multipurpose Australian Trees and Shrubs: Lesser-known Species for Fuelwood and Agroforestry. ACIAR, Canberra.

von Maydell, H.J. 1986. Trees and Shrubs of the Sahel: Their Characteristics and Uses. GTZ, Eschborn, West Germany.

Webb, D.B., P.J. Wood, J.P. Smith and G. Sian Henman. 1984. A Guide to Species Selection for Tropical and Sub-tropical Plantations. Commonwealth Forestry Institute, University of Oxford, U.K.

Weirsum, K. 1982. Tree gardening and taungya on Java: Examples of agroforestry techniques in the humid tropics. Agroforestry Systems 1:53-70.

NFT Highlights

A quick guide to multipurpose trees from around the world

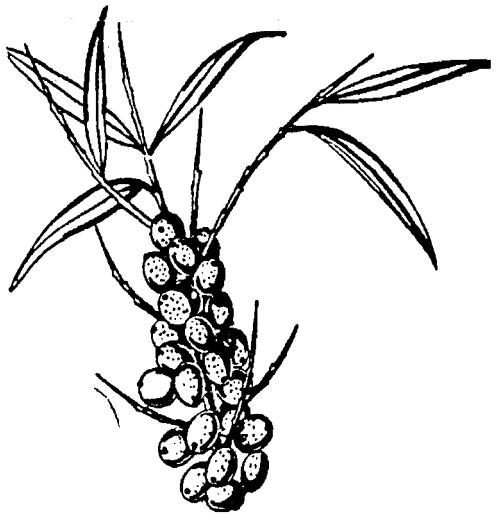
NFTA 86-03
May 1986

Actinorhizal Trees Useful In Cool to Cold Regions

A class of plants that helped develop soil on glaciated sites in the past has a future in agroforestry and land reclamation projects of today and tomorrow. These plants are known as actinorhizae, as they are nodulated by the nitrogen-fixing actinomycete, *Frankia* These predominately temperate trees are especially useful in areas where the mostly tropical woody legumes can not live or thrive.

Actinorhizal plants have been used historically to increase fertility in agricultural systems. Lack of knowledge about the group's ecology prevents more widespread use but the trees are currently used in the following four ways:

1. As a primary crop for timber and pulpwood (*Alnus, Casuarina* spp.)
2. As an interplanted "nurse" plant for other, more valuable species (*Elaeagnus* spp.)
3. As a component of a multipurpose agroforestry plantation (*Casuarina* spp.)
4 As a plantation for soil reclamation (*Elaeagnus, Shepherdia, Purshia* spp.)



Hippophae rhamnoides

Environmental protection and land reclamation are benefits provided by several actinorhizal species. *Elaeagnus, Purshia* and *Shepherdia* spp. are widely planted in North America to prevent soil erosion (Fessenden, 1979). *Hippophae rhamnoides* is used for this same purpose in western and northern Europe. *Casuarina* species are planted in shelterbelts along deserts and coastlines in western Africa, India, China and other Asian countries to stop encroachment of sand dunes, diminish winds and decrease downwind deposition of salt spray (Andeke-Lengui & Dommergues, 1981; Turnbull, 1981). A shelterbelt built mainly with casuarina in southern China forms a "green wall" ranging from 0.5 to 5 km wide for 3000 km along the South China Sea.

The greatest use of any one actinorhizal genus is probably the production of *Casuarina* for firewood in the tropics. Large plantations are maintained on 5 to 15 year rotations (Kondas,

Written by Dwight Baker from documents or observations by the authors cited.

1981). Agricultural crops often are interplanted with casuarina during the first few years of the rotation. Harvested trees can be sold as firewood or converted into charcoal.

Planting *Alnus*, or alders, for lumber, pulp or fuelwood production is the second most common use of actinorhizal trees. Wood harvested from native stands is sold as fuelwood (Smith, 1978) or pulped and combined with softwood pulp for paper production (Hrutfiord, 1978). Mean annual wood yields for 8 to 10-year-old red alder, *Alnus rubra*, were nine oven-dry tons/ha/yr in British Columbia, and maximum production was 28 oven-dry t/ha/yr (Smith, 1978). Natural regeneration of alnus stands is excellent. *Alnus acuminata* and *A. nepalensis* are tropical highland species.

Other actinorhizal species are used as nurse crops for other trees. In the United States, *Elaeagnus umbellata* has been shown to greatly increase the productivity and quality of *Juglans nigra*, a hardwood species used extensively in furniture production (Schlesinger and Williams 1984). *Elaeagnus* apparently increased soil fertility, moderated temperatures and/or provided beneficial competition, which led to self-pruning of the tree crop. Alder has been shown to improve the growth of *Populus, Pinus*, and *Pseudotsuga* in mixed stands (Silvester, 1977).

Various *Casuarina* species are planted from the tropics to temperate zones as windbreaks, to control soil erosion, as ornamentals, for particle board, and as a fallow -improvement crop in Papua New Guinea.

Alder foilage, twigs and sawdust have been successfully used as a cattle feed supplement (DeBell and Harrington, 1979).

Actinorhizal plants can contribute as much nitrogen per hectare as the most productive legumes (Torrey, 1978). A Senegal study estimated that casuarina fixed 288 kg/N/ha/yr (Gauthier et al., 1984). Alders accumulate between 40 to 200 kg/N/ha/yr, with maximum accumulations of up to 320 kg/ha/yr (Silvester, 1977).

Frankia is present in adequate amounts in most ecosystems for natural nodulation to occur. Inoculation might be necessary in disturbed soil, arid environments or sites where actinorhizal plants are not native. Pure cultures for many of the most important actinorhizal species are now available.

NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 89-02
May 1989

Acacias for the Hot Dry Subtropics

Of Australia's tropical area, almost 2 million km^2 receives less than 500 mm of rainfall annually. Soils are diverse, but typically low in plant nutrients, with widespread and severe deficiencies in phosphorus and nitrogen and some deficiencies in trace elements. Surface soils are physically poor, and in places may be alkaline/sodic or saline (Brown and Turnbull 1986). Summers are extremely hot and elevated inland areas (e.g. the Pilbara region of northwestern Australia) may receive winter frosts.

The dominant woody vegetation of this zone, 120 or so species of *Acacia,* have evolved adaptations such as symbioses with *Rhizobium* and mycorrhizas, to cope with nutritional deficiencies and other stresses. 'These species constitute a unique, potential resource for rehabilitating degraded lands in the dry tropics. A few species have already shown exciting potential in the Sahelian zone of West Africa, but many more species remain untested.

Acacia maconochieana is *a highly salt and waterlogging tolerant tree from northwestern Australia.*

FUELWOOD: *Acacia holosericea* has received fairly widespread attention in trials and plantings, and to a lesser extent, so have *A. brachystachya* and *A. cambagei* (NAS 1979, Turnbull 1988). Many other species are in the early stages of evaluation.

In a trial in Senegal, *A. trachycarpa* produced 10.6 t/ha of green wood/year, compared to 12.0 t/ha/yr. for *A. holosericea* at the same site (Cossafter 1985). *A. trachycarpa* appears best adapted to coastal areas where annual rainfall is greater than 500 mm or areas that receive run-on water (Cossalter 1987). At several such sites in Senegal, growth averaged 3.6 m $\pm$ *157* at 5.5 years. In another trial in Senegal on an alluvial soil with a mean annual rainfall of 587 mm and a dry season of 7 months, *A. trachycarpa at* 1.5 years of age had a mean height of 2.68 m and a survival rate of 95% (Hamel 1980).

For firewood production on short rotations, Fox (1987) recommends trying *A. murrayana, A. tumida,* and *A. cowleana;* as well as *A. pruinocarpa; A. xiphophylla* and *A. aneura* for harsher, drier environments. *A. aneura* grew into a healthy, multi-stemmed tree 3 in height with a 2-4 cm DBH and a 1 m crown radius on a site receiving 370 min of rain/yr. and little supplementary water (Kube 1987). It can grow 1 m/yr. with supplementary irrigation.

A. tumida (Fitzroy Crossing provenance) has shown the fastest growth in recent acacia trials in Niger, reaching 2.4 m after 14 months, compared to 1.9 rn for *A. holosericea* and *A. cowleana.* In trials in several West African countries with dry seasons of 5-8 months, *A. tumida* has exhibited erratic survival, but trees have grown 3 to 4 in in 4 years (CTFT 1983). The results are considered promising enough to merit further trials. *A. tumida* demonstrates wide morphological variation, as well as variation in economically important traits such as coppicing ability, and may constitute more than one taxa as currently circumscribed.

For sandy soils, species that show promise (rapid growth, moderately long life spans and good coppicing/pollarding ability) are *A. ampliceps, A. anaticeps, A. coriacea, A. eriopoda, A. jennerae,,* and *A. salicina* (Thomson, et al. 1988). Specimens of *A. ampliceps have* grown over 2 in in one year in Western Australia (Turnbull 1986). *A. coriacea* has reached 3 to 3.6 in in 7 years and withstood extreme drought periods in Senegal (CTFT 1983). A riverine form of this species from the Pilbara area has proven particularly fast growing in plantings in northwestern Australia. Early growth data from Iran indicated that *A. salicina* can have a mean annual height increment of 1 m/yr. (Webb 1973).

For areas receiving some run-on water and with heavy textured soils, *A. citrinoviridis, A. difficilis, A. distans, A. hemignosta, A. maconochieana, A. pachycarpa, A. stenophylla, A. trachycarpa,* and *A. victoriae* are promising (Thomson, et al. 1988).

FODDER POTENTLAL- Stock generally prefer grass and soft herbage to the relatively harsh phyllodes of and zone acacias (Fox 1987). During dry seasons, however, when other plant material is scarce, cattle and sheep will heavily browse certain more palatable species. *A. aneura* commonly called Mulga, is lopped to provide animal feed during drought periods. Biomass studies at Jodhpur, India, indicated that 7-year-old Mulga trees yielded 30 kg of fuelwood and 10 kg fodder when 75% of the canopy was pruned. International mulga trials coordinated by FAO/CSIRO are in progress to identify superior provenances (Midgley and Gunn 1985). Some early trial data suggest more rapid growth by provenances from the Charieville District of central Queensland. Despite its low to moderate digestibility (36-52%), it has a high crude protein content (11-16%), a low phosphorus content (0.05-0.12%) and good palatability, which increases with age (Turnbull 1986). In many parts of Australia, mulga is a significant part of a sheep's diet at all times of the year, but, without supplementary feed, it supplies barely sufficient protein and energy to provide a maintenance ration for sheep (Niven 1983).

A.trachycarpa was unknown as a fodder in Australia, but in West Africa the species has been readily browsed by cows, sheep, and goats (Cossafter 1987). A trial in Senegal planted at 3 in x 3 in produced 2.03 t/ha of foliage at 1-5 years (Hamel 1980). Close relatives of this species, such as *A. chisholmii,* and *A. lysiphloia,* grow rapidly on degraded, infertile, lateritic and sandy sites, but their fodder value is unknown.

Vercoe (1987) recommends that *A. shirleyi, A. bidwillii,* and *A. saticina* (with in vivo digestibilities > 50%) and *A. stenophylla* (digestibility < 50%) be further studied for their fodder potential. Turnbull (1986) indicates that *A. ampliceps , A. bidwillii* (immature foliage), *A. pachycarpa,* and *A. victoriae* appear to have some

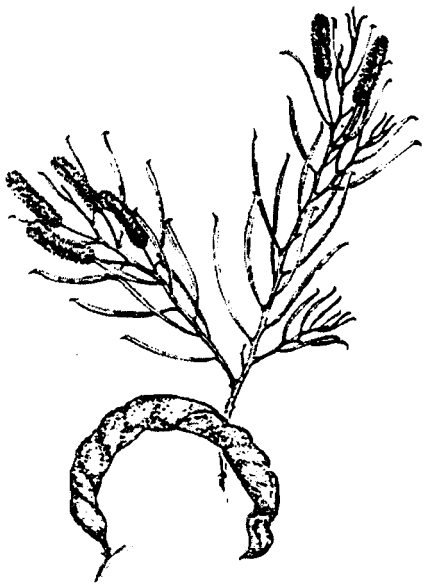
Written by Dr. Lex Thomson, Australian Tree Seed Centre, CSIRO Division of Forestry and Forest Products, P.O. Box 4008, Queen Victoria Terrace, Canberra A.C.T. 2600 Australia.

fodder value for cattle and sheep, and *A. salicina* and *A. stenophylla* are grazed by sheep.

A. tumida, which is moderately palatable to stock in West Africa, yielded an average of 2.6 kg of dry phyllodes/tree and 8.7 kg of wood/tree when planted at 3 x 3 in and harvested after 18 to 23 months (Cossafter 1987).

SALINE/ALKALINE SITES: *A. ampliceps,* called the salt wattle, is a very fast growing shrub/small tree from northwestern Australia that has considerable promise for fodder plantings on alkaline/saline soils, especially where its roots have access to a shallow brackish water table. Other highly promising multipurpose small trees for saline soils include *A. ligulata, A. maconochiena, A. salicina, A. sclerosperma, A. stenophylla,* and, *A. victoriae* (Thomson 1987, Aswathappa, et al. 1987).

FOOD VALUE: Seeds of many Australian *Acacia* species, including *A. ampliceps, A anaticeps, A. aneura, A. cowleana, A. dictyophleba, A. holosericea, A. jennerae, A. murrayana, A. stipuligera, A. tumida,* and *A. victoriae* are traditional foods of Australian aborigines (O'Connel et al. 1983). The Highly nutritious seeds are readily harvested (Brand and Cherikoff 1985) and can be stored for many years. Certain precocious and prolific seeding species, such as *A. holosericea* and *A. tumida* can yield in excess of 100 kg seed per ha from degraded and infertile sites within 2-3 years of planting. These species may have potential for food production on difficult sites in developing countries.



Acacia trachycarpa *is well adapted to coastal areas with annual rainfall greater than 500 mm, or in areas that receive runnoff water. Drawing from* Acacias in Australia *by M. Simmons, Thomson Nelson Australia 1982.*

OTHER USES: Many of the Australian acacia species, particularly ones adapted to the driest environments, may prove most useful in stabilizing sand dunes. Firewood and other products could be secondary benefits. *A. ampliceps* and its close relatives *(A. bivenosa, A. ligulata* and *A. sclerosperma)* have excelled in sand-dune stabilization plantings in Australia, Africa, the Middle East and India. *A. stenophylla,* of temperate Australian origin, has been extensively planted in dry parts of Tunisia for sand stabilization, honey production, and fodder/fuelwood production, but seed of sub-tropical provenances has become available only in recent years (Thomson and Cole 1987). Some species such as *A.coriacea* var. *pendula, A. cyperophylla* (pendulous variant from Nullagine), A. *grasbyi, A. hamersleyensis* (pendulous variant from Tom Price), A. *orthocarpa, A. sibilans, A. stipuligera,* and *A. wanyu* have superior potential as ornamentals. Others, such as *A. cambagei* and *A. pachycarpa* have offensive odors. Although competition for water and slow growth have made alley farming in and and semi-arid areas less successful than in humid regions, some of the more rapidly growing Australian acacias with a moderately long life spans, good coppicing/pollarding ability, and useful fodder/green manure, may be useful for this purpose (Thomson, et al. 1988).

PROBLEMS AND LIMITATIONS. Heavy seeding, root suckering or a tendency to form thickets make some of these species potential weedy pests. Turnbull (1986) indicates *A. bidwillii A. cowleana, A. ligulata, A. murrayana, A. salicina,* and *A. victoriae,* in particular, are potentially weedy. Since many species occupy wide geographic and environmental ranges, or may comprise several taxa, provenance testing and special attention to seed source are advised.

SEED SUPPLY. The Australian Tree Seed Centre of CSIRO's Division of Forestry and Forest Products stocks seed of many of the above mentioned species and will provide a quotation on request. Its address is:

CSIRO; P.O. Box 4008; Victoria Terrace; A.C.T. 2600, Australia.

REFERENCES:

Aswathappa, N., N.E. Marcar, and L.A.J. Thompson. 1987. Salt tolerance of Australian subtropial and tropical acacias. IN: Australian Acacias in Developing Countries, pp. 70-73. ACIAR, Canberra, Australia.

Brand, J.C., and V. Cherikoff. 1985. The nutritional composition of Australian Aboriginal food plants of the desert regions. IN. Plants for Arid Lands, pp. 53-68. George Allen and Unwin, London.

CTFT 1983. Document provisoire sur les acacias. Centre Technique Forestier Tropical. Nogent-sur-Mame, France. unpublished.

Cossalter, C. 1985. Introduction of Australian acacias in dry tropical Africa - First assessment and new plant material available for further introductions. Symposium on establishment and productivity of tree plantings in semi-arid regions. 29 April –3 May, 1985. Texas A & M University, USA.

Cossalter, C. 1987. Introducing Australian acacias in dry, tropical Africa. IN: Australian Acacias in Developing Countries, pp. 119-122. ACIAR, Canberra.

Fox, J.E.D. 1987. Potential of Australian acacias from and semi-arid zones. ACIAR Proceedings no. 16. Canberra.

Hamel, 0. 1980. Acclimatization and utilization of phyllodinous acacias from Australia in Senegal. IN: Browse in Africa - the current state of knowledge, pp. 361-373. ILCA, Addis Ababa, Ethiopia.

Kube, P.D. 1987. Growth rates, establishment techniques, and propagation of some central Australian acacias. ACIAR Proc. No. 16. Canberra.

Midgeley, S.J., and B.V. Gunn. 1985. *Acacia aneura* seed collections for international provenance trials. Forest Genetic Resources Information 13:21-29. FAO, Rome.

National Academy of Sciences. 1979. Firewood Crops. National Academy Press. Washington, DC.

Niven, D. 1983. Mulga supplementation of sheep in southwest Queensland. Queensland Agric. J. 109:207-209.

O'Connell, J.F., P.K Latz, and P. Barnett. 1983. Traditional and modern plant use among the Alyawara of central Australia. Economic Botany 37:80-109.

Thomson, L.A.J. 1987. Australian acacias for saline, alkaline soils in the hot, dry subtrapies and tropics. IN: Australian Acacias in Developing Countries. pp.66-69. ACIAR, Canberra.

Thomson, L.A.J. and F-G. Cole. 1987. Woody plant seed collections in tropical, arid, and semi-arid Australia and recommendations for international species trials. Forest Genetic Resources Information 15:3749. FAO, Rome.

Thomson, L.A.J., J.W. Turnbull, and B.R. Maslin. 1988. Characteristics and potential uses of *Acacia* from the subtropical dry zone of Australia. Paper in preparation.

Turnbull, J.W. (ed.). 1986. Multipurpose Australian trees and shrubs: lesser-known species for fuelwood and agroforestry. ACIAR Monograph No. 1, 316 p.

Vercoe, T.K 1987. Fodder potential of selected Australian tree species. ACIAR Proe. No. 16. Canberra.

Webb, D.B. 1973. The introduction and trial of exotic tree species in the semi-arid zone of Iran. Unpublished.

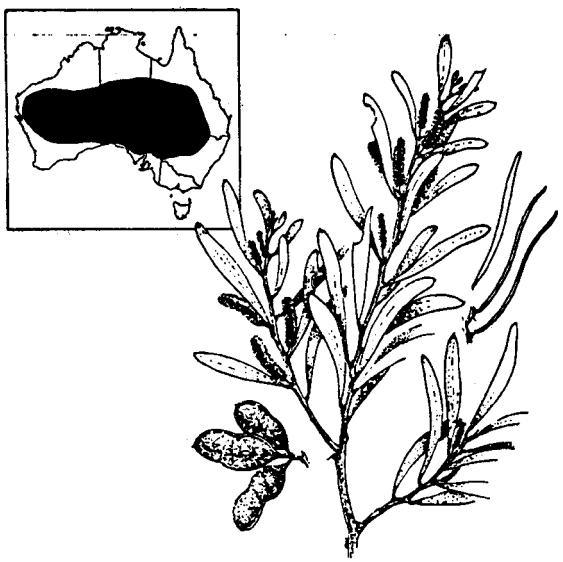
NFT Highlights

NFTA 90-03
July 1990

A publication of the Nitrogen Fixing Tree Association

Acacia aneura : A Desert Fodder Tree

Acacia aneura is known as mulga in its native Australia where it is one of the best known species in the genus. Mulga is the Aboriginal word for a long narrow shield made of acacia wood. It is probably the most important woody forage plant in Australia because it is palatable, abundant and widespread in regions of low rainfall. Its use as an exotic, however, has been restricted by its relatively slow growth rate and its limited capacity to regenerate after fire or severe branch lopping.



Acacia aneura, *reprinted with permission, M. Simmons, 1981. Inset map shows natural distribution of mulga in Australia (Turnbull et al. 1986).*

BOTANY: *Acacia aneura* F. Muell. ex Benth. is one of many thornless acacias endemic to Australia. It occurs as a 10-15 m tall, often single stemmed tree in higher rainfall areas but is a 2-3 m high shrub in dry situations or on very shallow soils. Its form and phyllode morphology are exceptionally variable (Midgley and Gunn 1985). The phyllodes range from short and needle-like to long (20 cm), broad (1 cm) and flat. Very fine hairs give the foliage an attractive silvery-grey appearance.

Small yellow flowers form spikes 1.5-2.0 cm long. Thin, flat membranous pods, 2-5 cm long, usually with an obvious narrow wing along their edge, contain dark brown seeds, each with a small pale aril at the base.

Flowering depends on favorable weather conditions and only late summer flowering followed by winter rain leads to seed set (Davies 1976).

ECOLOGY: Mulga is the one of the dominant species in Australian shrub woodlands. Natural populations extend over an area of 1.5 million km2 chiefly in the and climates where the annual rainfall is 200-250 mm. Mulga ranges in elevation from sea level to 300 m elevation. In many of the drier parts of its distribution mulga occurs as the only species in groves up to 50 m wide and 400 m long with intergrove areas acting as water catchments to provide substantial run-on water.

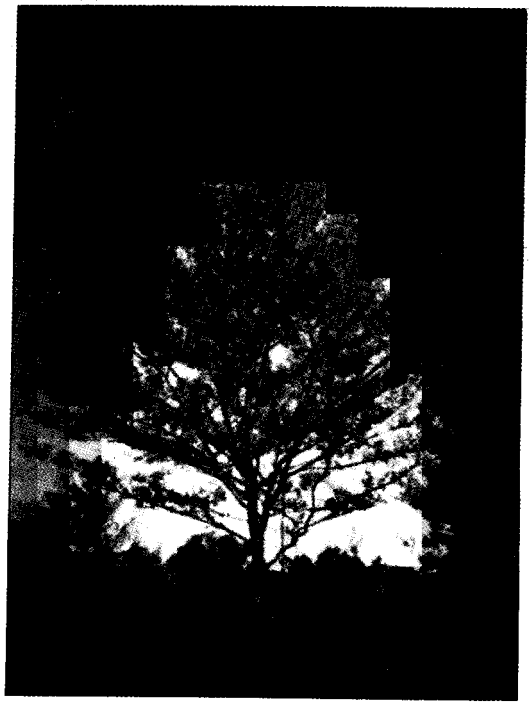
In the eastern part of its range in northern New South Wales and Queensland mulga is found in semiarid conditions with a mean annual rainfall of 300-500 mm. It experiences hot summers and cool winters with light frosts. Soils supporting mulga are usually acidic sands or sandy loams, which permit easy filtration of water into the upper horizons, but are usually very low in nitrogen and available phosphorus (Turnbull 1986). *Acacia aneura* can live for more than 50 years, it is drought-tolerant, but very fire sensitive (Kube 1987).

PROVENANCE TRIALS: The wide variability in soils and climate together with a high degree of polymorphism suggests that major provenance differences will occur in growth rates and drought and frost tolerance. International provenance trials were initiated in 1984 by FAO and CSIRO Division of Forestry and Forest Products, Canberra (Midgley and Gunn 1985) and trials were established in South Asia, the Middle East, Africa and South America.

WOOD USE: The heartwood of mulga is dark brown with contrasting markings of golden yellow; the sapwood is white. The wood is very hard, heavy (850-1100 kg/m^3) and durable in the ground; it turns well and takes a high polish (Boland et al. 1984). Mulga also makes an excellent firewood and charcoal. In Australia the wood has been used extensively for fence posts but a log size rarely exceeding 2 m x 25 cm usually restricts the use of the wood to small turnery items.

FODDER: In many parts of Australia mulga forms a significant part of a sheep's diet at all times of the year but without supplementary high quality feed it supplies protein and energy barely sufficient for maintenance of dry-range sheep (Goodchild and McMeniman 1987). Phyllodes have a high crude protein level (11-16%), low phosphorus content (0.05-0.12%) and good palatability (Turnbull et al. 1986, Vercoe in Boland, 1987). Excessive grazing may result in the death of mulga.

Written by Dr. J. W. Turnbull, ACIAR, P.O. Box 4008, Queen Victoria Terrace, ACT 2600 Australia.



Acacia aneura *(tree form) in a natural stand in Queensland*

OTHER USES: Mulga can be used in arid areas to provide shelter and shade, its attractive silvery grey foliage makes it a popular choice for amenity plantings. The Australian Aborigines ground the mulga seed for flour. The seeds have a protein content comparable to dried split peas or peanuts (Caffin et al. 1980). Aborigines also used the resinous phyllodes of desert mulga form as an adhesive resin (Turnbull et al. 1986).

ESTABLISHMENT: For good germination, seed (50,000-110,000/kg) should be scarified by mechanical abrasion or immersed in undiluted sulfuric acid (95% 36N) for 30 minutes and then thoroughly washed in water. Alternatively, immersion in hot water (90°C) for 1 minute will usually break dormancy (Doran and Gunn 1987). Seeds sown in a germination tray are ready for separating into containers within 10 days. The potting mix needs to drain freely but have good moisture holding capacity (Kube 1987).

Nursery growth is slow with seedlings often taking 6-8 months to reach 20 cm tall. When transplanted to the field the seedlings usually require several months without severe moisture stress to survive and in arid areas may need supplementary irrigation. Established seedlings have the ability to survive severe drought. They develop a long tap root and an extensive lateral root system in the top 30 cm of the soil. *Acacia aneura* needs to be protected from browsing animals while young.

GROWTH: Growth rate is generally slow but is related to moisture conditions. In central Australia planted specimens receiving an average of 370 mm of rainfall a year grew in ten years into multi-stemmed shrubs 3 m tall and 2-4 cm dbh with a crown diameter of 2 m (Kube 1987). Cultivated specimens receiving regular irrigation have reached 10 m tall and 10 cm dbh in 10 years. In trials where rainfall is relatively high, the Charleville, Queensland provenance, a broad phyllode form, has grown more rapidly than provenances from central Australia (Ryan and Bell 1989). Trees with different phyllode forms have been observed to have different growth rates (Fox 1980).

SYMBIOSIS: *A. aneura* forms nodules with *Rhizobium* with which it exhibits a degree of specificity (Roughley 1987). Ectomycorrhizal associations have been observed and there is almost certainly VA mycorrhizal symbiosis (Reddell and Warren 1987).

PESTS AND DISEASES: In its natural habitat *A. aneura* is subject to partial defoliation by a range of insects and root damage by termites. Termite damage was light (4% mortality) to moderate (30% mortality) to two provenances aged 18 months in a trial in Zimbabwe (Mitchell 1989).

WEEDINESS: With its relatively slow growth rate and irregular seeding habits *A. aneura* is unlikely to become a serious weed.

PRINCIPAL REFERENCES

Boland, D.J., M.H. Brooker, G.M. Chippendale, N. Hall, B.P.M. Hyland, R.D. Johnston, DA. Kleinig and J.D. Turner. 1984. Forest trees of Australia. 4th Ed. Nelson-CSIRO, Melbourne.

Boland, D.J. (ed). 1987. Trees for the tropics: Growing Australian multipurpose trees and shrubs in developing countries. ACIAR Monograph No. 10. ACIAR, Canberra, Australia.

Caffin, N., R. Bell, G. Nitchie, S. Weston and N. Ho. 1980. Protein and mineral content of several species of *Acacia* seeds. Mulga Research Centre Annual Rep. No. 3, 1979. W. Australian Inst. of Tech., Bentley, Australia. p. 43-44.

Davies, S.J.J.F. 1976. Studies of the flowering season and fruit production of some and zone shrubs and trees in western Australia. J. of Ecology 64:665-687.

Fox, J.E.D. 1980. Stability in mulga stands in times of drought. *in* Mulga Research Centre Annual Report, No. 3, 1979. W. Australian Inst. of Tech., Bentley, Australia.

Midgley, S.J. and B.V. Gunn. 1985. *Acacia aneura* seed collections for international provenance trials. Forest Genetic Resources Information 13:21-29.

Simmons, M. 1981. Acacias of Australia. Thomas Nelson, Melbourne.

Turnbull, J.W. (ed). 1986. Multipurpose Australian trees and shrubs. ACIAR Monograph No. 1. ACIAR, Canberra, Australia.

Turnbull, J.W. (ed). 1987. Australian acacias in developing countries. ACIAR Proceedings No. 16. ACIAR, Canberra, Australia.

FACT Net

FACT Sheet

FACT 99-01

A quick guide to multipurpose trees from around the world January 1999

Acacia angustissima : A Promising Species For Agroforestry?

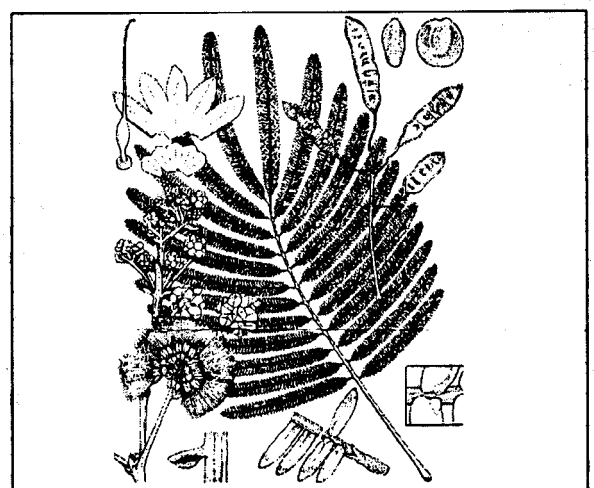
Acacia angustissima (Miller) Kuntze is a member of the Mimosaceae family and is thought to have originated in Belize, Central America (Dzowela 1994). Until recently very little work or study had been carried out on *A. angustissima*, but there is new interest in the use of this species in agroforestry systems due to its high potential growth rate and nitrogen fixing capabilities. Its common names include white ball acacia, fern leaf acacia and prairie acacia in the USA, while in Mexico and Central America it is known as barba de chivo, cantemo, guajillo, palo de pulque timbe and timbre. *Acacia angustissima* is closely related to and often confused botanically with *A. boliviana* and *A. villosa* (Gutteridge 1994).

Botany

Turner (1996) carried out the most recent general study on *Acacia angustissima*. He recognized *A. angustissima* as having six intergrading varieties (var. *angustissima*; var. *hirta*; var. *suffruticosa;* var. *chisosiana*; var. *leucothrix* and var. *oaxacana*). *Acacia angustissima* grows as a thornless shrub or small tree mostly 2-7 m high with a single short trunk. It exhibits much variation in pubescence (almost none, or of the branchlets mostly of short appressed hairs), in size and venation of the leaflets, and in size of flowers and heads (McVaugh 1987). The leaves are mostly asymmetric with a displaced mid-vein and 10-25 cm long, with 10-20 pairs of pinnae and leaflets without secondary venation (Isely 1973, Turner 1996). The inflorescences are ellipsoidal with whitish heads 1-1.5 cm in diameter, turning pinkish to dull orange when dried (McVaugh 1987). The species flowers throughout the year in its natural range, and at the end of the dry season in trials in Zimbabwe (Dzowela 1994). The pod is oblong, 3-6 cm long and 6-9 mm wide, with straight or sinuate margins (Isely 1973). The pods are initially green, turning coffee-brown as they ripen (Dzowela 1994).

Ecology

In its natural range *A. angustissima* is found on hillsides, rock slopes, summits, and in grassland with other shrubs. It is often found in tropical deciduous or semi-deciduous forest (McVaugh 1987). In the native range, annual rainfall varies from 895-2870 mm, and mean temperature ranges are between 5° and 30°C. It grows from near sea level to 2600 m, but shows better growth potential at higher elevations. At lowland sites (20 m) in Papua New Guinea, *A. angustissima* flowered but did not seed, while at higher elevation (1650 m) it seeded prolifically (Brook et al. 1992). It tolerates cold climates (occasional temperatures below freezing) and free-draining acid soils (Dzowela 1994). It also withstands periods of drought, possibly due to its substantial taproot. It retains green foliage in the long (8-month) dry season in Timor, Indonesia (Gutteridge 1994).



Acacia angustissima (Miller) Kuntze, drawn by Emmanuel Papadopoulos

Acacia angustissima grows rapidly and responds well to regular cutting. However, it produces weak branches that break off in moderate winds (Brook et al. 1992). This ability to grow quickly has resulted in *A. angustissima* becoming weedy and forming thickets, especially along roadsides and in sandy soil in pastures in its native range (McVaugh 1987). This weed potential has created concern among some researchers about the advisability of its use in agroforestry or agricultural systems (Bray et al. 1997).

Distribution

Acacia angustissima occurs in tropical and subtropical mesic habitats along both sides of Mexico from the states of Jalisco and Nuevo Leon southward to Panama (Turner 1996). *Acacia angustissima* is now also commonly found in Southeast Asia, particularly Indonesia, as well as in Australia, where it is used in experiments. There are similar experiments in Zimbabwe, Ethiopia, Hawaii, Haiti, Papua New Guinea, Brazil, and Indonesia to determine its potential as a fodder or mulch crop in tropical countries.

Uses

Fodder. *Acacia angustissima* produces large amounts of foliage with fodder potential. The crown architecture enables the tree to withstand frequent cuttings or defoliation with a high recovery and growth rate (Gutteridge 1994). Acacia angustissima has also been shown to respond well to coppicing. Biomass production has been shown to range from 10.3 t DM ha^{-1} (Dzowela et al. 1997) to 11.4 t DM ha^{-1} (Brook et al. 1992) at 2-m spacing. At 3-m spacing the biomass increases to a range from 11.5 t DM ha^{-1} (Bino 1997) to 12.4 t DM ha^{-1} (Isaac et al. 1994). These figures are based on cutting the trees back to 50 cm above ground level and oil yearly cuttings taken during, and/or at the end of the

Prepared by D. Preece and R. Brook, School of Agricultural and Forest Sciences, University of Wales, Bangor, North Wales, UK, LL57 2UW. Fax: 44 1248 354977. E-mail: r.m.brook@bangor.ac.uk

wet season. Research shows that *A. angustissima* cuttings contain high levels of N, P and K, but due to a high tannin content (6% DM), the protein is less accessible to the livestock. Tests have shown that *Acacia angustissima* leaves degrade poorly in the rumen of cows (48% after 48 hours of incubation) (Dzowela 1994). Bray et al. (1997) found similar results noting that *Acacia angustissima* produced significantly more leaves than other shrub legumes, notably *Leucaena spp., Calliandra calothyrsus, Gliricidia sepium, Cajuns cajan,* and *Sesbania* spp. But he also concluded that even though *A. angustissima* has the potential to produce a high leaf yield, the high tannin content and low palatability means it is of limited nutritional value to livestock. During feeding trials at the International Livestock Research Institute (ILRI) in Ethiopia, sheep fed 300 g of *A. angustissima* supplement per head per day died between 9 days and 21 days after consuming only 75-100 g per head per day at any time (Odenyo et al. 1997). This shows that the feed may contain toxins, and that the sheep did not particularly like it. Gutteridge (1994) found conflicting information regarding palatability and intake by livestock. In some areas of Indonesia *A. angustissima* leaf is reported to be eaten well and is regarded as an important source of forage. Additional trials are needed to evaluate the use of fresh and dry leaf for livestock feed, and to document any toxicity problems.

Farming systems. No information has been found about *A. angustissima* being used within farming systems in its native habitat. Elsewhere, research has been carried out to try and determine the tree's potential as a multipurpose tree to be used in agroforestry systems. In Papua New Guinea, trials have been carried out using *A. angustissima* in an alley cropping system intercropped with sweet potato. *Acacia angustissima* provided enough N, P and K for the crop, but due to the rapid growth shaded the crop and inhibited the tuber yield (Brook 1993). During other trials its potential as a mulch producer has come into question, because of the presence of secondary compounds that bind the N and result in low-quality (slowly decomposing) prunings. This may mean that the mulch is a poor N source for the present crop, but it may have greater residual effects that could benefit the subsequent crop, or be a good N source to help build up organic matter in the soil (Dzowela 1994, Mafongoya et al. 1997). These long-term benefits could outweigh the initial low nutrient return- to the-soil over a number of years. Slowly decomposing prunings may have value for suppressing weed growth in associated crops.

Other uses. Although *A. angustissima* is not commonly used for agroforestry in its native range, it is an important medicinal species for the Tzotzil and Tzeltal Maya Indians in Mexico. They rank it the 4th most important species in the cure of bloody diarrhea and 7th in the treatment of mucoid diarrhea. It is also used as a cure for toothache, rheumatism and skin lesions, and is reported to inhibit growth in malignant tumors. Tests also show that *A. angustissima* possesses a mild antimicrobial effect on *Escherichia coli* and *Staphylococcus aureus* (Berlin et al. 1996). The bitter astringent bark is also used in Mexico for precipitating mucilaginous matter and inducing fermentation in the making of alcoholic drinks (Graham 1941). During laboratory tests *A. angustissima* has been shown to completely inhibit growth (after 48 hours) of *Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumoniae,* and *Candida albicans* (Hoffman et al. 1993). This indicates that A. angustissima has the potential to be used in applications against human diseases caused by bacteria and yeasts.

Silviculture

Propagation. *Acacia angustissima* seems to fare better when grown from transplanted seedlings then from direct seeding. If it is to be directly seeded, then it is important not to sow too deeply. Roshetko et al. (1995) suggested sowing the seed on the surface of cultivated soil and covering with a layer of soil equal to the width of the seed. Weeds can suppress early growth and the establishment of the seedling; it is therefore necessary to maintain a weed free zone around the seed or seedling for successful establishment (Maasdorp and Gutteridge 1986).

Pretreatment of seeds has been described by Roshetko et al. (1995)-the best results for germination came from 12 hours soaking in cool water before sowing. The standard hot-water treatment (a two-minute soak in hot water followed by 12 hours in cool water) resulted in inferior germination. Shelton (1994) suggested scratching or nicking the round end of each seed with a file, knife or nail clipper (without damaging the cotyledon) before sowing.

The seeds are very small, 90,000-100,000 seeds/kg, and initially green then a coffee-brown. *Acacia angustissima* forms an association with soil *Rhizobium* to fix atmospheric nitrogen. When introducing *A. angustissima* into a new area it may be necessary to inoculate with an appropriate Rhizobium before planting. FACT Net's site on the world wide web has a list of suppliers of seed and *Rhizobium* bacteria.

Fertilization. The application of fertilizer to *A. angustissima* has been shown to have different effects depending on when added. Fertilizer added to seeds had a negative effect on emergence and did not improve the competitive ability of the seedling against weeds once it started to grow (Maasdorp and Gutteridge 1986). Once *A. angustissima* is established the application of fertilizer has a positive effect on the growth of the tree (7-fold increase in crown volume on acid soils (Cole et al. 1996)). Costa and Paulino (1997) estimated that 53.8 mg/kg K and 104.2 mg/kg P would give maximum dry matter production and showed that nodulation significantly improved with K and P fertilization.

Pests. In its native habitat *A. angustissima* is eaten by the *Acacia* skipper butterfly, *Cogia hippalus,* and by the moth larva of *Sphingicampa blanchardi* and S. *raspa.* Two local birds also eat the seeds, the masked bobwhite and the Arizona scaled quail (Graham 1941). In trials in Hawaii the tree has been shown to be naturally resistant to attack from the Chinese rose beetle (Cole et al. 1996).

Selected References

Bray, R.A., Palmer, B., Ibrahim, T.M. (1997). Performance of shrub legumes at four sites in Indonesia and Australia. Tropical Grasslands 31(1):31-39.

Brook, R.M. (1993) Alley cropping for sweet potato in Papua New Guinea. Nitrogen Fixing Tree Research Reports 11:35-39.

Brook, R.M., Kanua, M.B., Woruba, M.G. (1992). Multipurpose tree species evaluations in Papua New Guinea: Early results. Nitrogen Fixing Tree Reports 10:77-80.

Cole, T.G., Yost, R.S., Kablan, R., Olsen, T. (1996). Growth potential of twelve *Acacia* species on acid soils in Hawaii. Forest Ecology and Management 80:175-86.

Dzowela, B.H. (1994) *Acacia angustissima* a Central American tree that's going places. Agroforestry Today, 6 (3):13-14.

A full set of references is available from FACTNet

FACT Net

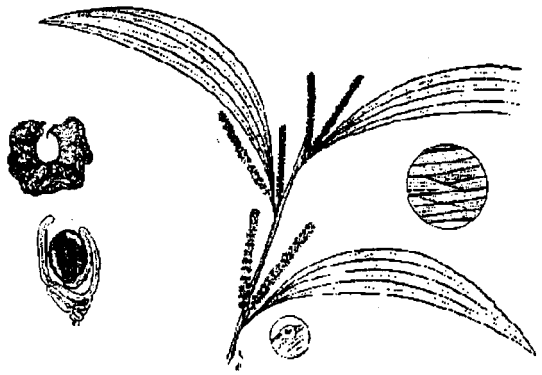
FACT Sheet

FACT 96-05

A quick guide to multipurpose trees from around the world September 1996

Acacia auriculiformis : A Multipurpose Tropical Wattle

Acacia auriculiformis A. Cunn. ex Benth. is a multipurpose, leguminous tree in the subfamily Mimosoideae. It has been planted for fuelwood production, erosion control, ornament and shade in many tropical areas in the world. Its rapid early growth; ability to fix nitrogen; tolerance of infertile, acid, alkaline, saline or seasonally waterlogged soils; and tolerance of moderate dry seasons make it a very useful species for rehabilitation of degraded lands. The scientific name comes from the Latin 'auricula'-- *external ear of animals* and 'forma'-- *form, figure or shape*, in allusion to the shape of the pod.



Leaves, gland, pod and seed of Acacia auriculiformis. *(Drawing: Margaret Pisoni)*

Botany

It is commonly a tree, 8-20 m in height, heavily branched with a short bole. On favorable sites it can grow to 30-40 m tall and 80-100 cm diameter with a straight, single stem. The bark is gray or brown, more or less smooth in young trees, becoming rough and longitudinal fissured with age. Mature foliage consists of phyllodes, which may be straight or falcate, acute or sub-falcate, 10-20 cm long and 1.5-3.0 cm wide. Phyllodes of sapling may attain 30 cm in length and up to 5.0 cm in width. There are 3 prominent longitudinal nerves running together towards the lower margin or in the middle near the base, with many fine crowded secondary nerves, and a distinct gland at the base of the phyllode (Pedley 1978).

Inflorescences are in spikes up to 8 cm long in pairs (seldom three) in the upper axils. Each inflorescence is comprised of about 100 tiny (3.8 x 4.1 mm) bright yellow flowers (Ibrahim and Awang 1991). Flowers are 5-merous; the calyx 0.7-1.0 mm long, with short lobes; the corolla is 2- 2.5 times as long as the calyx. Stamens are approximately 3 mm long. The pods are slightly woody, glaucous and transversely veined, about 6.5 cm long and 1.5 cm wide. They are initially straight or curved but become very twisted and irregularly coil on maturity. The seeds are broadly ovate to elliptical, about 4-6 mm long and 3-4 mm wide. Each seed is encircled by a long red, yellow or orange funicle. There are 60,000 seeds per kg.

Ecology

Acacia auriculiformis occurs from near sea level to 400 m, but is most common at elevation less than 80 m. It is redominantly found in the seasonally dry tropical lowlands in the humid and subhumid zones. The mean annual rainfall in its natural range varies from 700-2000 mm, and the dry season (i.e. monthly rainfall less than 40 mm) may be 7 months. The mean maximum temperature of the hottest month is 32-34° C and the mean minimum of the coolest month is 17-22° C.

The species is commonly riparian, i.e. ringing perennial rivers and semi-perennial creeks, and tends to form discontinuous populations along drainage systems. It is found most commonly on clay soil types, however it exhibits the ability to grow in a variety of soils including calcareous sands and black cracking clays. It can also tolerate highly alkaline and saline soils. Seedlings have the ability to compete with *Imperata cylindrica* during early growth phases and once mature may reduce the grass to a sparse ground cover.

Distribution

Acacia auriculiformis is endemic to Australia, Papua New Guinea and Indonesia, having a disjunct distribution in three main areas: the lowlands of southern half of the island of New Guinea (Papua New Guinea and Irian Jaya, Indonesia); the lowlands of tropical Northern Territory, Australia; and the Cape York Peninsula of northern Queensland, Australia. It has been widely introduced to many tropical countries in South and Southeast Asia, Africa and Latin America.

Uses

Wood. Heartwood varies from light brown to dark red. The wood makes attractive furniture and is suitable for construction work, turnery and carving. Plantation-grown trees have shown promise for the production of unbleached kraft pulp -- for bags and wrapping paper; and high quality neutral sulphite semi-chemical pulp -- for corrugating, medium and higher-grade packaging products (Logan 1987). The wood has a high basic density (500-650 kg/m^3) and a calorific value of 4700-4900 kcal/kg, which make it ideal for firewood and charcoal.

Land Rehabilitation & Landscaping. The spreading, densely-matted root system stabilizes eroding land. Its rapid early growth, even on infertile sites, and tolerance of both highly acidic and alkaline soils make it popular for stabilizing and revegetating mine spoils. It is used for

Written by Khongsak Pinyopusarerk. Senior Experimental Scientist CSIRO Forestry & Forest Products
PO 4008, Canberra, ACT 2600, Australia.

shade and ornamental purposes in cities where its hardiness, dense foliage and bright yellow flowers are positive attributes.

Other Uses. The bark has sufficient tannins for possible commercial exploitation (Abdul Razak et al. 1981). A natural dye, used in the batik textile industry in Indonesia, is also extracted from the bark. Its flowers are a source of bee forage for honey production (Moncur et al.1991).

Silviculture

Propagation. Propagation is generally by seed. Pregermination treatment is essential to promote seed germination. Immersion of seed in ample boiling water for 1-2 minutes is suitable to break dormancy. Germination is rapid after pretreatment and typically exceeds 70%. In general, 3-4 months are needed to raise seedlings to a plantable size, 25 cm in height. Inoculation with appropriate rhizobia may be beneficial, especially when seedlings are raised in sterilized soil.

Management. Establishment is successful by containerized seedlings or by direct seeding. Containerized seedling generally give higher survival, especially in areas of heavy weed competition. In the field, weed control is essential during the first 1-2 years. A small dose of NPK fertilizer in the first year helps improve initial growth - fertilization rates depend on site quality. Recommended spacing is 2x2 or 2x4 m. *Acacia auriculiformis* has the ability to coppice, but it is not a vigorous sprouter. It responds well to pollarding.

Yield. An increment in height of 2-4 m per year in the first few years is common even on soils of low fertility (Boland 1989). On relatively fertile Javanese soils receiving 2000 mm annual rainfall, a mean annual increment of 15-20 m^3/ha is obtainable but on less fertile or highly eroded sites the increment is reduced to 8-12 m^3/ha (Wiersum and Ramlan 1982). Recommended rotation is 4-5 years for fuelwood, 8-10 years for pulp and 12-15 years for timber. One or two thinnings are required with longer rotations, depending on initial spacing, site quality and tree growth.

Symbiosis

Acacia auriculiformis can fix nitrogen after nodulating with a range of *Rhizobium* and *Bradyrhizobium* strains. It also has associations with both ecto- and endo-mycorrhizal fungi.

Limitations

The propensity to produce multiple and crooked stems reduce its utility. It is susceptible to fire; even trees 10-15 years old can be killed. Stressed trees are found to be highly susceptible to attack by leaf insects.

Genetics & Provenances

Isozyme studies revealed marked genetic variation in *A. auriculiformis*. Three distinct groups of populations corresponding to the geographic distribution in Papua NewGuinea, Queensland and Northern Territory (Wickneswari and Norwati 1991). These regional groupings are also apparent in seedling morphology (Pinyopusarerk *et al.* 1991). Additionally, field trials have shown marked differences in growth and form. Provenances from Papua New Guinea have the highest production while those from Queensland have a high proportion of single stems. Those from the Northern Territory are inferior in both growth and form (Harwood et al. 1991).

Research Needs

Selection and breeding for superior growth and stem form are now underway in many countries, including Thailand and Vietnam. Natural hybrids of *A. auriculiformis* x *A. mangium* have shown desirable characteristics; e.g. vigor, fine branching and tendency for a strong apical dominance. These characteristics lead to healthy trees with single stems and a good clear bole. Production and vegetative propagation of these hybrids warrant detailed study.

References

Abdul Razak, M.A., Low, C.K. and Abu Said, A. 1981. Determination of relative tannin contents of the barks of some Malaysian plants. *Malaysian Forester* 44:87-92.

Boland, D.J. (ed.). 1989. *Trees for the tropics: growing Australian multipurpose trees and shrubs in developing countries.* ACIAR Monograph No. 10, 247 pp.

Harwood, C.E., Matheson, A.C. Gororo, N. and Haines, M.W 1991. Seed orchards of *Acacia auriculiformis* in Melville Island, Northern Territory, Australia. In: J.W. Turnbull (ed), *Advances in tropical acacia research.* ACIAR Proceedings No. 35. pp 87-91.

Ibrahim, Z. and Awang, K. 1991. Comparison of floral morphology, flower production and pollen yield of *Acacia mangium* and *A. auriculiformis*. In: *Advances in tropical acacia research.* pp 26-29. See Harwood et al. 1991.

Logan, A.F. 1987. Australian acacias for pulpwood. In: J.W. Turnbull (ed), *Australian acacias in developing countries.* ACIAR Proceedings No. 16. pp 89-94.

Moncur, M.W., Kleinschmidt, G. and Somerville, D. 1991. The role of acacia and eucalypt plantations for honey production. In: *Advances in tropical acacia research.* pp 123-27. See Harwood et al. 1991.

Pedley, L. 1978. A revision of Acacia Mill. in Queensland. *Austrobaileya* 1(2):75-234.

Pinyopusarerk, K. Williams, E.R., Boland, D.J. 1991. Geographic variation in seedling morphology of *Acacia auriculiformis*. *Australian Journal of Botany* 39:247-260.

Wickneswari, R. and Norwati, M. 1991. Genetic structure of natural populations of *Acacia auriculiformis* in Australia and Papua New Guinea. In: *Advances in tropical acacia research.* pp 94-95. See Harwood et al. 1991.

Wiersum, K.F. and Ramlan, A. 1982. Cultivation of *Acacia auriculiformis* in Java, Indonesia. *Commonwealth Forestry Review*61:135-144

NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 88-04
August 1988

Acacia holosericea : A Successful Newcomer for the Dry Tropics

This shrubby acacia is little used in its native Australia, yet it promises to be an outstanding multipurpose tree for the dry tropics. Its excellent potential for fuel, charcoal, animal fodder, land rehabilitation and as an ornamental is now being realized in Africa and the Indian subcontinent.

BOTANY: *A. holosericea* A. Cunn. ex G. Don is one of some 850 thornless species of the genus endemic to Australia. It bears large phyllodes, 10-25 cm long and 1.5 to 10 cm broad, usually covered densely with fine hairs, giving the tree attractive silvery foliage. Small bright yellow flowers are aggregated in prominent spikes 3-6 cm long.

Narrow, hairless pods, 3-6 can long, are coiled in dense clusters and contain shiny black seeds, each with a yellow aril at the base. Flowering is heavy and precocious, and abundant crops of mature seeds may be formed within two years of planting. It commonly forms a spreading shrub to 5 m in height with many ascending branches from just above ground level. Occasionally it grows as a small tree up to 8 m in height.

ECOLOGY: Natural populations occur in a wide range of tropical climates. In semiarid areas mean annual rainfall can be as low as 300 mm and in these conditions it is confined to seasonally dry stream banks. Throughout much of its natural distribution annual rainfall is 600-1200 mm with most rain concentrated in four months. It does occur, however, in areas where rainfall exceeds 1500 mm (Booth and Jovanovic 1988). Most of the distribution is frost-free, but up to ten frosts each year occur at some inland sites. It occurs on a variety of soil types, but mainly on shallow, acidic, stony sands and loams of low fertility (Turnbull, et al. 1986).

In Senegal, tests have shown that the species behaves satisfactorily with rainfall over 500 mm in areas under coastal influences and over 600 mm in continental Africa (Cossalter 1987). In extremely dry areas when annual rainfall is less than 250-300 mm seedlings can survive for 2 to 3 years but then die. In the island environment of Cape Verde, however, where low rainfall is counterbalanced by higher air moisture, cooler temperatures and lower evapotranspiration, *A. holosericea* has withstood an average annual rainfall of about 200 mm in a 5-year period. In Senegal, it reportedly tolerates saline and water. logged soils (Cossalter 1987).

The wide variability in soils and climate suggest major provenance differences will occur in growth rates and drought and frost tolerance. Provenance trials have been started, but results are not yet available.

FUELWOOD AND CHARCOAL: The wood is hard and has a high density of about 870 kg/m3. With calorific values for wood and charcoal of 4670 Kcal/kg and 7535 Kcal/kg, respectively; it is a good quality fuel (Cossalter 1987; CTFF 1983). The rapid early growth rate makes it a highly productive fuelwood source.

The shaded area is the natural range of Acacia holosericea (Turnbull, et al. 1986)

FODDER: The fodder potential is mainly due to the large phyllode biomass produced during the dry season, a period when most non-Australian acacias traditionally used for fodder shed their leaves. Fresh phyllodes are not palatable for cattle and sheep, but when the branches are lopped the dry foliage is eaten readily. Four-year-old trees in Senegal have produced about 3 tons of dry phyllodes per hectare, but estimates of crude protein and *in vivo* digestibility are low and suggest *A. holosericea* has a low feed value (Vercoe 1987).

Written by John Turnbull, Forestry Program Coordinator, ACIAR, G.P.O. Box 1571, Canberra, Australia.

WINDBREAKS & LAND REHABELITATION The large, dense crown of this shrubby acacia enables it to form a screen. In Africa it is used to form the lower part of a multistorey windbreak with the taller *Eucalyptus camaldulensis,* a species with which it is frequently found in its natural range (Hamel 1980).

Advantage can be taken of the fast growth, dense crown, nitrogen fixing ability and vigorous colonizing characteristic of this species to revegetate and restore degraded mining areas (Langkamp and Dalling 1983). It also shows promise for sand dune fixation in Senegal and Somalia (Hamel 1980).

ORNAMENTAL: The silvery foliage, early appearance of long yellow flower spikes, and prominent twisted pods make *A. holosericea* an attractive ornamental shrub or small tree.

ESTABLISHMENT: For good germination, seed (95,500 to 175,000/kg) should be scarified by mechanical abrasion or immersed for one minute in boiling (100^{o}C) water. Coppicing is generally regarded as poor, but contradictory reports suggest its resprouting ability may be influenced by tree age, season of cutting and height at which the cutting takes place.

GROWTH: Seedling growth is rapid. On favorable sites in Central Australia it has reached 4 m tall in 18 months. On drier sites 3 m growth in 3 years is average, and growth rate diminishes in succeeding years (Kube 1987). In Senegal a growth rate of 4.8 m in 40 months has been recorded in an area with 585 mm rainfall and a 7-month dry season (Cossaiter 1987). At Bambey, Senegal, 4 year old *Acacia holosericea* produced 13 tons/ha of green wood and ahnost 3 tons/ha of dry phyllodes, demonstrating its considerably greater productivity dm the local *Acacia senegal.*

SYMBIOSIS: *A. holosericea* forms nodules with rhizobium and develops endomycorrhizal associations. Greatly stimulated growth has been reported when seedlings were inoculated with a selected rhizobium and the endomycorrhizal fungus, *Glomus mosseae* (Comet and Diem 1982).

PESTS: This acacia appears to be relatively free of pests and diseases in cultivation and resists termite attack.

PROBLEMS: The early and abundant seeding habit has the potential to make *A. holosericea* a weed species under certain conditions. Like many acacias, it is relatively short-lived, from as little as 4-5 years to not more than 10-12 years, and this may be a problem under some circumstances.

(Simmons 1981)

REFERENCES

Booth, T.H. and T. Jovanovic. 1988. Assaying natural climatic variability in some Australian species with fuelwood and agroforestry potential. Commonwealth Forestry Review 67(l):27-34.

Cornet F. and H.G. Diem. 1982. Etude comparative de l'efficacite des souches de *Rhizobium d'Acacia* isolees de sols due Senegal et effet de la double symbiose *Rhizobium - Glomus mosseae* sur la croissance de *Acacia holosericea* et A. *raddiana* Bois et Forets des Tropiques 198:3-15.

Cossalter, C. 1987. Introducing Australian acacias into dry, tropical Africa. pp. 118-122. In J.W. Turnbull (ed.) Australian acacias in developing countries. ACIAR proceedings No. 16 (ACIAR: Canberra).

Hamel, O. 1980. Acclimatization and utilization of phyllodineous acacias from Australia in Senegal. pp. 361-373. In H.N. LeHouerou (ed.) Browse in Africa. (International Livestock Centre for Africa: Addis Ababa).

Kube, P. 1987. Growth rates, establishment techniques, and propagation of some Central Australian acacias. pp. 77-80. la J.W. Turnbull (ed.) Australian acacias in developing countries. ACIAR Proceedings No. 16 (ACIAR: Canberra).

Langkamp, P.J. and M.J. Dalling. 1983. Nutrient cycling in a stand of *Acacia holosericea* Australian Journal of Botany 31:141- 9.

Simmons, Marion. 1981. *Acacias* of Australia. Thomas Nelson Australia, Melbourne. 325 pp.

Turnbull, J.W., P. Martensz and N. Hall. 1986. *Acacia holosericea.* pp 144-5. In Multipurpose Australian Trees and Shrubs. ACIAR Monograph No. 1.

Vercoe, T.K. 1997. Fodder potential of selected Australian tree species. pp. 95-100. In J.W. Turnbull (ed.) Australian acacias in developing countries. ACIAR Proceedings No. 16 (ACIAR: Canberra).

NFT Highlights

NFTA 94-08

A quick guide to multipurpose trees from around the world September 1994

Acacia koa : Hawaii's Most Valued Native Tree

Koa (*Acacia koa* Gray.) is unquestionably Hawaii's most prized tree species—culturally, ecologically and economically. Hawaiians have always valued koa for its exceptionally beautiful and durable wood. It remains the premier Hawaiian timber for furniture, cabinetry, interior work and woodcrafts. Equally important, native koa forests provide unique wildlife habitat, critical watershed recharge areas and recreational opportunities. Unfortunately, forest clearing for agriculture, cattle grazing and feral pig activity have much diminished Hawaii's once extensive koa forest. The scarcity of koa wood is reflected in its ever increasing price—high enough now to economically justify helicopter logging.

Botany and Ecology

Acacia koa is a large, evergreen broadleaf tree and the only *Acacia* native—and endemic—to Hawaii. Trees occurring in dense, wet native forest stands typically reach heights of 25 m and stem diameters (DBH) of 150 cm, while retaining a straight, narrow form. In the open, trees develop more spreading, branching crowns and shorter, broader trunks. Koa bark is gray, rough, scaly and thick. Observations indicate that koa has one main tap root - and an otherwise shallow, spreading root system.

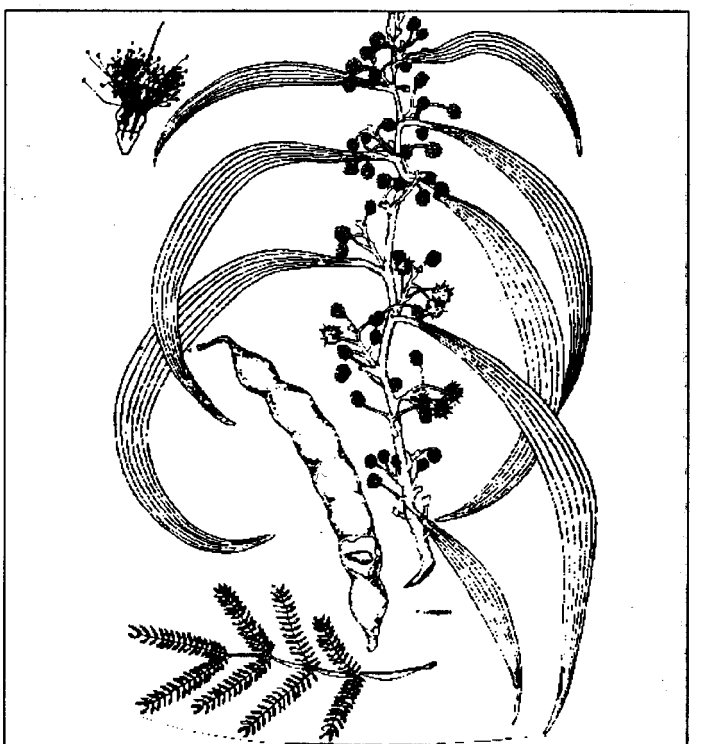
Koa belongs to the thorn-less, phyllodinous group of the *Acacia* subgenus *Heterophyllum* (Whitesell 1990). Like other phyllodial species, mature koa trees do not have true leaves. Instead they produce phyllodes, or flattened leaf petioles. Young seedlings have bipinnate compound true leaves with 12 to 15 pairs of leaflets. Where forest light is sufficient, seedlings stop producing true leaves while they are small less then 2 m tall. True leaves are retained longer by trees growing in dense shade.

Phyllodes are sickle-shaped and often more than 2.5 cm wide in the middle and blunt pointed on each end. Investigations suggest that true leaves promote more rapid early growth when moisture is adequate, whereas phyllodes are better adapted to drought. Phyllodes transpire only 20 percent as much as true leaves, and their stomata close four times faster after dark. Phyllodes typically hang down vertically, a position that enhances their ability to capture light during early morning and late afternoon hours. Seedlings are able to switch back from phyllode to true leave production when the sunlight reaching them is reduced (Walters and Bartholomew 1990). This adaptation allows them to survive and grow under a wide range of light regimes.

Observations suggest koa can flower almost any time of year, depending upon local weather conditions. The inflorescence of koa is a pale yellow ball averaging 8.5 mm in diameter, one to three on a common stalk. Each inflorescence is composed of many bisexual flowers. Each flower has an indefinite number of stamens and a single elongated style. One known pollinator of koa is the honeybee (*Apis mellifera*). Koa appears to be fully self-fertile (Brewbaker 1977).

Koa pods are slow to dehisce and about 15 cm long and 2.5 to 4 cm wide. They normally contain between 6 and 12 seeds that vary from dark brown to black. Pods reach maturity at 4 to 6 months, depending on location and weather conditions. Insect larvae of many species typically destroy a large proportion of the mature seeds before they dehisce.

Seed production typically begins when trees are 5 years old. Koa bears seed often and abundantly. Seeds are seldom dispersed far from the tree and remain viable in the soil for up to 25 years. Thus remnant koa stands are capable of dominant regeneration under favorable conditions. Koa seeds do not require sunlight to germinate, but seedling growth is slow in dark understories or in thick grass. The species thus requires large forest gaps, such as those created by storms, to successfully regenerate.



Acacia Koa, from E.L. Little and R.G. Skolmen. 1989. Common forest trees of Hawaii (native and introduced). Agricultural Handbook 679. Washington, D.C.: USDA, p. 131.

This issue was written by Karl Dalla Rosa, Hawaii State Deptartment of Land and Natural Resources, Division of Forestry and Wildlife, 1151 Punchbowl Street, Honolulu, Hawaii 96813.

Distribution

Acacia koa occurs at elevations from 180 to 6000 meters between 19 and 22 latitude on all of the major Hawaiian islands. It prefers an annual rainfall of 1900 to 5100 mm, and well drained acid soils. However, koa adapts to almost any of Hawaii's diverse environments indicating its potential elsewhere in the Pacific. Koa is found on all volcanic soil types of all geologic ages. It grows well in moderately to well-drained, medium to very strongly acid soils on both flatland and steep slopes. On dry, shallow, poorly drained soils koa's growth is slow and its form generally poor.

Occurring in both pure and mixed forest stands, koa is most commonly associated with the native ohia (*Metrosideros polymorpha*). It is also a codominant in several other major forest types including: Koa/Mamane (*Sophora chrysophylla*) Montane Dry Forest and Koa/Ohia/A'e (*Sapindus soponaria*) Forest (Wagner et al. 1990). Today *Acacia koa* stands are fragmented and concentrated in areas between 600 and 1800 meters elevation (Whitesell 1990). This distribution is largely the result of land conversion to agriculture and ranching. Cattle avidly graze koa seedlings, preventing regeneration.

Silviculture

Propagation is most successful from seed. One study recommends air-layering as the best vegetative propagation technique (Skolmen 1978). Koa seeds are durable and easy to store. They germinate after many years of storage if kept in a cool, dry place. The most effective method for improving seed germination is mechanical scarification. However, hot water soaking works well and is a more practical method. Boil water and remove it from the heat source. Soak seed in the boiled water for 24 hours. Once treated, seeds are typically sown in nursery beds. One week after germination, seedlings are transplanted into nursery tubes or bags. Seedlings are ready for transplanting into the field when they are approximately 20 cm tall—after 3 to 4 months in the nursery. Observations suggest that heart rot problems may be partially caused by root damage during transplanting. Therefore, establishment by direct seeding or encouragement of natural regeneration is recommended. On favorable sites, planted seedlings typically grow to 9 m in 5 years time (Judd 1920).

Koa's wide branching form is the result of open growth. Trees with long clear boles—called "Canoe trees" by native Hawaiians are now rare, but still found in forest gaps created by fallen trees. Dense stocking of seedlings, which mimics the competitive environment where superior "canoe trees" grow, encourages straight and rapid height growth. Initial spacing of 1.2 x 1.2 meters is currently recommended. Observation indicates that effective self-thinning will result in an adequate number of potential crop trees by age 25.

Where scattered koa cover is adequate, plantation establishment is most easily and successfully accomplished through the stimulation of natural regeneration. Pasture soils are scarified and competition from grasses reduced by the application of a contact herbicide. Gaps in the regeneration are filled with planted seedlings. Fertilizers are applied to give seedlings an initial "boost". Plantation thinning prescriptions should be based on desired products and management capabilities. The most important factors to consider in picking koa crop trees is stem form and height. Research on koa plantation management and various spacing and thinning regimes is direly needed.

Uses

Wood. Koa heartwood is highly valued by furniture and crafts people throughout Hawaii, and consumers the world-over, for its unique grain, varied color and workability. It seasons well without serious warping or splitting. Curly-grained wood, the result of both stress and genetics, is preferred over straight-grained wood. Wood color ranges from a subtle yellow to a striking dark red-purple. The specific gravity of koa wood averages .40, but with curly-grained wood can be as high as .65. Mature koa boles are commonly forking or fluting and often suffer from heart rot. These characteristics and wide branch angles limit its value as a large timber. Fortunately, these defects may be corrected through silviculture.

Forage and Wildlife Habitat. Cattle, sheep and pigs browse koa foliage aggressively, especially its juvenile leaves. Koa is spread geographically throughout Hawaii and thus offers a variety of wildlife habitats of diverse moisture regimes, soils and vegetative compositions. An overlay of a koa forest area map onto a forest bird "habitat island" map produced by Walker (1986) shows remarkable correlation.

Land Reclamation. Most koa plantations in Hawaii have been established to provide vegetative cover on sites degraded by decades of intense grazing. Where scattered koa already exists, seed stored in the soil will likely germinate if the soil is scarified and grass competition controlled.

Symbiosis

Acacia koa is nodulated by the slow-growing *Bradyrhizobium* spp. common in tropical soils. It nodulates heavily in a variety of soils, suggesting it is effective with a wide variety of *Bradyrhizobia* strains.

Pests and Diseases

Banana poka (*Passiflora mollissima*) is a fast growing vine that commonly outgrows and smothers young koa trees. Kikuyu grass (*Pennisetum clandestinum*), a dominant and extremely aggressive highland grass in Hawaii, is a major deterrent to the emergence of koa seedlings on cleared or formerly grazed lands. Successful koa plantation monoculture has historically been difficult to achieve due to associated insect and disease problems. Examples include the defoliating koa moth (*Scotorythra paludicola*) and a lethal "koa blight" first observed in 1988 on the island of Oahu.

References

Brewbaker, J.L. 1977. Final Report, *Acacia koa* project.Unpublished report on file at the Institute of Pacific Islands Forestry and University of Hawaii, Department of Horticulture, Honolulu, Hawaii.

Judd, C.S. 1920. The koa tree. Hawaii Forester and Agriculturalist 17(2):30-35.

Skolmen, R.G. 1978. Vegetative propagation of Acacia koa Gray. *In* Proceedings, Second Conference in Natural Sciences, Hawaii Volcanoes National Park, June 1-3, 1978, edited by C.W. Smith. p. 260-273.

Wagner, W.L., D.R. Herbst and S.H. Sohmer. 1990. Manual of the Flowering Plants of Hawai'i. Vol. 1. University of Hawaii Press, Bishop Museum, Honolulu, Hawaii.

Walker, R.L. 1986. Koa and wildlife - An enduring relationship. Unpublished paper on file at the Hawaii Division of Forestry and Wildlife, Honolulu, Hawaii.

Walters, G.A., and D.P. Bartholomew. 1990. Adaptation of Acacia koa leaves and phyllodes to changes in photosynthetic photon flux density. Forest Science 36(4):1050-1060.

Whitesell, C.D. 1990. *Acacia koa* Gray. *In* Silvics of North America; 2, Hardwoods. R.M. Burns and B.H. Honkala, Tech. Coordinators. Agricultural Handbook No. 654. USDA Forest Service, Washington, D.C.

FACT Net

FACT Sheet

A quick guide to multipurpose trees from around the world

FACT 96-03
June 1996

Acacia mangium : An Important Multipurpose Tree For The Tropic Lowlands

Acacia mangium Willd. is one of the major fast growing species used in plantation forestry programs throughout Asia and the Pacific. Due to its rapid growth and tolerance of very poor soils, *A. mangium* is playing an increasingly important role in efforts to sustain commercial supply of tree products while reducing pressure on natural forest ecosystems.

Botany

Acacia mangium is in the family Leguminosae, sub-family Mimosoideae. It has rapid early growth, and can attain a height of 30 meters and a diameter of over 60 centimeters (MacDicken and Brewbaker 1984). Inflorescences are on loose spikes up to 10 cm long with white or cream colored flowers. When in full blossom, the inflorescences resemble bottle brushes. The flower has a mild, sweet fragrance. The dark green, glabrous phyllodes can be up to 25 cm long and 10 cm broad. The seed pods are broad, linear, irregularly coiled, and up to 3-5 mm wide and 7-8 cm long. The seeds are dark brown to black, shiny, vary in shape, and range from 3-5 mm long and 2-3 mm wide. Seeds mature 6-7 months after flowering (Pinyopusarerk et al. 1993).

Acacia mangium has a chromosome number of 2n=26. Hybrids with *A. auriculiformis* have the potential to become an important source of planting material for plantation forestry. The hybrid seems to be more resistant to heart rot than *A. mangium* but tends to be more shrub-like. Moreover, the hybrid has the straight bole and stem of *Acacia mangium* and the self-pruning ability of *A. auriculiformis* (Ibrahim 1993).

Distribution and Ecology

Acacia mangium is native to Australia, Indonesia and Papua New Guinea, but now has a latitudinal range from 19° S to 24° N and a longitudinal range from 88° to 146° E. *Acacia mangium* is a low-elevation species associated with rain forest margins and disturbed, well-drained acid soils (pH 4.5-6.5). Altitudinal range is from sea level to about 100 meters, with an upper limit of 780 meters. It is typically found in the humid, tropical lowland climatic zone characterized by a short dry season and a mean annual rainfall between 1446 and 2970 mm. *Acacia mangium* can tolerate a minimum annual rainfall of 1000 mm. Mean monthly temperatures range from a low of 13-21C and a high of 25-32° C. Though considered an evergreen species, *A. mangium* does not grow continuously throughout the year. Growth seems to slow or cease in response to the combination of low rainfall and cool temperatures. Dieback occurs during prolonged frost (5-6° C). When monthly rainfall is below 100 mm, trees exhibit signs of moisture stress (Pinyopusarerk 1993).

Acacia mangium tolerates a soil pH as low as 3.8, and has performed well on lateritic soils with high amounts of iron and aluminum oxides. *Acacia mangium* has survived on soils with as much as 73% aluminum saturation (Duguma 1995). It is intolerant of saline conditions, shade, and low temperatures. Due to dense foliage, broad phyllodes, and shallow root system, *A. mangium* is more susceptible to wind damage than other *Acacia* species.

Propagation and Silviculture

Although natural regeneration is excellent in clear-felled and burned fields, nursery propagation is the most common regeneration practice. Hot water treatment for 30 seconds promotes quick seed germination. There are 80,000-100,000 seeds per kilogram. Seed can be sown directly into nursery pots or sown in trays and transplanted to pots after germination.

Drawing by Gillian Rankin (courtesy of Queensland Herbarium, Indooroopilly, Queensland, Australia).

Written by Mary Mackey, Program Associate, Winrock International.

Seedlings are retained in the nursery for 12 weeks or until they have attained a height of 25-40 cm. Srivastava (1993) recommends two root prunings and hardening off of the seedlings before out-planting. In low phosphorus soils in the Philippines, *Acacia mangium* seedlings fertilized with 30 g/tree of phosphorus showed significant increase in growth compared to seedlings that were not fertilized (Manubag et al. 1995).

Spacing of the seedlings in the plantation depends on the intended uses and soil fertility. Since natural pruning is poor, trees should be planted at close spacing. Plantations cultivated for pulpwood usually have a 4 x 4 m spacing with 830 trees per hectare. For timber production, seedlings planted at 3 x 3 m spacing provide strong lateral competition and fast diameter growth. Seedlings should be planted at wider spacing to produce heavier branches for chipwood and fuelwood (Srivastava 1993). On infertile sites, final stocking should be around 600-700 stems per hectare.

The first weeding should be two months after out-planting. Weeding of noxious plants such as climbers, creepers, and vines is recommended, but less harmful weeds can be left in the field to maintain lateral competition. The number of follow-up weedings will depend upon each site. In areas where *Imperata* has a stronghold, weedings should be frequent.

Pruning schedules also depend on intended use. In agroforestry systems, branches are pruned regularly to prevent competition with agricultural crops. To produce quality sawlogs, all branches below the height of 6 meters should be pruned regularly. These branches must be pruned before becoming 2 cm in diameter to avoid fungal infections (Srivastava 1993).

On degraded *Imperata* grasslands, Otsamo et al. (1995) observed that *A. mangium* had a mean annual volume increment of 10 m^3/ha/year. In a 15-year rotation, pre-commercial thinning should occur at 24 months, followed by a thinning at 36 months. Per this schedule, volumes are between 290 and 439 m^3/ha after ten years' growth.

Uses

Acacia mangium has a wood density ranging from 420 to 600 kg/m^3 and a specific gravity of 0.65 (MacDicken and Brewbaker 1984). Due to ease of drilling and turning, it is a popular wood for furniture, agricultural implements, crates, particle board, and wood chips. *Acacia mangium* is also suitable for manufacturing charcoal briquettes and activated carbon. It has a calorific value of 4,800-4,900 Kcal/kg. *Acacia mangium*'s susceptibility to heart rot limits its use for sawn timber, but it is a common pulp and paper crop in Sumatra, Sabah and Vietnam. Nontimber uses include honey production, adhesives, and as an ornamental and shade tree for roadsides or other urban forestry uses. *Acacia mangium* sawdust provides good-quality substrate for shiitake mushrooms.

Since *A. mangium* can grow on marginal soils, many farmers choose to plant this species to improve soil fertility of fallowed fields or pastures. Since trees with diameters of 7 cm are fire resistant, *Acacia mangium* plantations can be used as fire breaks.

Symbiosis

Highly effective *Rhizobium* strains have been identified for Acacia mangium (de Faria 1995). Acacia mangium has a relationship with some VAM fungi including *Thelephora ramariods*, *Gigaspora margarita*, *Glomus etunicaturm*, and *Scutellispora calospora.*

Pests and Diseases

The major pests associated with *A. mangium* cause damage to seedlings, branches and stems, or wilting caused by root damage. Damage does not result in death, but may deform or suppress tree growth (Hutacharern 1993).

Most disease agents of *A. mangium* are associated with or caused by fungi. Common disease symptoms are damping off, heart rot, powdery mildew, stem galls, dieback, leaf spots, and root rot (See 1993).

References

Duguma, B. 1995. Growth of nitrogen fixing trees on moderate to very acid soils of the humid lowlands of southern Cameroon. In Evans, D. O. and L.T. Szott eds. *Nitrogen Fixing Trees For Acid Soils*. Proceedings of Workshop in Turrialba, Costa Rica, July 3-8, 1994: Winrock International and CATIE. pp. 195-206.

Faria, S. M. de. 1995. Occurrence and rhizobial selection for egume trees adapted to acid soils. In *Nitrogen Fixing Trees For Acid Soils*. pp. 295-301. See Duguma 1995.

Hutacharern, C. 1993. Chapter 9: Insect pests. In Awang, K. and D. Taylor eds. Acacia mangium *Growing and Utilization.* MPTS Monograph Series No. 3. Bangkok, Thailand: Winrock International and FAO. pp. 163-203.

Ibrahim, Z. 1993. Chapter 2: Reproductive biology. In Acacia mangium *Growing and Utilization.* pp. 21-34. See Hutacharern 1993.

MacDicken, K. and J. L. Brewbaker. 1984. Descriptive summaries of economically important nitrogen fixing trees. NFT Res. Rpts. 2:46-54.

Manubag, J., B. Laureto, J. Nicholls, and P. Canon. 1995. *Acacia mangium* response to nitrogen and phosporus in the Philippines. In Acacia mangium *Growing and Utilization.* pp. 32-35. See Duguma 1995.

Pinyopusarerk K., S.B.Liang, and B.V. Gunn. 1993. Chapter 1: Taxonomy, distibution, biology, and uses as an exotic. In Acacia mangium *Growing and Utilization.* pp. 1-20. See Hutacharern 1993.

Otsamo, A., G. Adjer, T. S. Hadi, J. Kuusipalo, K. Tuomela, and R. Vuokkko. 1995. Effect of site preparation and initial fertilization on establishment and growth of four plantation trees species used in reforestation of *Imperata cylindrica* (L.) Beauv. dominated grasslands. For. Ecol. and Mgmt. 73:271-277.

See, L. S. 1993. Chapter 10: Diseases. In Acacia mangium *rowing and Utilization.* pp. 203-238. See Hutacharern 1993.

Srivastava, P.B.L. 1993. Chapter 7: Silvicultural practices. In Acacia mangium *Growing and Utilization.* pp. 113- 147. See Hutacharern 1993.

NFT Highlights

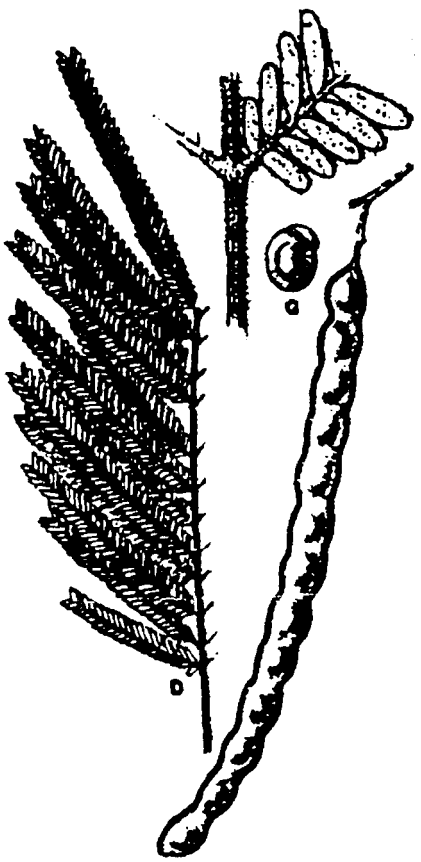
A Publication of the Nitrogen Fixing Tree Association

NFTA 85-02
May 1985

Acacia mearnsii : Multipurpose Highland Legume Tree

"Black wattle" is the common name of this respected Australian leguminous tree, *Acacia mearnsii* de Wild. The Australians dubbed the *Acacia* spp. "wattles" for their utility in providing the flexible framework ("wattle" or "hurdle") for fences or houses.

A. mearnsii now occurs worldwide and is used as **source of tannin, fuelwood, charcoal, poles, props, green manure and windbreaks.** In Australia it ranges widely from hot Queensland south to cool Tasmania and up to elevations of 1100 m. Introduced to Africa early this century, it became widely distributed naturally and in tannin plantations.



The black wattle is **one of the outstanding NFTrees for the cooler tropics.** It is moderately frost tolerant and vigorous at high elevations in India and East Africa. Height growth was over 10 m in 3 years at 2000 m in Kenya with mean annual temperature of 13-17C (Schonau, 1973).

Originally distributed as a source of tannin, black wattle is now **recognized as a valuable fuelwood.** The wood has a calorific value (dry) of 4600 kcal/kg and ash content of about 1.5%. It is dense, with specific gravity about 0.75, and yields a high-quality charcoal (NAS, 1980).

Wattle bark is the most widely used tannin material in the world. It contains 30-45% (dry basis) high-quality tannins that are used in tanning many classes of leather.

Such tannins are particularly effective on hard leathers for shoes and saddles. They give better color to leather than other tannins, do not precipitate in acid solution, and penetrate hides faster (Purseglove, 1968; NAS,1980).

An efficient nitrogen-fixer and good source of green manure, black wattle has given annual yields up to 250 kg/ha of fixed nitrogen (Wiersum, 1980). It thus can restore and regenerate soils. Wattles grow well even on slopes with **shallow or poor acid soils,** and can be very effective in **preventing soil erosion.**

Written By K.G. MacDicken, Editor and J.L Brewbaker, President, NFTA

Wattles grow to 20 m, and are erect with blackish bark and feathery foliage. Twigs are angled, young foliage yellowish, flowers clustered, yellow and sweet in scent. They **grow rapidly,** e.g., over 8 m in 2 years on a site with 22C average annual temperature (MacDicken, 1983). Annual yields of 15-25 m are reported from 6-10 year rotations (NAS, 1980).

Wattles are generally established using seedling transplants, although **they are suited to direct seeding and vegetative propagation.** Among seedling disease and insect pests are damping off, white grubs, grasshoppers and cutworms. Tannin plantations are established at 2,400 trees per hectare and thinned to 1,500 trees (Wattle Res. Inst., 1976)

Seeds must be scarified, e.g. with hot-water soaking (5 min. at 90C, 100 gm seed per liter). Direct seeding is made at depths of 5 cm using 2.5 kg seed per hectare (Wattle Res. Inst., 1975).

Vegetative propagation is possible using 10-15cm cuttings with leaves. Mist spray, constant heat of 28C, and auxin mixtures of IBA and NAA appear essential to good rooting (Zeijlemaker, 1976). Bud-grafting can be highly successful (Garbutt, 1971).

Although black wattle survives on acid soils, it responded positively to lime up to pH6 and showed chlorosis and high mortality in alkaline soils (Schonau, 1971). Phosphorous response was very good.

An **effective volume equation for trees** 10-25 m in height and 5-25 cm in diameter at breast height was the following:

$$\log V = 1.9532 (\log D) + 1.2315 (\log H) - 1.74059$$

where V = total volume in dm^3 to 5cm top diameter, D = diameter at breast height in cm, and H = total height in m (Schonau, 1-972).

A. mearnsii is known in the literature also as *A. mollissima* auct. (non Willd) and *A. decurrens* var. *mollis* Lindl. Dr. Mearns was an American physician and naturalist working in Africa early this century, from which the name derives; it was applied to trees introduced from Australia.

GENERAL REFERENCES

National Academy of Sciences. 1980. Firewood Crops: Shrub and Tree Species for Energy Production. NAS, Washington DC. p.72-73.

Little, E. L., Jr. 1981. Common Fuelwood Crops. Communi-Tech Assoc., Morgantown, W. Va. (Illustration used here is from p.16 of this useful book, and is based on Maiden 1907).

NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 92-04
June 1992

Acacia nilotica : Pioneer For Dry Lands

Acacia nilotica (L.) Willd. ex Del. (Leguminosae, subfamily Mimosoideae) is one of about 135 thorny African *Acacia* species. Variation is considerable with nine subspecies presently recognized, three occurring in the Indian subcontinent and six throughout Africa (Brenan 1983.) They are distinguished by the shape and pubescense of pods and the habit of the tree.

BOTANY. In habit *A. nilotica* varies from a shrubby tree with wide spreading crowns in savanna habitats (ssp. *subalata, leiocarpa, adstringens, hemispherica* and *kraussiana),* to a 20 meter tree (ssp. *nilotica, tomentosa,* and *indica)* in riverine situations. Ssp. *cupressiformis* has ascending branches like a poplar.

Acacia nilotica is easy to recognize by its bright yellow flowers in round heads, straight stipular spines often slightly deflexed, and dark indehiscent pods compressed over the seeds. Flowering is prolific, and can occur a number of times in a season. Often only about 0.1% of flowers set pods (Tybirk 1989.) The taxa form a polyploid complex most are tetraploids (2n=4x=52); but higher numbers have been found in ssp. *nilotica* (2n=8x=104) & ssp. *tomentosa* (2n=16x=208) (Nongonierma 1976.)

ECOLOGY. There are two very distinct ecological preferences in the African subspecies. Subspecies *subalata, leiocarpa* and *adstringens* occur in wooded grassland, savanna and dry scrub forests. Subspecies *nilotica* and *tomentosa* are restricted to riverine habitats and seasonally flooded areas. Subspecies *kraussiana* prefers dry grasslands and savannas, especially on compacted sandy loam, shallow granite or clay soils along drainages and rivers, but away from flooding.

On the subcontinent, ssp. *indica* forms low altitude dry forests usually on alluvium and black cotton soils. It has been widely planted on farms throughout the plains of the subcontinent. The species grows on saline, alkaline soils, and on those with calcareous pans. Subspecies *hemispherica* is restricted to dry sandy streams beds near Karchi, ssp. *cupressiformis* has similar preferences to ssp. *indica* though is less resilient to weed competition.

A. nilotica occurs from sea level to over 2000 m. It withstands extremes of temperature (-1 to 50°C), but is frost tender when young. Annual rainfall varies from 250 - 1500 mm. Trees are generally deciduous during the dry season, though riverine ssp. can be almost evergreen.

DISTRIBUTION. The species is naturally widespread in the drier areas of Africa, from Senegal to Egypt and down to South Africa, and in Asia from Arabia eastwards to India, Burma and Sri Lanka. It has also been cultivated elsewhere, including Australia, Cape Verde islands, Indonesia, Iran, Iraq, Nepal, Vietnam, and the West Indies.

USES. Wood. Since the time of the Pharoahs, large timber trees have been exploited from the riverine forests of the Nile. At present the Sudan forests are managed on a 20-30 year rotation producing termite resistant timber especially suitable for railway sleepers. In India and Pakistan riverine plantations are managed on a 15-20 year rotation for fuelwood and timber.

The dark brown wood is strong, durable, nearly twice as hard as teak, very shock resistant, and is used for construction, mine props, tool handles and carts. It is best carved in a green state. It has a high calorific value of 4950 kcal/kg, making excellent fuelwood and quality charcoal. It burns slow with little smoke when dry.

Fodder. The pods and leaves contain 8% digestible protein [12.4% crude protein], 7.2 MJ/kg energy, and are rich in minerals (Le Houerou 1980). In part of its range smallstock mainly consume it, but elsewhere it is also very popular with cattle. Pods are used as a supplement to poultry rations in India. Dried pods are particularly sought out by animals on rangelands. In India branches are commonly lopped for fodder. Pods are best fed dry as a supplement, not as a green fodder.

Agroforestry. Babul (ssp. *indica)* is a popular farm tree of the central plains of India. More recently interest has centred on the fastigiate form (ssp. *cupressiformis*). This subspecies makes an ideal windbreak surrounding fields; its narrow crown shades less than other windbreak species.

Acacia nilotica ssp. kraussiana *providing fodder and shade in the dry season at Chivu, Zimbabwe (photo RD Barnes)*

Written By Christopher Fagg, Department of Plant Sciences, University of Oxford, Oxford OXI 3 RB, UK

Land Rehabilitation. In India this species is used extensively on degraded saline/alkaline soils, growing on soils up to pH 9, with a soluble salt content below 3%. It also grows well when irrigated with tannery effluent, and colonises waste heaps from coal mines. Over 50,000 hectares of the Indian Chambal ravines have been rehabilitated with *A. nilotica* by aerial seeding (it is one of the 3 most frequently used trees for this purpose).

Tannins. The bark of ssp. *indica* has high levels of tannin (12-20%) which are used for tanning leathers. Ten year old trees yield 35-40 kg of bark. The pods of ssp. *nilotica* have been used for tanning in Egypt for 6,000 years. Subspecies *adstringens* is used for both tanning and dye making. Deseeded pods from ssp. *indica* have 18-27% tannin levels, whereas ssp. *tomentosa* and *nilotica* reach up to 50%.

Other Uses. The tannin also contributes to its medicinal use as a powerful astringent. It is also a powerful molluscicide and algicide. Fruits added to ponds in Sudan kill snail species which carry schistosomiasis without affecting the fish.

There are many other reported uses (Fagg & Greaves 1990). The tree makes effective live fencing, a good host plant for growing sandalwood, and an important source shellac in the Sind. The gum is used in paints and medicines and has been collected for a millennia. It has similar properties to gum arabic (from *A. senegal*) and is frequently used in calico printing in India.

SILVICULTURE. Propagation. It is a pioneer species, easily regenerated from seed. The nutritious indehiscent pods have evolved for animal dispersal. A mature tree can produce 2,000-3,000 pods in a good fruiting season, each with 8-16 seeds, yielding 5,000 - 16,000 seed/kg depending on the subspecies.

Hard coated seeds can be extracted by pounding the pods or collected from animal pens after the pods have been eaten (Sheikh 1989). Pretreatment is needed. Mechanical scarification works best for small seed lots. Acid scarification from 60 - 120 minutes (depending on seed provenance or age), or pouring boiling water over the seeds and allowing them to cool are also effective.

Seed from natural populations of some subspecies are available from India and some Sahelian countries. A broader range of germplasm and *Rhizobium* inoculum, is available from the Oxford Forestry Institute (Oxford OX1 3RB UK) for field trials.

Management The species can be direct seeded or established by seedlings. in the nursery long poly tubes (20 x 7 cm) should be used so as not to restrict rapid tap root growth. Frequent root pruning is advised. Nursery grown seedlings are usually outplanted after 6 months, but in some cases stay in the nursery up to a year.

Establishment varies depending on the site. Seedlings are shade intolerant. In irrigated plantations in the Sind and Punjab, 10-15 seeds are spot sown at 2x3 m spacing on the tops of trenches. They are thinned to 3-4 seedlings after 3-4 months. Further thinning occurs at 5 year intervals. Rotations are 20-25 years. In the Thal desert, Pakistan (250 mm of rain), promising growth resulted from irrigation on a 10 day interval. Growth rates varied considerably depending on the sites, with maximum mean annual increment of 13 m^3 /ha at 20 yrs old and 10.5 m^3 /ha at 30 years recorded.

LIMITATIONS. A wide range of pests and diseases affect this species. Of economic importance is the stem borer *Cerostema scabrator* on young plantations in India. *Euproctis lunata* & *E. subnotata* occasionally defoliate patches of forest in Sukkur and Hyderabad. Bruchid beetles attack the seeds, destroying up to 70 %. Buprestid beetles cause a dieback disease in Sudan. Fungal rots (*Fomes papianus* & *F. badius*) attack unhealthy trees, and powder post beetles (*Sibixylon anale* & *Lyctus africanus*) attack the sapwood of felled timber.

Acacia nilotica can become weedy when introduced out of its native range, particularly in more humid zones. Thorniness can be a problem when introduced to areas where people do not traditionally use thorn trees.

PRINCIPAL REFERENCES:

Brenan, J.P.M. 1983. Manual on the taxonomy of Acacia species: Present taxonomy of four species of Acacia (A. albida, A. senegal, A. nilotica, A. tortilis). FAO, Rome, Italy. 47 p.

Fagg, C.W. and A. Greaves.1990. Acacia nilotica 1869-1988. CABI/OFI Annotated bibliography No. F42. CAB International, Wallingford, Oxon, UK 77 p.

Le Houerou, H.N. 1980. Chemical composition and nutritional value of browse in tropical West Africa. In H.N. Le Houerou (ed), Browse in Africa, the Current State of Knowledge. ILCA, Ethiopia. p 261-289.

Nongonierma, A. 1976. Contribution a l'etude du genre Acacia Miller en Afrique occidentale. H. Caracteres des inflorescences, et des fleurs. Bulletin de l'IFAN Serie A. 38 (3) 487-657.

Tybirk, K 1989. Flowering, pollination, seed production of Acacia nilotica. Nordic Journal of Botany 9 (4) 375-381.

Sheik, M.I. 1989. Acacia nilotica (L.) Willd. ex Del. Its production, Management and Utilization. Pakistan. Regional wood energy development programme in Asia, GCP/RAS/111/NET Field document no. 20, FAO, Bankok 10200, Thailand. 45 p

NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 92-03
June 1992

Acacia saligna: For Dryland Fodder and Soil Stabilization

Acacia saligna is a small nitrogen fixing tree native to the southwest of Western Australia. It is commonly known as golden wreath, orange wattle, or blue-leafed wattle and was formerly known as *A. cyanophylla.* It is fast growing and tolerant of a wide range of soils, including calcareous and slightly saline types in temperate climates. *Acacia saligna* is planted in North Africa and the Middle East for fodder, fuelwood, sand stabilization, and as a wind break. In Australia it is most commonly used as an ornamental, but is being increasingly planted in agroforestry systems for fodder production and soil conservation.

BOTANY. *A. saligna* (Labill.) H. Wendl. is a dense and multi-stemmed, thornless, spreading shrub or singlestemmed small tree up to 9 m in height. The bark is smooth and grey to red-brown on branchlets. Young plants become dark grey and fissured with age. Dark green to blue-green phyllodes with conspicuous midribs are long and narrow to lanceolate and 8-25 cm long. Flower heads are globular and contain 25-55 (up to 78) bright yellow, five-parted flowers. The pods are narrow, 4-6 mm wide and usually 8-12 cm long. The seed is 5-6 mm long x 3-3.5 mm wide, dark brown to black and shiny (Maslin 1974); there are 14,000-25,000/kg. *Acacia saligna* is 2n=26 and outcrossing.

ECOLOGY. In its native range *Acacia saligna* is confined to southwest Western Australia. It has become naturalized in parts of eastern Australia, from Victoria to southeast Queensland. In its natural habitat, *A. saligna* occurs where the mean annual rainfall is 300 to 1,000 mm. In drier areas it normally receives additional run-on water.

Mean maximum temperature of the hottest month is 23 to 36°C and mean minimum of the coldest month is 4 to 9°C. Much of the area of natural distribution is frost-free but occasional light frosts occur in inland areas (Hall and Turnbull 1976). *A. saligna* is sensitive to frosts and damage is likely to be severe if the temperature falls below -4°C. The tree ranges from sea level to about 325 m elevation.

Trees are common on alkaline, infertile sandy soils. In many places *A. saligna* is more or less restricted to creeks and rivers and disturbed roadsides. It is moderately common along the south coast of Western Australia, but is best developed in the deep sands and loams along the water courses throughout the area. Further inland, in the wheatbelt, populations occur at the base of many of the large, granitic rock outcrops. On coastal dune systems it often forms dense thickets in the hollows between sand hills (Maslin 1974).

Marion Simmons

USES. Wood: *A. saligna* wood is used as fuel and charcoal, and for vine stakes and small agricultural implements (Michaelides 1979). It has been successfully processed into particle board in Tunisia (El-Lakany in Turnbull 1987).

Forage: The phyllodes, young shoots, pods and seeds, whether fresh or dry, are protein rich and non-toxic and palatable to both sheep and goats (Michaelides 1979). According to Woodward and Reed (1989), however, the phyllodes are not suitable for ruminants. This feed is especially valuable seasonally when other forage is scarce. The chemical composition shows the following ranges: dry matter (50-55%), crude protein (12-16%), crude fiber (20-24%), crude fat (6-9%), and ash (10-12%) (El-Lakany in Turnbull 1987). Analysis of phyllodes from trial plantings in southeast Queensland indicate a moderately low digestibility (36.5% predicted *in vivo)* but high levels of crude protein (18.3%) (Vercoe in Boland 1989). The low Ca/P ratio of 4.1 should enable efficient use of phosphorus supplements.

Windbreaks: The tree is used extensively for coastal sand dune fixation in North Africa, the Middle East, and

Written by Heather Crompton, ACIAR, G.P.O. Box 1571, Canberra, ACT 2601, Australia.

South Africa and for gully erosion control in Uruguay. In Australia it has been used in the rehabilitation of sand mining areas (Hall and Turnbull 1976).

Other Uses: Trees were planted in the past for tannin production from the bark (Hall and Turnbull 1976). The damaged bark exudes copious amounts of gum that is very acidic. Such acid-stable gum has promise for use for pickles and other acidic foodstuffs (Michaelides 1979). *A. saligna* is also widely planted as an ornamental.

ESTABLISHMENT. Prior to sowing, seed should be immersed in boiling water for 1 min to remove seedcoat dormancy. Seed coats can also be scratched or nicked with a file or nail clipper. Seeds are available from NFTA. Treated seed should be planted to a depth of 0.5 cm. Seedlings can be produced either by direct seeding or in a nursery. A nursery phase of 10-12 weeks is recommended. Soil should not be allowed to dry between sowing and germination. Young plants require protection from grazing animals.

GROWTH. In trials in southeast Queensland, *A. saligna* attained an average height of 6.2 in after only 41 months (Ryan and Bell in Boland 1989). The tree is tolerant of drought, light frost, alkalinity, and salt (Simmons 1981). Successful irrigation trials (6 liters/tree every 2nd day) have been undertaken at the Desert Development Center, The American University in Cairo. *A. saligna* coppices well and fodder biomass production is optimized by regular, annual harvesting (EI-Lakany in Turnbull 1987).

Acacia saligna *growing in its native southwest Western Australia.*

Trees grow poorly in tropical areas. In such areas the species A. *ampliceps,* a valuable alkaline soil fodder tree, may prove a more acceptable alternative.

SYMBIOSES. The tree nodulates with certain strains of *Rhizobium* (Roughley in Turnbull 1987). In common with many other acacias, it forms associations with VA mycorrhizal fungi (Reddell and Warren in Turnbull 1987).

PESTS AND DISEASES: Older plants are susceptible to gall rust, *Uromycladium tepperianum,* and various gall-exploiting insects. In parts of Western Australia more than 90 percent of *A. saligna* trees bear conspicuous woody galls (Van den Berg 1978). Trees are susceptible to white scale insects *(Coccidae)* which attack the leaves and stems. Rodents sometimes attack the roots. Termites may cause serious problems in tropical countries (Michaelides 1979).

WEEDINESS. Caution is advised using *A. saligna.* The tree has become a major weed in South Africa by invading and displacing the indigenous vegetation (Roux and Middlemiss 1963). The species was introduced to South Africa in the first half of the nineteenth century. It has spread to waterways and irrigation channels. The seed has also spread in river sand transported for road and dam construction. Its hardiness and ability to coppice rapidly after fires or from trunks has also led to widespread establishment (Stirton 1980).

PRINCIPAL REFERENCES:

Boland, DJ. (ed). 1989. Trees for the Tropics. ACIAR Monograph No. 10. ACIAR, Canberra, Australia.

Hall, N. and J.W. Turnbull. 1976. *Acacia saligna* (Labill.) H. Wendl. formerly known as *A. cyanophylla* Lindl. Australian Acacias No. 4. CSIRO Division of Forest Research, Canberra.

Maslin, B.R. 1974. Studies in the Genus Acacia, 3: The taxonomy of *A. saligna* (Labill.) H. Wendl. Nuytsia 1(4), 332-340.

Michaelides, E.D. 1979. Mini-monograph *on Acacia cyanophylla.* Technical Consultation on Fast-Growing Plantation Broadleaved Trees for Mediterranean and Temperate Zones. Lisbon, Portugal, 16-20 October 1979. FAO, Rome.

Roux, E.R. and E. Middlemiss. 1963. Studies in the autecology of Australian acacias in South Africa. The occurrence and distribution of *Acacia cyanophylla* and *A. cyclops* in the Cape Province. South Africa J. Science 59:286-294.

Simmons, M. 1981. Acacias of Australia. Thomas Nelson, Melbourne.

Stirton, C.H. (ed). 1980. Plant Invaders: Beautiful, but Dangerous. The Department of Nature and Environmental Conservation of the Provincial Administration, Cape Town, South Africa.

Turnbull, J.W. (ed). 1987. Australian Acacias in Developing Countries. ACIAR Proceedings No. 16. ACIAR, Canberra, Australia.

Van den Berg, MA. 1978. Natural enemies of certain acacias in Australia. Proc. 2nd Nat. Weeds Conf. S. Afr. 75-82.

Woodward, A. and J.D. Reed. 1989. The influence of polyphenolics on the nutritive value of browse: A summary of research conducted at ILCA. ILCA Bulletin 1989. No. 35, p 2-11

NFT Highlights

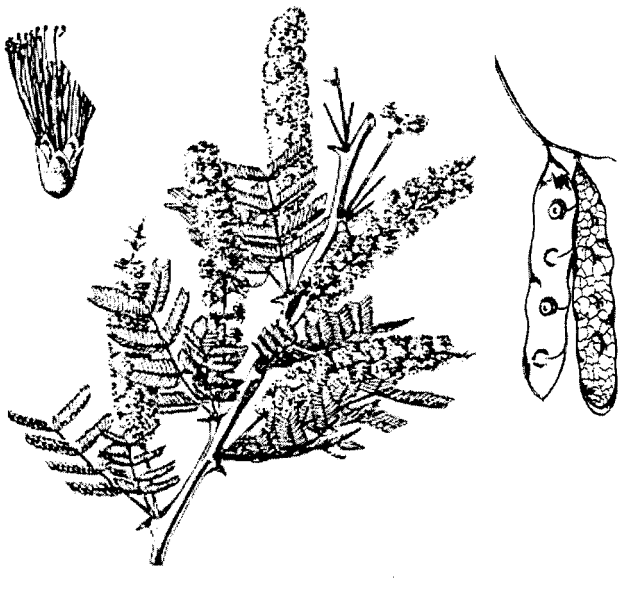
A Publication of the Nitrogen Fixing Tree Association

NFTA 91-02
April 1991

Acacia senegal: Gum Tree Promise for Agroforestry

Acacia senegal is a multipurpose African tree (subfamily Mimosoideae, family Leguminosae), highly valued for centuries for gum arabic production. Today, *A. senegal* is grown primarily for gum, but plays a secondary role in agricultural systems, restoring soil fertility and providing fuel and fodder.

BOTANY. A deciduous shrub or shrub tree, *Acacia senegal* (L.) Willd. grows to 2-6 m (occasionally to 15 m) tall with a flat to rounded crown. The tree has many branches and erect twigs spreading within the upright part. The bark is typically yellow/brown and smooth on younger trees, changing to dark grey, gnarled and cracked on older trees. The branchlets have thorns just below the nodes: either three thorns with the central one hooked downwards and laterals curved upwards, or a single thorn with laterals absent. Leaves are small, grey-green, alternate, and bipinnate. Pinnae occur in (2-)3-8(-12) pairs, and leaflets in 7-25 pairs. The rachis sometimes have prickles. The white or cream colored flowers occur on 2-12 cm long spikes. Pods are dehiscent (open by splitting at maturity), yellowish to brown, flat papery, and oblong (2-19 cm long by 1-3.4 cm wide). Seeds are nearly round to flat olive brown, and 8-12 mm in diameter. The tree flowers during the rainy season.



Acacia sengal flower, flowering branch, and mature pods.
(from Flora of West Tropical Africa)

Varietal differences in *Acacia senegal* are based on variation in natural distribution as well as differences in morphological characteristics such as: presence or absence of hair on the axis of the flower spike, color of the axis,shape of pod tips, number of pinnae pairs, occurrence of a distinct trunk, and shape of the crown. Four different varieties of *Acacia senegal* are recognized: var. *senegal,* var. *kerensis* Schweinf., var. *rostrata* Brenan, and var. *leiorhachis* Brenan.

DISTRIBUTION. *Acacia senegal* var. *senegal* is found in Mauritania, Senegal Gambia, Ghana, Burkina Faso, Cote d'Ivoire, Mali, Niger, Nigeria, Cameroon, Zaire, Central African Republic, Rwanda, Chad, Sudan, Ethiopia, Somalia, Uganda, Kenya, Tanzania, Mozambique, Oman, Pakistan, and India. It has been introduced into Egypt, Australia, Puerto Rico, and the Virgin Islands. Var. *kerensis* is found in Ethiopia, Somalia Uganda, Kenya, and Tanzania. Var. *rostrata* occurs in Somalia, Uganda, Kenya, Mozambique, south to Zimbabwe, Botswana, Angola, Namibia, and South Africa. Var. *leiorhachis* occurs in Ethiopia, Somalia, Kenya, Tanzania, southern Zambia, Zimbabwe, Mozambique, Botswana, and South Africa (Transvaal).

ECOLOGY. *Acacia senegal* is very drought resistant. It grows on sites with annual rainfall between 100-950 mm mainly between 300-400 mm, and 5-11 month dry periods. It tolerates high daily temperatures (mean maximum temperatures of up to 45°C or more), dry wind, and sandstorms. Generally it cannot withstand frost. *Acacia senegal* prefers coarse-textured soils such as fossil dunes, but it will also grow on slightly loamy sands and skeletal soils such as Lithosols. Although generally soils are well- drained, there are exceptions: in the Kayers region, South- Kordofan, East Sudan, *A. senegal* grows on heavy clay soils with approximately 800 mm annual precipitation. The best sites have pH of 5 to 8. The tree ranges from 100-1700 m elevation in the Sudan to 1950 m around Nakuru in Kenya.

USES. Gum: *Acacia senegal* and its close relatives are the defined source of commercial gum arabic for food purposes. *A. senegal* produces the only acacia gum evaluated toxicologically as a safe food additive (Anderson 1989). The gum from other *Acacia* species *(A. seyal* etc.*)* is available commercially as gum tahla (approx. 10% of all acacia gum marketed) for technological applications. Gum arabic has been used for at least 4,000 years by local people for preparation in food, in human and veterinary medicine, in crafts, and as a cosmetic. Today, gum arabic's applications are manifold. Formerly the international trade market largely

Compiled by Christian Cossalter, formerly Forestry Officer (Genetic Resources), Forest Resources Division, Forestry Department, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

absorbed all gum available, though recently international demand has declined together with gum prices.

Gum arabic is used in the food industry as a flavor fixative and emulsifier, to prevent crystallization of sugar in confections, as a stabilizer in frozen dairy products, for its viscosity and adhesive properties in bakery products, and as a foam stabilizer and clouding agent in beer. In pharmaceutics, it is used as a stabilizer for emulsions, binder and coating for tablets, and as an ingredient in cough drops and syrups. A soothing and softening agent, gum arabic is extensively employed in folk medicines. Among many other uses, it is used internally for coughs, diarrhea, dysentery, hemorrhage, and externally to cover inflammed areas. Gum arabic is used in cosmetics as an adhesive for facial masks and powders, and to give a smooth feel to lotions. Industrially, gum arabic is applied as an adhesive, as a protective colloid and safeguarding agent for inks, sensitizer for lithographic plates, coating for special papers, sizing agent for cloth to give body to certain fabrics, and coating to prevent metal corrosion. Gum arabic is also used in the manufacture of matches and ceramic pottery.

Wood: *Acacia senegal* wood is locally valued for fuelwood and charcoal although biomass yield per unit land area is not sufficient to plant *A. senegal* purely for fuelwood. Wood is used in local construction for poles and fenceposts, the light-colored wood for tool handles and dark heartwood for weaver's shuttles. Strong ropes are made from the bark fibers of the tree's long surface roots.

Food and fodder. Dried and preserved seeds of *A. senegal* are used by people as vegetables. The foliage and pods are browsed by sheep, goats, camels, impala, and giraffe. Leaves contain 10%-13% digestible protein and 0.12%-0.15% phosphorus, while the pods contain 15% digestible protein and 0.12%-0.14% phosphorus.

Dune stabilization: *Acacia senegal* is important for desertification control through sand dune stabilization and wind breaks.

Agroforestry: *Acacia senegal* is grown in agroforestry systems especially in the Sudan in "gum gardens' for gum as well as to restore soil fertility. Five-year-old trees are ready for tapping, and production peaks between 7 and 15 years. In Sudan, a traditional bush-fallow system is followed with a 20-year rotation during which time *Acacia senegal* is grown for 15 years. Agricultural crops are grown for five years (miuet, sesame, sorghum, groundnuts), followed by five years with young, unproductive *A. senegal* trees, which later produce gum during the last 10 years of the rotation. Corresponding to this rotation, 1/4 of the land is kept in agricultural crops, 1/4 in young unproductive trees, and 1/2 in productive trees. Controlled grazing is practiced after the trees have reached age four and under productive trees after the gum has been harvested. Wild trees are harvested during the dry season for gum exuded from cracks in the bark.

PROPAGATION. Seed should be harvested before pods have dried for easy collection and to avoid insect attack. Seed is easily extracted by hand. Freshly extracted seed should immediately be dusted with an insecticide. Seed will remain viable for 3-4 years if kept in opaque, airtight containers. There are 10,000-30,000 seeds/kg. Fresh seed requires no pretreatment if sown immediately after harvest. Seed collected in previous seasons, however, requires pretreatment to break seed dormancy. Soaking seed in water for 12-24 hours gives good results and is simple to apply. Seeds can also be nicked.

A. senegal is usually raised in the nursery in polyethylene pots, 2-4 seeds per pot, thinned to one seedling after 4-6 weeks. Direct seeding (5-8 seeds in 30 x 30 x 30 cm pits or larger) can also be used. Strict protection from fire and livestock grazing, and efficient control of weed competition during at least the first two years is important to seedling survival. Minimum spacing for block planting is 4 x 4 m. At 10 x 10 m spacing, agricultural intercropping is possible, for example, interplanting with millet, beans, or groundnuts.

PESTS AND DISEASES. The buffalo treehopper *(Stictocephala bubalus)* may destroy seed crops. Spiders *(Cyclops* sp.) can smother young growing apices. Larval stage of *Coleoptera* (bruchids), *Lepidoptera, and Hymenoptera* damage the seed. Locusts (Acridium *melanorhodon)* can defoliate vast areas overnight. *Acacia senegal* is also attacked by the fungi *Cladosporium herbarium, Fusarium sp., Ravenelia acaciae-senegalae and R. acaciocola.*

PRINCIPAL REFERENCES:

Anderson, DM.W. 1989. NFT gums: Ancient and modern commercial products. NFTA Highlight 89-01.

Booth, F.EM. and G.E. Wickens. 1988. Non-timber ues of selected and zone trees and shrubs in Africa. FAO Conservation Guide 19. Rome, FAO.

Brenan, J.P.M. 1983. Manual on Taxonomy of, *Acacia* Species. Rome, FAO Forestry Division.

Depierre, D. 1969. Les experiences de gommeraie cultivée á leurs enseignements au Tchad. Bois et Forets des Tropiques 125:27-34.

Doran, J.C., J.W. Turnbull, D.J. Boland and B.V. Gunn. 1983. Handbook on Seeds of Dry-Zone Acacias. FAO, Forestry Division, Rome.

Duke, JA. 1981. Handbook of Legumes of World Economic Importance. Plenum Press, New York.

FAO and UNEP. 1983. Notes on trees and shrubs in and and semi-arid regions. EMASAR Phase 11. FAO, Rome, Italy.

Giffard, P.L. 1966. Les gommiers *Acacia senegal* Willd. *Acacia laeta* R. Er. Bois et Forets des Tropiques 105.22,-32.

Giffard, P.L. 1975. Les gommiers, essences de reboisement pour les regions saheliennes. Bois et Forets des Tropiques 161:3- 20.

Little, E.L. 1983. Common Fuelwood Crops. Communi-Tech Assoc., Morgantown, West Virginia.

Maydell, H.J. von. 1983. Arbres et arbustes du Sahel. Leurs caracteristiques et leurs utilizations. Eschbom, GTZ.

Southgate, BJ. 1983. Handbook on Seed Insects of *Acacia* Species. FAO, Forestry Division, Rome.

Vassal, J. 1983. Dommiers et production gommiere. In Acquisitions Recentes dans les Domaines des Hydrocolloides Vegetaux Naturels. Pub. I.I.E.R.C.N. Presses Univ. Aix Marseille, France. p. 5-17.

NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 94-07
September 1994

Acacia seyal: Multipurpose Tree Of The Sahara Desert

One of few strongly gregarious sahelian tree species, *Acacia seyal* combines tolerance of periodically inundated heavy clays with major roles in fuel and fodder production in countries at the southern edge of die Sahara desert, especially Mali, Chad and Sudan. A gum (gum talha) is collected from the tree and a proportion enters international trade. The epithet *seyal* derives from an Arabic word for "torrent" used for the species in Egypt and denotes association with water courses.

Botany

Acacia seyal Delile (family Leguminosae, subfamily Mimosoideae) is one of over 60 African acacias referred to the Uniseriae group of subgenus *Acacia*. The species usually reaches 9-10 m in height at maturity and in well-formed individuals a flat-topped crown develops. There are two varieties, differing primarily in whether or not pseudo-galls ("ant galls") develop and in bark color. In var. *seyal* there are no pseudo-galls and a reddish bark color prevails, although periodic bark exfoliation exposes a pale powdery surface which darkens slowly. In var. *fistula* pseudo-galls are present and the powdery bark typically remains whitish or greenish-yellow. Both varieties have paired, straight, strong, pale-colored, stipular spines up to 8 cm long which in var. *fistula* are often fused at the base into the inflated pseudo-gall. The leaves are bipinnate - usually with 4-8 pairs of pinnae, each of which bears 10-20 pairs of close-set, obscurely veined leaflets. Individual leaflets are 1-15. mm wide and about 5-8 mm long. Small bundles of up to 5 pedunculate capitate inflorescences arise in axillary positions on the young parts of shoots. Each inflorescence is vivid yellow in color, about 15 mm in diameter, and is borne on a peduncle 3-4 mm long. The dehiscent pods are flat and somewhat curved, brown and up to about 20 cm long and 5-10 mm wide when ripe, with slight constrictions between the seeds. In a well-developed pod 6-10 seeds are present, each 6-9 mm long, 4-5 mm wide and about 2 mm thick - in 1 kg there are 20,000-25,000 seeds. The chromosome number of 2n = 52 suggests tetraploidy.

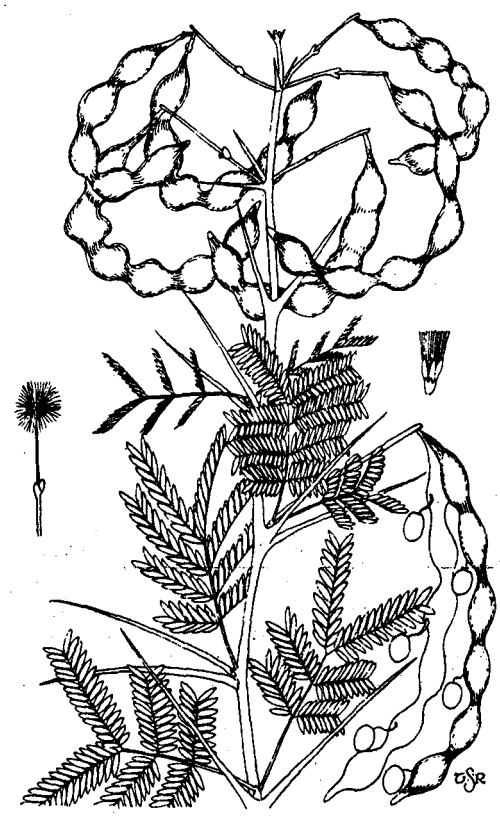
Distribution

The range of *A. seyal* extends from Senegal eastwards to western Somalia and the coastal lowlands east of the Red Sea, and from the Nile valley of southern Egypt to southern Zambia. The two varieties differ markedly in their ranges - var. *seyal* extends westwards from central Sudan and north of latitude 18°N and var. *fistula* extends south of latitude 10°S. The ranges overlap mainly in the upper Nile catchment, the Lake Victoria basin and the Ethiopian and East African rift valleys. Occurrence beyond the natural range is limited to arboreta (e.g. Iraq, Portugal) and experimental studies (e.g. India).

Ecology

Given suitable climatic and edaphic conditions closed, and essentially pure, stands of *A. seyal* develop but admit sufficient light for grass to grow in the understory.

Through the greater part of the range of *A. seyal* mean annual rainfall is 500-1200 mm and there is a well-defined 6-8 month dry season with mean annual rainfall less than 50 mm. Occurrences in more and climates are associated with the presence of water in addition to direct rainfall The phenological cycle relates closely to the rainfall regime. Where there is a well defined unimodal rainfall pattern, leaf fall takes place by the middle of the dry period and trees remain leafless for 4-7 months, depending on when the subsequent wet season begins. Leafless periods are briefer in bimodal equatorial rainfall regimes. Flowering is concentrated in the middle of the dry season and ripe fruits are present about 4 months later.Temperature regimes vary through the range, particularly for var. *seyal* which is subject to mean annual temperatures of 18-25°C.



Acacia seyal var. *seyal* from F.E.M. Booth and G.E. Wickens. 1988. *Non-timber uses of selected arid zone trees and shrubs in Africa*. FAO.

The issue was written by John B. Hall, School of Agriculture and Forest Sciencies, University of Wales, Bangor, Gwynedd LL57 2UV, UK

Var. *fistula* occurs mostly where mean annual temperatures are 20-25°C, but also in cooler climates in Ethiopia, at the upper elevation limit (1700-2000 m). Relationships with extreme temperatures follow a similar pattern - in parts of West Africa where var. *seyal* is presentabsolute temperature maxima are 50-55°C. Absolute minima through the range of the species are generally 5-10°C but below 5°C at the northern limit and at altitudes >1 800 m. The distribution pattern overall is indicative of a frost-sensitive species.

Relationships with soil are well-defined. There is an unusual degree of adaptation for deep, heavy soils (pH 6-8) accumulated at low points in a landscape or formed directly from fine-grained rocks, such as shales, and readily weathered volcanic materials. In communities containing both varieties, var. *fistula* displays greater tolerance of waterlogging and occupies lower positions in depressions and along drainage lines. Saline soils are not suitable.

Uses

Fuel. Var. *seyal,* especially, is an important source of rural energy as both fuelwood and charcoal. Stands managed on a 10-15 year rotation yield 10-35 m^3 ha^{-1} of fuelwood.

Fodder. Both varieties of A. *seyal* are viewed favorable as forage. Dry matter net energy contents are high: 6-8 MJ kg^{-1} (foliage) and 4-7 MJ kg^{-1} (fruits). The associated digestible protein levels are also high: 100-150 g kg^{-1} in the foliage, and higher in the fruits. For both foliage and fruits, analyses indicate a well balanced supply of minerals and very favorable qualities in terms of proximate fractions (e.g. crude fiber 10-20%; ether extract <7%). The foliage of var. *seyal* has been shown to contain secondary metabolites but experience suggests that levels are not a matter of serious concern.

Gum talha. Gum talha has not been toxicologically evaluated and is not listed as an approved food additive. It contrasts with gum arabic in several significant respects, being strongly dextrorotatory, of high molecular weight and low in nitrogen (0.06-0.24%) and rhamnose (<4% sugar composition). Ash contents of cobalt, copper, iron, nickel and, especially, aluminum (>6000 ppm) are high and tannin is present (2%). restricting acceptable use to such applications as a binder for foundry molding and a sizing agent in the textile industry.

Management of natural stands Both varieties of A. *seyal* are noteworthy for occurrence in the undisturbed state in seral, even-aged stands. Reconstitution of an exploited var. *seyal* stand depends not on coppice shoots but on the presence of abundant seed and its exposure to a mild fire which enhances the germination of var. *seyal* but checks the regeneration of competing species. Stands 15 years old when harvested are likely to have produced a seed reserve sufficient to regenerate the stand. However, individual trees or uncut patches of the original cover should be left as seed sources to insure abundant regeneration. Where management for fodder production is concerned, evaluation of responses to lopping and cutting of var. *seyal* indicate limited recovery capacity in mature trees. Beating branches to detach leaves and fruits without damage to axillary buds is therefore preferred to exploit these as dry season resources.

Propagation

Unopened, full-sized fruits are gathered off the trees and allowed to release seed. After cleaning, seed stores well in cool, dry conditions, remaining viable for up to 8 years.

Pretreatment in the nursery is advantageous, although not essential, to accelerate the germination rate. Scarification and acid treatments have proved favorable. However, germination rates have rarely exceeded 30% in 7 days. Seeds can be pregerminated in contact with moist cotton wool or filter paper to allow rapid identification of viable non-dormant seed. Transfer to containers filled with a silt-rich medium. Seedlings require shade until the second leaf expands and watering at intervals of 1-3 days as necessary to keep the medium moist but not waterlogged.

Formal stands

Stands of var. *seyal* have been established in Sudan, often by direct sowing of pretreated seeds to prepared planting spots. Sowing seed in batches ensures a high proportion of spots become occupied. Competition from weed growth is overcome by using taungya, with mechanized site preparation and sowing. *Sesamum* or *Sorghum* is intercropped among widely spaced (*ca* 4 m) rows of trees. For poles and fuelwood a 20 year rotation is projected. Initial stocking is 1000 stems ha^{-1}. Thinnings after 10 and 14 years reduce stocking to 675 and 450 stems ha^{-1}respectively.

Nodulation

Nodulation occurs in natural populations. In artificial regeneration it has been achieved by pelleting seed with culture of bacterial isolates, sowing into an infected medium or germinating in unsterilized soil. Uninfected seedlings have been inoculated successfully by treatment with a suspension of a symbiont. *Rhizobium* strains from *A. mellifera* and *A. senegal* and *Bradyrhizobium* from the latter have proved to be effective symbionts.

Pests

Over 40 species of insects are reported associated with *A. seyal.* These include 10 species of bruchid beetles which may damage high proportions of stored seeds. Beetles of various other families attack the wood, the bostrychid *Sinoxylon senegalense* being the most notorious and swiftly locating and infesting freshly cut wood, especially if lying on the ground. Attacks are much reduced if die bark is removed and die cut stems stacked upright. Subsequent creosote treatment ensures extended durability.

Selected references

Adams, M.E. 1967. A study of the ecology of *Acacia mellifera, A. seyal* and *Balanites aegyptiaca* in relation to land clearing. Journal of Applied Ecology, 4: 221-237.

Booth, F.E.M. & Wickens, G.E. 1988. Non-timber uses of selected afid zone trees and shrubs in Africa. FAO Conservation Guide, 19: 8-12.

Hall, J.B. & McAllan, A. 1993. *Acacia seyal:* a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor.

Le Houérou, H.N. 1980. Browse in Africa: the current state of knowledge. International Livestock Centre for Africa, Addis Ababa. 491 pp.

Tybirk, K. 1991. Regeneration of woody legumes in the sahel. Aarhus University Botanical Institute. AAU Report, 27: 1-81.

For a complete set of references contact the author or NFT

NFT Highlights

A quick guide to multipurpose trees from around the world

NFTA 91-01
April 1991

Acacia tortilis : Fodder Tree for Desert Sands

Acacia tortilis, often called the "umbrella thorn" for its distinctive spreading crown, is one of the most widespread trees in seasonally dry areas of Africa and the Middle East. The umbrella thorn is the dominant tree in many savanna communities and provides an important source of browse for both wild and domesticated animals.

BOTANY. *Acacia tortilis* (Forsk.) Hayne (subfamily Mimosoideae, family Leguminosae) is one of about 135 African acacia species. Unlike the Australian acacias, African acacias are armed with thorns and produce highly palatable pods. *A. tortilis* is a variable species, with six infraspecific taxa including four recognized subspecies: *tortilis*, *spirocarpa*, *heteracantha*, and *raddiana* (Brenan 1983). Although some French and Israeli authors consider ssp. *raddiana* a separate species (*A. raddiana*), recent revisions treat it as a subspecies (Brenan 1983, Ross 1979). As with other African acacias, *A. tortilis* is a polyploid complex: most are tetraploids (2n=4x=52); ssp. *raddiana* is an octoploid (2n = 8x = 104).

Acacia tortilis varies from multi-stemmed shrubs (ssp. *tortilis*), to trees up to 20 in tall with rounded (ssp. *raddiana*) or flat-topped (ssp. *heteracantha* and *spirocarpa*) crowns. The presence of very long thorns and two thorn types, long-straight and shorter-hooked, distinguish *Acacia tortilis* from other acacia species in Africa. The alternate leaflets (usually <1 mm wide) are smaller than those of most bipinnate acacias. White or pale-yellow fragrant flowers cluster in 1 cm diameter round heads. Flowering is prolific with up to 400 flowers/meter twig. Flowers later develop into bunches of spirally twisted, indehiscent pods. Straight pods also occur, though rarely (Somalia and Kenya). Pods vary considerably in size depending on provenance but range from 8 to 12 cm long.

ECOLOGY. *Acacia tortilis* occurs throughout dry Africa, ranging from Senegal to Somalia and down into South Africa. In Asia, trees occur in Israel, southern Arabia, and Iran. *A. tortilis* is found in all countries hinging the Sahara and is often the tree that extends furthest into the desert. Young *A. tortilis* forms natural thickets in heavily over-grazed savanna in southern Africa. The tree was introduced from Israel in 1958 into the district of Rajasthan, India, where it showed the greatest promise of 277 tested species. It is now widely planted in Rajasthan and has also been planted in Pakistan and on the Cape Verde Islands.

Acacia tortilis occurs from sand dunes and rocky scarps to alluvial valley bottoms, avoiding seasonally waterlogged sites. A very drought resistant species, the umbrella thorn grows in areas with annual rainfall as low as 40 mm and as much as 1200 mm, with dry seasons of 1-12 months. The tree favors alkaline soils but will colonize saline and gypseous soils. *A. tortilis* forms a deep tap root in sandy soils; the solitary landmark Tenere tree in the southern Sahara had roots reaching 35 m deep. On shallower soils and in arid sites, it can develop hose-pipe subsurface roots extending over twice the width of the crown. The umbrella thorn ranges from 390 to > 2000 m elevation. It survives sites where temperatures regularly reach 50°C at mid-day and fall to near freezing at night. Older trees (>3 m tall) can withstand frosts and light grass fires.

NODULATION. *A. tortilis* nodulates frequently over its natural range. Considerable variation in nodulation levels has been found under controlled environmental conditions. Fast-growing *Rhizobium* strains have been isolated at Dundee University.

In the Cherangani Hills in Kenya, Acacia tortilis ssp. spirocarpa var spirocarpa occurs up to 2000 m elevation.

USES. Forage: In semi-arid areas, *Acacia tortilis* provides a staple browse especially for camels and goats. Forage is available throughout most of the dry season when other sources are scarce. In the Turkana region of Kenya, large riverine trees (called *ekwar*) are individually owned. Pods are collected for sale in markets, such as in Lodwar (Turkana) and Msinga (South Africa), both as animal and human food. Pods are also fed to lactating animals to increase milk yields. Pods and leaves have a good level of digestible protein (mean = 12%) and energy 6.1 MJ/kg DM (Le Houerou 1980), as well as being rich in minerals. Seeds are high in crude protein (38%) and phosphorus, an element usually

Written by Christopher Fagg, Department of Plant Sciences, University of Oxford, South Parks Road, Oxford OX1 3RB.

scarce in grasslands. The pods require milling to increase digestion in cattle. Over 90% of the tree's flowers abort and drop from the trees, providing an additional important forage (Kayongo Male and Field 1983).

Few studies have quantified *A. tortilis* fodder production, but an estimated 1 dry ton/ha/yr shoot and leaf growth was available in semi-deciduous bushland in the Tugela Dry Valley, South Africa (Milton 1983). Yields from young plantations in India indicate similar productivity: 2.5 kg/tree/yr (at 400 trees/ha), discounting pod (1 kg/tree/yr by age 7) and fuelwood production (Gupta and Mohan 1982).

Silvipasture: *A. tortilis* provides shade for animals. Some of the most palatable grass species grow beneath its canopy (Walker 1979). In Turkana, Kenya, soil nutrients and herbaceous plant productivity and diversity were significantly greater under than away from the tree canopy (Weltzin and Coughenour 1990).

Sand dune stabilization and shelterbelts: *A. tortilis* has been used with some success to stabilize sand dunes in Somalia, United Arab Emirates, and Rajasthan, India. In India it has been grown successfully in shelterbelts with *Azadirachta indica.*

Wood: The dense, red wood of *A. tortilis* makes very good charcoal and fuelwood (4360 Cal/kg) (BOSTID). It burns slowly and produces little smoke when dry. Poles are commonly used in hut construction and for tools. The wood of ssp. *heteracantha* is durable if water-seasoned. The tree resprouts vigorously when coppiced and is managed for fuelwood in natural woodlands in Sudan. In plantations in India, trees are planted at 3 x 3 m spacing and coppiced for fuelwood. After 10-12 years over 50 tons/ha wood can be harvested. In other areas the trees are not cut, to avoid reducing pod yields.

Other uses: In traditional, pastoral societies every part of *Acacia tortilis* is used. The high value held by local people for the tree is reflected in the detailed nomenclature given to its cycles of development. In Oman, for example, local people call *A. tortilis* by more than a dozen different names in Dhofari Arabic.

Flowers provide a major source of good quality honey in some regions. Fruits are eaten in Kenya, the Turkana make porridge from pods after extracting the seed, and the Masai eat the immature seeds. The bark yields tannin and the inner bark cordage. Thorny branches are used for enclosures and livestock pens; roots are used for construction of nomad huts (Somali and Fulani). Leaves, bark, seeds, and a red gum are used in many local medicines. Two pharmacologically active compounds for treating asthma have been isolated from the bark (Hagos et al. 1987).

PROPAGATION. *A. tortilis* is a pioneer species easily regenerated from seed. Pods are best collected by shaking them from the canopy. In East Africa, a mature tree can produce over 6000 pods in a good year, each with 8-16 seeds (10,000 - 50,000/kg depending on the subspecies).

Seeds are often extracted by pounding pods in a mortar followed by winnowing and cleaning. The hard-coated seeds remain viable for several years under cool, dry conditions. They require pretreatment for good germination. Mechanical scarification works best for small seed lots. Soaking seeds either in sulfuric acid for 20-30 minutes, or in poured, boiled water allowed to cool, are both effective treatments (Fagg and Greaves 1990).

Seed are planted in the ground in 1 cm deep holes or in the nursery in 30 cm long tubes. Rapid tap root growth requires frequent root pruning. Seedlings are ready to be planted out after 3-8 months. On marginal sites, initial seedling growth is often slow but quickens once roots have reached a water source. For best growth, plants should be weeded and protected from browsing animals for the first three years. At Jodhpur, India (320 mm annual rainfall) average height of 20 selected 2.5-yr-old plants was 3.8 m.

Limited seed supplies are available from natural populations in a number of countries, primarily in Sahelian Africa, and from landraces in India. A broader range of germplasm. is available from the Oxford Forestry Institute (South Parks Road, Oxford OX1 3RB, UK) for establishment of field trials. Small quantities of seed from Kenyan provenances are also available from NFTA.

PESTS AND LIMITATIONS. A large number of insects have been recorded to attack living trees, but only bruchid beetles are of economic importance. They can destroy over 90% of seeds produced in any year. The buprestid beetle (*Julodisy* sp.) defoliated over 50% of a plantation in Rajasthan. *Acacia tortilis* is also susceptible to nematodes, mistletoes (*Loranthaceae*), and galls. Large numbers of insects and mammal feed on the flowers. In India, powder post beetles *(Sinoxylon spp.)* can reduce the wood of felled timber to dust over a period of weeks. A further consideration is in humid to subhumid areas where *A. tortilis* can become weedy if it is not being used (BOSTID 1979).

PRINCIPAL REFERENCES:

Brenan, J.P.M. 1983. Manual on taxonomy of *Acacia* species: Present taxonomy of four species of *Acacia (A. albida, A. senegal, A. nilotica, A. tortilis).* FAO, Rome, Italy. 47 p.

Fagg, CW. and A. Greaves. 1990. *Acacia tortilis* 1922-1988. CABI/OFI annotated bibliography. No. F41. CAB International, Wallingford, Oxon, UK.

Gupta, T. and D. Mohan. 1982. Economics of trees versus annual crops on marginal lands. Centre for Management in Agriculture (CMA), Monogr. No. 81. 139 p.

Hagos, M., G. Samuelsson, L. Kenne and B.M. Modawi. 1987. Isolation of smooth muscle relaxing 1,3-diaryl-propan-2-ol derivatives from *Acacia tortilis.* Planta Médica 53(1):27-31.

Kayongo Male, H. and C.R. Field. 1983. Feed quality and utilization by cattle grazing natural pasture in the range areas of northern Kenya. *In* W. Lusingi (ed), IPAL Report A5. p. 230-245.

Le Houerou, H.N. 1980. Chemical composition and nutritional value of browse in tropical West Africa. *In* H.N. Le Houerou (ed), Browse in Africa, the Current State of Knowledge. ILCA, Ethiopia. p. 261-289.

Milton, SI. 1983. *Acacia tortilis* ssp. *heteracantha* productivity in the Tugela dry valley bushveld: Preliminary results. Bothalia 14(3-4):767-772.

Ross, J.H. 1979. A conspectus of the African *Acacia* species. Memoirs of the Botanical Survey of S. Africa No. 44. 155 p. Walker, B.H. 1979. Game ranching in Africa. *In* B.H. Walker (ed), Management of Semi-Arid Ecosystems. Elsevier, Amsterdam. p. 55-81.

Weltzin, J.F. and M.B. Coughenour. 1990. Savanna tree influence on understory vegetation and soil nutrients in northwestern Kenya. J. Veg. Sci. 1:325-334.

NFT Highlights

A quick guide to multipurpose trees from around the world

NFTA 96-01
January 1996

Adenanthera pavonina : An Underutilized Tree Of The Humid Tropics

Adenanthera pavonina (L.) (family Leguminosae, subfamily Mimosoideae) has long been an important tree in Southeast Asia and the Pacific Islands. Cultivated in home gardens and often protected in forest clearings and village common areas, this useful tree provides quality fuelwood, wood for furniture, food, and shade for economic crops like coffee and spices. The tree has been planted extensively throughout the tropics as an ornamental and has become naturalized in many countries. The scientific name is derived from a combination of the Greek *aden*, "a gland," and *anthera*, "anther"; alluding to the anthers being tipped with a deciduous gland. The tree is known by a host of common names, including red-bead tree, red sandalwood, and Circassian-bean in English; raktakambal (India); saga (Malaysia); lopa (Samoa and Tonga); coralitos, peronias, and jumble-bead (Caribbean).

Botany

A medium- to large-sized deciduous tree, *A. pavonina* ranges in height from 6-15 m with diameters up to 45 cm, depending upon location. The tree is generally erect, having dark brown to grayish bark, and a spreading crown. Multiple stems are common, as are slightly buttressed trunks in older trees. The leaves are bipinnate with 2-6 opposite pairs of pinnae, each having 8-21 leaflets on short stalks. The alternate leaflets, 2.0-2.5 cm wide and 3 cm long, are oval-oblong with an asymmetric base and a blunt apex, being a dull green color on top and a blue-green beneath. The leaves yellow with age. Flowers are borne in narrow spike-like racemes, 12-15 cm long, at branch ends. They are small, creamy-yellow in color, and fragrant. Each flower is star-shaped with five petals, connate at the base, and having 10 prominent stamens bearing anthers tipped with minute glands. The curved pods are long and narrow, 15-22 cm by 2 cm, with slight constrictions between seeds, and dark brown in color turning black upon ripening. The leathery pods curve and twist upon dehiscence to reveal the 8-12 showy seeds characteristic of this species. The hard-coated seeds, 7.5-9.0 mm in diameter, are lens-shaped, vivid scarlet in color, and adhere to the pods. The ripened pods remain on the tree for long periods and may persist until the following spring. There are reportedly 1600 seeds per pound (Little and Wadsworth 1964).

Ecology

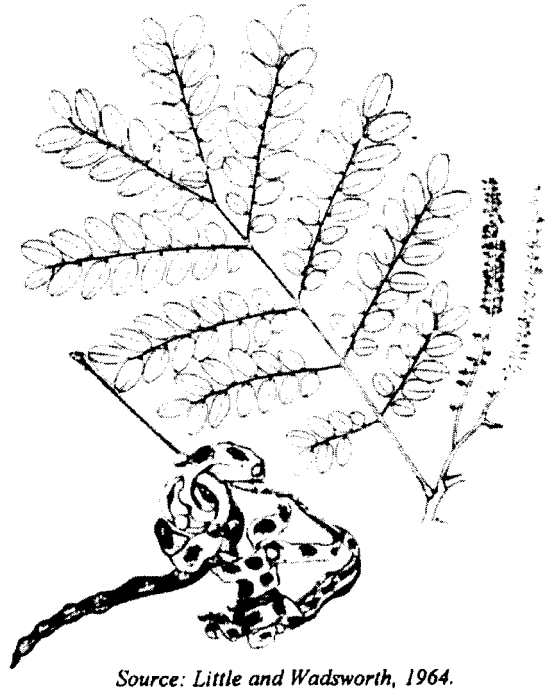
This species is common throughout the lowland tropics up to 300-400 m. *Adenanthera pavonina* is a secondary forest tree favoring precipitation ranging between 3000-5000 mm for optimal growth. Found on a variety of soils from deep, well-drained to shallow and rocky, this tree prefers neutral to slightly acidic soils. Initial seedling growth is slow, but rapid height and diameter increment occur from the second year onward. The tree is susceptible to breakage in high winds, with the majority of damage occurring in the crown. Rapid resprouting and growth following storm damage has been recorded in the Samoan Islands (Adkins 1994).

Distribution

Adenanthera pavonina is endemic to Southeast China and India, with first reports being recorded in India. The tree has been introduced throughout the humid tropics. It has become naturalized in Malaysia, Western and Eastern Africa and most island nations of both the Pacific and the Caribbean.

Uses

There are historical accounts from Southeast Asia and Africa of using all parts of tree for traditional medicines (Burkill 1966, Watt and Breyer-Brandwijk 1962). *Adenanthera pavonina* is extensively cultivated as an ornamental for planting along roadsides and in common areas. The fast growth and spreading crown of light, feathery foliage offer attractive shade. Interplanted among field and tree crops (spices, coffee, coconuts), along field borders as part of a windbreak or in plantation, *A. pavonina* is a valuable agroforestry species (Adkins 1994, Clark and Thaman 1993).



Source: Little and Wadsworth, 1964.

Written by Richard Van-C. Adkins, Forestry Consultant, PO Box 1433, Safford, Arizona 85548-1433 USA

Wood Products. *Adenanthera pavonina* is esteemed for fuelwood in the Pacific Islands, often being sold in local markets. The wood burns readily producing significant heat, and is used in both above- and below-ground ovens. Good sized fuelwood, larger than 11 cm in diameter, can be produced in five years. The wood is hard and durable having red-colored heartwood with light-grey sapwood. It is close- and even-grained, making it useful for constructing furniture, cabinets, and decorative wood products (Benthall 1946, Clark and Thaman 1993). It is also valued for home building.

Seeds. Known as "food trees" in Melanesia and Polynesia, the seeds of this tree are roasted over a fire and eaten by children and adults alike. Nutritional studies have shown one quarter of the seed weight to be oil with a high percentage of protein, and a fatty acid composition favoring high digestibility for both humans and livestock (Balogun and Fetuga 1985, Burkill 1966). Historically, the seeds were used as weight measures for jewelry and goldsmithing due to their small variation in weight (Benthall 1946, Burkill 1966). The bright red seeds are still used today in fashioning necklaces and decorative ornaments.

Foliage. The small leaves breakdown easily making for good use as a green manure. As a supplemental source of fodder, the leaves are fairly high in digestible crude protein (17-22%), but low in mineral content (Rajaguru 1990).

Silviculture

The tree is cultivated from seed. The seed coat is extremely hard and requires scarification if even germination is to occur. Untreated seeds can be stored up to 18 months without losing viability (Basu and Chakraverty 1986). Manual scarification, immersing the seeds in boiling water for one minute, or treatment with sulfuric acid has shown to significantly increase germination percentage. Following treatment, seed can be directly sown in the field or in a nursery. Germination occurs within 7-10 days with young seedlings obtaining a height of 8-15 cm in approximately three months. Seedling maturity occurs two to three months later at 20-30 cm in height. Nursery stock transplants well.

Growth is initially slow, but increase rapidly after the first year. Following the first year of establishment, average annual growth rates of 2.3-2.6 cm in diameter and 2.0-2.3 m height have been recorded in American Samoa (Adkins 1994). Trees planted 1 x 2 m apart for windbreaks, and at a spacing of 2 x 2 m in plantations can be thinned in three to five years to provide fuelwood and construction materials. As a shade tree, spacing varies from 5-10 m depending on the companion crop and site. The trees resprout easily allowing for coppice management with good survival.

Despite an inability to suppress weeds, the seedlings are rather hardy and can survive with minimal maintenance. *Adenanthera pavonina* is compatible with most tropical field and tree crops, allowing for their usage in integrated production systems.

Symbioses

Although Allen and Allen (1981) indicate the inability of *A. pavonina* to nodulate, this legume is generally considered to be nitrogen-fixing. Sparse, fast growing, brown nodules with isolates confirmed to be *Rhizobium* have been observed by Lim and Ng (1977). The author observed root nodules, both in old nursery stock and in the field, during research conducted in American Samoa. Norani (1983) confirmed the presence of VA mycorrhiza on the roots of nursery stock.

Limitations

Despite its susceptibility to crown damage in high winds, the ability to recover is remarkable. No insect or disease problems have been reported.

Research

Additional investigation concerning the nitrogen-fixing ability on native and naturalized populations is required. Continued research on fuelwood production and fodder usage is necessary.

References

Adkins, R. v-C. 1994. The role of agroforestry in the sustainability of South Pacific Islands: Species Trials in American Samoa. MS. Thesis, Utah State University. Logan, Utah. 133 p.

Allen, O.N. and E.K. Allen. 1981. The Leguminosae: a source book of characteristics, uses, and nodulation. University of Wisconsin Press. Madison, Wisconsin. 812 p.

Balogun, A.M. and B.L. Fetuga. 1985. Fatty acid composition of seed oils of some members of the Leguminosae Family. Food Chemistry, 17(3): 175-82.

Basu, D. and R.K. Chakraverty. 1986. Dormancy, viability and germination of *Adenanthera pavonina* seeds. Acta Botanica Indica, 14 (1): 68-72.

Benthall, A.P. 1946. Trees of Calcutta and its neighborhood. Thacker Spink and Co. Calcutta. 513 p.

Burkill, I.H. 1966. A dictionary of the economic products of the Malay peninsula, 2 ed., Volume 1, A-H. Government of Malaysia and Singapore. Kuala Lumpur, Malaysia. 1240 p.

Clark, W.C. and R.R.Thaman. (eds). 1993. Agroforestry in the Pacific Islands: Systems for sustainability. United Nations University Press. Tokyo, Japan. 279 p.

Lim, G. and H.L. Ng. 1977. Root nodules of some tropical legumes in Singapore. Plant and Soil, 46: 317-27.

Little, E.L. Jr. and F.H. Wadsworth. 1964. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249. USDA Forest Service. Washington, D.C. 144-46 p.

Norani, A. 1983. A preliminary survey on nodulation and VA mycorrhiza in legume roots. Malaysian Forester, 46: 171-74.

Rajaguru, A.S.B. 1990. Availability and use of shrubs and tree fodders in Sri Lanka. In: Devendra, C. (ed). Shrubs and tree fodders for farm animals. International Development Research Centre. Ottawa, Ontario, Canada. pp: 237-43.

Watt, J.M. and M.G. Breyer-Brandwijk. 1962. The medicinal and poisonous plants of southern and eastern Africa, 2 ed. E & S Livingstone, Ltd. London, England. 1457 p.

NFT Highlights

NFTA 88-03
July 1988

A publication of the Nitrogen Fixing Tree Association

Albizia lebbeck : A Promising Fodder Tree For Semi-Arid Regions

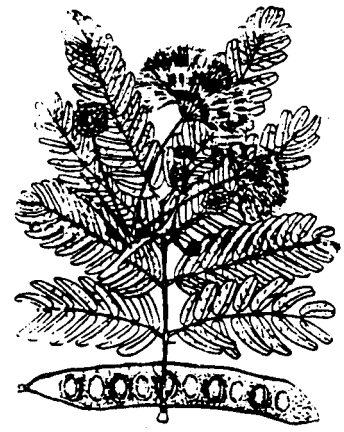
Providing high quality fodder during dry seasons is one of the most serious problems faced by many small-scale farmers in developing countries. *Albizia lebbeck is* particularly promising as a fodder tree for semi-arid regions in the tropics and subtropics, and it has many other uses as well.

BOTANY: A. *lebbeck* (L.) Benth. is a moderate to large deciduous tree that reaches 30 m in height in rain forests. The tree develops a straight bole when grown in dense forests, but is spreading and low branching in the open. Unless coppiced frequently, trees will annually produce an abundance of seed from papery pods about 20 cm long and 3 cm wide (author). Common names such as "woman's tongue" and "rattle pod" derive from the noise of pods shaking in the wind. Foliage is pale green when young and gray-green at maturity, and consists of 2-4 pairs of pinnae 50-100 mm long with 3-11 pairs of leaflets up to 50 mm long. Flowers are cream colored, hemispheric pompons.

ECOLOGY. The species is native to India, Burma and the Andaman Island , and naturalized in many other tropical and subtropical areas (Streets 1962). In these regions *A. lebbeck,* also known as "Siris" or "Indian Siris", grows in a wide range of climates, covering an annual rainfall range of 600 - 2500 mm. However, it also has been grown successfully in areas with an annual rainfall as low as 400 mm. It grows in Himalayan valleys up to 1600 in. The species is adapted to a wide range of soil types, from acid soils to alkaline and saline conditions (Prinsen 1986). Older trees withstand grass fires and night frosts of considerable intensity. Such stresses kill off above-ground growth of young trees, but new growth usually follows.

FODDER: Most livestock readily eat leaves and young twigs of this fine fodder tree. Crude protein concentration is about 20% for green leaves, 13% for leaf litter, and 10% for twigs. Edible material has no known toxic compounds. In general, the digestibility of edible material from leguminous fodder trees is lower than that of leguminous herbs. In this regard, *A. lebbeck* is average. *In vitro* digestibility ranges from 45% for mature leaf to 70% for young leaf. *In vitro* digestibility of twigs is around 40%, considerably higher than for twigs of most other fodder trees.

Studies in Townsville, Australia, (lat. 19° S, annual rainfall c. 900 mm) have shown that trees do not have to be browsed directly, as leaves, flowers and pods fall sequentially during the dry season (Lowry, unpublished). Pradhan and Dayal (1981) measured an annual leaf litter yield of 5000 kg/ha from Indian Siris compared to 1800 kg/ha from a *Eucalyptus* hybrid and 8000 kg/ha from *Acacia arabica*



TREES IN PASTURES: There is evidence that pasture herbage production is increased by low densities of *A. lebbeck.* Yields of *Panicum maximum* and speargrass under a canopy of *A. lebbeck* in a subhumid area of northern Australia were significantly higher than yields between the trees, 1710 vs. 753 kg/ha, for trees sufficiently isolated for considerable lateral light penetration (Lowry et al. 1988). Maintenance of moisture content appeared at least partly responsible for the difference. Increased grass growth was observed under a number of other tree species, but the difference was not as conspicuous and consistent as with *A. lebbeck,* suggesting the major factor was the right degree of shading. In a lower rainfall region, however, a much greener color of grasses under the *A. lebbeck* canopy suggested that increased yields were the result of increased levels of available nitrogen (Prinsen, unpublished).

YIELDS: *A. lebbeck* can be grown as a single-stemmed tree or as a multi-stemmed shrub. In the latter form it coppices as readily as *Leucaena leucocephala.* In a stand of naturalized A. *lebbeck* growing in shallow soil in a subtropical 750 mm rainfall area in Australia, estimates of average annual production of dry edible matter varied in different management systems. Stands of mature trees completely pruned back to the stem once every three years produced 1700 kg/ha/yr. Stands in hedgerows at a row distance of 3 m and defoliated by cattle twice a year produced 2500 kg/ha/yr. This production estimate compares favorably with a leucaena yield of 1500 kg/ha/yr in the same region, which indicates that *A. lebbeck* could serve as an alternative to leucaena in the lower rainfall tropics and subtropics. Although the digestibility of leucaena leaf is higher, *A.*

Written by John H. Prinsen, Department of Primary Industries, Brian Pastures Research Station, Gayndah, Queensland 4625, Australia. Photo provided by author. Botanical drawing from Little and Wadsworth. 1964.

lebbeck is less frost susceptible and better suited to acid soil.

In plantings corresponding to 2,500, 10,000, and 40,000 trees/ha in Puerto Rico, above ground biomass per unit area increased with density during the first 24 months, yielding 12.6, 14.5 and 17.4 t/ha, respectively (Parrotta 1988). After 36 months, however, the figures were 21.7, 29.5 and 18.7 t/ha. The percentage of above ground biomass contained in leaves increased with stand density, from 13% to 23% in the 2,500 and 40,000 tree/ha stands, respectively, at 36 months.

This 20-year-old tree was pruned 2 years ago, which caused a considerable increase in canopy density

WOOD: Heartwood is brown to dark, and sapwood is white and large. Timber, with a specific gravity of 0.55 - 0.60, is very suitable for construction, furniture and veneer. Pulp is short-fibered and used for paper production only when mixed with long-fibred pulp (Anonymous 1970). Wood provides good fuel and has a caloric value of 22 kilojoules per kg (Anonymous 1970). In India, annual wood yields of 5 m^3/ha were recorded in rotations of 10 - 15 years, but yields depend on environmental conditions.

NODULATION: *A. lebbeck* is not *Rhizobium* specific, and native strains are nearly always capable of producing an abundance of nodules.

PESTS AND DISEASES: This species has had no known serious pests or diseases, although a psyllid, probably of the genus *Heteropsylla,* recently was reported as seriously affecting seedlings in India (Hegde and Relwani 1988). The infestation could not be controlled with three sprayings of 0.2% Malathion, but was controlled by two sprayings of Nuvacron (0.05%) one week apart. Some records exist of termites damaging seedlings and fungal diseases attacking leaves in India. In Australia borers may kill off a few branches. However, no cases of significant yield losses have been reported.

ESTABLISHMENT: Seeds germinate well without scarification, but germination may be improved by immersing seed in boiling water for 3 seconds and then allowing it to cool and dry. Direct sowing is possible, but rows must be well-weeded for a few years. Another method is to raise seedlings in nursery beds for one year or more and then transplant them as stumps with about 25 cm root and 10 cm shoot (Anonymous 1970). This would considerably reduce the field establishment period.

OTHER USES: The tree is used as a folk remedy for many ailments. Another common use is as an avenue tree, and sometimes it is used to shade coffee and tea. Saponins and tannins in the bark can be used for making soap and in tanning, respectively. Bee keepers like the species for the light-colored honey its nectar provides, and the tree hosts the lac insect. Soil-binding ability makes it useful for soil conservation plantings (Sommen 1981).

REFERENCES:

Anonymous. 1970. Kokko, (siris) Indian Timber Information Series No. 6. Forest Research Institute and Colleges, Dehra Dun, India.

Little, E.L., and F.H. Wadsworth. 1964. Common Trees of Puerto Rico and the Virgin Islands. U.S. Department of Agriculture, Agricultural Handbook No. 249.

Hegde, N. and L. Relward. 1988. Psyllids attack *Albizia lebbeck* Benth. in India. NFTRR6:43-44.

Lowry, J.B., B.C. Lowry and R. Jones. Enhanced grass growth below a canopy of *A. lebbeck.* NFTRR6:45-46

Parrotta, J.A. Early growth and yield of *Albizia lebbeck* at a coastal site in Puerto Rico. NFTRR6:47-49.

Pradhan, I.P, and R. Dayal. 1981. Farm forestry in agricultural economy. Indian Forester 107:665-667.

Prinsen, J.H. 1986. Potential of *Albizia Lebbeck (Mimosaceae)* as a tropical fodder tree - a review of literature. Trop. Grasslands 20(2):78-83.

Prinsen, J.H. Unpublished. Over a period of five years observations/measurements were carried out in three stands of naturalized *A. lebbeck* near the "Brian Pastures" Pasture Research Station in South East Queensland. (25°38'S, 151°45'E, altitude 130 m, 735 mm mean annual rainfall.)

Sommen, F. van Der. 1981. Farm Forestry, In A Manual of Australian Agriculture, Fourth Edition. Ed. R.L. Reid (William Heinemann:Melbourne). pp. 277-280.

Streets, R.J. 1962. Exotic Forest Trees in the British Commonwealth. Clarendon Press, Oxford, pp 169-170.

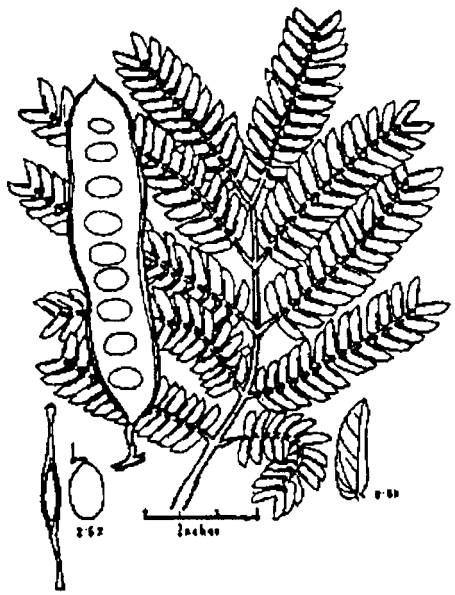
NFT Highlights

A quick guide to multipurpose trees from around the world

NFTA 95-01
January 1995

Albizia odoratissima : Tea Shade Tree

Albizia odoratissima, Benth. (Syn. *Mimosa odoratissima*, Roxb.) is a medium sized tree highly valued for shade and soil improvement in tea plantations of the Asian subcontinent. It is particularly popular in North-East India and Bangladesh. About 75% of total tea shade trees in Bangladesh are of this species (Sana 1989). On the subcontinent it is known as karuvagai, karmaru, bansa, bilkumbi (Troup 1921), chamkoroi (Hasan 1963), tetua-koroi (Kamaluddin 1984), and kalasiris (Sana 1989).



Source: *Sana, 1989*

Botany

Albizia odoratissima (Leguminosae, Subfamily Mimosoideae) is a multipurpose woody legume which obtains a height of 22-26 m and diameter of 120-150 cm. On good sites five-year-old trees can be 5 m in height and 14 cm in diameter. A mean annual diameter increment of 1.3 cm has been recorded for this species (Troup 1921). The bark is dark grey to light brown in color with horizontal lenticels. The crown is relatively dense. The dark green leaves are bipinnately compound, downy, with 6-9 pinnae and 16-20 pointed asymmetrical leaflets.

Flowers are corymbs, pale yellowish white, fragrant, and generally appear from March to June. Fruits appear in early August and start ripening at the end of October. The thin flat pods are 13-20 cm long and brown when ripe (Hasan 1963, Sana 1989). Trees produce large amounts of pods, each containing 8-12 seeds. *Albizia odoratissima* is deciduous, with a short leafless period from December to February. New leaves normally appear before the old ones have completely fallen. Branching habit is uniform, but irregularities occur when the tree is damaged.

Ecology

Albizia odoratissima tolerates a wide range of temperatures and rainfall. In its natural range the maximum shade temperature varies from 37°-50°C and the minimum from 0°-15°C. Normal rainfall varies from 650-3000 mm with a dry season from November to March. It occurs from sea level to 1500 meters (Troup 1921) and grows sporadically in both dry and moist deciduous forest zones.

Growth of *A. odoratissima* is best in deep, well drained sandy soils (Sana 1989). The species prefers soils with large amounts of organic matter. It tolerates hot humid conditions, but does not tolerate water-logging. On poor soils growth is stunted. Young plants are susceptible to frost. *Albizia odoratissima* is classified as moderately light demanding. Juvenile trees require shade. Trees coppice well, shoots reaching a height of 3 meters in two years. It is susceptible to fire, but resistant to weed competition and drought. It regenerates naturally in sheltered areas with good soil.

Distribution

Albizia odoratissima occurs naturally in Southern China, Burma, Peninsula India, and Tropical Africa. Under tropical conditions the species is not gregarious. It is frequently found on hill slopes and sometimes in valleys.

Uses

Shade. *Albizia odoratissima* has been extensively planted as a shade tree in tea and coffee plantations. The shade extends the productive life of crop plants and increases annual yields. Recommended spacing varies from 6x6 to 12x12 m. *Albizia odoratissima* benefits tea and coffee production in many ways. Its well developed root system decreases erosion and utilizes the subsoil moisture and nutrients not available to tea and coffee plants. Through leaf litter, *A. odoratissima* provides organic matter and soil nutrients to the rhizophere of understory plants. Tree canopies decrease soil desiccation, suppress weed growth and protect plants from hail and rain storms. *Albizia odoratissima's* presence in the tea monoculture reduces incidence of tea pests, particularly red spider mites and scarlet mites. The shade also provides plantation laborers a comfortable working environment under otherwise hot tropical conditions.

Wood uses. *Albizia odoratissima* produces valuable fuelwood. Dead and defective branches from shade trees are a major source of fuel for plantation laborers. The heartwood of

Writen by Md. Abdullah Hossain, Riaz Kazi Lane, Sutrapur, Bogra, Bangladesh.

mature trees is a beautiful dark brown color. The premium quality wood is suitable panelling and furniture. It is also used for carts, wheels, farm implements and construction timbers. Wood weight at 12% moisture content is 735 kg/cubic meter. The wood is 20-40% stronger than teak (Anon. undated).

Other uses. The pods of *Albizia odoratissima* are eaten by monkeys. The leaves are an excellent green manure and cattle fodder. Sana (1989) reports *Albizia odoratissima* contributed 16 kgs of nitrogen per hectare from 655 kgs of dry weight leaf liter.

Silviculture

Seed collection and handling. Pods should be collected while on the tree immediately after they turn brown. Half-opened pods are also collected from beneath trees. Following collection, pods are dried in the sun for 5-7 days. Pods are then lightly pounded with a hammer to extract seeds. Extracted seeds are dried again in the sun for 3-4 days and then stored in bags under well ventilated, dry conditions. If seeds are to be stored for a long period, they should be treated with a 5% DDT or Heptachlor dust at the rate of 100 grams per kg of seeds (Anon. 1988). There are approximately 21,000 seeds per kg. To break dormancy seed can be soaked; a) in cool water for one hour, b) in 80°C water for two minutes, or c) in boiling water for 30 seconds. Removed from the water, moist seed is stored overnight and sown the following morning. Seedlings emerge within a week. Fresh seed may have a germination rate of 99%. Germination of year-old seed decreases to 55-65%.

Propagation. Nursery production should be initiated in November or December, 4-5 months before the planting season. Well drained sandy loam soil from beneath *A. odoratissima* trees is recommended for nursery use. If available, well decomposed compost should be mixed with the soil at a ratio of 1:3. Additionally, 500 grams each of triple super phosphate (TSP) and lime should be added to every cubic meter of nursery soil. The use of large nursery bags is recommended to encourage growth of a deep taproot. In each nursery bag 2-3 seeds should be sown at a depth 5-20 mm and covered with a thin layer of sand. Every two weeks seedlings should be fertilized with a well decomposed liquid compost or a standard phosphorus and potassium fertilizer. In large nurseries, 4-10 cm seedlings are sprayed every two weeks for protection from insects and fungal diseases. Recommended spray contains 300 ml of malathion and 300 grams of copper oxychloride in 200 liters of water (Anon. 1988).

Albizia odoratissima is also established by direct seeding or stump cuttings. For quick establishment, stump cuttings give the best results. Stumps are prepared in the late dormant season immediately before buds swell. Trees with stem diameters of 5-7 cm are appropriate for stumps. Selected trees are cut at a height of 1.5-2 meters and all the lateral branches are removed. It is best to select trees with few lateral branches below the 1.5-2 meter cutting height. Trees should have well developed roots. Carefully, expose the root system to a depth of 90 cm. Sever the taproot at 80-90 cm and prune all lateral roots. Stumps should be planted immediately in pits 90 cm deep and 75 cm wide.

Planting and fertilization. At the beginning of the spring rains seedlings are ready for field planting. Seedlings are planted in pits 90 cm deep and 45 cm wide. They should be fertilized during planting. Recommended fertilization rates per seedling are 10 kgs of rotted cattle manure, 200 g TSP, 2.5 kg wood ash and 1 kg slaked lime. Components should be well mixed with the soil from the planting pit and replaced.

Fertilization of young shade trees improves tree growth and plantation production. For trees under 2.5 m height broadcast 300 grams TSP in a 1.5 meter diameter-circle around the tree. For trees up to 4 m height 333 grams TSP is applied to a 3 meter diameter-circle. Fertilization should be repeated three times per year; April, June and August (Anon. 1988).

Symbiosis

Through a symbiotic relationship with *Rhizobium* bacteria, *Albizia odoratissima* fixes atmospheric nitrogen. Under natural conditions seedlings generally bear abundant root nodules. For nursery production it is wise to use soil from under a stand of *A. odoratissima*. No quantitative data is available on the *Rhizobium* specificity of this species.

Limitations

Albizia odoratissima is prone to attack by caterpillars, root bores, and root diseases, particularly as a young tree (Barua 1989). Dieback, branch canker, and red rust are also problems for young trees. Damping-off, a fungus infection, is common in poorly managed nurseries. In India, heart-rot of this species is caused by *Ganoderma applanatum* (Lenné 1992). *Albizia odoratissima* sometimes produces uneven shade (Barua 1989) which causes management problems under plantation conditions.

Tree Improvement

Tree improvement programs for superior canopy characteristics and resistance to insects and disease should be initiated. In Bangladesh improved planting stock is obtained from root suckers of select varieties. Root cuttings of 1-2 cm diameter and 15-20 cm length are placed under heavy shade in a moist rooting bed. One-third of the root is exposed and two-thirds buried in the soil. Spacing between cuttings is approximate 20-30 cm. Within a few weeks the stock is ready for transplanting (Anon. 1988).

References

Anon., 1988. Guide line on management of shade trees. GL No. 5. The Consolidated Tea and Lands Company (BD) Ltd. The Baraoora (Sylhet)

Tea Company Ltd. (Incorporated in Great Britain) 1-4.

Anon., undated. Indian forest utilization. vol. II 925 pp.

Barua, D.N. 1989. Science and practice in tea culture. Tea Research Association, India 402-436.

Hasan, K.A. 1963. Shade trees for tea - their functions and behavior. Tea Journal of Pakistan 1(2):14 pp.

Kamaluddin, M, 1984. 1984. Forest Ecology, Institute of Forestry, University of Chittagong. Chittagong, Bangladesh. 164 pp.

Lenné, J.M. 1992. Disease of multipurpose woody legumes in the tropics, a review. Nitrogen Fixing Tree Research Reports 10:13-29.

Sana, D.L. 1989. Tea Science. BTRI, Moulvibazar, Bangladesh, 45-51.

Troup, R.S. 1921. Silviculture of Indian Trees. II:466-484.

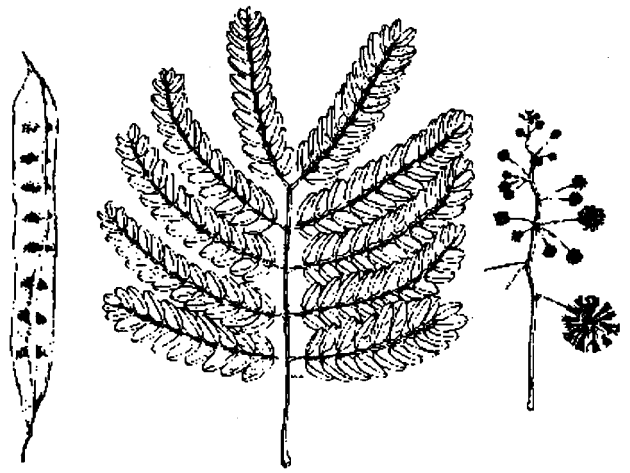
FACT Sheet

A quick guide to multipurpose trees from around the world

FACT 97-01
January 1997

Albizia procera : White Siris for Reforestation and Agroforestry

Albizia procera is a large, fast-growing tree that occurs on many different sites. Like other Asian *Albizias*, it occurs in forests and savanna woodlands, but prefers moister sites than its relatives. This species provides wood for a variety of purposes, nutritious fodder for livestock and shade for tea plantations. It is an important reforestation and agroforestry species. It is commonly called white siris or tall albizia and has many regional names.



Source: Little and Wadesworth, 1964

Botany

Albizia procera (Roxb.) Benth. is usually 60-70 cm in diameter and 25 meters in height. Troup (1921) reports trees as large as 95 cm in diameter and 36 meters in height. Mature individuals are characterized by a tall, clear, erect, sometimes curved trunk and large branches which form a thin, spreading crown. The bark is nearly smooth, whitish to light-greenish gray or light-brown. It exfoliates in thin flakes with red undersides (Troup 1921). Lateral roots are wide-spreading and the taproot stout. The bipinnate leaves, reddish when juvenile, mature to a length of 12-25 cm; leaflets are 2-4 cm long and 8-16 mm wide.

Flowering varies by geographic location; January to March in Indonesia (Djogo 1992), June to September in India, (Troup 1921) September in Manila (Hensleigh and Holaway 1988) and August to October in Puerto Rico (Parrotta 1987). Flowers are borne on racemes 8-25 cm long near the end of a twig. Numerous greenish-yellow flowers form whitish heads 20-24 mm in diameter. Individual flowers, 6-7 mm long, have long white threadlike spreading stamens about 10 mm long (Little and Wadsworth 1964). The reddish-brown flat pods, 10-20 cm long and 18-25 cm wide, are produced in large numbers and ripen 3-5 months after flowering. The mature brown pods, each containing 6-12 seeds, usually remain on the tree until the twig bearing the pods is shed (Troup 1921, Little and Wadsworth 1964). The natural regeneration of white siris is generally good. Following the beginning of the rainy season large numbers of seedlings are common near mature trees. Seedlings, saplings and mature trees coppice vigorously from stumps and roots (Parrotta 1987).

Ecology

White siris is a component of tropical and subtropical moist and wet forest types where rainfall is 1000-5000 mm/yr. It develops best when rainfall is above 2500 mm/yr. Growing to elevations of 1200 meters, this species is also common on moisture savannas and swamp forests. In its natural habitat, maximum temperatures vary from 37-46° C and minimum temperatures from 1-18° C. Once established white siris is drought tolerant. It is susceptible to frost (Troup 1921, Djogo 1992).

Like many nitrogen fixing trees, white siris survives on a variety of soils. It grows best on moist alluvial soils, well-drained loams or clay soils (Brandis 1906, Venkataramany 1968). Its ability to grow on dry, sandy, stony, and shallow soils makes it a useful species for reforestation of difficult sites. Good survival and rapid early growth have been reported in afforestation trials on both saline and alkaline soils (Ghosh 1976). It does not tolerate suppression, but will survive moderate shade between the seedling and small tree stage (Venkataramany 1968).

In India, white siris is dominant to co-dominant in mixed deciduous forest; or found as scattered individuals or in small groups in savanna woodlands (Benthall 1933, Bor 1953). In Puerto Rico, white siris is an aggressive pioneer, forming pure stands on abandoned farms and other disturbed sites. It is also common in pastures at elevations below 600 meters, including areas receiving as little as 800 mm of annual rainfall.

Distribution

The native range of *A. procera* is South and Southeast Asia between latitudes 30 degrees N to 15 degrees S. The tree occurs naturally in India, Nepal, Bangladesh, the Andaman Islands, Burma, southern China, Laos, Thailand, Cambodia, Vietnam, Malaysia, the Philippines, Indonesia, Papua New Guinea, Melanesia and northern Australia (Nielsen 1979). It is naturalized in the Virgin Islands and Puerto Rico.

Uses

Agroforestry. Natural regeneration of *A. procera* is often encouraged on farms to provide small timber, fuelwood, charcoal, fodder or shade. Seedlings are planted in family forests or home gardens for the same purposes. *Albizia procera* can be cultivated as shade for tea plantations.

Written by John A. Parrota and James M. Roshetko. Research Forester, USDA Forest Service, International Institute of Tropical Forestry, Rio Piedras, PR 00928-4984, USA and Program Officer,

However, *Albizia odoratissima* is preferred for this purpose because of its rapid early growth, fuller crown and resistance to red spidermites. The protein-rich fodder of *A. procera* is eaten by cattle, buffaloes, goats, camels and elephants in South Asia and the Philippines. However, the fodder is not utilized in Nusa Tenggara, Indonesia.

Wood. Durable, strong and resistant to termites, the wood is light- to chocolate-brown with light and dark bands. It is difficult to saw due to interlocking grain and has a specific gravity of 0.6-0.9. The wood is used to produce wheels, carts, boats, furniture, flooring, posts, agriculture implements, boxes and carvings. This species is considered a promising source of pulp for high-quality paper (Parrotta 1987).

Other Uses. Trees are often planted for shade or beautification along roads. *Albizia procera* is commonly used in traditional medicines (Venkalarammany 1968). The bark contains tannins and a reddish gum. Also, it can be used to make a poison. The leaves are used to treat ulcers and have insecticidal properties (Parrotta 1987). In the Philippines, the cooked leaves are eaten as a vegetable (Hensleigh and Holaway 1988).

Silviculture

Propagation. Seeds are small, greenish-brown, elliptical to round, flat and have a hard, smooth seedcoat. There are 20,000-24,000 seeds per kilogram (Roshetko 1997). Insect damage to seed is common in Indonesia (Djogo 1992) but not in India (Troup 1921). Fresh seed germinates readily without treatment (Parrotta 1987). Clean seed can be stored at room temperature for 10 months with minimal loss of viability (Roshetko 1997). Seed that has been stored should be treated before sowing; cut through the seedcoat with a knife or file, or soak seeds in boiled water for 3 minutes. After either treatment, soak seed in cool water for 12-24 hours and sow immediately (Roshetko 1997).

In the nursery, seed should be sown in containers or beds. Seedling growth is favored by loose soil, sufficient soil moisture, full sunlight and the absence of weeds. Healthy seedlings produce a thick, long taproot. After two months in the nursery containerized or bare-root seedlings should be transplanted to the field. Direct sowing of white siris is successful given abundant soil moisture and regular weed control (Troup 1921). Propagation is also possible by stem or root cutting and stump sprouts. Plantations should be weeded twice in the first year and once during the second. During weeding, soil should not be unduly exposed; only weeds directly interfering with seedlings should be removed (Venkataramany 1968).

Growth and Management. In Bangladesh, plantation trees have reached heights of 0.3 and 4.5 m in 1 and 5 years. In Burma 6-year-old trees average heights and diameters of 12.8 m and 16 cm, respectively. In Indonesia, 17-year-old trees average heights and diameters of 24.3 m and 22.4 cm, respectively. Total standing volumes of 87 m^3/ha have been reported in 8-year-old plantations in Burma and of 151 m^3/ha in 17-year-old plantations in Indonesia. Natural forests are managed for timber production by coppicing on a 40-year rotation. Fuelwood plantations are managed on a 20-year rotation (Venkataramany 1968).

Symbiosis

Albizia procera forms symbiotic association with *Rhizobium* bacteria enabling it to fix nitrogen and thrive on infertile soils. The application of phosphorus fertilizer can improve nodulation and nitrogen fixation, particularly on infertile soils.

Limitations

Because of its aggressive growth white siris may be a potential weed. This is particularly true in the Caribbean where white siris grows faster than many native species.

References

Benthall, A.P. 1933. The trees of Calcutta and its neighborhood. Thacker Spink and Co., Calcutta, India. 513 p.

Bor, N.L. 1953. Manual of Indian forest botany. Oxford University Press, London, UK. 441 p.

Brandis, D. 1906. Indian trees. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.

Djogo, A.P.Y. 1992. The possibilities of using local drought-resistant multipupose tree species as alternatives to lamtoro (*Leucaena leucocephala*) for agroforestry and social forestry in West Timor. Working Paper No. 32. EAPI, East West Center, Honolulu, Hawaii, USA. 41 p.

Ghosh, R.C. 1976. Afforestation problems of saline and alkaline soils in India. Van Vigyan 14(1): 1-17.

Hensleigh, T.E. and B.K. Holaway. 1988. Agroforestry species for the Philippines. Washington DC: US Peace Corps, 404 p.

Little, E.L., F.H. Wadsworth. 1964. Common trees of Puerto Rico and the Virgin Islands. Agric. Handbook 249. US Department of Agriculture, Washington DC. 548 p.

Nielsen, I. 1979. Notes on the genus *Albizia* Durazz. (Leguminosae-Mimosaceace) in mainland S.E. Asia. Adansonia 19(2): 199-229.

Parrotta, J.A. 1987. *Albizia procera* (Roxb.)Benth. Silvics of Forest Trees of the American Tropics. Rio Piedras, Puerto Rico USA: USDA Forest Service, International Institute of Tropical Forestry. 4 p.

Roshetko, J.M. 1997. Seed treatment for *Albizia* species. In: N.Q. Zabala (ed.) *Albizia & Paraserianthesis*. Proceedings of an international workshop. Morrilton, Arkansas, USA: Winrock International, in press.

Troup, R.S. 1921. The silviculture of Indian trees. Clarendon Press, Oxford, UK. 1195 p.

Venkataramany, P. 1968. Silvicuture of genus *Albizia* and species. Silviculture of Indian trees., No. 22. Government of India, Delhi, India. 54 p.

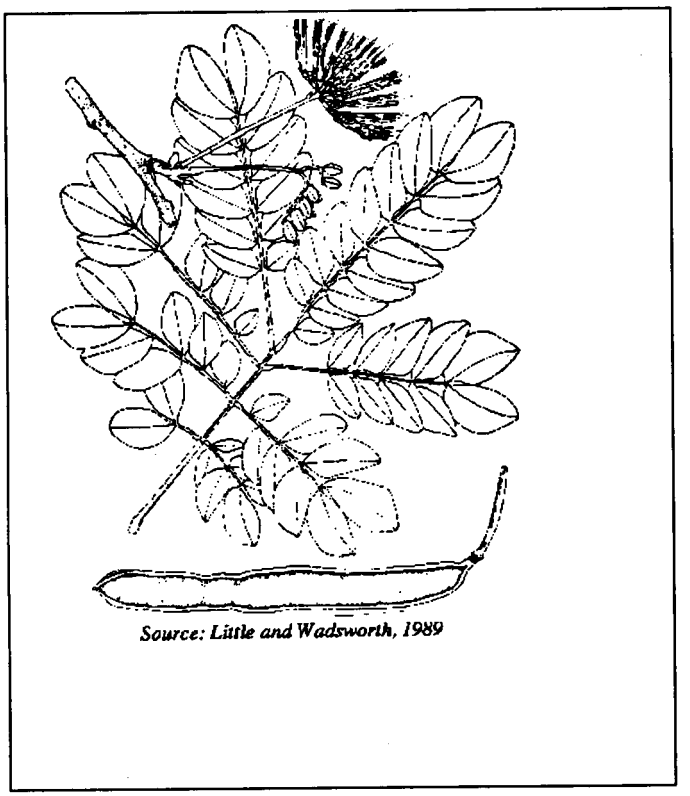
NFT Highlights

NFTA 95-02
(Replaces 87-06)

A quick guide to multipurpose trees from around the world **September 1999**

Albizia saman : pasture improvement, shade, timber and more

Albizia saman (Jacq.) F. Muell. (Leguminosae, Subfamily Mimosoideae) is a fast growing tree which obtains a large size. It is most common as a pasture, shade or ornamental tree, but has numerous uses. This New World tree is so widely cultivated and used in Southeast and South Asia it is often mistaken as native to that area. It was formerly classified as *Samanea saman, Pithecellobium saman* and *Enterolobium saman.* Common names include saman, monkey pod, raintree, cow tamarind, algarrabo and guango.



Source: Little and Wadsworth, 1989

Botany

Albizias are related to and often mistaken for Acacias—in the Philippines acacia is a common name for *A. saman. Albizia saman* can obtain a height of 30-45 m and diameter breast height (DBH) of 150-250 cm. Open-grown specimens have short stems and stout wide-spreading nearly horizontal branches. The umbrella-shaped crown may be wider than the height of the tree. The brown gray bark is rough and furrowed into ridges and plates (Little and Wadsworth 1989). Limb bark is lighter in color. Twigs are stout and green. The bipinnately compound leaves are 25-40 cm long dark green above and light green below. The stalkless leaflets are arranged in pairs numbering from 12 to 32 (Little and Wadsworth 1989). Leaflets are wider towards the apex. Both leaves and leaflets are progressively larger towards their terminal ends.

The showy flower heads, composed of many narrow pink flowers, are found near the end of twigs and appear from March to September (Hensleigh and Holaway 1988). The dark-brown to black pods are hard and thick with a raised seam. They are 8-20 cm long and about 2 cm wide. The pods do not readily open and remain on trees for long periods. Seeds are red-brown oblong and squarish. There are 5000-8000 seed/kg.

Ecology

Albizia saman is found in the tropics from sea-level to 1000 meters where the temperature is 20-35° Celsius. It is a common component of dry forests and grass savannas. Annual rainfall in these areas is 600-3000 mm/year. *Albizia saman* easily survives dry seasons of 2-4 months. While more common on drier sites, this species grows best in moist, well-drained fertile soils (Hensleigh and Holaway 1988). It tolerates heavy clays and infertile or waterlogged soils. Although normally found in neutral to moderately acid soils, it will grow in soil with pH as low as 4.6 (Franco et al. 1995).

Distribution

This species is native from Southern Mexico and Guatemala south to Peru, Bolivia and Brazil. It is naturalized throughout the tropics and has been introduced to sub-tropical areas.

Uses

Shade and ornamental. *Albizia saman* is planted along roads throughout the tropics. In parks and commons, its high arching branches provide welcome protection from the heat of the tropical sun. Having crowns of great diameter, trees furnish ample shade. Trees serve as windbreaks and are cultivated for their beautiful pink flowers.

Wood. The wood of *Albizia saman* is highly valued for the manufacture of furniture, cabinets, decorative veneers, bowls and other handicrafts. The chocolate heartwood and yellow sapwood form a beautiful contrast. The light-weight wood (specific gravity 0.48) is strong, durable, works easily and takes a good finish (Chudnoff 1984). It shrinks so little that products made from green wood dry without warping (NAS 1979). *Albizia saman* is a good quality fuel and charcoal, producing 5200-5600 kcal/kg (F/FRED 1994). Other uses of the wood include fencing, construction timbers, plywood and the manufacture of crates, wheels and boats.

Pasture and fodder. *Albizia saman* is a valuable component of pasture systems. Its shade protects livestock

Writen by James M Roshetko, Program Associate, Winrock International

from the hot tropical sun. Its nutritious pods contain 12-18% crude protein and are 40% digestible (F/FRED 1994). Relished by livestock, pods are an important dry-season fodder. Tree leaves are also nutritious, but are not an important fodder. The shade and nitrogen-rich leaf-litter of *A. saman* improve the nutritional value of understory grass (Allen and Allen 1981). During the dry-season, grass beneath trees remains green and succulent while exposed grass becomes dry and unpalatable. Leaves fold inward at night which may increase the amount of moisture, rain and dew, reaching the understory. In the morning leaves unfold giving full shade and conserving soil moisture.

Agroforestry. This species is used as shade for tea, coffee, cacao, nutmeg and vanilla. Performance has been fair in alley- and hedgerow-cropping studies. Initial growth is slower than other woody perennials, but *A. saman* coppices well and yields nitrogen-rich green manure. However, shallow roots and large branch size compete heavily with companion crops, especially in dry areas. In these systems, *A. saman* must be heavily pruned. In most areas, other species will be more appropriate for alley- and hedgerow-cropping studies. *Albizia saman* is appropriate in home gardens where it provides a service role and multiple products simultaneously.

Other uses. Children eat the pods which contain a sticky sweet-flavored pulp. A fruit drink is also made from the pulp. Honey is produced from the flowers. The bark yields gums and resins. In Thailand, *A. saman* is an important host plant for lac production (Subansenee 1994).

Silviculture

Propagation. Seeds of *A. saman* have hard, impermeable seedcoats. Two methods of seed scarification are recommended. For small quantities of seed, cut through the seedcoat opposite the micropyle, or pointed-end of the seed, taking care not to damage the seed embryo. For large quantities of seed, pour boiled water over the seeds, soak and stir for two minutes. Drain off the hot water. The hot water should equal five times the volume of seeds. With either method of scarification, the seed should be soaked in cool water overnight before sowing (NFTA 1989). Seed should be sown at a depth equal to its width in large nursery bags. The recommended nursery mixture is 3 parts soil: 1 part sand: 1 part compost. Seedlings should receive partial shade for 2-4 weeks and then be exposed to full sunlight. After 3-5 months seedlings will be 20-30 cm tall and ready for field planting. Direct sowing is possible, but success depends on rigorous weed control. *Albizia saman* can be propagated by cutting or stump cutting.

Management. Open-grown *A. saman* have short trunks and spreading limbs which are considered poor form for timber production. Close spacing, 1.5x2 meters, does produce straighter trees with less branching, but boles retain a spiral form. For this reason, *A. saman* is not commonly planted in single-purpose timber plantations. In pastures, home gardens or other multiple-purpose plantings, tree spacing will depend on companion plants and management strategy.

A light-demanding species, *A. saman* grows fast and is tolerant of heavy weed competition. However, survival and growth can be improved through vigorous weed control until trees achieve dominance over competing vegetation. Wood production varies by site and management system. A good site can produce 10-25 m^3/hectare/year under a 10-15 year rotation (F/FRED 1994).

Symbiosis

Albizia saman forms nitrogen fixing symbiosis with many strains of *Rhizobium*. In the field it readily forms root nodules.

Limitations

Heterophylla cubana, *Psylla acacia-baileyanae* and other defoliators are common pests (Braza 1990) but do not cause serious stress problems. Wide spreading branches and shallow roots make *A. saman* susceptible to damage during intense storms. The destruction of natural forests threatens the genetic diversity of this species. In response to this threat, the Oxford Forestry Institute has included *A. saman* in its gene conservation program (Hughes 1989).

References

Allen, O.N. and E.K. Allen. 1981. The Leguminosae. a source book of characteristics, uses and nodulation. Wisconsin Press. Madison, Wisconsin, USA. pp. 590-92

Braza, R.D. 1990. Psyllids on nitrogen fixing trees in the Philippines. NFTRR 8:62-63

Chudnoff, M. 1984. Tropical timbers of the world. Agriculture Handbook 607. USDA Forest Service. Washington, DC. p. 134

F/FRED. 1994. Growing Multipurpose Trees on Small Farms (2nd ed.). Module 9. Species fact sheets. Bangkok, Thailand. Winrock International, pp. 22-23

Franco, A., E.F.C. Campello, L.E. Dias and S.M. de Faria.,1995. Revegetation of acidic residues from bauxite mining using nodulated and mycorrhizal legume trees. In: D. Evans and L. Szott (eds.), Nitrogen fixing trees for acid soils. Nitrogen Fixing Tree Research Reports (Special Issue). Morrilton, Arkansas, USA. In press

Hensleigh, T.E. and B.K. Holaway. 1988. Agroforestry species for the Philippines. US Peace Corps. Washington, DC. pp. 281-84

Hughes, C.E. 1989. Intensive study of multipurpose tree genetic resources. Oxford Forestry Institute, University of Oxford, UK. pp. 66-79

Little, E.L. and F.H. Wadsworth. 1989. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249. USDA Forest Service. Washington, DC. pp. 164-66

NAS. 1979. Tropical legumes: Resources for the future. National Academy of Sciences, National Research Council. Washington, DC. pp. 202-03

Macklin, B., N. Glover, J. Chamberlain and M. Treacy. 1989. NFTA cooperative planting program establishment guide. Nitrogen Fixing Tree Association. Morrilton, Arkansas, USA. 36 p

Subansenee, W. 1994. Economic value of *Albizia saman*. In: J.B. Raintree and H. A. Francisco (eds.). Marketing of Multipurpose Tree Products in Asia. Bangkok, Thailand. Winrock International, pp. 229-35

NFT Highlights

A quick guide to useful nitrogen fixing trees from around the world

NFTA 94-03
April 1994

Alnus acuminata : Valuable Timber Tree For Tropical Highlands

Alnus acuminata is a fast-growing species valued for its wood, watershed protection and soil improvement. Native from Mexico to Northern Argentina, it is known as: aliso (Mexico, Argentina, Colombia, Ecuador and Peru); aile, ilite (Mexico); ramrám, lambdn (Guatemala, Costa Rica and Peru); jaúl (Costa Rica); palo de lama (Guatemala) and; cerezo and chaquiro (Colombia). Easily propagated from seed or by natural regeneration, *A.acuminata* is a popular agroforestry species in its native range. It has been successfully introduced into southern Chile and southern New Zealand.

Botany

Alnus acuminata ssp. *arguta* (Schlectendal) Furlow (Betufaceae) grows to 30 m in height and to 50 cm in diameter (after 30 years) in natural conditions. Maximum age may be 60 years (L Fournier, personal communication). The leaves are simple, alternate, elliptical, 6 to 15 cm long, 3 to 8 cm wide, border double dentate, deciduous or semideciduos. The upper leaf surface is dark green and the lower surface is pale, whitish to light green. The bark is light-grey or silvery with yellowish lenticels. Crown shape is open rounded to pyramidal. Male and female flowers occur in separate catkins on the same branch. Inflorescences are cone-like with lignified scales, dark brown when ripened, and bearing more than 100 fruits per cone. The fruit is a small membranous-winged samara, 2 to 3 mm long that contains one seed. Dispersal is mainly by the wind. Seeds ripen in February, March and August in South America (NAS, 1980), and from September to January in Costa Rica (Rajas et al., 1991).

There is considerable confusion in the taxonomy of *Alnus acuminata*. Furlow (1977) reported the species as *Alnus acuminata* H.B.K., but in his last revision (1979) he classified it as *Alnus acuminata* ssp. *arguta*. The species also has been described as *Alnus jorullensis* H.B.K. by Carlson and Dawson (1985). Holdridge (1951) concluded that if subspecies populations exist they apparently intergrade into each other and because of similarities in wood and silvicultural characteristics they may be considered as a single species, at least from a forestry viewpoint.

Distribution and ecology

Alnus acuminata is native to the American continent ranging from Mexico to Northern Argentina in elevations between 1,200 and 3,200 m.a.s.l. where annual rainfall is 1,000 to 3,000 mm or more. The species occurs where mean annual temperature ranges between 4°, and 27°C; however it can withstand temperatures dipping briefly below 0° C (NAS, 1980).

Alnus acuminata is a fast-growing pioneer species that regenerates naturally in open, disturbed areas. It grows in moist soil environments, usually along the banks of streams, rivers, ponds, and swamps where it typically forms dense pure stands. It also can be associated with wet flood plains, or moist mountain slopes, although it may be adapted to somewhat drier conditions. However, it is usually restricted to zones with extra soil moisture such as cool, tropical highlands, and cool, high-latitude regions with abundant rainfall where mist and cloud cover can be a source of fog-drip precipitation. In tropical highlands of Central and South America, clouds and mist are important in supporting *Alnus acuminata* and grass, when associated, through the dry season.

Alnus acuminata prefers deep, well-drained soils with high organic matter content. However, it is commonly found growing on shallow soils, such as landslides. Rojas et al. (1991) report that it will grow in soil with pH as low as 4.5.

Wide-spaced Alnus acuminata in a Costa Rican pasture. Photo: Nancy Glover.

Uses

Timber. *Alnus acuminata* wood is light brown-yellow to pink, odorless, and tasteless, without differences between the heartwood and the sapwood. Reports on specific gravity vary from 0.34 to 0.39 (Tuk, 1980) and 0.5 to 0.6 (NAS, 1980). The calorific value is 19,250 kJ/kg (CATIE 1986). The wood dries easily and preserves well. It has even grain, seasons fairly well, and is easy to work and finish by hand or machine. Despite its light weight it is tough and strong, and is sometimes used for construction. Timber is also used for fuelwood, posts poles, light lumber, boxes, broom handles, domestic implements, plywood cores, particle board, and musical instruments. A match company in Colombia evaluated more than 20 native species and found *Alnus acuminata* wood best suited for making stick matches (Ing. R. Arismendi, Personal Communication).

This issue was prepared by Ricardo O. Russo, Professor of Silviculture, College of Apiculture for the Humid Tropic Region (E.A.R.T.H.), P.O. Box 4442-1000, San loss, Costa Rica.

Agroforestry. Farmers in Costa Rica have grown *Alnus acuminata* in pastures and as a shade tree for coffee crops for more than 90 years. Trees are regenerated naturally or planted from nursery stock at spacings of 8 to 14 m (about 100 trees/ha).

One benefit of including trees in cattle pastures is greater milk production--cows on pastures with *Alnus acuminata* produce more than cows on pastures without it (Budowski, 1983). Farmers in Costa Rica sometimes construct crude fences around individual seedlings to protect them from livestock. Protection is needed until trees grow tall enough that livestock can not browse new growth.

Silviculture

Propagation. *Alnus acuminata* is propagated by seeds (more than 2 million pure seeds/kg). Seeds are recalcitrant and must be planted quickly-viability decreases from 70% to 20% in a few months. Seed viability can be extended by storing seed in airtight containers at 5°C-viability is 50% and 31 % after 2 and 3 months, respectively (Rojas et al., 1991).

No seed pre-treatment is necessary. Rojas et al. (1991) recommend broadcasting seed in germination beds (15 to 20 g of seed per ml of bed) and covering them with a very thin layer of mixed soil and sand. The germination bed should be a 1:1:2 mixture of fine soil, sand and organic material. Seeds should be watered twice daily with a very fine mist to maintain soil humidity. Overwatering may cause damping-off. Germination starts 6 to 7 days after sowing and is complete within 15 days. The most vigorous seedlings should be transplanted to pots or back plastic bags 20 days after germination. Seedlings may be planted out when they are 20 cm tall (in about four months). Bare-root seedlings and stump cuttings are possible alternatives to container-grown seedlings. Seedlings do not compete well with weeds so frequent weeding is important (Rojas et al., 1991).

Management. *Alnus acuminata* is grown in plantations mainly in Colombia and Costa Rica, but in other countries as well. In Colombia, an initial spacing of 2.6 x 2.6 m (1,480 trees/ha) is common (Sieco Smit, 1971). In Costa Rica, an initial spacing of 3 x 3 m is preferred. At least two thinnings are recommended, the first after the third year and the second after 10 to 15 years, leaving 250 to 350 trees per hectare. Trees are harvested in rotations of about 20 years. Average annual wood production is 15 to 20 M^3 per hectare. According to Canet (1985), a stand of 30-year-old trees with a density of 35 trees/ha yielded 70 m3/ha of timber, 18.3 ton/ha of dry fuelwood, and 3.6 ton/ha of leaves and fine branches. *Alnus acuminata* resprouts vigorously from the stump after cutting.

Symbiosis

Alnus acuminata, like other *Alnus* species, forms a symbiosis with actinomycetes of the genus *Frankia*. Rojas et al. (1991) report that nodules begin to grow on 13-day-old nursery seedlings. Estimates of nitrogen fixation for *Alnus* species vary widely between 62 kg/ha/yr for *A. sinuata* in Alaska and 125 kg/ha/yr for *A. glutinosa* to 320 kg/ha/yr for *A. rubra* in Oregon (Carlson and Dawson, 1985). In a 2-year-old *A. acuminata* plantation in the Colombian highlands (1200 trees/ha), Carlson and Dawson (1985) estimate an annual increase in soil nitrogen of 279 kg/ha. Acetylene reduction values for 120-day-old *A. acuminata* greenhouse seedlings inoculated with a crushed nodule suspension were between 32.5 and 86.4 *p*mol of ethylene produced per gram of nodule dry weight per hour (Russo and Berlyn, 1988).

Pets and Deseases.

Alnus acuminata is susceptible to attack by defoliators (*Nodonota irazuensis* and *Nodonota* ca. *parvula*, Coleoptera, Chrysomelidae). A stem borer *Scolytoes alni*, (Coleoptera, Scolytidae) has been observed in Costa Rica during the dry season. Vertebrates such as *Sciurus* sp. (Rodentia, Sciuridae) may cause debarking and *Sylvilagus brasiliensis* (Lafomorpha, Leporidae) may destroy seedlings. Fungi such as *Fusarium* sp. and *Trichoderma* sp. may damage seeds; *Colletotrichum* Sp. and *Phomopsis* sp. may affect leaves; and *Rosellinia* sp. may affect stems and roots in mature trees (CATIE, 1991).

References

Budowski, G. 1983. An attempt to quantify some current agroforestry practices in Costa Rica. In Huxley, P.A. ed. *Plant Research in Agroforestry*. Nairobi, Kenya, ICRAF. Pp. 43-62.

Canet, G.C. 1985. Caracteristicas del sistema silvo-pastoril jaúl (*Alnus acuminata*) con lecheria de altura en Costa Rica. In R. Salazar ed. *Técnicas de producción de leña en fincas pequenas. Actas de los simposios.* CATIE, Turrialba, 24-28 de junio, 1985. pp. 241-249.

Carlson, PJ. and J.0. Dawson. 1985. Soil nitrogen changes, early growth, and response to soil internal drainage of a plantation of *Alnus jorullensis* in the Colombian highlands. *Turrialba* 35(2):141-150.

CATIE. 1986. *Silvicultura de especies promisorias para producción de leña en América Central.* CATIE, Turrialba, Costa Rica. p. 51.

CATIE- 1991. *Plagas y enfermedades forestales en América Central: guía de campo.* CATIE, Turrialba, Costa Rica. 185 p.

Furlow, JJ. 1977. Betulaceae.. In Burger, W. Flora Costaricensis. Fieldiana: *Botany* 40-56-58.

Furlow, JJ. 1979. The systematics of the American species of Alnus (Betulaceae). *Rhodora* 81(825):1-121.

Holdridge, L.R. 1951. The alder, *Alnus acuminata*, as a farm timber tree in Costa Rica. *Caribbean Forester* 12(2):47-57.

National Academy of Sciences. 1980. *Firewood crops: shrub and tree species for energy production* Vol. 1. National Academy of Sciences, Washington, D.C.

Rojas, F., G. Torres, E. Arnáez and I, Moreira. 1991. *Jaúl cuademos cientificos y tecnológicos, especies forestales tropicales*, No. 1. Instituto Tecnológico de Costa Rica, Cartago, Costa Rica. 9 p.

Russo, R.O. and G.P. Berlyn. 1989. The effect of a new growth biostimulant on acetylene reduction in modulated seedlings of *Alnus acuminata*. *Nitrogen Fixing Conference Abstracts*. Ames, Iowa. July 30-August 3, 1989.

Sicco Smit, G. 1971. Notas silviculturales sobre Alnus joti;;rmdods de Caldas, Colombia. *Turrialba* 21:83-88.

Tuk, J. 1980. *Informe general del proyecto: Clasificación y normalización de maderas para uso estructural..* Instituto Tecnológico de Costa Rica, Cartago, C.R.

NFT Highlights

NFT 90-06

A quick guide to multipurpose trees from around the world **November 1990**

Alnus nepalensis : A Multipurpose Tree For The Tropical Highlands

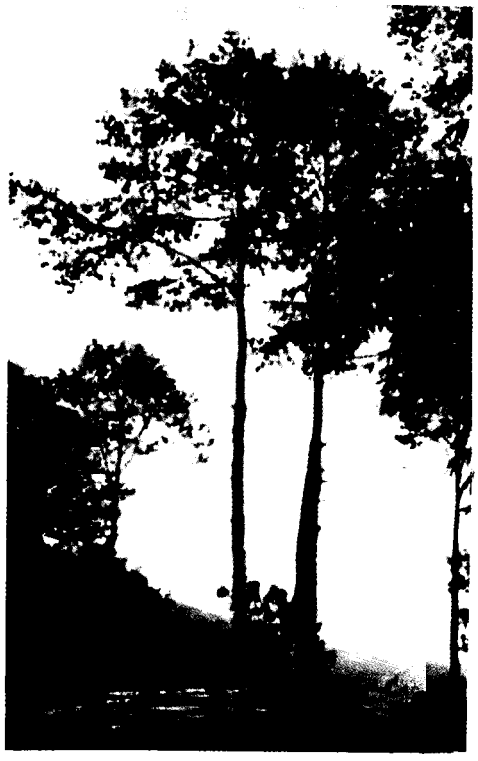
Alnus nepalensis D. Don. (Betulaceae) called utis in Nepal, maibau in Burma, and Indian or Nepalese alder in English, is one of 35 species of alder worldwide. *Alnus* is one of 15 genera of trees that fix nitrogen but are not in the legume family.

BOTANY. Utis is a deciduous or semideciduous tree with a straight trunk that reaches up to 30 m in height and 60 cm (rarely to 2 m) in diameter. The bark is dark green or grey, often with yellowish patches and short, raised lenticels. The leaves, which are frequently damaged by insects, are alternate, elliptical, 6-20 cm long, 5-10 cm wide, entire, denticulate or sinuate. The upper leaf surface is dull or shiny dark green, the lower is pale with dot-like, yehow-brown scales.

The narrowly cylindrical clusters of tiny flowers, or catkins, occur as male or female separately on the same or different twigs in autumn. Male catkins are yellow, 10-25 cm long, and hang in clusters at the end of twigs. Female catkins are much shorter, erect and woody, and occur on branching side twigs. The fruits, which superficially resemble cones of the pine family, are dark brown, upright on short stalks, elliptical, composed of many spreading, hard woody scales. Empty cones may persist on the tree. The seeds are light brown, circular and flat with two broad membranous wings, more than 2 mm across. Seeds ripen from November to March depending on geographical locality.

ECOLOGY. *A. nepalensis* occurs throughout the Hiinalaya at 500-3000 m elevation from Pakistan through Nepal, northern India, Bhutan and Upper Burma to southwest China and Indochina. It is found naturally in moist, cool or subtropical mountain monsoon climates, with an average annual rainfall of 500-2500 mm and a 4-8 month dry season. Mean annual temperatures range from 13-26°C. Soils tend to be moist and well-drained, varying from loam and loamy sand to gravel, sand, and clay. At lower altitudes particularly, utis occurs on moist sites, such as near rivers and in ravines, but it will colonize rocky sites exposed by landslips, or lands abandoned following cultivation. It occurs naturally in both pure and mixed stands.

Alnus nepalensis is a pioneer species and grows well in full light although it will also tolerate shade. It does not require high soil fertility, but prefers permeable soils and should not be planted on compacted or eroded soils. Utis grows well on soils with high water content, but not on waterlogged soils. It grows poorly on dry, exposed ridge-tops.



Open-grown Alnus nepalensis *in eastern Nepal. (Peter Neil)*

USES. Utis wood is moderately soft with densities of 320-370 kg/M^3 (NAS 1980) to 480-590 kg/m^3 (Lamichhaney 1984). Wood calorific value is low (18,230 kJ/kg - Hawkins 1982, or 20,480 kJ/kg - Webb et al. 1984), but utis wood, like that of other alders, dries rapidly and burns easily. Although not among the best construction timbers, utis has an even grain, seasons fairly well, and is easy to saw and finish by hand or machine. The wood preserves fairly well, but is perishable if subject to alternately wet and dry conditions. The wood is also subject to discoloration by oxidation and fungal sap stain. It is suitable for boxes, splints and matches (Dey and Ramaswami 1960) and for newsprint (Guha 1965).

The foliage is of low to moderate value as fodder. Mature leaves are eaten by sheep and goats, but not cattle (Panday 1982, Singh 1982). Leaves are also used as animal bedding. The tree's bark is occasionally used for tanning and dyeing (Little 1983).

Utis is well known as a species that gives some stability to slopes that tend to slip and erode. Seed has been broadcast to stabilize landslides. In Burma, *A. nepalensis* has been effectively used to reforest abandoned taungya areas (Troup 1921, NAS 1980).

Written by Peter E. Neil, Nepal-United Kingdom Forestry Research Project, Department of Forestry and Plant Research, P.O. Box 106, Kathmandu, Nepal. A full list of references for the highlight is available on request from NFTA.

Cardamom is planted under utis in eastern Nepal (including about 80% of cardamom plantations in Ilam District - Ghimire 1985). On terraced slopes in Nagaland State, India, *A. nepalensis* is commonly pouarded for poles and interplanted with crops such as maize, barley, chili and pumpkin (Zeliang et al. 1985). The trees provide fuelwood, green leaf manure, and help in soil conservation. Farmers in India cultivate utis on the berms (mounded earth borders) of crop fields (Kayasha 1985).

ACTINORHIZAL SYMBIOSIS. *Alnus nepalensis* forms a symbiosis with N-fixing actinomyeetes of the genus *Frankia*. Although the biochemistry and physiology of the 'alder-type' symbiosis with *Frankia* are not fully understood, cell-free preparations of nitrogenase have been obtained from, *Alnus* nodules (Postgate 1979). Studies in West Bengal indicated that nitrogenase activity was highest in young nodules irrespective of tree age and concluded that, *A. nepalensis* is capable of fixing significant amounts of nitrogen (Sharma and Ambast 1984). Sharma et al. (1985) investigating soil properties under five stands in the Eastern Himalaya found that total soil N increased with increasing stand age.

PROPAGATION. The species is readily propagated from seed (1.6 to 2.3 million seeds/kg, if pure). It is orthodox and will retain viability for at least a year if properly dried and stored in seated containers. No pretreatment is needed. Germination starts 1-2 weeks after sowing and is completed 2 weeks later. Transplanting into containers can begin 4-5 weeks after germination. Below 1200 m elevation seedlings should reach planting size (25-35 cm) in 4-5 months, but above this altitude they may take as long as 11 months (Napier and Robbins 1989). Young seedlings are liable to damage by ants and defoliation by frost and are very often killed.

Most planting is done with containerized seedlings, although bare-rooted seedlings have proven successful given proper lifting and handling and moist site conditions. Wildings (natural seedlings) have also been used successfully, especially on north-facing slopes. Direct sowing is an alternative. The seed must be fresh and have a high germination capacity. Ample quantities should be used, and the seed sown on exposed mineral soils. Good results are obtained when soil from under old trees is mixed with seed to facilitate even broadcasting and to introduce *Frankia*. Vegetative propagation has been unsuccessful (Lohani et al. 1980).

SILVICULTURE. *Alnus nepalensis* has a wider range of site tolerance than its natural distribution would suggest. It has been successfully established in plantations in a number of countries, mostly within its natural range, but also in Hawaii and Costa Rica. A spacing of 2.5 x 2.5 m is commonly used for plantations in Nepal, although a closer spacing is desirable for fuelwood crops. Poles and fuelwood can be harvested after five years on good sites.

Utis will coppice after cutting, but successful regrowth seems to depend on season and locality - wet season felling and moist localities being best. Small diameter timber can be harvested in less than 10 years. Longer rotations are needed for ordinary saw timber.

Actual growth rates of *A. nepalensis* vary considerably, particularly in response to differences in soil moisture. Recorded growth in Nepal's middle mountains - compares favorably with figures from West Bengal and Hawaii. A 9-year-old stand in Nepal had a mean annual increment in height of 2.7 m and in diameter at breast height of 2.9 cm. Corresponding figures for 10-year-old stands in West Bengal and 8.5-year-old trees in Hawaii were 1.7 m and 1.6 cm (Homfray 1937) and 0.7 m and 1.2 cm (Whitesell 1976), respectively. In Costa Rica a 3-year-old stand had a mean annual icrement in height of 2.3 m and in diameter of 3.6 cm (Palmer, cited in Lamichhaney 1984). Biomass and volume tables have been produced in Nepal.

PROVENANCES. Research in Nepal has shown local provenances to perform best at any given site. No provenances have proven to be of overall superiority (Lamichhaney 1984, Jackson 1987).

PESTS AND DISEASES. Utis is very susceptible to attack by defoliators (*Oreina* sp., *Anomala* sp.). The stem borers *Batocera* spp. (Webb et al. 1984) and possibly *Zeuzera* sp. (Jackson 1987) may also become pests. An aphid, *Eutfichosiphum alnifoliae*, is a pest of economic importance (Das and Raychaudhari 1983).

PRINCIPAL RFFERFNCES:

Ghimire, M.P. 1985. Growing *Alnus* trees over cardamom plantations for fuetwood in Ilam District. Community For" Development Project, occasional Paper No. 9, FAO/UNDP/HMG, Nepal.

Jackson, J.K. 1987. Manual of afforestation for Nepal. Nepal UK Forestry Research Project, Kathmandu, Nepal.

Lamichhaney, B.P. 1984. Variation of *Alnus nepalensis* D. Don in Nepal. Unpublished M.Sc. thesis, Oxford University, UK.

Little, E.L. Jr. 1983. Common fuelwood crops. A handbook for their identification. Comniuni-Tech Associates, McClain Printing Company, USA.

Napier, I. and M. Robbins. 1989. Forest seed and nursery practice in Nepal. Nepal-UK Forestry Research Project, Kathmandu, Nepal.

NAS. 1980. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, D.C. p. 78-79.

Postgate, J. 1979. Nitrogen fixation. The Institute of Biology, Studies in Biology No. 92. Arnold, London.

FACT Net

FACT Sheet

A quick guide to multipurpose trees from around the world

FACT 96-02
January 1996

Andira inermis : More Then A Beautiful Ornamental Tree

Andira inermis (Sw.) Kunth ex DC (Berendsohn 1989) is a nitrogen fixing tree that is commonly grown as an ornamental. It has a handsome spreading crown, evergreen foliage, showy pink flowers and responds easily to management. In El Salvador it is known as almendro de río or river almond because its fruits are similar to the fruits of *Terminalia catappa* (beach almond). *Andira inermis* is a multiple use tree that has not been extensively used in agroforestry or other reforestation programs because of relatively slow growth rates; however, it offers refuge for wildlife year-round and could be used as fodder for ruminants and other domestic animals.

Botany

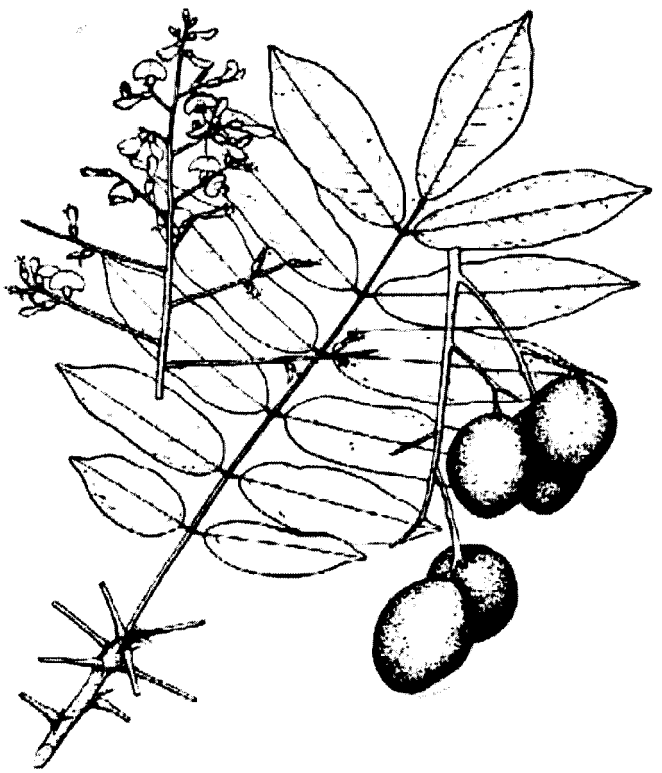
This tree is a legume that belongs to the Papilionoideae sub-family. It grows to 35 m in height and more than 90 cm in diameter (Allen and Allen 1981, personal observations). It has pink flowers in racemes that are self-incompatible and outcrossers (Bawa 1974). It has a dense and spreading crown with bright tan young leaves and shiny green mature leaves with entire margins. Leaves are pinnately compound with 7 to 17 leaflets. The stem has a rough outer surface. It has a drupe-like fruit with one seed that does not open at maturity, an exception among the legumes (Witsberger et al. 1982, Little and Wadsworth 1964). In the Pacific plains of Guatemala, the trunk frequently forms buttresses up to 3 m tall (Standley and Steyermark 1964).

Synonyms include *Andira jamaicensis* (W. Wright) Urban and *Geoffroya inermis* W. Wright (Little and Wadsworth 1964).

The number of common names that *Andira inermis* has is related to its widespread distribution, many uses and botanical characteristics. Names include Almendro de río (river almond) and almendro macho in El Salvador, Guacamayo in Honduras, carne asada in Costa Rica, moca blanca in Puerto Rico, and cabbage angelin, partridge wood or cabbage bark in the United States (Witsberger et al. 1982, Little and Wadsworth 1964).

Ecology

Andira inermis is found in riparian zones, along rivers and in areas with a high water table. It grows in alluvial forests in Central America but may be found in drier areas. It is found along roadsides, river banks, woodlands and pastures, from sea level to 900 m above sea level (Witsberger et al 1982)



Andira inermis. From: Witsberger et al. 1982

Little and Wadsworth 1964). It requires low light for establishment and high light for development. It is an evergreen tree with the foliage continually being replaced throughout the year, especially before flowering (personal observations). In Puerto Rico, two flowering seasons are observed, one between January and February and the second one, between May and September (Little and Wadsworth 1964). In Barro Colorado Island, Panamá, trees may flower for nine months under suitable moist conditions (Croat 1978). This pattern is also observed in trees growing in urban areas in El Salvador where trees flower between December and July (personal observations).

Distribution

Andira inermis is native from southern Mexico to Peru, Bolivia and Brazil. It has been introduced in the Antilles, Caribbean islands, Florida and Africa (Witsberger et al. 1982).

Written by Nadia Evelyn Navarrete, Graduate Research Assistant, Department of Plant Biology, Southern Illinois University, Carbondale, IL 62901 - 6430

Uses

Landscaping. Planted in parks and yards *Andira inermis* is a very attractive tree with a dense, spreading crown, showy pink flowers and bright colored leaves.

Agroforestry. It is used as a shade tree in coffee plantations because it has a spreading crown and responds well to pruning (Witsberger et al. 1982).

Wildlife. Bats eat the fruits. Flowers are visited by bees, birds, and butterflies (Allen and Allen 1981; Janzen 1976; Little and Wadsworth 1964).

Forage. Preliminary studies by scientists at the University of El Salvador showed that the foliage is edible and palatable for ruminants. Research is now being done with rabbits (Jacob Palacios, personal communication).

Wood. The wood is very hard, heavy (0.77g/cm^3), and very resistant to attack by fungi and termites (Guzmán 1947; Little and Wadsworth 1964; Behrendt et al. 1968; Allen and Allen 1981). *Andira inermis* lumber has been used for bridges, railroad tracks and waterfront docks and also to make furniture, billiard-cues, umbrella handles and boats (Little and Wadsworth 1964).

Other uses. The bark is reported to have vermifuge, purgative and narcotic properties (Guzmán 1947). Prunings from shade trees in coffee plantations are good firewood. In the wild, this tree also offers a suitable environment for some plant epiphytes like orchids, bromeliads, mosses and ferns. In conservation programs, it has been used to restore degraded watersheds where moist conditions are prevalent (El Salvador Forest Service, personal communication).

Silviculture

Propagation. Mature fruits are collected and kept under cool conditions. The hard seeds need to be scarified before planting. The El Salvador Forest Service recommends making a cut on the hard fruit endocarp with a file and then planting them in seed beds or plastic bags.

A recent seed treatment study for *A. inermis* compared seeds that were scarified with a file; placed in hot water at two temperatures (70°C and 80°C) for 5, 10, and 15 seconds; or non-treated (Navarrete and Orellana, unpublished).

Seeds started to germinate at week five. Maximum germination for all treatments was observed at week 16. Germination was 43% to 56% for all treatments. The lowest germination recorded was 43% and 46% from seeds at 80°C for 15 seconds and non-treated control, respectively.

Establishment. One-year-old plants, 50 cm tall or more, can be transplanted during the rainy season. *Andira inermis* can also be direct seeded. Two or three seeds, per site, are planted directly in the field (El Salvador Forest Service, personal communication).

Management. In the field, little or no management is done. Occasionally lower branches are pruned to induce faster growth and a straight trunk. In landscaping, top branches are pruned to control height growth.

Symbiosis

Allen and Allen (1981) reported nodulation of *A. inermis* in Hawaii. In Brazil, Faria et al. (1987b, 1986) found that *A. inermis* and six more *Andira* species showed nitrogenase activity with the acetylene reduction assay. They also report that isolated rhizobial strains showed an infective-host range within the cowpea miscellany.

Limitations

Andira inermis does not grow well in areas with a marked dry season. It grows very slowly even with suitable moist conditions (Little and Wadsworth 1964). Bark and seeds are reported to be poisonous (Guzmán 1947).

Processed wood is attacked by borer insects when used under saltwater (Behrendt et al. 1968). Fruits are attacked by the weevil, *Cleogonis* sp. (Janzen 1976) with possible effects on seed germination.

Related Species

There are approximately 30 *Andira* species distributed in Tropical America and one in Africa (Pennington 1995). Some important species in Brazil are *A. racemosa* Lam., *A. fraxinifolia, A. nitida* Mart., *A. frondosa, A. legalis* and *A. anthelmia* (Vell.) Macbr. (Faria et al. 1987a, 1987b, 1986). *Andira galeothiana* Standl. and *A. vermifuga* Mart. are used as fish poison, vermifuge, narcotic or vomiting agents. *Andira retusa* HBK and *A. inermis* yield the alkaloids berberine and angelin. *Andira araroba*, is the source of a fungicide (chrysarobin) used to treat skin diseases (Allen and Allen 1981).

Research Needs

Studies are needed to determine the amount of nitrogen *Andira inermis* provides to crops in agroforestry systems. Provenance and propagation studies are also needed.

Selected References

Behrendt, G., J.D. Brazier., and G.L. Franklin. 1968. Maderas nicaraguenses. Características y usos potenciales. FAO y Min. de Ag. y Ganaderia. Honduras. pp 21-22.

Berendsohn, W.G. 1989. Listado básico de la flora salvadorensis. Dicotoyledonae. Familia 118:Leguminosae. Cuscatlania (El Salvador) I(2):118-8.

Faria. S.M., J. Sutherland, and J. Sprent. 1986. A new type of infected cell in root nodules of *Andira* spp. (Leguminosae). Plant Science 45:143-147.

Guzmán, D.J. 1947. Especies útiles de la flora salvadoreña. Médico-agrícola-industrial. Imprenta Nacional. San Salvador, El Salvador. p.506.

Little, E.L. and F.H. Wadsworth. 1964. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No.249. USDA Forest Service. p.188-190.

Witsberger, D., D. Current, and E. Archer. 1982. Arboles del Parque Deininger. Ministerio de Educación, El Salvador. p. 146-147.

For a complete set of references write to the FACT Net. The author acknowledges the assistance of the Facultad de Ciencias Agronómicas, Universidad de El Salvador.

FACT Sheet

FACT 97-05
A quick guide to multipurpose trees from around the world September 1997

Azadirachta indica : Neem, A Versatile Tree For The Tropic And Subtropics

Azadirachta indica A. Juss. is widely known as neem, a tree that has proven value to both city and farm dwellers throughout the dry tropics and subtropics. Neem has long been recognized as a versatile multipurpose tree for urban regreening, agroforestry, fuelwood production, and for a variety of other products, including biopesticides. *Azadirachta indica* is a member of the Meliaceae (mahogany) family. It has been referred to in the past by the botanical names, *Melia indica* and *M. azadirachta*, which is perhaps why it is sometimes confused with a related species, *Melia azedarach* (chinaberry). The tree is also known as nim, margosa, limba, mimba, nimba, kohomba, and Indian lilac.

Botany

Neem is a small to medium-sized tree, with a short, straight bole. The stem branches at 2-5 m forming a broad, dense, round or oval crown. Total height is 15-25 m, occasionally reaching up to 30 m, with a stem diameter ranging from 30 to 90 cm. Neem is characterized by a long, penetrating lateral root system, which can extend up to 15 m, with a relatively short taproot. Neem has moderately thick, fissured, gray outer bark, with a reddish-brown inner bark. It is evergreen or deciduous depending on the climate; leafless periods are usually brief, occurring during extended drought. Leaves are alternate, imparipinnately compound, 20-38 cm and bunched at the tip of branches. The tree produces many small, sweet-scented, white or cream-colored, bisexual flowers. The fruit is a smooth, ellipsoidal drupe, 1.2-2.0 cm long, containing usually one seed. The fruit is initially green and turns yellow as it ripens in about 12 weeks after full bloom. Neem trees are prolific fruit producers, starting as early as 3-5 years, and becoming fully productive at 10-12 years.

Ecology

Neem adapts to a broad range of climate and soil conditions. It is normally found at elevations between sea level and 700 m. Neem can grow at altitudes up to 1500 m, as long as temperatures remain moderate, as it does not withstand cold or frost. Neem tolerates extremely high temperatures, but its normal range is about 9.5°C - 37°C. It is also highly drought tolerant, and once established, it can survive 7-8 month dry seasons. It requires as little as 150 mm rainfall per year in areas where the root system can access groundwater within 9-12 m of the surface, however, it performs best in zones receiving 450-1200 mm/year. Neem prefers deep, permeable, sandy soils, but can be planted in a wide variety of soil types, including difficult sites where most other species do not perform well. It can thrive on rocky, dry, shallow, infertile soils, but is not recommended for silty or micaceous loams, silty clay soils, saline soils, or where sub-surface hardpan or laterite outcroppings occur (NRC, 1992). Neem should also not be planted on sites where soils become waterlogged or seasonally inundated. It prefers a soil pH in the 6.2-7.0 range, but can grow within a range of 5.0-8.0 pH.

Leaves, seed and flower. Source: Parkar, 1933

Mature neem trees are light demanding, but seedlings tolerate moderate shade during their first growing season, especially on dry sites.

Distribution

Azadirachta indica is indigenous to South Asia, possibly originating in northern Myanmar and the Assam region of India. Neem's natural habitat is dry, deciduous, mixed forest, occurring in association with *Acacia* spp. and *Dalbergia sissoo* (Lemmens *et al*, 1995). It is widespread in India, Pakistan, Myanmar, Sri Lanka, Thailand, Malaysia and Indonesia. Neem has been introduced and established throughout the tropics and subtropics, especially in drier areas in Southeast Asia, the Pacific Islands, Australia, South and Central America, the Caribbean, sub-Saharan Africa, and the Middle East.

Uses

Agroforestry and urban forestry. Neem plays an important role in both urban and rural landscapes. Its well-formed crown and short deciduous period has made it a popular choice for shade plantings around buildings and along roadsides. It is also used on farms as a pasture tree to shade livestock and in boundary rows. Neem is not usually selected for hedgerows or alley cropping, but is used in windbreaks and shelterbelts to protect crops from wind damage and soils from erosion.

Wood products. Neem produces a moderately dense wood, somewhat similar to mahogany. The wood has a specific gravity of 0.52-0.85, averaging 0.68 (NRC, 1992). The heartwood portion is reddish to reddish-brown, while the sapwood has a yellowish-gray or grayish-white color. The wood is hard, durable, dull to somewhat lustrous, aromatic and resistant to insects and fungi. The wood dries with only slight shrinkage, seasons well, and is easy to work, but the rough, interlocked grain does not take a high polish. Neem sawtimber is used in light construction, and to make beams, door and window frames, boxes, crates, carts, axles, yokes, cabinets, panels, boats, oars, cigar boxes, carvings, toys, drums, and agricultural implements. It is also used for furniture, especially wardrobes, book cases, and closets, because the wood repels insects.

Written by Carol Stoney, Program Officer, Winrock International.

Neem trees are often managed under pollarding or coppicing systems to produce posts and poles. The roundwood is also used as fuelwood and makes very good charcoal. At 14% moisture content the wood gives an energy value of 16.92 megajoules/kg (Lemmens, 1995).

Non-timber products. Useful products can be harvested from almost every part of the neem tree. The bark produces tannins, a fiber used to make rope, and a resin used to make glue. Bark is used medicinally as a remedy for fever, and fruit pulp is also used as a tonic. Leaves are used as mulch and green manure, and can also be used as fodder. The leaves have a crude protein content of 12-18%, but because they have a bitter taste, livestock usually prefer other foods. Neem leaves mixed in with stored grain have traditionally been used in India to repel insects and prevent food and seed losses.

Azadirachtin. The principal active compound in the leaves is azadirachtin, which repels pests, acts as an antifeedant, and disrupts insects' growth and reproduction. Several bioactive compounds are found in the leaves and other tissues, however, the neem seed kernels are the main source of azadirachtin. Neem seed contains the most concentrated and accessible amounts of other potentially useful compounds as well. Neem-based pesticides have already been approved for various applications and are being produced commercially in several countries. Low-tech methods have also been developed to produce neem extracts. These methods will be described in a future *FACT Sheet.*

Neem oil and neem seed cake. Neem seeds will yield 40-50% oil when the dry kernels are crushed or pressed through an oil mill. Neem oil is used as fuel for lamps, an antiseptic for animal wounds, a lubricant for machinery, an insect repellent, to remove tobacco suckers, and in the production of soap, toothpaste and cosmetics. It has also traditionally been used for a variety of medicinal purposes, but there is evidence that it should not be ingested orally. Neem oil may also have potential in the development of pesticides and fungicides, although it does not contain azadirachtin (NRC, 1992). Neem seed cake is the residue left after the oil has been extracted from the kernel. Neem cake is used as a fertilizer with insecticidal and fungicidal effect.

Silviculture

Propagation. Neem seedlings can be produced vegetatively by air layering, cuttings, grafting and tissue culture, however, they are usually grown from seed in nurseries as bare-root stock or in containers. Direct sowing is more cost-effective, but may result in poor survival in drier zones. Neem wildlings are an inexpensive source of seedlings, as natural regeneration is normally abundant. Although neem is a prolific seed producer, seed supply is frequently a problem. The viability of fresh seed decreases rapidly after two weeks, and improperly stored seeds have low germination rates. Ripe seed should be collected from the tree and processed immediately. First the pulp is removed and the seeds are washed clean. Seeds are air dried for 3-7 days in the shade, or until the moisture content is about 30%. They can then be stored for up to four months if kept at 15°C. Seed will remain viable even longer if dried to 6-7% moisture content and refrigerated in sealed containers at 4° C.

Sow seed in nursery beds in rows 15-25 cm apart, and 2.5-5 cm spacing within the rows. Seedlings can be pricked out when two pairs of leaves have developed (1-2 months), or the rows should be thinned to 15 cm x 15 cm spacing.

Plastic pots are commonly used to produce neem seedlings, although rigid container systems are used in Haiti with success. Seeds should be sown horizontally at a depth of 1 cm. Fresh seeds will have the highest germination rate, and seedlings will emerge within in 1-3 weeks. Removal of the seed coat may increase germination rates for stored seeds. Both bare-root and containerized seedlings should be raised under partial shade for the first 1-2 months, or until about 30 cm tall, then gradually exposed to full sunlight.

Bare-rooted seedlings are usually kept in the nursery for 1-2 years before outplanting. The roots and shoots of seedlings lifted from nursery beds should be pruned before transplanting. Bare-rooted seedlings can also be prepared for stump planting. Stumps are made from 1-2 year old seedlings by trimming the root to 20-22 cm root and the shoot to 5 cm. Containerized seedlings should be outplanted after 3-4 months in the nursery, when they reach 30-50 cm. Fuelwood plantations are laid out at a 2.5 m x 2.5 m spacing, and then later thinned to 5 m x 5 m. The recommended spacing for windbreaks is 4 m x 2 m. Neem trees managed to maximize fruit yield should be more widely spaced to allow the crown to develop fully.

Management. Young seedlings suffer from weed competition, but weed control is usually only needed during the first growing season. Neem seedlings should also be protected from fire, although mature trees can recover from fire damage. Once the root system is well-established, early growth is rapid for about five years, then slows gradually. Neem responds well to coppicing and pollarding to produce poles, posts, or fuelwood. Coppicing to produce fuelwood is managed on a 7-8 year cycle. Pollarding is used to manage windbreaks, and to produce posts. Yields vary greatly depending on site conditions, but fuelwood production reports range from 6-57 m^3/ha/year.

Limitations

Azadirachta indica has few serious pests or diseases. The most serious insect pests are scale insects, including the neem scale (*Palvinaria maxima*) and the oriental yellow scale (*Aspidiotus orientalis*), both of which can cause considerable damage. The oriental yellow scale has been associated with a widespread neem defoliation in West Africa in the mid-eighties, although severe drought may have previously weakened the trees (NRC, 1992). In the early 1990's another neem die-back in West Africa was reported. This was at first thought to be caused by a soil fungus, but after several years of observation, no specific pathogen or pest was identified. The cause of the disorder is now believed to have been stress-related due to low soil moisture brought on by extended drought and soil compaction.

Selected References :

Lemmens, R.H.M.J.; I. Soerianegara and W.C. Wong (Eds.), 1995. *Plant Resources of South-East Asia* No 5(2). Timber trees: Minor commercial timbers. Backhuys Publishers, Leiden. 655 pp.

National Research Council, 1992. *Neem: A Tree For Solving Global Problems*. National Academy Press, Washington, D.C.

Randhawa, N.S. and B.S. Parmar, 1993. *Neem Research and Development*. New Delhi: Society of Pesticide Science, India.

Read, Michael D. and James H. French, eds. 1993. *Genetic Improvement of Neem: Strategies for the Future*. Proc. of the International Consultation on Neem Improvement held at Kasetsart University, Bangkok, Thailand, 18-22 January, 1993. Bangkok, Thailand: Winrock International. 194 + x pp.

FACT Sheet

A quick guide to multipurpose trees from around the world

FACT 98-01
January 1998

Azadirachta indica : Use of neem as a Biological Pest Control agent

The neem tree (*Azadirachta indica*) has been introduced and established throughout the tropics and sub-tropics for its highly valued hardiness, its almost year-round shade, and its multiple wood and non-wood products. Agroforesters have promoted it for use in windbreaks, fuelwood plantations, and silvo-pastoral systems, especially for dry zones and infertile, rocky, sandy or shallow soils. People have long recognized that the leaves, bark, wood and fruit of the neem tree either repel or otherwise discourage insect pests, and they incorporated these plant parts into traditional soil preparation, grain storage, and animal husbandry practices. Through more recent chemical analysis the active compounds in neem tissues have been identified. Several neem-based biological pest control (BPC) products have been developed and approved for commercial distribution in some countries. The neem tree can provide an inexpensive integrated pest management (IPM) resource for farmers, the raw material for small rural enterprises, or the development of neem-based industries.

Neem's active ingredients and their impact on pests

Azadirachtin has been identified as neem's principal active compound. It acts on insects by repelling them, by inhibiting feeding, and by disrupting their growth, metamorphosis and reproduction. Neem-based formulations do not usually kill insects directly, but they can alter their behavior in significant ways to reduce pest damage to crops, and reduce their reproductive potential. Azadirachtin affects insect physiology by mimicking a natural hormone. It has been shown to affect egg production and hatching rates. In larvae, azadirachtin can inhibit molting, preventing them from developing into pupae.

Many foliage feeding species will avoid plants treated with neem compounds or will cease eating after ingesting them (NRC, 1992). Its has proven effective as an antifeedant on about 100 insect species (Read & French, 1993). Thus, the extracts work especially well to protect plants from defoliation without affecting beneficial pollinating insects like honeybees.

Overall tests of neem extracts have shown results on about 300 insect species, mostly in the Orthoptera (grasshoppers, katydids, etc.); Homoptera (aphids, leafhoppers, etc.); Dictyoptera (cockroaches and mantids); Lepidoptera (moths and butterflies); Heteroptera (true bugs); Diptera (flies); Coleoptera (beetles and weevils); Hymenoptera (bees, wasps and ants); Isoptera (termites); Thysanoptera (thrips), and Siphonaptera (flea) orders (NRC, 1992; Randhawa and Parmar, 1993).

Even crudely produced neem extracts can provide excellent control of caterpillars and beetle larvae, and are effective on grasshoppers, leaf miners, and leaf and plant-hoppers. Commercially produced neem preparations can suppress a broad range of pests including insects, centipedes, millipedes, mites, and nematodes.

Traditional uses of neem

Farmers have traditionally used various components of the neem tree such as oil extracted from the seed, neem cake, (the residue left after pressing the oil) and the leaves as well as the wood. Farmers in India use neem cake as an organic manure and soil amendment. It is believed to enhance the efficiency of nitrogen fertilizers by reducing the rate of nitrification and to inhibit soil pests including nematodes, fungi, and insects (Gupta, 1993). Neem leaves and small twigs are also used as mulch and green manure.

Neem leaves and neem oil have also been used traditionally to protect stored grains and legumes. Neem leaves are mixed with the grain in storage or the grain is stored in jute bags treated with neem oil or other neem extracts. These methods can protect food and seed stores from insect pests for several months.

Another traditional agricultural practice involves the production of "neem tea." The seeds are dried, crushed and soaked in water overnight to produce a liquid pesticide that can be applied directly to crops. Crushed seed kernels are also sometimes used as a dry pesticide application, especially to control stem borers on young plants. These home-made remedies are often very effective at repelling pests or acting on insects as a feeding deterrent, even if they do not actually kill them. The strength of home-made preparations can vary due to the concentration of azadirachtin and other compounds in the seed, which can in turn depend on the genetic source of the seeds. It can also be affected by the process of handling and drying the seeds, contaminants in the water, and exposure to high temperatures or sunlight. The active compounds break down quickly, so an application of neem tea can generally provide protection for only about one week.

Neem is a species of the Mahogany family, and although it has some of the characteristics of a cabinetry wood, its grain is rough and does not polish well. Neem wood is, nevertheless, used to make wardrobes, book cases and closets, as well as packing cases because the wood helps to protect the contents from insect damage (Read & French, 1993). The main stem of the tree is also widely used to make posts for construction or fencing, because the wood is termite resistant.

Written by Carol Stoney, Program Officer, and Erin Hughes, Program Associate, Winrock International

Farm-level production and use of neem extracts

Farmers with ready access to seed producing neem trees can prepare their own "neem tea" using simple procedures to extract the active compounds. Ripe seeds should be collected from the trees, and the seeds should be depulped, washed clean and dried as soon as possible after harvesting. Seeds should be dried in the shade for 3-7 days. Seeds should be checked, and any that have been contaminated by mold or fungus should be rejected. The dried seeds are then finely crushed in a mortar or mill. About 500g crushed seeds should be mixed with 10 liters water and the mixture should be left to sit overnight. The next day the mixture should be filtered through fine cloth or gauze. It is then ready to be applied directly to crops using a spraying, brush or swab technique. The mixture should not be applied more than once a week, and treatments every 10-15 days is usually adequate for control of normal pest problems. Unused extract should be carefully stored in a closed container in a cool dark protected area (GTZ, n.d.).

Neem extracts can be made from leaves and other tissues, but the seeds contain the highest concentrations of azadirachtin. Industrial scale extraction processes use solvents such as alcohol, ether, and hydrocarbons instead of water. Some sources claim that the waterbased extracts work nearly as well, although using the method described above it is difficult to determine the concentration and therefore the appropriate amount to be applied. In Pakistan a process of freeze drying the water-based neem extract produces a crystalline powder called "neem bitters" that is water soluble (Read & French, 1993).

Small-scale processing for use in rural enterprises

Although efforts have been undertaken by NGOs to promote neem-based micro-enterprises in rural areas to increase employment opportunities, few have succeeded. Challenges they have faced include difficulty in producing uniform concentrations; problems with packaging, storage, and transportation; and lack of information about potential markets. These are common constraints to the development of small agro-enterprises and probably can be overcome. Neem-based enterprises have special potential where it is possible to reach producers who have a market for organic produce and in areas where commercially distributed pesticides are unavailable or too expensive for the average farmer to afford.

Commercial uses of neem

Neem oil has long been produced in Asia on an industrial scale in soaps, cosmetics, and pharmaceuticals. During the 1980s companies began commercial production and distribution of pest control formulations that use azadirachtin as the principal active ingredient. Interest in BPC agents has developed along with the environmental and consumer rights movements, and the recognition that IPM strategies are needed to sustain agricultural production. New markets for organically grown produce and "natural" products also spurred the development of the BPC industry, and azadirachtin was among the first to be commercialized.

In the United States neem-based BPCs were first approved for use on non-food crops in 1985. After subsequent testing, the Environmental Protection Agency (EPA) regulated the use of Dihydroazadirachtin (DAZA), a reduced derivative of azadirachtin, for use on food crops. In 1996 the EPA exempted raw agricultural commodities from meeting DAZA residue requirements, as long as the chemical is applied as an insect growth regulator or antifeedant at no more than 20gms/acre with a maximum of seven applications per growing season (EPA, 1997). The EPA only allows this exemption if approved commercial products are used; food products treated with home-made extracts would not meet these requirements.

Environmental issues

Neem compounds do not persist or accumulate in the environment after being applied as pesticides. They break down quickly when exposed to sunlight, usually within one week. Commercial preparations contain sunscreens which maintain their effectiveness for 2-3 weeks. Neem extracts may have toxic effects on fish, other aquatic wildlife, and some beneficial insects. Therefore, care should be taken in disposing of any unused extracts, by exposing them to heat or sunlight to break down the active compounds.

Neem fruits are an important source of food for some wildlife, especially birds and bats, although they only digest the pulp, not the seed. Neem compounds have been judged to be relatively non-toxic to mammals. Azadirachtin is so effective against insects, because it imitates a naturally occurring hormone that disrupts insect life cycles, however, this hormone does not occur in vertebrates. The United States EPA has concluded that if approved procedures for its application are followed that, "no unreasonable adverse effects to human health are expected from the use of DAZA" and "there is a reasonable certainty of no harm from dietary exposure" (EPA, 1997). Neem oil has been used traditionally as a topical treatment for skin symptoms in both humans and livestock, but it should not be injested orally.

Issues for research

Researchers believe that even modest efforts at genetic improvement could result in higher seed yields, higher levels of azadirachtin, and other useful compounds in the seed. Management of neem plantations for BPC production will require research to determine appropriate silvicultural practices, such as tree spacing, pruning or lopping to promote seed production, as well as possibilities for intercropping within the plantations. More research is also needed on the other bioactive compounds found in neem and on how they interact to repel or deter insect predators. Some of these also have shown anti-fungal and anti-viral properties. Farmers need better methods for preparing neem extracts to ensure uniform concentrations and quality. They also need better information about how to apply the extracts to maximum effect on different insect species at different life cycle stages. Long-term environmental impacts of the use of neem-based BPCs should be monitored and assessed.

An introduction to neem botany, ecology, distribution, uses, silviculture, and management is provided in FACT-Net's FACT Sheet 97-05: *Azadirachta indica: neem, a versatile tree for the tropics and subtropics* (September, 1997). Key references for this FACT Sheet include:

Selected References

Bunders, Joske; Bertus Haverkort, and Wim Hiemstra (eds.), 1996. *Biotechnology: Building on Farmers' Knowledge.* London: MacMillan Education Ltd.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), not dated. *Neem a Natural Insecticide.* 34 pp.

Gupta, R.K., 1993. *Multipurpose Trees for Agroforestry and Wasteland Utilization.* International Science Publisher, New York, NY.

National Research Council (NRC), 1992. *Neem: A Tree For Solving Global Problems.* National Academy Press, Washington, D.C.

Randhawa, N.S. and B.S. Parmar (eds.), 1993. *Neem Research and Development.* New Delhi: Society of Pesticide Science, India.

Read, Michael D. and James H. French, eds. 1993. *Genetic Improvement of Neem: Strategies for the Future.* Proceedings of the International Consultation on Neem Improvement held at Kasetsart University, Bangkok, Thailand, 18-22 January, 1993. Bangkok, Thailand: Winrock International. 194 + x pp.

United States Environmental Protection Agency (EPA), 1997. Pesticide Fact Sheet.

NFT Highlights

NFTA 88-06

A quick guide to useful nitrogen fixing trees from around the world November 1988

Cajanus cajan : It's More Than Just A Pulse Crop

A variety of cultivars and the many ways they can be used in farming systems have made pigeonpea (*Cajanus cajan*) popular to small scale farmers. It is the major pulse crop of the semiarid tropics, has been used for centuries in intercropping systems, and is an ideal source of fodder, food and firewood in agroforestry systems.

BOTANY

C. cajan (L.) Millsp. is a leguminous shrub that can attain heights of 5 m. Pigeonpea probably evolved in South Asia and appeared about 2000 BC in West Africa, which is considered a second major center of origin. The slave trade took it to the West Indies, where its use as bird feed led to the name "pigeonpea" in 1692 (van der Maesen 1986). Leaves are trifoliate and spirally arranged on the stem. Flowers occur in terminal or axillary racemes, are 2-3 cm long (Purseglove 1968), and are usually yellow, but can be flocked or streaked with purple or red. Pods are flat, usually green in color, sometimes hairy, sometimes streaked or colored dark purple, with 2-9 seeds/pod. Seeds are, widely variable in color, 6-9 nun in diameter, and weigh 4-25 g/100 seed (Sheldrake 1984). *C. cajan* was long considered to be one of two species (with a minor W. African species) of the genus *Cajanus* DC. However, this genus is now thought to be congeneric with *Atylosia* and *Endomallus*, and also includes species of *Rhynchosia* and *Dunbaria* (van der Maesen 1986). *Cajanus* is now recognized as having 32 species.

ECOLOGY: Pigeonpea is hardy, widely adaptable, and more tolerant of drought and high temperatures than most other crops. It grows on acid sands in the Sahel and alkali clays in India. Frost or excessive soil salinity are not tolerated. and waterlogging for 3-4 days severely reduces yields (Chauhan 1987). Various cultivars are grown from sea level to 3,000 in.

USES: **Food**. Pigeonpea is best known as a human food. Short duration shrubby varieties such as ICPL 87 can yield 5-8 t/ha of grain when grown as sole crops (Reed 1987). In India, decorticated, split dried peas (dam) are an important protein source. Dahl is 25% protein and has a good balance of all amino acids except methionine and cystine, which are slightly deficient for the human diet (Faris et al. 1987). Some anti-nutritional factors are present, but are destroyed by cooking. In the Caribbean and East Africa, pigeonpeas are eaten green as a vegetable and are commercial grown and canned in the West Indies. Vitamin A (470 mg/100g) and C (25 mg/100g) contents of vegetable pigeonpeas are five times those of green peas (Faris et al. 1987). When grown as a perennial, pods may be picked ripe or green for a long time. The vegetable line ICPL24 produced 11 t/ha of green pods in five pickings in Gujarat, India (Faris et al. 1987).

Animal feed. Pigeonpea is an excellent fodder species. Crude protein values of fresh forage range from 15-24% (Whiteman and Norton 1981). Its exceptional nutritional value and high productivity can give good liveweight gains. In Hawaii, Henke et al. (1940) reported cattle weight gains of 280 kg/ha/yr in pure pigeonpea compared with 181 kg/ha/yr in mixed grass pastures over a 6.5 mo grazing period. Foliage is retained well into dry seasons. Although forage production depends on the stage of the crop, growing conditions, and management, experimental yields exceeding 50 dry tons/ha/yr have been reported in intensively managed cut and carry sole stands (Whiteman and Norton 1981). Under less intensive management, 3-8 dry t/ha/yr can be expected. Poor early growth makes it unable to compete well in mixtures with grasses. Grain, whole pods, and milling trash have been proposed as a substitute for soybeans and maize in poultry and pig feed, but deficiencies in some amino acids and antinutritional factors may limit its suitability unless expensive additives or processing are used (Wallis et al. 1986).

Wood. Pigeonpea sticks are an important household fuel in many areas. Productivity more than makes up for comparatively poor fuel characteristics (low specific gravity and high moisture content). Stick yields of 7-10 dry t/ha/yr are routinely reported for medium and early duration lines, and yields of 30 t/ha/yr from irrigated, early duration varieties have been reported in India (ICRISAT 1986). Perennial varieties can produce 10 t/ha/yr of dry material over a 2-3 year period on good sites. Sticks also produce thatch and basket materials.

Other Uses. Pigeonpea is nodulated with *Rhizobium* of the cowpea type and is an effective green manure crop. Whiteman and Norton (1981) recommend incorporating high density plantings at or about the time of flowering. When allowed to perennialize, pigeonpea can drop 1.6 dry t/ha/yr of litter in the first year (Sheldrake and Narayanan 1979). It is used in folk medicine in West Africa and has been proposed as a nurse crop in India (Purseglove 1968).

CROPPING SYSTEMS: Pigeonpea is used in a great variety of cropping systems throughout the tropics. Although average grain yield (650 kg/ha) and harvest index (20-25%) are low, its hardiness and ability to grow on residual soil moisture make it attractive to small farmers (Sheldrake and Narayanan 1979). Early growth is slow,

Written by Dr. Rick J. Van Den Beldt, ICRISAT Sahelian Centre, B.P. 12404, Niamey, Niger (via Paris)

making it an ideal, noncompetitive intercrop with cereals such as sorghum and millet. Such systems give full sorghum yields and over 70% of the pigeon pea grain harvest that could be obtained if the two crops were grown separately (Willey et al. 1981). Pigeonpea is a short-day plant, and its maturation period is related to daylength sensitivity of particular cultivars (Sheldrake and Narayanan 1979). Farmers in India, where pigeonpea is usually grown as an annual, exploit this trait. In the north, it is planted as a late-maturing crop (9-11 mos.) at relatively wide spacings (50,000/ha) during the longest summer days. In the peninsula, medium duration varieties (6-8 mos.). which flower as days grow shorter, are planted solely or intercropped with cereals (Willy et al. 1981; Sheldrake 1984). Early varieties, which are usually determinate (flowers borne on terminal racemes) and photoperiod insensitive, are sown densely (100,000 plants/ha) as sole crops during the rainy season or the post rainy season, when they use stored soil moisture and benefit from fewer pests and diseases (Sheldrake 1984).

In Africa, greater use is made of its perennial nature. In East Africa, long duration pigeonpea is sown with cereals or short duration grain legumes such as cowpea. After the grain crop is harvested, pigeonpea grows to its full height and pods are used as a green vegetable or pulse. In the next year, pigeonpea is either ratooned and the cereals are planted, or it is allowed to dominate the field for pod production (Omanga and Matala 1987). Cereals are rarely planted among unratooned pigeonpea in the second year, because it is too competitive. Animals allowed to graze fields after cereals are removed eagerly browse the pigeonpea (Omanga and Matala 1987).

Ongoing work at ICRISAT suggests it can be used as a semipermanent, perennial component in alley cropping. Its traditional uses as a rotational/fallow crop in East Africa and as a part of shifting agriculture in SE Asia deserves more attention. It has been used as food and fodder- bearing windbreaks and live fences. It is widely planted as a backyard plant for shade and as a green vegetable.

ICRISAT (India) will help cooperators establish provenance trials, such as this 4-month-old trial Hawaii.

ESTABLISHMENT: Pigeonpea is best established by direct seeding in a well-prepared field. Gaps should be filled with seedlings grown -in pots. No pre-germination treatment of seeds is needed.

BREEDING SYSTEMS: Pigeonpea (2n=22) is mostly self-pollinating, but a range of 3 - 95% outcrossing has been reported. This is probably a function of environment and populations of pollinating insects (Sheldrake 1984). When pure lines need to be maintained, it may be necessary to cover plants with muslin bags to exclude insects. The "wrapped flower" character, with overlapping petal lobes, delays flower opening and has been used to increase the degree of selfing (Sheldrake 1984). Male sterile lines have been developed and are used in hybridization programs. One ICRISAT hybrid, ICPH8, consistently yielded 25% more grain than the best control in 15 trials in India (Wallis et al. 1986). Interspecific hybrids with species of the congeneric genus *Atylosia* have shown promise as fodder and cover crops.

PESTS AND DISEASES: In India, wilt (*Fusariun udum*) and sterility mosaic (mite-borne virus?) are the most important diseases (ICRISAT 1986). Wilt and leaf spot (*Mycovellosiella cajani*) are important in East Africa (Omana and Matala 1987). Rust (*Uredo cajani*) is the major disease in the Caribbean (Reed 1987). Root rot (*Phytophthora dreschsleri*) can be a problem in poorly drained fields. Resistance to these diseases, notably wilt and sterility mosaic, exists and should be exploited when pigeonpea is used as a perennial or grown in areas of heavy rainfall. Important insect pests include the pod borer, (*Heliothis armigera)*, and the podfly, *Melanagromyza obtusa*, (Reed 1987). Scale insects (*Coccus* spp.) can build up rapidly and severely damage perennial stands. Insect resistant lines are not yet widely available.

OBTAINING SEEDS: Small seed packets of a perennial variety are available from NFTA. For other seeds, contact ICRISAT, Patancheru, Andhra Pradesh 502324, India.

REFERENCES:

Chauhan, Y.S. 1987. Screening for tolerance to salinity and waterlogging: case studies with pigeonpea and chickpea IN: Adaptation of chickpea and pigeonpea to abiotic stresses.Proc. of Consultants' Work 19-21 Dec. 1984, ICRISAT India.

Faris, D.G., K.B. Saxena, S. Mazumdar and U. Singh. 1987. Vegetable pigeonpea: a promising crop for India. Patancheru, A.P. 502 324, India. ICRISAT.

Henke, L.A., S.H. Work and A.W. Burt 1940. Beef cattle feeding trials in Hawaii. Univ. of Hawaii Agric. Exp. Station Bull. 85 Honolulu, Hawaii U.S.A.

ICRISAT. 1986. Annual Report, 1985. Patancheru, India.

Purseglove, J.W. 1968. Trop. Crops: Dicotyl. Longman, London.

Reed, W. 1987. ICRISAT's research on pigeonpea.. IN: Res. on grain legumes in Eastern and Central Africa. Summ. proc. of the consultative group meeting for Eastern and Central African Reg. Res. on grain legumes, 8-10 Dec. 1986. ILCA, Addis Ababa, Ethiopia. ICRISAT, India.

Sheldrake, A.R. 1984. Pigeonpea.. IN: Goldsworthy and Fisher, eds., The Phys. of Trop. Field Crops Wiley , London

Sheldrake, A.R. & A . Narayanan. 1979 Growth, dev. & nutrient uptake in pigeonpeas. J. Agric. Sci. Camb. 92:513-526.

van der Maesen, L.J.G. 1986. *Cajanus* DC and *Alylosia* W.&.A. (Leguminosae). Agric. Univ. of Wageningen Papers 85-4 (1985) Wallis,E.S., D.G. Faris, R. Elliot & D.E. Byth. 1986. Varietal improvement of pigeonpea for smallholder livestock production systems. Workshop on Crop-Livestock Systems Res., Khon Kaen, Thailand, July 7-11, 1986. IRRI, Los Banos, Philippines,

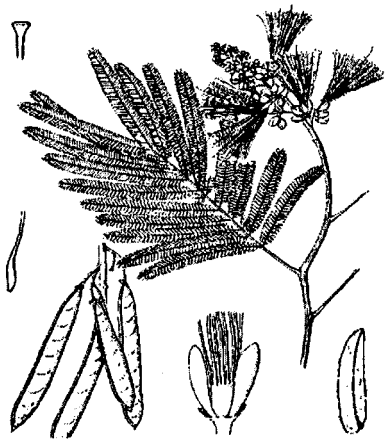
Whiteman, P.C. and B.W. Norton. 1981. Alternative uses pigeonpea. IN. Proceedings of the International Workshop on Pigeonpeas, Volume 1. 15-19 December 1980. ICRISAT, India.

Willey, R.W., M.R. Rao and M. Natarajan. 1981. Traditional cropping systems with pigeonpeas and their improvement IN: Proceedings of the International Workshop on Pigeonpeas, Volume 1. 15-19 December 1980, ICRISAT, India.

FACT Sheet

FACT 99-02
A quick guide to multipurpose trees from around the world January 1999

Calliandra calothyrsus : An Indonesian Discovery For Humid Tropical Regions



From Macqueen 1993

Calliandra calothyrsus is easy to establish and manage, grows quickly, and provides multiple products and services. Introduced to Indonesia in 1936 as a shade tree, it proved unsuitable for that purpose, but was adopted by Javanese farmers for fuelwood production and land reclamation. It has since been planted for green manure, animal fodder, bee forage, and pulpwood. The successful use of *C. calothyrsus* in Indonesia stimulated global interest in the species, and it is now cultivated for agroforestry throughout the tropics.

Botany[1]

Calliandra calothyrsus Meissner is a small, branching tree growing to a maximum height of 12 m and a maximum basal stem diameter of 20 cm. The stems have red or pale gray bark covered with small, pale, oval lenticels. Toward the tip, the stems tend to be ridged, and in trees with red-brown bark the final stem portion may be tinged with red.

The species has soft leaves divided into many straight leaflets. The leaves may reach 20 cm long and 15 cm wide, and they fold against the stem at night. The leaf stalks are ridged with a groove on the upper surface, but they do not have glands between the pairs of secondary axes.

In the species' native range, flowering occurs throughout the year, but it tends to peak between July and March. The inflorescences develop at the branch terminals. Several clusters of flowers develop around nodes below the axis. The flowers mature over a period of many months, beginning at the base of the in-florescence and progressing to its tip. Each flower opens for a single night to display showy filaments, which usually are white at the very base and red at the tip (although, exceptionally, they may be pink). By the next day, the filaments have wilted, and unfertilized flowers drop.

Pods take from two to four months to develop, and when mature they may be 14 cm long and almost 2 cm wide. They are straight, medium-brown, and contain 8-12 ovules, which may develop into flat, hard, oval seeds up to 8 mm long. In its native range, seed set peaks between November and April. As the pods dry, tensions created in the thickened pod margins cause an explosive splitting from the pod tip to the base that ejects seeds with a spinning motion, dispersing them as much as 10 m away. The species has several common names in its native range, the most frequently used being "cabello de angel" (meaning "angel's hair") and "barbe sol" ("the sun's beard"). In Indonesia, the species is referred to as "calliandra merah" ("red calliandra").

Taxonomy[1]

Calliandra calothyrsus can be distinguished from species of similar appearance by a unique combination of features. The species' almost straight leaflets do not tend to overlap, and they do not have a glossy upper surface. The leaves are soft and tend to fold after a branch is cut. The stems, flowers, and pods are almost always glabrous (without hairs). The petals are never thick or woody nor covered in hairs of any length or color.

Ecology and Native Range[1]

Calliandra calothyrsus occurs naturally along riverbanks but will rapidly colonize any area of disturbed vegetation (roadsides, for example). It is not particularly tolerant of shade and may soon be out-competed in secondary vegetation. It inhabits a range of sites within Mexico and Central America from sea level to an elevation of 1900 m. It primarily occurs in areas with a mean annual rainfall of between 1000 and 4000 mm, although exceptional populations occur in areas with only 800 mm annual rainfall. It principally occurs in areas with 2-4-month dry seasons (< 50 mm/month rainfall), although it has been found in areas with a dry season as long as 6 months. It occupies areas with a mean annual minimum temperature of 18-22°C. It is not frost tolerant. Within its natural distribution, it occurs on a variety of soils and appears to be tolerant of acidic soils with pH values around 4.5. It does not tolerate soils with poor drainage or that are regularly inundated.

Uses

Fodder.[2] Because of its fast growth and ability to resprout after repeated cutting, calliandra is a useful component of animal production systems. The edible fraction (leaves, flowers, and twigs) contains 20-25% crude protein, which makes it a good supple-ment for basal diets of grass or other low-quality roughages. The leaves contain high levels of tannin, which may account for its low digestibility of 30-60%. Calliandra should compose no more than 30% of a ration (dry-matter basis). The fodder should be used fresh, because animals respond poorly when it has dried. Small ruminants readily consume calliandra. Cattle may need an adjustment period when this fodder is introduced to their

diet. Rabbits and chickens can eat calliandra in small quantities as part of a mixed diet (up to 5% on an as-fed basis). Calliandra is reportedly used as fish feed in Vietnam.

Calliandra may be used in both cut-and-carry and direct grazing systems. For fodder banks, it is often planted at 1 x 1 m, or in hedgerows 2 m apart with trees 50 cm apart within the rows. In either system, planting distances may be adjusted to permit the use of machinery. Depending on the environmental conditions, calliandra may be harvested 4-6 times each year. Trees should be cut again after about 1 m of regrowth. Lopping should not be lower than 30 cm above ground. Under this management, fodder dry matter yields can be 3-8 tons/ha/year.

Wood and pulp.[3] Calliandra is widely used as a fuelwood. In Indonesia, over 30,000 hectares of fuelwood plantations are established on Java alone. The wood has a specific gravity of 0.5-0.8, dries rapidly, and burns well, producing 4600 kcal/kg (7200 kcal/kg as charcoal). It is burned to produce palm sugar, smoke sheet rubber, dry copra, and heat brick and tile ovens. Fuelwood plantations are normally planted at 1 x 1 m or 1 x 2 m spacing. The recommended cutting height is 30-50 cm. Annual yields are 5-20 m^3/ha for one-year-old plantations and 30-65 m^3/ha for 20-year-old plantations. With a cellulose content of 44-51%, *Calliandra calothyrsus* is suitable for paper pulp, but it should comprise no more than 10% of a pulp. In Indonesia, pulpwood plantations are planted at 2 x 2 m spacing.

Agriculture Systems.[3] In agriculture systems, calliandra is used to reduce weed growth, conserve soil moisture, and improve soil structure and fertility. It is used as an understory component in coconut plantations, a shade tree in coffee and tea plantations, and a nurse tree in timber plantations. To reduce competition with crops, calliandra is pruned when necessary, commonly 3-4 times a year, to a height of 0.5-1 m. Tree density varies from 160 to 2500 per hectare. Calliandra is also used in hedgerow systems, often on steep slopes, with corn, rice, groundnuts or other crops. Hedges are usually planted 1.5-2 m apart, with trees 1-2.5 m apart within rows. *Calliandra calothyrsus* is also becoming an important source of forage for honeybees in Indonesia.

Reclamation and rehabilitation.[3] Calliandra is used to reduce fallow periods and improve soil fertility at densities of 5000-10,000 trees per hectare. It is planted in contour hedge-rows to decrease erosion on steep slopes, with in-row spacing as close as 5 cm. Calliandra has been successfully used to rehabilitate imperata grasslands in Indonesia. Spacing varies from 1.5 x 1.5 m to 5 x 5 m.

Silviculture

Propagation.[4] To achieve rapid and uniform germination, calliandra seed (18,000-20,000/kg) should be scarified before sowing. For small quantities of seed, the seed coat may be cut or scraped opposite the thin micropyle or hilum and soaked in cool water for 12-24 hours before sowing. For large quantities, soak in cool water for a minimum of 24 hours. Soaking in hot water for 2-5 minutes before the cool-water treatment may increase germination, although hot water may also kill the seed. Careful testing of the chosen technique is recommended.

Seed generally should be sown at a depth equal to its width. Germination should occur in 4-10 days. The choice of nursery container depends on the desired seedling size. For large seedlings, use large containers. Large seedlings compete better and need less care after transplanting. However, small seedlings are easier and less expensive to grow and transport. Seedlings are normally ready for field planting after 6-12 weeks in the nursery when 15-50 cm tall. Standard nursery management and seedling hardening-off procedures should be followed.

Calliandra may be established by directly sowing scarified seed at the planting site. Sowing should be done at the beginning of the rainy season. Stump sprouts of 4-12-month-old seedlings, or vegetative cuttings from succulent stems or roots (cultivated in propagation boxes), can also be used to produce suitable planting material. All calliandra planting material is susceptible to early competition. Intensive weed control should be practiced until calliandra is well established, particularly in grass ecosystems.

Seed production and collection.[5] Compared to other leguminous tree species, calliandra is known to be a "shy" seed producer outside its native range. One reason for this is that the primary pollinator, bats, may require a few years to identify new stands of calliandra as feed resources. Trees flower through-out the year but have a peak flowering period 3 months before the dry season. Individual flowers are receptive to pollination for only one night. Individual trees may produce receptive flowers over a 4-6 week period. Demand for high-quality calliandra seed is growing and exceeds supply. The Oxford Forestry Institute is currently working on seed orchard guidelines.

Calliandra seed is sensitive to improper handling—only fully mature seed should be collected, before pods open. Dried seed can be stored in air-tight containers at 4°C for up to 5 years. Bulk seed should be stored in sacks in a shaded, cool, dry area, protected from insects, rats, and mice.

Symbiosis.[4] Calliandra root systems form symbiotic relationships with both *Rhizobium* bacteria and vesicular-arbuscular mychorrhizal fungi (VAM).

Pests and Diseases.[6] Information is available on pests and diseases of the genus *Calliandra*, but there has been little systematic study of pests or diseases of *C. calothyrsus*. However, it does not appear to suffer serious damage from pests or diseases in its native range or in areas where it has been introduced.

References

All references are from Powell (1997).

Powell, M. (ed), *Calliandra calothyrsus* production and use: a field manual. FACT Net, Winrock International, Morrilton, Arkansas, USA.; the Taiwan Forestry Research Institute; and the Council of Agriculture, Taipei, Taiwan, Republic of China.

[1]Macqueen, D. Botany and ecology. p. 1-10.

[2]Paterson, R., B. Palmer, M. Shelton, R. Merkel, T.M. Ibrahim, R. Arias, K. Berhe and A.N.F. Perera. Fodder production. p. 29-34.

[3]Ty, H.X., E. Hernawan, M. de S. Liyanage, M. Sila, H. Ramdan, A.N. Gintings, K. Hidayat, A. Setijoprodjo, R. Roothaert, R. Arias and D. Macqueen. Uses. p. 23-29.

[4]Roshetko, J.M., D. Lesueur, and J.M. Sarrailh. Establishment. p. 11-22.

[5]Chamberlain, J.R., A.J. Pottinger, and R. Rajaselvam. Seed collection and production. p. 7-10.

[6]Boa, E. 1997. Pests and diseases. p. 35-44.

NFT Highlights

NFTA 85-03
A Publication of the Nitrogen Fixing Tree Association December 1985

Casuarina : Difficult Sites Are Home to Casuarina

Sand, sun and salt spray are part of home to the *Casuarina* spp. that thrive on beaches from the tropics to temperate zones. The ability to tolerate diverse and difficult niches such as seashores characterize the genus. Casuarinas also have been grown on limestone quarries and infertile tin mine tailings.

C. equisetifolia, which occurs naturally on coastlines from India to Australia, is the most widely used species. A 3000 km shelterbelt was built mainly with *C. equisetifolia* along the People's Republic of China's southern coast to stop encroachment of sand dunes and to decrease strong winds. A similar shelterbelt in Taiwan reduced downwind salt deposition by 60 percent (Kpki, 1978).

C. equisetifolia In Egypt, C. *glauca* and *C. cunninghamiana* shelterbelts protect farms, highways and irrigation canals from clogging by sandstorms.

Casuarina has been called the best firewood in the world. Its wood is very dense, splits easily, burns when green, has low ash content and makes excellent charcoal (NRC, 1984). It is the main plantation species in peninsular India, where 7-15 year rotations yield 100-200 tons of fuelwood per ha (NRC, 1984) and even the roots are sometimes harvested for charcoal. Yields of 7.5- year-old stands in Florida were up to 17 dry t/ha/yr (Rockwood, et al.; 1985).

In Thailand, hybrids of *C. equisetifolia* and *C. cunninghamiana* grow on heavy acid soils and are harvested five years after planting for posts, firewood and other products. Villagers in southern China gather four tons/ha/yr of Casuarina litter from shelter- belts and use it for domestic fuel (NRC, 1984).

Most Casuarina wood is hard, heavy and difficult to saw. It also tends to split, crack and warp as it dries. However, the wood is used for fencing, pilings, beams, rafters, ship masts, scaffolding, flooring, particle board, roof shingles and pulp.

C. oligodon shades coffee trees and is a fallow-improvement crop in Papua New Guinea. Soil samples collected after five years of such a fallow show substantial increases in soil nitrogen and

organic matter (NRC, 1984). Casuarina roots are modulated by the nitrogen-fixing actinomycete, *Frankia*. Annual nitrogen fixing rates for established

C. equisetifolia stands has been estimated near 60 kg/ha (Dommergues, 1963). Inoculating seedlings with Frankia and mycorrhizal fungi promotes faster growth and survival, and seedlings are ready for planting in six months or less.

Suitable growing conditions for *C. equisetifolia* in the tropics and subtropics include: temperatures of 10-300 C with no frost, 200 to 5000 mm annual rainfall, 6-8 month dry season, sea level to 1500 m, and sandy, calcareous soils. *C. cunninghamiana* tolerates about 50 light frosts annually and survives periodic inundation in fresh water. C. *glauca* survives tidal inundation and is very drought tolerant. *C. oligodon* grows well in humid highlands up to 2500 meters above sea level, and C,, iunghuhniana grows in drier highlands up to 3000 meters.

Casuarinas normally are propagated by seeds. *C. equisetifolia* produces seed prolifically by the age of 5 years. Most species have separate male and female trees, but some species have both flowers on one tree, and *C. equisetifolia* is reported as fitting into both of these categories. Seeds of different species vary greatly in size. *C. equisetifolia* has between 300,000 to 450,000 seeds/lb. Germination generally takes 2-3 weeks. Germination rates for *C. equisetifolia* range from 75 percent for fresh seed to 30 and 40 percent for stored seeds.

A male clone presumed to be a hybrid of *C. equisetifolia* and *C. junghuhniana* is reproduced by young, short cuttings in Thailand and India. Vegetative propagation efforts with *C. equisetifolia* have not been very successful, although rooting of properly treated young lateral shoots has been as high as 90 percent (Somasundaram and Jagadees, 1977). Trees coppice poorly or not at all. The root-derived shoots of some species allow for a type of "coppice" management, however (NRC, 1984).

Pest problems on casuarinas have been minor. Root rot in Florida and a blister disease in India have occurred. Many species survive fires well, but even light fires kill *C. equisetifolia.* Some casuarinas can become pests. *C. glauca's* vigorous root suckering has created problems in Hawaiian pastures and in Florida, where some counties have banned its planting. Additionally, leaf litter of some species may be toxic to some plants and increase soil acidity or salinity.