Handbook of LEGUMES of World Economic Importance

James A. Duke

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Duke, P. (tracings of xerocopies): Figs. 8, 13, 20, 34, 44, 54, 69, 88, 107, 111, 120.
Engler, H. G. A., *Pflanzenfam:* Figs. 11, 15, 27, 52, 82.
Engler, H.G.A., and Drude, C. G. O., *Veget. der Erde,* 1911: Fig. 17.
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Faul, K. (drawing): Fig. 85.
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Contents

Introduction

In 1971, Dr. Quentin Jones, now of the National Program Staff, SEA, USDA, suggested that the Plant Taxonomy Laboratory devise a format for concise write-ups on 1,000 economic plants (Duke and Terrell, 1974; Duke *et al.,* 1975). Dr. C. F. Reed was contracted to search the literature on these economic plants, which included 146 species of legumes. From 1971 through 1974, Dr. Reed prepared rough drafts of write-ups on the 1,000 species. It was my responsibility to establish the format and monitor the write-ups, to ensure that they would answer many questions on legumes directed to the USDA by our taxpaying public. Since then, a computerized system alerts me to new publications on legumes. I have ordered for our files copies of the more promising documents. With the evolution of the manual, many later references supplanted earlier ones. Some repetitive information was dropped by condensing the write-ups on secondary species within the genera.

Informally in 1975 and formally in 1976, Dr. Roger Polhill, Curator of Legumes, Royal Botanical Gardens, Kew, joined by Dr. A. S. Bunting, Professor, The University of Reading, and Dr. J. P. M. Brenan, Director, Royal Botanical Gardens, Kew, conceived the splendid idea of an International Legume Conference at Kew. We agreed that this would be a good forum for presentation of the *Handbook of Legumes*. Beginning in 1976, I circulated second drafts of the individual legume write-ups to a mailing list of contributors. Responses ranged from obloquy to praise; many contributors went over the drafts carefully.

I also benefited from attending a National Academy of Science Legume Conference in Maui, Hawaii, where an international panel convened to discuss and assemble information on underexploited tropical legumes. Conversations at that meeting and subsequent correspondence with the participants also yielded new information on some of the tropical legumes.

Finally in 1978, 100 copies of the writeups were delivered to the International Legume Conference at Kew, July 24th–August 4, and all were given to potential cooperators before my lecture on the manual (July 31st). New information presented in lectures at that conference and personal communications behind the scenes have also been used to update and embellish the write-ups so that they are more than a bibliographic echo

On May 7, 1978, I was transferred from USDA's Plant Taxonomy Laboratory to the Medicinal Plant Resources Laboratory (now the Economic Botany Laboratory). Since then, I have included the Folk Medicine paragraph in the final format. My computerized ecosystematic program (Duke, 1978b) includes data not only on legumes, but on economic plants in general, many of which are intercropped with legumes to good advantage.

FORMAT

Except for beginning each write-up under the heading of scientific name, there was little unanimity about what should be included or excluded, and in what order the included paragraphs should be arranged. I have, without sacrificing clarity, adopted a terse style, often leaving out the verbs in descriptive sentences. Furthermore, I have generously sprinkled the text with abbreviations that are identified in the following section titled Text Abbreviations. It should be noted that these abbreviations may differ from those specifically defined in tables found in the Appendix. I finally elected to follow the format below, at least for the first species in each genus.

NOMENCLATURE: All agreed that the scientific name, authority, and recent significant synonyms be included. Because Anglicans consistently use the word "lucerne" for the plant Americans call "alfalfa," and because this manual was intended for international usage, common names in a few major languages are included. However, the large number of common names dictated that most of them be omitted.

USES: Following the Nomenclature Section, important general uses are reported. Some of the uses that may seem trivial in developed countries are important in developing countries, and vice versa.

FOLK MEDICINE: Folk medicine is separated from general uses, even though many collaborators believe that the information is parascientific at best. Frequently, however, folk medical usage is related to chemical characteristics. Certainly the USDA does not recommend folk medicine, and discourages self-medication. Still, I quote Dr. R. J. McCracken from Perdue and Hartwell (1975). "We have heard much lately about the use of plants and the products derived from them, in meeting world food problems. But of equal concern and importance is human health and in this respect plants have much to contribute that is of therapeutic value." In the cancer-screening program of the National Institutes of Health, several compounds found in legumes have proved active against experimental cancers. *Cassia obtusa* has been reported to give the active colubrinol; *Cercidium microphyllum* has given an active; *Coronilla varia* gave hyrcanoside; *Crotalaria spectabilis,* monocrotaline; *Derris trifoliata,* rotenone; *Entada phaseoloides,* an active; *Lonchocarpus urucu,* rotenone; and *Piscidia erythrina,* rotenone (Perdue and Hartwell, 1975). Folklore on medicinal plants is a good guide in our quest for new medicinal chemicals.

CHEMISTRY: I did not include detailed analytical data on the chemistry of legumes but included nutritional data, where available. Often approximate nutritional composition varied widely among sources. In the individual chapters I have reported the nutritional data from the various sources listed in the references. Many of these data were recently published (Duke 1977a). To facilitate comparison, I tabulated nutrients (zero-moisture basis) in Table 6 and amino acid compositions in Table 7 of the Appendix. I also list chemurgic chemicals and/or those cited as "toxic" (NIOSH, 1975). There has been discussion in the United States urging that plants containing toxins be so labeled. Consequently they were included in Appendix Tables 1 and 2, derived from my Phytotoxin Tables (Duke, 1977b). Many correspondents questioned the merit of including mere generic lists. I have initiated a computer program to accommodate the quantitative distribution of chemicals within the species and the location in the plant, rather than in the genera. That should prove even more useful than the Phytotoxin Tables.

DESCRIPTION: The manual was designed more specifically for agronomists than for taxonomists, although I hope both groups will find it useful. Simple terms were sought for the descriptions. Line drawings have been borrowed from the open literature where possible.

GERMPLASM: Space limited the discussion of germplasm to the more important cultivars, comments on the centers of origin, breeding mechanisms, tolerances, and chromosome counts.

DISTRIBUTION: Modern distribution of many economically important legumes bears little relation to their historic distribution. In this section I tried to summarize facts about current and historic distribution.

ECOLOGY: For more than 5 years, I have solicited local floral checklists associated with ecological data. The resultant data complement other published data. Ecological data from my computerized ecosystematic data base (Duke, 1978a,b,c) on legumes are tabulated in the Appendix (Table 3). If Table 3 represented the entire world rather than a small biased sample, the climate and pH of a remote area might be estimated by a study of its native legumes. The concluding sentence of the Ecology Section with data on life zones, annual precipitation, annual temperature, and pH is derived from my ecosystematic program; the data were confirmed by my computer program. Some data may differ from those published but each datum was based on a case history that is retrievable by computer.

CULTIVATION: Here I included information for developed "mechanized" societies, for developing "manual" societies, or for both, on land preparation, planting, fertilization, intercropping, cultivation and maintenance of the legume until harvest. Some data on field spacing and seed rates were often included, but these vary so much from system to system, that I reported only a few.

HARVESTING: Methods for harvesting were reported, often with notes on processing the harvested plant. Data on optimum stage of growth and conditions for harvest also were included, where available.

YIELDS AND ECONOMICS: Conventional data for yields were reported. Data for biomass, nitrogen fixation, and any other available nonconventional estimates of yield also were included. Dollar figures, where possible, are tied to dates so that this manual would not immediately lose its comparative value.

BIOTIC FACTORS: Pests, at least some of the more important ones, were listed. I consulted the historic file maintained in the U.S. National Fungus Collection at Beltsville, and was assisted editorially by many of my colleagues in other disciplines at Beltsville. However they can be held responsible only for the correct names. I found no one with time enough to check out all the names recorded in the National Fungus Collection, hence many synonyms have crept in. I would rather have a species listed under an outdated name than not listed at all. For conservation of space, the authors of the species names of the various pests have been deleted. Occasionally, I have listed pesticides in this section. This section is strictly bibliographic, and the lists do not constitute a recommendation or endorsement of these pesticides by the USDA. As a matter of fact, some of them are prohibited in the US and many are dangerous, unless used strictly according to the instructions.

SPECIFIC REFERENCES: Many correspondents have pointed out several recent references, too many for inclusion. General familial or generic references consulted in early drafts or in final revisions have been placed in the reference citations of the section titled General References. Even though these works were consulted in preparing individual write-ups, they are listed only in the final general collection of references. For inclusion with each write-up, preference has been given to specific references or those dated 1975 or later, especially review papers. General references were listed only at the end of the manual; a few specific references were listed at the end of most chapters.

TEXT ABBREVIATIONS

ann	annum, annual
Apr.	April
Aug.	August
avg.	average
AVRDC	The Asian Vegetable Research and Development Center
B	boron
B.C.	before Christ
BP	before present
Br	bromine
bu	bushel
BYMV	bean yellow mosaic virus
°C	degrees centigrade (Celsius)
Ca	calcium
ca.	about, nearly
cf.	compare with
CIAT	Centro Internacional de Agricultura Tropical
Cl	chlorine
cm	centimeter
Cu	copper
cu	cubic
cv	cultivar
cvgr	cultigroups
cwt	hundredweight
Dec.	December
DM	dry matter
dm	decimeters
EC	electrical conductivity
e.g.	for example
et al.	and others
etc.	and so forth
FAO	Food and Agricultural Organization of the United Nations
FDA	Federal Drug Administration
Fe	iron
Feb.	February
Fig.	figure

Fl.	flower
Fr.	fruit
g	gram
ha	hectare
HCN	hydrogen cyanide
hr	hour
I	iodine
i.e.	that is
IITA	International Institute of Tropical Agriculture
IU	International Unit
Jan.	January
K	potassium
kg	kilogram
km	kilometer
lb	pounds
LAI	Leaf Area Index
m	meter
MD	Maryland
Mar.	March
max.	maximum
Mg	magnesium
mg	milligram
ml	milliliter
mm	millimeter
min	minute
min.	minimum
Mn	manganese
Mo	molybdenum
mos.	months
MT	metric ton
N	nitrogen
n as in 2*n*	number (specifically chromosome number when given $2n = $)
Na	sodium
NC	cultigroups
Ni	nickel
NIOSH	National Institute of Occupational Safety and Health
N.H.	Northern Hemisphere
No.	number
Nov.	November
NPK	nitrogen: phosphorus: potassium
Oct.	October
p.	page
pp.	pages
P	phosphorus
PA	Pennsylvania
PI	plant introduction
ppm	parts per million
prec	precipitation
R	reproductive
S	sulfur
SA	South America
Sep.	September
sp.	species (singular)
spp.	species (plural)
sq	square
ssp.	subspecies (singular)
sspp.	subspecies (plural)
temp.	temperature
μg	microgram
U.K.	United Kingdom
USDA	United States Department of Agriculture
USSR	Russia
V	vegetative
var	variety
WARF	Wisconsin Alumni Research Foundation
WI	West Indies
WM	wet matter (as opposed to DM)
WOI	Wealth of India
wt.	weight
yr	year

Collaborators: Perhaps the most important item in each chapter is the list of contributors. Many specialists have contributed and some lists may be incomplete. I wish, however, to thank R. F. Barnes, L. R. Batra, T. E. Boswell, J. L. Brewbaker, K. R. Bromfield, A. H. Bunting, J. C. Burton, W. V. Campbell, S. Chandra, W. A. Cope, S. Dana, T. C. Davidson, T. E. Devine, D. Ellington, N. R. Farnsworth, M. B. Forde, A. Fyson, M. Golden, H. J. Gotz, P. H. Graham, W. C. Gregory, C. R. Gunn, R. O. Hammons, R. Hegnauer, C. C. Heyn, E. M. Hoover, C. S. Hoveland, E. M. Hutton, T. Hymowitz, T. J. Kahn, R. F. Keeler, L. Knutson, A. E. Kretschmer, Jr., J. Langenheim, R. M. Lantican, R. L. Lynch, R. Marechal, J. D. Miller, A. J. Norden, B. N. Okigbo, B. P. Pandya, R. M. Polhill, H. Pollard, K. O. Rachie, C. F. Reed, P. P. Rotar, D. G. Roux, C. E. Simpson, A. E. Slinkard, J. Smartt, D. H. Smith, O. D. Smith, J. I. Sprent, R. J. Summerfield, R. A. Taber, N. L. Taylor, E. E. Terrell, C. E. Townsend, L. J. G. van der Maesen, J. K. P. Weder, E. B. Whitty, E. C. Williams, M. C. Williams, J. C. Wynne, C. T Young, and D. Zohary.

Legume Species

Acacia farnesiana (L.) Willd.

FAMILY: Mimosaceae
COMMON NAMES: Cassie, Huisache
SYNONYM: *Mimosa farnesiana* L.

USES: Cassie perfume distilled from the flowers. Cassie absolute used in preparation of violet bouquets, extensively used in European perfumery. Cassie pomades manufactured in Uttar Pradesh and the Punjab. Pods contain 23% tannin, a glucoside of ellagic acid, and are used for tanning leather. Bark also used for tanning and dyeing leather in combination with iron ores and salts. In Bengal and West Indies pods used for a black leather dye. Gummy substance from pods used in Java as cement for broken crockery. Gum exuding from trunk considered superior to gum arabic in arts. In Ivory Coast trees used as ingredient in arrow poison; elsewhere used as fences and to check erosion. Wood is hard and durable underground, used for wooden plows and for pegs. Often planted as an ornamental.

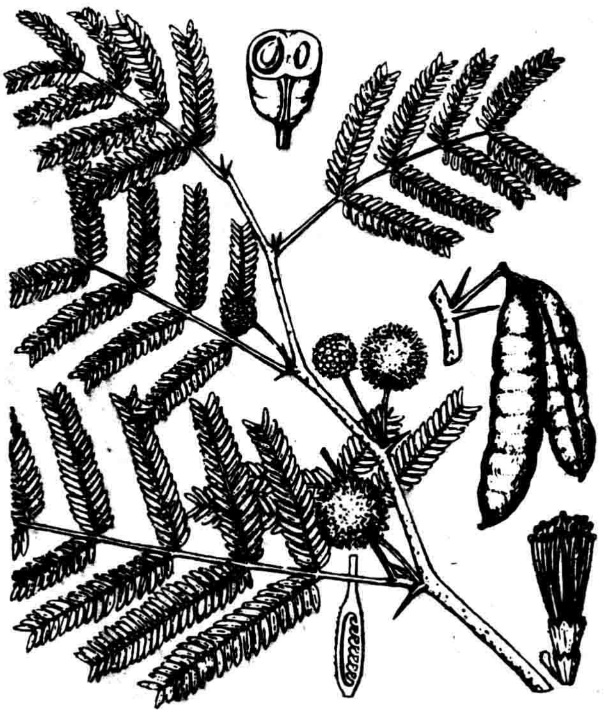

Figure 1. *Acacia farnesiana* (L.) Willd.

FOLK MEDICINE: Bark is astringent and demulcent, and with leaves and roots is used for medicinal purposes. Woody branches used in India as toothbrushes; gummy roots chewed for sore throat. Said to be used as alterative, antispasmodic, aphrodisiac, astringent, demulcent, antidiarrhetic, febrifuge, antirheumatic, and stimulant.

CHEMISTRY: Dried seeds of one *Acacia* sp. reported to contain per 100 g: 377 calories, 7.0% moisture, 12.6 g protein, 4.6 g fat, 72.4 g carbohydrate, 9.5 g fiber, and 3.4 g ash. Raw leaves of *Acacia* contain per 100 g: 57 calories, 81.4% moisture, 8.0 g protein, 0.6 g fat, 9.0 g carbohydrate, 5.7 g fiber, 1.0 g ash, 93 mg Ca, 84 mg P, 3.7 mg Fe, 12,255 μg β-carotene equivalent, 0.20 mg thiamine, 0.17 mg riboflavin, 8.5 mg niacin, and 49 mg ascorbic acid. Reporting 55% protein on a dryweight basis, Van Etten *et al.* (1963) break down the amino acids as follows: lysine, 4.7 (g/16 g N); methionine, 0.9;

arginine, 9.2; glycine, 3.4; histidine, 2.3; isoleucine, 3.5; leucine, 7.5; phenylalanine, 3.5; tyrosine, 2.8; threonine, 2.5; valine, 3.9; alanine, 4.3; aspartic acid, 8.8; glutamic acid, 12.6; hydroxyproline, 0.0; proline, 5.1; serine, 4.1; with 76% of the total nitrogen as amino acids. Cassie has been reported to contain anisaldehyde, benzoic acid, benzyl alcohol, butyric acid, coumarin, cresol, cuminaldehyde, decyl aldehyde, eicosane, eugenol, farnesol, geraniol, hydroxyacetophenone, methyleugenol, methyl salicylate, nerolidol, palmitic acid, salicylic acid, and terpineol. The genus *Acacia* is reported to contain: anhaline, anisaldehyde, anthraquinone, benzaldehyde, benzyl alcohol, butyraldehyde, cresol, cuminic aldehyde, decanal, dimethyl tryptamine, eugenol methyl ether, gallic acid, heptanoic acid, hydrocyanic acid, indole, isobutyraldehyde, linalool, methyl salicylate, nicotine, palmitic acid, phenethylamine, quercitin, rutin, saponin, tannic acid, terpineol, trigonelline, tyramine (for relative toxicities, see Appendix Table 2). Seeds of the genus *Acacia* reported to contain trypsin inhibitors and chymotrypsin inhibitors.

DESCRIPTION: Thorny bush or small tree, 1.5 m tall; bark, light brown, rough; branches glabrous or nearly, purplish to gray, with very small glands; stipules spinescent, usually short, up to 1.8 cm long, rarely longer, never inflated; leaves twicepinnate, with a small gland on petiole and sometimes one on the rachis near top of pinnae; pinnae 2–8 pairs, leaflets 10–12 pairs, minute, 2–7 mm long, 0.75–1.75 mm wide, glabrous, leathery; flowers in axillary pedunculate heads, calyx and corolla glabrous, scented; pod indehiscent, straight or curved, 4–7.5 cm long, about 1.5 cm wide, subterete and turgid, dark brown to blackish, glabrous, finely longitudinally striate, pointed at both ends; seeds chestnut brown, in 2 rows, embedded in a dry spongy tissue, 7–8 mm long, about 5.5 mm broad, smooth, elliptic, thick, only slightly compressed; areole 6.5–7 mm long, 4 mm wide.

GERMPLASM: Both *A. farnesiana* and its var *cavenia* are extensively cultivated in and around Cannes, southern France, the center for production of the perfume; *cavenia* seems more resistant to drought and frost. Assigned to the South American Center of Diversity, cassie or cvs thereof is reported to exhibit tolerance to drought, high pH, heat, low pH, salt, sand, slope, and savanna. ($2n$ = 52, 104).

DISTRIBUTION: Probably native to tropical America, but widely naturalized and cultivated—Africa (Rhodesia, Mozambique) and Australia. Planted in coastal areas of Ghana and elsewhere in tropical Africa. Grown throughout India, often in gardens.

ECOLOGY: Thrives in dry localities and on loamy or sandy soils; may serve as a sand binder. Grows on loose, sandy soil of river beds, on pure sand in plains of Punjab. Requires a dry tropical climate. Ranging from Warm Temperate Dry through Tropical Desert to Moist Forest Life Zones, cassie is reported to tolerate annual precipitation of 6.4–40.3 dm (mean of 20 cases = 14.0 dm), annual mean temperature of 14.7–27.8°C (mean of 20 cases = 24.1°C), and pH of 5.0–8.0 (mean of 15 cases = 6.8).

CULTIVATION: Propagated mainly from seed and cuttings. Seeds germinate readily and plants grow rapidly. Plants do not require much cultivation, watering, or care.

HARVESTING: Trees begin to flower from the third year, mainly November–March. Perfume is extracted from the flowers in form of concrete or pomade. Macerated flowers held several hours in melted purified natural fat, then repeatedly replaced by fresh flowers until the fat is saturated with perfume. Fat melted, strained, and cooled to yield pomade. Odor is that of violets but more intense. For absolute, pomade is mixed with alcohol (2–3 kg to ca. 4 liters) and held for 3–4 weeks at ca. −5°C. The alcohol is separated by distillation. The extract is an olive-green liquid with strong odor of cassie flowers.

YIELDS AND ECONOMICS: Mature trees yield up to 1 kg of flowers per season. Southern France (Cannes and Grasse) is main production center for cassie flower perfume. India and other Eastern countries produce much for local use.

BIOTIC FACTORS: Fungi reported on this plant include: *Camptomeris albizziae, Clitocybe tabescens, Hypocrea borneensis, Lenzites palisoti, L. repanda, Phyllachora acaciae, Phymatotrichum* *omnivorum, Polystictus flavus, Ravenelia austris, R. hieronymi, R. siliquae, R. spegazziniana, Schizophyllum commune, Systingophora hieronymi, Tryblidiella rufula,* and *Uromycladium notabile.* It may also be parasitized by the flowering plants *Dendrophthoe falcata* and *Santalum album.*

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Acacia mearnsii de Wild.

FAMILY: Mimosaceae

COMMON NAMES: Black wattle, Acacia negra, Acacia noir, Schwarze akazie, Gomboom

SYNONYMS: *Acacia mollissima* auct., not Willd.
Acacia decurrens var *mollis* Lindl.

USES: Tree of economic importance in South and East Africa, Rhodesia, India, and Rio Grande do Sul area of South America and environs for fuel and for tanning of soft leather. Dried bark contains 30–54% tannin. Trees furnish fuel and lumber in some areas and add nitrogen and organic material to the soil. Bark is used for wood adhesives and flotation agents.

FOLK MEDICINE: Products are often used in folk medicine as styptics or astringents.

CHEMISTRY: Black wattle bark contains (−)-robinetinidol and (+)-catechin; the biflavonoids (−)-fisetinidol-(+)-catechin (2 diastereoisomers), (−)-robinetinidol-(+)-catechin and (−)-robinetinidol-(+)-gallocatechin; triflavonoids and condensed tannins. The heartwood is rich in (+)-leucofisetinidin (mollisacacidin) together with (−)-fisetinidol, (+)-fustin, butin, fisetin, butein, and biflavonoid condensates (tannins).

DESCRIPTION: Tree 6–20 m tall, 10–60 cm in diameter; crown conical or rounded; all parts except flowers usually pubescent or puberulous; stems without spines or prickles; leaves bipinnate, on petioles 1.5–2.5 cm long, with a gland above; rachis 4–12 cm long with numerous raised glands all along its upper side; pinnae in 8–30 pairs, pinnules in 16–70 pairs, linear-oblong, 1.5–4 mm long, 0.5–0.75 mm wide; flowers in globose heads 5–8 mm in diameter, borne in panicles or racemes, on peduncles 2–6 mm long; pale yellow and fragrant; pods gray-puberulous, or sometimes glabrous, almost moniliform, dehiscing, usually 3–10 cm long, 0.5–0.8 cm wide, with 3–14 joints; seeds black, smooth, elliptic or compressed ovoid, 3–5 mm long, 2–3.5 mm wide; caruncle conspicuous; areole 3.5 mm long, 2 mm wide. Seeds 66,000–110,000/kg.

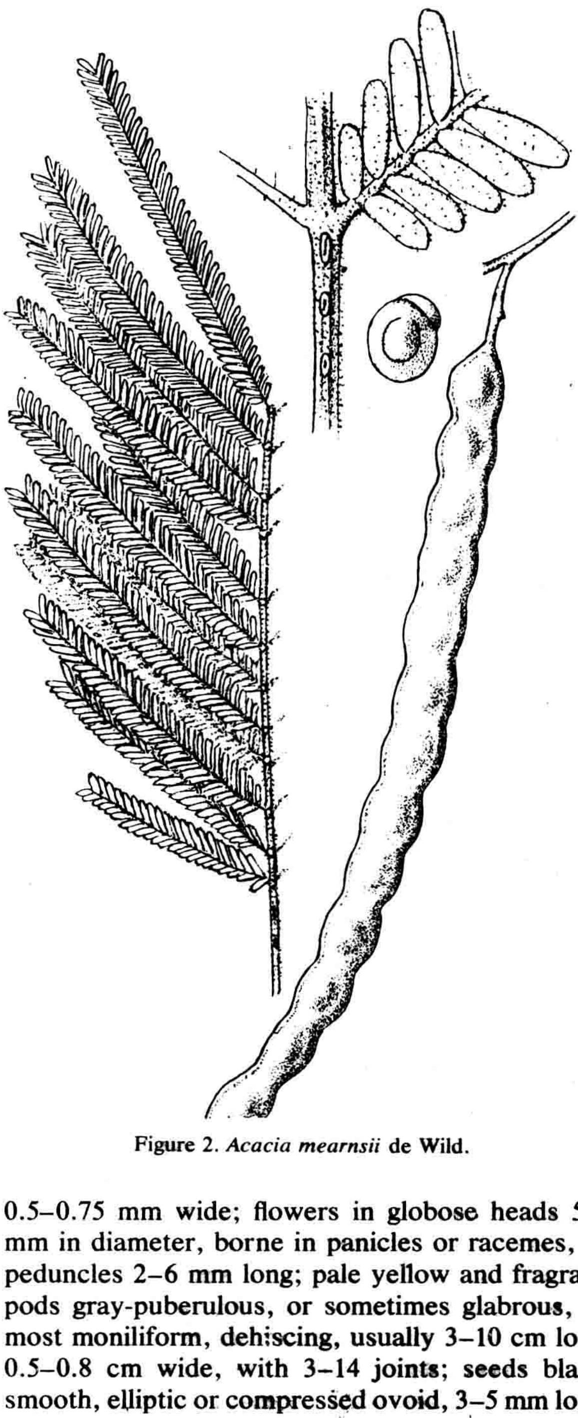

Figure 2. *Acacia mearnsii* de Wild.

GERMPLASM: Can be crossed with *Acacia decurrens;* hybrids show more sterility than parents.

Meiosis is regular, with no gross cytological abnormalities, and sterility may be due to gene differentiation between species. There is little geographic overlap in the native Australian ranges of the species, and there are differences in phenology (flowering; seedset). Most of the characters that vary among species are quantitative. The development of black wattle strains or of hybrids with enhanced vigor, better quality bark, outstanding stem form, or resistance to insect pests and disease would benefit the wattle industry. Assigned to the Australian Center of Diversity, black wattle or cvs thereof is reported to exhibit tolerance to drought, laterite, and poor soil. ($2n = 26$.)

DISTRIBUTION: Native to Southeast Australia (Victoria to New South Wales and southern Queensland) and Tasmania. Introduced and cultivated widely for afforestations. See Sherry (1971) for details.

ECOLOGY: In Kenya grows on or near Equator at altitudes of 2,000–2,800 m; is well adjusted to the climate of East Africa. Grows well at 30°S Lat. in South America on rolling terrain at altitudes of 50–70 m. Thrives on poor, dry soils but favors deep, moist, fertile soils. In Australia, black wattle may occur on soils derived from shales, mudstones, sandstones, conglomerates, and alluvial deposits; in Kenya on podsols, krasnozems, sandy hills, lava flows or on mixtures of lava and contemporaneous volcanic tuffs and breccias. In South America, grows on red clay or sandy soils that have suffered from severe erosion and soil depletion (ferruginous clay loams with little or no free silica). In East Africa grows where annual rainfall is 1,041–1,321 mm, (about 75% between April and September). On the equator where black wattle is grown in South America, the rain pattern is nearly opposite, mean annual temperature range is 17–23°C; there is little seasonal variation, but considerable diurnal variation. At higher altitudes in South America, frost is a risk and heavy snows may break tree limbs. Tannin content varies inversely with precipitation. Ranging from Warm Temperate Dry through Tropical Thorn to Tropical Moist Forest Life Zones, black wattle is reported to tolerate annual precipitation of 6.6–22.8 dm (mean of 6 cases = 12.6), annual mean temperature of 14.7–27.8°C (mean of 6 cases = 22.6°C), and pH of 5.0–7.2 (mean of 5 cases = 6.5).

CULTIVATION: Propagation by seed is easy. Seeds retain their viability for several years. For germination seeds are covered with boiling water and allowed to stand until cool. This cracks the hard outer coat and facilitates germination. Seeds may be broadcast or sown in rows on any barren site. Usually they are sown about 5 cm apart in seedbeds, and are transplanted after 3–6 months. In South America, fields are usually plowed and harrowed in April or May. Seedlings are set out May–November, but usually in winter, June–August, after a rain. Plants are spaced 2 m each way, at rate of 2,500/ha. Propagation by cuttings is almost impossible without mist. Air layering is more promising. Two types of farmers grow acacia: the tanner or business person plants 200 ha or so entirely to black wattle, usually one section at a time so that seeds can be planted and harvested within the same year and continue year after year; the farmer plants half or less of the land to black wattle and the rest to crops such as corn, beans, manioc, sugarcane, other vegetables, or pasture. The farmer plants 2–6 ha of acacia each year and thus evenly distributes work and production. Oxen may be useful for plowing, but most work is manual, using only plows and hoes. Intercrops may be grown the first year during which trees grow about 4–5 m in height, and about 2.5 cm in diameter.

HARVESTING: Trees provide bark 5–10 years after seeding (ave. 7). Bark is stripped from lower part of tree, then tree is felled, the remaining bark removed, and tree and bark are cut into 1-m lengths. Thoroughly dried bark is arranged in bales of 75–80 kg when ready for transportation. Tanning power improves by 10–15% in bark carefully stored for a season. Percent tannin does not differ between barks harvested in dry and wet seasons. However, the amount of bark on trees may be less on poor than on rich soils. Tannin runs about 25–35% of dried bark, on either poor or rich soil. Acacia bark may be sold as baled bark or bark powder. Dried bark may go first to commercial bark processors where it is ground or shredded in a hammermill, then sold in 40-kg sacks. Bark powder is sold in 60-kg sacks. Liquid extract is sold in 300-kg wooden barrels. In Rio Grande do Sul an estimated 5,000 MT of liquid extract is produced annually.

YIELDS AND ECONOMICS: Like some mangrove species, black wattle in pure stand produces more