



Government of the Union of Myanmar
Ministry of Forestry
Forest Department
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**The Study of Morphological and Anatomical
Characteristics of Five Species of
the Family Anacardiaceae**

Daw Aye Aye Than, M.Sc. (Mdy.), Demonstrator,
Botany Department, Monywa Degree College,
U Myint, M.Sc. (Mdy.), Lecturer, Botany Department,
University of Mandalay
and
U Thein Kywe, M.Sc. (Ygn.), M.S. (SUNY, CESF)
Assistant Director,
Forest Research Institute
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သရက်မျိုးရင်း (Anacardiaceae) ဝင်မျိုးစိတ် (၅)မျိုးတို့ ၏ ပြင်ပရုပ်သွင်နှင့်
သစ်အင်္ဂါဗေဒလက္ခဏာများကို စူးစမ်းလေ့လာခြင်း

ဒေါ်အေးအေးသန်း၊ M.Sc. (Mdy.)၊ သရုပ်ပြဆရာမ၊ ရုက္ခဗေဒဌာန၊ မုံရွာဒီဂရီကောလိပ်
ဦးမြင့်၊ M.Sc. (Mdy.)၊ ကထိက၊ ရုက္ခဗေဒဌာန၊ မန္တလေးတက္ကသိုလ်
နှင့်
ဦးသိန်းကြွယ်၊ M.Sc. (Rgn.), M.S. (SUNY, CESF)၊ လက်ထောက်ညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်းချုပ်

ဤစူးစမ်းလေ့လာမှုသည် မြန်မာပြည်ရှိ သရက်မျိုးရင်း (Anacardiaceae) ဝင် အပူပိုင်းသစ်မာပင်
(၅)မျိုးကို ပြင်ပရုပ်သွင်နှင့်သစ်အင်္ဂါဗေဒရှုထောင့်မှ လေ့လာတင်ပြထားပါသည်။ လေ့လာထားသော
အပင်များမှာ *Anacardium occidentale* Linn. (သီဟိုသရက်)၊ *Bouea burmanica* Griff. (မရမ်း)၊
Mangifera indica Linn.var.1 (မချစ်စုသရက်)၊ *Mangifera indica* Linn.var.2. (ပန်းဘင်္ဂလားသရက်)
နှင့် *Rhus paniculata* Wall. (ပြိစင်) တို့ဖြစ်ပါသည်။ အပင်မျိုးခွဲပညာအရ ပြင်ပရုပ်သွင်လက္ခဏာ များကို
ဖော်ပြထားပြီး အရေးကြီးသော သစ်အင်္ဂါဗေဒလက္ခဏာများနှင့် အသုံးနည်းသော သစ်မာပင်၏
သစ်သားအသုံးဝင်ခြင်းတို့ကိုပါ ဆွေးနွေးထားပါသည်။

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Daw Aye Aye Than, M.Sc. (Mdy.), Demonstrator,
Botany Department, Monywa Degree College,
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University of Mandalay
and
U Thein Kywe, M.Sc. (Ygn.), M.S. (SUNY, CESF)
Assistant Director,
Forest Research Institute

Abstract

This study has been done to know the wood of five tropical trees of the family Anacardiaceae in Myanmar from the standpoint of the morphological and anatomical characters. The species which have been undertaken in this study were *Anacardium occidentale* Linn. (Theho-thayet), *Bouea burmanica* Griff.. (Mayan), *Mangifera indica* Linn.var.1 (Machitsu-thayet), *Mangifera indica* Linn.var.2. (Panbengala-thayet), and *Rhus paniculata* Wall. (Byi-zin). The taxonomically diagnostic characteristics of the species and anatomically important observations with their relative reference to wood usefulness have been discussed as lesser - known species.

Contents

	Page
Acknowledgements	i
စာတမ်းအကျဉ်းချုပ်	ii
Abstract	iii
1. Introduction	1
2. Literature Review	1
3. Materials and Methods	5
4. Observations	5
Morphology	5
Anatomy	7
5. Discussion	16
References	

1. Introduction

Anacardiaceae is an important family to the foresters with few exceptions all are woody trees (Kurz,1877). The family is of economic importance not only for its timbers but also its multivarious minor products like edible fruits and nuts as food, tannins, lacquer and mastic, oleoresins, gums, turpentine, fat, oils, waxes, dyes, vitamins, and medicine (Purseglove, 1968). The woods of the Anacardiaceae present a very wide range of variation in physical properties and structure, and even sour and worthless species were cut down and used as firewood (Watt,1889).

Various parts of the Anacardiaceous species have been used in traditional medicine to cure diseases. Eg. Mangiferin (a xanthone C-glycoside) was extracted from the bark and leaves in Vietnam to cure dysenteriae, parodontosis, psoriasis, lichen and other skin diseases (Anon,1993).

Light hardwoods include all the relatively light weight and soft timbers which range in weight from about 25 to 45 lb/cu. ft. at 15 percent moisture content. They are the general utility timbers in temperate climates. These light hardwoods are excellent for high class joinery work, cabinet making furniture and decorative panelling. Although these hardwoods were not naturally durable in tropical climate, some are durable in temperate regions. Proper precautions are taken against attack by wood destroying agents. The light hardwoods as a whole make very satisfactory timbers for general construction even when used in tropical climate (Anon., 1968).

In the present study, 5 species of 4 genera belonging to the family Anacardiaceae has been undertaken. These species are *Anacardium occidentale* Linn. (Theho-thayet), *Bouea burmanica* Griff. (Mayan), *Mangifera indica* Linn. var.1 (Machitsu-thayet), *Mangifera indica* Linn. var.2 (Panbengala-thayet), and *Rhus paniculata* Wall. (Byi-zin).

The present investigation of the five species of the Anacardiaceae will be beneficial for the significant value of lesser-known trees with their non-wood forest products and useful for market economy in the near future.

2. Literature Review

The family Anacardiaceae was formerly known by the name Terebinthaceae and the order was designated as the Terebinthales. The name Anacardiaceae Lindl.(1830) was conserved over Terebinthaceae Juss. (1789) in Lawrence(1969).

According to Kupicha (1978), the Anacardiaceae was placed in the super order Rosidae, under the order-Sapindales. The Anacardiaceae was treated before Simaroubaceae and after Burseraceae.

Watt (1889) mentioned that 23 genera and 116 species were distributed in India out Gamble (1922) stated that only 20 genera and 116 species were found. Hundley and Chit Ko Ko (1978) described 19 genera and 63 species which are widely distributed throughout Myanmar.

In contrast with reference to Hundley and Chit Ko Ko (1978) and Gamble (1922), 4 genera (*Solenocarpus*, *Odina*, *Nothopegia* and *Camptosperma*) are not recorded in Myanmar, but found in India while 3 genera (*Allospondias*, *Schinus* and *Tapiria*) are not recorded in India, but found in Myanmar.

The members of this family are found mainly in tropical regions of the Old World and subtropical with a few temperate representatives. Many of the species are very important forest trees, and are dispersed over the tropical Asia-chiefly in the Malay Peninsula, over the

whole of India (Particularly in Madras), and throughout Myanmar. But they extended into the North temperate areas (E.G North America), and Southern Europe and Africa, Australia.

The members of the Anacardiaceae are mostly trees or occasionally shrubs or rarely woody climbers which are found worldwide in distribution, but woody climbers (Lianas) are not recorded in Myanmar.

The family abound in resinous, sometimes acrid, often poisonous principles (Kurz,1877), which are termed caustic juice (Backer and Brink, 1965) or milky juice (Hooker, 1879) or resinous sap(Purseglove, 1968), exuding from the bark.

These Anacardiaceous plants do not, as a general rule, yield good and durable timber for major construction works. The wood is usually used for fuel and frequently for book-cases, wooden slippers, cheap furniture and curving (Renalds, 1960).

1. *Anacardium occidentale* Linn.

The name of *Anacardium* was referred to the heart-shaped character to the nut (Popenoe,1953). The members of *Anacardium* contained trees and shrubs in the tropical America and it was widely cultivated throughout the tropics for its nuts (Anon,1948; Purseglove, 1968; Popenoe, 1953; Watt, 1889). Only one species was naturalized in Asia (Hooker,1879; Backer and Brink, 1965) including Myanmar (Hundley and Chit Ko Ko, 1978).

Anacardium occidentale Linn, cashew, was native to Brazil (Purseglove, 1968 and Oliver-Bever, 1986). It was discovered during 15th century by Portuguese missionaries (Anon,1768) but (Purseglove, 1968) said that it was one of the first fruit trees from the New World to be widely distributed throughout the tropics by the early Portuguese and Spanish adventurers.

The morphological characteristics of *A. occidentale* were described by Kurz (1877), Hooker (1879), Gamble (1922), Popenoe (1953), Renalds (1960), Backer and Brink (1965), and Anon (1986).

The anatomy of the wood of the genus *Anacardium* was described by Metcalfe and (1957), in their work on the study of the family Anacardiaceae. General characteristics of the wood of *A. occidentale* was noted by Kurz(1877), Watt (1889), Gamble(1922) and Dalziel (1955).

The nuts and seeds were high in nutrients (Purseglove, 1968). Young leaves were rich in calcium and could be eaten as a vegetable (Anon,1985). The roots were used in purgative (Chopra,1956).

The cashew apple was soft and juicy. When tendered it was acidic and highly astringent, but when fully riped it was sweet and only slightly astringent. It was edible and yielded a delicious beverage. The juice was fermented and made into a wine (Anon,1948). The fruit was used in antidiarrhoel (Chopra,1956).

The other uses of wood were described by Gamble, (1922) and Dalziel (1955) for packing-cases in Ceylon and Myanmar, for boat-building and charcoal, boxes and tea-chests.

Renalds (1960) described as a source of excellent charcoal. The resin from the tree was thick and dark in colour and was used as a varnish, to waterproof wood, and as a polish for furniture. The natives in Brazil made flour and also feed cattle and domestic birds with the leftovers of the pseudo-fruit (Anon,1986).

2. *Bouea burmanica* Griff.

The genus *Bouea* Meissn, included 4- Indo-Malayan species of fruit trees, 3 of which had been introduced into India (Anon,1948). Hooker (1879) described that it contained 5 species, all native to tropical Asia and the Malay Archipelago. It was distributed to Bago, Tanintharyi and Andaman Islands from Java.

It is found in Malaya, Andaman Islands, Sudarban, Tanintharyi, Thaug-gyeen and cultivated in the moister parts of Myanmar Kurz (1877) Watt (1889), Gamble(1922); Anon (1948). Only one species was found in Myanmar (Hundley and Chit Ko Ko, 1978).

The name of *Bouea burmanica* Griff. In Malaya was Gondangan or Kundagan (Macmillan,1962). The morphological characteristics of *B. burmanica* were described by Kurz (1877), Hooker (1879), Renalds(1960), and Backer and Brink (1965).

The wood anatomy of the genus *Bouea* was mentioned by Dadswell and Ingle (1948) and Metcalfe and Chalk (1957) in their work on the study of the family Anacardiaceae. General characteristics of the wood of *B. burmanica* was described by Watt (1889), Gamble (1922) and Anon (1948).

The tree was cultivated for edible fruits (Gamble,1922). It sometimes yielded gum (Anon,1948). The wood was stated by Roxburgh to be very durable and Heining mentioned that it was used for parts of the boat above the water-line in the Sundarhans (Gamble, 1922). Dadswell and Ingle (1948) describes that it was locally used for house posts and general construction.

3. *Mangifera indica* Linn.

The genus *Mangifera* included 30 species which were native of Southeastern Asia, where some of them had been distributed by man throughout the tropics of both hemispheres (Anon,1827) but (Watt,1891) described that these 30 species which were found in tropical Asia, chiefly in the Malay Peninsula. Purselove (1968) mentioned about 62 species of tall evergreen trees in South-east Asia and Malaysia to New Guinea, with the greatest number of species in the Malay Peninsula. Among these, about 15 species yielded as edible fruits, but only one species, *M.indica*, was popular and widely planted throughout the tropics. According to Hundley and Chit Ko Ko (1978), 6 species of *Mangifera* was found in Myanmar.

Mangifera indica literally meant "an Indian plant bearing mangoes" (Singh,1960). The name mango was derived from Tamil 'man-kay' or 'man-gay' and the Portuguese adopted as 'manga' when they settled in Western India. The English and Spanish also described as mango (Anon,1768).

Anon (1829) described that they were native plants of India. Some of them had been distributed by man throughout the tropics of both hemispheres, but the mangoes were said to have originated in the Indo-Myanmar region (De candolle, 1904; Popenoe, 1920; Vavilov,1949-50; Mukherijee,1951).

The mango trees had been grown in India for the last four thousand years (De candolle,1904) or even for six thousand years (Hill, 1952). Mangoes have been growing very well both in Upper and Lower Myanmar, but large groves of the finer varieties are concentrated in the area around Innwa and Mandalay (Grant and Williams, 1949).

The morphological characteristics of *M. indica* were described by Kurz (1877), Hooker (1879), Renalds (1960), Backer and Brink (1965) and Brandis (1972). The wood anatomy of the genus *Mangifera* was described by Pearson and Brown (1932), Dadswell and Ingle (1948) and Matcalfe and Chalk (1950), in their work on the study of family

Anacardiaceae. General characteristics of the wood of *M. indica* was mentioned by Kurz (1877), Gamble (1922), Pearson and Brown (1932) and Dadswell and Ingle (1948).

The trees, *M. indica* was valued for shade, being large size and attractive form, and very leafy. The leaves were large, leathery and ever green (Anon, 1829). Gamble (1922) and Purseglove (1968) described that the mango tree was important one in some of the ceremonies of the Hindus.

The barks and leaves had astringent properties and were used in Nigeria as a lotion to relieve toothache sore gums, sore throat, etc., or as an infusion on diarrhoea and dysentery (Dalziel, 1955). The bark was used in tanning leather. The smoke of burning leaves was believed to be efficacious against hiccoughs and several throat troubles (Gangolly, 1957). Festoons of mango leaves were used as decorative at almost all Hindu ceremonials and festivals. A mango grove was presented to Lord Buddha (Purseglove, 1968).

The mango was popular because of its high-nutrient fruit (Anon, 1993). Fruits contained large quantities of vitamin C and carotene also. Fruits in general provided little protein and fat but usually no starch (Goode, 1989). The fruits were widely used for human food, especially in the East, either ripe as they were eaten raw with or without wine, sugar and spices, or unripe as preserves, jellies or pickles. Fruits were also used for making wine and glucose (Anon, 1929).

The kernel of the seed was dried, roasted and then eaten. In periods of food scarcity, the kernel was ground into flour and eaten as gruel (Gangolly, 1957). It was used for dysentery and the dried kernel of the ripe fruit was used as an astringent in diarrhoea (Watt, 1891).

The dried flowers were used as a useful astringent in looseness of the bowels, chronic dysentery, and gleet (Watt, 1891).

The gum of the mango tree was used for cracked feet with good effect (Watt, 1891). Gangolly (1957) described that the gum of tree and the resinous substance exuded from the stem-end of the fruit were given, mixed with lime juice, in cutaneous affections and scabies.

The other use of the wood were described by Gamble (1922) where it is used for planking, door-and window-frames, packing-cases, opium-and indigo-boxes, canoes and masula boats, tea-boxes. According to Kurz (1877) it was occasionally used for cabinet-work, house - and coach-building purposes and packing -cases.

4. *Rhus paniculata* Wall.

The genus *Rhus* was an ancient Greek name and ornamental woody plants, grown chiefly for their handsome foliage, often assuming brilliant autumnal colours, and some species also for their showy fruiting panicles. (Rehder, 1953).

Gamble (1922), supposed that 12 species were the natives of East Indies, most of which were economically valued. The true Sumach, tree of Europe was found both wild and cultivated in the adjacent countries of Afghanistan and Persia. Ridley (1922) described that about 114 species were found in both hemispheres. Dadswell and Ingle (1948) mentioned that 130 species of shrubs and trees distributed throughout subtropical and warm temperate regions. According to Rendle (1952). *Rhus* was the largest genus of the family Anacardiaceae containing 120 species which were widely distributed in the warmer parts of the world. About 150 species were found in the temperate and subtropical regions of both hemispheres (Rehder, 1953). Trease and Evans (1978) described as 250 species in this genus. According to Hundley and Chit Ko Ko (1978), 8 species of *Rhus* were found in Myanmar.

The *Rhus paniculata* Wall. was a small deciduous tree of Bhutan and also extended to Upper Myanmar and Shan Hills (Gamble, 1922). It was not common in the dry forests of Pyay and Innwa (Kurz, 1877).

Morphological characteristics of *R. paniculata* were described by Hooker (1879), Renalds (1960), Brandis (1972), Tin Tin Than (1975), Aung Kyaw (1976) and Hla Aye (1979).

The woody anatomy of the genus *Rhus* was described by Dadswell and Ingle (1948) and Metcalfe and Chalk (1957). General characteristics of wood of *R. paniculata* was mentioned by Gamble (1922) and Dadswell and Ingle (1948).

The species of this genus were nearly all poisonous, and have most of them a very acrid juice, which were highly astringent and were used for tanning. Its leaves and fruits were extensively imported in India for industrial and medicinal purposes (Watt, 1889). The bark was used to adulterate cutch (Gamble, 1922). The wood was chiefly used as fuel (Renalds, 1960).

3. Materials and Methods

All the species of genera *Anacardium*, *Bouea*, *Mangifera* and *Rhus* which included in the family Anacardiaceae in this research were collected from the Mandalay Division and Sagaing Division. These specimens were collected respectively during their flowering and fruiting periods.

For morphological studies, both fresh and preserved specimens of the vegetative and reproductive parts were used.

For anatomical studies, the wood samples measured 8" x 6" x 1" were taken from the main trunk particularly breast height level of stem. Each wood sample includes the bark, the sapwood and a portion of heartwood.

In this work, the preparation of microscopic sections of the wood samples have been undertaken according to the method of Jeffery (1917) with slight modification.

Maceration of wood were prepared by heating them in equal volume of 30% hydrogen peroxide and glacial acetic acid according to Franklians method (1946).

The photomicrographs were taken by using the Olympus Universal Research Microscope, Vanox model.

For microscopic descriptions the terminology used in this work was as given by Chattaway (1932), and Wheeler, Baas and Gassan (1989).

4. Observations

Morphology

In this study of *Anacardium occidentale* Linn., *Bouea burmanica* Griff., and *Mangifera indica* Linn. are medium- or large-sized trees with umbelliform crown, evergreen but *Rhus paniculata* Wall. is deciduous, a little leaf-shedding tree.

The bark is 8 mm thick in *A. occidentale*, 5mm thick in both. *B. burmanica* and *R. paniculata* and 15-20 mm thick in *M. indica*. The colour of bark is grey to greyish white in *A. occidentale*, grey to greyish black in *B. burmanica*, grey to dark grey in *M. indica*, and reddish brown with exfoliating scales in *R. paniculata*.

All stems were woody. The colour of wood is pinkish white to white in *A. occidentale*, light brown with brownish grey heartwood in *B. burmanica*, yellowish

white to white in *M. indica*, and yellow to pinkish yellow with pinkish brown heartwood in *R. paniculata*.

The leaves are simple in most species, but in *R. paniculata*. The leaves are palmately 3-foliolate. The phyllotaxy is alternate in most species but opposite and decussate in *B. burmanica*.

The leaf blades are obovate to ovovate-oblong in *A. occidentale* oblong-lanceolate in *B. burmanica*, oblong or linear-oblong or elliptic or obovate - lanceolate in *M. indica*, and leaflet is obovate-oblong or cuneate-obovate, rarely oblanceolate in *R. paniculata*.

The midribs are prominent in all species with 8-14 pairs of lateral nerves consisting of distinct veins in *A. occidentale*, 10 -14 pairs of lateral nerves consisting of faint veins in *B. burmanica*, 12-26 pairs of lateral nerves consisting of distinct veins in *M. indica*, and 9-30 pairs of lateral nerves consisting of distinct veins in *R. paniculata*.

The leafbases are mostly acute in *A. occidentale*, *B. burmanica* and *M. indica* but obliquely cuneata in *R. paniculata*. The leafmargins are mostly entire and undulate in both *A. occidentale*, and *M. indica*, entire and rarely sub-undulate in both *A. occidentale*, and *M. indica* entire and rarely sub-undulate in *B. burmanica* and entire and very obscurely sinuate - lobed in *R. paniculata*. The leafapices are broadly rounded or obtuse in *A. occidentale*, mostly acuminate, rarely obtuse in *B. burmanica*, *M. indica* and *R. paniculata*.

The inflorescences are terminal and apically axillary in all species but mostly terminal, rarely axillary in *B. burmanica*. Their primary peduncle is 7-21 cm long in *A. occidentale*, up to 7 cm long in *B. burmanica*, 16-30 cm long in *M. indica* and up to 33 cm long in *R. paniculata*. They are glabrous in both *A. occidentale* and *B. burmanica*, or apically densely white pubescent and basally sub-glabrous in *M. indica* or finely puberulous in *R. paniculata*. They all bearing minute alternate glabrous bracts but pubescent, opposite and decussate in *B. burmanica*. Although the bracts are similar as oblong ovate in *R. paniculata* and *M. indica*, oblong elliptic in *B. burmanica* and ovate in *A. occidentale*.

The flowers are 7-8 mm across at anthesis in *A. occidentale*, about 2 mm in both *B. burmanica* and *R. paniculata*, and 4-6 mm in *M. indica* and (3-) 5(-6)- merous in *A. occidentale*, (3 -) 4 (-5)- merous in *B. burmanica*, (4 -) 5(-6)- merous in *M. indica* and 5-merous in *R. paniculata* where the colour is red in *A. occidentale* and yellow in *R. paniculata* during and after anthesis, yellow at anthesis then brown after anthesis in *B. burmanica*, and yellow at anthesis sooner or later tinge or not tinged after anthesis in *M. indica*. They are bracteate but ebracteate in *B. burmanica* pedicelate in all species, but articulate pedicel is found in *M. indica*.

The sepals are free in all species, erect in *B. burmanica* and patent in *M. indica*, pubescent in all species but glabrous in *R. paniculata*.

The petals are imbricate in all species, patent to deflexed in both *A. occidentale* and *M. indica*, obliquely erecto-patent in *B. burmanica*, carinate (a distinct longitudinal line) on the inside in *B. burmanica*, but in *M. indica* they are with basally connate into ridge-like 3-5 nerves and 1-nerved with 3 upper lateral veins in *R. paniculata*, densely short-hairy on both surfaces in *A. occidentale*.

The stamens are 5 in most species except *A. occidentale*, in which they are 7-10 or as many as petals, usually one of them fertile and others are reduced to staminodes in *A. occidentale* and *M. indica* which are basally connate into a tube in *A. occidentale*; staminode unequal in length in both type of flowers of *A. occidentale* but equal in *M. indica*, lacking in *B. burmanica*; anther medifixed in both

A. occidentale and *M. indica*, but basifixed in both *B. burmanica* and *R. paniculata*, longitudinally dehiscent; connective is mucronate in *B. burmanica*.

The ovaries in all species are monocarpellary, superior, unilocular, with a single ovule on the parietal placenta seeming basal, glabrous; rudimentary ovary present in staminate flowers of *A. occidentale* but absent in others.

The style is solitary and nearly central in *A. occidentale*, *B. burmanica* and *M. indica*, but 3 and terminal in *R. paniculata*; stigma slightly capitate in *A. occidentale* and mostly hardly widened in *M. indica*, usually bifid or rarely capitate in *B. burmanica* and usually simple or rarely capitate in *R. paniculata*.

The fruiting pedicel is obconical in cashew but in the remaining species it is not swollen. Fruit is a reniform nut in *A. occidentale*, ellipsoid in *B. burmanica*, subglobose to oblong-lanceolate in *M. indica* and subglobose depressed in *R. paniculata*, but the rest are drupaceous. All fruits are edible.

The pyrenes are fibrous and indehiscent in *B. burmanica* and *M. indica*, but smooth and dehiscent into 2-valves in *R. paniculata*. The seed is oleiferous in *A. occidentale* but non-oleiferous in others.

Anatomy

Key to the species

1. Apotracheal parenchyma band with dark gum-like contents; paratracheal parenchyma vascentric. Rays 1-2 cells wide, mostly uniseriate2. *Bouea burmanica*.
1. Apotracheal parenchyma rare or scanty without dark gum-like contents; paratracheal parenchyma vascentric, aliform, and confluent connecting few pore forming tangential bands. Rays 1-4 cells wide, mostly uniseriate to biseriate2.
2. Pores solitary present less than 40%. Parenchyma with or without crystals. Heartwood present or absent 3.
2. Pores solitary present more than 40%. Parenchyma without crystals. Heartwood absent..... 4.
3. Vessels very small to medium-sized, maximum diameter of the pores less than 200 μm . Rays with crystals and gum deposits. Heartwood pinkish brown. Moderately fine-textured5. *Rhus paniculata*
3. Vessels very small to moderately large, maximum diameter of the pores more than 200 μm . Rays without crystals and gum deposits. Heartwood lacking. Medium to coarse-textured1. *Anacardium occidentale*
4. Rays 1-3 cells wide, mostly uniseriate to biseriate. Pores solitary and in radial multiples of 2-5 3. *Mangifera indica* var. 1
4. Rays 1-4 cells wide, mostly biseriate. Pores solitary and in radial multiples of 2-9 4. *Mangifera indica* var. 2

4.3.1.1 *Anacardium occidentale* Linn.

General Features: Growth rings absent or faint; heartwood absent, sapwood pinkish white to white. Texture medium to coarse, grain interlocked.

Microscopic Features: Wood diffuse porous, solitary 27% and in short radial multiples of 2-5 rows and few irregular clusters up to 10; 4 -14 per sq.mm, circular or oval, very small to moderately large, mean tangential diameter 128 μm (range 41-236 μm). Perforation simple, end walls transverse or oblique or tailed both end. Inter vascular pits alternate, crowded, oval, round, polygonal, half-bordered to bordered, 8-3 μm . Vessel-ray and vessel parenchyma pits smaller, round, oval, half-bordered to bordered. Thin - walled tyloses abundant. Fibres non septate, with small simple pits restricted to the radial walls; wall 3.7 μm thick, lumina 7.9 μm ; mean length 691 μm (range 492-943 μm). F/V ratio 1.8 (range 0.8 - 3.4). Rays uniseriate and multiseriate, heterogeneous, 14-22 per mm, tangentially. Uniseriate rays composed of mainly procumbent cells and upright cells, height up to 1-11 cells (41-379 μm). Multiseriate rays composed of mainly procumbent cell and upright cells; 2-4 cells wide, up to 123-646 μm high. Paratracheal parenchyma occasionally scanty, mostly vasicentric, sometimes aliform and confluent.

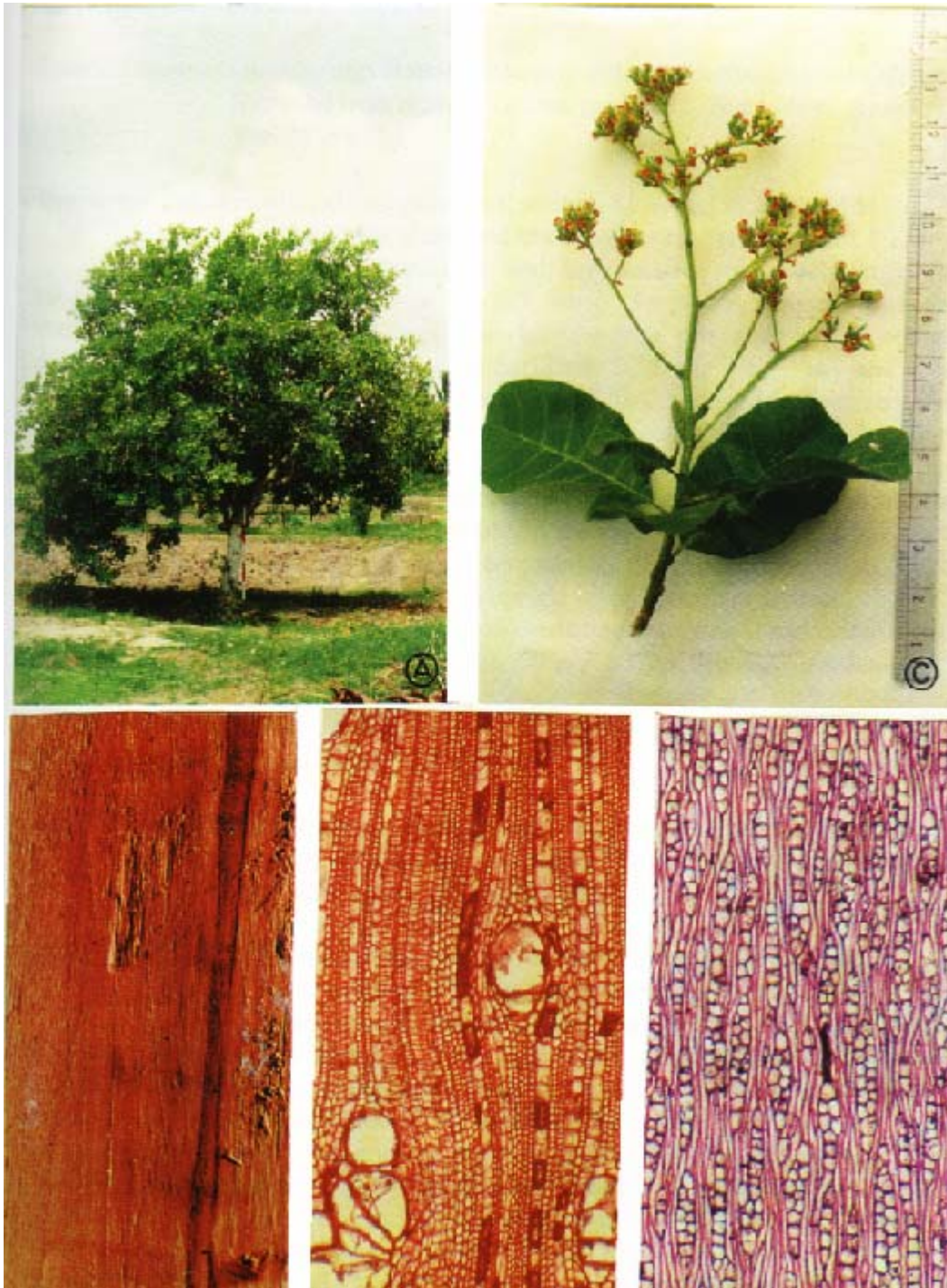


Fig. 1. *Anacardium occidentale* A. A plant in natural habit.
B. An Inflorescence.
C. Portion of wood in natural colour as seen.
D. Cross section of wood (x 83)
E. Tangential longitudinal section of wood (x 83)

4.3.1.2. *Bouea burmanica* Griff.

General Features: Growth rings absent or scarcely distinct; heartwood brownish grey. Sapwood light brown. Texture moderately fine to fine, generally straight grained.

Microscopic Features: Wood diffuse porous, solitary 81% and in short radial multiples of 2-6 and few irregular clusters up to 15; 4-13 per sq.mm, circular or oval, very small to moderately large, mean tangential diameter 111 μm (range 41-205 μm). Perforation simple, end walls transverse or oblique or tailed both end. Inter vascular pits alternate to opposite, crowded, oval, elliptical, half-bordered to bordered, 5-38 μm . Vessel-ray and vessel parenchyma pits smaller, oval or round, or elliptical, half-bordered to bordered. Thin walled tyloses and gum deposits abundant. Fibres non septate, with small simple pits restricted to the radial walls; wall 4.4 μm thick, lumina 4.9 μm ; mean length 723 μm (range 379-912 μm). F/V ratio 1.7 (range 0.8-5.2). Rays uniseriate and biseriate, heterogeneous, 15-21 per mm tangentially. Uniseriate rays composed of mainly procumbent cells and upright cells, height up to 1-15 cells (41-543 μm). Biseriate rays composed of mainly procumbent cells and upright cells; up to 2 cells wide, up to 154-984 μm high. Paratracheal parenchyma vascentric, and apotracheal parenchyma bands forming 3-13 seriates, sometimes connecting 2-3 pores. Gum deposits abundant.

4.3.1.3 *Mangifera indica* Linn.var.1

General Features: Growth rings absent or faint; heartwood generally lacking,, sapwood yellowish white to white. Texture coarse, grain straight or interlocked or curly-grained.

Microscopic Features: Wood diffuse porous, solitary 53% and in short radial multiples of 2-5 rows and few irregular clusters up to 6; 3-13 per sq.mm, circular or oval, moderately small to moderately large, mean tangential diameter 132 μm (range 51-236 μm). Perforation simple, end walls transverse or oblique or tailed both end. Intervascular pits alternate to opposite, crowded, oval, round, half-bordered to bordered, 5-25 μm . Vessel-ray and vessel parenchyma pits smaller, oval or round, half-bordered to bordered. Thin-walled tyloses abundant. Fibres non septate, with small simple pits restricted to the radial wall; wall 4 μm thick, lumina 7.7 μm ; mean length 650 μm (range 369-912 μm). F/V ratio 2.2 (range 1.2-4.0). Rays uniseriate and biseriate or occasionally triseriate, heterogeneous, 11-18 per mm tangentially. Uniseriate rays composed of mainly procumbent cells and upright cells, height up to 1-11 cells (51-297 μm). Multiseriate rays composed of mainly procumbent cells and upright cells; 2-3 cells wide, up to 123-482 μm high, crystals and gum deposits abundant in the ray cells. Paratracheal parenchyma vascentric, mostly aliform to confluent and very few forming short concentric band 4-12 seriates, apotracheal parenchyma scanty.



Fig. 2. *Bouea burmanica*

- A. A plant in natural habit.
- B. An Inflorescence.
- C. Portion of wood in natural colour as seen.
- D. Cross section of wood (x 83)
- E. Tangential longitudinal section of wood (x 83)

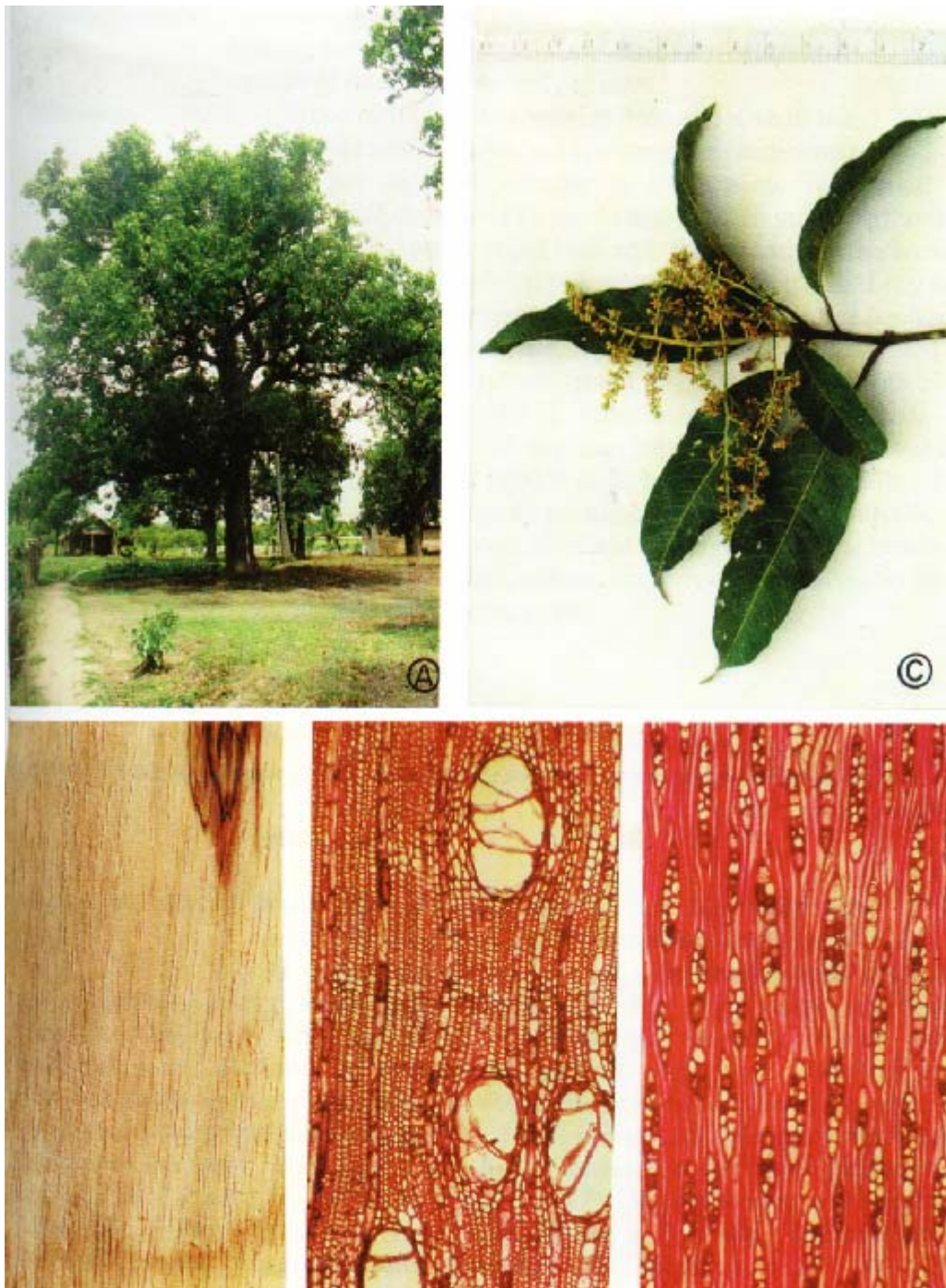


Fig. 3. *Mangifera indica* var.1

- A. A plant in natural habit.
- B. An Inflorescence.
- C. Portion of wood in natural colour as seen.
- D. Cross section of wood (x 83)
- E. Tangential longitudinal section of wood (x 83)

4.3.1.4 *Mangifera indica* Linn.var.2

General Features: Growth rings absent or scarcely distinct; heartwood generally lacking, sapwood yellowish white to white. Texture coarse, grain straight or interlocked or curly-grained.

Microscopic Features: Wood diffuse porous, solitary 46% and in short radial multiples of 2-9 rows and few irregular clusters up to 14; 3-16 per sq.mm, circular or oval, pores very small to moderately large, mean tangential diameter 116 μm (range 31-236 μm). Perforation simple, end walls transverse or oblique or tailed both end. Intervascular pits alternate or opposite, crowded, oval, round, half-bordered to bordered, 5-35 μm . Vessel-ray and vessel parenchyma pits smaller, oval or round or elongate, half-bordered to bordered. Thin-walled tyloses abundant. Fibres non-septate, with small simple pits restricted to the radial wall; wall 4.4 μm thick, lumina 7 μm ; mean length 813 μm (range 574-1015 μm). F/V ratio 2.2 (range 1.1-4.3). Rays uniseriate and biseriate or occasionally tetraseriate, heterogeneous, 6-16 per mm tangentially. Uniseriate rays composed of mainly procumbent cells and upright cells, height up to 1-11 cells (51-246 μm). Multiseriate rays composed of mainly procumbent cells and upright cells; 2-3 cells wide, up to 133-420 μm high, crystals abundant in the ray cells. Paratracheal parenchyma vasicentric, mostly aliform to confluent and very few concentric band forming 2-20 seriates, apotracheal parenchyma scanty.

4.3.1.5 *Rhus paniculata* Wall.

General Features: Growth rings absent or faint; heartwood pinkish brown, sapwood yellow to pinkish yellow. Texture moderately fine, grain straight or interlocked.

Microscopic Features: Wood diffuse porous, solitary 26% and in short radial multiples of 2-8 rows and few irregular clusters up to 15; 14-43 per sq.mm, circular or oval, very small to medium sized, mean tangential diameter 88 μm (range 31-185 μm). Perforation simple, end walls transverse or oblique or tailed both end. Inter vascular pits alternate, crowded, oval, round, polygonal, elliptical, half-bordered to bordered, 4-18 μm . Vessel-ray and vessel parenchyma pits smaller, round or oval or elliptical, half-bordered to bordered. Thin-walled tyloses abundant, gum deposits. Fibres non-septate, with small simple pits restricted to the radial wall; wall 4 μm thick, lumina 6.1 μm ; mean length 645 μm (range 502-789 μm). F/V ratio 2.4 (range 1.4-5.1). Rays uniseriate and biseriate, occasionally multiseriate, heterogeneous, 11-18 per mm, tangentially. Uniseriate rays composed of mainly procumbent cells and upright cells, height up to 2-19 cells (51-533 μm). Multiseriate rays composed of mainly procumbent cells and upright cells; 2-4 cells wide, up to 174-851 μm high, crystals and gum deposits abundant in the ray cells. Paratracheal parenchyma scanty, terminal band forming 2-14 seriates, along the tangential line; apotracheal parenchyma sparse, crystals present.



Fig. 4. *Mangifera indica* var.2

- A. A plant in natural habit.
- B. An Inflorescence.
- C. Portion of wood in natural colour as seen.
- D. Cross section of wood (x 83)
- E. Tangential longitudinal section of wood (x 83)

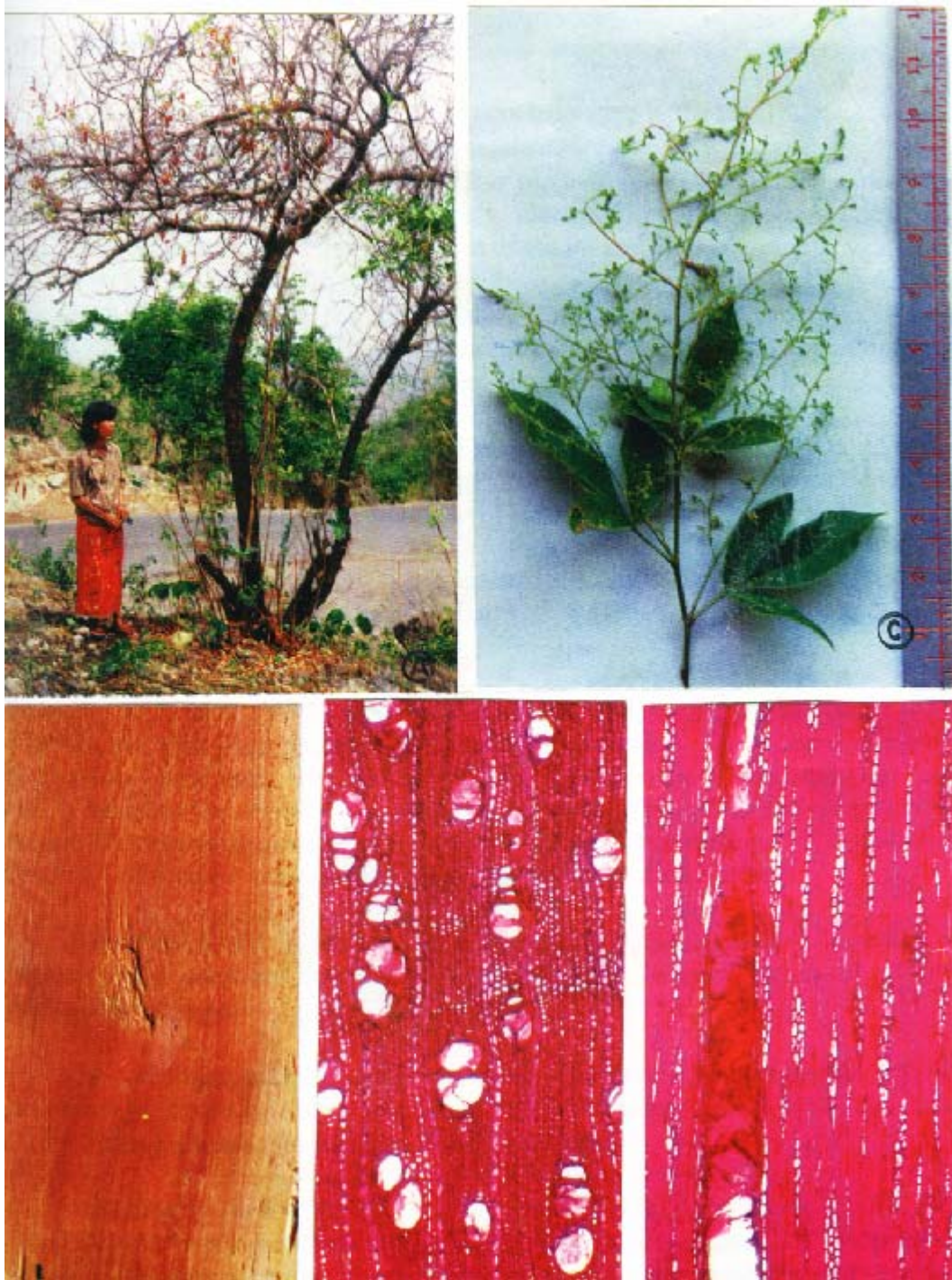


Fig. 5. *Rhus paniculata*

- A. A plant in natural habit.
- B. An Inflorescence.
- C. Portion of wood in natural colour as seen.
- D. Cross section of wood (x 83)
- E. Tangential longitudinal section of wood (x 83)

5. Discussion

In the present study 5 species of 4 genera belonging to the family Anacardiaceae has been undertaken. These species are *Occidentale* Linn., *Bouea burmanica* Griff., *Mangifera indica* Linn. var.1 & 2 and *Rhus paniculata* Wall. The comparison has been made between some of the variety identification, the morphological and anatomical characteristics of these species in this work and those of the other workers.

In *B. burmanica* the leafblade is usually oblong-lanceolate or often oblong – elliptic. However, Kurz (1877) and Hooker (1879) described that it was elliptically lanceolate but Backer and (1965) mentioned oblong-lanceolate.

In *M.incida* the leafblade is oblong-lanceolate but Kurz (1877) described that it was elliptically oblong to oblong-lanceolate. However, Hooker mentioned that it was oblong or linear- oblong or elliptic or obovate-lanceolate. Their greatest width is below or above the middle. Their whole length is less than 5 times as long as width, Hooker (1879) and Brands (1972) described that the margin was quite entire. According to Kurz (1877) often undulate but both are found in this present study.

In *R.paniculata* the leaflets are elliptic or elliptic-oblong in this study. According to Hooker (1872) they were elliptic or elliptic-oblong but kurz (1877) described that they were obovte-oblong or cuneate-obovate. Their central one large than the two lateral ones. The base is obliquely cuneate in the present study but Kurz (1877) described that it was narrowed, nearly so blunt or bluntish. The margin being entire or very obscurely sinuate-lobed in the present study but Hooker (1872) described that it was quite entire or seriate and Kurz (1877) also mentioned entire.

The nerves on the leaf are found 8-14 pairs in *A. occidentale*. According to Hooker (1879) described that they were found about 10 pairs but Anon (1986) mentioned 13-14 pairs.

The veins are conspicuously nerved on both side in *A.occidentale* and *R.paniculata* which are agreement with Kurz (1877). However Anon (1986) described that they were prominent below the leaf in *A.occidentale*.

According to Hooker (1872), Tin Tin Than (1975), Aung Kyaw (1976), Hla Aye (1977) the petals was ovate-oblong in *R. paniculata* but Kurz (1977) described oblong. In this present study the petal being the shape as they described and the mid –nerve contains 3-lateral veins on each side.

In *M.indica* the disc is 5-lobed but Backer and Brink (1965) described that it was more or less lobed.

In *A.occidentale* the stamens are 7.10 in the present study which is agreement in with Backer and Brink (1965). According to Hooker (1879) found that they were usually 9, Kurz (1877) described 9 or 10, Renalds (1960) also mentioned usually 10.

In *B. burmanica* the stamens are as many as petals which is agreement in with Backer and Brink (1965). According to Hooker (1879) they were usually 4, Hooker, Kurz (1877) mentioned that they were 8 and Renalds (1960) also described 4 or 5.

In *R.paniculata* the anther is basifixed which is agreement in with Tin Tin Than (1975), Aung Kyaw (1976), Hla Aye (1977). However, Renalds (1960) described that it was dorsifixed.

In *B. burmanica* the stigma is bifid. However, Backer and Brink (1965) mentioned it was simple but Renalds (1960) also described that it was trifid.

Backer and Brink (1965) described that fruiting pedicel of *A. occidentale* had a red spot or not but it has no not a red spot in this study.

In *R.paniculata* the drupe is laterally compressed subgloboid in shape. Hooker (1879) described that it was nearly orbicular but Hooker (1879) and Kurz (1877) also described compressed.

As observed in the present study, the colour of wood is pinkish white to white in *Anacardium occidentale* Linn. According to Kurz (1877) it was dark-brown. Watt (1889) described that it was red but Gamble (1922) and Dalziel (1955) also mentioned that it was reddish brown.

In *Bouea burmanica* Griff, the colour of wood is light brown with brownish grey heartwood. According to Watt (1889), Gamble (1922) and Anon (1948), it was grey and hard with reddish brown. Dadswell and Ingle (1948) described that it was pale brown with a pinkish tinge.

In *Mangifera indica* Linn. var . 1 & 2 the colour of wood is yellowish white to white. However, Kurz (1877) described that it was yellowish or dull grey and Gamble (1922) mentioned grey. Pearson and Brown (1932) described that it was white to greyish-white, greyish-brown or light brown and frequently splashed with pale yellow, and the heartwood was generally lacking or if present it was small and light chocolate brown. Dadswell and Ingle (1948) also stated that greyish to greyish-brown often streaked with darker bands, sapwood was distinct from the heartwood.

In *Rhus paniculata* Wall, the colour of wood is yellow to pinkish yellow with pinkish brown heartwood at the present study. However, Gamble (1922) described that it was grey often with yellow or brown heartwood. Dadswell and Ingle (1948) mentioned usually pale pinkish-brown.

The anatomical characteristics for these woods studied are in accordance with the descriptions of the species as given in the literature and secondary xylem characteristics observed for all the species are shown in Table 1. Growth rings are absent or faint in all the species studied.

The vessels of *B. burmanica* are very small to moderately large in this present study but Metcalfe and Chalk (1957) described that they were mostly moderately small to medium-sized. In this study they were mostly solitary but with a few radial and irregular multiples of several small cells which is in agreement with Metcalfe and Chalk (1957).

As observed in the presents study the vessels of *M.indica* Linn. var.1 are moderately small to moderately large and *M.indica* Linn. var.2 are very small to moderately large. The maximum tangential diameter is 236 μm in both *M.indica* Linn. var. 1 & 2 which is in agreement with Dadswell and Ingle (1948) . Pearson and Brown (1932), Metcalfe and Chalk (1950) mentioned that they were very large to medium sized or large and more than 200 μm in some species of *Mangifera*.

Dadswell and Ingle (1948), Metcalfe and Chalk (1957) described that the vessels of *R.paniculata* were small and solitary but in this study they were very small to medium and solitary, multiples and a few clusters. Tangential pore diameters exhibit the wide range among these species, however, the maximum diameter occur in *R.paniculata* as shown in Diagram 1.1. Dadswell and Ingles (1948) mentioned that the solitary pore percent was 40-50 in *Rhus*. However, 26% is found in this study. It is minimum among these species which is shown in Diagram 1.2. However the pores frequency of this species are nearly equal in number as stated in Diagram 1.3.

Average length of vessel elements of these species ranges from 286 to 438 μm with the maximum length occurring in *B. burmanica* and the minimum length occurring in *R. paniculata*. Their average variations are shown in Diagram 1.4.

At the present study the non-septate fibres are found in all species which is in agreement with Dadswell and Ingle (1948). However, Metcalfe and Chalk (1957) mentioned that the septate - fibres were found in all or some species of *A. occidentale* and *R. paniculata* but in *M.indica* the septate fibres were occasionally intermingled among the non-septate fibres. The fibre length are varing among these species. Their average fibre length fibre diameter and fibre lumen are shown in Diagram 2.1, 2.2 and 2.3.

Metcalf and Chalk (1957) mentioned that the rays of *Bouea* were mostly 2-3 cells wide but in *B. burmanica* uniseriate and biseriate are usually found which is in agreement with Dadswell and Ingle (1948).

At the present study the rays are mostly uniseriate and biseriate but occasionally triseriate in *M. indica* Linn. var.1 and sometimes tetraseriate in *M. indica* Linn. var.2. However, Dadswell and Ingle (1948), Metcalf and Chalk (1957) mentioned that they were usually uniseriate or occasionally biseriate but Dadswell and Ingle (1948) described that they were found up to triseriate in other species of *mangifera*.

In *R. paniculata* the rays are mostly uniseriate and biseriate occasionally up to tetraseriate and those are in agreement with Dadswell and Ingle (1948).

The height of uniseriate ray and multiseriate ray vary their average among these species. The maximum height of uniseriate and multiseriate occur in *B. burmanica* as shown in Diagram 3.1 and 3.2.

The ray width of these species are varying in those species as shown in Diagram 3.3.

Metcalf and Chalk (1957) mentioned that dark gum-like substance and crystals were present in the ray cells in *A. occidentale* and Dadswell and Ingle (1948), Metcalf and Chalk (1957) described that they are found in *B. burmanica*. However, they are not found in this study.

In *M. indica* Linn. var.1, dark gum-like substances and crystals were present which is in agreement with Pearson and Brown (1935), Metcalf and Chalk (1950) but *M. indica* Linn. var.2. only crystals are found.

In *R. paniculata* the crystals are abundant which agrees with Dadswell and Ingle (1948), Metcalf and Chalk (1957). The gum deposits are abundant which is in agreement with Dadswell and Ingle (1948).

The ray frequency of these species are nearly equal in number, the minimum frequency occur in *M. indica* Linn. var.2 as shown in Diagram 3.4.

In *B. burmanica* vessel-ray pitting are half-bordered and bordered but Dadswell and Ingle (1948) described half-bordered only.

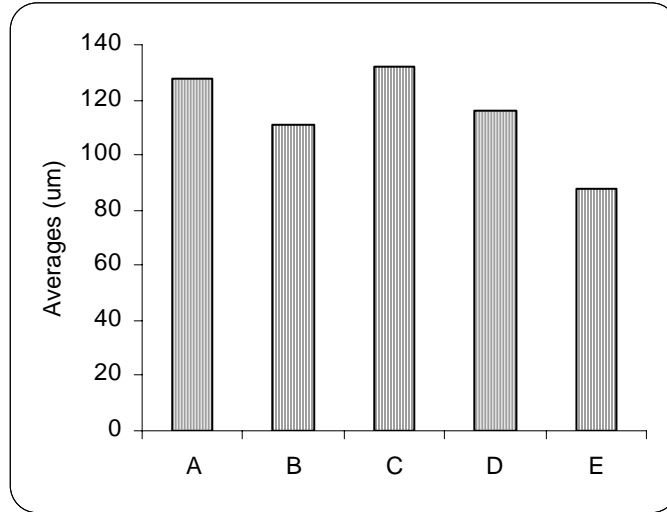
The parenchyma of *A. occidentale* are paratracheal scanty or vasicentric, aliform or confluent which agrees with Metcalf and Chalk (1957).

Table 1. Results and measurement of wood anatomical characteristics of the species of *Anacardium occidentale*, *Bouea burmanica*, *Mangifera indica* var. 1, *Mangifera indica* var. 2. and *Rhus paniculata*.

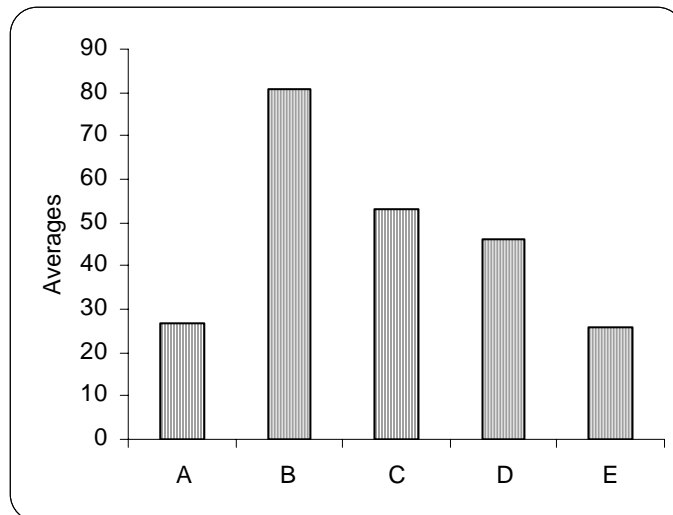
	A.occidentale	B.burmanica	<i>M.indica</i> Linn var.1.	<i>M.indica</i> Linn. var.2	R.paniculta
pores frequency (per mm ²)	8 (4-14)	7(4-13)	7(3-13)	7 (3-16)	9 (14-43)
solitary pore (%)	27(0-80)	81(33-100)	53(14-100)	46(0-100)	26(0-63)
vessel diameter (µm)	128 (41-236)	111(41-205)	132 (51-236)	116 (31-236)	88 (31-185)
vessel length(µm)	414(236-677)	438(205-595)	315(154-461)	407(154-584)	286(144-441)
ray frequency (per mm)	18(14-22)	18(15-21)	15(11-18)	10(6-16)	15(11-18)
uniseriate ray height (µm)	190(41-379)	268(41-543)	175(51-279)	152(51-246)	230(51-533)
no. of uniray cell (range)	1-11	1-15	1-11	1-11	2-19
multiseriate ray height (µm)	334(123-646)	407(154-984)	261(123-482)	249(133-420)	390(174-851)
no.of multi ray cell (range)	4-27	5-40	5-22	4-2	9-49
ray width (µm)	43(18-68)	34(13-55)	34(15-55)	38(13-63)	21(8-40)
fibre length (µm)	691(492-943)	723(379-912)	650(369-912)	813(574-1015)	649(502-789)
fibre diameter (µm)	15(10-20)	14(8-25)	16(8-25)	16(8-25)	14(8-25)

1. Diagrams showing the variation in the average of vessel element of the species of *Anacardium occidentale*, *Bouea burmanica*, *Mangifera indica* var 1, *Mangifera indica* var. 2 and *Rhus paniculata*.

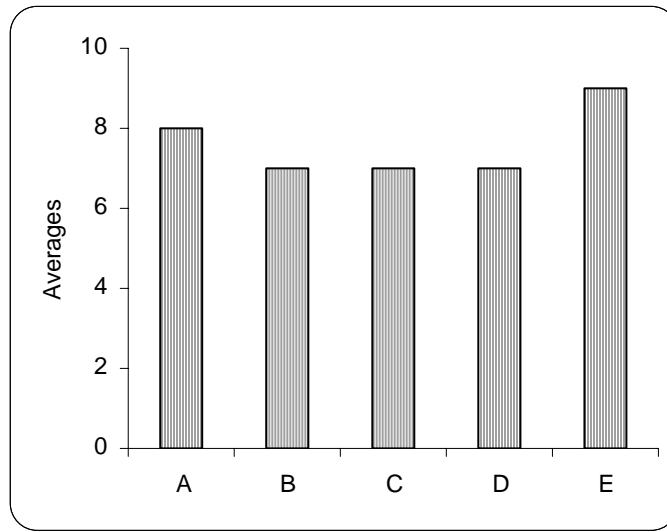
1.1 tangential diameter of vessel lumens



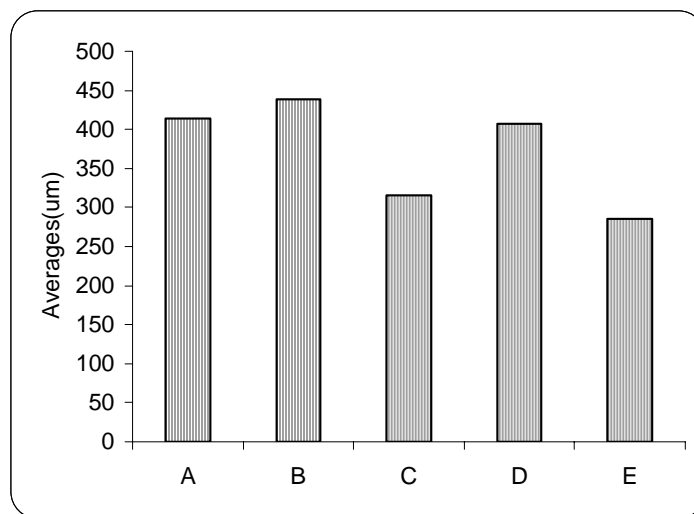
1.2 solitary pore percentage (%)



1.3 vessel per sq.mm.



1.4 mean vessel elements length (um)



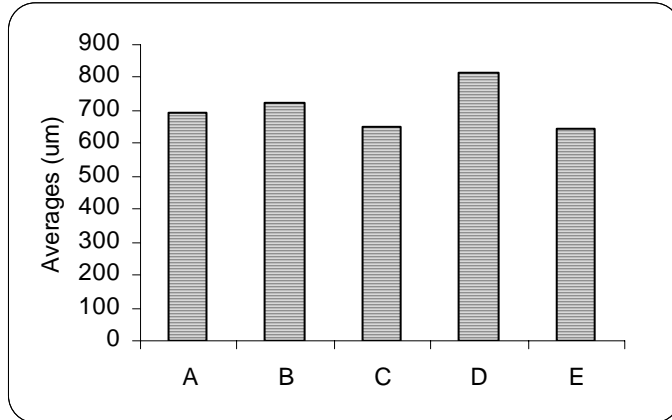
A = *A.occidentale*
D = *M. indica* var.2

B = *B. burmanica*
E = *R.paniculata*

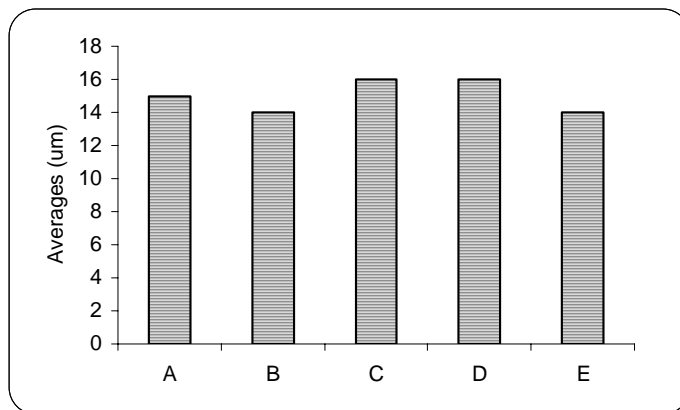
C = *M.indica* var 1

2. Diagrams showing the variation in the average of the fibre characteristics of the species of *Anacardium occidentale*, *Bouea burmanica*, *Mangifera indica* var 1, *Mangifera indica* var. 2 and *Rhus paniculata*.

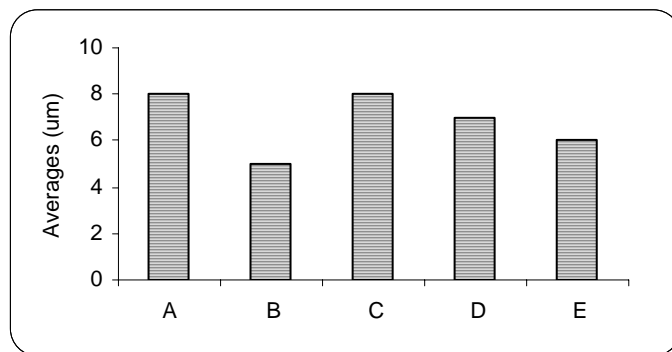
2.1 mean fibre length (um)



2.2 fibre diameter (um)



2.3 fibre lumen (um)



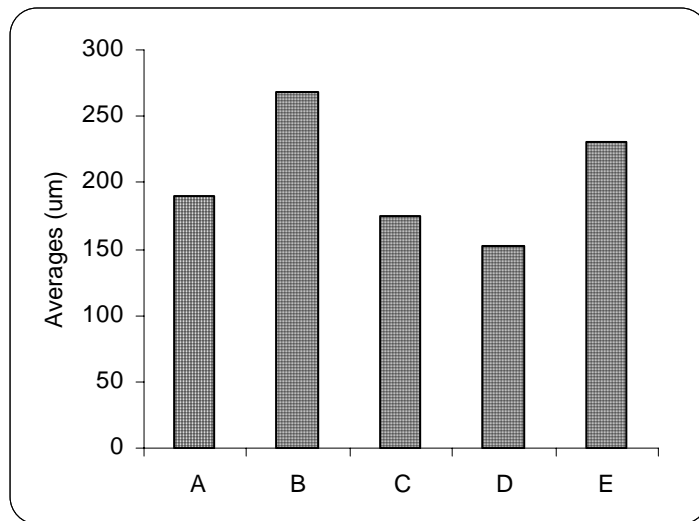
A = *A.occidentale*
D = *M. indica* var.2

B = *B. burmanica*
E = *R.paniculata*

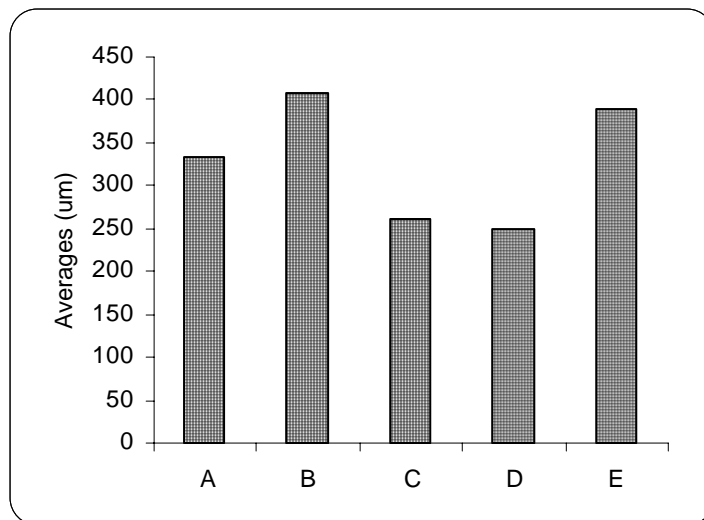
C = *M.indica* var 1

3. Diagrams showing the variation in the average of the species of *Anacardium occidentale*, *Bouea burmanica*, *Mangifera indica* var 1, *Mangifera indica* var 2 and *Rhus paniculata*.

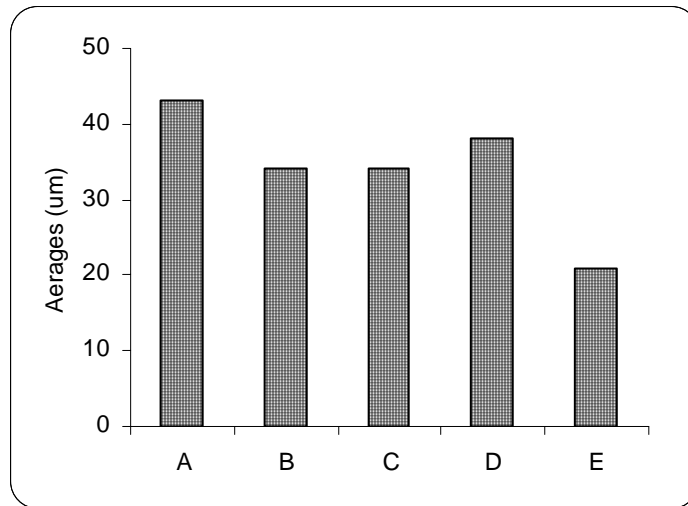
3.1 uniseriate ray height (um)



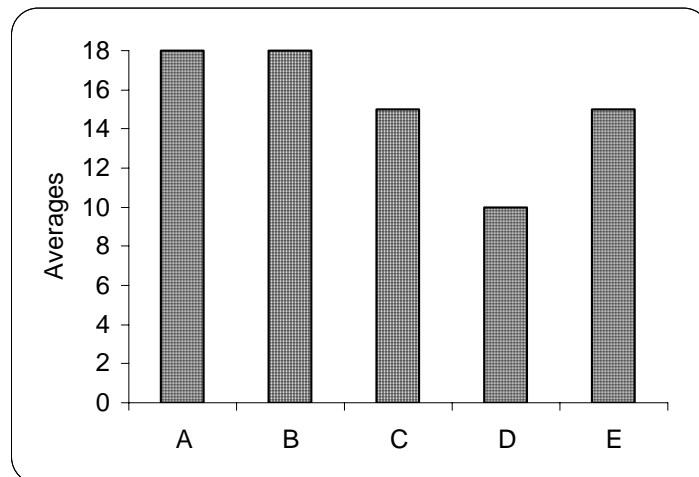
3.2 multiseriate ray height (um)



3.3 Ray width (um)



3.4 Ray per mm.



A = *A. occidentale*
D = *M. indica* var.2

B = *B. burmanica*
E = *R. paniculata*

C = *M. indica* var 1

Dadswell and Ingle (1948), Metcalfe and Chalk (1957) described that the parenchyma were paratracheal, vasicentric to occasionally aliform in *Bouea* but they are mostly paratracheal, vasicentric except aliform in this study. The apotracheal parenchyma bands up to 3-10 seriates is found in this study. It is in agreement with Dadswell and Ingle (1948).

At the present work the parenchyma of *M.indica* are vasicentric to aliform, occasionally confluent which agrees with Dadswell and Ingle (1948), Metcalfe and Chalk (1957) but concentric band and scanty apotracheal parenchyma are also found in this study. Dadswell and Ingle (1948) described that the crystals were present but they are not found in this study.

The parenchyma of *R.paniculata* are paratracheal scanty and found terminal band up to 13 seriates in the present study but Dadswell and Ingle (1948), Metcalfe and Chalk (1957) mentioned that they were paratracheal, vasicentric to occasionally aliform. The crystals were also present which is in agreement with Dadswell and Ingle (1948).

Variety discussion of *Mangifera indica* Linn.

According to literature, no survey had so far been done for identification of mango varieties in Myanmar.

Maries (1901-2) made the first attempt to describe mango varieties scientifically in India. Woodhouse (1901), Rolps (1915), Burns and Prayag (1921) and Sturrock (1951) used the characters of fruit for identification of mango varieties, and those are in agreement with the present study.

Apart from that the pyrene characters include shape, size, nerves on the pyrene and fibres. The seed characters consist of size, seed - coat and funicle.

However, fruit characters could be distinguished for classifying mango varieties like Woodhouse (1909), Rolps (1915), Burns and Prayag (1921) and Sturrock (1951), Popenoe (1932), Mukherjee (1948), Singh and Singh (1956).

Grant and Williams (1949) described that Myanmar has a great many named varieties of mango, and most of them are polyembryonic.

Gangolly and et al (1957) and Sing (1960) supposed that most of the cultivated varieties are polyembryonic type but all varieties grown in India, except about ten grown on the Western Coast of India, are monoembryonic type.

In this work, it is found that *M.indica* Linn. var.1, Myanmar race, is polyembryonic type and *M.indica* Linn. var.2, Indian race, is monoembryonic type.

Singh (1960) mentioned that they could easily be distinguished as monoembryonic or polyembryonic on the basis of number of taproot. Single taproot would be a fair indication of its being monoembryonic, whereas more than one tap root with equal numbers of shoots would mean that the variety is polyembryonic.

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