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Programme: Bachelor of Science in Forestry

MONOGRAPH
ON
NAGLINGAM TREE
(Couroupita guianensis Aubl.)

ASHIQUE TANVIR SIJAR
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[This review paper has been prepared and submitted for the partial fulfilment of 4-years professional degree of B.Sc. (Hon's) in Forestry from Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh]

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ON

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(*Couroupita guianensis* Aubl.)

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Dedicated

To

My Beloved Parents

DECLARATION

The review paper has been prepared by me. Information quoted from any source has been duly acknowledged by mentioning the author's at appropriate place. This has not been concurrently submitted elsewhere for any other degree.

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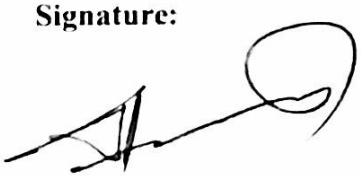
APPROVAL

Project thesis submitted to the Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh, in partial fulfilment of the requirements for the 4-years professional B. Sc. (Hon's) degree in Forestry. I have approved the style and format of the project thesis.

Signature:



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ABSTRACT

Couroupita guianensis is one of the important species in its native areas. It is a member of *Lecythidaceae* family. It is well known for its ornamental and botanical purposes. In the native area the species is a popular medicinal plant viz. skin diseases, stomach ache, enteral gas formation, antithrombotic and vasodilatory actions, upset, tumours, pain and inflammatory processes, haemorrhage, piles, scabies, dysentery, scorpion poison etc. treatment. The tree normally attains 30-35 m in height, produces pink to red colour flower with sweet scent and big cannon ball shape fruits. The wood of the species is not good for construction and furniture work. It grows well in the area where the temperature is 40°- 44° C and rainfall is 1200-1500 mm and humidity is 60-90%. The fruit is edible but has very unpleasant odour. The seed viability of the species is very short. The germination is very high in summer seasons. When saplings age is 7 month they are planted in the field. The growth rate is moderately high. It is a semi- evergreen species. The leaves of the species are long 10-20 cm and wide 4-10 cm and dark green in colour. Pollination is autogamy. Different chemical constituents are extracted from different parts of the species. In the pharmaceutical research all parts of the species have shown medicinal values. It has anti-bacterial, anti-fungal and anti- viral activities. The ecology of the species is yet to be studies. In Bangladesh it is an exotic species and is located only in private gardens.

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% = Percentage	°c = Degree Celsius	cm = Centimetre
m = Metre	cc = Cubic-centimetre	µg = Micro-gram
ml = Mili-litre	mg = Mili-gram	kg = Kilo-gram
E = East	W = West	N = North
S = South	mm = Mili-meter	

BNPD = Brazil National Plant Database

BD = Bangladesh

ZZD = Zip code Zoo Database

DNA = Deoxyribonucleic Acid

FACS = Fluorescence-activated Cell Sorting

EPM = Elevated Plus Maze

LD = Light and Dark

OFT = Open Field Test

SRBC = Sheep Red Blood Cell

TST = Tail Suspension Test

FST = Forced Swim Test

FWT = Forestry and Wood Technology

C. guianensis = *Couroupita guianensis*

Chapter-1: Introduction

1.1 Background of the study

Couroupita guianensis Aubl. is native to Central and tropical Southern America. It is a member of Lecythidaceae family. It is well known for its ornamental and botanical purposes. (Giuseppe, 2015).

In the native area the species use as medicinal purposes i.e. skin diseases, stomach ache, enteral gas formation, antithrombotic and vasodilatory actions, upset, tumours, pain and inflammatory processes, haemorrhage, piles, scabies, dysentery, scorpion poison etc. treatment (Golatkar *et al*, 2001; Elumalai *et al*, 2012; Satyavathi *et al*, 1976; Sanz *et al*, 2009; Kumar *et al*, 2011).

Different chemical constituents are extracting from different part of the species. In the pharmaceutical research all parts of the species have medicinal values. Different parts of the species are use different diseases i.e. immunomodulatory, neuropharmacological, wound healing activities etc. (Sundararajan *et al*, 2014).

The ecology of the species is not clearly traced any literature (Silva & Tasso, 2015; Pradhan *et al*; 2009; Prance & Mori, 1986).

The cannonball tree was first introduced in Bangladesh by Maharaja Dayaram, King of Dighapatia Jamindarbari Natore Under ancient Rajshahi district in the early 19th century (Personal Communication, 2015).

The species has good botanical value but huge information is not available about it. So here is a great chance to research over it and identified the ecological effect on the Bangladesh. It is an exotic species in our country but has different medicinal activity on its different parts. So the available cultivation in our country which types of environmental effect creates on our country and awareness increase about its medicinal purpose on our country people. So there create a good research field for our country researcher and pharmacist and wild life conservation the species will keep significant role.

1.2 Objectives of the study

i. To collect the available literature on *Couroupita guianensis*.
ii. To accumulate and organize information about *Couroupita guianensis*.
iii. To find knowledge gap.

1.3 Methodology

This monograph is based on literature review. To prepare this monograph all relevant available information were collected from secondary sources, like textbook, newspaper, journals and online sources. In the online system we have used the scholar Google with *Couroupita guianensis*, distribution, use, chemical constituent's etc. key words and collected different information of the species. Then I have organized the materials according to the topic I needed e.g. taxonomy, distribution, morphology, phenology, wood properties, use etc. Then the collected information has been classified and synthesized under different heading and sub-heading. The literatures were sorted out by subject matter of the titles. Information were organized in an orderly way to prepare this monograph of *Couroupita guianensis* Aubl.

Chapter-2: Taxonomy

Couroupita guianensis Aubl.is native to Central and tropical Southern America (Brazil, Colombia, Costa Rica, Ecuador, French Guyana, Guyana, Panama, Peru, Surinam and Venezuela), where it grows in the thick humid forests, often along the rivers, at low altitude. The name of the genus is the native one of the French Guyana, "couroupitoutoumou". The name of the species refers to its origin country (Giuseppe, 2015).

2.1 Scientific Classification

The scientific classification of *Couroupita guianensis* Aubl. tree that has taken (Source: BNPD, 2004) is given in below.

Kingdom: Plantae

Phylum: Tracheophyta

Class: Magnoliopsida

Sub-class: Magnoliidae

Order: Lecythidales

Family: Lecythidaceae

Genus: *Couroupita*

Species: *C. guianensis*

Botanical name *Couroupita guianensis* Aubl.

(Source: BNPD, 2004)

2.2 Common names

The tree has common names in different languages. In the Indian sub-continent the species is named according to God Shiva. The ovary of the species look like the statue of Shiva lingam, so in Hindi it is called Shiva lingam and locally planted beside the temple of God Shiva (Giuseppe, 2015).

The anther of the species has resemblance to snake hood, so in Bangla and Tamil it's called Naga lingam (Naga means snake) (Satyavati *et al*, 1976). The lists of common names of the species are presented on the table.

Table-1: Common Name of *C. guianensis*

Language	Name
English	Cannonball-tree
French	Abricotsauvage
	Arbre a bombres
	Arbre a boulet de canon
Portuguese – Brazil	Abrico-de-macaco
	Abricoteiro-de-macaco
	Amêndoa-dos-Andes
	Castanha de macaco
	Curupita
	Macacarecuia
Spanish	Bala de canon
	Bola de canon
	Coco de mono
	Granadillo de lashuaca
	Mameyhediono
	Maraco
	Muco
	Palo de paraiso
	Palo santo
	Taparo de monte
German	Kanonenkugelbaum
Bangla, Tamil	Nag lingam
Hindi	Shiva lingam

(Source: ZZD, 2014)

2.3 Synonyms

The species belongs to the Lecythidaceae family. Since its discovery, and en route to nomenclature the species got different names by taxonomists (Table-2). A list of names used as synonym for the species are,

Table 2: Synonyms of *C. guianensis*

Name	Author	Year
Lecythis bracteata	Willd.	1799
Pekea couroupita	Juss. ex DC.	1828
Couroupita surinamensis	Mart. ex Berg	1858
Couroupita peruviana	O.Berg	1862
Couroupita antillan	Miers	1874
Couroupita membranacea	Miers	1874
Couroupita froesii	R. Knuth	1934
Couroupita saintcroixiana	R. Knuth	1934
Couroupita venezuelensis	R. Knuth	1934
Couroupita acreensis	R. Knuth	1939
Couroupita idolica	Dwyer	1965
Couratari pedicellaris	Rizzini	1976

(Source: BNPD, 2004)

2.4 Family: Lecythidaceae

The family Lecythidaceae is in the major group Angiosperms (Flowering plants).The Lecythidaceae are a pan tropical family of trees found in the tropics of Central and South America, Southeast Asia, and Africa, including Madagascar. The family is divided into three subfamilies, the Planchonioideae, with six genera, the best known of which is Barringtonia, and 59 species in tropical Asia, Malaysia, northern Australia, the Pacific Islands, and Madagascar; the Foetidioideae, with a single genus, Foetidia, and 17 species in Madagascar, Mauritius, and East Africa; and the Lecythidoideae of the Western Hemisphere (Anon, 1950).

Napoleonaeaceae and Scytopetalaceae two other closely related families, were previously considered sub-families of the Lecythidaceae but they are now treated as closely related families. One South American species, *Asteranthos brasiliensis*, was at one time placed in the Napoleonaeaceae, but embryological, morphological, and molecular evidence demonstrate that it has a stronger relationship with the Scytopetalaceae (Anon, 1950).

According to the Angiosperm Phylogeny Group (APG), the Brazil nut family belongs to the order Ericales which is basal to the euasterid clade. Within the Ericales, the position of the Lecythidaceae is not resolved (Source: BNPD, 2004).

Species of the Brazil nut family in the New World range from Veracruz, Mexico (*Eschweilera mexicana*) to Paraguay (*Cariniana estrellensis*); the Caribbean is home only to Griascauliflora which occurs in Jamaica and Central America from Belize and Guatemala to northwestern Colombia; and several species of Eschweilera grow in Trinidad and Tobago, but these islands harbour a South American, not a Caribbean, flora (Silva & Lima 2010).

2.5 Members of the family Lecythidaceae

Table-3: Members of the family

Members of the Family			
Abdulmajidia	*Allantoma*	*Asteranthos*	*Barringtonia*
Bertholletia	*Brazzeia*	*Careya*	*Cariniana*
Chydenanthus	*Corythophora*	*Couratari*	*Couroupita*
Crateranthus	*Eschweilera*	*Foetidia*	*Grias*
Gustavia	*Lecythis*	*Napoleonaea*	*Oubanguia*
Petersianthus	*Planchonia*	*Rhaptopetalum*	*Scytopetalum*

(Source: ZZD, 2014)

2.6 Characteristics of the Family Lecythidaceae

- **General Habitat:** Under this family all species are trees, some are shrubs or rarely under shrubs, semi evergreen or semi deciduous or deciduous (Mitre, 2012).
- **Stem:** Woody, semi-solid or solid, branched and hard (Mitre, 2012).
- **Leaf:** Leaves are cluster. Simple in structure. Size around 10-22cm and semi acute angle on the tips (Source: BNPD, 2004).
- **Flower:** Flowers are bisexual and hypogynous. Rarely some species contains unisexual flowers. The calyx 4-6 free or closed sepal, usually basally connate (Source: BNPD, 2004).
- **Corolla:** Usually petals 4-6, rarely fewer or more, free or united, imbricate or valvate or quincuncial (Source: ZZD, 2014).
- **Androecium:** Only the *Couroupita* genus the androecium structure is snake hood shape and infinite anthers. But other genus has different structure anther some are long, some are twisted, some are thin etc. All types of androecium hold infinite anthers (Source: ZZD, 2014).
- **Gynoecium:** Bi to hexacarpellary, superior ovary, usually 2-6 locus, 1 style and stigma (Mitre; 2012).

- **Fruits and Seeds:** Fruits are generally round, capsule or some case drupe. Seed has fleshy structure in outside (Source: BNPD, 2004).
- **Pollination and Dispersal:** Pollination generally entomophilouse. Insect are attract because of the nectar secreted by instrastaminal disc. Seeds are dispersed by the birds, wild boar and foul, elephants and other animals (Mitre, 2012).

2.7 Economic Importance of the family Lecythidaceae

(a) Edible Uses

Although the fruits are edible, the smell of the flesh discourages most people from trying them, so they are only occasionally eaten. Some genus are produces toxic fruits that's not edible (Guiesppe, 2015).

(b) Medicinal

The pulp of the wood is used, after exposure, in the treatment of skin diseases of animals, flowers phytochemicals are the activity of antifungal, antiviral and antibacterial, dry leaves are use as natural soap and cleaner. The fruit pulp and the seeds are ingested as a refresh ant (Kumar *et al*, 2011).

(c) Perfume Production

The flowers have a wonderful smell and can be used to scent perfumes and cosmetics (Anon, 1950).

(d) Fruit Shell

The hard shells of the fruit are sometimes used as containers (Anon, 1950).

(e) Wood

The heartwood is light yellow; it is not clearly demarcated from the sapwood. The wood is used for various lower value purposes including toys, boxes and crates, matches, interior joinery and panelling, furniture components, wood-ware, floats, block board and fibre boards (Wardrop, 1964; Fisher & Stevenson, 1981).

(f) Minor Use

The all species of the family has ornamental value so recreational purpose the species is planted on the personal home garden (Brown, 2009).

2.8 Member of the Genus *Couroupita*

Couroupita is a genus of flowering plants of Lecythidaceae family first described as a genus in 1775. It is native to tropical South America and Central America.

There are three species under this genus. They are same characteristics. Flower colours are yellowish to dark red, 6 closed calyx, 6 petals, more androecium, one gynoecium (Anon, 1950).

Couroupita guianensis– is found in Costa Rica, Honduras, Panama, and East to Amapa and south to Bolivia; naturalized in the West Indies, India, Bangladesh and Andaman & Nicobar.

Couroupita nicaraguarensis – is found in Central America, Colombia, Ecuador.

Couroupita subsessilis- is found in northern Brazil, northern Peru. (Silva & Tasso, 2015; Prance & Mori, 1986).

Chapter-3: Climatic and Edaphic Requirements

New World Lecythidaceae are most common and dominant in undisturbed, lowland forests on well drained soils between 19° N and 25° S latitudes.

3.1 Climatic factors

It grows in humid and semi-humid or semi-arid area of tropical and sub-tropical area. *C. guianensis* grows well in tropical and sub-tropical warm climate and found in both dry deciduous or in rain forest. It is a medium drought resistance species. It is reproduces from seed and germination is rapid and grows rapidly during April to June. It is adapted to a wide range of climatic extremes, especially of temperature and rainfall (Arber, 1937).

3.1.1 Rainfall

It can tolerate as a little rainfall as 150 mm in dry season, it can thrive in areas having a mean annual rainfall of 1200-1500 mm (Arber, 1937) and the relative humidity is 60-90% in June and 35-60% in January (Brown, 2009).

3.1.2 Temperature

The species comes from the area where the maximum temperature 42°- 44°c. It is a high light demander species. But the low temperature is around 12°c and minimum 3°-4°c (Rai, 2014).

3.2 Topography

The cannonball tree is a tree of riverbank and plain or lower foot hills. It also grows in Himalayan tract near the temple of God Shiva. It is adapted to drier and well drained soils of the various region of Indian sub-continent (Rai, 2014).

3.3 Edaphic factors

The tree grows well in semi acidic and clayey soil with good sub-surface water. Soil pH is 3.45-7.00 and some area 5.1-9.56 (Arber, 1937). It cannot grow well in saline soil (Brown, 2009). The growth is related to available moisture present on soil. It is intolerant to water logged conditions (Guiesppe, 2015).

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Chapter-4: Distribution

The species is very widespread but not common everywhere. It naturally grows all over the amazon. But it is available 10°S latitude to 76°W longitudes and 4°N latitude to 55°W longitude (Silva & Tasso, 2015). The species is native to Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guyana, Panama, Peru, Suriname and Venezuela. However, it is reported in different parts of the world for its ornamental use. In Africa it has been reported from Ivory Coast, Chad, Sierra Leone and Kenya. In Europe it has been reported from Germany and France. The species is generally reported from south East Asian countries in Asian continent. It has been reported from Thailand, Vietnam, Malaysia Srilanka, India and Bangladesh. In India the species was officially introduced in Kolkata Botanical garden in 18th century (Anon, 1950).

It is a fast growing species commonly distributed central to South America, but present time it is cultivated all tropical humid area (Silva & Tasso, 2015).

4.1 Distribution in the World

- In the South American countries Brazil, French Guiana, Colombia, Guyana, Peru, Surinam, Venezuela, Argentina, Bolivia and Chiele the species is present (Source: ZZD, 2014).
- In the North American countries the species is shown Panama, Haiti and Cuba (Source: ZZD, 2014).
- In the Africa continent the species is present in Ivory Coast, Chad, Sierra Leone and Kenya (Source: ZZD, 2014).
- The European area the species is reported in Germany, France, Greece, and Spain (Source: ZZD, 2014).
- In the Asia only the south-east part the species are shown, the species is introduced in the Asian countries as an ornamental species. For example in Sri Lanka, Thailand, Vietnam, Laos and Andaman & Nicobor (Source: ZZD, 2014).
- India it is found between latitude of 22° 00' N and longitude of 77° 00' E. The species is present some provinces of India i.e. Gujrat, Merrut, Karnataka, Uttar Prodesh, Kashmir, Madraj, West Bengal etc. (Rai, 2014).

The distribution of *C. guianensis* has been shown on figure world.

(Source: ZZD map, 2014)

Plate-1: Distribution of *C. guianensis* in the World

4.2 Existence in Bangladesh

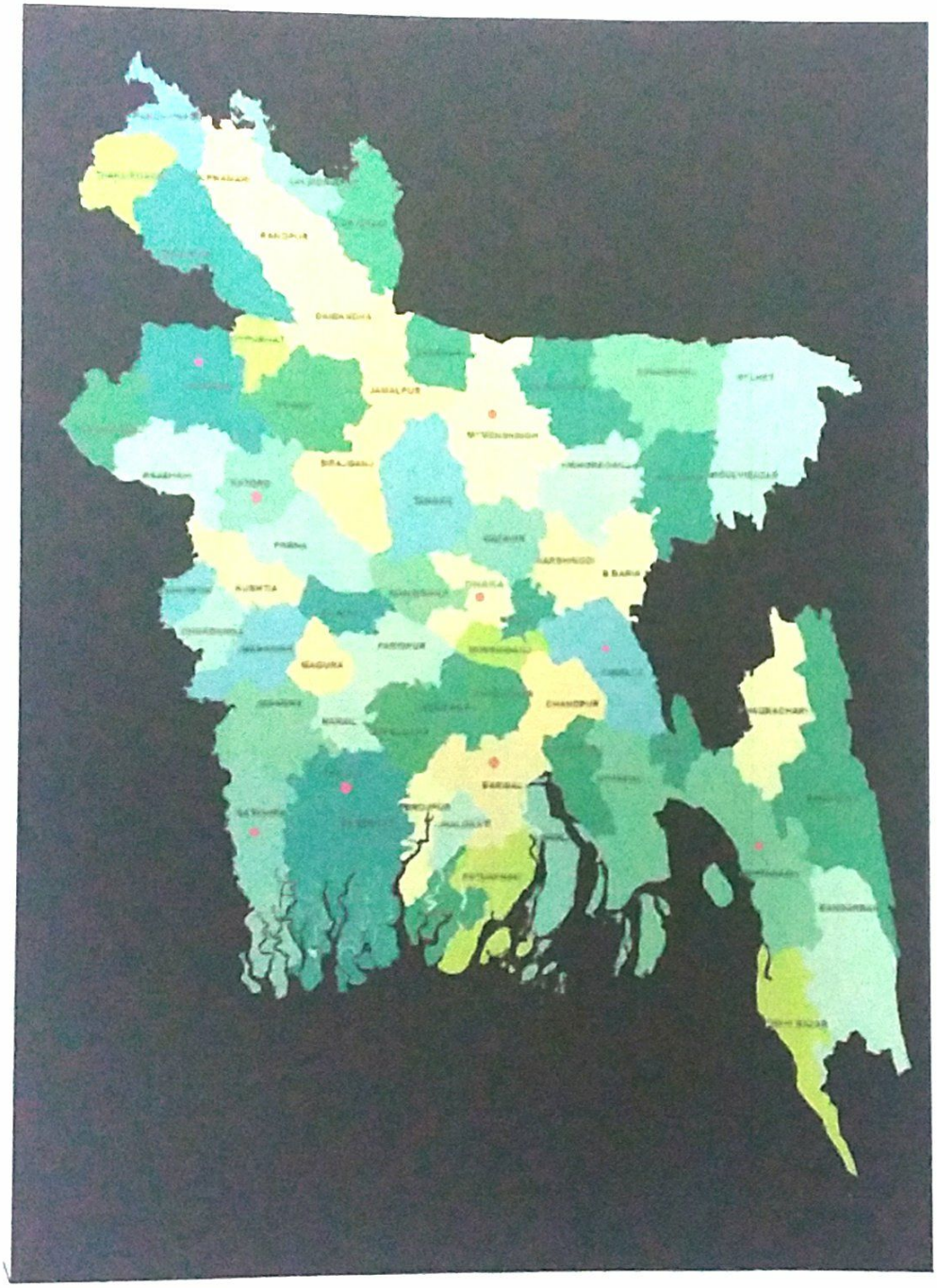
Bangladesh is situated between 20° 34' to 26° 38' North latitude and 88°01' to 92° 41' East longitude. Bangladesh is situated within such a latitude and longitude that it has got a weather that is tropical to sub-tropical in nature. During summer season the climate is very hot and humid. In fact Bangladesh has got a very wet type of weather. In winter the climate is cold with and dry. Bangladesh receives a very high amount of precipitation each year that amounts to more than 1,500-1800 mm. the climate of Bangladesh is suitable for *C. guianensis*.

The cannonball tree was first introduced in Bangladesh by Maharaja Dayaram, King of Dighapatia Jamindarbari Natore Under ancient Rajshahi district. He had collected the species from Kolkata Botanical garden in the early 19th century. The species now stay on the Qadirabad Cantonment area in Natore District (Personal communication).

Zamindar of Muktagacha of Mymensingh District established a garden of cannon ball tree for elephant nursing. Because the fruits of the cannonball were commonly used as natural medicine for elephant (ProthomAlo, 2015).

In Bangladesh the species is planted only for its ornamental purpose. It is found in different parks and institution in different parts of the country. In our country the species are reported from Qadirabad Cantonment area, Natore; Muktagacha Zamindarbari, Mymensingh; National botanical garden, Mirpur; Baldha Garden, Dhaka; Naogao District; Satkhira District; Jahangirnagar University campus, Savar, Dhaka; B. M. College, Barisal; Ramna Park, Dhaka; Bangladesh Academy for Rural Development (BARD), Comilla, Chittagong University Campus, Chittagong; Khulna University Campus, Khulna etc. (Personal communication, 2015).

The distribution of *C. guianensis* has been shown on figure Bangladesh.



(Source: BD map, 2014)

Plate-2: Existence of *C. guianensis* in Bangladesh

Chapter-5: Morphology, Phenology and Physiology

5.1 Mature tree

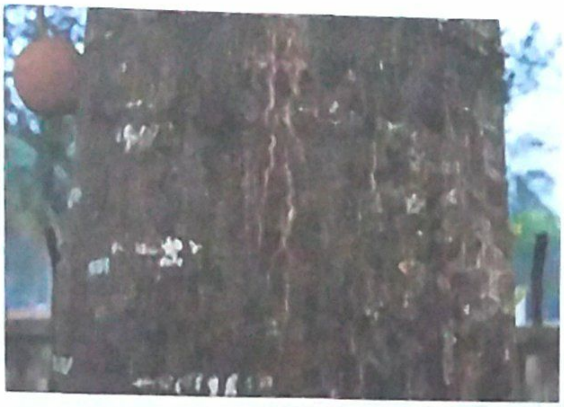
The *Couroupita guianensis* Aubl. is show evergreen or semi-evergreen character (it may lose the leaves several times during the year, but they are replaced in a few days), which is generally 30-35m tall, with a cylindrical trunk which can exceed the 20-70 cm of diameter, and a brownish grey to dark brown colour. The trunk of the adult specimens may be covered with flowers and fruits, present at the same time (Dick, 2014).

(Photograph by: Mehedi Hasan, 2016)

Plate-3: *Couroupita guianensis* a mature tree

5.2 Bark

The Bark is brownish to dark brown in colour with depth is 0.09 to 1.5 cm. The sap wood and the bark is very close combination in the interior part and some time it is very difficult to identify the actual depth of the bark (Dick, 2014).



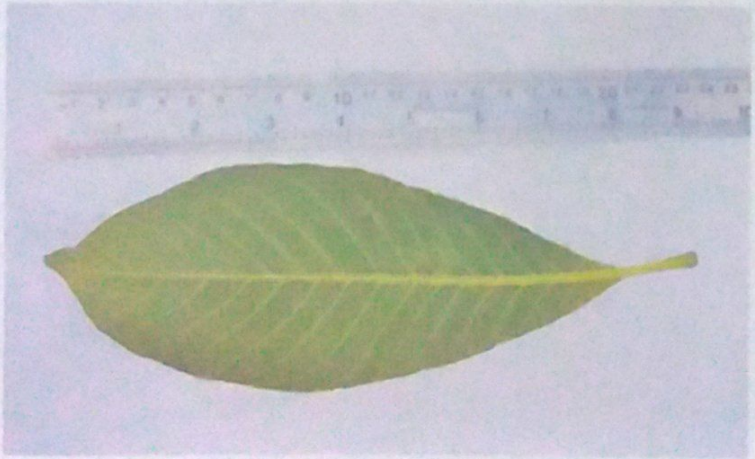
(Photograph by: Mehedi Hasan, 2016)

Plate-4: *Couroupita guianensis* bark

5.3 Leaves and Leaf behaviour

The leaves, grouped at the tip of the branches, are alternate, ovate or lanceolate, with entire or slightly toothed margin, 10-20 cm long and 4-10 cm broad, are of an intense green colour (Stalin, 2012).

The morphological and physiological characteristics of plants show convergent adaptations to their particular native environment and exotic environment. All the species exhibited maximum transpiration rate from their lower surface the stomata are amphistomatic (Anon, 1950).



(Photograph by: Mehedi Hasan, 2016)

Plate-5: *Couroupita guianensis* leaf

5.4 Flower and Flowering Time

The flowers are, strongly perfumed, of 6-12 cm of diameter, generate several time of a year, are carried by woody, up to 0.5-2 m long, racemes, which generate on the trunk (cauliflory) or at the base of the main branches (Giuseppe, 2015). The flowers have a pink to dark red in colour. The flower has strong scents that attract honey bees and other insects.

The bat and insects are playing important role for pollination. The flowers bloom generally at 12:00 am in night and stay 12:00 pm at the day (Fahn, 1974; Sedgley & Buthose, 1978; Ormond *et al*, 1981; Prance & Mori, 1986; Ramirez *et al*, 1986; Silva & Tasso, 2015). However flowers bloom in during 6:00 am to stay 5:00 pm of a day has also been reported (Ramirez *et al*, 1986).

The corolla is formed by six fleshy, concave, roundish, petals, two of which are larger, of a colour going from orange to pinkish red, internally red, often yellowish outside, with a white central disc, and several stamina divided in two groups, one fertile around the pistil, and one of sterile stamina, about 1-2 cm long, united in a sort of a hood over the pistil (Giuseppe, 2015).

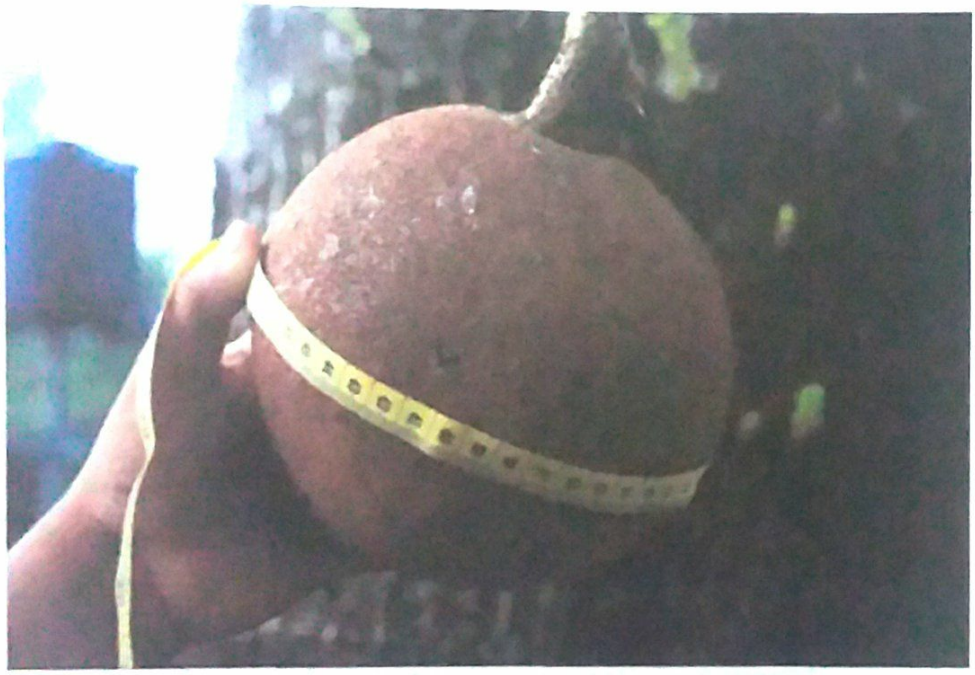
The flower generate during March to September (Sharma, 2011). But in Bangladesh the flowering also found in November to January. Thus periodicity of flowering is not pronounced (Stalin, 2012).

(Photograph by: Sajjad Hossain, 2015)

Plate-6: *Couroupita guianensis* Flower

5.5 Fruits and Fruiting Time

The fruits, which take about one year for ripening, are globular, 6 -22 cm of diameter, woody, of brown colour, and contain some hundred tiny seeds immersed in a white pulp, of pleasant odour when the fruit is just ripe, but, quickly, becomes bluish as soon as exposed to open air and with a nauseating smell (Satyavati *et al*, 1976). The fruits last just one year, but are produced in sequence and in great quantity. Fruits may ripe any time of a year. Generally 8-18 months has taken for ripen after fruit formation (Prance & Mori, 1986; Ramirez *et al*, 1986; Silva & Tasso, 2015). The pulp is edible and at times is locally consumed, but the odour discourages its alimentary utilization, but for the animals (Stevia, 2005).



(Photograph by: Mehedi Hasan, 2016)

Plate-7: *Couroupita guianensis* Fruit

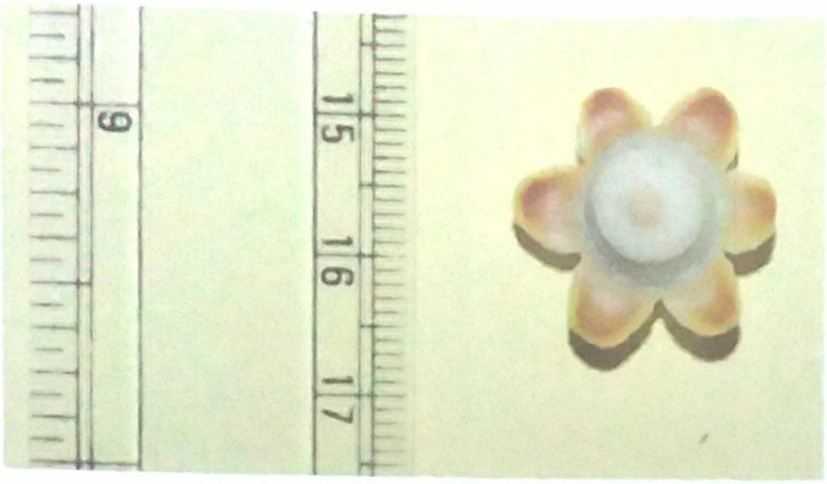
5.6 Floral Biology

The flowers of *C. guianensis* are very fragrant and attracted by insects. Generally the flowers bloom gradually 7:30am-8:00am (Ramirez *et al*; 1986), but sometime it bloom 12:00am and stay 12:00pm at the day. It is a complete and bi-sexual flower. Every complete flower fills up six parts and *C. guianensis* is complete this term. The flower has,

i. Calyx
ii. Corolla
iii. Androecium
iv. Gynoecium
v. Floral axis or Receptacle

5.6.1 Calyx

The calyx of the species is 6 in number they are closed in the end. The calyxes are yellowish to pale brown in colour (Prance & Mori, 1986; Silva & Tasso, 2015).

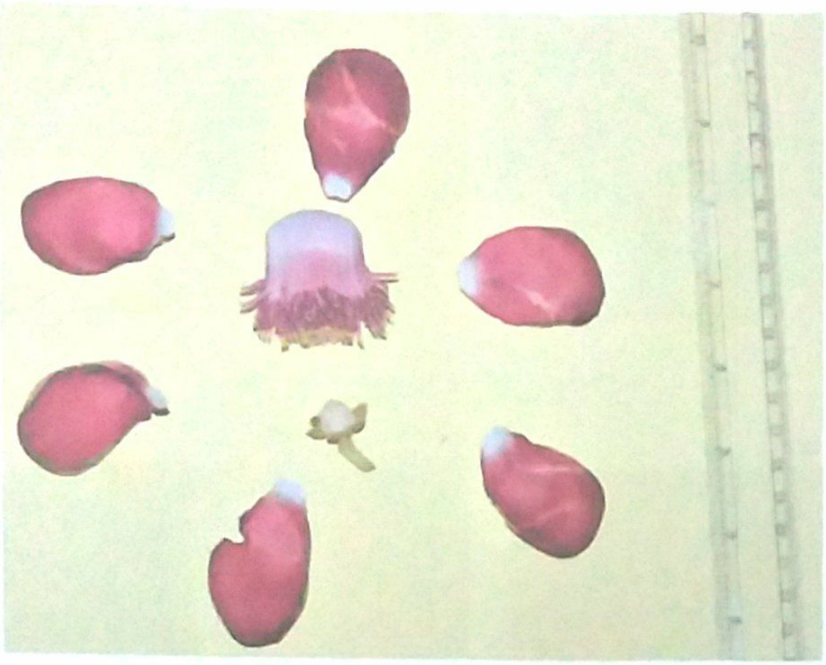


(Photograph by: Sajjad Hossain, 2015)

Plate-8: *Couroupita guianensis* calyx

5.6.2 Corolla

The corollas of *C. guianensis* are 6 in numbers. They are pink to dark red in colour. The outer portion of the flower is yellowish to pale orange in colour. The petal length of the flower is average 5-6 cm in length (Fahn, 1974; Sedgley & Buthose, 1978; Ormond *et al*, 1981). When flowers bloom the flowers diameter is 9.5-11.5 cm. The internal red colours of the flower highly attract the pollinators (Fahn, 1974).



(Photograph by: Sajjad Hossain, 2015)

Plate-9: *Couroupita guianensis* corolla

5.6.3 Androecium

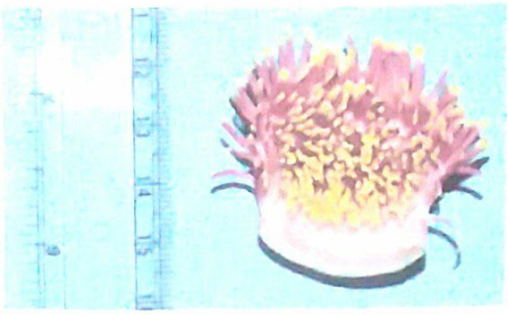
The flower of *Couroupita guianensis* is large and strikingly showy with zygomorphic and great number of stamen (Ormond *et al*, 1981). The androecium of the flower looks like the snake hood. The androecium of the flower produces anther of two categories. One part termed as hood and other part is termed as disk.

The pollen of the cannonball is dimorphic. The anthers produced from the hood are termed as hood pollen and they are large and anther produced from disk termed as ring pollen and small in size. The hood containing average 2850 tetrads where ring containing approximately 450 pollen grains (Ramirez *et al*, 1986).

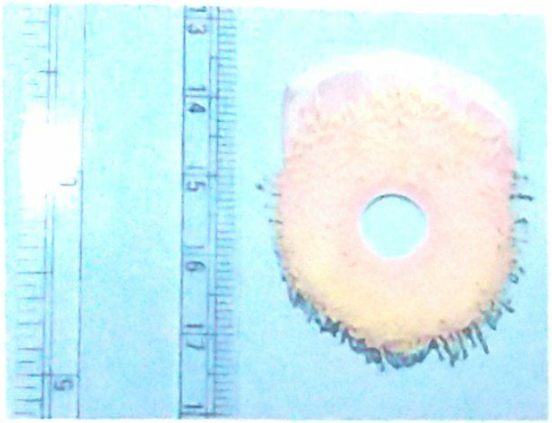
The fertility of the both pollen are same. But only ring pollens are transferring for pollination. Because the hood of the flower is used as the landing platform of the pollinators and they are situated some distance from the stigma of gynoecium (Ramirez *et al*, 1986).

The hood pollen is rich in nutrients, provide food for the pollinators and play important role in the pollination process (Ormond *et al*, 1981)

(a)



(b)



(c)

(d)

(e)

(Photograph by: Sajjad Hossain, 2015)

Plate-10: *Couroupita guianensis* (a) cross section of androecium; (b) ring androecium; (c) hood androecium; (d) hood anther; (e) ring anther.

5.6.4 Gynoecium

The gynoecium of the flower is look like the Hindus god, Shiva lingam (Rai, 2014). The stigma has different parts and they are describing below.

a) **Stigma:** The stigma exhibits a star like fissure with 6-8 points that co-respond to the number of carpels. Two types of tissue are present in stigma i.e. functional tissue and structural tissue and these both tissues participants on fertilizations (Ormond *et al*, 1981).

b) **Collectors and Secretory Hairs:** The hairs are unicellular secreting structures with abundant cytoplasm and thick cellulose walls (Ormond *et al*, 1981). They produces uneven surface with points and protuberances. The hairs form dense vesture at the edge of fissures (Ormond *et al*, 1981). The points and protuberances are the superior part of the hairs (Ormond *et al*, 1981).

c) **Papillose Cells:** Stigmatic tissues cell are made up thin-walled papillose cell and carbohydrate in internal part.it is that part of the stigma where pollen grains are germinate (Ormond et. al.; 1981). In the other plants, the stigmatic tissue can be found totally exposed forming stigmatic papillae (Arber, 1937; Martin & Ortiz, 1967; Fahn, 1974; Sedgley & Buthose, 1978).

d) **Style:** The style of the flower is conical shape and 0.2-0.25cm in length (Ormond *et al*, 1981).

(i)

(j)

(Photograph by: Sajjad Hossain, 2015 and Mehedi Hasan, 2016)

Plate-12: *Couroupita guianensis* (i) floral axis; (j) fruit receptacle

5.7 Pollination

The bat is the main pollinators in the native area (Fahn, 1974; Sedgley & Buthose, 1978; Ormond *et al*, 1981; Prance & Mori, 1986; Satyavathi *et al*, 1976; Golatkar *et al*, 2001; Kumar *et al*, 2011; Rai, 2014).

The flowers of *C. guianensis* are without nectar and are mostly visited by bees in search of pollen (Ramirez *et al*, 1986). The structure of the male part of the flower is not found in any other plant family in the world except for other species of the Brazil nut family (Fahn, 1974; Ormond *et al*, 1981; Prance & Mori, 1986; Ramirez *et al*, 1986; Silva & Tasso, 2015).

In *C. guianensis*, fertile stamens are found in a ring around the reduced style and stamens with sterile pollen are located in the anthers of staminodes located in the hood (a prolongation from one side of the staminal ring that arches over the ovary) (Ramirez *et al*, 1986).

Carpenter bees (*Xylocopa brasilianorum*) have been reported as the principal pollinators outside of the native range of the *C. guianensis* in the botanical garden of the Museuri National in Rio de Janeiro (Sedgley & Buthose, 1978). The large black carpenter bees enter the flowers with their ventral side toward the sterile stamens of the hood and their head and backs against the ring with fertile pollen and, as a result of their position; they are dusted with pollen on their heads and back (Ramirez *et al*, 1986).

In the Indian sub-continent *Apis melifera* is the main pollinators and different types of insects, carpenter bees, spiders, domestics fly, various butterflies etc. also play important role or pollination (Satyavathi *et al*, 1976; Golatkar *et al*, 2001; Kumar *et al*, 2011; Rai, 2014).

The two types of pollen were first described as being different in 1825 by the French botanist Pierre Antoine Poteau who was the first to recognize the family Lecythidaceae in the same publication (Sedgley & Buthose, 1978). The morphological and physical differences of the pollen have been demonstrated by several botanists since that time (Fahn, 1974).

The most important pollen difference is that the pollen of the ring stamens germinates and is fertile while the hood pollen does not and is sterile (Ramirez *et al*, 1986). Thus, hood pollen has become specialized as the reward to attract pollinators to the flowers (Ormond *et al*, 1981). In turn, the fertile pollen is transferred to the next flowers the bees visit and as a result fruits and seeds develop (Fahn, 1974). Most fruits of this species in nature are probably the result of the movement of pollen from one tree to another, but experiments show that self-pollinated plants of the *C. guianensis* tree also set fruit (Ormond *et al*, 1981).

(k)

(l)

(m)

(Source: ZZD, 2014)

Plate-13: Pollination agents (k) bat; (l) *Xylocopa brasilianorum*; (m) *Apis melifera*

5.8 Reproductive System and Seeds Development

The reproductive system of *C. guianensis* is autogamy, self-compatibility and artificial outer breeding. The pollen tube developed 45 minutes. After 24 hours all the tubes had reached the base of ovary (Ormond *et al*; 1981).

Seed are angular and fitted completely into the cavity of the fruits internal kernel and the outer surface is pressed against the inner fruit wall. The seeds are coated with trichomes and the seed outer potion is convex in structure (Prance & Mori, 1986; Silva & Tasso, 2015). Fresh seed are best for germination because the longevity of the seeds is very short ant insects eat the embryo if seed are not preserving properly (Silva & Tasso, 2015).

5.9 Seeds and Seed Germination

The seeds are 0.5- 1.8 cm long and 0.3 to 1.4 cm wide. Every fruit contains 95-350 seed as their size (Silva & Tasso, 2015). It is reproduced by seed which is to be planted when still fresh as it has a short germination time. Reproduction has also been reported by suckers (Prance & Mori, 1986). It is one of the oldest and most popular ornamental trees. It is a tropical and marginally humid tropical climate species; it may bear exceptional drops in temperature down to even -1 °C for a quite short time (Giuseppe, 2015).

The seeds start germination within 42° to 44° C in their native zone. Germination in winter was observed between 3^0 to 12^0C but at low (Rai; 2014).

(Photograph by: Mehedi Hasan, 2016)

Plate-14: *Couroupita guianensis* seeds

5.10 Others

5.10.1 Photosynthesis

In photosynthesis, the light-dependent reactions take place on the thylakoid membranes. The inside of the thylakoid membrane is called the lumen, and outside the thylakoid membrane is the stroma, where the light-independent reactions take place (Anon, 1950). The thylakoid membrane contains some integral membrane protein complexes that catalyse the light reactions. There are four major protein complexes in the thylakoid membrane:

i. Photosystem II (PSII),

ii. Cytochrome b6f complex,

iii. Photosystem I (PSI), and

iv. ATP synthase.

These four complexes work together to ultimately create the products ATP and NADPH (Dick, 2014).

The two photosystems absorb light energy through pigments - primarily the chlorophylls, which are responsible for the green colour of leaves (Anon, 1950). The light-dependent reactions begin in photosystem II. When a chlorophyll a molecule within the reaction center of PSII absorbs a photon, an electron in this molecule attains a higher energy level (Anon, 1950). Because this state of an electron is very unstable, the electron is transferred from one to another molecule creating a chain of redox reactions, called an electron transport chain (ETC) (Dick, 2014). The electron flow goes from PSII to cytochrome b6f to PSI. In PSI, the electron gets the energy from another photon. The final electron acceptor is NADP. In oxygenic photosynthesis, the first electron donor is water, creating oxygen as a waste product. In an oxygenic photosynthesis various electron donors are used (Gamble, 1957).

5.10.2 Stomata Characteristics

In transvers section, there is a beak like cuticular outgrowth overarching the stomata pore either at the outer side or at both the outer and inner side of the stomata pore. The guard cell mother cells divides once longitudinally to from two guard cells and the development of subsidiary cells is not at all concerned with the former cell (Dick, 2014).

5.10.3 The hypodermis

It is the outermost cell layer of the cortex of plants. It forms a prominent layer immediately under the epidermis in many but not all plants (Anon, 1950). In shoots, the hypodermis may be composed of parenchyma, collenchyma, or sclerenchyma and be from one to several cells thick. In roots, the hypodermis is often called the exodermises; it resembles the endodermis, and it develops casparian strips, suberin deposits, and cellulose deposits impregnated with phenolic or quinoidal substances (Anon, 1950). Thus the root hypodermis is similar to the endodermis in cell wall anatomy and in its reaction to histo-chemical tests. The hypodermis is

the mirror image of the endodermis in appearance. In the endodermis, wall deposits develop from the inner tangential wall outward; in the hypodermis, they develop from the outer tangential wall inward (Dick, 2014).

5.10.4 Root leaf osmotic potential

Osmotic potential has important implications for many living organisms. If a living cell is surrounded by a more concentrated solution, the cell will tend to lose water to the more negative water potential of the surrounding environment (Anon, 1950). This can be the case for marine organisms living in sea water and halophytic plants growing in saline environments (Anon, 1950). In the case of a plant cell, the flow of water out of the cell may eventually cause the plasma membrane to pull away from the cell wall, leading to plasmolysis (Dick, 2014). Most plants, however, have the ability to increase solute inside the cell to drive the flow of water into the cell and maintain turgor (Dick, 2014).

A soil solution also experiences osmotic potential. As water molecules increasingly clump around solute ions or molecules, the freedom of movement, and thus the potential energy, of the water is lowered (Dick, 2014). As the concentration of solutes is increased, the osmotic potential of the soil solution is reduced. Since water has a tendency to move toward lower energy levels, water will want to travel toward the zone of higher solute concentrations (Anon, 1950). Although, liquid water will only move in response to such differences in osmotic potential if a semipermeable membrane exists between the zones of high and low osmotic potential (Anon, 1950). A semipermeable membrane is necessary because it allows water through its membrane while preventing solutes from moving through its membrane. If no membrane is present, movement of the solute, rather than of the water, largely equalizes concentrations (Dick, 2014).

Chapter-6: Silvicultural Characteristics and Management

The species is a gorgeous tree species generally found in tropical or sub-tropical area near the equator. It generally produces strong clean bole and considered as moderate to large tree. It possesses a dense, often narrow crown, with leaves clustered at the tip of branches. Where native, *C. guianensis* is a tree of river banks and lowlands.

The species is a strong light demander but can grow in slight shade (Anon, 1950).

It is moderately drought resistance, but excessive drought is harmful for the species (Brown, 2009). It cannot tolerate excessive moisture in soil and cannot withstand water logging (Brown, 2009).

It is intolerant to frost. Frost has been reported to destroy seedlings and saplings (Rai, 2004; Brown, 2009). The species has shown low salt tolerance in nature but generally not preferred. The species is also susceptible to fire (Brown, 2009)

6.1 Sprouting

It has no coppicing power (Prance & Mori, 1986). The stump produces shoot around the cutting edge surface (Alam *et al*, 2005).

6.2 Seed dispersal

The fruit falls from the tree and often cracks open when it hits the ground. Sometimes they remain whole until an animal such as a peccary breaks it open. Many animals feed on the fruit pulp and the seeds, such as the domestic chickens and pigs (Sedgley & Buthose, 1978; Ormond *et al*, 1981; Ramirez *et al*, 1986). The seeds are coated with trichomes which may help them pass through animal intestines (Brown, 2009).

6.3 Seed Collection

While flowers are short-lived, fruits take up to a year to mature. The fruits do not open but fall from the tree and rot with an unpleasant odour, unlike that of the flowers (Rai, 2014). When ripen fruits are fall that time best way to collect seed directly from fruits or eat the fruits kernel by domestic chicken or pigs and collected seed from their natural rubbish (Brown, 2009). Seeds are collected by the hand is discouraged as the fruit kernel contains high amount of acidic substances that is skin sensitive (Anon, 1950).

6.4 Seed germination

The best time of seed sown is as soon after harvesting as possible, it does not require pre-treatment. Seeds can be sown in semi-shade, either in nursery beds or in individual containers (Anon, 1950). When fresh seed is used, a germination rate in excess of 80% usually occurs within 8 - 15 days (Rai, 2014). Seedlings should be placed in individual containers by the time they are 6 - 10cm tall, and are ready to plant out when 7 months old (Rai, 2014).

6.5 Regeneration

6.5.1 Natural Regeneration

C. guianensis germinate from seed easily. Generally the seedling growth is high in during summer (Rai, 2014). Seed predation rate is high due to presence of high carbohydrate content (Anon, 1950). Complete germination within 18 days during the hot seasons has been reported. The total germination percentages were observed 95 % (Rai, 2014).

6.5.2 Artificial Regeneration

The artificial regeneration of cannon ball is probably easy in nature in nursery stages (Rai, 2014). Care should be taken when seed collection. Physiologically mature seed with maximum germination capacity and longevity are obtained 7-180 days (Silva & Tasso, 2015). And sown as soon as possible (Rai, 2014).

The shade is not necessary because it is a high light demander species. Without high temperature the seed cannot germinate (Rai, 2014).

6.6 Management

The species is not a timber species. Thus huge lacks are present on the management system. It occur naturally and dispersal by animals i.e. wild boar, wild foul, elephant etc. (Silva & Tasso, 2015). But some area of the different part of the Brazil and African country some commercial plantation raised for medicinal research (Silva & Tasso, 2015). Here the data collected that maximum tree matured 12-15 years and flowering and fruiting on main trunk of the tree (Sen, 1974). Tree has been 30-35m tall and 20-70cm in diameter. Pruning and thinning of the tree occur occasionally. In the nursery stages the sterilization of nursery soil and treatment of pesticide occur (Jayashree, 2001). Diseases affected seedlings or saplings throw out from the nursery (Jayashree, 2001). When the saplings have an age nearly or around 7 month and at a height of 42-75cm, it is planted on the field (Rai, 2014).

6.6.1 Growth rate

The species has high growth rate on the normal soil. The growth rate of saplings per month recorded 0.5-2.5cm on dry condition (Jayashree, 2001). It is a high light demander species (Rai, 2014). Not tolerate the salt and water logging condition (Rai, 2014).

6.6.2 Harvesting

Wood quality is not standard so the felling cycle is not defined. But the medicinal properties analyses that time the small branches are collected when they are 6- 15 cm in diameter and bark collection 0.5-1.15 cm (Jayashree, 2001). The fresh flower collection as soon as possible when they stay on the tree, leaves are collected when they attain a length around 6-20 cm (Anon, 1950).

Chapter-7: Wood Properties and Chemical Constituents

7.1 Physical Properties

7.1.1 Wood properties and Density

Couroupita guianensis has moderately low density wood (Patel, 1964). The anatomy of the secondary xylem and distribution pattern of gelatinous fibres (G-fibres) have been studied in the developing and heavy fruit bearing mature peduncles of *Couroupita guianensis* (Chaffey, 2000). The peduncle developed reaction xylem as a result of growth stresses caused by development of large fruits. In *Couroupita* peduncles which are originally horizontal, G-fibre distribution was unilateral (Wardrop, 1964; Fisher & Stevenson, 1981). The tension xylem severity was higher in the basal region and decreased towards the terminal region but after fruit development a drastic increase in tension wood severity was observed in the terminal region (Pramod *et al*, 2010).

7.1.2 Vessels

The cells are tubular in structure (Patel, 1964). Vessels present in angiosperm. Cell walls are combined with lignin (Hasan, 2007). Small vessels are termed as proto-xylem and fat vessels termed as meta-xylem. The elements give strength to the species, storage food and transfer water and mineral root to leaves (Hasan, 2007). In *Couroupita*, in both inflorescence and fruit bearing peduncles the vessel element length and width differed significantly among all three regions (Pramod *et al*, 2010). Vessel element length increased significantly from basal to terminal region (Chaffey, 2000). The increase in vessel element length is followed by a decrease in width of vessel elements (Pramod *et al*, 2010). Compared to peduncles, branch wood showed shorter and wider vessel elements (Wardrop, 1964; Fisher & Stevenson, 1981).

7.1.3 Xylem and Fibers

Normal fibres with highly lignified walls were found distributed in the lower region of the xylem cylinder in *Couroupita spp.* wall thickness of normal fibres at different regions of the same peduncle (Evert, 2006). The peduncle also showed normal fibres to be more thick-walled than G-fibres including its G-layer. The fibre wall thickness varies significantly of one year old fruit bearing peduncles (Evert, 2006). In *Couroupita*, fibres are longer towards the terminal region of the peduncle and the fibre diameter was inversely proportional to fibre length (Evert, 2006). There was a significant difference in fibre dimensions between different regions of peduncles of all the three developmental stages (Evert, 2006).

7.1.4 Pulping quality

Couroupita guianensis generally a medicinal species the wood properties and the micro-fibril length are not good for paper production (Staff, 1974). The pulping quality is not good and high treatments are required for developing paper quality (Patel, 1964). High number of G-layer present on cell wall that is increased the paper manufacturing cost (Wardrop, 1964; Fisher & Stevenson, 1981).

7.2 Chemical Properties

7.2.1 Chemical constituents of wood

The wood of cannonballs has no good strength. The wood is white to greyish in colour. The heart wood structure is moderate, but not good for furniture making or other wood based work. The wood is unusable without chemical treatment. The heart wood of the tree used for extraction of different chemicals used as anti-bacterial (Khan *et al*, 2003).

Table-4: Chemical constituents of wood

Plant tissue	Fraction	Yield (%)	Constituents
Stem heart wood	Petrol	0.9	Flavonoids, sterols, tannins, triterpenoids
	Dichloromethane	0.5	Flavonoids, sterols, tannins, triterpenoids
	Ethyl acetate	1.1	Flavonoids, saponins, sterols, triterpenoids
	Butanol	3.8	Saponins, tannins
Root heart wood	Ethyl acetate	1.9	Flavonoids, saponins, sterols, tannins, triterpenoids
	Butanol	3.8	Flavonoids, saponins, tannins

(From: Khan *et al*, 2003)

7.2.2 Chemical constituents of bark

The bark of *C. guianensis* is used in South America for treatment of skin infections, boils, malaria, stomach-ache, and sores. It is known to contain couropitone, Beta-amyrin, Beta-amyrone, Beta-amyrin acetate, stigmasterol, ergosta-4,6,8, 22-tetraen-3-one, Beata-sitosterol and glycoside (Khan *et al*, 2003).

Table-5: Major Chemicals of bark

Plant tissue	Fraction	Yield (%)	Constituents
Stem bark	Petrol	3.3	Alkaloids, sterols, triterpenoids
	Dichloromethane	3.6	Alkaloids, sterols, triterpenoids
	Ethyl acetate	5.2	Flavonoids, sterols, tannins, triterpenoids
	Butanol	22.9	Saponins, flavonoids, sterols, tannins, triterpenoids
Root bark	Petrol	1.5	Saponins, sterols, triterpenoids
	Dichloromethane	12.7	Saponins, sterols, triterpenoids
	Ethyl acetate	15.3	Alkaloids, flavonoids, sterols, tannins, triterpenoids
	Butanol	40.4	Flavonoids, sterols, tannins, triterpenoids

(From: Khan *et al*, 2003)

7.2.3 Chemical constituents of Fruit middle core

The middle core of the fruit is pale in colour but when the inner shell of the fruits break down the middle core turn into greenish to bluish in colour. Some time it may to turn reddish colour. The middle core weighs 0.3-2.35 kg but varies with the size of the fruit. The middle core has a dread full unpleasant odour. The middle core contains sterols, small amount of chloroform, triterpinoids, methanol etc. (Khan *et al*, 2003).

Table-6: Major Chemicals of Fruit middle core

Plant tissue	Fraction	Yield (%)	Constituents
Fruit kernel	Petrol	7.6	Saponins, sterols, triterpenoids
	Dichloromethane	11.1	Saponins, sterols, triterpenoids
	Ethyl acetate	1.7	Flavonoids, sterols, tannins, triterpenoids
	Butanol	19.8	Flavonoids, saponins, sterols, triterpenoids

(From: Khan *et al*, 2003)

7.2.4 Chemical composition of Leaf

The leaf of the species is green to dark green in colour. Leaf is simple in structure remains as a cluster on the branch. Every twig hold 4-12 leaves. The leaf size is around 6-25cm or rarely 27-35cm. The leaf use as anti-bacterial, anti-diabetic, skin infection etc. (Sundararajan *et al*, 2014).

Table-7: Major Chemicals of leaf

Plant tissue	Fraction	Yield (%)	Constituents
Leaves	Petrol	10.3	Alkaloids, saponins, sterols, tannins, triterpenoids
	Butanol	22.3	Flavonoids, sterols, tannins, triterpenoids

(From: Khan *et al*; 2003)

7.2.5 Chemical composition of Flower

Some chemical Components extracts from flowers.

Table-8: Major Chemicals of Flower

Plant tissue	Fraction	Yield (%)	Constituents
Flowers	Petrol	5.1	Essential oil
	Dichloromethane	2.4	Saponins, sterols, triterpenoids
	Ethyl acetate	6.6	Saponins, sterols, triterpenoids
	Butanol	11.5	Flavonoids, tannins

(From: Khan *et al*, 2003)

Chapter-8: Uses of the Species

Plants are the basic source of knowledge of modern medicine. Almost all the parts of the plant, namely leaves, flowers, fruits, roots, stem and seeds are known to have various medicinal properties. The trend of using natural products has increased and the active plant extracts are frequently screened for new drug discoveries. The use of the medicinal herbs for curing disease has been documented in the history. *Couroupita guianensis* has showed a broad spectrum of anti-bacterial and anti-fungal activities (Sundararajan *et al*, 2014).

8.1 Traditional Uses

Fruits of *Couroupita guianensis* is edible, however unpleasant smell of white flesh discourages the general public. The fruit pulp, bark and flowers are to use for varied medicative applications. The pulp of the fruit is rubbed on the infected skin of animal disease; leaves and flowers of *Couroupita guianensis* used for upset, tumours, pain and inflammatory processes (Sanz *et al*, 2009); cold and abdomen ache (Elumalai *et al*, 2012). The fruit clean wounds and young leaves cure odontalgia (Kumar *et al*, 2011).

Traditionally leaves are used as antiseptic. Juice made up of the leaves is employed to cure skin ailments and treating protozoal infection. Historically, the leaves of this plant are utilized in the treatment of skin diseases, stomach ache, and enteral gas formation, antithrombotic, treatment of skin diseases and vasodilatory actions (Golatkar *et al*, 2001; Elumalai *et al*, 2012; Satyavathi *et al*, 1976).

The volatile oils from the flowers have antibacterial and antifungal properties. It's one in every of the ingredients within the several preparations that cure redness, hemorrhage, piles, scabies, dysentery, scorpion poison (Shah *et al*, 2012). Different parts of *Couroupita guianensis* with ethno medical information are stated in Table.

Table-9: Traditional uses of *Couroupita guianensis*

Parts	Diseases	Source
Leaves	Skin diseases, stomach ache, and enteral gas formation, antithrombotic, vasodilatory actions, Skin infections	Elumalai *et al*, 2012; Golatkar *et al*, 2001; Satyavathi *et al*, 1976
Flowers	Upset, tumors, pain and inflammatory processes	Sanz *et al*, 2009
Leaves and Flowers	Hemorrhage, piles, scabies, dysentery, scorpion poison	Shah *et al*, 2012
Fruit	Skin infections ,Odontalgia	Kumar *et al*, 2011; Sanz *et al*, 2009

8.2 Pharmaceutical Activities

Different parts of *Couroupita guianensis* with pharmaceutical information are mentioned in analgesic and anti-inflammatory activity (*Geetha et al*, 2004), analgesic and anti-inflammatory activities in benzene, ethyl alcohol (95%) extract of *Couroupita guianensis* flowers and barks.

Potent to paracetamol in its analgesic activity and to in its anti-inflammatory activity was discovered and additionally explicit those ethanolic extracts of *Couroupita guianensis* possess anti-inflammatory activity (Pinheiroa *et al*, 2013).

8.2.1 Antibacterial Activity

The antibacterial activity in ethyl alcohol (95%) extract of *Couroupita guianensis* fruit pulp (Shah *et al*, 2012).

The antibacterial activity of *Couroupita guianensis* ethyl alcohol extract was studied against gram-positive microorganism (*Staphylococcus aureus*, *Bacillus subtilis*) and gram-negative bacteria (*Escherichia coli*, *Pseudomonas aeruoginosa*). Compared to doxycycline, ciprofloxacin and fluconazole, vital activity was found against *Bacillus subtilis* at a standard concentration. This study conjointly disclosed the presence of some phytoconstituents like tannins, sugars and polyphenols (Shah *et al*, 2012).

Antibacterial property of ethanolic extract of *Couroupita guianensis* oil has also showed (Azimi *et al*, 2012).

8.2.2Antioxidant and Antiulcer Activity

This study focused on in-vitro inhibitor activity by victimization completely different parameters like 2, 2-diphenyl-1-picrylhydrazyl assay, superoxide scavenging impact, reducing power and in-vitro lipid peroxidation. Ethyl acetate fraction of water extract of *Couroupita guianensis* possesses a robust in vitro antioxidant activity (Bafna *et al*, 2011).

The antiulcer activity has showed from *Couroupita guianensis* leaves in ethanolic extract (Elumalai *et al*, 2012). Numerous parameters like reduction in internal organ volume, free acidity and lesion index were lowered upon administration of ethanolic extract of *Couroupita guianensis* (150 mg/kg and 300 mg/kg) (Elumalai *et al*, 2012).

8.2.3 Antioxidant and Antitumor Activities

Flower extract of *Couroupita guianensis* was showed sturdy antioxidant and antitumor activities (Premanathan *et al*, 2012).

The radical scavenging activity was performed by victimization lipid peroxidation assay. Cytotoxicity against human promylocyticleukemia cells was determined by (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide assay. Apoptotic activity by deoxyribonucleic acid (DNA) fragmentation and flowcytometry were measured. Results disclosed that isatin is a vital compound showed solid inhibitor activity with the worth of 72.

80 µg/ml, toxicity against human promylocytic cancer of the blood HL60 cells in dose-dependent manner by worth of 2.94 µg/ cc and eventually caspase-mediated cell death was confirmed by fluorescence-activated cell sorting (FACS) analysis (Sundararajan *et al*, 2014).

8.2.4 Antidepressant and Antifertility Activity

Antidepressant activity has showed in methanolic extract of *Couroupita guianensis* root (Wankhede *et al*, 2009).

This study focused on measure of assorted parameters like tail suspension test (TST), forced swim test (FST) and antihypertensive antagonism in mice. Results of this study indicated that considerably decrease within the immobility time in TST and FST, almost like that of the imipramine (10 mg/kg). In antihypertensive antagonism exhibited deeply decline in period of hypersomnia and degree of ptosis in tested mice (Sundararajan *et al*, 2014).

Benzene, ethyl alcohol and water extracts of bark and flowers of *C. guianensis* showed antifertility activity was studied for their impact on period of assorted stages of estrus cycle in female person rats and on the number implantation sites within the pregnant rats (Geetha *et al*, 2005).

The ethyl alcohol extract of *C. guianensis* bark and every one the extracts of its flower condensed the quantity of implantations. Supported the on top of criteria *Couroupita guianensis* extract shows protective activity in a very therapeutic vary (Sundararajan *et al*, 2014).

8.2.5 Antimicrobial, Anti-mycobacterial and Anti-biofilm Properties

Antimicrobial, antimycobacterial and antibiofilm properties in chloroform extract of fruit of *Couroupita guianensis* has been showed (Al-Dhabi *et al*, 2012).

Chloroform extract of *Couroupita guianensis* fruit showed sensible antimicrobial and anti-biofilm forming activities however it showed less anti-mycobacterial activity. The zones of inhibition by chloroform extract ranged from zero to twenty six millimetres. Chloroform extract showed effective anti-biofilm activity against gram-negative microorganism referred to as *Pseudomonas aeruginosa* ranging from two mg/mL biofilm repressive concentration, with 52 inhibition of biofilm formation (Al-Dhabi *et al*, 2012).

There are also conjointly showed antimicrobial property of methanolic extract *Couroupita guianensis* flowers (Ramalakshmi *et al*, 2013).

The results of the antimicrobial activity showed effective repressing activity against *Plesiomonas*, *Shigelloides*, *Cocciaureus*, *Vibrio mimicus*, and *Proteus vulgaris*. Moderate antimicrobial activity was recorded against *E.coli*, *Klebsiella pneumonia* and *Salmonella typhi* (Ramalakshmi *et al*, 2013).

Additionally incontestable that chloroform, hexaneane and ethanol extract of fruit rind of *Couroupita guianensis* Aubl. showed its vital antibacterial and antifungal activity at the assorted conc.(10 mg/ml) during which the fermentation ethanol extract showed sensible

restrictive activity against *S. aureus, E. coli, C. diptheriaeand Micrococcus sp.* among the alternative tested extracts whereas chloform extracts showed sensible restrictive activity against *C. albicans* (Regina *et al*, 2012).

8.2.6 Antipyretic and Anxiolytic Activity

Antipyretic activity of flower and bark a part of *Couroupita guianensis* in chloroform, ethanol, water, ether, petroleum ether extracts was done by victimization yeast induces febrility methodology (Usman *et al*, 2012). This yeast induces febrility methodology suggesting that the antipyretic action of all the extracts was reflective; chloroform, ethanol, water extracts have vital onset of action on reduction of temperature (within 30 minutes) almost like that of paracetmol (30 minutes) (Sundararajan *et al*, 2014).

Anxiolytic impact has been showed in aqueous and methanolic extract of *Couroupita guianensis* flowers (Vinod *et al*, 2013). Elevated plus maze (EPM), light and dark (LD), and open field test (OFT) models were measured. From the results of the aqueous associate degrade methanolic of *Couroupita guianensis* at a dose of 500 mg/kg showed an anxiolytic activity associated with vehicle management in LD, EPM and open field test in mice (Vinod *et al*, 2013).

8.2.7 Immunomodulatory Activity and Neuropharmacological Action

Immunomodulatory activity in acetone, benzene, petroleum ether, chloroform, and methanol and water extracts of *Couroupita guianensis* flowers has invented by victimization rat as an animal model (Pradhan *et al*, 2009).

Hypersensitivity, hem agglutinations reactions were calculated by victimization sheep red blood cells (SRBC) as matter. Within the in-vivo studies, the continual fuel extract was found to exhibit a dose connected increasing within the hypersensitivity, to the SRBC matter at concentration of one hundred and two hundred mg/kg in animal studies. This study conjointly according that methanolic extract was found to stimulate cell mediate and antibody mediate immune responses in rats (Sundararajan *et al*, 2014).

Methanolic extract of *Couroupita guianensis* flowers in mice showed numerous neuropharmacological actions (Vinod *et al*, 2012). Spontaneous motor activity, rotarod performance and sodium thiopental sleeping time in mice were measured (Sundararajan *et al*, 2014). Beside medicine actions some phytoconstituents conjointly (alkaloids, glycosides, tannins and flavonoids) known.

From the results methanolic extract (100, 250 and 500 mg/kg) of *Couroupita guianensis* showed vital reduction in spontaneous motor activity however no impact had on motor co-ordination (Vinod *et al*, 2012). It conjointly leads to reduction of the onset and period of pentobarbitone evoked psychological state. Finally this study declared that extract contained associate degree agent that has pivotal role on each central and peripheral nervous system (Sundararajan *et al*, 2014).

8.2.8 Wound Healing, Anti-arthritic and Anti-stress Activity

Wound healing activityis discovered in ethanolic extract of *Couroupita guianensis* whole plant i.e. barks, leaves, flowers and fruits (Umachigi *et al*, 2007).

Many parameters like incision wound, epithelisation amount, scar area, enduringness and aminoalkanoic acid (hydroxyl proline) measurements beside wound contraction, were accustomed assess the impact of *Couroupita guianensis* on wound healing. The results indicated that *Couroupita guianensis* hurries the wound healing method by declining the expanse of the wound and increasing the enduringness (Sundararajan *et al*, 2014).

Victimization in-vitro technique showed anti-arthritic activity of *Couroupita guianensis* leaves in methanolic extract. Protein denaturation methodology was assessed. The activity of extract was principally reckoning on concentration. Protein denaturation was found to be 87.41% at a dose of 500 µg /ml (Elumalai *et al*, 2012).

Couroupita guianensis possess sturdy anti-stress activity in methanolic extract was studied by victimization cold restrain stress (RS) (Vinod *et al*, 2013). During this measure parameters like levels of glyceride, sterol and glucocorticoid to live the capability of methanolic extract on anti-stress (Vinod *et al*, 2013).

Animals treated with methanolic extract of *Couroupita guianensis* 100 mg/kg and 250 mg/kg, 500 mg/kg doses considerably lowered in the least the 3 doses in a very dose dependent manner as compared to stress control. Cold restrain stress caused an increase within the weight of adrenal glands at advanced dose (Sundararajan *et al*, 2014).

8.2.9 Antidiarrheal Action and Ovicidal Activity

Antidiarrheal action of *Couroupita guianensis* leaves on Castrol oil evoked diarrhoea in unusual person rats was disclosed (Elumalai *et al*, 2013). In Castrol oil evoked diarrhoea each the methanolic and liquid extracts beside common place loperamide showed vital reduction in diarrheic episodes. 100 mg/kg of methanolic extract and 100 mg/kg of liquid extract of *Couroupita guianensis* dried leaves are used for anti-diarrheal activity (Sundararajan *et al*, 2014).

Ovicidal activity was disclosed in hexane, chloroform and ester extracts of *Couroupita guianensis* plant on the eggs of Helicoverpaarmigera (Baskar *et al*, 2013). All the extracts showed ovicidal activity, and among them alkane extract showed additional (64.28%) ovicidal activity 0.62% and regression worth of 83.5% (Sundararajan *et al*, 2014).

8.2.10 Anti-nociceptive, Anti-feedent and Larvcidal Activity

Ethanol extract of *Couroupita guianensis* leaves exhibited sturdy anti-nociceptive activity was illustrated by victimization 3 analgesic models (acetic acid-induced contortions, tail flick, and hot plate) (Pinheiro *et al*, 2010).

Results are clearly showed that ethyl alcohol extract of *Couroupita guianesis* all fractions showed anti-nociceptive activity within the tail flick model whereas within the hot plate

methodology the best impact discovered was at the dose of 100 mg/kg and eventually extract considerably restrained the quantity of contortions evoked by ethanolic acid (Sundararajan *et al*, 2014).

Ethyl acetate and n-Hexane extract of *Couroupita guianensis* leaves exhibited anti-feedent and larvcidal activity was illustrated (Lingathurai *et al*, 2011; Baskar *et al*, 2012).

Table-10: Pharmaceutical uses of *Couroupita guianensis*

Plant Part	Solvent used for Extraction	Uses	References
Leaves	Not mentioned	Anti-stress	Elumalai, 2013
	Hexane, ethyl acetate, chloroform	Ovicidal	Bhasker *et al*, 2013
	Methanol	Anti-arthritic	Elumalai *et al*, 2012
	Ethyl acetate	Anti-feedent, larvcidal	Baskar *et al*, 2012
	Ethanol	Anti-ulcer	Elumalai *et al*, 2012
	n-Hexane	Anti-feedent & larvicidal	Lingathurai *et al*, 2011
	Ethanol	Anti-nociceptive	Pinheiroa *et al*, 2010
Flower	Methanol	Anxiolytic	Vinod *et al*, 2013
	Methanol	Antimicrobial	Ramalakshmi *et al*, 2013
	Ethyl acetate fraction of water	Antioxidant	Bafna *et al*, 2011
	Methanol	Immunomodulatory	Pradhan, 2009
Flowers and Bark	Not mentioned	Antipyretic	Usman *et al*, 2012
	Benzene, ethanol and water	Antifertility	Geetha *et al*, 2005
	Benzene, ethanol (95%)	Analgesic & Anti-inflammatory	Geetha *et al*, 2004
Dried flowers	Not mentioned	Anticancer & antioxidant	Premanathan *et al*, 2010
Fruits	Chloroform	Antimicrobial, anti-mycobacterial, anti-biofilm	Al-dhabi *et al*, 2012
	Ethanol	Antifungal and Antimicrobial	Regina *et al*, 2012
Fruit pulp	Alcohol (95%)	Antibacterial	Shah *et al*, 2012
Oil	Ethanol	Antibacterial	Azimi *et al*, 2012
Plant	Methanol	Neuropharmacological	Vinod *et al*, 2012
	Methanol	Anti-diarrheal	Gupta *et al*, 2013
Whole plant	Not mentioned	Wound healing	Umachigi *et al*, 2007
Root	Methanol	Antidepressant	Wankhede *et al*, 2009

Chapter-9: Pest and Diseases

Generally the species is medicinal tree species. The mature trees are not reported to be affected by pests and diseases as different parts of the tree contain strong medicinal chemical. The species is attacked by the pest and diseases when it is at the seedling and sapling stages (Rai, 2014).

The common pests and diseases are mentioned below.

9.1 Damping off seedling

Symptoms: Seedlings are attacked by more fungus on the hypocotyl or root or both while still in cotyledon stage. Seedlings wilt completely or fall over on the ground because of death and decay of tender tissue of the seedling at collar region (Pradhan *et al*, 2009).

Pathogens: *Fusarium spp., Pythium spp., Rinzoctoniasolani* (Silva & Tasso, 2015).

Control:

i. Maintaining soil pH 5-6 and moderate density of the seedlings.
ii. Well drainage and application of organic manure.
iii. Sterilization of the nursery soil with steam and drenching soil with 2% formalin or both.
iv. Application of fungicide such as thiram, captan, copper oxychloride (Silva & Tasso, 2015).

9.2 Root rot

Symptoms: Reduced growth and dull green colour of leaves and death of the apex of the shoot and gradual death of leaves are the major signs of the diseases. Small brown spots have shown on the secondary root (Silva & Tasso, 2015).

Pathogens: *Fusarium solani* (Silva & Tasso, 2015).

Control:

i. Application of Granosan M at control percentages.
ii. Drenching the nursery soil with application of formalin (Silva & Tasso, 2015).

9.3 Storage seed

Storage seed have generally attacked by red ant and mill bugs. Because seed contains high amount of carbohydrate, small amount of sugar and difference types edible materials (Silva & Tasso, 2015).

Control: When storage the seed that time toxic substances i.e. copper sulphate solvent 10% or potassium chloride and sodium chloride 1:3 ratio solvent use. Because the upper surface if toxic that time the insects cannot move near the seed (Silva & Tasso, 2015).

Chapter-10: Conclusions and Recommendations

10.1 Conclusions

Couroupita guianensis is an important species of Brazil nut family. It is an introduced exotic species in our country mostly for ornamental purposes. The species is highly medicinal one and being commercially planted on South America and Africa considered its pharmaceutical contribution. For the same reason the species has potential to be considered as important medicinal plant at commercial scale in our country and become as an economic tree species. However the species lacks ecological study even at its native region which requires careful attention before to introduction in plantation.

10.2 Recommendations

Some recommendations about *Couroupita guianensis* are given below:

- Ecology of the species is needed to be studied.
- Collect more literature, accumulate and organize information and find knowledge gap about the species.
- Pharmaceutical research for commercial medicine produces.
- Food source for elephant and wild animals.
- Wood treatment method to utilize the species.
- Commercial plantation for composite wood industries.

Chapter-11: References

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