

On behalf of:



Federal Ministry for the  
Environment, Nature Conservation,  
Building and Nuclear Safety



of the Federal Republic of Germany



# GUIDE TO REGENERATE MANGROVE AREAS WITH SUITABLE SPECIES

## RECOMMENDATIONS FOR BAC LIEU PROVINCE

Implemented by

**giz** Deutsche Gesellschaft  
für Internationale  
Zusammenarbeit (GIZ) GmbH



## PREFACE

Mangroves occupy a relatively small area in Bac Lieu Province compared with some other coastal provinces in the Mekong Delta. Nevertheless, they play an important role in protecting the coastline from erosion and minimizing the impact of coastal storms. They provide habitat and nursery areas for coastal aquatic species such as fish, crabs, shrimp and others, which support the livelihoods of coastal residents. Mangroves also make a small but nonetheless important contribution to reducing atmospheric carbon dioxide levels by storing carbon as biomass, both above and below ground.

Over the past three decades, and especially in the 1990s, the development of intensive shrimp culture in the coastal area of Bac Lieu Province has led to significant degradation of coastal mangroves, adversely affecting their capacity to protect the coastline and support the livelihoods of coastal people. Coastal mangrove forests in Bac Lieu province now consist of a narrow coastal fringe of natural *Avicennia marina* forest interspersed with plantations of mainly *Rhizophora apiculata*. Further inland, shrimp ponds are interspersed with patches of mangrove, again mainly *Rhizophora apiculata*, with *Lumnitzera racemosa*, *Ceriops tagal*, *Thespesia populnea* and *Casuarina equisetifolia* in more elevated areas. The loss of species diversity can be attributed mainly to the rapid expansion of coastal shrimp aquaculture, together with environmental degradation associated with over-exploitation of aquatic natural resources.

The project "Sustainable Management of Coastal Forest Ecosystems in Bac Lieu Province - Bac Lieu MCE", implemented jointly by GTZ and the People's Committee of Bac Lieu province, is sponsored by the Ministry of Environment, Resources and Nuclear Safety (BMU) of the Federal Republic of Germany. One of its primary objectives is to rehabilitate coastal mangrove forests by increasing species diversity, in order to enhance coastal protection, improve the livelihoods of local people and increase their resiliency to the consequences of climate change.

This manual is a supplement to the "Toolbox for Mangrove Rehabilitation and Management" for Soc Trang Province" by Thinh et al. (2009) It provides a set of "best-practice" guidelines on seed collection, nursery practices, site selection and planting for additional mangrove species that are considered to be appropriate to diversify the species composition of mangrove forests in Bac Lieu Province.

# TABLE OF CONTENTS

---

Preface .....	i
Table of Contents.....	ii
List of Figures .....	iv
<b>1. <i>Bruguiera parviflora</i> .....</b>	<b>2</b>
1.1. Description.....	2
1.2. Ecology .....	2
1.3. Seed collection and storage.....	3
1.4. Propagule collection .....	3
1.6. Care after planting .....	4
<b>2. <i>Intsia bijuga</i> .....</b>	<b>6</b>
2.1. Description.....	6
2.2. Ecology .....	6
2.3. Collecting and storing fruit .....	7
2.4. Germination .....	8
2.5. Planting .....	9
2.6. Care after planting .....	9
<b>3. <i>Kandelia candel</i>.....</b>	<b>11</b>
3.1. Description.....	11
3.2. Ecology .....	12
3.3. Seed collection and storage.....	13
3.4. Harvesting propagules .....	13
3.5. Planting .....	13
<b>4. <i>Sonneratia alba</i>.....</b>	<b>16</b>
4.1. Description.....	16

4.2. Ecology .....	17
4.3. Seed collection and storage.....	17
4.4. Sowing .....	17
4.5. Planting .....	18
4.6. Tending and protection .....	19
<b>5. <i>Xylocarpus moluccensis</i> .....</b>	<b>21</b>
5.1. Description.....	21
5.2. Ecology .....	22
5.3. Collecting and storing fruit .....	22
5.4. Nursery practices .....	23
5.5. Planting .....	23
5.6. Care after planting .....	24
REFERENCES .....	25
Appendix 1. Inundation classes of mangroves (Watson, 1928).....	i
Appendix 2. Common species found in the various inundation .....	i
classes of mangroves .....	i
Appendix 3: Identifying mature fruit of five mangrove species ..	ii
Appendix 4: The site classes in mangrove .....	ii
<b>Site classes</b> .....	ii
<b>Species</b> .....	ii
Appendix 5: Calendar harvest fruit and seed some species of mangrove trees for planting .....	iii
<b>No</b> .....	iii
<b>Vernacular name</b> .....	iii
<b>1</b> .....	iii

## LIST OF FIGURES

**Figure.1.1:** *Bruguiera parviflora* (Roxb.) W. & A. ex Griff. (a) Branchlet with hypocotyls ('fruits'), (b) cluster of five flowers, (c) flower seen from above, (d) petal, and (e) hypocotyl ('fruit').

**Figure 1.2:** Natural Regenerated seedlings under mother tree.

**Figure 1.3:** *Bruguiera parviflora* seedlings grow on the sowing bed.

**Figure 2.1:** *Intsia bijuga* (Colebr.) Kuntze. (a) Branchlet with buds, (b) flower, and (c) pod.

**Figure 2.2:** Flowers and leaf of *Intsia bijuga*.

**Figure 2.3:** Fruit and pods of *Intsia bijuga*.

**Figure 2.4:** Seedlings with cotyledons

**Figure 2.5:** Seedlings under shade.

**Figure 2.6:** Multi stems of *Intsia bijuga*.

**Figure 3.1:** *Kandelia candel* (L.) Druce. (a) Branchlet with buds and flowers, (b) flower, (c) longitudinal section of flower, (d) petal, (e) stamen, and (f) hypocotyl ('fruit'), (g) Branchlet with flowers.

**Figure 3.2:** *Kandelia candel* tree with propagules.

**Figure 3.3:** *Kandelia candel* plant with *Nipa fruticans*.

**Figure 3.4:** Wildling corer for transplanting.

**Figure 3.5:** Natural regeneration of *Kandelia candel*.

**Figure 3.6:** *Kandelia candel* plantation for coastal protection.

**Figure 4.1:** *Sonneratia alba* J.E. Smith. (a) Habit, (b) branchlet with flowers and immature fruit, (c) fruit with typical reflexed sepals, and (d) fruit with sepals in horizontal plane.

**Figure 4.2:** *Sonneratia alba* trees with pneumatophores.

**Figure 5.1:** *Xylocarpus moluccensis* (Lamk) M. Roem. (a) Branchlet with flowers, (b) base of tree trunk, showing the pneumatophores, (c) detail of bark, (d) flower, and (e) fruit.

**Figure 5.2:** The trunk and pneumatophores.

**Figure 5.3:** Fruit and seed of *Xylocarpus moluccensis*.

**Figure 5.4:** Mature fruit and seeds.

**Figure 5.5:** *Xylocarpus moluccensis* that grows on sand and deciduous in the dry season.

# Introduction

---

The mangrove flora can be broadly grouped into two groups, true mangroves and mangrove associates. There is some debate about the distinction between which species are true mangroves and which species are mangrove associates. For the purposes of this manual, we will use the following definitions: True mangroves are plants that normally grow naturally only in intertidal areas between about mean sea level and the highest equinoctial tides. Mangrove associates are species that are often found intermixed with true mangroves in intertidal areas, especially higher intertidal areas, but can also be found commonly in habitats that are not tidally influenced.

The capacity of mangroves to protect the coast against erosion and storms depends on the tree species present, and their density and size. Species that do not grow to be trees, such as the fern *Acrostichum* and other small shrubby or non-woody species make a relatively small contribution to coastal protection, and in any case, tend to grow in areas where tidal inundation is less frequent, inland away from the seaward fringe. For this reason, we will limit the scope of this manual to true mangrove tree species that are likely to enhance biodiversity and contribute to coastal protection.

A recent survey of the mangrove flora of Bac Lieu Province (GTZ report ) recorded 15 species of true mangroves and a further 34 species widely regarded as mangrove associates. The most common true mangrove tree species were, in descending order, *Avicennia marina*, *Ceriops tagal*, *Rhizophora apiculata* and *Ceriops zippeliana*. Other true mangrove tree species recorded as being fairly common were *Excoecaria agallocha* and *Lumnitzera racemosa*. Some species were rare, notably *Sonneratia caseolaris*, *Sonneratia ovata*, *Rhizophora mucronata*, *Bruguiera cylindrica*, *Xylocarpus mollucensis*, *Avicennia officinalis* and *Avicennia alba*; *Bruguiera parviflora* and *Kandelia candel* were not recorded at all.

In addition to the species described by Thinh et al. (2009), five other mangrove species found in the coastal areas of the southern Mekong Delta are considered suitable for diversifying the mangrove forest in Bac Lieu Province. These are *Bruguiera parviflora*, *Intsia bijuga*, *Kandelia candel*, *Xylocarpus mollucensis* and *Sonneratia alba*.



# Species Descriptions and Cultivation

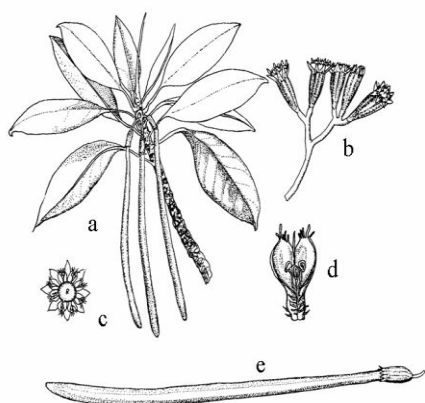
## 1. *Bruguiera parviflora*

**Vernacular name:** Vẹt tách

**Scientific name:** *Bruguiera parviflora* (Roxb.) W.& A. ex Griff.

**Synonyms:** *Bruguiera ritchiei* Merr., *Kanilia parviflora* Bl., *Rhizophora cylindrica* (non L.) Roxb., *Rhizophora parviflora* Roxb. (After Wim Giesen et al, 2006).

**Family:** RHIZOPHORACEAE (Đước)



*Bruguiera parviflora* (Roxb.) W.& A. ex Griff.



(f)

**Figure.1.1:** *Bruguiera parviflora* (Roxb.) W. & A. ex Griff. (a) & (f) Branchlet with hypocotyls ('fruits'), (b) cluster of five flowers, (c) flower seen from above, (d) petal, and (e) hypocotyl ('fruit').

### 1.1. Description

Trees up to 20 m tall with grey, fissured bark and knee roots. Trunk diameter can reach 40-50cm. Leaves pointed, elliptical in shape, yellow-green in colour with dark spots. Inflorescence is a small cluster of 3 - 7 flowers. The calyx tube is conical and the calyx is straight, not curved. Propagules are cylindrical, about 8 - 15cm long and about 0.3 - 0.5cm in diameter.

### 1.2. Ecology

*Bruguiera parviflora* is a true mangrove species that prefers to grow in well-drained areas that are flooded 10-20 days per month, so it is usually found in the inner parts of the mangrove forest away from the seaward margin, often in mixed stands with *Rhizophora*,

and sometimes with *Bruguiera gymnorhiza*. However, it can also be found along the edge of more elevated river banks, for example at the southern tip of Ca Mau Peninsula. It is suited to salinities ranging from brackish to seawater.

Flowering takes place from March to July, and fruiting from July to September. The propagule is light and small so it easily distributed by water. There is often a dense carpet of seedlings and occasional saplings under mother trees, but seedlings and saplings require direct sunlight to develop, so naturally regenerated seedlings seldom survive for more than a year beneath a closed canopy. Flowers are pollinated by insects.

### 1.3. Seed collection and storage



**Figure 1.2:** Natural regenerated seedlings under mother tree.

### 1.4. Propagule collection

**Propagule collection:** Fruiting from July to September every year. There are about 300 - 320 propagules per kilogram

Harvest propagules from healthy mother trees by shaking the tree so that mature propagules fall to the ground. Fallen propagules should be selected according to the following criteria:

- No new leaves have sprouted.
- Propagules are free from borer holes
- Propagules should be of approximately equal length.
- Propagules should be intact, fresh and free of borers, not withered, broken or with other visible signs of damage.
- Propagules will curve after lying on the forest floor for a long time, so make sure

that only straight propagules with the ability to germinate are selected.

**Propagule storage:** Propagules should be carried from the harvest to planting sites, and stored, in mesh bags or baskets to avoid damage. They need to be stored in the shade in layers not more than 20 cm thick and watered twice a day with brackish water or seawater. If they are stored in an area that is flooded by the tide, make sure that they are secured to prevent them being washed away.

## 1.5. Planting

**Site selection:** Plant on soft clays and silty clays, located at about mean high tide. Can also be planted in areas along higher river banks or dikes that are flooded every day. It can be grown mixed with Rhizophora.

**Planting method:** Insert the hypocotyl vertically to a depth of  $\frac{1}{3}$  -  $\frac{1}{2}$  its length, making sure that shoot is uppermost. It is important to make sure that the calyx is detached from the top of propagule before planting. When propagules are mature, it is easy to separate the calyx from the hypocotyl. Propagules should be planted within 10 days after collection for better survival.

**Planting season:** From August to October

**Density:** Planting density depends on the objectives of the planting programme and proximity to existing well-established trees, but generally a density 10.000 trees/ha (1 m x 1 m spacing) is recommended.

## 1.6. Care after planting

Newly planted areas should be checked after about four weeks and any dead seedlings replaced. Further checks should be carried out annually for the first three years, again replacing any dead seedlings or saplings.



**Figure 1.3:** *Bruguiera parviflora* seedlings grow on the sowing bed.

**Protection:** As with all new plantations, it is important to keep people and livestock out of the plantation area to ensure a high survival rate.

*Source of drawing: Wim Giesen, Stephan Wulffraat, Max Zieren và Liesbeth Scholten, 2006. Mangrove Guidebook for Southeast Asia, FAO và Wetlands International, pp 696 – 697.*

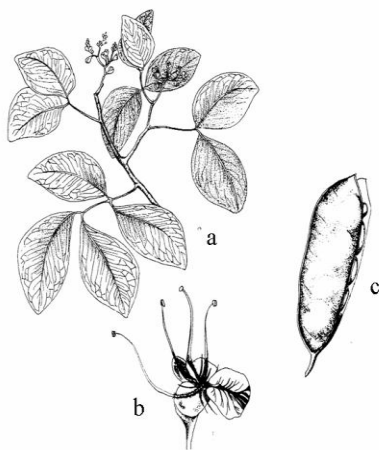
## 2. *Intsia bijuga*

**Vernacular name:** Gõ biển

**Scientific name:** *Intsia bijuga* (Colebr.) Kuntze

**Synonyms:** *Afzelia bijuga* A. Gray, *Afzelia retusa* Kurz., *Eperua decandra* Blanco, *Intsia amboinensis* Thouars., *Intsia madagascariensis* Thouars ex DC, *Intsia retusa* Colebr., *Macrolobium amboinensis* Teijsm. ex Hassk., *Macrolobium bijugum* Colebr., *Outea bijuga* DC. (After Wim Giesen et al, 2006).

**Family:** LEGUMINOSEA (Đậu)



*Intsia bijuga* (Colebr.) Kuntze.



(e)

**Figure 2.1:** *Intsia bijuga* (Colebr.) Kuntze. (a) Branchlet with buds, (b) flower, (c) pod and (e) Branchlet with flowers.

### 2.1. Description

Deciduous tree of up to about 25 m in height., with a spreading canopy. Compound leaves usually with four ovate leaflets without stipules. The inflorescence is red, 5 - 15 cm long, with many flowers having white petals when immature, turning to orange or red when mature.. Fruits are ball-shaped with 3 - 5 seeds. Fruits and seeds are both brown in colour when mature. Seeds are typically bean-like, about 3 to 5 cm in length and 2 - 3 cm diameter.

### 2.2. Ecology



*Intsia bijuga* is a relatively slow growing mangrove associate, found typically on higher ground that has minimal tidal flooding and/or a good supply of freshwater. It cannot withstand high salinity or long periods with its roots submerged. The trees are deciduous, losing all their leaves from late December to January. This species fruits twice a year, from February to June, and again from July to October.

Natural regeneration is by seeds and copicing.



**Fig 2.2:** Flowers and leaf of *Intsia bijuga*



**Fig 2.3:** Fruit and pods

### 2.3. Collecting and storing fruit

**Fruit collection:** Collect fruit from healthy trees between March and June, and again between August and September. There are 250 - 300 seeds/kg.

Use the following criteria for selecting fruit and seed:

- Select mature pods that are brown in colour.
- Select seeds that are relatively round for sowing, not seeds that are flattened or irregular in shape.
- Seeds should be intact and not cracked, broken or otherwise damaged.
- Remove the floaters (the small white bits that attach the seed to the pod) before storage

**Seed storage:** Like the seeds of most legumes, the seeds of *Intsia bijuga* can be stored and remain viable for quite a long time. It is best to put the seeds in bright sunshine for an hour or two to make sure they are completely dry before storing in clay pots or plastic jars covered at the top with a thick closely woven cloth to prevent attack by weevils. Seeds should be stored in a dry place, preferably with low humidity. Jars containing seeds should be shaken once or twice a week to ensure they are well aerated.

## 2.4. Germination

Like most legume seeds, the seeds of *Intsia bijuga* have a hard seed coat that prevents the entry of water needed for germination. The seed coat must therefore be abraded or softened to allow water to enter and ensure good germination. After sorting the seeds, add water to remove any unviable floating seed or debris. Then abrade the surface of the seed or soften the seed coat as describe in Annex X. After abrading or softening the seed coat, soak the seeds in fresh water for about 12 hours.

After soaking for 12 hours, the seeds picked out and incubated with sand, ground-up coconut husk or jute bag. Water with freshwater 4 to 5 times each day.

The seeds should germinate after 3 to 4 days with a high germination rate; with better seeds the germination rate is above 90%. After the seed has germinated, seeds are transplanted into a PVC bag or other seedling tube and put in a nursery as described below.

### Nursery practices

After seeds germinate, then transplanted into the PVC bag size 14 x 24 cm and placed under the shade. Should choose the shade cover mesh with 50% of light pass through.



**Figure 2.4:** Seedlings with cotyledons



**Figure 2.5:** Seedlings under shade.

After being placed in the nursery, young seedlings should be watered with freshwater to avoid root rot. Acclimation of seedlings to a salinity similar to that of the area in which they will be planted is essential to ensure good survival after planting in the field. To do this, begin at about six months by watering with dilute brackish water (not full strength seawater) using seepage irrigation. Gradually increase the salinity of the irrigation water over the next 2 to 4 months until it is similar to that of the field planting site.

Plant seedlings when they are around 8 - 12 months old. Select trees with a height of 50 -100 cm with brown woody stems.

## **2.5. Planting**

**Selection of planting site:** *Instia bijuga* should be planted in areas that are not flooded by salt water, so it is suitable for planting on dikes and levees that the tide does not reach. It can be planted on hard clays.

**Standard of seedling for planting:** Seedlings should be 80 - 100 cm in height with dark green leaves and no sign of pests. Reduce the amount of irrigation water 15 - 20 days before planting in the field to enable seedlings to adapt to a drier environment after planting.

**Plantation techniques:** Planting should be carried out late in the afternoon if the weather is sunny and dry, but can be carried out anytime during the day if it is raining. Dig a small hole approximately 25cm x 25 cm and 30 cm deep. Remove the seedling carefully from its bag and put it in the middle of the hole, then refill the hole to a level just below the surrounding soil level, making sure to pack the soil tightly around the roots. Be careful to ensure that seedlings are not damaged during transportation to the planting site.

**Planting season:** Plant from June to August.

**Density:** For larger areas plant 1,100 trees/ha (a spacing of about 3 m x 3 m). For smaller areas along dikes or levees seedlings can be planted further apart.

## **2.6. Care after planting**

Check seedling about one month after planting and replace dead trees or use bamboo (or other wooden) stakes to support leaning or fallen trees. This species is not a fast grower, and its rate of growth is even slower on poor, infertile soils. In this case it is a good idea to surround the base of the tree with an organic compost to promote faster growth.

New plantings should be checked once or twice yearly for the first three years, where possible replacing dead trees with fresh seedlings. Since this species is planted on higher ground, it is likely to suffer from competition by other faster growing weedy species. It is therefore advisable to remove other weedy species during the first three to four years.

As with all new plantings it is advisable to control access to the area in order to avoid or minimise damage caused by people or livestock.

Source of drawing: Wim Giesen, Stephan Wulffraat, Max Zieren and Liesbeth Scholten, 2006. *Mangrove Guidebook for Southeast Asia*, FAO and Wetlands International, pp 696 – 697.





**Figure 2.6:** Multi stems of *Intsia bijuga*

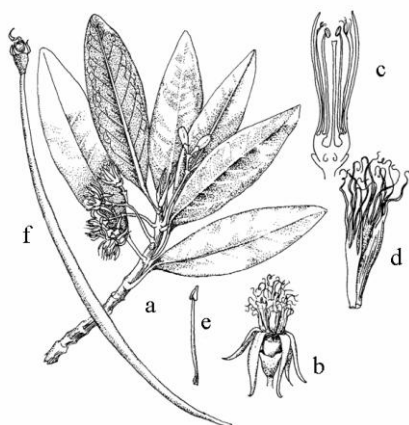
### 3. *Kandelia candel*

**Vernacular name:** Trang

**Scientific name:** *Kandelia candel* (L.) Druce.

**Synonyms:** *Kandelia rheedei* Wight & Arn., *Rhizophora candel* Linné (After Wim Giesen et al, 2006).

**Family:** Đước (Rhizophoraceae)



*Kandelia candel* (L.) Druce.



(g)

**Figure 3.1:** *Kandelia candel* (L.) Druce. (a) Branchlet with buds and flowers, (b) flower, (c) longitudinal section of flower, (d) petal, (e) stamen, and (f) hypocotyl (fruit), (g) Branchlet with flowers.

#### 3.1. Description

A small tree often bulging at the base to form a buttress, and smooth, grey to orange coloured bark. Simple, opposite ovate leaves similar in general shape to other members of the family Rhizophoraceae. Leaves are usually 6 -12 cm long and 2.5 to 6 cm wide, with petioles of 1 to 1.5 cm in length.

White flowers, the inflorescence cyme consisting of 10-20 flowers with a composite flower stalk and racemes 5-6, 1.2 cm long. The fruit is a truncated cone having sepals with curved

lobes. Propagules are cylindrical in cross section, with a bulge in the middle and tapered to the ends.



**Figure 3.2:** *Kandelia candel* tree with propagules.

### **3.2. Ecology**

A true mangrove, trees of this species are usually found on riverine or coastal alluvial soils in areas with salinities ranging from brackish up to seawater. It often grows in mixed stands with *Rhizophora* and *Sonneratia*, and it is often planted together with *Nipa fruticans*.



**Figure 3.3:** *Kandelia candel* plant with *Nipa fruticans*.

### **3.3. Seed collection and storage**

**Collecting propagules:** The flowering season is from May to June and the fruiting season from August to October. Propagules should be collected from big, healthy trees with round canopies. Fruit is usually collected from July to September as fruit collected late in the fruiting season is often of poor quality. There are about 30 - 45 propagule/kg. The mature propagules have yellow-green collar.

**Propagule storage:** The procedure for storage is the same as that described earlier for *Bruguiera parviflora*. Store propagules in mesh bags or in baskets in layers not more than 20 cm thick. Keep them moist and make sure they do not get washed away if they are stored in an area that is tidally flooded.

### **3.4. Harvesting propagules**

Harvest the propagules in the selected trees by shaking the tree to release mature propagules. Select propagules according to the following criteria:

- The top of the propagule is intact but without leaves.
- Propagules are free from borer holes
- Propagules should be straight and at least 21 cm in length.
- Propagules should be intact, fresh and free of borers, not withered, broken or with other visible signs of damage.

### **3.5. Planting**

**Sites for planting:** Plant on soft clay or silty clay soils in areas that are flooded 15 to 25 days per month by water with a salinity ranging from brackish up to seawater. This species



is not suitable for planting on unconsolidated mud in low intertidal areas along the sea front, but it can be planted along the seaward side of dikes, or together with *Nipa fruticans* on land along river and canal margins.

**Planting techniques:** No nursery phase is required. Plant propagules directly in the field by pushing them, base down, vertically into the soil to a depth of  $\frac{1}{3}$  -  $\frac{1}{2}$  the length of the propagules. The fruit cap (calyx), if still present, should be removed from the top of propagule before planting.

Planting densities depend on the location and area to be planted. Along dikes propagules can be planted in lines with about 1m x 1m spacing. A 1m x 1m spacing is also appropriate for more extensive areas and for planting to fill gaps, but propagules need not be planted in lines.

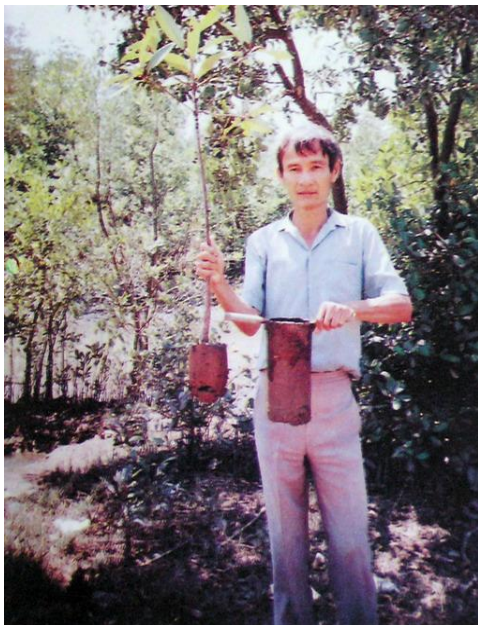


Figure 3.4: Wildling corer for transplanting.

**Wildling planting:** In areas with good natural regeneration of seedlings, wildlings collected from the forest can be planted the same day they are collected with a good survival rate. Seedlings of 30 - 50 cm in height can be collected using a corer (Fig. 3.4), which is also used to dig the holes for planting.

**Planting season:** From August to October.

**Density:** Planting at 10,000 propagules/ha, spacing is 1 m x 1 m.



Figure 3.5: Natural regeneration of *Kandelia candel*.



**Figure 3.6:** *Kandelia candel* plantation for coastal protection.

### **3.6. Care of plantations**

Check planted areas 7-10 days after planting and replace dead seedlings or use bamboo stakes to support leaning seedlings, it is to check in the plantation areas to detect dead or down trees, carry out planting where trees die immediately, repair collapsed or fallen trees. In estuarine situations, seedling/saplings can be attacked by barnacles. Where possible these should be removed with a knife.

Restrict access and fishing or collecting activities by local people to help improve survival.

Source of drawing: Wim Giesen, Stephan Wulffraat, Max Zieren and Liesbeth Scholten, 2006. *Mangrove Guidebook for Southeast Asia*, FAO and Wetlands International, pp 704 – 705.

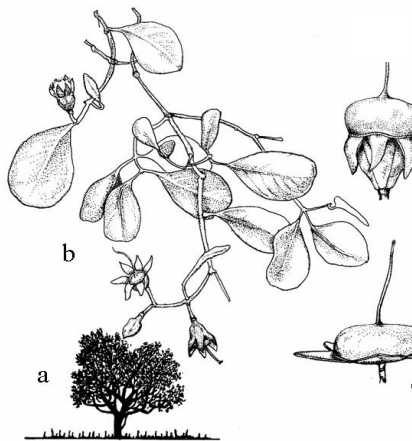
## 4. *Sonneratia alba*

**Vernacular name:** Bàn trắng, Bàn đấng

**Scientific name:** *Sonneratia alba* J. E. Smith.

**Synonyms:** *Chiratia leucantha* Montr., *Mangium caseolare album* Rumph., *Rhizophora caseolaris* Linné, *Sonneratia acida* Benth., *Sonneratia alba* F.Vill., *Sonneratia caseolaris* Engl., *Sonneratia griffithii* (non Kurz) Watson, *Sonneratia iriomotensis* Masamune, *Sonneratia mossambicensis* Klotzsch ex Peters. (After Wim Giesen et al, 2006).

**Family:** SONNERATIACEAE (Bàn)



*Sonneratia alba* J.E. Smith



(e) Leaves, flowers and fruits

**Figure 4.1:** *Sonneratia alba* J.E. Smith. (a) Habit, (b) branchlet with flowers and immature fruit, (c) fruit with typical reflexed sepals, and (d) fruit with sepals in horizontal plane.

### 4.1. Description

A true mangrove growing to a height of 10 - 15 m. The obovate leaves are succulent, so they are thick, hard and brittle. The flowers are large, with red petals and long white anthers. Flowering takes place from February to March, and fruiting from May to September. The fruit has many seeds and fruits are not edible because of a bitter taste.

Characteristics distinguished from other *Sonneratia* species is on the tip leaf imarginate has a pink line about 1 - 2 cm.

## 4.2. Ecology

*Sonneratia alba*, a true mangrove, is a pioneering species in lower intertidal areas near the mouths of estuaries where the salinity is close to that of seawater, and along the coastal sea front. It is often found mixed with *Avicennia alba* and *Avicennia marina*, two other common pioneering species suited to the same habitat. *Sonneratia alba* prefers more saline areas and is seldom found at low salinities upstream in rivers, where it is replaced by its close cousins *Sonneratia caseolaris* or *Sonneratia ovata*. *Sonneratia alba* grows best on sandier soils, but also grows on muddy soils. Flowering takes place throughout the year. Fruits float and are disseminated by the tides to the area suitable for development. To supply oxygen to the underground roots, *Sonneratia alba* usually develops pneumatophores that protrude 20-30 cm above the soil surface, but these may be absent on firmer soils in more elevated areas that are flooded less frequently.

## 4.3. Seed collection and storage

**Collecting fruit:** Harvest fruit from August to October. Collect big fruit that have no insect grubs (larvae) inside. Put the fruit in jute bags then soak in water for 3 - 4 days to soften the flesh. The fruits contain many small sickle-shaped seeds, which need to be removed and washed free of pulp, then lightly air-dried in the shade. There are 12 to 15 fruits/kg and 500 - 1500 seeds/kg.

**Seed storage:** Seeds should be sown in a nursery immediately (see below). If absolutely necessary, seeds that are air-dry can be stored in a refrigerator in a small bottle with a cap for a short time.

## 4.4. Sowing

**Seeds treatment before sowing:** Put the seeds in water (2 parts boiling water and 3 parts cold water) soak until water cools, pour out the water and replace it with cold water and soak for 30 minutes. Repeat the cold water soaking 1 - 2 times. At last, seed soaked in cold water in 5 - 6 hours. Then get out to dry and put them in the cloth bags for 2 to 3 days of incubation. Wash seeds 1 times daily, when the seed germinate then sown it into PVC bag.

Since the seeds are very small, germination and seedling development should be done in a nursery. After treatment, sow seeds in a seedbed (described below) or sow 1 to 2 seeds in a PVC bag (also described below).

**Seedbed:** Seedbeds should be raised, about 15-20m long and 1-1.5 m wide, with a space of 0.6 to 0.8m between them. Having drainage system. when low tide, water go out and come in when high tides. The seedbed should be built with a loamy soil, not too high in clay content, mixed with compost. The seeds are sown directly on the bed surface at the low tide. The seeds are



sprayed strong to hold on the soil and avoiding washed away by tidal water before germination. It usually takes 3 - 5 days for germination. Seedling germinated in the seedbed should be transplanted into PVC bags when they are 10 to 15 cm in height.

**Plastic seedling bags:** (14cm wide x 24cm deep) filled with a well-mixed mixture of 90% soil (comprised of approximately 30% clay and 70% sand) and 10% compost. The bags should have holes in the bottom or have the bottom corners removed to facilitate drainage.

**Transplanting to the field:** Seedlings should be transplanted from the nursery to the field between March and April, when they are about 5 - 6 months old. Use a round stick 2-3 cm in diameter to make holes about 26 cm deep. Carefully cut off the plastic bag and put the roots into the hole so that they are a little below the surrounding soil surface. and let the roots straight, then use stick compressed soil around roots and stems are straight. Trees should be transplanted at neep tide. Besides, wildings also collect from forest for transplanting to PVC bag.

**Collecting wildings to plant:** Wildings collected directly from the field can also be used. Wildings should be kept in a nursery area for two months before transplanting into the field. Use an iron corer (Figure 3.4) to collect wildings; this ensures that the root system and soil are both intact and minimizes root damage. The seedlings are transported to areas where the tide inundating daily to tending for 20 - 30 days. When tree roots and bear new leaves are carried for planting.

**Tending:** In the days of low tide, the water does not flood to the bags so watering is need to insure adequate moisture for seedlings to develop normally. In the nursery, seedlings are attacked by insects, crabs, snails or some species eat stems, leaves... infestation should use nylon mesh size 1 x 1 mm around the bed to limit the penetration of them.

#### **4.5. Planting**

- **Site selection:** Planting the *Sonneratia alba* in the areas of alluvial estuaries with sandy mud, in the low to the average tidal flooded areas. This is a pioneering species with pneumatophores system which is deep underground should be planted for protection and erosion control.

#### **- *Standard of seedling for planting***

- Planting trees against erosion in tidal flat of coastal estuaries, the height of trees > 1 m, stem diameter is 3 - 4 cm.
- Planting trees along the coast, using the potted seedlings or wildings are height of 50 - 100 cm.
- The seedlings are not broken tops, straight stem, spread evenly canopy, not pests.
- Wildings for planting erosion control need to be nurtured in the shade and have new leaves to plant.

#### **- *Planting techniques***

**+ *Planting in the muddy flat and estuary:*** Tighten the string by knots in the distance between two knots is 1.5 m. Use a hoe to dig a hole with the size of 40 cm x 40 cm or corer tools in the position of the knots to plant for the right distance. Place the trees in the middle of planting holes and fill soil at base. The distance between two strings is 2 m. Before planting should investigate where the mean sea level. Many tidal flats are at low tide, but planting will be fail due to growing wrong locations because of below mean sea level.

**- *Planting season:*** From May to June.

**- *Density:*** Planting density of 3,300 trees/ha (spacing 2 m x 1.5 m) in the muddy flat eroded in the estuaries. In muddy flat of rivers bank, the density of planting is 5,000 trees/ha (2 m x 1 m).

#### **4.6. Tending and protection**

**- *Tending:*** After growing from 20 to 30 days, to conduct the re-planting of

trees killed, repaired the fallen trees.

- **Protection:** People, boats, and fishing are not allowed operating in the new plantation areas. Prevent animals eating leaf will affect to plantations.



**Figure 4.2:** *Sonneratia alba* trees with pneumatophores.

- Source of drawing: Wim Giesen, Stephan Wulffraat, Max Zieren and Liesbeth Scholten, 2006. *Mangrove Guidebook for Southeast Asia*, FAO and Wetlands International, pp 740 – 741.

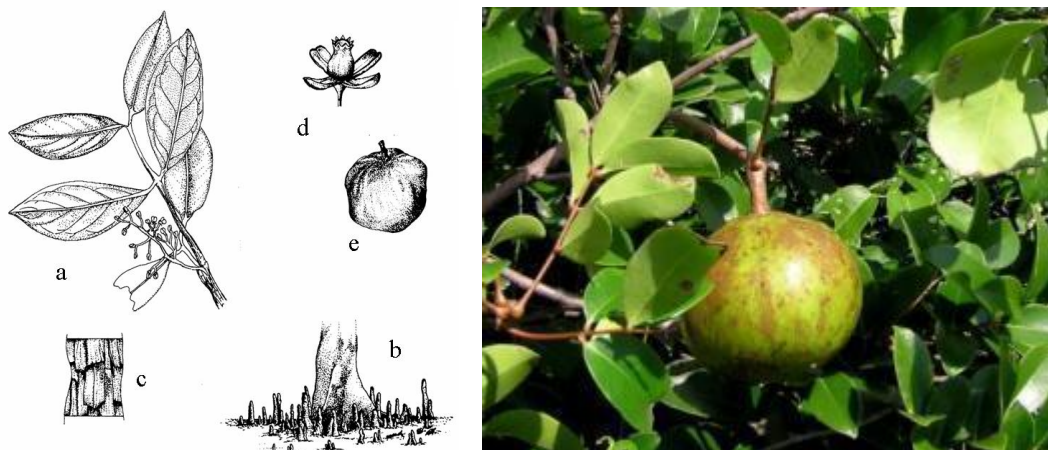
## 5. *Xylocarpus moluccensis*

Vernacular name: Xu sung, Xu sùng

Scientific name: *Xylocarpus moluccensis* (Lamk) M. Roem.

Synonyms: *Carapa borneensis* Becc., *Carapa mekongensis* (Pierre) Pellegr., *Carapa moluccensis* Lam., *Carapa obovata* auct. non Blume, *Granatum litoreum parvifolium* Rumph., *Granatum moluccensis* (Lam.) Kuntze, *Xylocarpus australiasicus* Ridley, *Xylocarpus gangeticus* (Prain.) C.E. Parkinson, *Xylocarpus parvifolius* Ridley, *Xylocarpus mekongensis* Pierre (After Wim Giesen et al, 2006).

Family: MELIACEAE (Xoan)



*Xylocarpus moluccensis* (Lamk) M. Roem.

**Figure 5.1:** *Xylocarpus moluccensis* (Lamk) M. Roem. (a) Branchlet with flowers, (b) base of tree trunk, showing the pneumatophores, (c) detail of bark, (d) flower, and (e) fruit.

### 5.1. Description

This is a deciduous tree that loses its leaves during the dry season and grows to a height of 6 - 12 m in more elevated areas near the upper tidal limit. It has a buttress and short, thick pneumatophores. The stem is usually dark in colour, rough and fissured. Branches have smooth, greenish bark. The leaves are compound with 2 - 3 pairs of leaflets, each leaflet about 10 cm long, pointed at the top and broader at the base. The flowers grow in clusters. They have yellow petals and white, rounded calyx lobes of about 1.5 mm in

length. The fruits are more or less spherical in shape and, when mature, brown in colour and 8 - 15 cm in diameter, with 4 - 6 seeds. There are about 50 - 80 seeds/kg.

This species is considered to be a true mangrove.

## 5.2. Ecology

Trees growing in flooded areas at high tide where the riversides with high salinity, sometimes growing on sandy soils, often grown in scattered areas, but the concentrate in the riparian zone. Deciduous trees in the dry season, the leaves change from green to yellow then red. This is true mangrove species.



Fig 5.2: The trunk and pneumatophores



Fig 5.3: Fruit and seed of *Xylocarpus moluccensis*

## 5.3. Collecting and storing fruit

**Fruit collecting:** Fruit are usually collected from June to July, and when their colour changes from green to a light brown. Seeds can also be collected from fruit that have split after falling to the ground. However, the seeds of all *Xylocarpus* species are often attacked by the larvae of a moth, so special care needs to be taken to ensure that the seeds have no holes in them, though seeds that have been attacked often germinate successfully.

**Seed storage:** Seed can be stored for up to several weeks provided it is kept moist. Intact fruit that has not split to release the seeds can be kept in the shade until it dries out and splits. The collected seeds sow into the PVC pot size of 14 x 24 cm. When the seed have not yet put in the PVC pots, it is necessary to water for fresh seeds and germinate easily.



**Figure 5.4:** Mature fruit and seeds

#### **5.4. Nursery practices**

Seedlings need to be kept in a nursery area until they are big enough to plant in the field. They are usually grown in a plastic bag (about 14 cm in diameter and 24 cm deep) filled with a loamy soil (50% silt, 50% sand) to which compost has been added. The bag should be perforated at the bottom and down the sides, or the bottom corners removed to facilitate drainage. Seedlings should be pushed firmly about 1 cm into the top of the soil in the bag, making sure that the embryonic bulge is downwards in the soil (Fig. ). During germination, the bags need to be kept in the shade and watered with daily with freshwater. After two months from germination, seedlings should be alternately watered with freshwater and brackish water, and from six months onwards only with brackish water. This gives them time to adapt to the saline conditions they will encounter in the field. At about 3 months, seedlings should be moved out of the shade into a more exposed situation to adapt them to sunlight and heat. Daily watering is then essential.

#### **5.5. Planting**

Seedlings should be transplanted from the nursery to the field after about 10 months, when they will be 80 - 100 cm high. It is best to plant in the field from June to July during the wet season.

**Site selection:** Plant on solid ground in higher elevated areas that are flooded between 5 and 10 times a month, and along the edges of dikes at about the same elevation. *Xylocarpus moluccensis* is often grown in pure stands, but it can also grown together with *Intsia bijuga* along more elevated canal and river banks.

**Field planting:** Dig a hole about 30cm x 30cm x 30 cm deep. Carefully remove the PVC bag and put the seedling in the hole so that its roots are below the level of the surrounding



soil and then fill the hole to 1 - 2 cm below the surrounding soil level, packing the soil firmly around the roots. Plant late in the afternoon if the weather is dry, or anytime during the day in wet weather. For larger areas, plant at 3,300 to 5,000 trees per hectare (a spacing of 2 to 3 metres between trees).

Use bamboo or other stakes to support seedlings in areas exposed to wind.



**Figure 5.5:** *Xylocarpus moluccensis* that grows on sand and deciduous in the dry season.

### **5.6. Care after planting**

Check new plantations after 10 to 15 days and replace any seedlings that have died or stake any seedlings that have fallen over. A layer of compost around the base of the seedling will help prevent the soil from drying out too much, and may improve growth.

Restrict access and fishing or collecting activities by local people to help improve survival.

**Source of drawing:** Wim Giesen, Stephan Wulffraat, Max Zieren and Liesbeth Scholten, 2006. *Mangrove Guidebook for Southeast Asia*, FAO and Wetlands International, pp 652 – 653.

## REFERENCES

Chan, H. T. and Baba, S., 2009. *Manual on Guidelines for Rehabilitation of Coastal Forests damaged by Natural Hazards in the Asia-Pacific Region*. International Society for Mangrove Ecosystems (ISME) and International Tropical Timber Organization (ITTO), 66 pp.

Pham Trong Thinh, Hoang Thoi, Tran Huy Manh, Le Trong Hai and Klaus Schmitt 2009. *Management of Natural Resources in the Coastal Zone of Soc Trang Province: Tool Box for Mangrove Rehabilitation and Management*. GTZ. 58pp.

Vien Ngoc Nam and Nguyen Son Thuy, 1993. *Mangrove and Plantation Techniques*. Agricultural Service of Ho Chi Minh City, 25 pp.

Wim Giesen, Stephan Wulffraat, Max Zieren and Liesbeth Scholten, 2007. *Mangrove Guidebook for Southeast Asia*, FAO and Wetlands International, 769 pp.

Watson, J.G., 1928. *Mangrove Forests of the Malay Peninsula*. Malayan Forest Records No. 6, 275 pp.



**Appendix 1.** Inundation classes of mangroves (Watson, 1928)

Class	Flood by	High above Chart datum (m)	Frequency (times/month)
1	All high tides	0 < 2.4	56 – 62
2	Medium high tides	2.4 < 3.4	45 – 59
3	Normal high tides	3.4 < 4.0	20 – 45
4	Spring high tides	4.0 < 4.6	2 – 20
5	Equinoctial tides	> 4.6	< 2

**Appendix 2.** Common species found in the various inundation classes of mangroves

Inundation class	Common tree species
1. Deeply inundated by all high tides (Seaward shores)	<i>Avicennia alba</i> , <i>Avicennia marina</i> and <i>Sonneratia alba</i>
2. Inundated by all high tides (banks of tidal creeks)	<i>Rhizophora mucronata</i> and <i>Sonneratia caseolaris</i>
3. Inundated by normal high tides (Central mangroves)	<i>Bruguiera gymnorrhiza</i> , <i>Bruguiera cylindrica</i> , <i>Bruguiera parviflora</i> , <i>Bruguiera sexangula</i> and <i>Rhizophora apiculata</i> , <i>Kandelia candel</i>
4. Inundated only by occasional spring tides (Back mangroves)	<i>Excoecaria agallocha</i> , <i>Instia bijuga</i> , <i>Lumnitzera racemosa</i> , <i>Xylocarpus granatum</i> and <i>Xylocarpus moluccensis</i>
5. Inundated only by very rare equinoctial tides (Riverine mangroves)	<i>Cerbera manghas</i> , <i>Cerbera odollam</i> , <i>Nypa fruticans</i> ,

Source: Chan, H. T. and Baba, S., 2009 and Modified

**Appendix 3:** Identifying mature fruit of five mangrove species

No	Species	Mature fruit
1	Vẹt tách ( <i>Bruguiera parviflora</i> (Roxb.))	Propagule from bluish to brown
2	Gỗ biển ( <i>Intsia bijuga</i> (Colebr.) Kuntze)	Fruits brown, seed dark brown
3	Trang ( <i>Kandelia candel</i> (L.) Druce.)	Propagule slightly brown, yellow green collar
4	Bần trắng ( <i>Sonneratia alba</i> J.E. Smith.)	Fruit from green to brownish
5	Xu sung ( <i>Xylocarpus moluccensis</i> (Lamk) M. Roem)	Fruit from green to brown

**Appendix 4:** The site classes in mangrove

No	Tide regime		Deeply inundated by all high	Inundated by all high tides	Inundated by mean tides		Inundated only by occasional spring tides	Inundated only by very rare equinoctial tides
					Low	High		
	Topography (m)		0.0 - 2.44 m	2.45 - 3.34 m	3.35 - 3.5 m	3.6 - 3.95 m	3.96 - 4.5 m	> 4.5 m
	Soil			<i>Soft mud</i>	<i>Hard mudt</i>	<i>Soft clay</i>	<i>Hard clay</i>	<i>Solid soil</i>
		Site classes	la	lb	lc	ld	le	lg
	Salinity	Species						
1	Salty	Sonneratia alba		—————				
2	Brackish water - Salty	Kandelia candel			—————			
3	Brackish water	Intsia bijuga					—————	
4	Brackish water - Salty	Xylocarpus moluccensis				—————		
5	Salty	Bruguiera parviflora				—————		

**Appendix 5:** Calendar harvest fruit and seed some species of mangrove trees for planting

No	Vernacular name	Species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Bần trắng	<i>Sonneratia alba</i>					—————			— — — —	— — — —	— — — —		
2	Trang	<i>Kandelia candel</i>							— — — —	— — — — —————	— — — — —————	—————		
3	Gỗ biển	<i>Intsia bijuga</i>			— — — —	— — — —	— — — —	—————	—————	— — — — —————	— — — —			
4	Xu sung	<i>Xylocarpus moluccensis</i>						— — — — —————	— — — — —————					
10	Vẹt tách	<i>Bruguiera parviflora</i>							— — — —	— — — — —————	— — — — —————	—————		

Note: Planting



Fruit or seed collecting



## Imprint

### **Published by the**

Deutsche Gesellschaft für  
Internationale Zusammenarbeit (GIZ) GmbH

### **Registered offices**

Bonn and Eschborn, Germany

Sustainable Management of Coastal Forest Ecosystems in  
Bac Lieu Province

215, 23/8 Street, Ward 8  
Bac Lieu City  
Bac Lieu Province, Viet Nam

### **As at**

October 2010

### **Photo credits**

© GIZ

### **Text**

Dr. Vien Ngoc Nam

GIZ is responsible for the content of this publication.

### **On behalf of the**

Federal Ministry for the Environment, Nature  
Conservation,  
Building and Nuclear Safety of the Federal Republic of  
Germany.

Deutsche Gesellschaft für Internationale  
Zusammenarbeit (GIZ) GmbH  
Số 215, đường 23/8, Phường 8, Tp Bạc Liêu,  
Tỉnh Bạc Liêu, Việt Nam  
T: +84 781 39 49 448  
F: +84 781 39 49 446  
E: office.baclieu@giz.de

[www.giz.de/viet-nam](http://www.giz.de/viet-nam)

