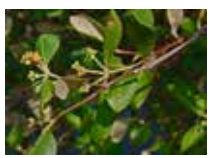
PROJECT

REHABILITATION AND DEVELOPMENT OF MANGROVE FOREST ECOSYSTEM IN THAI BINH PROVINCE

GUIDANCE ON NEW PLANTING AND SUPPLEMENTARY PLANTING TECHNIQUE FOR 3 MANGROVE PLANT SPECIES

- Sonneratia caseolaris (L.) Engler;

- Kandelia obovata Sheue, Liu & Yong;



- Avicennia marina (Forssk.) Vierh

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PART I: GUIDANCE ON NEW PLANTING TECHNIQUE

A. GUIDANCE ON *SONNERATIA CASEOLARIS* PLANTING TECHNIQUE

I. Introduction

Scientific name: *Sonneratia caseolaris* (L.) Engler

Local name: Bần chua

Other name: Bần sẻ

Family: Sonneratiaceae

Distribution and ecological characteristic: Distributed from the Northern region to the Southern region, where warp soil of seaports have a lot of clay and low salinity, rarely surpass 20‰. Tree, with height reaches to 15m or above, diameter at 1.3m can reach 60cm. Thinly scattered canopy; Leaf is single, opposite, elliptic, acumen, usually has red petiole and main vein. Aerial root has radial asparagus shaped, root can grow to the height of 70 cm, diameter of root close to surface can reach 2 - 3 cm.

Figure A1: Leaves and fruits of Sonneratia caseolaris

II. General regulation

2.1. Objective

This technical guidance aims to protection forest plantation in order to block wave, wind, to protect ecological environment, to fix alluvial ground by *Sonneratia caseolaris*, contributes to rehabilitation and sustainable development of mangrove forest ecosystem in Thai Binh Province.

2.2. Content

This technical guidance develops content, regulation and technical requirement from choosing plant condition, seed supply, forest plantation, tendance, and protection of Sonneratia caseolaris.

2.3. Object and scope of application

This technical guidance is applied for *Sonneratia caseolaris* plantation in mangrove forest planting of the project entitled Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

This technical guidance is recommended for all production units, enterprises and subjects of every economical component to plant mangrove forest by other sources in Thai Binh and other local with the same condition.

This technical guidance is the basis to develop economical and technical standards and *Sonneratia caseolaris* seedling production in Thai Binh, concurrently for organization, management, approval in seedling production.

2.4. Term explanation

Terms in this technical guidance are explained as follow:

- **Growing condition:** Some characteristics of site condition, tidal regime, ground exposure time and salinity of seawater.

- **Mangrove ground (warp):** The mangrove grounds at estuaries, coastal areas, or along the rivers, canals with brackish water by daily tidal regime.

- **Physical component:** Divided into 3 types, including Mud (soft or weak mud, tight mud, hard mud), clay (soft clay, tight clay, hard clay), sand (muddy sand).

- **Ground exposure time:** The average hour in day that the area is not inundated by tide.

- **Inundated time:** The average hour in day or the average day in month that the area is inundated by tide.

- **Salinity:** The total content of soluble salts (in gram) contained in 1000g seawater, denoted S (‰ or g/kg).

- **Deep tidal regime:** The inundated phenomenon when tidal level is low.

- **Low tidal regime:** The inundated phenomenon only when the tidal level is high.

- **Medium tidal regime:** The inundated phenomenon only when the tidal level is average (equals the average sea level at 0 cm).

III. Growing condition

Sonneratia caseolaris is usually planted at stable warp areas, coastal areas, near estuaries. The appropriate salinity is from 5 to 20‰. Growing condition of *Sonneratia caseolaris* is divided into 3 categories: Favorable condition (category I), average condition (category II) and difficult condition (category III) are illustrated specifically in the following table:

Table 01. Growing condition of *Sonneratia caseolaris*

No.	Favorable condition (category I)	Average condition (category II)	Difficult condition (category III)
1	Site condition: Soft silt soil or tight mud, sink from 15 to 40cm	Site condition: Hard silt soil or soft clay soil, sink from 5 to 15cm, sandy (sand <50%)	Site condition: Tight clay soil or hard clay or sandy soil (sandy rate from 50 to 70%), sink less than 5cm
2	Tidal regime: average	Tidal regime: average	Tidal regime: deep

IV. Forest planting

4.1. Seedling standard

Figure A2: Sonneratia caseolaris seedlings (18 months) meet the planting standard and brought on land to drain before transportation

Table 02. Sonneratia caseolaris seedlings on different site conditions

No.	Growing condition	Age (month)	Root diameter (cm)	Height (cm)	Quality
1	Category I	8-12	≥ 1.0	≥ 60	Well growth, well-propotioned development, no pestilent insect, no shortened top of seedling, verdant leaf, soil pot is not broken.
2	Category II	>12-18	≥ 1.5	≥ 100	
3	Category III	>18	≥ 2.0	≥ 120	

4.2. Planting season

Plant *Sonneratia caseolaris* when it has least wave in year, avoid storm season, from June to August in Nothern region (Thai Binh).

4.3. Planting method

Sonneratia caseolaris can be mono or mix planted in line with other species such as *Aegiceras corniculatum*, *Kandelia obovata*...depend on each region.

4.4. Planting density

Planting density is divided according to 3 growing conditions as following table:

Table 03. Sonneratia caseolaris density on site conditions

No.	Planting method	Category I	Category II	Category III
1	Mono-plantation by potted seedling	1330 seedlings/ha 1600 seedlings/ha	1600 seedlings/ha 2000 seedlings/ha	2000 seedlings/ha 2500 seedlings/ha

2	Mixed plantation in line by potted seedling	- Mixed plantation Sonneratia caseolaris with Kandelia obovata , area ratio: 1/3 Sonneratia caseolaris : 2/3 Kandelia obovata. Total density from 2500 to 3300 seedlings/ha, including Sonneratia caseolaris from 800 to 1100 seedlings/ha, Kandelia obovata from 1700 to 2200 seedlings/ha. - Mixed plantation Sonneratia caseolaris with Kandelia obovata , area ratio: 2/3 Aegiceras corniculatum: 1/3 Sonneratia caseolaris. Plant in band, total seedlingsfrom 3600 to 5000 seedlings /ha, including Aegiceras corniculatum from 3000 to 4200 seedlings /ha, Sonneratia caseolaris from 600 to 800 seedlings /ha.

Figure A3: Density identification and holes digging

Figure A4: Scattering

4.5. Tillage

- **Category I:** Digging hole with size larger than pot for easy seedling arranging and planting after digging.

- **Category II:** Digging hole with size of 30x30x30cm or 40x40x40cm.

- **Category III:** Digging hole with size of 40x40x40cm. Digging rehabilitated hole with size of 50x50x50cm or 60x60x60cm; after digging, spill mud to fill 2/3 hole's depth, then full fill the hole with sand and piling

4.6. Planting method

- Choose satisfied seedling for planting, before growing from 5 to 7 days, bring the seedlings on land to drain and maintain the pot.

- Use basket, plank, and boat to transport seedlings, avoid breaking the pot and root.

- Planting method: Can cut off 1/3 top of seedling before planting to avoid damage from waves after plantation. Take off pot cover before planting, do not break or distort the pot. Place the seedling in vertical, the seedling's soil pot surface lower than digged hole's surface from 3 to 5cm, then cover the hole; use hand, foot to press mud, soil tightly around the pot. The pot cover after being taken off need to be gathered to dumping ground (self-decomposing pot don't need to take off the cover).

- In areas with large waves, pot may be broken or drifted, before planting, put the pot into basket made of bamboo or other suitable decomposable materials in less than 1 year. Before putting the pot into the basket, take off the cover and avoid breaking the pot. Keep the seedlings time in bamboo baskets at least 1 month, only growing when the seedlings already stable.

- Piling to hold the seedlings if plant at big waves areas. Use bamboo or available materials at local. Length from 70 to 100cm, diameter from 1.5 to 3cm. Tie 1 end of rope to pile, the other end tie to stem (do not not tie pile close to the stem, to avoid rub), the rope's lenght between the pile and the seedling is from 5 to 7cm, away from stump 20cm.

Figure A5: Take off pot cover before planting

Figure A6: Seedling plantation


Figure A7: Planting and piling

- Can stake 1 or 3 piles depend on the wave's level; tilt 1 pile 450, pile's head seawards; tilt 3 piles 450 in a tripodal position. If have sack, plunge through it.

4.7. Replanting

Checking after 1-2 months:

- If number of dead seedlings are few (≤ 10%) and scattered (below 3 closing trees), do not replanting.

- If number of dead seedlings > 10% or ≥ 3 closing seedlings die, need replanting. Replanting in the first 3 years (forest plantation year and 2 following years). Replanting rate as in the following table:

Table 04. Replanting rate of Sonneratia caseolaris on site conditions

No.	Growing condition	Replanting rate compare to main planting rate		
		First year	Second year	Third year
1	Category I	10%	5%	5%
2	Category II	15%	10%	5%
3	Category III	20%	15%	10%

V. Forest tendance and protection

5.1. Forest tendance

Tendance must carried out in the first 4 years. First 3 months after planting, in periodic of once every 20-30 days: trash picking, pile

rearranging, re-tie loosen rope. After that, tending in periodic of once every 2-4 months: grass removing, trash picking, fallen tree bristling up. Shipworms have sticked for a long time can cause tree dying, so need to be removed when they just stick to the tree.

5.2. Forest protection

- Set up warning signs to ban exploitation activities, aquatic fishing in plantation area in the first 2 years.

- Prevent forest exploitation, forest destruction and harmful species.

- Do not ridge soil, surround net to prevent flows in plantation forest for aquaculture or combined production in the first 5 years.

- In the following years, if aquacultural activities happen, need to have plans to avoid damage to plantation forest.

5.3. Approval

- Approval is carried out according to current regulations.

- Survival rate is defined as follows: After 1 year, survival rate reaches at least 70%; After 2 years, survival rate reaches at least 60%; After 3 years, survival rate reaches at least 50%, it meets requirements if trees evenly distributed on the forest plantation area.

Figure 8: 6-year-old Sonneratia caseolaris forest

VI. Excecution provision

6.1. This technical guidance is applied to all production units in every economical components participate in producing *Sonneratia caseolaris* seedlings in the project Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

6.2. This technical guidance takes effect after approval.

B. GUIDANCE ON *KANDELIA OBOVATA* PLANTING TECHNIQUE

I. Introduction

Scientific name: *Kandelia obovata* Sheue, Liu & Yong

Local name: Trang

Family: Rhizophoraceae

Figure B1: Leaves, flowers and fruits of Kandelia obovata

Figure B2: Stump of Kandelia obovata with buttress

Distribution and ecological characteristic: Distributed mainly in the North of Vietnam, especially in the North-East and Nothern Delta. Tree height from 4 to 8m, adapt to soft muddy soil and sandy mud soil , grow mainly in high or average tidal regime area, prefer high salinity from 20 to 34‰, withstand frozen winter of Northern region and harsh amplitude of temperature. Stump has buttress. Leaves grow opposite, elliptic, have acuminate apex. Flowers bloom actinomorphic with nectary. Fruit has small pear shaped when it is young, smooth fruited, fawn colored.

II. General regulation

2.1. Objective

This technical guidance aims to protection forest plantation in order to block wave, wind, to protect ecological environment, to fix alluvial ground by Kandelia obovata, contributes to rehabilitation and sustainable development of mangrove forest ecosystem in Thai Binh Province.

2.2. Content

This technical guidance develops content, regulation and technical requirement from choosing plant condition, seed supply, forest plantation, tendance, and protection of Kandelia obovata.

2.3. Object and scope of application

This technical guidance is applied for Kandelia obovata plantation in mangrove forest planting of the project entitled Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

This technical guidance is recommended for all production units, enterprises and subjects of every economical component to plant mangrove forest by other sources in Thai Binh and other local with the same condition.

This technical guidance is the basis to develop economical and technical standards and Kandelia obovata seedling production in Thai Binh, concurrently for organization, management, approval in seedling production.

2.4. Term explanation

Terms in this technical guidance are explained as follow:

- **Growing condition:** Some characteristics of site condition, tidal regime, ground exposure time and salinity of seawater.

- **Mangrove ground (warp):** The mangrove grounds at estuaries, coastal areas, or along the rivers, canals with brackish water by daily tidal regime.

- **Physical component:** Divided into 3 types, including Mud (soft or weak mud, tight mud, hard mud), clay (soft clay, tight clay, hard clay), sand (muddy sand).

- **Ground exposure time:** The average hour in day that the area is not inundated by tide.

- **Inundated time:** The average hour in day or the average day in month that the area is inundated by tide.

- **Salinity:** The total content of soluble salts (in gram) contained in 1000g seawater, denoted S (‰ or g/kg).

- **Deep tidal regime:** The inundated phenomenon when tidal level is low.

- **Low tidal regime:** The inundated phenomenon only when the tidal level is high.

- **Medium tidal regime:** The inundated phenomenon only when the tidal level is average (equals the average sea level at 0 cm).

Figure B3: Protective mangrove forest at estuaries, coastal areas by Kandelia obovata

III. Growing condition

Kandelia obovata is planted at estuaries and coastal areas, where have stable warp. The salinity of water area is from 10 to 30‰ (the most appropriate salinity is from 15 to 20‰). Growing condition of *Kandelia obovata* is divided into 3 categories: Favorable condition (category I), average condition (category II), and difficult condition (category III), are illustrated specifically in the following table:

Table 01. Growing condition of *Kandelia obovata*

No.	Favorable condition (category I)	Average condition (category II)	Difficult condition (category III)
1	Site condition: Soft silt soil, sink from 15 to 40cm	Site condition: Hard silt soil or clay soil, sink from 5 to 15cm, sandy rate from 50 to 70%)	Site condition: Tight clay soil or hard clay or sandy soil, sink less than 5cm, muddy sand (sandy rate >70%)
2	Tidal regime: low	Tidal regime: average	Tidal regime: deep

IV. Forest planting

4.1. Seedling standard

Table 02. Kandelia obovata seedlings on site conditions

No.	Growing condition	Age (month)	Root diameter (cm)	Height (cm)	Quality
1	Category I	8-12	≥ 0.6	≥ 50	Well growth, well-propotioned development, no pestilent insect, no shortened top of seedling, verdant leaf, soil pot is not broken.
2	Category II	12-18	≥ 1.0	≥ 80	
3	Category III	>18	≥ 1.2	≥ 100	

4.2. Planting season

Plant Kandelia obovata when it has least wave in year and suitable salinity, avoid storm season, from June to August in Nothern region (Thai Binh).

4.3. Planting method

Kandelia obovata can be mono or mix planted in line with other species such as *Rhizophora stylosa*, *Sonneratia caseolaris, Aegiceras corniculatum*...depend on each region.

4.4. Planting density

Kandelia obovata is planted by sprout and potted seedling. Planting density and planting method is divided into 3 growing conditions as following table:

Table 03. *Sonneratia caseolaris* density on site conditions

No.	Planting method	Category I	Category II	Category III
1	Planting by sprout	5000 seedlings/ha 20000 seedlings/ha		
2	Mono-plantation by potted seedling	2500 seedlings/ha 3300 seedlings/ha	3300 seedlings/ha 4400 seedlings/ha	4400 seedlings/ha 5000 seedlings/ha
3	Mixed plantation in line by potted seedling	- Mixed plantation Kandelia obovata with Sonneratia caseolaris or Rhizophora stylosa, area ratio 2/3 Kandelia obovata: 1/3 Sonneratia caseolaris or Rhizophora stylosa. Total density from 2500 to 3300 seedlings/ha. - Mixed plantation with Aegiceras corniculatum, area ratio 2/3 Kandelia obovata: 1/3 Aegiceras corniculatum. Total density from 3600 to 5000 seedlings/ha.		

4.5. Tillage

- **Category I:** Implement forest planting in 2 methods, plant with sprout or plant with potted seedling.

+ Plant with sprout: Don't need tillage.

+ Plant with potted seedling: Dig hole with size larger than the pot's size to put the seedling into it easily and plant immediately after digging, hole's size is 20x20x20cm.

- **Category II:** Dig hole with size of 30x30x30cm or 40x40x40cm.

- **Category III:** Digging rehabilitated hole with size of 50x50x50cm or 60x60x60cm; after digging, spill mud to fill 2/3 hole's depth, then full fill the hole with sand and pile stake.

4.6. Planting method

4.6.1. Planting with sprout

When planting, plunge 1/3 length of the sprout into soil, top of the sprout upward, each place only grow 1 sprout.

4.6.2. Planting with potted seedling

- Choose satisfied seedling for planting, before growing from 5 to 7 days, bring the seedlings on land to drain and maintain the pot.

- In areas with large waves, pot may be broken or drifted, before planting, put the pot into basket made of bamboo or other suitable decomposable materials in less than 1 year. Before putting the pot into the basket, take off the cover and avoid breaking the pot. Keep the seedlings time in bamboo baskets at least 1 month, only growing when the seedlings already stable.

- Use basket, plank, and boat to transport seedlings, avoid breaking the pot and root.

- Planting method: Can cut off 1/3 top of seedling before planting to avoid damage from waves after plantation. Take off pot cover before planting, do not break or distort the pot. Place the seedling in vertical, the seedling's soil pot surface lower than digged hole's surface from 3 to 5cm, then cover the hole; use hand, foot to press mud, soil tightly around the pot. The pot cover after being taken off need to be gathered to dumping ground (self-decomposing pot don't need to take off the cover).

- Piling: If plant at big waves areas. Use bamboo or available materials at local. Length from 70 to 100cm, diameter from 1.5 to 3cm. Tie 1 end of rope to pile, the other end tie to stem (do not not tie pile close to the stem, to avoid rub), the rope's lenght between the pile and the seedling is from 5 to 7cm, away from stump 20cm.

- Can stake 1 or 3 piles depend on the wave's level; tilt 1 pile 450, pile's head seawards; tilt 3 piles 450 in a tripodal position. If have sack, plunge through it.

4.7. Replanting

Checking after 1-2 months:

- If number of dead seedlings are few (≤ 10%) and scattered (below 3 closing trees), do not replanting.

- If number of dead seedlings > 10% or ≥ 3 closing seedlings are death, need replanting. Replanting is implemented in the first 3 years (plantation year and 2 following years). Replanting rate is in the table below:

Table 04. Replanting rate of Kandelia obovata on site conditions

No.	Growing condition	Replanting rate compare to main planting rate		
		First year	Second year	Third year
1	Category I	15%	10%	5%
2	Category II	20%	15%	10%
3	Category III	25%	20%	15%

V. Forest tendance and protection

5.1. Forest tendance

Tendance must carried out in the first 4 years. First 3 months after planting, in periodic of once every 20-30 days: trash picking, pile rearranging, re-tie loosen rope. After that, tending in periodic of once every 2-4 months: grass removing, trash picking, fallen tree bristling up. Shipworms have sticked for a long time can cause tree dying, so need to be removed when they just stick to the tree.

5.2. Forest protection

- Set up warning signs to ban exploitation activities, aquatic fishing in plantation area in the first 2 years.

- Prevent forest exploitation, forest destruction and harmful species.

- Do not ridge soil, surround net to prevent flows in plantation forest for aquaculture or combined production in the first 5 years.

- In the following years, if aquacultural activities happen, need to have plans to avoid damage to plantation forest.

5.3. Approval

- Approval is carried out according to current regulations.

- Survival rate is defined as follows: After 1 year, survival rate reaches at least 70%; After 2 years, survival rate reaches at least 60%; After 3 years,

survival rate reaches at least 50%, it meets requirements if trees evenly distributed on the forest plantation area.

Figure B4: Kandelia obovata forest in the second year

Figure B5: Kandelia obovata forest in the third year

VI. Excecution provision

6.1. This technical guidance is applied to all production units in every economical components participate in producing *Kandelia obovata* seedlings in the project Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

6.2. This technical guidance takes effect after approval.

C. GUIDANCE ON *AVICENNIA MARINA* PLANTING TECHNIQUE

I. Introduction

Scientific name: *Avicennia marina* (Forssk.) Vierh

Local name: Avicennia marina, Mấm biển

Family: Avicenniaceae

Distribution and ecological characteristic: Distributed from the North region to the South region; mainly in the North East, North Central and West South. Tree has average height from 4 to 6m, can reach to 10m, trunk diameter up to 40cm. There are many pneumatophores

with small spike shaped like fingers, high from 10 to 15cm, diameter of 6mm. Avicennia marina is pioneer tree, grows primarily in medium or high tide, suitable with salinity from 20 to 35‰. Leaves opposite, ovate, pale green on the upper surface, the underside is gray white and has fuzz, with salt glands on 2 sides. Petiole 5 to 10mm long, hairless. Flowers small, sessile, 6mm diameter, orange, with 4 petals. Fruits are heart shaped, 1.5-2 x 1.5-2.5cm sized, many pale green woolly when young, pale yellow when ripe. Sprouts are in fruits.

Figure C1: Leaves, flowers and fruits of Kandelia obovata

II. General regulation

2.1. Objective

This technical guidance aims to protection forest plantation in order to block wave, wind, to protect ecological environment, to fix alluvial ground by Kandelia obovata, contributes to rehabilitation and sustainable development of mangrove forest ecosystem in Thai Binh Province.

2.2. Content

This technical guidance develops content, regulation and technical requirement from choosing plant condition, seed supply, forest plantation, tendance, and protection of *Kandelia obovata.*

2.3. Object and scope of application

This technical guidance is applied for Kandelia obovata plantation in mangrove forest planting of the project entitled Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

This technical guidance is recommended for all production units, enterprises

and subjects of every economical component to plant mangrove forest by other sources in Thai Binh and other local with the same condition.

This technical guidance is the basis to develop economical and technical standards and Kandelia obovata seedling production in Thai Binh, concurrently for organization, management, approval in seedling production.

2.4. Term explanation

Terms in this technical guidance are explained as follow:

- **Growing condition:** Some characteristics of site condition, tidal regime, ground exposure time and salinity of seawater.

- **Mangrove ground (warp):** The mangrove grounds at estuaries, coastal areas, or along the rivers, canals with brackish water by daily tidal regime.

- **Physical component:** Divided into 3 types, including Mud (soft or weak mud, tight mud, hard mud), clay (soft clay, tight clay, hard clay), sand (muddy sand).

- **Ground exposure time:** The average hour in day that the area is not inundated by tide.

- **Inundated time:** The average hour in day or the average day in month that the area is inundated by tide.

- **Salinity:** The total content of soluble salts (in gram) contained in 1000g seawater, denoted S (‰ or g/kg).

- **Deep tidal regime:** The inundated phenomenon when tidal level is low.

- **Low tidal regime:** The inundated phenomenon only when the tidal level is high.

- **Medium tidal regime:** The inundated phenomenon only when the tidal level is average (equals the average sea level at 0 cm).

III. Growing condition

Avicennia marina is natural distributed at the tidal grounds near coastal areas and estuaries. *Avicennia marina* can grow on many types of soil, and since it is the fixed pioneer species, it usually distributed at sandy ground. The appropriate salinity for *Avicennia marina* fluctuates from 20 to 35‰.

Growing condition of *Avicennia marina* is divided into 3 categories:

Favorable condition (category I), average condition (category II), and difficult condition (category III), are illustrated specifically in the following table:

Table 01. Growing condition of *Avicennia marina*

No.	Criteria	Favorable condition (category I)	Average condition (category II)	Difficult condition (category III)
1	Site condition	Tight silt soil or sandy soil <30%.	Soft clay soil or sandy soil 30-50%.	Hard clay soil or clay soil 50%-70%
2	Number of inundated day	Average tidal regime from 10-19 days/month.	Average tidal regime from 20-25 days/month.	Average tidal regime from 2-9 days/month.
3	Ground exposure time	9-14 hours/day	5-8 hours/day	15-24 hours/day
4	Site form	Ic	Ib	Id, Ie

Note: *For hazard site, sandy rate more than 70%, limit forest planting. If planting on this site form, need to have high requirement on technical solution (improving site condition, planting method and suitable seedling standard).*

IV. Forest planting

4.1. Seedling standard

Seedling standard of *Avicennia marina* is regulated in the following table:

Table 02. Seedling standard of *Avicennia marina*

No.	Age (month)	Root diameter (cm)	Height (cm)	Quality
1	6 - 8	≥ 0.5	≥ 30	- Number of leaf: ≥ 10 leaves - No pestilent insect. - No shortened top of seedling.
2	8 - 10	≥ 0.6	≥ 40	
3	> 10	≥ 0.8	≥ 60	

4.2. Planting season

Planting with potted seedling from May to August.

4.3. Planting method

Mono-plantation, arrange in quincunx shaped. *Avicennia marina* can be mix-planted in line with other species such as *Rhizophora stylosa*, *Bruguiera gymnorrihira*...

4.4. Planting density

Table 03. Planting density of *Avicennia marina*

No.	Planting method	Category I	Category II	Category III
1	Mono-plantation by potted seedling	3300 seedlings/ha Interval space (1.5 x 2.0 m)	4400 seedlings/ha Interval space (1.5x 1.5m)	5000 seedlings/ha Interval space (1.0 x 2.0m)
2	Seedling standard	6 - 8 months	8 - 10 months	> 10 months
3	Mix-plantation	Avicennia marina can be mix-planted with Rhizophora stylosa, Bruguiera gymnorrihira... Planting density as for mono-plantation; mix-plantation rate: 3 lines of Avicennia marina and 1 line of other species (3:1).		

4.5. Tillage

Use nylon rope to knot, divide into segments, and pull in a straight line to plant in correct distance.

- **Category I:** Plant *Avicennia marina* in favorable site, don't need tillage; when planting, use hands or suitable tools to create holes with just sufficient size to put seedling pots into easily and plant immediately.

- **Category II:** On average site, dig hole with size of 30x30x30cm.

- **Category III:**

+ For hard clay soil, dig hole with size of 40x40x40cm.

+ For sandy soil which more than 50%, dig hole with size of 40x40x40cm and add more mud or nutrient soil to improve site condition.

4.6. Planting method

- Before growing from 5 to 7 days, bring the seedlings on land to drain and maintain the pot.

- Transport seedlings to ground; wait until tide ebbing equal the ground surface then conduct planting. Use basket, plank, and boat to transport the seedlings, avoid breaking the pot and root.

- Plant when tide ebb.

- Take off the cover before planting and don not break seedling's root, lace the seedling in vertical, then fill holes and use foot to press mud, soil tightly around the pot in order to keep the seedlings not to fall. Remember to pick up and collect all PE pot covers out of plantation area.

- In areas with large waves, after planting, potted seedlings still can be damage by waves, so knit basket made of bamboo or suitable self-decomposable materials in less than 1 year, basket size fit the pot, space between knitting spokes is from 3 to 4cm. Before putting the pot into the basket, take off the pot cover and avoid breaking the pot. Keep the seedlings in bamboo baskets at least 1 month, only plant when the seedlings are stable.

Figure C2: New planting of Avicennia marina seedlings

- Piling: Can stake 1 or 3 piles depend on the wave's level. Piles are made of available materials at local like bamboo. If use 1 pile with length from1.2 to 1.5m, diameter from 2 to 3cm, tilt 45^0 with pile's head seawards, tie 1 end of rope to pile, the other end tie to stem (do not not tie pile close to the stem, to avoid rub), the rope's lenght between the pile and the seedling is from 5 to 7cm, away from stump 20cm. If use 3 piles, pile's length from 70 to 80cm, diameter from 1 to 3cm, titl 45^0 in a tripodal position with the length above, so that the intersection of 3 piles located next to the stem at position about 15-20cm. Firstly, tie 1 end of rope to

the stem, then tie the other end to the intersection of the 3 piles (do not not tie pile close to the stem, to avoid rub), the rope's lenght between the pile and the seedling is from 5 to 7cm, away from stump 20cm.

4.7. Replanting

- After planting about 1month, need to check the planted area, if there is dead or floating seedling, implement replanting immediately:

+ If number of dead seedlings are few (≤10%) and scattered, do not replanting.

+ If number of dead seedlings > 10% or die in clumps, need to replant.

Table 04. Replanting rate of *Avicennia marina* compare to main planting rate

Growing condition	Replanting rate compare to main planting rate		
	First year	Second year	Third year
Category I, II, III	20%	10%	5%

V. Forest tendance and protection

5.1. Forest tendance

- 4 years of tendance (1 year for planting and 3 years for tending) is regulated as follow:

- Tending time: First year: 2 times; Second year, third year: 2-4 times, and fourth year: 2 times. Depend on plantation area where have many or little trash and where have shipworms.

- Tending content:

+ Remove algae, moss on the stem, leaves, and facilitate photosynthesis of seedlings.

+ Rearrange piles, retie ropes.

+ Remove shipworms.

5.2. Forest protection

- Make fences to block trash, limit ships, boats from traveling by available materials at the local. Fences have endurance at least 3 years after planting.

- Set up warning signs to ban exploitation activities, aquatic fishing in plantation area. Strictly ban ships and boats from anchorage and travel within the new planting forest.

- Prevent forest exploitation, forest destruction and harmful species.

- Do not ridge soil, surround net to prevent flows in plantation forest for aquaculture or combined production.

- In the following years, if aquacultural activities happen, need to have plans to avoid damage to plantation forest.

5.3. Approval

- Approval is carried out according to current regulations.

Table 05. Required survival rate compare to planting density

Growing condition	First year	Second year	Third year
Category I,II,III	70%	60%	50%

In case trees die because of extreme weather, storms, cold and pests, must set up inspection teams to assess the causes and suggest dealing methods.

Figure C3: Avicennia marina forest

VI. Excecution provision

6.1. This technical guidance is applied to all production units in every economical components participate in producing *Avicennia marina* seedlings in the project Rehabilitation and Sustainable Development of Mangrove Forest Ecosystem in Thai Binh Province.

6.2. This technical guidance takes effect after approval.

PART II: GUIDANCE ON SUPPLEMENTARY PLANTING TECHNIQUE

I. Objective:

Rehabilitation and sustainable development of mangrove forest ecosystem in improving forest quality, satisfying the protection capacity in disaster prevention and coping with climate change.

II. Technical principle

- Salvage the currently mangrove forest status for not ensure protection function in disaster prevention, such as wavebreak, wind, storms, erosion... to supplementary plant a certain number of plants in rehabilitation and sustainable development of mangrove ecosystems.

- Depend on site conditions and the currently forest status, selected species for supplementary planting are the natural distributed plants at the local or species origin from elsewhere which were assayed to ensure the adaptability with the local site condition.

- Can be mono or mixed planted with available species.

The project entitled "Rehabilitation and sustainable Development of mangrove forest ecosystem in Thai Binh Province" has chosen 3 species, include: *Sonneratia caseolaris* (L.) Engl., *Kandelia obovata* Sheue, Liu & Yong and *Avicennia mavina* (Forssk.) Vierh for supplementary planting in current forests which are poor forests, degraded forest…, species for supplementary planting are determined as follow:

- The status of mangrove forest was supplementary planted with available species which are big trees, salinity ≤ 20‰, then supplementary plant with Sonneratia caseolaris.

- The status of mangrove forest was supplementary planted with available species which are small or medium trees, salinity from 20 to 35‰, then supplementary mono plant with Kandelia obovata or Avicennia mavina, or mix plant both of these species. Avicennia mavina is the pioneer species so it has higher adaptability with salinity than Kandelia obovata.

III. Supplementary planting object

Using combination of current normative legal documents on criteria for forest identification and classification, and classification system in the world, including:

3.1. Circular No. 34/2009/TT-BNNPTNT criteria for forest identification and classification

- Poor forests: Timber reserve of standing trees from 10 to 100 m3/ha (Article 8).

- Forests with no reserve: timber tree average diameter < 8 cm, timber reserve of standing trees below 10 m3/ha (Article 8).

- Land with forest plantation not yet constituting forests: are land areas with forest plantations reaching an average height of less than 1.5m, for slow-growing trees, or 3m, for fast-growing trees and a density of less than 1,000 trees/ha (Article 9).

3.2. Classification system of Loeschau (1963)

- Category I: Without or not yet forested, only grass, shrubs or timber tree, bamboo scattered with the cover of less than 30%.

- Category II and Category III: Lack of regeneration (<1.000 promising regeneration purpose/ha).

3.3. Priority object for supplementary planting

From 2 classification systems above, the project gives priority to supplementary rehabilitation planting for mangrove forest status which has one or some of following criteria:

- Coverage < 30%.

- Mangrove forests are timber trees with average diameter < 8 cm, timber reserve of standing trees below 50 m^3/ha.

- Average height not reach 1.5 m for slow-growing trees, or 3m, for fast-growing trees and a density of less than 1,000 trees/ha.

IV. Supplementary planting technique

* Depend on actual state of each forest to implement supplementary planting in 2 methodologies:

- Supplementary planting in line: Supplementary planting in line as before.

- Supplementary planting in mass: Only carry out supplementary planting in mass on spaces with the area larger than 1/4ha (2500m2).

* Seedling standard, planting season, planting density, tillage, planting technique, replantation, tendance and forest protection, re-check when:

- Supplementary planting by Sonneratia caseolaris: apply part I, section A.

- Supplementary planting by Kandelia obovata: apply part I, section B.

- Supplementary planting by Avicennia mavina: apply part I, section C.

DỰ ÁN
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