

FARMER SPECIES CARDS

# COMPANION CROP AND MANAGEMENT OPTIONS for Smallholder Cacao Agroforestry Systems

Riyandoko, James M. Roshetko, Yulya Saputri, Dikdik Permadi, Endri Martini,  
Hamran, Samantha Forbes, Masrijal, and Andrew Ward



World Agroforestry (ICRAF)



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# **COMPANION CROP AND MANAGEMENT OPTIONS**

**for Smallholder  
Cacao Agroforestry Systems**

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# ***Farmer species cards – companion crop and management options for smallholder cacao agroforestry systems***

## **Citation**

Riyandoko, Roshetko JM, Saputri Y, Permadi D, Martini E, Hamran, Forbes S, Masrijal, Ward A. 2024. *Farmer species cards – companion crop and management options for smallholder cacao agroforestry systems*. Bogor, Indonesia: World Agroforestry (ICRAF); and Indonesia: Mars Symbioscience Indonesia.

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## **CIFOR-ICRAF Indonesia Program**

Jl. CIFOR, Situ Gede, Sindang Barang,  
Bogor 16115 [PO Box 161 Bogor 16001] Indonesia  
Tel: +(62) 251 8625 415  
Email: [cifor-icraf-indonesia@cifor-icraf.org](mailto:cifor-icraf-indonesia@cifor-icraf.org)  
[www.cifor-icraf.org/locations/asia/indonesia](http://www.cifor-icraf.org/locations/asia/indonesia)

Cover photos: Riky Mulya Hilmansyah/CIFOR-ICRAF Indonesia Program  
Layout: Riky Mulya Hilmansyah



# Use of the farmer tree cards

Smallholder farmers are the primary producers of cacao in Indonesia and across the world. Many farmers intercrop their cacao with companion tree species and other crops in 'cacao agroforestry systems'. Species diversification in these systems reduces the biological, market and livelihood risks faced by farmers. Additionally, tree intercrops help maintain soil moisture, structure, and fertility; sustaining medium-to-long term productivity. Species diversity also reduces the occurrence of pest and disease problems. Together, these impacts often lead to reduced reliance on agricultural inputs, particularly chemical fertilizers, and pesticides. Competition from companion crops may lower cacao yields, but this is balanced by greater systems resilience, flexible management options, and overall

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system productivity. Besides biodiversity, cacao agroforestry systems also provide other ecosystem services and represent a climate-smart alternative. Most smallholder farmers are aware of cacao agroforestry options and their positive impacts. However, adequate knowledge of cacao agroforestry design options and good management practices is often lacking.

This set of 'farmer species cards' was developed from the knowledge and insight of ICRAF Indonesia and Mars Symbioscience colleagues gained from years of experience working with communities of smallholder cacao farmers. That knowledge was confirmed and augmented with a review of relevant literature. The farmer cards aim to provide the users, farmers and the extension staff who support them, with sufficient information and examples to develop and



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manage cacao agroforestry by starting with a set of proven options. A recommended standard spacing of 3.8 m x 2.5 m for cacao is used to promote the development of 'mechanisation ready' cacao agroforestry systems. The 15 species featured in the set are common and compatible cacao companion crops, yielding commercial products that simultaneously have valuable household uses. The cards summarize information on:

- Site suitability
- Main and secondary products
- Production and general price ranges
- Seed selection criteria
- Key species characteristics
- Intercropping spacing recommendations
- Cultivation and reproduction management recommendations
- Key pests and diseases
- Environmental services
- Key references

Much of the knowledge contained in the cards, was generated in South Sulawesi and other parts of Indonesia. However, the information is applicable to all cacao growing agroecological zone and social conditions. Users are encouraged to apply, adapt, and share the information in these cards to support and spread the development of technically and commercially viable cacao agroforestry systems.

# List of plant commodities

## Fruits and commodities

|    |                                           |    |
|----|-------------------------------------------|----|
| 1  | Durian ( <i>Durio zibethinus</i> )        | 6  |
| 2  | Mango ( <i>Mangifera indica</i> )         | 8  |
| 3  | Mangosteen ( <i>Garcinia mangostana</i> ) | 10 |
| 4  | Avocado ( <i>Persea americana</i> )       | 12 |
| 5  | Nutmeg ( <i>Myristica fragrans</i> )      | 14 |
| 6  | Coconut ( <i>Cocos nucifera</i> )         | 16 |
| 7  | Petai ( <i>Parkia speciosa</i> )          | 18 |
| 8  | Jengkol ( <i>Archidendron jiringa</i> )   | 20 |
| 9  | Papaya ( <i>Carica papaya</i> )           | 22 |
| 10 | Banana ( <i>Musa sp</i> )                 | 24 |
| 11 | Pineapple ( <i>Ananas comosus</i> )       | 26 |

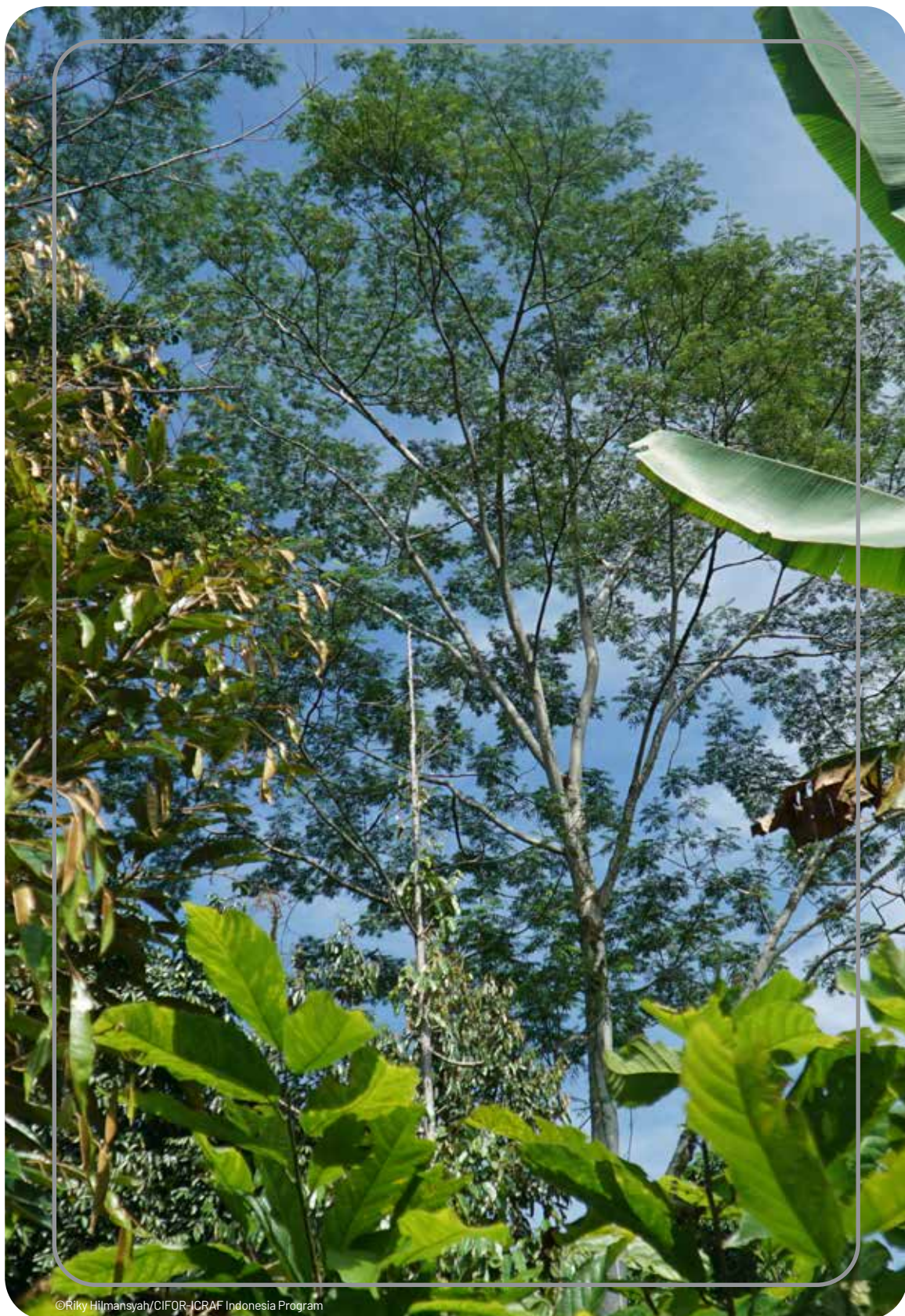
## Timber

|   |                                                                              |    |
|---|------------------------------------------------------------------------------|----|
| 1 | Teak ( <i>Tectona grandis</i> )                                              | 28 |
| 2 | Mahogany ( <i>Swietenia macrophylla</i> )                                    | 30 |
| 3 | Sengon ( <i>Paraserianthes falcataria</i> syn. <i>Falcataria moluccana</i> ) | 32 |

## Annual crop

|   |                          |    |
|---|--------------------------|----|
| 1 | Corn ( <i>Zea mays</i> ) | 34 |
|---|--------------------------|----|





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© Mars

## Site suitability:

- Elevation: 100 – 800 masl
- Slope: 0 – 10%
- Annual rainfall: 1500 – 2000 mm
- Soil pH: 5.5 – 6
- Soil type: clay loam soils

## Main product:

- Fruit

Figure 1. Durian fruit.

Image source: vectorpocket on Freepik



## Production:

- Age at first fruiting: 4 – 8 years
- Optimal production: 10 – 15 years
- If the average weight is 3 kg, then 120 fruits can reach 0.36 tons/tree/year

## General price range:

Durian fruit in South Sulawesi at the farm level, 2023

- Grade A: IDR 20,000 – IDR 30,000/fruit
- Grade B: IDR 15,000 – IDR 20,000/fruit
- Grade C: IDR 5,000 – IDR 10,000/fruit

Image source: www.flaticon.com

## Other products:



Timber –  
construction  
and furniture



Bee fodder  
(pollen/  
nectar)

## Seedling selection:

- 1 Select durian seedlings that are:
  - ◆ High quality and of varieties suitable for the planting location,
  - ◆ Healthy and not attacked by pests.
- 2 Plant several varieties of durian in one garden, so that cross-pollination occurs between varieties.



## Tree crown characteristics:

### Leaves

- Length: 10–15 cm;
- Width: 3–4 cm
- Dense crown and shade

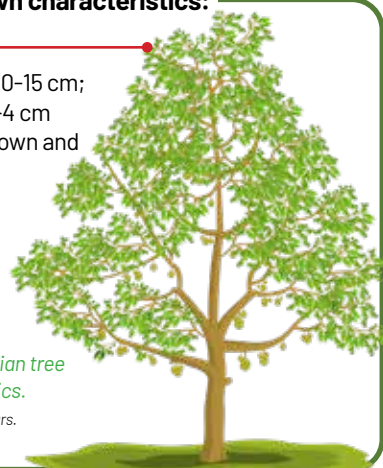


Figure 2. Durian tree characteristics.

Image source: Mars.

## Tree spacing:

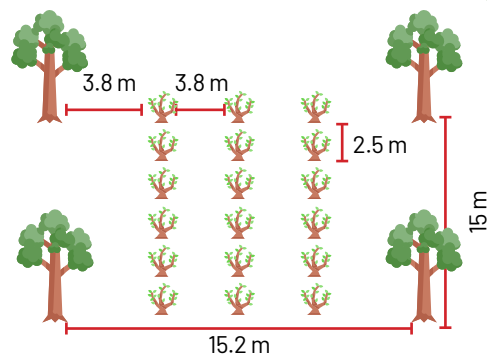


Figure 3. Tree spacing for mixed durian and cacao farmer plantation.

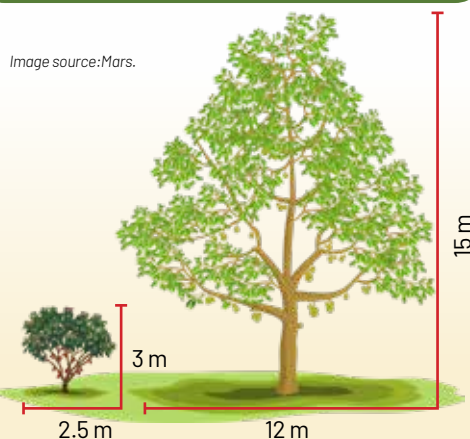


Image source: Mars.

Planting distances that are too close will be detrimental to the yields of cocoa and durian.



# Durian (*Durio zibethinus*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for durian.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: September – November
- Fruiting period: December – March
- Main pollinators: bats, nocturnal flying insects (moths)
- Annual pruning is conducted to stimulate flowering
- Fertilizer application is recommended twice a year
- **Fertilizer dosage:** N-P-K 1.5 kg/tree/year; K-Mg-S 1 kg/tree/year
- Watering or irrigation should be conducted in the dry season, if feasible
- A lack of calcium/lime or boron/borax, and excessive water during fruit ripening may cause the fruit to have a bland flavor. Soil analysis recommended if this occurs



## Pests:

- Stem borer
- Fruit borer



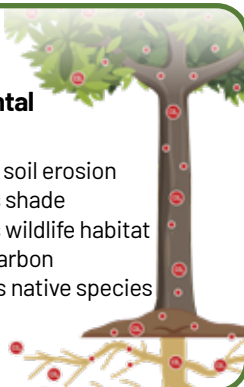
## Diseases:

- Stem canker (causes fruit to rot and drop)
- Shares similar diseases with cocoa (specifically *Phytophthora palmivora*)



## Environmental services:

- Controls soil erosion
- Provides shade
- Provides wildlife habitat
- Stores carbon
- Supports native species



## References:

- <https://repository.pertanian.go.id/bitstreams/84d425b4-7dac-4a5f-b79d-1c36b63ca862/download>
- <https://repository.pertanian.go.id/handle/123456789/6487>
- <http://apps.worldagroforestry.org/sea/Publications/files/booklet/BL0050-14.pdf>
- [https://www.researchgate.net/publication/322715866\\_ENSO\\_Impacts\\_on\\_Production\\_and\\_Peak\\_Harvest\\_Season\\_of\\_Durian\\_in\\_Indonesia](https://www.researchgate.net/publication/322715866_ENSO_Impacts_on_Production_and_Peak_Harvest_Season_of_Durian_in_Indonesia)
- <https://www.worldagroforestry.org/output/agroforestree-database>

# Mango (*Mangifera indica*)

## Site suitability:

- Elevation: 0 – 1200 masl
- Slope: < 30%
- Annual rainfall: 300 – 2500 mm
- Soil pH: 5 – 6.5
- Soil type: Sandy loam to clay

## Main product:

- Fruit

Figure 1. Mango fruit.

Image source:freepik



## Production:

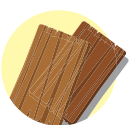
- Age at first fruiting: 5 – 8 years
- Fruit harvested once a year
- Average production:
  - ◆ 500 kg/tree/year

## General price range:

Mango fruit in traditional markets:

- IDR 20,000 to IDR 35,000 / kg

## Other products:



Construction  
timber /  
fuelwood



Bee fodder  
(pollen/  
nectar)



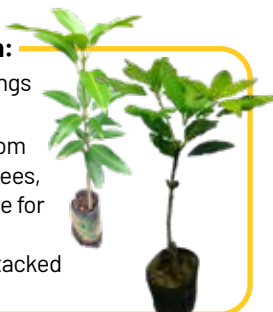
Supplemental  
livestock feed

Image source:www.flaticon.com & pngtree.com

## Seedling selection:

Select mango seedlings that are:

- high quality and from superior mother trees,
- of varieties suitable for planting location,
- healthy and not attacked by pests



## Tree crown characteristics:

### Leaf size:

- Length: 16 – 30 cm
- Width: 3 – 7 cm
- Heavy canopy density

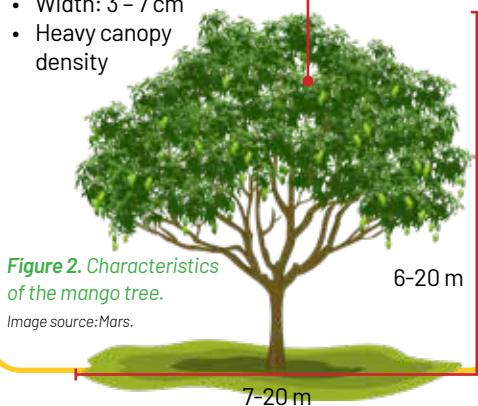


Figure 2. Characteristics of the mango tree.

Image source:Mars.

Image source:www.flaticon.com

## Tree spacing:

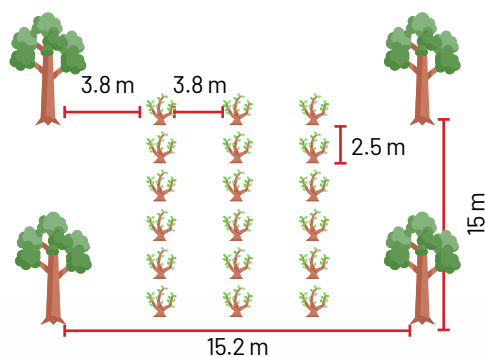


Figure 3. Recommended planting distance and density of cocoa and mango trees.

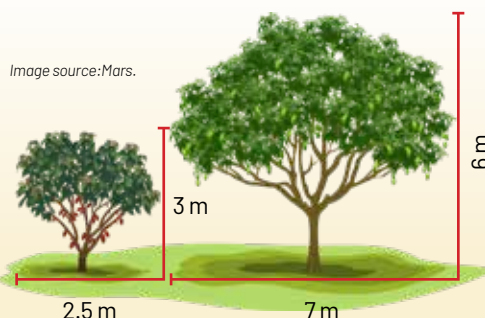


Image source:Mars.

Planting distances that are too close will be detrimental to the yield of cocoa and mango.

# Mango (*Mangifera indica*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for mango.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: June - August
  - Main pollinators: bees, other insects and bats
  - Fruiting period: September - November
  - Pruning during the productive phase is conducted to remove dead branches and infested by pest - diseases
  - Fertilizer application is recommended twice a year, at the beginning of the dry season (after pruning) and the beginning of the rainy season (at the beginning of flowering)
- Fertilizer dosage:** organic fertilizer 40-50 kg/tree/year; Urea (N) 0.5 kg/tree/year; SP-36 (P) 0.4 kg/tree/year; KCl (K) 0.6 kg/tree/year
- Watering or irrigation is recommended in the dry season, if feasible



## Pests:



Stem borer



Fruit borer



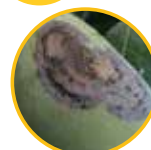
Fruit flies



Mango planthopper



## Diseases:



Anthracnose disease



Diplodia disease

Image source: plantix.net



## Environmental services:

- Provides shade
- Improves soil
- Stores carbon



## References:

- <https://repository.pertanian.go.id/items/5b269637-53f6-4cfc-a9b0-57b2e4f146e5>
- <https://gaphortikultura.puslithorti.net/wp-content/uploads/2018/12/SOP-Mango-2015.pdf>
- <https://repository.pertanian.go.id/items/fc42a49b-c80f-4fdf-b962-11a6424b2be0>
- <https://repository.pertanian.go.id/items/7d305758-35d6-4361-ba4e-d0608a11790e>
- <https://repository.pertanian.go.id/items/65f17c4a-2ee9-4146-9564-ee150065e102>
- [Mangifera indica \(mango\) \(hawaii.edu\)](https://hawaii.edu/mangifera/)



### 3 Mangosteen (*Garcinia mangostana*)

#### Site suitability:

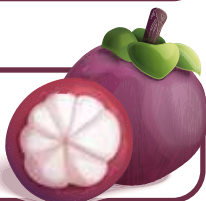
- Elevation: 75 – 1500 masl
- Slope: 0 – 8%
- Annual rainfall: 1500 mm
- Soil pH: 5.5 – 6.8
- Soil type: Sandy loam

#### Main product:

- Fruit

Figure 1. Mangosteen fruit.

Image source: pikisuperstar on Freepik



#### Production:

- Age of first fruit: 10 – 12 years
- Fruit is harvested once a year
- Average production:
  - ◆ 500 – 700 kg/tree/year

#### General price range:

Mangosteen fruit in traditional markets:

- IDR 15,000 to IDR 35,000 / kg

#### Other products:

Image source: www.flaticon.com



Fuel  
wood



Medicine and  
cosmetics  
(fruit peels)

#### Seedling selection:

Select mangosteen seedlings that are

- high quality and have a certification (blue) label
- have strong roots and upright stems
- of varieties that are suitable for planting location
- healthy and not attacked by pests



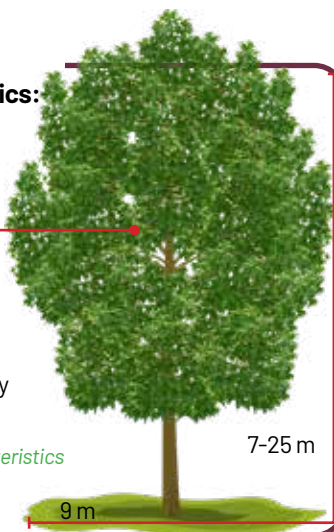
#### Tree crown characteristics:

##### Leaf size:

- Length: 9 – 25 cm
- Width: 4.5 – 10 cm
- Heavy canopy density

Figure 2. Characteristics of mangosteen.

Image source: Mars.



#### Tree spacing:

Image source: www.flaticon.com

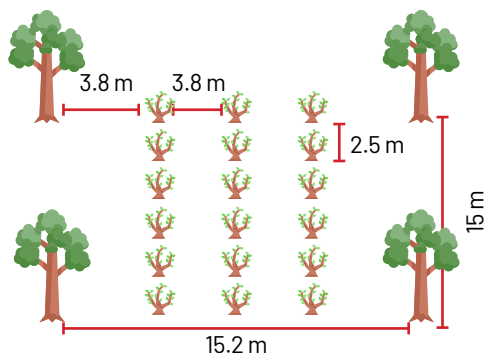
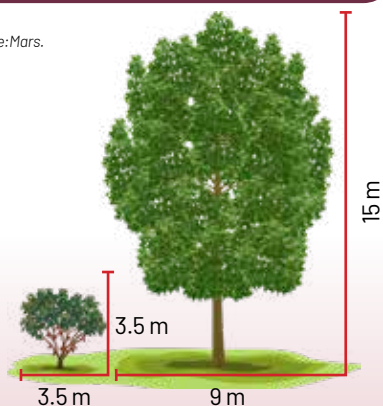


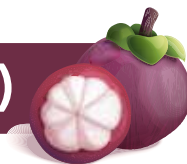
Figure 3. Recommended planting distance for cocoa and mangosteen trees.

Image source: Mars.



Planting distances that are too close will be detrimental to yields of cocoa and mangosteen

# Mangosteen (*Garcinia mangostana*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for mangosteen.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Mangosteen seedlings require shade in the early stages of growth
- Flowering period : June - August
- Main pollinators: wind, animals and humans
- Fruiting period: September - April
- Pruning can be conducted to remove dead branches
- Fertilizer application is recommended twice a year, at the beginning of the rainy season and at the end of the rainy season (after fruit harvest)

**Fertilizer dosage:** Urea(N) 0.6 kg/tree/year; SP-36(P) 0.4 kg/tree/year; KCI(K) 0.8 kg/tree/year

- Watering or irrigation is needed in the dry season, if feasible



## Pests:



Image source: wikipedia

- Leaf and fruit suckers (*Helopeltis antonii*)
- Leafminers (*Phyllocnistis citrella*)
- Mealybugs (*Pseudococcus* spp)



## Diseases:



Image source: repository.pertanian.go.id

- Fungus (*Upasia salmonicolor*)
- Yellow sap and gummosis disease
- Fruit rot disease



## Environmental services:

- Provides shade
- Stores carbon
- Food for primates and birds



## References:

- <https://repository.pertanian.go.id/items/447f685b-afb9-40c9-a98d-fe3e9c9aa54c>
- <https://repository.pertanian.go.id/server/api/core/bitstreams/6900a2b9-a551-4ba4-8109-945171770fe5/content>
- <https://repository.pertanian.go.id/server/api/core/bitstreams/3c2f60c6-f979-4702-9c4d-391f104665da/content>
- <https://repository.pertanian.go.id/server/api/core/bitstreams/86dadfdb-e2d1-46aa-92e6-02888f6c10a8/content>
- <https://eprints.untirta.ac.id/23687/1/Buku%20SOP%20Bibit%20Manggis%20Macakal%202023.pdf>

# 4

## Avocado (*Persea americana*)

### Site suitability:

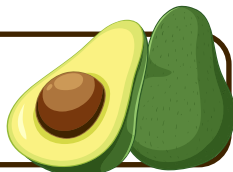
- Elevation: 0 – 2500 masl
- Slope: 0 – 30%
- Annual rainfall: 300 – 2500 mm
- Soil pH: 5.5 – 7.8
- Soil type: Sandy loam, clay loam and silt loam

### Main product:

- Fruit

Figure 1. Avocado fruit.

Image source:brgfx on Freepik



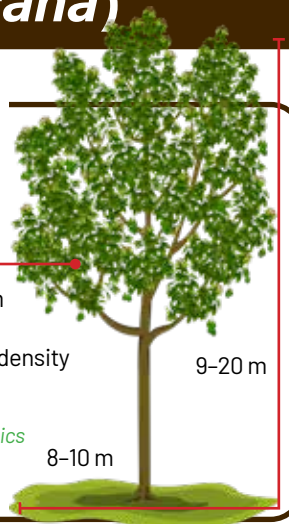
### Tree crown characteristics:

#### Leaf size:

- Length: 7 – 41 cm
- Shape: oval
- Medium canopy density

Figure 2. Characteristics of avocado tree.

Image source:Mars.



### Production:

- Age at first fruiting: 3 – 4 years
- Fruit harvested twice a year
- Miki variety: 300 kg/tree/year
- Pameling variety: 500 – 900 kg/tree/year

### General price range:

Avocado fruit in South Sulawesi traditional markets (2023)

- IDR 20,000 to IDR 25,000 / kg

### Tree spacing:

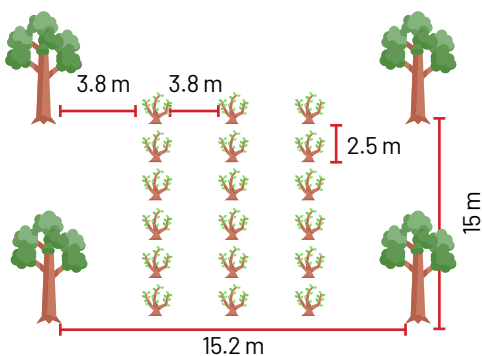
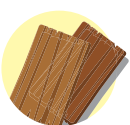


Image source:www.flaticon.com

Figure 3. Recommended planting distance and density for cocoa and avocado trees.

### Other products:



Construction  
timber /  
furniture



Bee forage  
(pollen/  
nectar)



Medical  
(essential oil)

Image source:www.flaticon.com

### Seedling selection:

Select avocado seedlings that are:

- 1 high quality and suitable for the planting location
- 2 healthy and not attacked by pests
- 3 Plant several varieties of avocado in one garden, so that cross-pollination occurs between the varieties

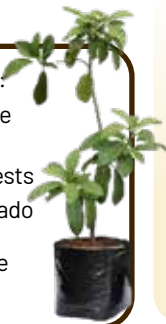
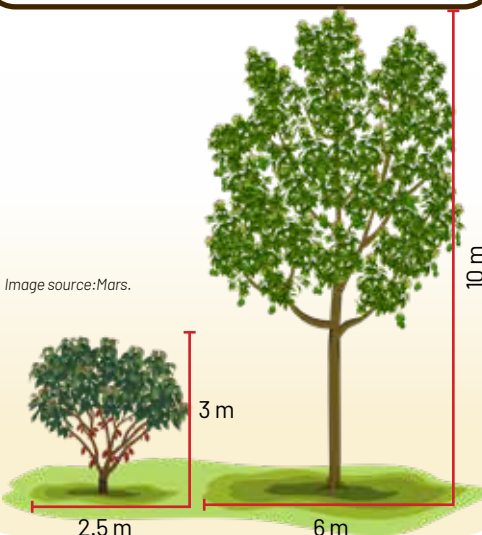


Image source:Mars.





# Avocado (*Persea americana*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for avocado.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period is generally at the beginning of the rainy season, namely: October – December
  - Main pollinators: honey-bees (*Apis mellifera*), stingless bees (Tribe: *Meliponini*)
  - General fruiting period is January – March
  - Form pruning every two years and annual pruning to stimulate flowers
  - Fertilizer application is recommended twice a year, at the beginning of the dry season (after pruning) and the beginning of the rainy season (at the beginning of flowering)
- Fertilizer dosage:** Organic fertilizer 30 kg/tree/year; urea (N) 0.5 kg/tree/year; SP - 36 (P) 0.5 kg/tree/year; KCl (K) 0.8 kg/tree/year
- Watering or irrigation is recommended in the dry season, if feasible



## Pests:



Silk moth caterpillars



Atlas moth caterpillars



Fruit flies



Red mites

Image source: www.klbrispr.org, id.wikipedia.org



## Diseases:

- Fruit rot
- Anthracnose
- Stem cancer
- Leaf spot



Image source: kebun buah nusantara



## Environmental services:

- Controls soil erosion
- Provides shade
- Improves soil



## References:

- <https://www.scribd.com/document/541930755/Buku-Lapang-Alpukat-2021>
- <https://www.scribd.com/document/419519318/Budidaya-alpukat>
- <https://eprints.untirta.ac.id/23683/1/Buku%20SOP%20bibit%20Alpukat%20YM%202022.pdf>
- <http://www.nasih.staff.ugm.ac.id/wp-content/uploads/Petunjuk-teknis-evaluasi-lahan-untuk-komoditas-pertanian-2011.pdf>
- <https://www.worldagroforestry.org/output/agroforestree-database>

# 5

## Nutmeg (*Myristica fragrans*)

### Site suitability:

- Elevation: 0 – 900 masl
- Slope: 0 – 10%
- Annual rainfall: 2000 – 3000 mm
- Soil pH: 5.5 – 6.5
- Soil type: Clay, sandy loam

### Main product:

- Fruit and seed

Figure 1. Nutmeg fruit.

Image source: wikipedia



### Production:

- Age of first fruit: 5 – 10 years
- Nutmeg is harvested once a year
- Average production:
  - a. Banda variety: 307 kg /tree/year
  - b. Ternate1 variety: 606 kg/tree/year
  - c. Tidore 1 variety: 574 kg/tree/year

### General price range:

Market price for key products:

- Dry beans: IDR 75,000 – IDR 85,000/kg
- Flowers: IDR 180,000 – IDR 200,000/kg

### Other products:

Image source: www.flaticon.com



Nutmeg  
beverage



Medicinal  
(essential oil)

### Seedling selection:



Select nutmeg seedlings that are:

- Of superior quality and ready to plant (75 – 100 cm)
- Healthy and not attacked by pests
- Female trees should come from 'mother trees' with a pyramidal shape
- For every 10 female trees, plant 1 male tree in the middle

### Tree crown characteristics:

#### Leaf size:

- Length: 5 – 15 cm
- Width: 2 – 7 cm
- Dense canopy cover

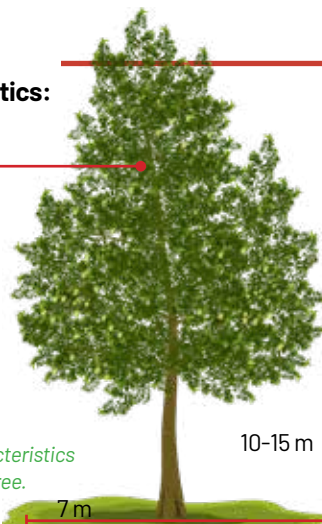


Figure 2. Characteristics of the nutmeg tree.

Image source: Mars.

### Tree spacing:

Image source: www.flaticon.com

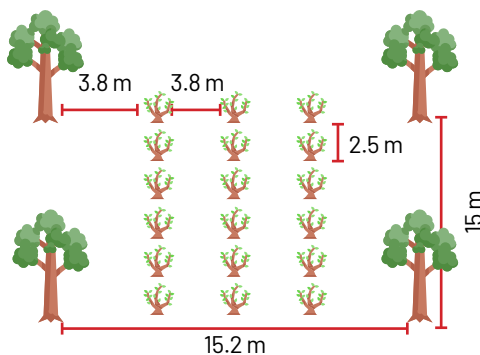
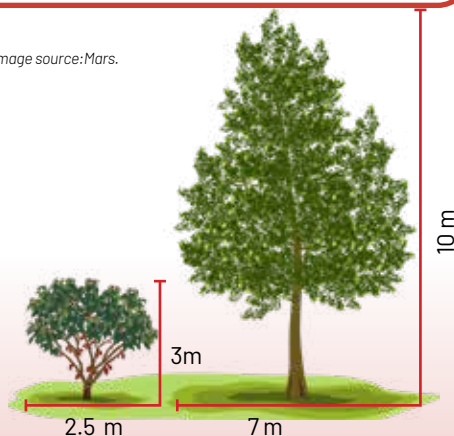


Figure 3. Recommended planting distance for cocoa and nutmeg trees.

Image source: Mars.



Tree spacing that are too close will be detrimental to the yield of cocoa and nutmeg.

# Nutmeg (*Myristica fragrans*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for nutmeg.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Main flowering period: July – August, with some flowering throughout the year
  - Main pollinators: beetles, thrips
  - Fruiting period: September – May
  - Main harvesting in March and April for oil and in October for spices, mace and sweets
  - Pruning is conducted to remove dead branches
  - Fertilizer application is recommended twice a year, at the beginning of the rainy season and at the end of the rainy season (after harvest)
- Fertilizer dosage:** organic fertilizer 10 kg/plant/year; urea (N) 1.7 kg/tree/year; SP-36 (P) 1.7 kg/tree/year; and KCl (K) 1.6 kg/tree/year.



## Pests:



- Beetle (*Areoceum foriculatus*)
- Stem borer (*Batocera* sp)
- Termites (various)

Image source: sinta.ditjenbun.pertanian.go.id



## Diseases:



- Wet fruit rot disease (*Colletotrichum gloeosporioides*)
- Fruit rot and leaf fall (*Phytophthora palmivora*)
- Dry fruit rot disease (*Siigmina myristicae*)

Image source: sinta.ditjenbun.pertanian.go.id



## Environmental services:

- Limited information exists regarding nutmeg's potential for environmental services
- Potential for carbon storage



## References:

- <https://apps.worldagroforestry.org/sea/Publications/files/booklet/BL0055-16.pdf>
- <https://ppid.pertanian.go.id/doc/1/Budidaya%20Pala.pdf>
- <https://agreeculture.id/agreepedia/info-budi-daya/50>
- [https://ejournal.unpatti.ac.id/ppr\\_iteminfo\\_Ink.php?id=351](https://ejournal.unpatti.ac.id/ppr_iteminfo_Ink.php?id=351)
- <https://journals.sagepub.com/doi/full/10.1177/194008291300600502>



# 6

## Coconut (*Cocos nucifera*)

### Site suitability:

- Elevation: 0 – 500 masl
- Slope: 0- 15%
- Annual rainfall: 1000 – 3500 mm
- Soil pH: 4.5 – 8
- Soil type: Various - alluvial, laterite, volcanic, sandy, or clay rocky soils

### Main product:

- Fruit
- Copra

Figure 1. Coconut fruit.

Image source:elements.envato.com



### Production:

- Age of first fruit: 3 – 5 years
- Flowering period: all year
- Fruiting period: all year
- Average production:
  - Early maturing coconut: 80 – 90 coconuts/tree/year
  - Common coconut: 100 – 150 coconuts /tree/year

### General price range:

- Price : IDR 1500 – IDR 3000/coconut

### Other products:

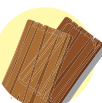
Image source:www.flaticon.com



Coconut

Virgin Oil

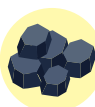
Average price:  
IDR 75,000 –  
IDR 100,000/liter



Construction  
timber/  
furniture



Bee feed/  
apiculture



Fuel /  
charcoal



Animal  
feed



Coconut  
milk and oil

### Seedling selection:

Select coconut seedlings that are:

- Superior quality and come from high producing mother trees
- Healthy and not attacked by pests

Image source:elements.envato.com



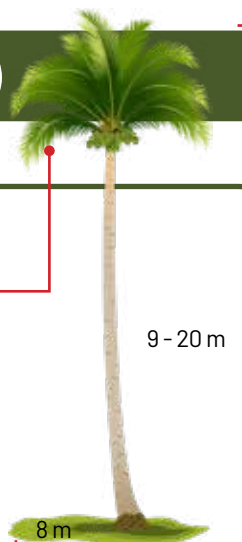
### Tree crown characteristics:

#### Leaf size:

- Length: 4-7 m
- Width: 1 – 1.5 m
- Dense canopy cover

Figure 2. Characteristics of a coconut tree.

Image source:Mars.



### Tree spacing:

Image source:www.flaticon.com

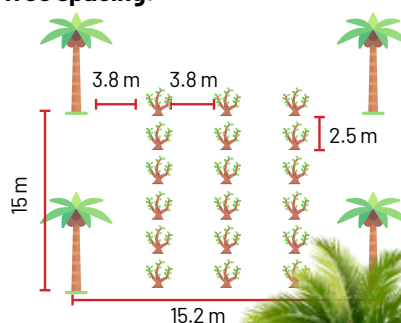


Figure 3. Recommended planting distance for cocoa and nutmeg trees.

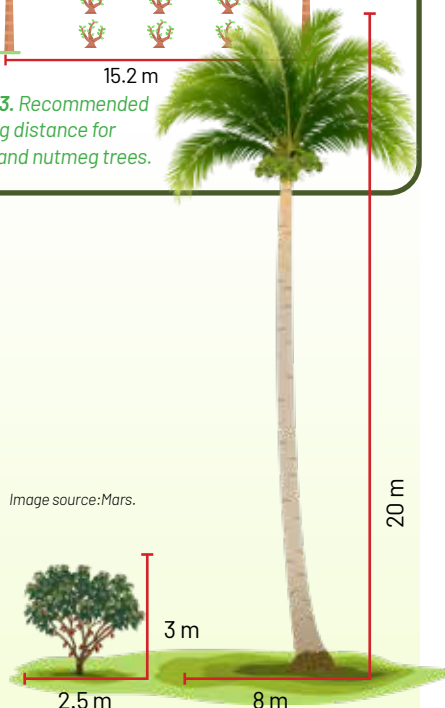


Image source:Mars.

Tree spacing that are too close will be detrimental to the yield of cocoa and coconut.

# Coconut (*Cocos nucifera*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for coconut.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally year-round
- Main pollinators: insects and wind
- Fruiting period: generally, 9 – 10 months (varies by tree)
- Coconuts are usually harvested at 12-14 months, if left unharvested the coconuts will fall
- Pruning is sometimes conducted to reduce old or dead leaf sheaths
- Fertilizer application is recommended twice a year, at the beginning of the rainy season and at the end of the rainy season (after harvest)

**Fertilizer dosage:** urea (N) 0.7 kg/tree/year; SP-36 (P) 0.5 kg/tree/year; KCl (K) 1.5 kg/tree/year



## Pests:



- Coconut leaf beetle (*Brontispa longissima*)
- Moth caterpillar (*Darna catenatus*)
- Rhino beetle (*Oryctes rhinoceros*)
- Grasshoppers (*Sexava* sp)

Image source: www.cabdigitalibrary.org



## Diseases:



- Gray spot disease (*Pestalotiopsis palmarum*)
- Phytoplasma disease (*Phytoplasma* sp)
- Dry rot disease
- Shoot rot disease
- Fruit drop disease

Image source: sinta.ditjenbun.pertanian.go.id



## Environmental services:

- Provides shade
- Improves soil



Image source: elements.envato.com



## References:

- [https://www.academia.edu/35557474/PENAKSIRAN\\_PRODUKTIVITAS\\_TANAMAN\\_KELAPA](https://www.academia.edu/35557474/PENAKSIRAN_PRODUKTIVITAS_TANAMAN_KELAPA)
- <https://repository.pertanian.go.id/server/api/core/bitstreams/dfe7ccc4-c53a-4acf-a967-11d06ba64a42/content>
- [https://www.researchgate.net/profile/Gun-Mardiatmoko/publication/323257747\\_Produksi\\_Tanaman\\_Kelapa\\_Cocos\\_nucifera\\_L/links/5abc2d57a6fdccda6561122/Produksi-Tanaman-Kelapa-Cocos-nucifera-L.pdf](https://www.researchgate.net/profile/Gun-Mardiatmoko/publication/323257747_Produksi_Tanaman_Kelapa_Cocos_nucifera_L/links/5abc2d57a6fdccda6561122/Produksi-Tanaman-Kelapa-Cocos-nucifera-L.pdf)

# 7

## Petai (*Parkia speciosa*)

### Site suitability:

- Elevation: max 1400 masl
- Slope: 0-8%
- Annual rainfall: 1000 - 2000 mm
- Soil pH: 5.5 - 6
- Soil type: Latosol

### Main product:

- Fruit

Figure 1. Petai fruit.

Image source: elements.envato.com



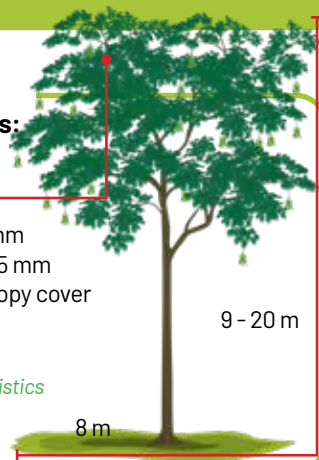
### Tree crown characteristics:

#### Leaf size:

- Length: 5-9 mm
- Width: 1.5 - 2.5 mm
- Moderate canopy cover

Figure 2. Characteristics of petai trees.

Image source: Mars.



### Production:

- Age of first fruiting: 5 - 7 years
- Fruiting period: twice a year
- Average production: 1000 - 2000 pods/tree/year

### General price range:

- Petai fruit: IDR 3,000/pod or IDR 10,000/bundle
- Petai seed: IDR 150,000/kg

### Tree spacing:

Image source: www.flaticon.com

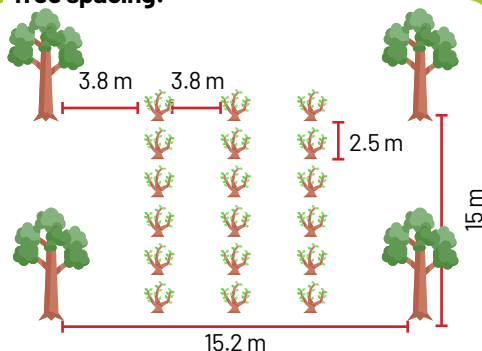


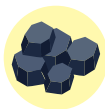
Figure 3. Recommended planting distance for cocoa and petai trees.

### Other products:

Image source: www.flaticon.com



Construction timber /furniture



Fuelwood



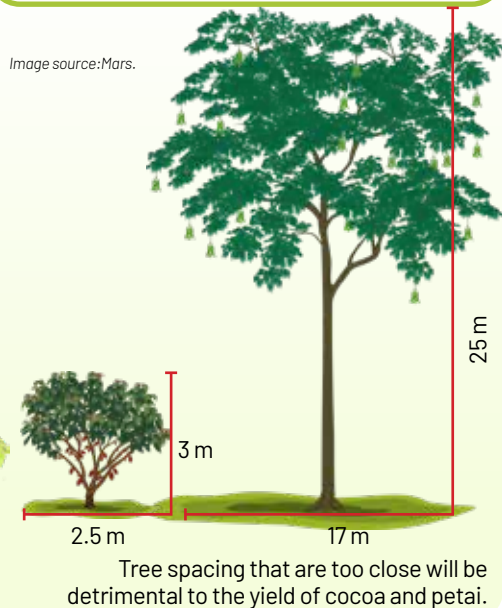
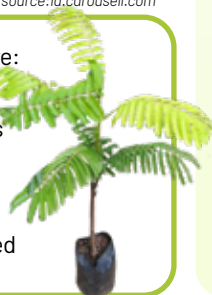
Medicinal uses

### Seedling selection:

Image source: id.carousell.com

Select petai seedlings that are:

- Superior quality, healthy and not attacked by pests
- Originate from seeds collected from superior quality, healthy 'mother trees' that are not attacked by pests



Tree spacing that are too close will be detrimental to the yield of cocoa and petai.

# Petai (*Parkia speciosa*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for petai.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May                                                                               | Jun | Jul | Aug                                                                               | Sep                                                                               | Oct                                                                                | Nov                                                                                 | Dec |
|-----|-----|-----|-----|-----------------------------------------------------------------------------------|-----|-----|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----|
|     |     |     |     |                                                                                   |     |     |  |  |  |  |     |
|     |     |     |     |  |     |     |                                                                                   |  |                                                                                    |  |     |
|     |     |     |     |  |     |     |                                                                                   |  |                                                                                    |                                                                                     |     |

**Legend:**  Pest control  Harvesting  Pruning branches  Providing Fertilizer  
 Watering  Fruit reduction

- Flowering period: generally, in August – September
- Main pollinators: bats
- Fruiting period: generally, in September – November
- Fertilizer application is recommended twice a year, at the beginning of the rainy season and at the end of the rainy season (after harvest)

**Fertilizer dosage:** urea (N) 0.125 kg/tree/year; SP-36 (P) 0.1 kg/tree/year; KCl (K) 0.5 kg/tree/year



### Pests:



Stem borers



Squirrels



Monkeys

Image source: URSchmidt/commons.wikimedia.org, elements.envato.com



### Diseases:

- Root rot caused by *Botryodiplodia* sp, young plants are particularly vulnerable



### Environmental services:

- Provides shade
- Fixes nitrogen, which enhances soil fertility



Image source: World Agroforestry (ICRAF)



### References:

- <https://journal.unj.ac.id/unj/index.php/snppm/article/download/25542/12210/>
- [https://www.researchgate.net/publication/334768480-Budidaya\\_Tanaman\\_Petai\\_di\\_Lahan\\_Pekarangan\\_dan\\_Manfaatnya\\_Untuk\\_Kesehatan](https://www.researchgate.net/publication/334768480-Budidaya_Tanaman_Petai_di_Lahan_Pekarangan_dan_Manfaatnya_Untuk_Kesehatan)
- <http://www.nasih.staff.ugm.ac.id/wp-content/uploads/Petunjuk-teknis-evaluasi-lahan-untuk-komoditas-pertanian-2011.pdf>
- <https://www.worldagroforestry.org/output/agroforestree-database>



# 8 Jengkol (*Archidendron jiringa*)

## Site suitability:

- Elevation: 0–1600 masl
- Slope: 0–8%
- Annual rainfall: 2000–3000 mm
- Soil pH : 5.5–6.5
- Soil type: sandy loam

## Main product:

- Fruit

Figure 1. Jengkol fruit.

Image source: Mohamed Yosri Mohamed Yong/ wikipedia.org



## Production:

- First fruiting: 4.5–7 years
- Average production: 50–100 kg/tree/year

## General price range:

- Fruit price at **farmer level**: IDR 18,000–IDR 20,000/kilogram
- Seed (peeled) price in **traditional markets**: IDR 35,000–IDR 50,000/kilogram.

Image source: www.flaticon.com

## Other products:



Construction  
timber /  
fuelwood



Natural dyes  
(tannin) for  
textiles



Medicinal  
uses

## Seedling selection:

Select jengkol seedlings that are:

- Good quality and match specifications for vegetative propagation
- Comes from a quality mother tree that produces lots of fruit
- From varieties suitable for planting location
- Healthy and not attacked by pests



## Tree crown characteristics:

### Leaf:

- Length: 8–15 cm;
- Width: 4–5 cm
- Dense canopy cover

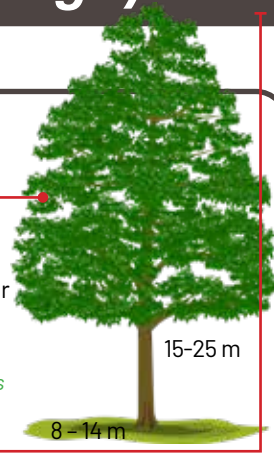


Figure 2. Characteristics of jengkol trees.

Image source: Mars.

## Tree spacing:

Image source: www.flaticon.com

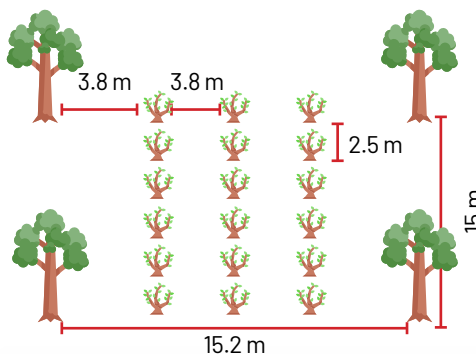
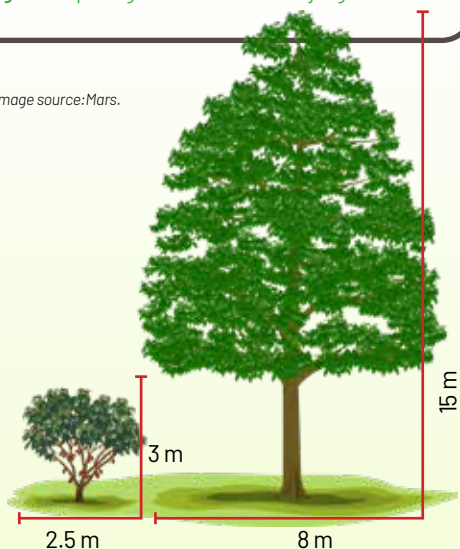


Figure 3. Spacing between cocoa and jengkol trees.

Image source: Mars.



Planting distances that are too close will be detrimental to yields of cocoa and jengkol.

# Jengkol (*Archidendron jiringa*)



## Cultivation and reproduction:

**Table 1.** Standard cultivation and reproduction calendar for jengkol.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: throughout the year, with peak flowering generally in August – October
- Main pollinators: moths and other insects
- Fruiting period: throughout the year, with peak fruiting generally in October – December
- Shape pruning is conducted when the tree is 2-3 years old
- Fertilizer application is recommended once a year at the beginning of the rainy season with compost and half a dose of urea, TSP and KCL

**Fertilizer dosage:** urea (N) 0.125 kg/tree/year; SP-36 (P) 0.1 kg/tree/year; KCl (K) 0.5 kg/tree/year



## Pests:

Weaver ants  
(*Oecophylla smaragdina*)

Image source: Muhammad Mahdi Karim/  
www.micro2macro.net



Image source: Pixabay

Fruit  
caterpillar



## Diseases:

- Various fungal diseases (*Diplodia* sp)



## Environmental services:

- Provides shade
- Wildlife habitat
- Fixes nitrogen, which enhances soil fertility



Image source: World Agroforestry (ICRAF)



## References:

- [https://www.academia.edu/42862365/Cara\\_Menanam\\_Jengkol\\_Supaya\\_Cepat\\_Berbuah](https://www.academia.edu/42862365/Cara_Menanam_Jengkol_Supaya_Cepat_Berbuah)
- <https://www.scribd.com/presentation/365854853/BUDIDAYA-JENGKOL>
- <https://jurnal.unpad.ac.id/kultivasi/article/download/12007/5607>

## Site suitability:

- Elevation: 0 – 1600 masl
- Slope: 0 – 10%
- Annual rainfall: 1000 – 2000 mm
- Soil pH : 5.6 – 7.5
- Soil type: Loamy loose soil

## Main product:

- Fruit
- Flower for vegetable

Figure 1. Papaya fruit.

Image source: macrovector on Freepik



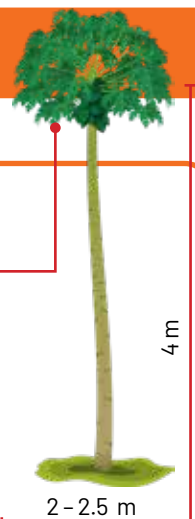
## Tree crown characteristics:

### Leaf size:

- Length: 5 – 15 cm
- Width: 2 – 7 cm
- Dense canopy cover

Figure 2. Characteristics of papaya trees.

Image source: Mars.



## Production:

- Age of first fruit: 9–12 months
- Fruit are harvested all year
- Average production: 30 –150 fruit / tree / year
- Papaya trees should be replaced after 2.5 years.

## Tree spacing:

Image source: www.flaticon.com

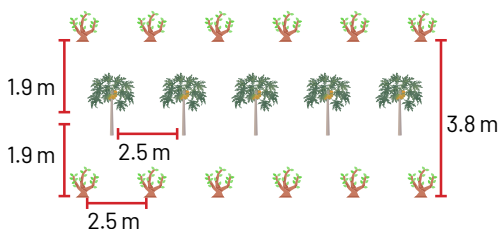


Figure 3. Recommended planting distance for cocoa and papaya trees.

## General price range:

- Fruit prices in local markets:  
Papaya fruit: IDR 5,000 – IDR 7,000/kg

## Seedling selection:

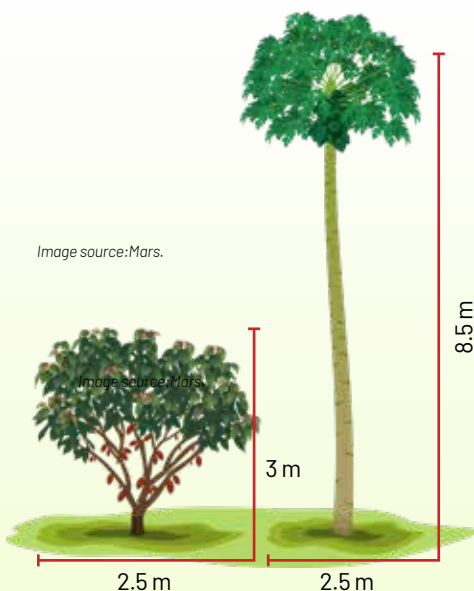
Select papaya seedlings that are:

- Superior quality, come from fruit that were properly ripe and come from quality trees
- Quality seeds and seedlings can also be obtained by purchasing at agricultural stores
- Healthy, not attacked by disease or pests



Image source: pi88y/carousell.sg

Image source: Mars.



Planting distances that are too close will be detrimental to the yields of cocoa and papaya.

# Papaya (*Carica papaya*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for papaya.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally year-round
  - Main pollinators: honeybees, stingless bees (*Trigona* sp), long-tongued sphinx moths (Family: *Sphingidae*), hummingbirds (*Macroglossa* sp), wind
  - Fruiting period: generally year-round
  - Harvesting can be done every 10 days
  - Fertilizer application is recommended twice a year, generally at the beginning of the rainy season and at the end of the rainy season (after harvest)
- Fertilizer dosage:** NPK (16:16:16) 0.25 kg/tree/year; KCl (K) 0.05 kg/tree/year
- Weed cleaning is recommended every two months or adjusted to garden conditions



## Pests:



Image source: wikipedia, invasive.org

- Fruit flies (*Bactrocera dorsalis*)
- Mealybugs (*Desmicoccus brevipes*)
- Aphids (*Myzus persicae*)
- Red mites (*Tetranychus* sp)
- Thrips (*Thrips tabaci*)



## Diseases:

Image source: wikipedia, invasive.org



- *Erwinia papaya* disease
- Papaya Mosaic Virus/ Potexvirus PapMV (Papaya mozaik virus)
- Papaya Ringspot Virus (PRSV)



## Environmental services:

- Improves soil conditions
- Provides shade
- Intercropping



## References:

- <https://distan.jogjaprovo.go.id/wp-content/download/buah/pepaya.pdf>
- <https://www.scribd.com/document/354915441/Budidaya-Pepaya-California>
- <https://www.slideshare.net/faizfaizin1/juknis-pepaya2>
- [silva1607.13.3-2019.480.485.pdf](https://silva1607.13.3-2019.480.485.pdf) (croj.com)



# 10 Banana (*Musa sp*)

## Site suitability:

- Elevation: 0 – 1000 masl
- Slope: 0 – 15%
- Annual rainfall: 1500 – 2000 mm
- Soil pH : 5.5 – 6.5
- Soil type: tolerant of various soil types

## Main product:

- Fruit

Figure 1. Banana fruit.

Image source: elements.envato.com



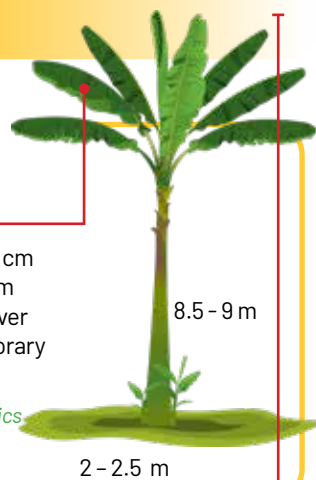
## Tree crown characteristics:

### Leaf size:

- Length: 150 – 400 cm
- Width: 70 – 100 cm
- Dense canopy cover
- Useful as a temporary shade tree

Figure 2. Characteristics of banana.

Image source: Mars.



## Production:

- Fruiting age: 10–18 months
- Flowering period: all year round
- Fruiting period: all year round
- Average production:
  - ◆ Kapok variety: 1 bunch, 20 – 30 kgs
  - ◆ Cavendish variety: 1 bunch, 15 – 30 kgs
  - ◆ Mas variety: 1 bunch, 8–18 kg

## General price range:

- **Kapok variety:**  
IDR 80,000 – IDR 100,000 /bunch
- **Cavendish variety:**  
IDR 100,000 – IDR 150,000/bunch
- **Mas variety:**  
IDR 50,000 – IDR 60,000 /bunch

## Other products:



Food wrapping



Handicraft materials (dry fronds)



Supplemental livestock feed (leaves and fronds)



Banana flowers are eaten as vegetables

Image source: elements.envato.com, www.rumah-bumh.id

## Seedling selection:

Banana is propagated vegetatively.

Select banana sprouts that are:

- Superior quality and come from trees that producing quality fruit
- Healthy and not attacked by pests



Image source: id.carousell.com

## Plant spacing:

Image source: www.flaticon.com

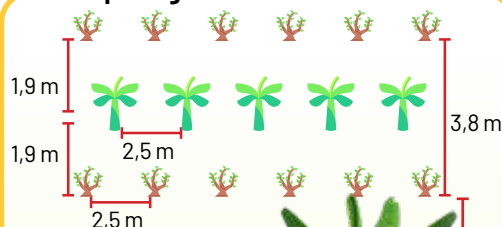
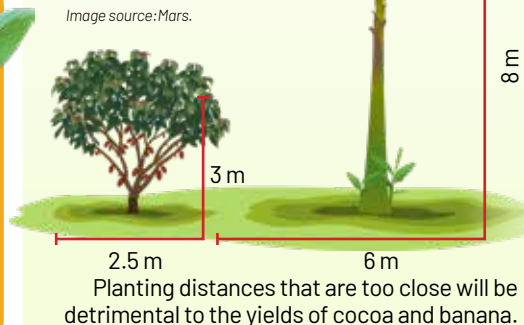


Figure 3.

Recommended planting distance for cocoa and banana trees.

Image source: Mars.



# Banana (*Musa sp*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for banana.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally year-round
- Main pollinators: birds, bats
- Fruiting period: generally year-round, fruit will ripen 90 days after flowering in the dry season or 120 days after the wet season
- Clump management should retain 3 stems per clump – a main stem, a maturing stem and a young sprout. The younger stems replace the main stem after fruit are harvested
- Prune old and dead leaves to prevent the spread of disease
- Weed cleaning is conducted intensively in the first 3 months and continues until 5 months of age
- Fertilizer application is recommended twice a year

**Fertilizer dosage:** urea (N) 103.5 kg/Ha/year; SP-36 (P) 69 kg/ha/year; KCl (K) 304 kg/Ha/year



## Pests:



Image source:  
w/insectscience.co.za

- Banana borer (weevil) (*Cosmopolites sordidus*)
- Banana skipper (butterfly) (*Erieta thrax*)
- Banana scab moth (*Nacoleila octasema*)
- Nematoda



## Diseases:

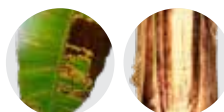


Image  
source: sinta.  
ditjenbun.  
pertanian.go.id

- Wilt disease
- Sigatoka leaf spot fungal disease
- Banana dwarf disease



## Environmental services:

- Provides shade
- Protects soil fertility and quality



Image source: elements.envato.com



## References:

- <https://repository.pertanian.go.id/server/api/core/bitstreams/650af8ff-94fb-4a63-816a-1cb30eea671c/content>
- <https://repository.pertanian.go.id/server/api/core/bitstreams/04cee136-861b-4a6b-ab10-5c1fa5dad4a1/content>
- <https://media.neliti.com/media/publications/296167-analisis-usahatani-pisang-kepok-di-desa-e5a49393.pdf>

**Site suitability:**

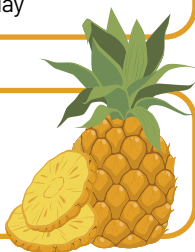
- Elevation: 0 - 1800 masl
- Slope: 0 - 8%
- Annual rainfall: 1000 - 1500 mm
- Soil pH : 4.5 - 6.5
- Soil type: clay, sandy clay

**Main product:**

- Fruit

*Figure 1. Pineapple fruit.*

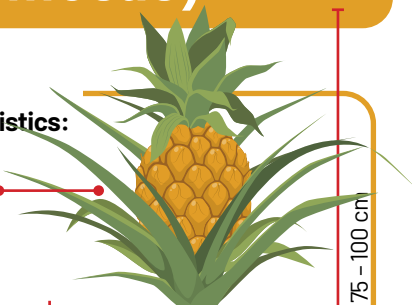
Image source: storyset on Freepik

**Plant characteristics:****Leaf size:**

- Width: 6 - 9 cm
- Length: 71 - 95 cm
- Intercropping is implemented when the cocoa trees are 0 - 3 years old

*Figure 2. Characteristics of pineapple.*

Image source: storyset on Freepik

**Production:**

- Age of first fruiting: 18 - 24 months
- Fruiting period: 3 - 5 times throughout the life of the plant
- Average pineapple production: 95 - 97 tons/Ha

**General price range:**

- Honey pineapple: IDR 5800 - IDR 8000/kg

Image source: www.flaticon.com

**Other products:**

Pineapple fiber are used for textile materials



Pineapple peels are used to produce bioethanol and liquid fertilizer

**Plant spacing:**

Image source: www.flaticon.com

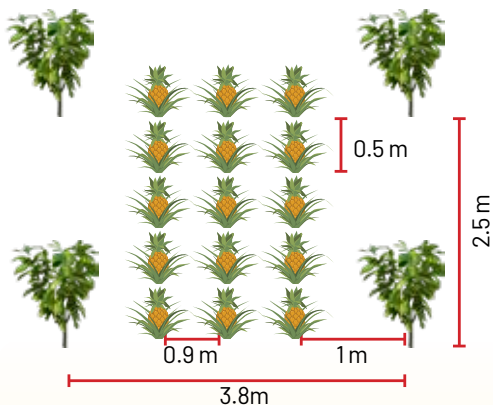
*Figure 3. Recommended planting distance for cocoa and pineapple.***Seedling selection:**

Image source: anekabudidaya.com

Pineapple is propagated vegetatively.

Select pineapple suckers (sprouts) that are:

- collected from quality parents that produces good fruit
- select suckers that are 35 - 45 cm long
- free from disease and pests
- select a single variety for each planting location

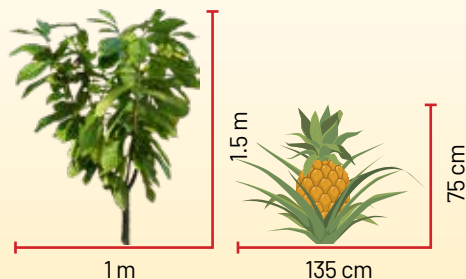


Image source: Riky Hilmanasyah/ CIFOR-ICRAF Indonesia Program

Image source: storyset on Freepik

If pineapples are planted too close to cocoa trees, there will be a negative effect on the growth of the young cocoa trees and the yields of pineapple.

# Pineapple (*Ananas comosus*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for pineapple.

Image source: www.flaticon.com

| 3 MAP | 4 MAP | 5 MAP | 6 MAP | 7 MAP | 8 MAP | 9 MAP | 10MAP | 11 MAP | 12 MAP | 13 MAP | 14 MAP |
|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|
|       |       |       |       |       |       |       |       |        |        |        |        |
|       |       |       |       |       |       |       |       |        |        |        |        |

\* MAP: month after planting

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally, 10 -13 months old for plants
  - Synchronization of flowering is done by administering ethylene (Ethephon) or carbide (calcium carbide)
  - Pineapple harvesting: generally, 152 -157 days after synchronization
  - Fertilizer application is recommended three times, namely during the growth period (3 months after planting), 1 month before forcing and during the flowering period
- Fertilizer dosage:** urea (N) 0.094kg/plant/year; SP-36 (P) 0.062 kg/plant/year; KCl (K) 0.28 kg/plant/year



## Pests:

- White grubs (*Lepidiota stigma*)
- Mealybugs (*Dysmicoccus brevipes*)
- Rodents



Image source: invasive.org



## Diseases:

- Stem root rot disease (*Ceratocystis paradoxa*)
- Fusariosis disease (*Fusarium moniliforme*)
- Root rot disease (*Phytophthora* sp)



## Environmental services:

- Suppresses weed growth
- Increases soil fertility
- Prevent erosion and stabilize slopes by forming contour lines



## References:

- <https://repository.pertanian.go.id/server/api/core/bitstreams/8391d61e-9bb9-4957-8968-dced4dab1b59/content>
- <https://pkht.ipb.ac.id/index.php/category/nanas/>
- <https://media.neliti.com/media/publications/489045-none-aa5c7e4f.pdf>
- <https://itpc.or.jp/wp-content/uploads/2018/10/4.-MB-Nanas-HS-0804.pdf>



# 1 Teak (*Tectona grandis*)

## Site suitability:

- Elevation: 0 – 1200 masl
- Slope: 0 – 20%
- Annual rainfall: 1200 – 2500 mm
- Soil pH : 6.5 – 8.0
- Soil type: Fertile alluvial and colluvial soils

## Main product:

- Timber

Figure 1. Teak wood.

Image source: pch.vector on Freepik



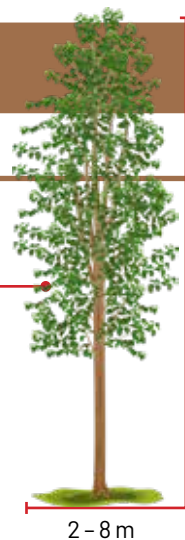
## Tree crown characteristics:

### Leaf:

- Length: 30 – 70 cm
- Width: 25 – 40 cm
- Shape: oval
- Medium canopy cover

Figure 2. Characteristics of teak trees.

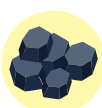
Image source: Mars.



## Production:

- Recommended harvest age for cocoa intercropping is 20 years
- Average production:
  - ◆ On good sites: standing timber volume at 20 years: 66.40 m<sup>3</sup>/Ha – 78.29 m<sup>3</sup>/Ha
  - ◆ On poor sites: standing timber volume at 20 years: 12.46 m<sup>3</sup>/Ha – 57.76 m<sup>3</sup>/Ha

## Other products:



Fuel



Textile dyes (tannin)



Medicinal uses

Image source: www.flaticon.com

## Seedling selection:

Select teak seedlings that are:

- Quality, suitable for planting location
- Single stemmed, sturdy and woody
- Healthy shoots with fresh leaves and not attacked by pests or diseases

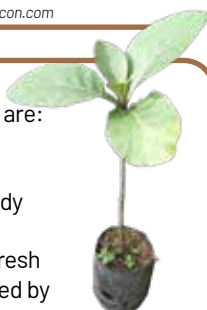


Image source: BumiHijau99

## Tree spacing:

Image source: www.flaticon.com

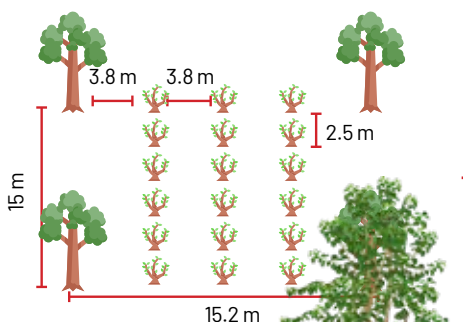
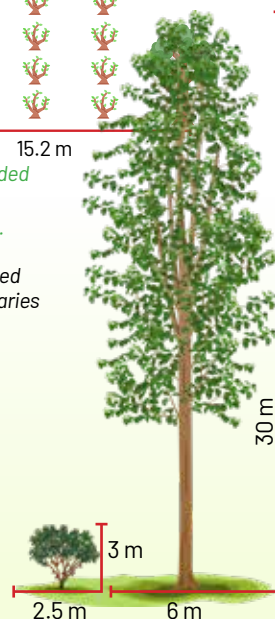


Figure 3. Recommended planting distance for cocoa and teak trees.

Note: Should be planted along the farm boundaries

Image source: Mars.



## General price range:

- Grade A4 teak timber, diameter 40 – 49 cm  
IDR 7,000,000 – IDR 7,800,000/ m<sup>3</sup>
- Grade A3 teak timber, diameter 30 – 39 cm  
IDR 5,000,000 – IDR 5,500,000/ m<sup>3</sup>
- Grade A2 teak timber, diameter 20 – 29 cm  
IDR 3,000,000 – IDR 3,700,000/ m<sup>3</sup>
- Grade A1 teak timber, diameter 11 – 19 cm  
IDR 2,000,000 – IDR 2,500,000/ m<sup>3</sup>

# Teak (*Tectona grandis*)



## Cultivation and reproduction:

**Table 1.** Standard cultivation and propagation calendar for teak.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally at the beginning of the rainy season, in Sulawesi, October – November
- Main pollinators: black ants and bees
- Fruiting period: generally, January – February (50 days after pollination)
- Pruning is conducted once a year in September – October (to reduce shading of cocoa)
- Thinning: recommended every 3 – 5 years, until trees are 15 years old. Thinning should be based on growth and market opportunities for small diameter logs
- Fertilizer application is recommended at the age of 1-3 years. Farmers may not fertilize teak due to expense. Teak will benefit from fertilizer applied to cocoa. Fertilizer should be applied at the following doses: Year 1 NPK 50 grams/plant/year; Year 2 NPK 100 grams/plant/year; Year 3 NPK 150 grams/plant/year



## Pests:

- Teak caterpillars (*Hyblaea puera*) attack the leaves
- Termites (*Neotermes tectonae*)
- Grasshoppers (*Valanga nigricornis*)
- Stem borers (*Xyleborus destruens*; *Xyleutes ceramica*)



## Diseases:

- Pink disease (*Corticium salmonicolor*)
- Wilt disease (*Pseudomonas tectonae*)

Image source: www.wikipedia.com



## Environmental services:

- Provides shade
- Windbreak
- Land rehabilitation



Image source: World Agroforestry (ICRAF)



## References:

- [https://www.cifor.org/publications/pdf\\_files/Books/BCIFOR1001.pdf](https://www.cifor.org/publications/pdf_files/Books/BCIFOR1001.pdf)
- <https://core.ac.uk/download/pdf/294923508.pdf>
- [journal.ipb.ac.id/index.php/jsilvik/article/download/5376/3955](https://journal.ipb.ac.id/index.php/jsilvik/article/download/5376/3955)
- <https://www.mdpi.com/2073-4395/12/2/449>
- <https://apps.worldagroforestry.org/downloads/Publications/PDFS/MA10364.PDF>

## 2 Mahogany (*Swietenia macrophylla*)

### Site suitability:

- Elevation: 0 – 1500 masl
- Slope: 0 – 10%
- Annual rainfall: 1600 – 2500 mm
- Soil pH: 6.5 – 7.5
- Soil types: all soil types

### Main product:

- Timber

Figure 1. Mahogany wood.

Image source: ajeg.co.id



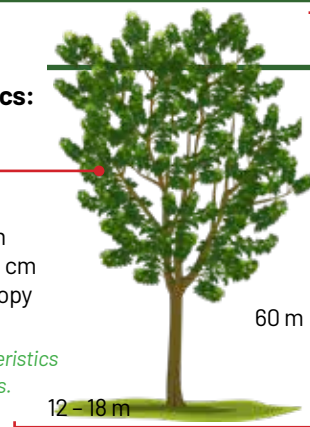
### Tree crown characteristics:

#### Leaf size:

- Length: | 12.5 – 17.5 cm
- Width: 5 – 10 cm
- Medium canopy cover

Figure 2. Characteristics of mahogany trees.

Image source: Mars.



### Production:

- Harvest age is minimum 20 years
- Average production:
  - ◆ Mahogany 15 years: 107.05 m<sup>3</sup>/Ha
  - ◆ Mahogany 20 years : 174.35 m<sup>3</sup>/Ha
  - ◆ Mahogany 30 years : 281.05 m<sup>3</sup>/Ha

### General price range:

- Mahogany log diameter 20 – 59 cm, with a length 200 – 300 cm: IDR 1,200,000 – 1,700,000

### Other products:

Image source: www.flaticon.com



Textile dyes (tannin)



Medicinal uses

### Seedling selection:

Select mahogany seedlings that are:

- Quality and were propagated from seed collected from superior trees
- 6 months old, with a height of ± 25 cm
- Fresh, healthy, and woody and upright



Image source: GOLDEN BLOOM

### Tree spacing:

Image source: www.flaticon.com

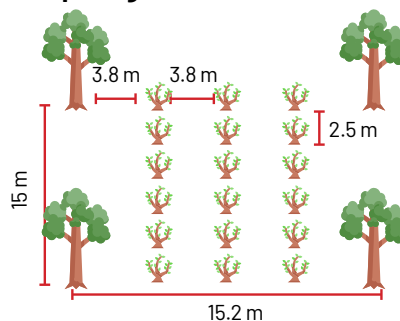


Figure 3. Recommended planting distance for cocoa and mahogany trees.

Note: Should be planted along the farm boundaries

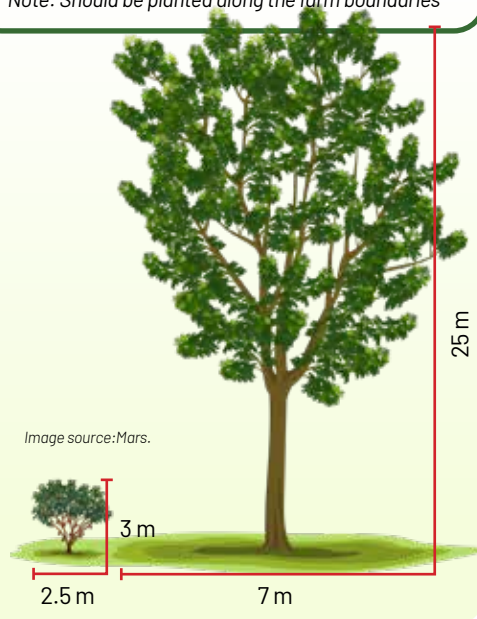


Image source: Mars.

# Mahogany (*Swietenia macrophylla*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for mahogany.

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally, July – September
- Mahogany flowers are self-pollinating
- Fruiting period: generally, December – February
- Pruning is conducted annually until age 3 years
- Fertilizer application is recommended once a year in the initial growth phase. Farmers may not fertilize mahogany due to expense. Mahogany will benefit from fertilizer applied to cocoa. If farmers will apply fertilizer at the following doses NPK 0.1 kg/plant
- It is noteworthy that mahogany leaves have allelopathic potential and are harvested for that purpose



## Pests:



Mahogany shoot borer (*Hypsipyla grandella*)

Image source: Heiner Ziegler/naturalist.org



Black borer (*Apate monachus*)

Image source: Georg Goergen/IITA Insect Museum, Cotonou, Benin



Shoot weevil (*Xylosandrus compactus*)

Image source: www.cabidigitallibrary.org



## Diseases:

- Stem rot (*Athelia rolfsii*)
- Root rot (*Phellinus noxius*)



## Environmental services:

- Provides shade
- Improves soil



## References:

- <https://ejournal.unhi.ac.id/index.php/sewakabhakti/article/download/20/3>
- <https://www.scribd.com/document/540851878/Budidaya-Mahoni>
- [https://www.researchgate.net/publication/328195021\\_ANALISIS\\_PERTUMBUHAN\\_GMELINA\\_Gmelina\\_alboreaRoxb\\_DAN\\_MAHONI\\_Swietenia\\_magrophyllaKing\\_di\\_GORONTALO](https://www.researchgate.net/publication/328195021_ANALISIS_PERTUMBUHAN_GMELINA_Gmelina_alboreaRoxb_DAN_MAHONI_Swietenia_magrophyllaKing_di_GORONTALO)
- <https://journal.ipb.ac.id/index.php/jsilvik/article/download/48115/25733/>



### 3 Sengon (*Paraserianthes falcataria*)

#### Site suitability:

- Elevation: 0 – 1200 masl
- Slope: 0 – 15%
- Annual rainfall: 2000 – 4000 mm
- Soil pH: 5.5 – 7.0
- Soil types: Clay loams, tolerant of various types of soil except grumusol

#### Main product:

- Timber and pulp



Figure 1. Sengon timber.

Image source: wasteorganic4healthy.files.wordpress.com

#### Production:

- Timber production age: 10 – 15 years
- Pulp production age: 8 years
- Average production:
  - ◆ On good sites: total volume at 6 years of age is 403 m<sup>3</sup> /Ha
  - ◆ On moderate sites: total volume at 8 years of age is 350–400 m<sup>3</sup> /Ha
  - ◆ On poorer sites: total volume at 8 years is 313 m<sup>3</sup> /Ha

#### General price range:

- Sengon logs 103 cm long, diameter 20–59: IDR 600,000 – IDR 800,000
- Sengon logs 130 cm long diameter 15–59: IDR 550,000 – IDR 800,000
- Sengon logs 200 cm long diameter 20–59: IDR 500,000 – IDR 800,000

#### Other products:

Image source: www.flaticon.com



Supplemental livestock fodder



Fuel



Medicinal uses



Leaf extract for laundry soap

#### Tree crown characteristics:

##### Leaf:

- Size: small
- Length: 2 – 6 mm
- Low canopy cover

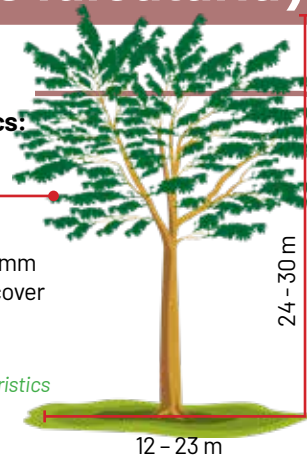


Figure 2. Characteristics of sengon trees.

Image source: Mars.

#### Seedling selection:

Select sengon seedlings that are:

- Quality and were propagated from seed collected from superior trees
- Fresh, healthy, and woody
- Seedlings that are 25 – 30 cm tall are ready to plant

#### Tree spacing:

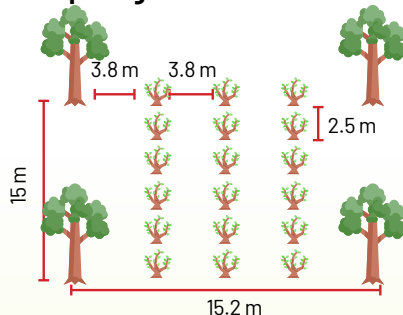


Image source: www.flaticon.com

Figure 3. Recommended planting distance for cocoa and sengon.

Note: Should be planted along the farm boundaries



Image source: Mars.

# Sengon (*Paraserianthes falcataria*)



## Cultivation and reproduction:

**Tabel 1.** Standard cultivation and reproduction calendar for sengon

Image source: www.flaticon.com

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally, October - January
- Main pollinators: insects (*Oecophylla smaragdina*; *Xylocopa latipes*; *Apis cerana indica*; *Iridomyrmex* sp)
- Fruiting period: generally, December - March
- Pruning is conducted in the first two years of age; or annually if the trees are used as shade for cocoa
- Fertilizer application is recommended at planting and at 5 years of age. Farmers may not fertilize sengon due to expense. Sengon will benefit from fertilizer applied to cocoa. If farmers will apply fertilizer at the following doses NPK 0.1 kg/plant



## Pests:

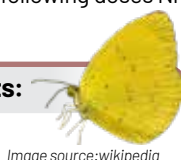


Image source: wikipedia

- Yellow butterflies (*Eurema* spp)
- Bagworms (*Pteroma plagiophleps*)
- Stem borer (*Xystrocera festiva*)



## Diseases:

- Root rot disease (*Botryodiplodia* sp and *Phytophthora* sp)
- Seedling damping off disease (*Pythium* sp)
- Stem and root rot (*Rhizoctonia* sp)
- Gall rust disease (*Uromycladium tepperianum*)



## Environmental services:

- Provides shade
- Fast growing tree for carbon storage
- Windbreak
- Nitrogen-fixing tree that increases soil fertility



Image source: World Agroforestry (ICRAF)



## References:

- [https://www.cifor.org/publications/pdf\\_files/Books/BKrisnawati1109.pdf](https://www.cifor.org/publications/pdf_files/Books/BKrisnawati1109.pdf)
- <https://journal.ipb.ac.id/index.php/jsilvik/article/download/41849/24367>
- <https://media.neliti.com/media/publications/474302-simpanan-unsur-hara-makro-n-p-k-ca-dan-m-d77968de.pdf>

# 1 Corn (*Zea mays*)

## Site suitability:

- Elevation: 0 - 200 masl
- Slope: 0- 8%
- Annual rainfall: 800 - 1200 mm
- Soil pH: 5.5 - 6.5
- Soil type: Sandy soils, red clays (Latosol)

## Main product:

- Grain (fruit and seed)

**Figure 1. Corn fruit.**

Image source: elements.envato.com



## Production:

- Harvest age: 100-120 days after planting
- Average production: 5.3 tons /Ha

## General price range:

- Wet corn: IDR 4,000 - IDR 5,000/kg

## Other products:

Image source: www.flaticon.com



Livestock feed silage



Livestock feed



Compost material



Cooking oil

## Seedling selection:

Select corn seed that:

- Is of a variety recommended for the local area
- Has a germination capacity of 95% or more
- Free from disease and pests
- Uniform in color and size
- Low moisture content of 9-11%



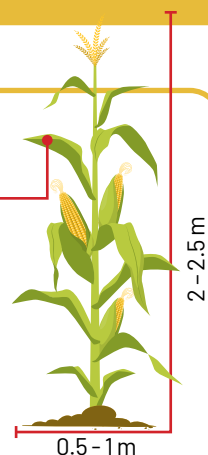
## Plant characteristics:

### Leaf size:

- Width: 5 - 11 cm
- Intercropping can be conducted until cocoa trees are 2 years old

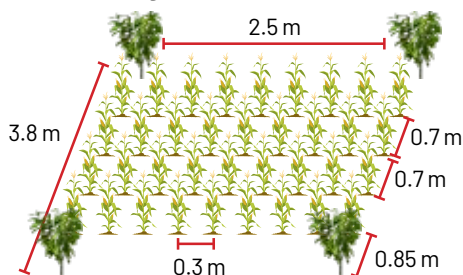
**Figure 2. Characteristics of corn.**

Image source: storyset on Freepik



## Plant spacing:

Image source: www.flaticon.com



**Figure 3. Recommended planting distance for cocoa trees and corn.**

When cocoa trees are young, the distance from corn to the cocoa tree can be 50 cm, with the distance increasing as cocoa trees become older and larger

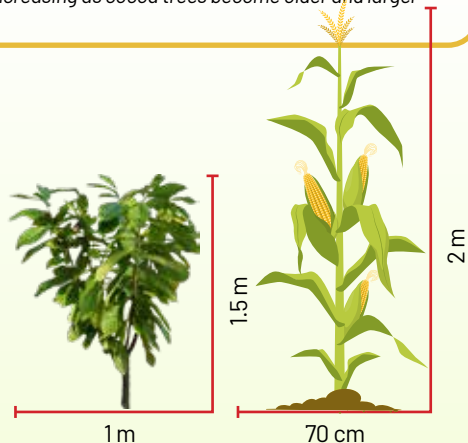


Image source: Riky Hilmansyah/ CIFOR-ICRAF Indonesia Program

Image source: storyset on Freepik

Corn planted too close to cocoa trees will affect the growth of young cocoa and affect corn yields

# Corn (*Zea mays*)



## Cultivation and reproduction:

Table 1. Standard cultivation and reproduction calendar for corn (in weeks).

Image source: www.flaticon.com

| 1 WAP | 2 WAP | 3 WAP | 4 WAP | 5 WAP | 6 WAP | 7 WAP | 8 WAP | 9 WAP | 10 WAP | 11 WAP | 12 WAP |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|
|       |       |       |       |       |       |       |       |       |        |        |        |
|       |       |       |       |       |       |       |       |       |        |        |        |

\* WAP: Week After Planting

**Legend:** Pest control Harvesting Pruning branches Providing Fertilizer  
 Watering Fruit reduction

- Flowering period: generally in the 6th to 8th week after planting
- Main pollinators: bees and butterflies
- Fruiting period: generally from week 9 to week 12
- Fertilizer application is recommended twice, namely during the growth period (30 after planting or week 4) and during the flowering period or when the fruit first appears
- Three cycles of corn are possible per year, depending on local climatic conditions
- Cultivating corn on steep land can result in erosion and landslides, so careful and preventative measures are needed



## Pests:



Image source: biotagroup.id

- Fruit flies (*Atherigona* sp)
- Cob borer (*Helicoverpa armigera*)
- Stem borer (*Ostrinia furnacalis*)
- Grain weevil (*Sitophilus zeamais*)
- Armyworms (*Spodoptera litura*)



## Diseases:

- Stem rot disease (*Fusarium* sp)
- Leaf blight disease (*Helminthosporium* sp)
- Maize Dwarf Mosaic Virus/MDMV (virus disease)
- Leaf spot disease



## Environmental services:



Image source: www.needpix.com

- Source of green manure
- Intercropping
- Protects soil fertility



## References:

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# MARS

**CIFOR-ICRAF Indonesia Program**

Jl. CIFOR, Situ Gede, Sindang Barang, Bogor 16115

[PO Box 161 Bogor 16001] Indonesia | Tel: +(62) 251 8625 415

Email: [cifor-icraf-indonesia@cifor-icraf.org](mailto:cifor-icraf-indonesia@cifor-icraf.org)

[www.cifor-icraf.org/locations/asia/indonesia](http://www.cifor-icraf.org/locations/asia/indonesia)