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**FiBL**

African Organic Agriculture Training Manual  
A Resource Manual for Trainers in Mali

# 9-24 ORGANIC MANGO POST-HARVEST MANAGEMENT



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Ready for field testing

# IMPRINT

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This is an interim version. Comments and  
recommendations for improvement are welcome.

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# 9-24 POST-HARVEST MANAGEMENT OF ORGANIC MANGOES IN MALI



## SET OF TRANSPARENCIES

### Learning targets for farmers:

- > Recognize good pre-harvest husbandry practices in mango orchards
- > Learn good harvesting methods
- > Learn proper handling of mangoes after harvest
- > Learn how to cater for mango trees after harvesting season



## THE MANAGEMENT CYCLE OF MANGOES

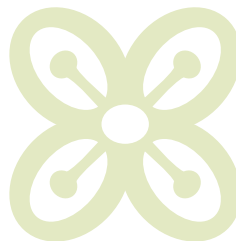
### Pre- and post-harvest management of mangoes



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## 1. Introduction

Mango (*Mangifera indica* L.) is a delicate fruit, very susceptible to post harvest losses. According to the World Bank's 'Growing Mali's Mango Exports' 2010 report, up to 50% of mango production is lost after harvest. Fruit damage is a common problem as a result of poor crop husbandry and harvesting practices. This is further worsened by the poor handling of harvested fruits and transport infrastructure to markets and the limited capacity to properly store and/or process the fruits. A number of **before-, during- and after-harvest practices and operations** can significantly help to maintain the quality of harvested organic mangoes and help to reduce losses thereby improving availability of the fruits for household consumption and for the market. It is therefore not adequate to talk about post-harvest without referring to the pre-harvest processes of managing mango trees and the during-harvest processes of handling the mango fruits.



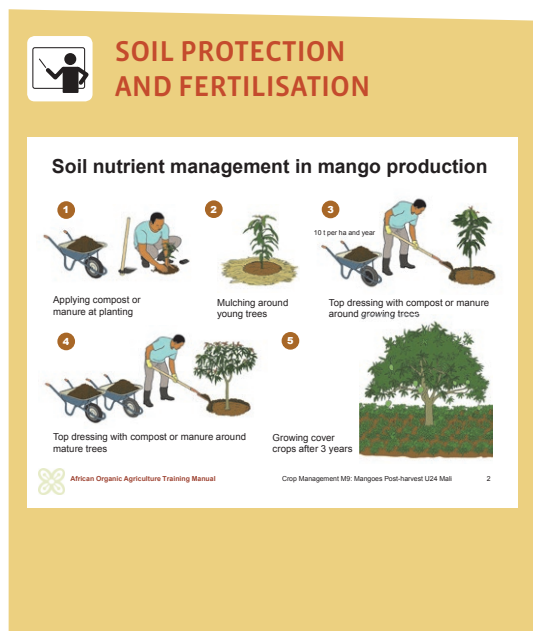
## 2. Pre-harvest management of mango orchards

Several pre-harvest factors including varietal and rootstock selection, pruning to control tree size and vigor, fertilization, irrigation, and disease and pest control influence the physiology, chemical composition and morphology of fruits, and thus the quality and susceptibility to damage of the harvested fruits.

### 2.1 Soil fertility management

In general, like many crops, good soil fertility management, especially in young orchards, leads to adequate rapid growth, flowering, and fruiting. Nutrient imbalances in the soils should be avoided as this will negatively affect the quality and shelf life of the fruits. In organic production, proper application of organic manures in conjunction with appropriate soil conservation measures can improve soil fertility. But the availability, quality and accessibility of organic manures as well as the timing of their application to support nutrient release for crop growth is critical. Excessive application of organic manures (nitrogen) can negatively affect the color and flavor of the mature fruit. However this may be rare in Mali where good and adequate sources of organic materials are limited coupled with the competition for the same materials by annual crops such as maize. Under organic management, it is recommended to apply moderate amounts of animal manure and / or compost (10 tons per ha and year) for optimal quantity and quality of mangoes.

After three years when intercropping in the mango has reduced, growing of appropriate leguminous cover crops is recommended to contribute to the nitrogen content of the soil, provide organic matter while protecting the soil from erosion and weed growth. However, it is recommended that farmers should test the performance and interaction of different legume cover crops with the mango trees on a few selected gardens within their context, before promoting them on a large scale.



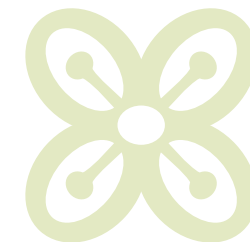
#### **i** Note

For further reading on soil fertility management, check the manual on soil fertility management of mangoes in Mali.



#### **Local sources of organic materials**

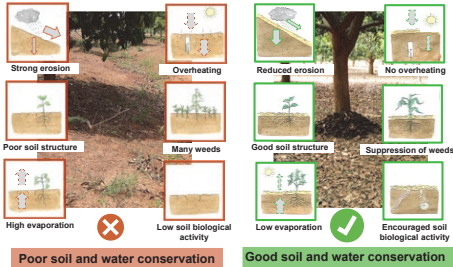
In a brainstorming session, list the commonly available organic sources of nutrients available to mango farmers. Identify the opportunities and challenges of encouraging more farmers to adopt the use of each of these materials. Finally select at least two sources that organic farmers should focus on.





## BENEFITS OF GOOD SOIL AND WATER CONSERVATION

### Benefits of good soil and water conservation

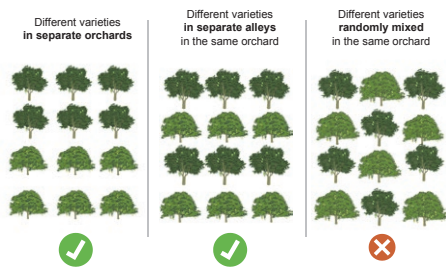


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## ARRANGEMENT OF VARIETIES IN THE ORCHARD

### Arranging varieties in the mango orchard



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## 2.2 Water conservation and irrigation

Although mangoes require plenty of sunshine for optimum growth and fruiting, they require sufficient water supply of at least 600 mm/year with a dry period of at least 3 months for flowering. Where feasible, drip irrigation can be used to supplement the water supply, especially in young (less than three years) mango orchards. Water conservation practices such as mulching of especially newly planted and young mango trees helps to conserve moisture, which improves mango tree establishment. In addition, appropriate soil conservation through terracing or digging of water trenches, improves water infiltration into the soil. For older orchards, the use of appropriate cover crops is recommended to conserve soil water.

## 2.3 Mixed mango varieties in the same orchard

Mixing of different varieties in the same orchard is common in Mali (mostly orchards planted 20 or more years ago). This is partly due to the erratic availability and cost of certain mango varieties. The practice of mixing varieties has certain advantages like extending the fruit ripening period and ensuring a longer availability of fruits for household consumption and marketing.

This practice, however, can contribute to major difficulties and increased costs of cultural management and can lower yields, if the trees are not well managed. Different varieties may have different tree canopy sizes, rates of growth and susceptibilities (to water stress, pests and diseases) making it difficult to coordinate crop management practices, like fertilization, pest and disease control, pruning and harvesting. This makes it also more difficult for pickers to find all the fruit ready to be picked. When establishing a new orchard or extending an existing one, it is therefore recommended to arrange different varieties in separate orchards or plots, or in separate alleys in the same orchard.

For already existing orchards, adequate pruning of the trees to a more uniform structure is recommended: in some cases some wildly-growing trees that are shadowing others may be removed completely and gradually replaced with better varieties. This can be done progressively, to minimize drastic effects on harvest and thus farm incomes, by cutting back older trees, while allowing young trees planted below them to establish.



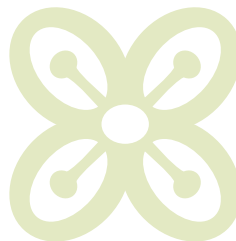
### Note

For further reading on water conservation, check the manual on soil fertility management of mangoes in Mali.



### Experiences regarding use of cover crops

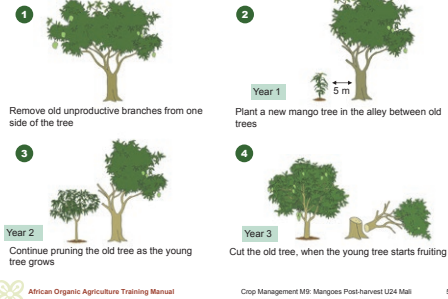
Identify samples of commonly available leguminous cover crops. Display them to the participants and let them share experiences of growing some of the cover crops on their farms, highlighting some advantages and disadvantages. Identify participants who are willing to test them in their mango orchards and agree on the source of seeds for these trials.





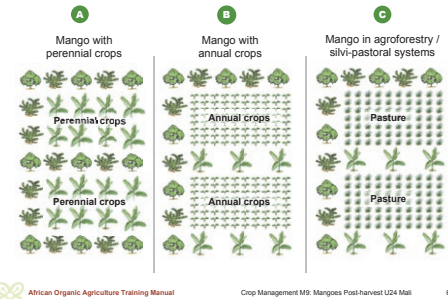
## HOW TO REPLACE OLD TREES

### Replacing old trees in the orchard



## OPTIONS OF INTERCROPPING MANGO TREES

### Intercropping in mango orchards



For replacement or establishing of new orchards, the use of grafted or budded varieties is recommended for quicker establishment.

Common improved mango varieties include Keitt, Kent, Amélie, Brooks, Valencia, and Beverly. The export market however prefers Kent and Keitt for fresh mangoes, and Amelis and Brooks for dried mangoes. Further guidance on where to obtain budded or grafted seedlings of recommended improved mango varieties may be obtained from the extension agent.

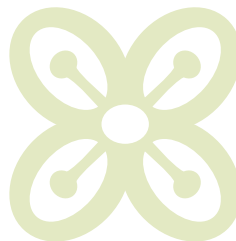
## 2.4 Intercropping in mango orchards

Diversification of crops in the garden can increase yield safety of the crops by creating favorable growing conditions, protecting the soil, reducing disease and pest pressure and thus minimize the risk of income loss. Therefore, intercropping mango trees with annual crops such as groundnuts, sorghum, and vegetables like green beans and cabbage is recommended especially during the early stage of mango orchard establishment (less than three years). Mangoes can also be intercropped with appropriate perennial crops like fruit trees such as citrus, cashew trees, bananas. To avoid competition for soil moisture and nutrients, the selected perennial intercrops should be appropriately spaced, tolerant to shade and routinely pruned. Additionally, by promoting natural or semi-natural habitats near or around the mango orchards, pollination and pest control in mangoes will be improved.



### Commonly grown mango varieties in Mali

Identify the commonly grown mango varieties in Mali and how they are often planted in different orchards by the farmers. Discuss and identify the pros and cons of the existing practices of mixing varieties, and how this can be improved to enhance productivity.

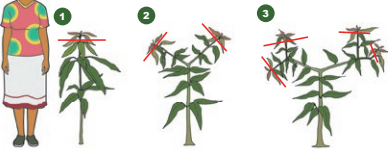




## FORMATIVE PRUNING OF YOUNG TREES

### How to form young mango trees

Prune before the node!  
If you prune after the node, the tree will produce too many shoots.



In the 1<sup>st</sup> year, when trees are about 1 m

Leave 3 to 4 branches

After every second flush of leaves



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## 2.5 Tree size control and pruning

Mango trees can grow very high and vigorous. This makes pest and disease control difficult, and can result in significant decreases in mango yields. It further increases harvesting costs. Existing trees, which have not been managed well in the past, can be improved by pruning them properly. This includes regulating the size of the trees, removal of dead wood/branches, removal of shading branches, opening the canopy for better aeration and exposure of the interior of the canopy to light. Appropriate pruning should always be done after every harvesting season. In new orchards, trees can be well trained to ensure suitable formation of the trees, controlling the tree height during the first three years after planting. With some mango varieties, the tree branch may become so heavy with mango fruit that it eventually breaks. The farmer can thus intervene to save the harvest by pegging the heavy branches with wooden poles.



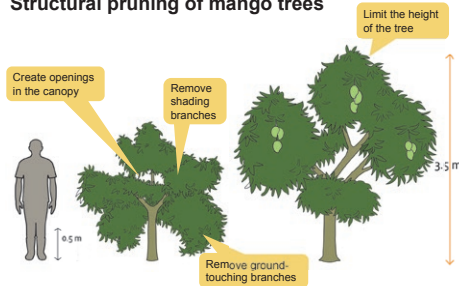
### Mango tree size control

Identify mango varieties in Mali that can grow very tall and thus difficult to manage by farmers. Equally discuss varieties that naturally don't grow very tall. Discuss the difficulties in managing and harvesting from tall mango trees and collectively suggest options of how tree size can be better managed.



## STRUCTURAL PRUNING OF MATURE TREES

### Structural pruning of mango trees



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## PEGGING OF HEAVY BRANCHES

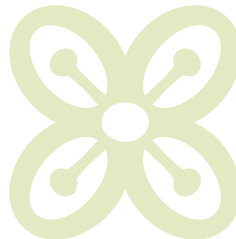
### Pegging of heavy branches



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## 2.6 Pests and diseases

Good pre-harvest pest and disease control contributes to increased yield and improved fruit quality. Mango is more sensitive to pest and disease infestations towards maturity. Rain and high humidity favour the development of most pests and diseases, so late varieties are the most exposed; varieties that mature in March and April are less affected.

### Mango fruit flies (*Bactrocera invadens*)

The mango fruit fly is one of the important pests for mangoes in Mali. It can lead to rejection of shipments and/or destruction of the mangoes at the destination ports. Fruit flies can lead to more than 50% losses in mangoes in Mali. Female fruit flies puncture the fruit skin and lay eggs that develop into maggots (larvae) in the flesh of the fruit after hatching. The larvae feed on the fruit and cause it to drop prematurely and destroy the pulp of the fruit. Generally the fruit falls to the ground as, or just before, the maggots pupate. In fruit for export, fruit flies cause indirect losses resulting from quarantine restrictions that are imposed by importing countries to prevent introduction of fruit flies. Nearly all fruit fly species are quarantine pests. Fruit flies attack soft, fleshy fruit of a wide variety of fruit and vegetables. Varieties like Brooks, Amelie, Kent, Keitt Valencia and Bavery are mostly susceptible to mango fruit fly. Management strategies of fruit flies include:

- › Continuous monitoring of fruit flies to determine when they arrive in the orchard and to decide when treatment is needed. Monitoring can be done using bait traps like the 'bait trap'. The farmer should, however, be able to identify fruit flies from among other trapped insects. Pheromone traps are also available to attract male fruit flies, hence reducing reproducing populations.
- › Orchard sanitation is important as poorly managed or abandoned orchards can result in buildup of fruit fly populations. All fruit with dimples and oozing, clear sap should regularly (e.g. twice a week for the entire season) be removed from the tree as well as all rotten fruit from the ground. The maggots are killed by burning or tying collected fruit in black plastic bags and exposing them to the heat of the sun for some hours. The fruit can also be buried deep, at least 50 cm (about two feet), to prevent emerging adult flies from reaching the soil surface.

**MANGO FRUIT FLY DAMAGES**


**Fruit fly**

**Symptoms:**

- › Infected or rotting mango flesh, sometimes with fruit fly larvae or maggots (the mango seed is not affected, only the flesh)

**Control:**

- › Continuous monitoring
- › Orchard sanitation
- › Natural enemies
- › Biopesticides
- › Bagging

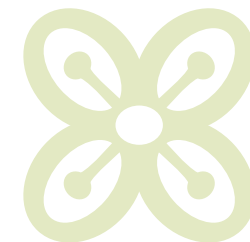


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### Pest and disease management in Mango production

Identify which pests and diseases affect mango production in Mali and which varieties are easily affected. Discuss the strategies commonly used by farmers. Identify those that can be applied in organic production and how they can easily be promoted among farmers.

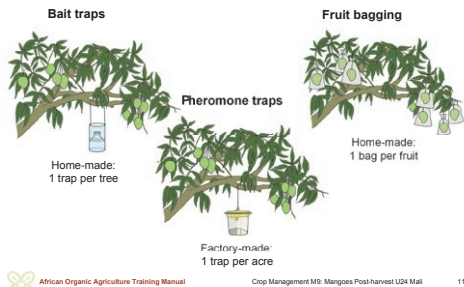






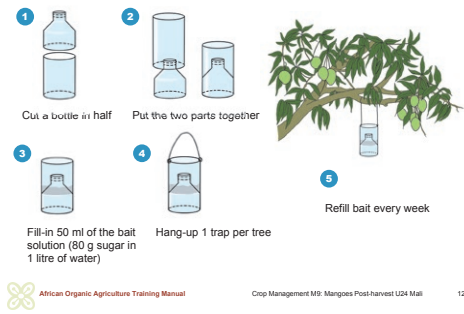
## TRAPS AGAINST INSECT PESTS

### Physical pest control methods



## HOW TO MAKE A BAIT TRAP

### How to make a bait trap

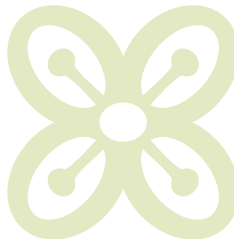


- › Several natural enemies can contribute to the suppression of fruit flies. Major natural enemies are parasitic wasps (e.g. *Bracon* spp.) that attack the maggots of fruit flies and predators such as rove beetles, weaver ants, spiders, and birds and bats. In particular, weaver ants have been shown to be very efficient in protecting fruit trees from pests, including fruit flies. These ants pray on fruit flies, but most importantly, their presence and foraging activity hinders the fruit flies from laying eggs, resulting in reduced fruit fly damage, as shown in mango orchards in Benin. Although natural enemies alone do not give satisfactory control of fruit flies, efforts should be made to protect them, and to complement their effect on fruit flies with other management options. Dill, parsley, yarrow, zinnia, clover, alfalfa, parsley, cosmos, sunflower and marigold are flowering crops that attract the native wasp populations and provide good habitats for them when planted on the boundaries of the mango orchard.

### Mango seed weevil (*Sternochetus mangiferae*)

Mango seed weevil, also called the mango stone weevil, is another major pest of mangoes in Mali. The larva, which is the damaging stage of the pest, enters the fruit by burrowing through the flesh into the seeds, where it feeds until pupation, destroying the seed. Early attack (when the fruit is forming) leads to premature fruit fall. If the attacks occur at a later stage, fruit infestation is very difficult to detect, since there are no external signs of infestation. When the adult emerges, it tunnels through the flesh, leaving a hole in the fruit skin which may serve as an entry point for secondary fungal infections, greatly affecting the quality of the fruit. This is particularly a problem because, in many instances, weevil attack remains undetected in the field, and is first noticed in storage or when cutting the fruit. The weevil spreads into clean areas through the movement of infested fruit for propagation or consumption. Varieties like Keitt, Kent, Amélie, Brooks, Valencia, and Beverly are mostly susceptible to mango seed weevil. It can, however, be managed by:

- › Continuous monitoring to ensure timely intervention is important, for instance, a weevil attack can be detected by monitoring for egg-laying marks on young fruit. Regular fruit scouting is important to detect adult activity during fruit growth.
- › Ensuring good orchard sanitation by collecting and destroying all scattered mango seeds and fallen fruit. All collected fruit and seeds should be buried



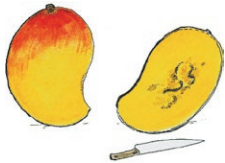


## MANGO SEED WEEVIL DAMAGES

### Mango seed weevil

#### Symptoms:

- › Infected or rotting fruit seed, sometimes with visible weevil larvae/maggots



#### Control:

- › Continuous monitoring to ensure timely intervention
- › Orchard sanitation
- › Orchard quarantine
- › Applying sticky bands



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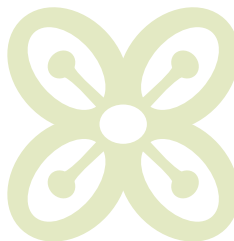
deeply (about 50 cm deep).

- › Ensuring orchard quarantine by restricting movement of fruit from old orchards or areas known to have mango seed weevils to areas where young orchards, free of seed weevil, have been established.
- › Applying sticky bands at the upper end of tree trunks when the trees start flowering to reduce migration of weevils to branches for egg laying.

### Anthracnose

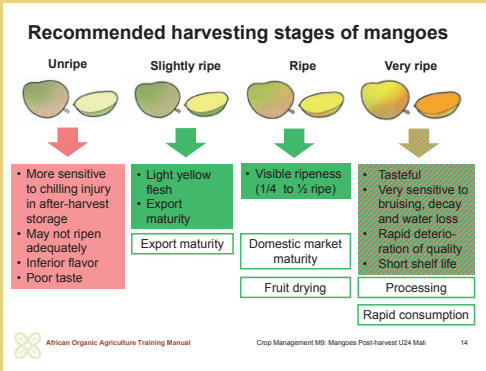
Caused by the fungus *Collectrichum gloeosporioides*, anthracnose is the most important disease that affects the mango fruits after harvest, especially in regions that have high rainfall and heavy dews. It affects leaves, stems and floral panicle, but the fruit receive the most damage. The fungus causes brown spots on leaves and black spots on fruit and flowers and makes the young branches brittle. Varieties like Kent, Keitt, Amelie, Brooks, Bevery, and Sprifild are mostly susceptible to anthracnose. The infestation can be reduced if dead material (branches, leaves and infested fruit) is removed from the orchard. After harvest, anthracnose can be controlled if the fruit is given a water bath for 3 to 5 minutes at 55 °C.

Spraying with fungicides is effective in controlling anthracnose mangoes. However, for organic production, a limited number of fungicides, such as copper or sulphur, is allowed during production. Therefore before any fungicide is used on organic mangoes, check with the organic certifier.

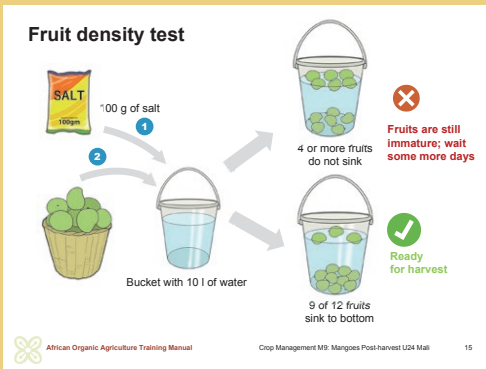




## RECOMMENDED HARVESTING STAGES OF MANGOES



## FRUIT DENSITY TEST



## 3 During-harvest handling of mangoes

The type of market (fresh or processed, local or export), distance to market, weather, packaging, and transportation means should be considered when deciding when to harvest and the harvesting methods to use.

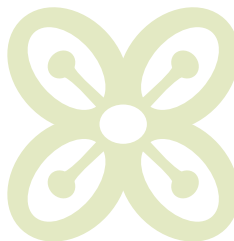
### 3.1 Maturity

Mango fruits should be harvested at the ideal stage in order to develop the most adequate organoleptic quality and the longest postharvest life. Less mature fruit is usually more sensitive to chilling injury during after-harvest storage and often develop an inferior aroma and flavor. The immature fruit may not ripen adequately after harvest, and in some cases it may never ripen. On the other hand, fruits harvested when over-ripe are very sensitive to bruising, decay and to water loss and quality deterioration, and will have a short shelf life. The right stage of maturity at harvest will depend on whether the fruits are intended for immediate consumption, sale in nearby markets or processing (late harvest) or fruits harvested at physiological maturity and intended for transport to distant export markets ('mature green mangoes').

**NB:** It is recommended that fruit for drying is also picked as soon as visible signs of ripening appear (¾ to ½ ripe), to minimize damages during handling and to regulate the ripening process viz-a-viz the processing quantity requirements.

Generally, physiological maturity in mango is reached about 12 to 16 weeks after fruit set, with variations depending on the variety, geographical region and environmental conditions. Commonly farmers use physical characteristics of the fruit to determine maturity, for example; skin / flesh colour, fruit size, or softness to touch;

- › At the time of maturity, the mango stone becomes hard and pulp colour changes from white to yellow starting at the endocarp and progressing outward to the skin during maturation.
- › Floating fruits in water (fruit density test) – as mango fruits mature they accumulate dry matter and thus become denser. Using a 1.0% salt solution (100gm salt in 10 litres water), pick 12 fruits at random per tree, if 9 out of 12 fruits sink to the bottom, these are ready for harvest. More floaters mean fruits are immature hence, additional days are needed.



At commercial scale, total soluble solids, total acidity, and the sugar/acid ratio are good criteria for determining the maturity stage. During maturation soluble solids increase and titratable acidity decreases. Most markets require mangoes to be harvested with about 9 to 11% total soluble solids (°Brix), pH (3.5 to 4) and °Brix/acid ratio 32.

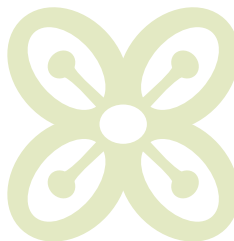
### 3.2 Harvesting time of the day

It is recommended that mangoes are picked at hours when the temperature is not high. This would reduce field heat in the fruit and thus would maintain it for longer periods. Cultivars with high latex content should not be harvested very early in the morning to reduce latex flow. Harvesting is best in the late morning, because the oil glands of these fruits are full in the early morning, causing immediate discolouration. After harvesting, the fruits should never be left in direct sunlight, they must be kept in the shade (or properly covered) to avoid dehydration. Harvesting under wet conditions should be avoided, since wet fruits are more susceptible to microbial growth and soil particles may cling to harvested fruits, exposing them to soil-borne decay organisms.

### 3.3 Harvesting methods

In practice many methods are employed by farmers for harvesting mangoes. Sometimes trees are shaken and fruits drop to the ground causing serious damages to the fruit and the tree. Some farmers use long sticks with a hook to pull the fruit and drop it resulting in the same fruit damages as with shaking the trees. In few farms, a pole with a net at the end is used to pick fruits from the upper part of the tree. However, most of these nets are not constructed in a way that enables the fruit to be cut, but rather to pull it. Therefore, although the net receives the fruit and prevents it from dropping on the ground, it does not allow cutting it with a stalk.

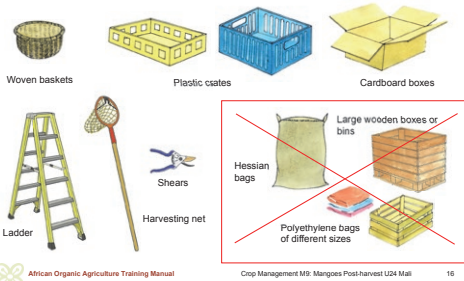
With all these methods, the fruit is harvested without a stalk. Harvesting fruits without the stem increases latex flow, water loss, and decay. Latex causes burning of fruit skin, deterioration of fruit color, and even health problems for allergic pickers and packers. To avoid these problems, fruits should either be





## HARVESTING TOOLS AND CONTAINERS

### Appropriate harvesting tools and containers



picked individually by hand using appropriate instruments like clippers/shears or by carefully pulling the fruit from the tree into a basket or net, or by two people, one on a ladder picking the fruit and the other person catching the falling fruit. Either way, ensure that the fruit has a 10 cm stalk which after harvest can be cut to 2–3 cm and laid stalk down on a wooden grid to let latex flow out without spoiling the fruit-skin. When fruits are harvested after 08:00 hours, the turgor pressure in the fruit will be lower and hence less latex will be exuded from the cut stems.

In Mali, some farmers leave the harvesting of mango to buying agents (– known in French as ‘pisteurs’) who upon payment of the agreed amount to the farmer, will harvest themselves. Commonly they maximize the harvest by taking all of the fruit they can, regardless of its quality and ripeness. However, alternatively farmers are organizing themselves in ‘harvesting teams’ (‘Coupeurs’). It is therefore necessary that, as long as such teams are used, training intended to improve organic mango fruit quality should also be provided to these teams.

### 3.4 Hygiene during harvesting

The people harvesting and handling fruits must observe strict personal hygiene and sanitary practices to avoid possible contamination of the fruits and damaging the fruits. Practices such as proper handwashing (with soap) and drying before handling fruit (including after smoking), nail cutting, ought to be observed. Harvesting crates must be clean, all corners and edges must be rounded, a paper inlay sheet or leaves are used to cover the bottom of the crate. Crates should never be overfilled (the uppermost mango must be > 5 cm under the rim of the crate). Do not pick in large pallet-crates which can lead to pressure damage. When using ladders, the harvesters should avoid touching the ladder steps as this can lead to soil contamination (transferring soil from shoes to the hands and then the fruit).



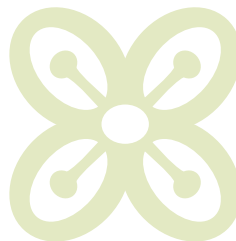
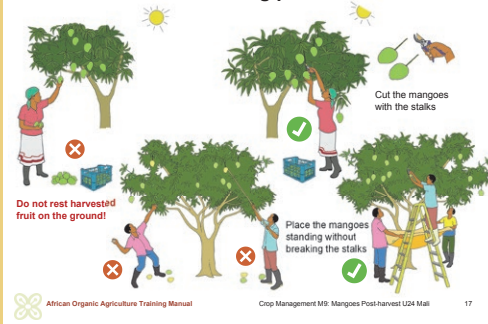
### Hygiene during mango harvesting process

Select one participant to describe how they handle mangoes during the harvesting process. Sketch the process on the flip-chart or blackboard. In a brainstorming session, identify hygiene risks to mango quality at every stage and discuss, how they can be mitigated. Conclude by agreeing on a preferred handling process agreed upon by all participants.



## HARVESTING PROCEDURES

### Recommended harvesting procedures



## 4 After-harvest handling of mangoes for fresh fruit market

Mechanical injury is a very common after-harvest source of fruit damage. Poor handling of fruit after harvesting, during sorting and packing, as well as transportation can lead to mechanical injury. Good post-harvest management of mangoes will minimize fruit injuries and contamination, prolong storage life, and ensure freshness and an attractive appearance. It is a requirement that organic fruits must be kept separate from any conventional fruits at the field, farm and subsequent levels of the postharvest chain.

### 4.1 Sorting

Immediately after harvesting, while still in the field but under a shade, all immature, overripe, damaged and diseased fruits should be sorted-out and properly disposed.

### 4.2 Washing

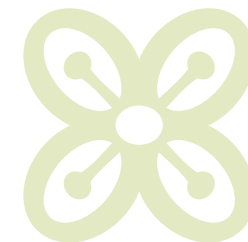
Normally, mangoes do not need any treatment for marketing in local markets, except simple washing with water to remove the latex and dust immediately after harvest before the latex dries on the fruit; if the latex has dried off while still on the fruits it becomes practically impossible to remove it afterwards.

To increase shelf-life, however, freshly harvested fruits may be dipped in a hot water bath (55 °C for 3 to a maximum of 5 minutes), to minimize fruit fly damage, anthracnose, and stem-end rot infections, and then slowly cooled to room temperature. Afterwards, the mangoes should be left to drip dry. Care should be taken with the hot water treatment: prolonged dipping in hot water can result in fruit skin damages which may cause more severe postharvest losses. The water used in all processes, including in the packinghouses, should be clean and portable (safe to drink). Equally, the fruit washing facilities and tools should be regularly inspected and cleaned of any debris, dirt or other foreign objects. Regular cleaning reduces the built up of diseases along the handling lines. Only permissible detergents (for organic) should be used to clean and/ or sanitize the surfaces, containers and tools. Reference to the regulations of the destination market (domestic and export) ought to be made.



### Visit to mango handling facility

Where possible, organize a learning visit to a fresh mango handling facility for participants to observe the fresh mango handling in practice. Share and discuss key lessons learnt.



### 4.3 Other treatments

In conventional production, mangoes are commonly dipped in hot water, containing fungicide for the control of diseases, but this is not permitted in organic production. However, naturally derived fruit coating materials, such as pyrethrum and mineral oil, are allowed (refer to Annex II of the EU Reg 889-2008). Equally, the use of chlorinated water is allowed to the extent that at the end of the washing line the residual chlorine content equals that of drinking water (World Health Organization (WHO) recommendations of 10 ppm).

### 4.4 Curing

Mangoes that are planned for the domestic market or processing are usually spread in a cool place, either on the floor in the orchard's yard, having the cushion materials like leaves or clean washable sheets or on a raised platform for nearly 24 hours, avoiding direct contact of fruits with the soil. This allows the skin to lose some water, becoming harder and less succulent hence less susceptible to damage and to fungal growth. For the export market, proper curing of washed mangoes in crates on a raised platform for 4 to 5 hours is necessary to ensure storage for long periods.

### 4.5 Delivery to packhouse

The fruits should be packed carefully into padded field crates, well-ventilated plastic containers, or picking bags, avoiding overfilling before delivery to the packing house or shed where final packing is done according to the requirements of the target market.

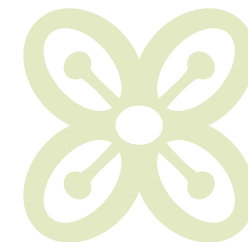
### 4.6 Grading

Mango fruits can be graded according to their size, weight, colour and maturity. It has been observed that bigger size fruits take 2–4 days more time in ripening than smaller ones and may not achieve uniform ripening. Therefore, grading ac-



#### Discussion on after-harvest handling and treatment of mango

Either through personal experiences or from the visit to a fresh mango handling facility, discuss observations of how mangoes are treated, cured and graded before packing. Check with the certification agency which treatments are allowed in organic farming before you apply them.





## QUALITY CRITERIA FOR MANGO

### Quality criteria for mango according to the Codex Alimentarius

- ✓ Whole, firm, sound and fresh in appearance
- ✓ Clean, practically free of any visible foreign matter
- ✓ Free of black necrotic stains or trails
- ✓ Free of marked bruising
- ✓ Free of abnormal external moisture, excluding condensation following removal from cold storage
- ✓ Free from damage caused by low or high temperature
- ✓ Free of any foreign smell and / or taste
- ✓ Free of damage caused by pests
- ✓ Sufficiently developed and of satisfactory ripeness
- ✓ If peduncle, then not longer than 1.0 cm
- ✓ Comply with the residue levels of heavy metals, pesticides and other food safety parameters as laid down by the Codex Alimentarius Commission



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According to size before packaging of the fruits plays an important role to obtain fruits with a uniform ripening period. During grading, any remaining immature, overripe, damaged and diseased fruits should be sorted-out.

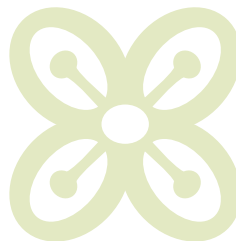
According to Codex standards, good quality mango fruits should be; (i) whole, firm, sound and fresh in appearance; (ii) clean, practically free of any visible foreign matter; (iii) free of black necrotic stains or trails; (iv) free of marked bruising; (v) free of abnormal external moisture, excluding condensation following removal from cold storage; (vi) free from damage caused by low / or high temperature; (vii) free of any foreign smell and / or taste; (viii) Free of damage caused by pests; (ix) Sufficiently developed and display satisfactory ripeness; (x) When a peduncle is present, it shall not be any longer than 1.0 cm. (xi) comply with the residue levels of heavy metals, pesticides and other food safety parameters as laid down by the Codex Alimentarius Commission.

## 4.7 Cooling

After curing, fruit for export should be cooled to 12–13 °C, in 85 to 90 per cent relative humidity, as soon as possible after curing until shipping. Cooling removes field heat from harvested fruits, which helps in stabilizing the metabolic process, suppresses enzymatic degradation, slows or inhibits water loss (wilting), slows or inhibits the growth of decay-causing microorganisms (moulds and bacteria) and reduces production of ethylene (a ripening agent).

Different cooling methods are used prior to shipping. Packed and palletized mangoes should be cooled as quickly as possible to their optimum shipping and storage temperature (12 °C [54 °F] for mature green mangoes). Temperatures below 12 °C expose the mangoes to chilling injury.

- › **Room cooling.** Rapid cooling requires good contact between the refrigerated air in the postharvest environment and the product in the package. Heat transfer in room cooling is achieved by cold, refrigerated air coming into contact with exposed pallet surfaces, with the heat from the interior of the pallet slowly transferred by conduction to the surface. Thus, room cooling is a relatively slow cooling method that typically requires 24 to 48 hours for palletized mangoes.
- › **Forced-air cooling.** It is recommended that mangos be forced-air cooled in order to remove heat from the fruit as rapidly as possible. Forced air (or ‘pres-



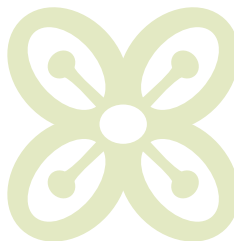


sure') cooling improves heat transfer compared to room cooling by creating a pressure differential from one side of a pallet to the opposite side that pulls the cold, refrigerated air through the ventilation holes in the cartons, directly past the fruit within the pallet. Properly designed forced-air cooling systems are capable of reducing mango flesh temperatures from an initial range of 30 to 40 °C (86 to 104 °F) down to around 12 to 15 °C (54 to 59 °F) within 2 to 4 hours.

- › **Hydrocooling.** Hydrocooling involves immersing or drenching the fruits in cold water to remove heat. Although hydrocooling cools faster than forced-air cooling, it is not typically used to cool mangoes prior to shipping due to logistical and sanitization management challenges. Hydrocooling presents several logistical challenges. Water sanitation, e.g. with chlorine, is critical to avoid transfer of decay pathogens between fruit. Hydrocooling must either be applied before packing, in which case the fruit must be thoroughly dried prior to packing, or the fruit to be hydrocooled must be packed in water-resistant shipping cartons.

## 4.8 Ripening

Mango fruits may be picked early in the season (premature stage) to capture early market and to allow long transportation, e.g. if by sea. Mangoes which are airfreighted can be picked and transported at a riper stage compared to those exported by sea. Mangoes harvested before ripening are normally subjected to artificial ripening. Under conventional production, many ripening aids are used, for example, ethylene, and acetylene gas or calcium carbide treatments. The spray of calcium in conventional mangoes has been found useful in delaying ripening of mangoes hence extend the shelf life. In organic mango production, however, the use of ripening treatments is restricted, rather fruits are encouraged to be picked at near or peak maturity to allow natural ripening especially for the domestic fresh mango market or processing purposes. Since mangoes intended for export are picked before ripening, artificial ripening with ethylene (ethylene C<sub>2</sub>H<sub>4</sub>) is allowed according to the EU Reg. It is important to note that acetylene (ethylene C<sub>2</sub>H<sub>2</sub>) is not listed in Annex II of the EU Regulation and therefore prohibited.



### Ripening Protocol:

- › Before ripening begins, the fruit pulp temperatures should be raised to 68 to 72°F (20 to 22°C). Once the fruit pulp temperature stabilizes, apply 100 ppm ethylene for a minimum of 12 hours. Actual time of exposure to ethylene is determined by the maturity of the fruit; a slight change in fruit color indicates that the mangoes are producing ethylene and the external ethylene source is no longer needed.
- › Humidity is very important and it should be maintained at 90–95%.
- › Carbon dioxide will build up during ripening. If no automatic ventilation system is in place, then be sure to vent the room approximately every 12 hours by opening the doors for 20 minutes even while applying ethylene. The actual CO<sub>2</sub> level must be kept below 1% for proper ripening. After ethylene application, keep pulp temperature at 65 to 72°F (18 to 22°C) until desired level of ripeness is attained (typically 5–9 days). Then store ripened mangoes at 50 to 55°F (10 to 13°C) in a high humidity environment and ship to final destination soon.

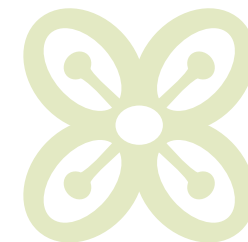
## 4.9 Packaging

Packaging is an important component of the postharvest operations for mango. Mango fruits are delicate, especially when they are ripe. They are prone to different types of damage such as compression, skin bruising, and should therefore, be well packaged for proper transportation to the market. Mangoes-for-export are normally packaged in single layers (to avoid compression) in rigid packages made of safe and good quality cardboard material. Exporters have different types of packages – the sizes of packages depend on market/customer specifications. For the local markets, the fruits can be arranged in larger boxes or plastic crates, depending on the market to be supplied.



### Mango handling for fresh fruit market






Select two participants – one to describe how he/she handle mangoes for local fresh market, and another for the fresh export market. Sketch the process on the flipchart or blackboard. In a brainstorming session, identify risks to mango quality at every stage and discuss how they can be mitigated. Conclude by agreeing on a preferred handling process agreed upon by all participants.





## EMPLOYEE SANITATION PRACTICES CHECKLIST

### Employee sanitation practices checklist




	Provide access to restroom facilities, soap, single-use paper towels, and clean water at all times.		Monitor workers to ensure proper use of facilities. Hand-washing stations located outside of restrooms can aid supervisors in ensuring employee hygiene.
	Provide a place for workers to remove aprons, hair covers, and/or gloves and store them outside of the restroom.		Do not allow injured or ill workers to handle fruit.
	Instruct workers to wash hands before and after eating, smoking, or using the restroom.		Do not allow workers to sit or stand on fruit handling containers and surfaces that will get into contact with fruit.

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## PACKINGHOUSE EQUIPMENT AND FACILITIES SANITATION

### Packinghouse equipment and facilities sanitation checklist

	Clean and sanitize harvesting crates, packing line equipment, refrigeration units, trucks, and other equipment prior to use. Use a chlorine solution of 200 ppm (parts per million) that is between 25 and 43 °C (77 and 110 °F) and adjusted to pH 7 with citric or acetic acid for sanitization.		Exclude pets, rodents, birds, and insects from storage and enclosed work areas.
	Physically separate mangoes that have gone through the packing line from the rest of mangoes. Separate mangoes from any other materials like chemicals, or any other potential contaminants.		Do not transport soil, manure, chemicals, livestock, or other animals on trucks that are used to carry mangoes.

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## 4.10 For large scale operations – sanitation of workers, packinghouse facilities and equipment is important

Packinghouses should conduct regular worker training at the beginning of each harvest season. Workers inspecting and handling mangoes must be trained and must adhere to proper hand-washing and sanitizing procedures. A program of regular training (and retraining, as needed), along with monitoring by supervisors to ensure compliance, is an important management practice to ensure fruit quality and safety. Workers should understand how careless handling of mangoes can cause stress and injuries that can reduce fruit quality during marketing. Workers should also understand how personal and facility cleanliness reduce the risk of fruit contamination, which can have devastating consequences for the business and their own jobs.

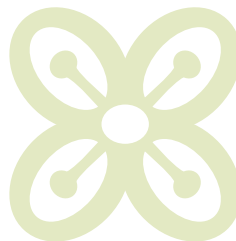
Cleaning and sanitizing packing line equipment is critical. Just one source of pathogen introduction, at any point, can potentially inoculate all fruit that passes through the line. Cleaning means physically removing debris, biofilm buildup, and any other residuals on the line. This is done with detergent and physical labor (such as scrubbing or a pressure washer). Sanitation involves using sanitizers like chlorine or quaternary ammonia to kill microbes on clean surfaces. Sanitation is not effective until after a surface has first been cleaned. Regular cleaning and sanitation greatly reduces opportunities for pathogen buildup and inoculation to occur. Many steps can easily be overlooked during cleaning. Here are some key points to remember:

- › Remove debris accumulation from all surfaces,
- › Clean all surfaces that fruit or employees may contact, including benches, table tops, drains, walls, cooler coils, ceilings, etc., as appropriate,
- › Clean using a top-to-bottom method to avoid re-soiling already clean surfaces,
- › Never put fruit that have fallen from the handling line back into circulation,
- › Have waste bins available for employee use; regularly empty and clean them.



### Note

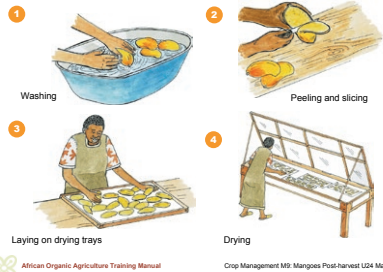
Check the following publication:  
<http://ucce.ucdavis.edu/files/datastore/234-1904.pdf> for some details.





## FRUIT DRYING AT FARMER LEVEL

### Mango fruit drying at farm level



## 5 After-harvest handling of mangoes for dried fruit market

In most cases, there are harvested fruits which do not meet the fresh mango market requirements due to size or minor bruises, but still useful for processing. To avoid wastage, farmers may dry the mangoes so that they can sell them on the dried fruit market. Fruit drying is a process whereby mangoes are dried to a certain moisture level where they can be stored for a longer time. However, the quality of the dried mangoes will depend on how the process of drying is done. Many technologies for fruit drying are available, ranging from simple plastic tunnel driers to stainless steel cabinet driers.

Mango for drying should be harvested at a more ripe stage than mango for fresh fruit market, that is, when the fruit has started showing visible signs of ripening ( $\frac{1}{4}$  to  $\frac{1}{2}$  ripe). Mangoes harvested before this stage will not ripen well and the dried product will be whitish, acidic and slightly sweetened. Very ripe mangoes are also very susceptible to damage and fermentation during transport and storage, leading to off-flavours and darkening in colour during drying. The Kent and Amélie varieties are particularly sensitive to damage during transport and storage.

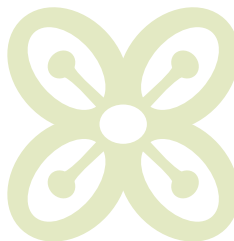
At the processing unit, the mango drying process is done as follows:

### 5.1 Reception and storage

Upon receipt, a first sorting is carried out to separate the mangoes according to the variety and the degree of maturity. Afterwards, depending on their degree of maturity, the mangoes are left, often in crates, but covered with for example a black plastic, to ripen further.

### 5.2 Sorting and washing

Depending on the harvesting stage, mangoes commonly ripen at different rates. Therefore daily sorting of mangoes in stock is done to select sufficiently ripe mangoes for processing – only the fresh, fully ripened and unfermented fruit is good for drying in order to produce the aroma, colour and sweetness desired by the market. Overripe and/or rotten mangoes do not dry well.





## HANDLING MANGOES FOR DRYING AT DRYING FACILITY

### Handling mangoes for drying



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The ready-to-dry mangoes are then washed in clean water to remove any dirt and contaminations on the fruit skin. Equally the work space, knives, tables, containers and staff handling the process should be clean, as per the packhouse requirements for fresh mangoes indicated in the slide.

### 5.3 Peeling and slicing

The skin of the fruit is removed manually with a stainless steel knife on tables with holes to directly remove the waste. The peeled fruits are then cut into similar sized pieces and laid out to dry in thin layers on drying racks. The slicing of mangoes is done manually according to the customer's specifications – in whole patties, slices or pieces. The slices or pieces are made by different people and may not always be homogeneous. There is no other pre-treatment accepted in organic production.

### 5.4 Drying

The racks loaded with fruit slices or pieces are laid into the dryers at temperatures between 50 and 60 °C.

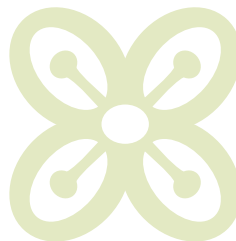
### 5.5 Sorting and packaging

The dried fruit (12–15% moisture content) is hand-removed from the racks and sorted again to remove skin remnants and discoloured fruit, before they are packed. Well dried fruit should have good colour (yellow to orange depending on the variety), strong flavour and low stickiness. Poorly dried fruit will have irregular colour with brown/black patches, lack of taste, and too dry or hard. Dried mangoes are then packed in bigger bulk packs (1 to 2 kg) and kept in a dry cool store at room temperature, awaiting final packaging according to customer specifications. Generally, mango fruit drying specifications and packaging will depend on the specific target market.



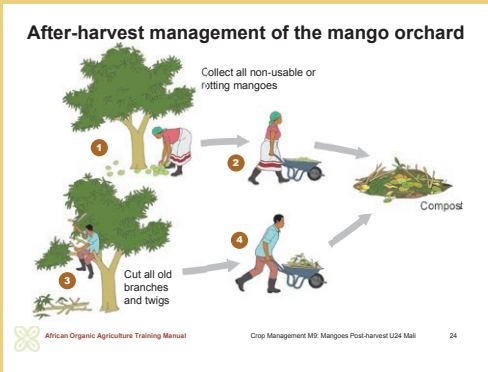
### Mango handling for drying

Select a participant (involved in fruit drying) to describe how he/she handles mangoes for drying. Sketch the process on the flipchart or blackboard. In a brainstorming session, identify risks to mango quality at every stage and discuss how they can be mitigated. Conclude by agreeing on a preferred handling process agreed upon by all participants.





## AFTER-HARVEST MANAGEMENT OF THE ORCHARD



## 6 After-harvest field management

Immediately after the harvesting season is completed, the mango orchard needs proper cleaning in preparation for the next season. This is done by;

- › Pruning of old, weak, shading or broken branches and twigs,
- › Removing all fallen fruits from the ground and taking them to the composting site.
- › Trimming or slashing of the grass around the trees, which provide good habitats for various pests, including the fruit fly.

### Sources and further reading

Infonet Biovision: <https://www.infonet-biovision.org/PlantHealth/Crops/Mango>

FAO: Mango Post Harvest Operations: [http://www.fao.org/fileadmin/user\\_upload/inpho/docs/Post\\_Harvest\\_Compndium\\_-\\_Mango.pdf](http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compndium_-_Mango.pdf)

The World Bank: Growing Mali's Mango Exports: [http://siteresources.worldbank.org/AFRICAEXT/Resources/258643-1271798012256/Mali\\_Mangoes\\_Success.pdf](http://siteresources.worldbank.org/AFRICAEXT/Resources/258643-1271798012256/Mali_Mangoes_Success.pdf)

Organic mango production: strategies and methods. Government of Western Australia. Department of Primary Industries and Regional Development. Agriculture and Food. 15th March. 2018. <https://www.agric.wa.gov.au/mangoes/organic-mango-production-strategies-and-methods>

