TRAINING MANUAL FOR AGROECOLOGY BUSINESS ACTORS IN MANGO VALUE CHAIN

PRODUCED BY: THE CGIAR INITIATIVE ON AGROECOLOGY, KENYA

December 2024

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INTRODUCTION

Agroecology is sustainable farming that works with, not against, nature. It explores interactions between plants, animals, humans and the environment within agricultural systems. Agroecology promotes application of ecological principles to agricultural systems, focusing on the sustainable management of natural resources and biodiversity (Vikas & Ranjan, 2024; Wezel et al., 2020; Sinclair et al., 2019). Agroecology blends science, practice, and social movements to design and manage sustainable farming systems that are environmentally sound, economically viable, and socially just. Vested on13 principles, agroecology aims to address challenges facing agriculture and food systems in a myriad of ways (HLPE, 2019). These involve enhancement of soil health, conservation of biodiversity, increasing climate resilience, reduction of environmental degradation, promotion of food security and nutrition, supporting smallholder farmers, encouraging social and economic equity, and fostering circular economies, among others.

This manual was produced to help promote scaling of agroecological principles, under the Accelerator Program of the CGIAR Initiative on Agroecology. Through the program, agroecology experts from the Initiative collaborated with the private sector partners in the input and output segments of the mango value chain in Makueni County, Kenya, and trained 100 Trainers of Trainees (ToTs). The training covered diverse topics included in this manual. Each ToT was provided with material to train 20 trainees mostly mango producers, ultimately resulting to about 2000 people trained on agroecological practices in Makueni County.

This manual can be used by others to promote scaling of agroecological interventions under different contexts, through trainings, knowledge sharing and dissemination, scaling and adaptation.

The manual covers several sections. The first part gives a general introduction to agroecology, which details its 13 principles, practices, transition levels and exclusion criteria for non-agricultural practices. In the second section, the manual covers good agriculture management practices, touching on environmental management, farm management, food safety and post-harvest handling. The manual also introduces the trainees to the Integrated Soil Fertility Management (ISFM), Integrated pest management (IPM), preparation of compost manure and neem concoction for pest control, alongside understanding plant nutrients in the soil and identification of their crop deficiency symptoms. The manual further provides details on planting and management of fruit trees, pests and diseases, mango fruit fly, and proper harvesting, handling and storage of mangoes. Finally, the manual introduces agroforestry, reforestation and restoration, as well as introducing trainees on the inputs and output markets for mangoes.

INTRODUCTION TO AGROECOLOGY

Introduction

Agroecology is the study of interactions between plants, animals, humans and the environment within agricultural systems. It is a combination of science, a set of practices and social movement geared towards transformation of food and agricultural systems through optimization of interactions between plants, animals, humans and the environment.

- **As a science**, agroecology investigates the ecological processes and interactions in agricultural lands. It integrates ecology of food systems, agroecosystems, plots, fields and herds.
- **As a set of practices,** agroecology entails the integration of technologies or sustainable practices.
- **As a social movement**, agroecology entails sustainable agriculture, environmentalism and rural development aspects

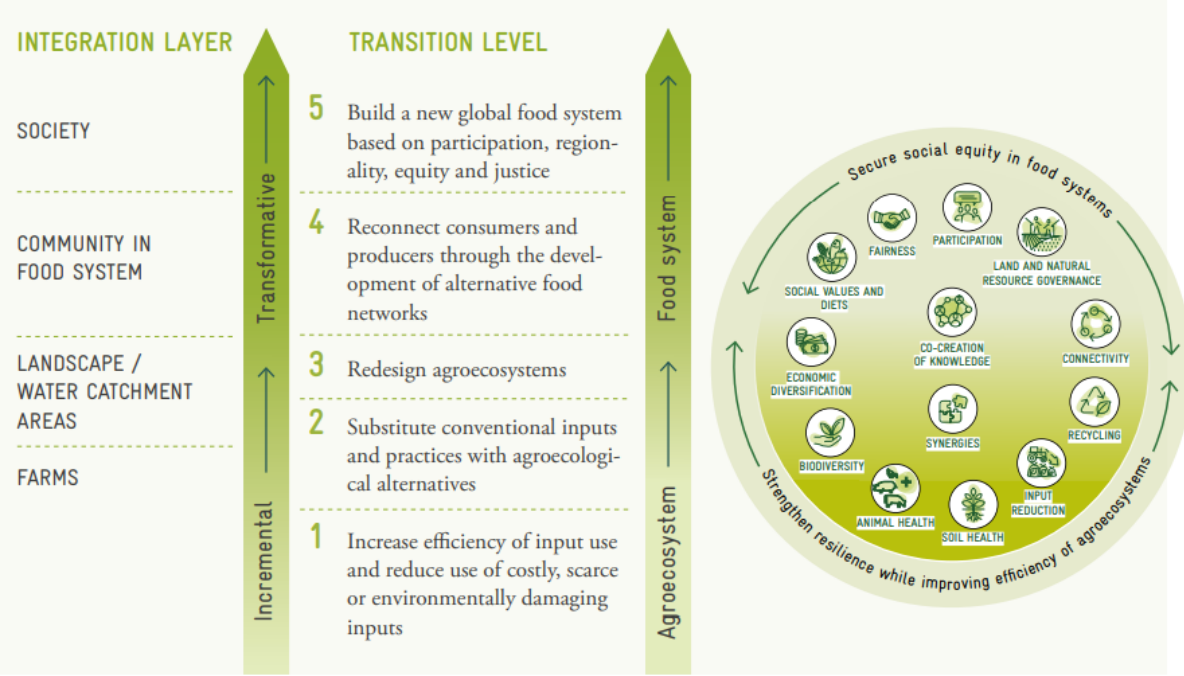
An intervention is considered **agroecological** if it **adheres to the 13 principles** and meets the **internally agreed exclusion criteria**.

The 13 Principles of Agroecology

Agroecology is anchored on **13 principles** (HLPE, 201**9),** each with certain practices that foster adoption of holistic approach to sustainable food and agricultural systems.

1. **Recycling**: Preferentially use local renewable resources and recycle nutrients and biomass
2. **Input reduction:** Reduce or eliminate dependency on purchased inputs and increase self-sufficiency
3. **Soil health:** Secure and enhance soil health and functioning
4. **Animal health:** Ensure animal health and welfare.
5. **Biodiversity:** Maintain and enhance diversity of species, functional and genetic diversity
6. **Synergy:** Maintain ecological interactions
7. **Economic diversification:** Diversify on-farm incomes
8. **Co-creation and sharing of knowledge:** Enhance co-creation and horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange
9. **Social values and diets:** Build food systems based on the culture, identity, tradition, social and gender equity of local communities
10. **Fairness:** Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment and fair treatment of intellectual property rights.
11. **Connectivity:** Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.
12. **Land and natural resource governance:** Strengthen institutional arrangements to improve, including the recognition and support of family farmers, smallholders and peasant food producers as sustainable managers of natural and genetic resources.
13. **Participation:** Encourage social organization and greater participation in decision-making by food producers and consumers

AGROECOLOGICAL PRACTICES, EXCLUSION CRITERIA AND TRANSITION LEVELS OF AGROECOLOGY

The exclusion criteria	**Agroecological practices**	**The five transition levels of agroecology**
To be termed agroecological, a practice/ project cannot: i. Focus on the introduction of GMOs and associated genome-editing technologies, ii. Focus on the promotion of synthetic fertilizers and pesticides, iii. Focus exclusively on promoting large scale single cash crop production at the expense of diversified strategies, iv. Focus exclusively on productivity resulting in avoidable destruction of vital eco systems and their functions and services, v. Promote regulations and/or actions that hamper and/or destroy local and farmer managed seed systems, vi. Focus on large-scale intensification of animal production, vii. Exclude or actively discriminating against women and other marginalized groups, viii. Focus exclusively on promoting highly processed or industrially produced food (with low nutrient value), ix. Promote extractive raw material production that depletes local resources over time, x. Promote approaches that violate rights, including customary rights, ignoring prior informed consent or results in population displacement and/ or land grabbing	• Crop Rotation and Diversification • Agroforestry • Conservation Agriculture (No-Till Farming) • Cover Cropping • Biological Pest Control • Integrated Pest Management – IPM • Composting and Organic Fertilizers • Sustainable Livestock Integration • Permaculture • Polyculture • Integrated Nutrient Management • Soil Conservation • Water Conservation • Livestock Integration	Level 1: Increase resource efficiency to reduce the use of scarce, costly and/or environmentally harmful external inputs. Level 2: Substitution of conventional inputs and practices by agroecological alternatives. Level 3: Redesign of agroecological systems so that they function based on ecological processes. Level 4: Re-establish a more direct connection between food producers and consumers and develop alternative food networks. Level 5: Build a new global food system, based on equity, participation, fairness, justice and regionality. 

GOOD AGRICULTURAL MANAGEMENT PRACTICES

Good Agricultural Practices (GAPs) are principles, standards, and codes of practice that address environmental, economic, and social sustainability for on-farm production and post-production processes. In agroecology, GAP practices are important linkages in ensuring production of safe and healthy foods while protecting the environment and ensuring social and economic viability. The GAPS under the following sections should be observed:

Good Agricultural Practices (GAPs)

1. **Environmental Management and Conservation.** The following apply:

i. **Water Management:** Use **drip irrigation** to reduce reduces water use when possible; **Harvest rainwater** in reservoirs for use during dry periods.

ii. **Integrated Pest Management (IPM);** Use **natural predators** like ladybirds, Syrphid fly larvae, Green lacewing larvae and Damsel bugs to feed on aphids, mealybugs, thrips, spider mites, caterpillars, leafhoppers among others. Alternate pesticide use to reduce resistance buildup. Use **parasitoids** like ***Trichogramma* wasp** that attacks eggs of pests of more than 200 pest species preventing from hatching.

The principles of IPM: monitoring pests, using biological control, cultural practices, and chemical control as a last resort. IPM has environmental, economic, and health benefits.

Pests: insects, weeds, etc; understand their life cycle for effective management.

Control strategies: Cultural, biological, mechanical, behavioral, chemical (last resort)

Safe pesticide use: Understand labels, have personal protective equipment, properly store, handle, dispose chemicals.

iii. **Integrated Soil Fertility Management;** do soil testing; practice crop rotation, use quality seeds, mulch, organic inputs, residues, compost together with other inputs

2. Farm Management: The following apply:

Irrigate when necessary.
Establish a monitoring system for pests, diseases, and soil conditions. Keep detailed records of all farm activities.

Types of records to maintain:

Planting (date; variety, location, spacing); growth and maintenance (fertilization, pruning, pest/disease control, irrigation); Harvest (dates, quantity; quality); post-harvest (sorting and grading; packaging); Financial records (expenses, income; profit, loss); Market (sales, prices, etc)

3. Food Safety and handling. Observe the following:

***Pre-Harvest Practices:** Do not apply pesticides close to harvest time; Follow recommended pre-harvest intervals to ensure that pesticide residues on vegetables are within acceptable limits; Inspect for signs of pests or diseases regularly.

***Harvesting:** Harvest vegetables at the right time, preferably early in the morning or in the evening. Be careful not to break or bruise them. Harvest those of good quality. Follow proper harvesting intervals of harvesting, preferably two-week intervals.

4. Post-harvest handling. Do cleaning to remove dirt and residues from vegetables. Sort and remove damaged, diseased or rotten leaves if any; Properly package, avoiding breaking the leaves and use appropriate mode of transportation.

COMPOST MAKING PROCEDURE

Make 3 rectangular pits (150 cm x 150 cm x 30 cm; L,W,H)
Arrange the materials in layers from the bottom as follows; start with thick fibrous materials e.g dry twigs (10cm); dry vegetation e.g grass (10 cm); decomposed manure (2 cm); sprinkle wood ash; green leguminous material (15-20 cm); topsoil (2 cm).

Sprinkle water after every layer added. Repeat the entire process until the heap is about 150 cm. Put a final layer of topsoil (5cm), cover entire heap with dry vegetation like banana leaves and insert thermometer stick. Turn over the compost to the second pit after 2-3 weeks and to the third pit after 2-3 weeks again. Store compost well and apply appropriately to the crops.

PREPARATION OF PLANT CONCOCTIONS

Gather green leaves from your preferred plant. Pound the leaves in a mortar. Mix the plant infusion with 10g non-perfumed soap solution; cover tightly and let it rest in a cool place for 24 hours. Dilute the infused plant material by mixing in an equal amount of water (5 litres), shake well and strain/sieve before use (Use kitchen sieve or muslin cloth to eliminate any leaf particles)

Procedure for Making Neem concoction

- Weigh 2 kg of fresh succulent leaves
- Crush them well using paste and motor
- After crushing, put the crushed materials in a bucket
- Add 5 liters of cold water and stir
- Prepare foam bubbles using 10g of bar soap in 1 liter of cold water. The soap should not have a scent.
- Mix the 5 litres of water with 1 litre of neem leaves and 1 litre soap bubbles in a bucket
- Cover the bucket and keep the mixture in a cool place for 24 hrs.
- After 24hrs remove the lid, shake well, add 5 litres of cold water, and stir well.
- Sieve the mixture before use.
- The lifespan is 7 days after preparation.

Planting and management of fruit trees

(A) Planting grafted mango seedling

1.**Required materials:** Assemble all the necessary materials and equipment; grafted mango seedling(s) manure and/or fertilizer, watering can with water, spade and a hoe (jembe).

2.Selection of seedlings for planting: Identify and select seedlings that are healthy and big enough. Selected seedlings lack signs of pests and diseases

Transportation of seedlings for planting: Don't pile them up on each other; transport upright in boxes, plastic crates or bags. Water the selected seedling before transporting

Land preparation and planting: Ideal climate ranges from the humid tropical to the semi-arid sub-tropical.

3.Spacing varies with variety and growing environment (dry and wet zone). Spacing is 10 m x 10 m (dry zone) or (12m x 12m) (wet zone).

4.Planting holes should be dug (1m x 1m x 1m); before the onset of a rainy season, observing tree canopy and soil fertility of the area

5.Planting: Holes refilled with a ¼ of the topsoil; soil mixed with manure (at ratio 3:1). Polythene bag removed, seedling carefully removed; placed at the centre of the hole, half filled with topsoil, pressed gently, filled with water and finally filled completely with soil. Do not remove soils around the roots.

Make a basin around the base of tree by gently pressing down the soil around the seedling.

The basin will help hold the water after watering.

Ensure that the seedling remains upright just as it was in the polythene tube in the nursery. Apply a mulch layer under young trees. Mulch provides organic matter (a valuable source of tree nutrients and food for beneficial soil micro-organisms), reduces moisture loss and competition from weeds.

(B).Management of the planted seedlings

Irrigation: Watering should be done immediately after planting in the field to foster proper establishment. If possible, you can water the mango tree at intervals of 8-12 days from when it starts to produce flowers to maturity to attain higher yields.

Pruning and training: The height and form of the fruit tree needs to be controlled. This is meant to guide the tree and facilitate its harvesting during the later stages. It is advisable that you carry out pruning in the first year to guide the tree into the desired shape, and when tree is about 1 m from the ground, cap the seedling (by limiting the upward growth of the tree) to encourage side branches. Carry out pruning later for proper tree maintenance (should be carried out after fruit harvest). Control the height to about 3.5 m and all branches at knee level (about 0.5 m) should be pruned. Remove all dead branches to allow sunlight through the canopy to the ground

Flowering and fruit formation

Grafted fruit trees usually start to flower within two years from planting. However, fruit formation should be discouraged at this stage as it can affect growth of the fruit tree. For grafted mangoes; it is advisable that fruit formation is allowed from the fourth year onwards.

Integrated Soil Fertility Management (ISFM)

ISFM is a set of agricultural practices that combine the use of mineral fertilizers with organic inputs and improved crop management practices to enhance soil fertility and increase productivity. It entails:

1. Soil fertility assessment: soil testing (physical) or (chemical; pH and nutrients); identification of symptoms and remedy of common nutrient deficiencies.

2. Organic inputs management: Composting, use, storage; use of green manure and cover crops; FYM, etc

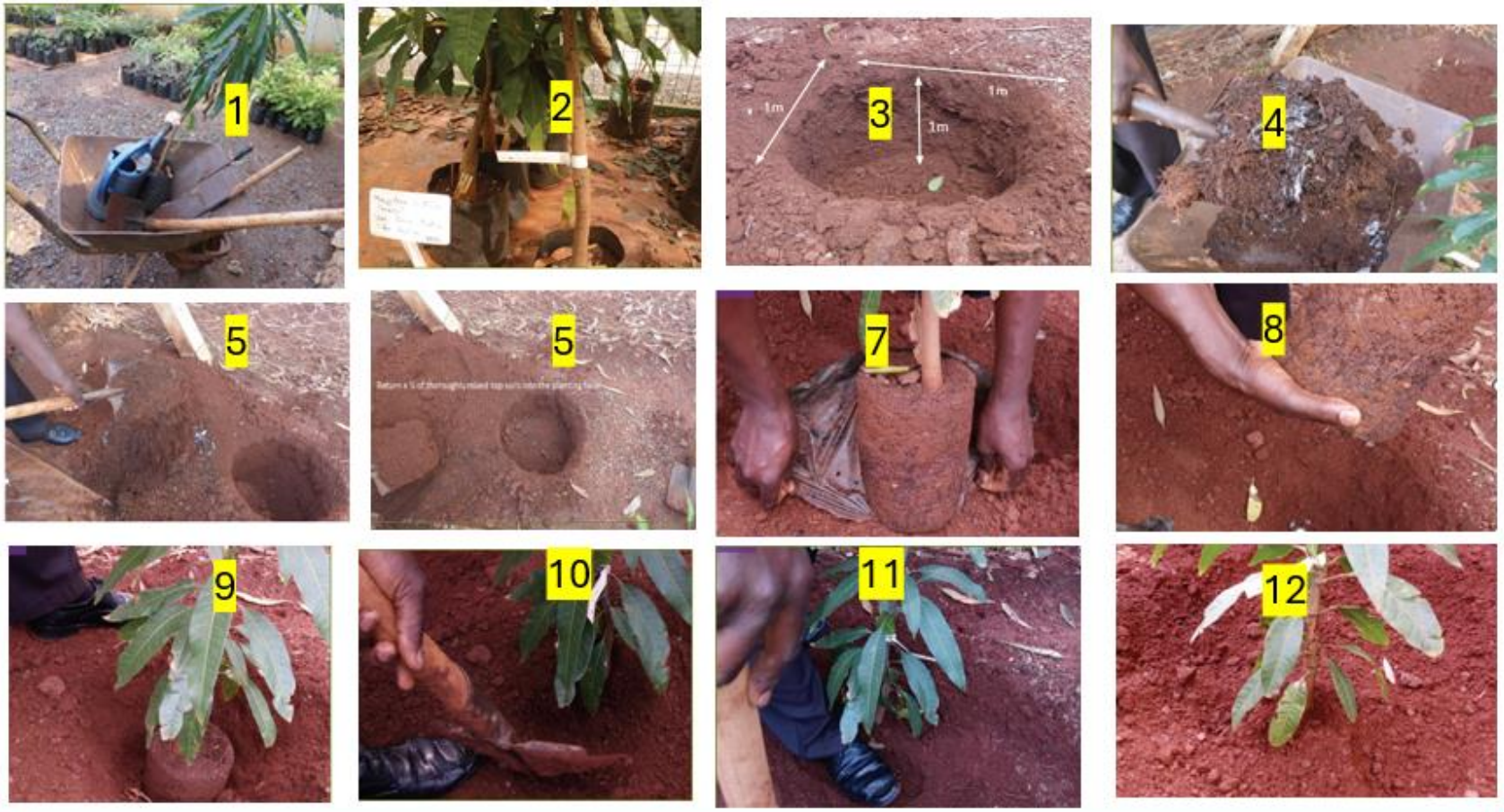
3. Efficient fertilizer use: Choose appropriate type of fertilizer based on soil needs; Use the right source, rate, placement method and right time

4. Agroecological Practices: Crop rotation, mulching, intercropping, minimum tillage, residue retention, CA

5. Soil and water conservation techniques: terracing, contour farming, mulching, water harvesting, etc

6. Integrating livestock with crops: Manure here enhances soil fertility while crops provide animal feed, thus maintaining the animal health and productivity.

Pictorial guide for planting of tree seedlings

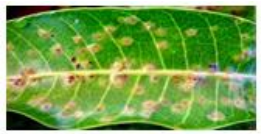


1. Assemble all the required materials and equipment **2.** Select a healthy seedling. **3.** Dig a hole 1m x 1m x 1m. **4.** Use manure or fertiliser to plant. **5.** Mix the soil thoroughly with manure at a ratio of 3:1 **(6).** Return ¼ of the thoroughly mixed topsoil into the planting hole. **7.** remove the polythene by tearing as shown, making sure not to disturb the soils at the root of the seedling. **8.** Seedling is ready to be transplanted. **9.** Place the seedling at the centre of the hole. **10.** Place the soils back in the hole all around the seedling ensuring the roots are covered properly. **11.** Firm the soils at the base of the seedling. **12.** Firm the base of the seedling into a well or basin shape so that it can hold water

Pest management in mangoes

1. Mango fruit fly

2.Mango gall flies

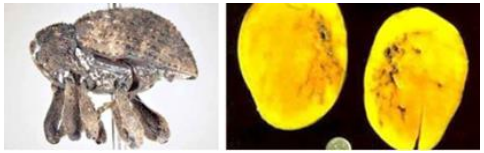


3.Whiteflies and black flies

4.Mango aphid (*Toxoptera odinae*)

5.Mango seed (Stone) weevil

6.Mango Pulp Weevil (*Sternochetus frigidus*)



7.Mealybugs

8.Thrips (*Selenothrips rubrocinctus)*

9.Bugs

10.Scale insects

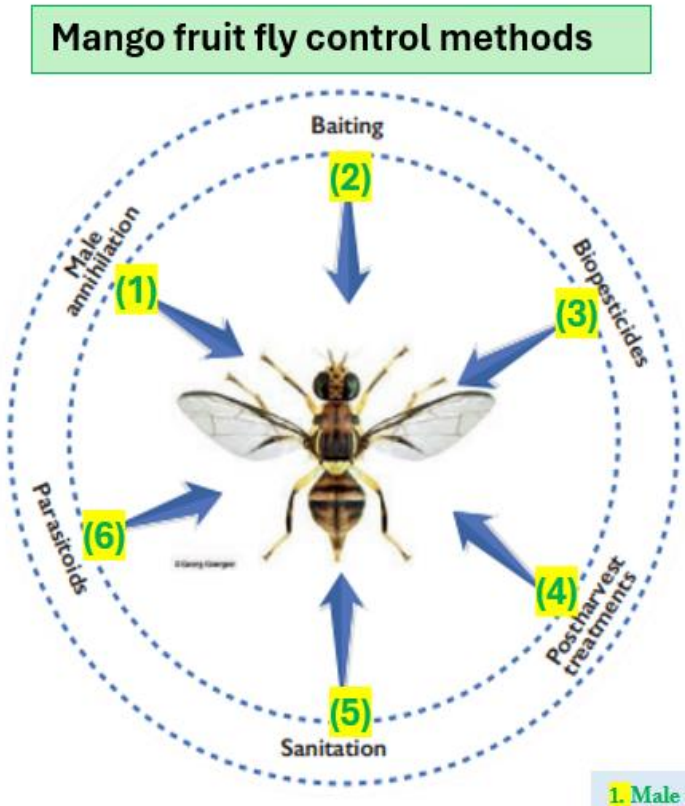
11.Termites

12.Leaf coating mice

General agroecological mango pest control methods

- Conserve natural enemies e.g parasitoids **(All)**
- Regular orchard sanitation **(1)**
- Using bait traps; protein based and male annihilation traps **(1)**
- Using biopesticides **(All)**
- Regular poison-bait applications (organic fruit-fly attractant) **(1)**
- If needed, apply biopesticides e.g. neem extracts, which inhibit the growth and development of immature stages, repel adult whiteflies, and reduce egg laying **(3)**
- Use of sticky traps and maintain hygiene/sanitation **(1)**
- Ensure proper weed control **(All)**
- Practise crop rotations with non-host plants **(All)**
- Prune excess branches **(All);**
- Ensure a proper nutrition to improve plant vigour **(10)**
- In cases of heavy infestations, flood soil around the tree before flowering **(2)**
- Keep orchards clean by collecting, burying, or burning fallen fruit and plant material **(All)**
- Use sticky bands on the trunk to prevent weevil migration, though they may still fly and infest trees **(5)**
- Regularly inspect fruits for egg-laying marks and destroy affected fruits and weevils in mango seeds **(5)**
- Hand pick and kill bugs regularly **(9)**
- Tree smoking may help against bugs **(9).**

The Mango Fruit Fly Management Techniques



1. **Male annihilation technology:** Use fruit fly traps to "attract and kill males" controlling their population by reducing mating with females.
2. **Protein baits (Fruit Fly Mania):** These are put in traps and produce smells/odors, attract fruit flies, they drown and die in the baits.
3. **Biopesticides:** Fungal (Metarhizium anisopliae) based biopesticide e.g Campaign™ (from real**IPM**) can be applied around mango canopy.
4. **Post harvest treatments** e.g., Hot Water Treatment kills all stages of development of fruit flies and ensures that mangoes are free of fruit flies.
5. **Sanitation:** Fallen mango fruits should be collected and disposed appropriately.
6. **Parasitoids:** These are natural enemies of fruit flies (like wasps e.g., *Fopius arisanus* and *Diachasmimorpha longicaudata*) that control the eggs, the maggots, or even the adult insect pests. Parasitoids only attack fruit flies, but don't attack crops, livestock, humans or any beneficial insects e.g. bees. They are susceptible to synthetic pesticides.

Diseases management in mangoes

Diseases	Description	Organic control methods
1.<u>Anthracnose (*Colletotrichum gloeosporiodes*)</u> 	• Caused by the fungus *Colletotrichum gloeosporioides* • Symptoms involve minute brown or black spots on flowers and panicles. • Infected flowers die before fruit set. • Young fruits are readily infected; black spots on nearly mature/ripe fruits with surface cracks leading to rotting.	• Orchard sanitation and pruning of dead twigs and branches **(1,3).** • Supplementary spray applications with Organic Copper **(1,3).** • Spray at flower-bud formation, fortnightly until fruits are half-grown, then monthly. Full cover spray needed for first two applications **(1)**. • Combined fungicide/insecticide treatments needed to counter powdery mildew and mango weevil during critical stages **(1).** • Monitor for the disease weekly **(1,2,3).** • Use tolerant varieties (**1, 3**) • Avoid overhead irrigation **(All)** • Improve orchard air circulation **(All).** • Use disease free seedlings **(All)** • Monitor for the disease weekly **(All)**
2.<u>Powdery mildew (*Oidium mangifera*)</u> 	• Affects leaves, buds, flowers, young fruits; • Infected tissues are covered in a whitish, powdery fungal growth • Spores are spread by wind or remain dormant until favourable conditions arise. • Prevalent under cool, cloudy, warm, and humid climates	
3.<u>Bacterial black spot</u> 	• **Spread by r**ain splashes and planting infected planting material • Infection caused by small wounds from wind or rain that make plants vulnerable. • **Leaf symptoms** include dark, shiny, angular spots, bordered by veins. • **Fruit Symptoms**: Water-soaked spots on fruits turn black, eventually cracking in a star pattern and exuding gum in wet conditions.	

Mango Harvesting, Handling and Storage

Mango harvesting, handling and storage

1. Getting ready to harvest mangoes: Take all the necessary equipment and facilities needed to harvest. Ensure the tools are regularly cleaned and sanitized. Regularly clean and sanitize the crates used for transporting mangoes. Discard or repair any broken containers or tools to prevent contamination. Maintain personal hygiene, take bath, maintain short fingernails, wash hands with soap after visiting toilet, Cover wounds on the hands/fingers using bandages. Ensure accessible toilet and handwashing facilities for workers in the fields, located safely away from the mango orchards to prevent contamination. Remove any foreign objects like glass, metal, or stones from the field to ensure the safety of the mangoes.

2. Mango Harvesting: Harvest using tools that cut and hold fruits from the top. Do not harvest when it is raining, or in rainy conditions. Harvest fruits early in the morning or late in the afternoon. Harvest the fruits along with about 4-inch pedicles/stalks to restrict sap that may burn the fruits. The longer the pedicle, the better. Carefully place the harvested fruits vertically in crates. Only harvested fruits should be taken. Do not pick fruits that have fallen on the ground by themselves. Place the harvested fruits under shade and cover crates to protect from injuries caused by heat. Use different colours for crates with fruits for processing (preferably blue) or rejected fruits (preferably red crates). Use purified water with Chlorine to wash harvested mangoes and remove excess dirt before processing.

3. Transportation to the pack house: Ensure vehicles used are clean, free of bad odours or contaminants that could affect the mangoes during transit. Carefully load the fruits in the crates, leaving small space at the top. Use clean, sanitized crates to carry mangoes during transportation. Carefully load the crates on the vehicle and cover the crates to avoid dust and exposure to direct sunlight. Transport the fruits from the field to the storage facility as soon as possible. Ensure the vehicles are driven at the appropriate speed, observing the road conditions to avoid bundling of bins and fruits. Drivers should often check tyre air pressure, keeping them well balanced. Unnecessary stops at roadside should be avoided with loaded fruits. If possible, refrigerated facilities/vehicles may be used, though not common in most cases.

4. Receival and post-harvest handling:

4.1 Receival and sorting: Carefully unload the crates from the vehicle, and fruits from the crates. Keep traceability where the fruits were harvested from. Using separate crates, sort the fruits manually by removing defected, damaged and diseased ones. Carefully dispose the infected fruits in a pit and cover the pit with soil.

4.2 Sap management: To avoid sap burn, sap can be managed in three ways: physical desapping, lime desapping and short stemming. **Physical desapping**: Cut the fruit pedicles (at 1cm) and place on racks with stem end facing towards the ground.

4.3 Lime desapping: fruits are dipped in lime solution (0.5%) and pedicle is manually broken with the fruit dipped in solution for 2 minutes. Short stemming: fruits pedicles are recut above the flush node to prevent sap flow and carefully placed into the boxes with short stems.

4.4 Washing/water treatment: Wash and brush the fruits carefully to remove foreign matter. Use soft nylon brush and brush for 30seconds maximum.

5. Processing, grading, packaging and storage: Keep the processing area for slicing and drying clean and organized. Sanitize surfaces and equipment used in the slicing and drying process. Do the drying in a clean, controlled environment, free from contaminants, to maintain the quality of the dried mangoes. After drying, store the dried mangoes in a cold room to maintain their quality and extend shelf life. Regularly clean the storage area, including the cold room, and ensure that crates are sealed to protect against contamination by pests. Store any non-food grade substances away from the mangoes to prevent contamination. Regularly clean and maintain any mechanical equipment used during the storage process.

Carefully grade the mangoes with different quality attributes (skin defects, size, shape, etc) to help in uniformity and increase market returns. After processing, carefully pack the processed fruits to ease handling and transportation. Preferably use strong tight corrugated boxes. Use labels with food grade glues and maintain traceability. Ensure optimum conditions during storage to prolong the shelf life. ensure the storage room has enough cooling capacity and air circulation to maintain uniform temperature. Load the storage room in a way that allows air to pass freely and uniformly through all the storage items used.

INTRODUCTION TO AGROFORESTRY

Introduction to Agroforestry

Definition: Agroforestry is intensive land use management combining trees and/or shrubs with crops and/or livestock. The practices help farmers to diversify products, markets, and farm income; improve soil and water quality; and reduce soil erosion

Examples of Agro-forestry trees:

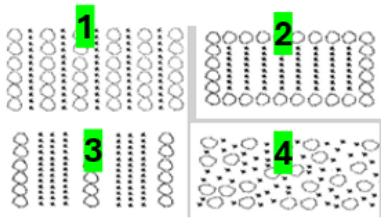
Moringa oleifera;Sesbania sesban;Senna siamea; Senna spectabilis;Acacia auriculiformis; *Leucaena leucocephala* (except in acidic soils); Casuarina; Calliandra; *Gliricidia sepium*

Roles of Agroforestry trees: Nitrogen fixation; Substitution of nitrogenous fertilizer by leguminous trees; Humus from root and litter decomposition; Improving soil chemical condition; Water conservation; Wind breaks; Shade; Soil conservation

Agroforestry systems/methods: **Agrosilvicultural systems**: Trees with crops e.g. taungya and alley cropping. **Silvopastoral systems:** Trees integrated with livestock or pasture e.g. trees and shrubs on pastures and multipurpose trees, fodder trees and shrubs grown on or around cropland. **Agrosilvopastoral systems:** Trees with both crops and livestock e.g. mixed farming

Advantages of agroforestry: Improvement of soil fertility; Positive effects on soil moisture and microclimate; Soil conservation; improvement of biodiversity; carbon sequestration

Plant Arrangement Patterns



1: Alternative rows on plant component

2: Trees along border fields

3: Alternate strips or alley cropping

Role of Various Important Plant Nutrients and Identification of their Deficiency Symptoms

1. Nitrogen: This is the major nutrient for tree growth. Excess nitrogen fertilization has adverse effects on the quality of the mangos and should be avoided.

2. Phosphorus: Phosphorus fosters the development of the root system, floral initiation and the fruit's ability to remain attached to the tree. They are poorly soluble, with slow soil uptake, affected by low pH and high iron.

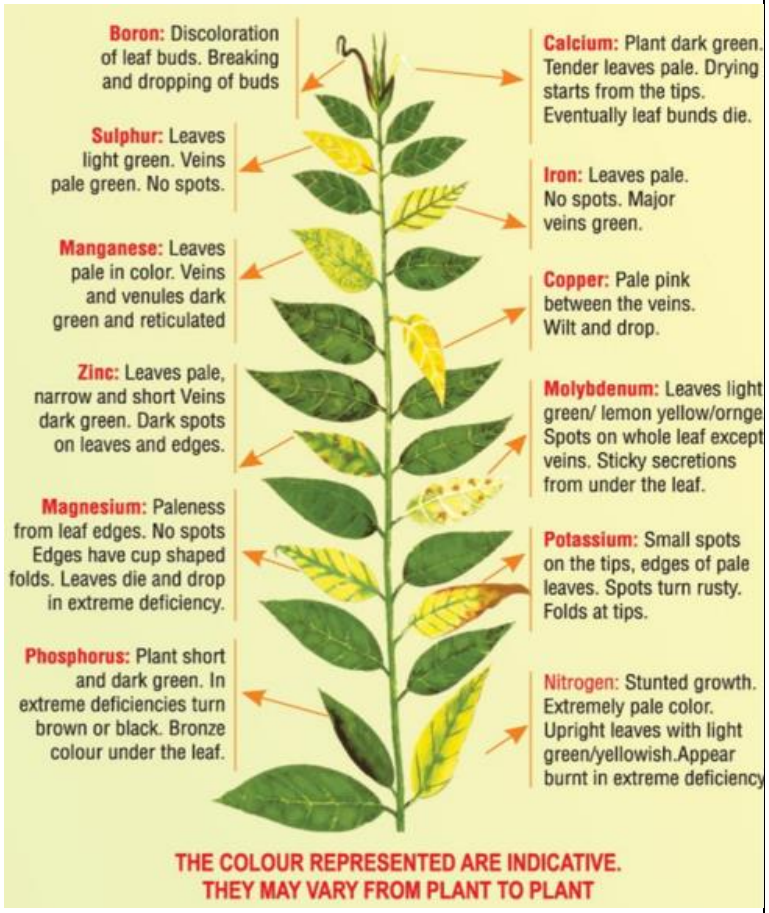
3. Potassium: Is important in terms of organoleptic quality and post-harvest storage. May be applied yearly based on the productivity level of the orchard.

4. Calcium: This can be applied to acidic soils as dolomite, natural and tri-calcium phosphate or gypsum. Its deficiencies affect fruit quality and storage properties

5. Magnesium: Helps in chlorophyll formation. Its deficiencies mostly affect old leaves. Applied as dolomite (in acidic soils) or magnesium sulphate base soils.

6. Boron: Boron is important for pollination of the flowers and fruit growth. It is sometimes necessary to spray leaves during flowering so as to meet instantaneous boron demand.

7. Zinc: Zinc is involved in chlorophyll and fruit formation in combination with iron and manganese. Excess phosphorus can lead to zinc deficiencies as reflected by the emergence of smaller leaves, at the tips of new shoots, whose limb has discolouring between the veins



REFORESTATION AND RESTORATION

Introduction to Nursery Establishment

Nursery: A nursery is a protected seedbed for raising planting materials before establishing them in the main field

Nurseries are established where: Seeds are too small to be sown directly in the main field; Seedlings are delicate when young hence require extra car; Management is eased by watering, weeding etc.

Site selection and preparation: Located near water source; secure; easily accessible; away from tree shade/runoff channels; climate suitable for the crop

Types of nurseries: Vegetable nurseries, fruit, tree

Characteristics of good media for nursery establishment: A good nursery substrate should be light in weight and easy to transport; Have good water holding capacity, aeration and drainage; Free from weed seeds, nematodes and other pathogens; Has adequate fertility (should contain all necessary nutrients for plant growth and development); be readily available; and relatively inexpensive

Equipment needed for making a nursery: hoe, spade, rake, and shovel; sieve; watering can/hose with nozzle; wheelbarrow

Benefits of a plant nursery: Careful tending of plants at a young stage; maximise space; reduce labour; protects plants from harsh conditions

Nursery preparation:

Nurseries can be established in form of Seed beds (raised or sunken) or Movable beds (Flats), Seed boxes and containers

Raised nursery beds: These are suitable in rainy areas. Fertile and healthy soil is required. The soil should be loam to sandy loam, loose and friable, rich in organic matter and well drained.

Making the raised beds: Select site and clear grasses and weeds. Measure 1metre wide and any length – should be east to west oriented to facilitate light penetration, minimize effects of heat and to welcome light rays. Loosen the soil 1 feet deep and pour 1 wheelbarrow of well decomposed and fine compost per every 3 meters and mix well in the soil. Prepare beds as **1m (width**) by **3-5 m (length**); Raise beds to 15 -20 cm high from the ground level leave a space of 30 - 40 cm between two beds for weeding, management and draining of excess rainwater. Rake the bed into a uniform size. Make drills or furrows across the bed at 10 – 15cm apart. Spread seeds thinly and cover with a thin layer of soil. Beds are firmed by palm after sowing to ensure close contact between soil and seeds. Sprinkle water after firming. Mulch after first watering

Nursery management practices

Security: Fence the area around the nursery

Bed cover- cover the nursery bed after sowing.

Use mulch to maintain the soil moisture and temperature for better seed germination; suppress the weeds; protects nursery from direct sunlight and raindrops; protect against bird damage.

Removal of mulch-Carefully remove the mulch after about three days, observe the seed beds daily.

Use of shedding net-After seed germination during the seedling growth, if there is very high temperature (> 30° C) then beds should be covered by 50% or 60% shedding nets about 60 – 90 cm above ground by the use of suitable support.

Watering: Water twice a day (morning and evening) using sprinklers or manually. Drain out excess rainwater or irrigated water. Watering depends upon the weather condition; no watering when soils are wet.

Thinning -Thin to remove weak, unhealthy, diseased, insect pests damaged and dense plants. Thinning allows light and air to each and every plant; and also helps in watching the diseased and insect pest attacked plants while moving around the nursery.

Pricking out – Transplanting small seedlings to a new seedbed to give them more room.

Weed control: Do timely weeding

Potting or transplanting: Do timely **t**ransplanting
Prevention and control from pests and diseases- use fertile soil, crop rotation, maintain hygiene, use natural remedies, avoid congestion of seedlings and damp conditions.

Fertilization – Use compost manure while sowing

Hardening-off -Hardening-off – the seedlings to train the seedlings to adapt to adverse condition in the planting sites. In this process seedlings are given some artificial shocks at least 7-10 days before uprooting and transplanting. These shocks include: Exposure to the full sunlight; Removal/ opening shading nets of all the shedding nets, polythene sheets; Irrigation is stopped slowly and slowly- reducing watering intensity; cutting the overgrown roots, opening shading nets, and no fertilizer application.

Transplanting: preferably done in the afternoon or during cloudy days. Water seedlings before uprooting and remove seeds with damp soil around their roots and do not leave them lying for too long. Water the holes before transplanting. Place the seedlings in the hole and pack the soil around it and firm gently. Water the transplanted seedlings well to settle the soil

INPUT AND OUTPUT MARKETS FOR MANGOES

Selling agro-inputs to local farmers

The contents will include:

1. **Understanding farmer needs**: identifying common challenges and recommending suitable products
2. **Sales techniques:**
   - Building rapport and trust with farmers.
   - Product demonstrations and trials: showcasing effectiveness.
   - Addressing objections and providing solutions.
3. **Creating a sales plan:**
   - Target setting: defining goals for sales volume and outreach.
   - Record-keeping: tracking sales, customer feedback, and follow-ups.
4. **Tools for effective sales:** brochures, product samples, demonstration plots.

Activities: **Role-playing**: practice selling agro-inputs to a farmer with specific needs; Create a personal sales pitch for a selected agro-input product.

Group discussion: strategies for reaching new customers and expanding sales.

Aggregation and collective marketing

The contents will include:

1. **Benefits of aggregation:** reducing costs, improving quality, and accessing larger markets**.**
2. **Organizing farmer groups:** forming cooperatives, managing group dynamics.
3. **Collective marketing:**

- **Pooling resources:** joint storage, transport, and marketing**.**
- **Negotiating with buyers:** strategies for securing better prices and contracts.

4. **Record-keeping and financial management:** maintaining transparency and accountability.
5. **Case studies of successful collective marketing initiatives.**

Determining Sales Margins: The contents include

1. **Basics of cost accounting:** understanding fixed and variable costs**.**
2. **Pricing strategies:**
   - **Cost-plus pricing:** adding a standard markup to cost.
   - **Value-based pricing:** setting prices based on perceived value to the customer.
3. **Calculating margins:** using formulas to determine gross and net margins.
4. Offering discounts and payment plans: strategies to boost sales while maintaining profitability.
5. **Activities:**
   - **Practical exercise**: calculate sales margins for different agro-inputs.
   - **Case study:** analyze the profitability of a small agro-input business.
   - **Group activity:** develop a pricing strategy for a new agro-input product.

Marketing farm produce

The content includes:

1. Market analysis: understanding demand and supply dynamics for different crops.
2. Value addition: techniques for enhancing produce quality and shelf-life.
3. Pricing produce: factors affecting prices (quality, seasonality, market conditions).
4. Channels of distribution: local markets, cooperatives, and online platforms.
5. Marketing strategies:
   - Branding and packaging: creating an identity for farm produce.
   - Digital marketing: using social media and online marketplaces.
6. Forming market linkages: connecting farmers with buyers and processors.

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Cover Photo: Mango farm in Makueni County, Photo credit: Peter Bolo (Alliance Bioversity-CIAT)

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