Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

Smallholder Horticulture Empowerment & Promotion Project for Local and Up-Scaling (SHEP PLUS)

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

MANGO PRODUCTION

Presented to the County & AFA (HCD) Staff in charge of the SHEP PLUS Model Farmer Groups during the FT-FaDDE

Prepared by SHEP PLUS

1. Introduction:

1.1 Background

Photo: © Mr. Wambua Mutuvi , HCD 2019

Mango (Embe)

1. Introduction:

1.1 Background

- Mango is a member of the ***Anacardiaceae*** **family** which includes plants such as **Cashew**, **Pistachio Nut** and **Pepper tree**
- It is best adapted to **a warm tropical climate** with a dry season **(>3 months)** followed by rains
- Most important considerations for Mango production are **a dry period at flowering** and **sufficient heat during ripening**
- Main fruit seasons in Kenya are from **November** to **April** and **May** to **July**
- The main export markets for Kenyan mangoes is the **Middle East countries**

1. Introduction:

1.1 Background Cont'

- The fruit can be used as **fresh fruit, juice**, **puree**, **jam**, **chutney**, **pickles**, **canned** or **dried**
- The fruit contains almost **all known vitamins** and **many essential minerals** including **Thiamine**, **Niacin**, **Ca**, **Fe** etc.
- Mango fruits of various cultivars differ greatly in **shape**, **size**, **appearance** and **internal characteristics**
- The quality of fruit is based on **scarcity of fibre**, **sweetness** and **minimum turpentine taste**

1.2 Common Varieties

1-2

Photo: SHEP PLUS

1-3

Photo: By Asit K. Ghosh Thaumaturgist - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9782908

“Apple”

“Kent”

1.2 Common Varieties

“Apple”

- The fruits are **medium to large**, **nearly round in shape** and have a rich yellow/orange to red colour
- The skin is smooth and thin, the juicy yellow flesh has excellent flavour and a melting texture virtually free from fibre
- **Average Length: 9.7 cm** with a width of **11 cm**
- **Weight: 397g** (medium/ large)
- **Harvesting Periods:** Oct to Mar and May to Jul
- **Advantages:** Early cultivar of excellent fruit quality, small/medium seed size, free from fibres
- **Disadvantages:** Susceptible to Anthracnose and Powdery Mildew, Alternate Bearing, range of altitude adaptation is limited

http://www.cglrc.cgiar.org/icraf/mangoBook/default.htm#Description_of_Mango_Cultivars.htm

1.2 Common Varieties Cont'

"Kent"

- The fruits are large & ovate with a **greenish-yellow** skin, **red or crimson blush** shoulders and **a rounded base shape**
- The skin is thick and tough with small numerous yellow lenticels; the flesh is juicy, melting, deep yellow, fibreless and of a rich flavour
- **Length: 12.4 cm** with a width of **9.7 cm** (Large)
- **Weight: 545 g** (Large)
- **Advantages:** late maturing, fibreless and of excellent internal quality. Fruits ship well
- **Disadvantages:** skin coloration is often inadequate, prone to storage diseases, may exhibit alternate bearing

http://www.cglrc.cgiar.org/icraf/mangoBook/default.htm#Description_of_Mango_Cultivars.htm

1.2 Common Varieties Cont’

Photo: By Asit K. Ghosh Thaumaturgist - (CC BY-SA 3.0), https://commons.wikimedia.org/w/index.php?curid=9833525

“Tommy Atkins”

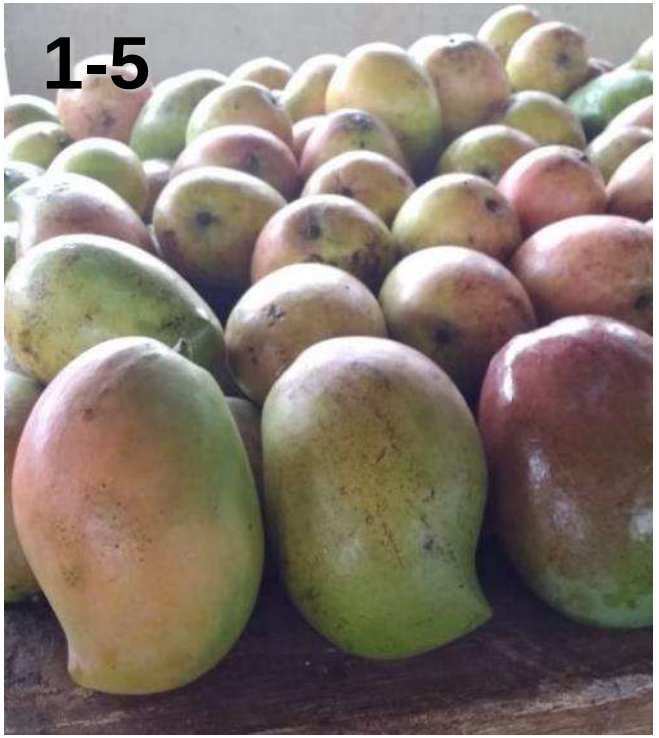


Photo: SHEP PLUS

“Ngowe”

1.2 Common Varieties Cont'

"Tommy Atkins"

- The fruits are **medium to large**, oval to oblong longer than broad, **orange/yellow** with a heavy red blush, **numerous white lenticels** and a broadly rounded base
- **Resistant** to **anthracnose** and **powdery mildew**
- The smooth skin is **tough** and **thick**
- **Average Length: 12.6 cm** with a width of **9.9 cm**
- **Average Weight: 522 g**
- **Early to mid-season** cultivar
- **Advantages:** very attractive fruits, excellent shipping and shelf-life qualities, consistent producer, good resistance to Anthracnose and Powdery Mildew
- **Disadvantages:** danger of internal breakdown (jelly seed), fibre content is slightly higher than average

1.2 Common Varieties Cont'

"Ngowe"

- The fruits are **large**, **slender**, oblong longer than broad with **a very prominent hook-like beak** at the apex
- The deep yellow flesh is of excellent quality, virtually fibreless, melting, and carries no turpentine taste
- **Average Length: 14 cm** with a width of **9.5 cm**
- **Weight: 523 g** (Large)
- **Harvesting Periods:** November – March
- **Advantages:** Good to excellent fruit quality, moderate tree size, good shipper, seed propagation possible (polyembryonic),Excellent for processing
- **Disadvantages:** Susceptible to Powdery Mildew, tendency of alternate bearing

http://www.cgiar.org/icraf/mangoBook/default.htm#Description_of_Mango_Cultivars.htm

1.2 Common Varieties Cont'

Photo: asitkghosh@yahoo.com Thaumaturgist - Own work (CC BY-SA 3.0)

"Keitt"

Photo: Asit K. Ghosh Thaumaturgist - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9798714

"Van Dyke"

By Thaumaturgist - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9752729

"Sensation"

By Asit K. Ghosh Thaumaturgist - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9782055

"Haden"

By Roei.tabak - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=11469664

"Maya"

1.2 Common Varieties Cont'

Other varieties grown in Kenya are:

- **"Keitt":** Large, ovate & plumb, rounded base shape and without a beak. **Average Length: 11.7 cm** by **9.2 cm** in wide. **Weight: 456 g** (Large).
- **Advantages:** Late maturity, good marketing qualities and productivity, fair resistance to Anthracnose
- **"Van Dyke":** Ovate shape, bright yellow ground colour with a heavy crimson blush and prominent beak.
- **Average Length: 10.5 cm** by **7.9 cm** in width. **Weight: 280g** (Small/Medium).
- **Advantages:** Good resistance to Anthracnose and Powdery Mildew, regular bearer

1.2 Common Varieties Cont'

- **"Sensation":** Oval/oblique, deep yellow colour with a prominent dark-red to purple blush. **Average Length: 10.8 cm** by **7.8 cm** in width. **Weight: 307g** (Medium).
- **Advantages:** Beautifully coloured late cultivar, none to scanty fibres, heavy yielder
- **"Sabine":** Elongated, bright yellow colour with a dark red blush.
- **Average Length: 14.2 cm** by **6.6 cm** in width. **Weight: 435g** (Medium/large).
- **Advantages:** Only slightly affected by Anthracnose and Powdery Mildew, no distinct biennial bearing, no fibres

1.2 Common Varieties Cont’

- **“Haden”:** Bright yellow colour with deep crimson or red blush, numerous large whitish/yellow glands. **Average Length: 10 cm** by **8 cm** in width. **Weight: 431g** (Medium/large). **Advantages:** Excellent fruit quality, suitable for commercial plantings, good shipper
- **“Maya”:** Ovate and plumb, yellow colour with a reddish blush. **Average Length: 10.3 cm** by **7.8 cm** in width. **Weight: 295g** (Medium). **Advantages:** Resembles Haden, good to excellent eating quality

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,500 meter above sea level**
Rainfall	**500 – 1,000 mm of rainfall annually**
Growing Temperature	**24 – 27 ^{0}C**
Soils	**• Sandy, loam, black cotton and even murram soils** **•Well drained, deep soils** **• pH range 5.5 – 7.5**

2. G20 technologies

- Make sure to support farmers carry out G20 techniques for any crop

1. Market survey
2. Crop planting calendar
3. Soil testing
4. Composting
5. Use of quality planting materials
6. Recommended land preparation practices
7. Incorporating crop residues
8. Basal application of compost/ manure
9. Recommended practices of seedling preparation/ seedlings from registered nursery

2. G20 technologies

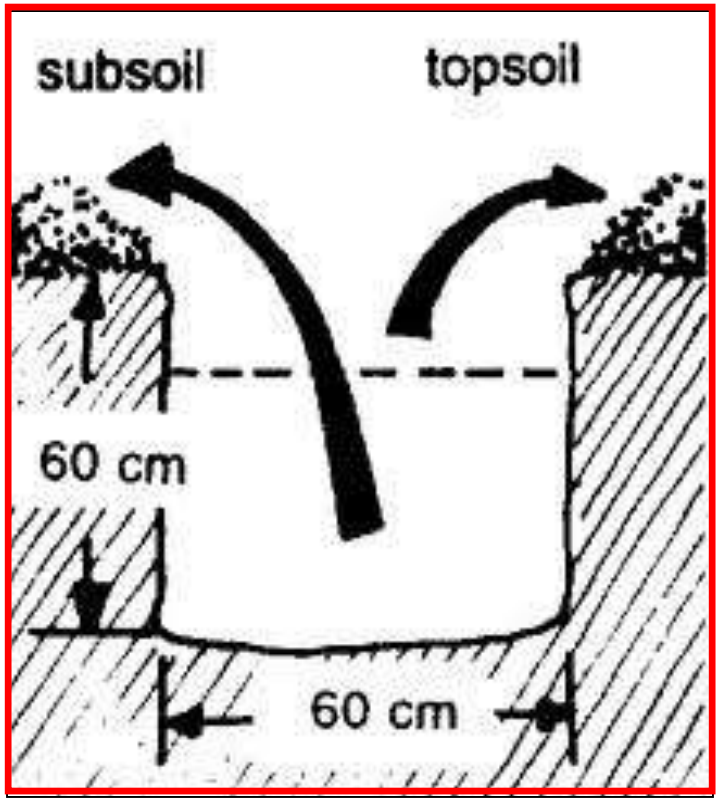
10. Recommended spacing
11. Recommended fertilizer application rate
12. Supplementing water
13. Timely weeding
14. Top-dressing
15. IPM practices
16. Safe and effective use of pesticides
17. Use of harvesting indices
18. Appropriate post harvest handling containers
19. Value addition techniques
20. Keeping farm records

3.1 Soil and Leaf Analysis

- **Leaf analysis** when the trees are dormant is also recommended
- Leaves collected must be **fully expanded** and **“hardened off”** i.e. green not red or pink
- The leaves selected should come from **the end of the branch**, the 3rd and 4th leaf from the terminal bud
- **About 24 leaves from each tree** are needed for a sample

3.2 Land Preparation

A group facilitator demonstrating how to prepare planting holes



Source: Trees and their management (IIRR, 1992)

Size of Planting Hole

3.2 Land Preparation (GHCP&PHHT20: Q6)

3.2.1 Land Clearing

- Slashing weedy fields and removal of stumps of shrubs
- In some cases, hoeing to loosen the soil is done before planting/transplanting
- On a slope if irrigation is required, construction of drainage channels and choice of proper orchard layout system (square, hexagonal etc.) are done
- In wind prone zones, the planting of windbreak rows of fast growing trees is necessary ideally 2 – 3 years before establishment of the orchard

3.2 Land Preparation Cont'

3.1.2 Recommended Spacing (GHCP&PHHT20: Q10)

- **Spacing:** Range from **9 x 9 m** to **13 x 13 m** depending on growth characteristic of the individual variety, the type of soil, and agro-ecological conditions
- **Closer Spacing: 6 X 4 m** or **5 X 5 m** could be used, however, alternate plants should be removed once overcrowding starts to set in
- **Hole Size: 60 x 60 x 60 cm. Separate** the **topsoil** and the **subsoil**

3.2 Land Preparation Cont'

3.2.3 Basal Application (GHCP&PHHT20: Q8)

- After the preparation of planting holes, apply manure/compost and basal fertilizer. Mix thoroughly with topsoil

Application rate:

- Topsoil is mixed with **two debes** (**40 kg per hole = 4 tons per acre**) of well decomposed manure and **125 g of TSP** or **DSP** before refilling the hole
- Allow mixture to settle before planting the seedlings

3.3 Raising Seedlings

Source: SHEP PLUS

A Mango Nursery

3.3 Raising Seedlings (GHCP&PHHT20: Q9)

3.3.1 Nursery Site Selection:

- Nearness to quality water source
- Good drainage
- Security against animals, thieves etc.
- Accessibility to the road
- Availability of wind breaks (Casuarina, Grevillea etc.)

3.3.2 Nursery Establishment:

- Prepare a seedbed of **width 1 m** and a desirable length by removing farm soil from the seedbed to **a depth of 30 cm** and refill the **30 cm depression** with sand

3.3 Raising Seedlings Cont'

3.3.3 Seed Preparation:

- Pick fruit **from the tree** rather than from off the ground
- Seeds must be taken from **ripe fruits** of mature, healthy and vigorous trees
- Mango seed should be **healthy**, **fresh** and **not dried** at the time of planting
- Cultivars used as **rootstocks** are: Peach, Sabre, Sikio punda and Dodo

3-3

Photo: Asit K. Ghosh Thaumaturgist - Own work (CC BY 2.0) https://commons.wikimedia.org/wiki/File:Mango_Alphonso06_Asit.jpg#/media/File:Mango_Alphonso06_Asit.jpg

An extracted seed of mango

3.3 Raising Seedlings Cont’

3.3.3 Seed Preparation Cont’:

- Place seeds into a bucket filled with water, then seperate **floating seeds** (poor seeds) with those which sink
- Remove the **hard woody endocarp** to accelerate germination
- Make a small cut **at the distal end of the seed**
- Pull the **husk** away to get the seed **without damaging the embryo**

3.3 Raising Seedlings Cont’

3.3.3 Seed Preparation Cont’:

- Wash the **de-husked seeds** and dry in the shade for a few days
- Cut off **any damaged parts** of viable seeds

3.3 Raising Seedlings Cont’

3.3.4 Sowing Seeds:

- Seeds can be sown in nursery beds (sand),
- Sow the seeds at a spacing of **15 cm x 30 cm**, **5 cm deep**, with the flat basal side downward
- Seedbed should be **mulched** and **watered regularly**

3.3 Raising Seedlings Cont'

3.3.5 Transplanting

Preparation:

- Use **forest soil** to prepare **the potting media (where forest soil is not available, solarized top soil should be used)**
- **Top soil** can also be mixed with well decomposed manure and sand at a ratio of **4:1:1**

Appropriate Time:

- Seeds germinate and seedlings emerge **10 – 14 days after planting**

3.3 Raising Seedlings Cont'

3.3.5 Transplanting cont'd

- About **4-5 weeks after emergence**, seedlings have **5 to 6 reddish/coppery leaves**, **10 cm high** and ready for transplanting
- Seedlings are carefully **lifted** with their stones attached and **separated from one another**
- **Weak plants** with **twisted tap roots** or **stems** are not used
- Transplant in perforated **appropriate potting bags (eco friendly bags)** (**15 x 22 cm**) or **tins with holes at the base** at least **15 cm deep**

3.3 Raising Seedlings Cont'

Nursery Management:

- **Fertilizer application** (**DAP**, **CAN**) results to **scorching** (**burning**) of leaves and should only be applied by knowledgeable nursery operators
- **Foliar feeds** are a better alternative and application should start **3 weeks after potting**
- Ensure **regular watering** i.e.) not excess nor too little

3.3 Raising Seedlings Cont'

Nursery Management Cont':

- Avoid formation of hard pans on the potted plant by regularly pricking the soil with a sharp stick
- Scout regularly for pests and diseases
  - **Common Pests:** Aphids Leaf Miners and White Flies
  - **Common Diseases:** Powdery Mildew, Die back and Damping-off in case of excess watering

3.3 Raising Seedlings Cont'

3.3.6: Grafting

Grafting Materials:

1) Rootstock

- The rootstocks is ready for grafting when it is about **5-10 mm thick** or **pencil thickness** and about **20-25 cm above soil level**
- Grafted seedlings are ready for planting out to the field **after 4 – 6 months**

3.2 Raising Seedlings Cont'

Grafting Materials Cont':

2) **Secateurs**
3) **Grafting Tape**

- In the abscence of the grafting tape use transparent **20 microns poly bags**. Use of black poly bags should be avoided as this encourages desiccation

4) **Disinfectant**

- A solution can be prepared by mixing **2 ml** of "Jik (breach)" in **1 litre** of water

5) **Plastic Container**
6) **Grafting Knife** or **Surgical Blades** (size 24)
7) **Biodegradable/Eco-bags**

3.2 Raising Seedlings Cont'

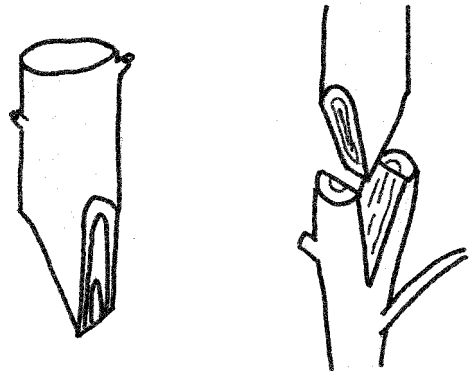
Grafting Materials Cont':

8) Scions

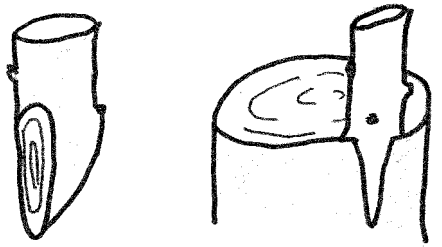
- Take scion wood with **healthy well developed vegetative shoot** with no flower buds
- Shoot buds are long and pointed while flower buds are round and fat
- The plant from which scion is taken must be true to type
- Scions should be collected during **dormant stages**
- Do not cut buds which have started to grow
- The scion wood should be **one year old** (growth of previous season)

3.3 Raising Seedlings Cont'

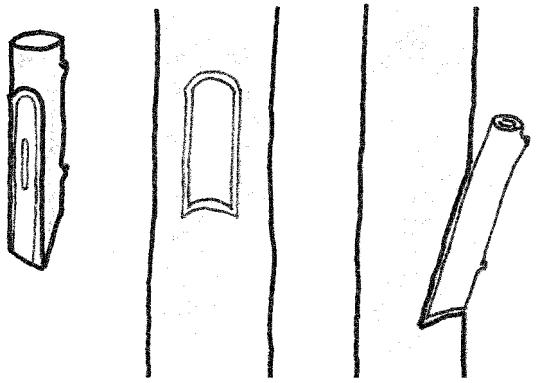
3.3.7: Grafting Techniques:



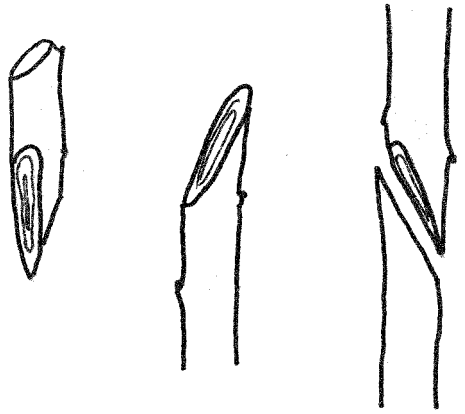
"Cleft/Wedge Graft"



"Bark Graft"



"Side Graft"



"Whip Graft"

Source: SHEP PLUS

3.3 Raising Seedlings Cont’

Preparation for Grafting Exercise

- Cut the grafting tape into strips of **4 cm x 30 cm**
- Dip the **secateur**, **grafting strip**, **grafting knife** into the disinfectant for **5 – 10 minutes** before use
- Decide on the method of grafting

3.3 Raising Seedlings Cont'

"Cleft/ Wedge Graft"

- Gives a stronger graft union

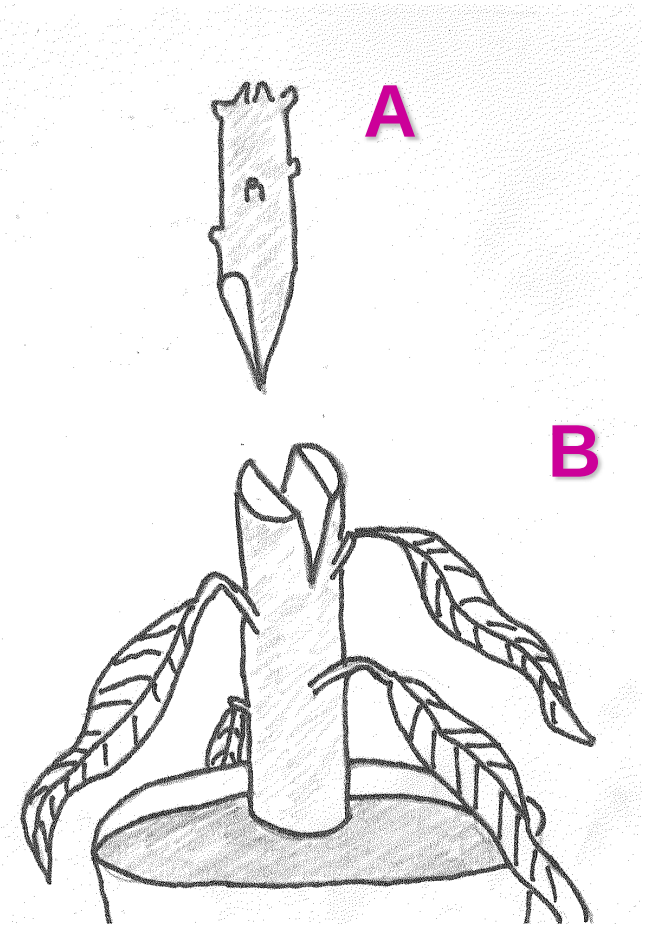
How to do cleft grafting:

- Select and prepare your **bud stick/scion**
- Cut them about **15 cm long**
- Remove **all the leaves** carefully
- The cut bud stick should be the **same thickness** as the rootstock stem

3.3 Raising Seedlings Cont'

How to do cleft grafting Cont':

- With a very sharp knife, cut the bottom of the budstick with two **sloping cuts 3 ½ cm long** (**A**)
- Cut off the top of the rootstock about **30 cm** above the soil
- Make one straight cut about **3 cm deep** in the top of the rootstock (**B**)



Source: SHEP PLUS

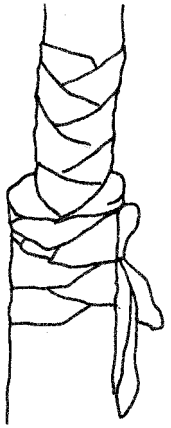
3.3 Raising Seedlings Cont'

How to do cleft grafting Cont':

- Push **the scion** firmly **into the rootstock cut**
- Leave ½ **cm** of the cut scion outside the rootstock as shown (**C**)
- Use clear plastic tape (or cut up plastic bags) to wrap firmly around the graft (**D**)
- Do not remove the tape until the scion begins to grow – showing the graft has been successful
- Remove any buds which grow below the graft

C

D



3.3 Raising Seedlings Cont’

Care of Newly grafted seedlings:

- Place the grafted seedling **under a shade net** of about **30 – 40 %** to avoid sun scorching and lay polythene paper beneath them
- If you do not have a shade net, use **a poly bag** to cover the seedling
- Warm environment helps formation of callus in the new joint

3.3 Raising Seedlings Cont'

Management of Grafted Seedlings:

- **Label** the variety
- Apply **foliar feed**
- Remove the grafting strip **once the graft union has healed** (visible from the swelling at the union)
- The tape is removed when **the first flush turns completely green**
- Prune taproot **once a month** to encourage development of feeder roots

3.3 Raising Seedlings Cont'

Management of Grafted Seedlings Cont':

- Grafted seedlings should be kept **under appropriate shade** which does not allow direct rays of the sun
- **The graft union** should be protected from water
- **Regular check for moisture content** and water should be done when necessary
- **Pest and disease control operation** are regularly carried out

3.3 Raising Seedlings Cont'

Management of Grafted Seedlings Cont':

- **Any growth from the rootstock** should be removed **immediately**
- The buds will start to shoot **after 21 days from the date of grafting**
- The shade is reduced **when the tender leaves start to turn green**
- The shade is removed completely **when second flush takes place**

3.4 Orchard establishment

Farmers can still plant seeds in situ and graft later on

3.4.1 Appropriate Time:

- Grafted seedlings are ready for transplanting out to the field **after 4 – 6 months**
- A mango tree must never be transplanted while it is **flushing** or **when the leaves are still tender**
- Transplant after **the second flush has hardened**
- Transplant **at the beginning of rains or** Water the holes **before planting** to ensure contact of the roots with moist soil

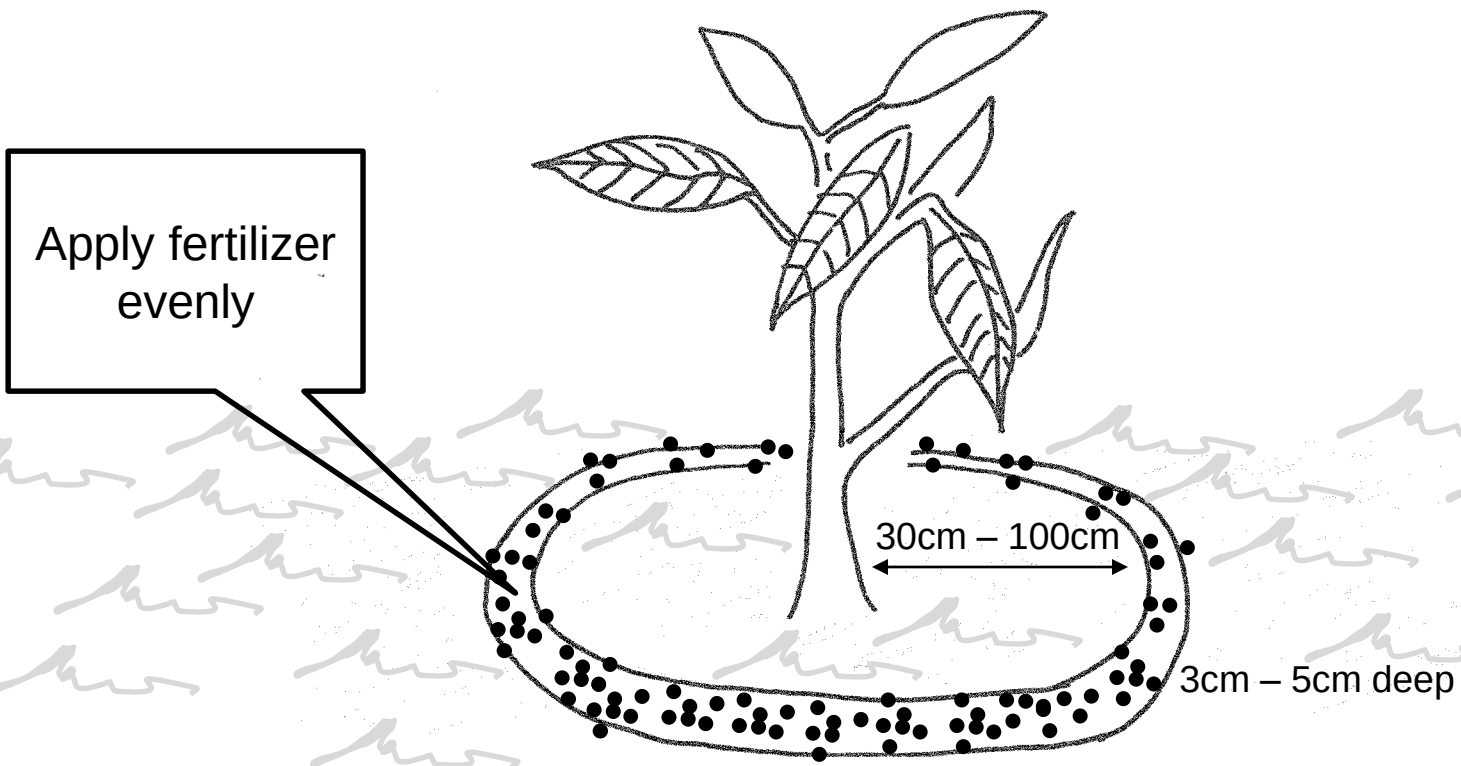
3.4 Orchard establishment Cont’

3.4.2 Transplanting:

- **Carefully remove** the seedling from the eco-bag
- Excavate as much soil as necessary at the centre of the planting hole to accommodate the root-ball
- Firmly cover the root-ball **with moist soil**
- Planting should ensure **all roots are well covered** and **graft union is above the soil surface**
- Water **well** and **mulch**

3.5 Top-dressing

3-6



Source: SHEP PLUS

Application of Fertilizer

3.5 Top-dressing (GHCP&PHHT20: Q14)

- Regular fertilizer application is necessary
- Application of fertilizer should gradually increase

Year(s) after transplanting	1-3yrs	4-5yrs	6-7yrs+
CAN (g)/ tree	240	400	400
DAP/TSP (g)/ tree	150	500	1,000

Source: FERTILIZER CONSUMPTION AND FERTILIZER USE BY CROP (FUBC) IN KENYA By Edwin Oseko and Tom Dienya September, 2015

- Manure of **3 debes** (**60 kg**) per tree should be applied in the early years

Application Methods:

- Apply fertilizer and manure **around the tree canopy** at the beginning of the rains
- Incorporate it well in the soil

3.6 Crop Management:

3.6.1 Training

- Formative training is done when the seedlings are about **1 m high**
- The central leader is cut off to encourage **lateral growth of branches**
- **3 – 4 lateral branches are left** to grow to **about 40 cm** and are cut off to encourage more lateral branches to grow outwards
- **4 – 5 stories** are recommended

3.6.2 Pruning

- Pruning can restrict **height** and **branching**
- Mango plants should develop into strong well-shaped trees **within the first 4 years**
- Depending on the cultivar and growth pattern, **selective pruning of branches** may be required to encourage growth of **lateral branches** that better supports fruit production

3.6.3 Flower inducement

- There are several ways of flower inducement (Chemical, Smudging and physiological stress)
- Spraying the trees with **1% potassium nitrate** solution when plants are dormant
- **Smudging**: burn **smoky** fire **below** the tree **canopy**, and allow smoke to pass through the foliage for **several days**
- Induce physiological stress:
  - **Deprive** the trees water for **1-2 months** then **irrigate regularly**
  - **Ringing** the branches or **root pruning**

3.6.4 Smudging

Mango hygiene by smudging

3.6.4 Smudging

Mango Hygiene by Smudging

- Mango smoking **reduces insect population** drastically and improves fruit setting
- It also **induces flowering** in mango trees

Method:

- Prepare **smoke pots** with **holes** in the bottom for air intake
- Put **wood shavings** or **sawdust** with a topping of **aromatic herbs** (**lemongrass** etc.) in the pots
- Hang the smoke pots at **strategic places** within the Mango tree

3.6.5 Intercropping

Photo: SHEP PLUS

Intercropping Mango with Tomatoes

3.6.5 Intercropping

Intercropping:

- Intercrops of **short-lived fruit trees**, such as **papaya** or **annual crops**, could be used for better utilization of land in widely spaced young plantations
- Avoid intercropping with the crops which share common pest/diseases. e.g. **Beans**

Notes:

- Overcrowding results in **the production of fewer fruits** which are **poorly coloured** and **infected with diseases**

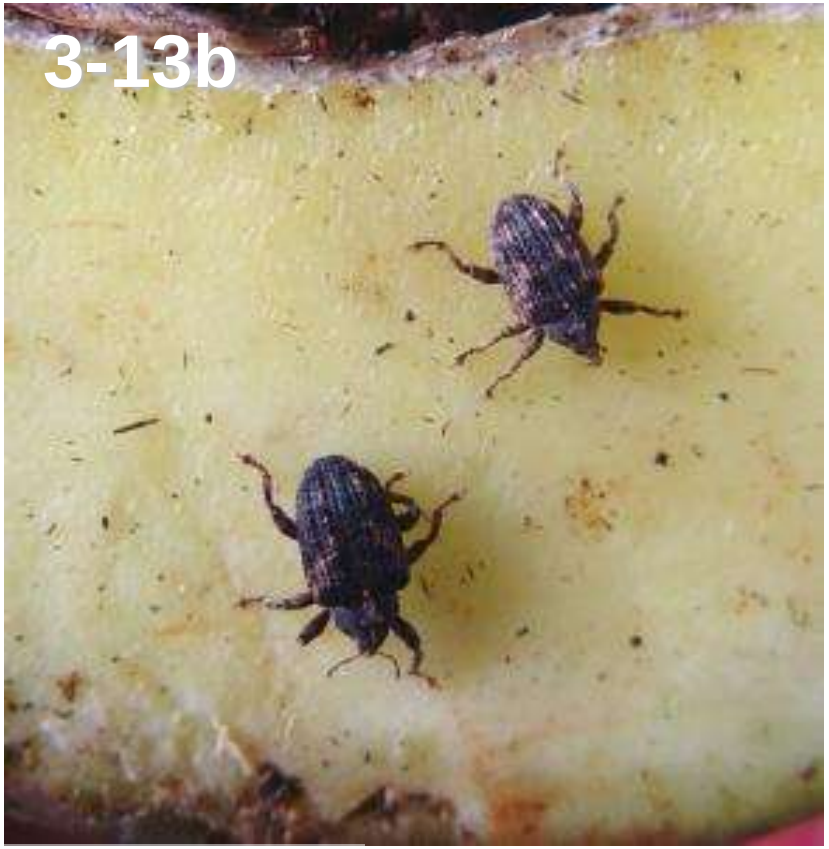
3.7 Pests & Diseases Control:

(GHCP&PHHT20: Q15 & 16)

3.7.1 Major Pests

- The following are the major pests of Mango in Kenya:
  - **A. Mango Seed Weevil**
  - **B. Mango Gall midges**
  - **C. Fruit Fly**
  - **D. Mango Scales**
  - **E. Mealybugs**

3.7.1.A: Mango Seed Weevil



Mango Seed Weevil larva and adult

3.7.1.A: Mango Seed Weevil

Identification:

- The adult is **6 – 9 mm long** with **grayish brown colour**
- Usually active **after dusk**
- Pretend to be dead when disturbed
- Hide on the bark of mango tree trunks

Damage

- Feeds on **leaves**, **tender shoots** or **flower buds**
- The beetle lays eggs on **young fruit**
- Larva **burrows into the flesh** and **destroys the seed/embryo**
- **No external signs** of fruit damage

3.7.1.A: Mango Seed Weevil Cont'

Control:

- Collect **fallen fruits** and destroy by burying or burning
- Paint the tree trunk with **agricultural lime mixture** at flowering to prevent adult weevils from climbing up the tree
- Spray biweekly with **Deltamethrin (**Decis 2.5EC®). Spray before flowering and during fruit set and repeat every 14 days focused on single fruits

3.7.1.B: Mango Gall Midge

Photos: http://www.infonet-biovision.org/PlantHealth/Crops/Mango © A.M. Varela, icipe (CC BY-NC-SA 3.0)

Mango leaf damaged by the Mango Gall Midges

3.7.1.B: Mango Gall Midge

Identification:

- The gall midges are small insects measuring about **3 mm** in length

Damage

- Adults lay eggs on young tender leaves
- The larvae mine the leaves producing **galls** or **swelling tissues/pimples**
- **Dark green**, **circular galls** randomly distributed on the leaf blade
- Under heavy infestations, the leaves **wrinkle** and **remain necrotic** and eventually drops

3.7.1.B: Mango Gall midge Cont'

Control:

- **Orchard sanitation** is important
- **Clear weedy areas** since adults prefer to stay on these plants
- **Prune crowded branches** (particularly irregular branches) to allow light penetration
- Conserve **natural enemies**
- **Spray insecticides** e.g.) **Deltamethrin such as Decis 2.5EC® mixed with mineral oil** (mineral oil should Not exceed 2 % **i.e.** 400 ml in 20 L of water) as soon as new shoots and leaves appear

3.7.1.C: Fruit Fly

Photo: http://www.infonet-biovision.org/PlantHealth/Crops/Mango
© A.M. Varela, icipe (CC BY-NC-SA 3.0)

Photo: http://www.infonet-biovision.org/PlantHealth/Crops/Mango
© A.M. Varela, icipe (CC BY-NC-SA 3.0)

Left: Fruit Fly larvae and adult

Photo: SHEP PLUS

Right: ADD Trap

3.7.1.C: Fruit Fly

Identification:

- Adult fruit flies are small, about **4 to 7 mm** long, **dull brownish-yellow** to **brownish-black** with red eyes in some species
- Yellowish flies that are commonly attracted to **fermenting fruit** of all kinds
- Fruit flies lay eggs under the skin of mature and ripening fruits
- Eggs hatch in 1 – 2 days
- Larvae are about **6 – 7 mm long** and can be found in **very ripe cull** and **damaged fruit** in the fields

3.7.1.C: Fruit Fly Cont'

Damage:

- Fruit flies cause direct damage by **puncturing the fruit skin** to lay eggs
- During egg laying, **bacteria from the intestinal flora** of the fly are introduced into the fruit. These bacteria cause **rotting** of the tissues surrounding the egg.
- The eggs hatch, maggots feed on the fruit flesh making **galleries**. These provide entry for pathogens and increase the fruit decay
- **Fruit dropping** to the ground just before the maggots pupate
- **Premature ripening** of fruits

3.7.1.C: Fruit Fly Cont'

Control:

- Collect all fallen fruits and destroy by burying at least **50 cm deep or put them in a drum of water with 1 inch oil for 2 weeks**
- Spray with **Deltamethrin** (DECIS2.5 EC®) etc.

The chemicals can be mixed with **hydrolyzed protein** at a rate of **200 – 1,000 ml/tree** or sugar/ molasses and sprayed to **act as bait**

- Harvest mangoes before they become ripe
- Use of **fruit fly trap** such as Auto Dissemination Device (ADD) by Real IPM, Hydrolysed protein (CERA TRAP)
- Use of natural enemies, especially **parasitic wasps** *(Diachasmimorpha longicaudata, Fopius arisanus* etc.*)*
- **Post-harvest Treatment (Hot Water Dip):** Dip fruits for 5minutes at 50 ^{o}C water

3.7.1.D: Mango Scales

Photos: http://www.infonet-biovision.org/PlantHealth/Crops/Mango © A.M. Varela, icipe (CC BY-NC-SA 3.0)

White Scales on the Mango Fruits

3.7.1.D: Mango Scales

Identification:

- Small round reddish brown to white insects
- Usually found in **clusters** which are immobile
- Insects can be **1 – 7 mm long** while the cluster can be 2 cm in diameter
- Clusters found on upper surface of leaves, branches, stem and fruit
- Females are **circular in appearance**, have **dark spot on one side**, have neither wings nor legs
- Adult males have **two wings**

3.7.1.D: Mango Scales Cont’

Damage:

- Scales **suck the cell sap** from the infested areas
- Infested leaves turn **pale green to yellow** eventually **die and drop**
- Infested fruits have **pink blemishes** and **drop**
- **Poor growth** and **dieback of branches**
- Infested young seedlings may die
- **Honey dew** is produced which form sooty mold, thus reduction of photosynthetic capacity

3.7.1.D: Mango Scales Cont'

Control:

- Cut and burn infested tree parts
- **Use of natural enemies** e.g.) Parasitic Wasps, Ladybird Beetle, Lacewings etc.
- **Spray with insecticide mixed with white mineral oils 2% :** paraffin oil is sprayed at **3 %** water emulsion. Avoid spraying mineral oil during very hot periods of the day
- Use of D-C Tron(Caltex oil) to suffocate the insects

3.7.1.E: Mealybugs

Identification:

- Mealybugs are small, flat, soft bodied insects covered with a distinctive segmentation
- Their body is covered with a white woolly secretion

Mealybugs on a mango fruit

3.7.1.E: Mealybugs

Damage:

- They suck sap from tender leaves, petioles and fruits
- Seriously attacked leaves turn yellow and eventually dry
- This can lead to shedding of leaves, inflorescences, and young fruit
- Mealybugs excrete honeydew on which sooty mould developed.

Control:

- Insecticides do not generally provide adequate control of mealybugs owing to their wax coating
- Destroy affected parts at the beginning of the infestation
- Heavily infested branches may be pruned to control the pest, especially on the tender branches before flowering begins.
- Conserve natural enemies.

3.7.2 Major Diseases & Physiological Disorders

- The following are the major diseases and physiological disorders of Mango in Kenya:
  a. **Powdery Mildew**
  b. **Anthracnose**
  c. **Jelly seed**

3.7.2.a: Powdery Mildew

Descriptions

- Caused by a fungus which survive in dormant buds
- Infection prevalent during cool and cloudy weather

Powdery mildew on leaves (left) and panicles (right)

3.7.2.a: Powdery Mildew

Symptoms:

- Appears as **white powdery growth** on leaves, flowers, flower stalks, and young fruits
- The white powdery growth **turn black** later in the season
- **Grayish necrotic lesions/spots** on leaves
- Infected leaves **curl** and become **distorted**
- Infected young fruits have **purplish haze**
- Infected flowers and young fruits turn **brown** and **gray eventually drop**
- **Poor fruit set**

3.7.2.a: Powdery Mildew Cont’

Control:

- Choice of resistant varieties **e.g.)** Sensation, Van Dyke, Tommy Atkins
- Cultural practices e.g.) **spacing**, **pruning**, **sanitation** etc.
- Observe plant nutrition
- Spray **70%** Neem Oil
- Pesticides: Trifloxystrobin 100g/L + Tebuconazole 200g/L (NATIVO SC 300®), Thiophanate-methyl 500g/L (TOPSIN M®)

3.7.2.b: Anthracnose

Source: http://www.infonet-biovision.org/PlantHealth/Crops/Mango

Anthracnose damage on mango fruits

3.7.2.b: Anthracnose

Descriptions:

- Mango anthracnose is caused by the **fungus during humid conditions**
- Prevalent during **flowering** and **fruit set**
- The anthracnose fungus can be **re-activated** in response to physiological changes associated with ripening, resulting in **the development of lesions with subsequent spoilage** of the fruit

Symptoms:

- Occur on **leaves, twigs, petioles, flower clusters (panicles)** and **fruits**

3.7.2.b: Anthracnose Cont'

Symptoms Cont':

On Leaves, Petioles, Twigs and Stems

- Lesions start as **small angular brown** to **black spots** that can enlarge to form extensive dead areas
- Infection of young leaf flushes may show up as **lesions** along the margins of the young bronze or pale green leaves, in which case they are **semi-circular in shape**
- In very humid weather, new twigs may show a dark affected area from the tip backwards, sometimes with defoliation of the young shoots

3.7.2.b: Anthracnose Cont'

Symptoms Cont':

On Panicles

- **Small black** to **dark-brown spots** that enlarge, coalesce and **kill the flowers** before fruit set

On Fruits

- Affected fruits develop **sunken**, **prominent**, **dark brown to black decay spots** before or after picking

3.7.2.b: Anthracnose Cont'

Control:

- **Remove** and **destroy** dead twigs and branches
- Spray Propineb (**Antracol®**) every 14 days before and after flowering

Post-harvest Treatment:

- **Hot Water Dip:** Dip fruits for 5 minutes at 50 ^{o}C water
- Store fruits in a cool place
- Pesticides: Carbendazim 500g/L (BENDAZIM 500 SC, RONDAZIM)

3.7.2.c: Jelly Seed

Photo: © Scot Nelson https://www.flickr.com/photos/scotnelson/25272628997 Public Domain Mark 1.0

Jelly Seed caused by Calcium Deficiency

3.7.2.c: Jelly Seed

Descriptions:

- Jelly Seed is a Physiological Disorder caused by the **Calcium deficiency**

Symptoms:

- **Degeneration of fruit pulp** after harvesting fruit characterized by **premature** and **uneven ripening** of the mesocarp
- Other symptoms include **internal breakdown**, **soft nose**, **stem-end cavity** or **spongy tissue**

Control:

- Application of **dolomitic lime** ($CaCO_3.MgCO_3$) at the rate of **3.2 tones per acre per year** applied once at the onset of long rains (Mar. – Apr.)

4. Harvest

4-1

Photo: By User:Aahafezi - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=30675545

Harvesting Mangoes with sticks

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Maturity Period: 12 – 16 weeks** after fruit set
- **Maturity:** Some indicators of maturity include:
  - **Well developed shoulders**
  - Skin changes from **green** to **yellow**
  - **Colour of flesh**: The flesh around the seed turn from **white** to **yellow**
  - **Sugar content** increases
- **Harvesting:** Use secateurs**. Do not knock or drop the fruits.** Fruits should be harvested with **3 – 4 cm** stalk. Drain the latex from the fruits by turning.
- **Yields: 10,000 – 15,000kg per acre** from the 7th year

5. Post-Harvest Handling

Photo: SHEP PLUS

Harvested Mangoes being packed in card board boxes

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- For export market, pack in single layer in fibreboard cartons of **4 – 5 kg weight**. The fruits per carton range from **6 – 24**.The cartons should be well ventilated

5.2 Value Addition Techniques: Sorting, Cleaning & Grading (GHCP&PHHT20: Q19)

- **Sorting:** Remove **diseased**, **mis-shaped, damaged** and **unripe fruits** and foreign matter
- **Cleaning:** Cleaning with a clean damp cloth
- **Grading:** According to **size**, **colour**, and **texture** (Class 1 & Class11)

5. Post-Harvest Handling Cont'

5.2 Value Addition Techniques: Sorting, Cleaning & Grading Cont'

- **Pre-cooling** to slow down the metabolic processes (Temperatures 10 ^{o}C – 11.2 ^{o}C)
- Place fruits in water containing 100ppm sodium hyperchloride to remove latex and sterilizing
- **Hot Water Treatment:** Immersing the mango fruits in water bath of **50 ^{o}C** for **5 minutes** to minimize **Fruit Fly** damage and **Anthracnose**

5. Post-Harvest Handling Cont'

5.3 Storage

- Mature mangoes are **sensitive to chilling injury**
- There is impaired ripening resulting to poor colour and flavour development (Temperature **5.5 ºC – 15 ºC**, Relative Humidity **85 % – 90 %)**

5.4 Transportation

- Containers should be **well stacked** to avoid any movement
- Vehicles must always be **covered** or **insulated**
- Vehicles must be **cushioned**
- Fruits must be protected from **dust**, **sun** and **rain**

Reference

- Wiikipedia: Mango Tommy Atkins (accessed on 12 Oct 2016)
  https://en.wikipedia.org/wiki/Tommy_Atkins_(mango)
  https://commons.wikimedia.org/wiki/File:Aesthetic_Nadu_Salai_Mango.jpg
- International Tropical Fruits Network (accessed on 12 Oct 2016)
  http://www.itfnet.org/v1/2016/05/mango-common-varieties/
- Trees and Their Management (IIRR, 1992)
- Techie2Aggie (accessed on 12 Oct 2016)
  http://techie2aggie.blogspot.co.ke/2011/10/ultra-high-density-mango-uhd-planting.html
- Chorao-Madel Farmers Club
  https://choraofarmers.wordpress.com/2010/03/24/visit-to-nabars-mango-orchard-vengurla/
- Infonet-Biovision
  http://rachel.golearn.us/modules/en-infonet/export/defaultct124$crops.html
- Clinton Foundation: How farmers are benefitting from carbon credits in nine photos
  https://www.clintonfoundation.org/blog/2014/04/25/how-farmers-are-benefiting-carbon-credits-nine-photos

Reference

- Valentina's country portfolio
  http://valentinasproject.weebly.com/agriculture1.html
- UC Davis postharvest technology
  http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Fruit_English/?uid=37&ds=798
- Africa Food & Pack
  http://foodpackafrica.com/detail_news.php?newsid=222&t=Kenya:%20Mango%20exports%20on%20the%20rise
- Juergen Griesbach, Mango Growing in Kenya, 2003, ICRAF
- The proposed agrochemicals are in accordance with "Products Registered for Use on Crops Version 1_2018" by Pest Control Products Board. The registered agrochemicals are subject to change. Please refer to the latest registered agrochemicals by Pest Control Product Board.

THANK YOU

ASANTE SANA

DOMO ARIGATO GOZAIMASU

Contact: SHEP PLUS Office (4th Floor, N.H.I.F. Building, Upper Hill, Nairobi)
Tel. No: 0737-293867/0712-504095
E-mail: info.shepunit@gmail.com