

PROCEDURAL MANUAL FOR PRODUCTION AND COMMERCIALIZATION OF MANGO CLEAN PLANTING MATERIAL

Production Manual on Propagation of
Clean Mango Planting Material



Republic of Kenya
Ministry of Industrialization, Trade
and Enterprise Development



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European Union



East African Community



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MANGO CLEAN PLANTING MATERIAL**

**PRODUCTION MANUAL ON PROPAGATION OF
CLEAN MANGO PLANTING MATERIAL**

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ACKNOWLEDGMENTS

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“Build resilient infrastructure,
promote inclusive and
sustainable industrialization
and foster innovation”

FOREWORD

Mango Procedural Manual for Clean Planting Material

The European Union (EU) in partnership with the East African Community (EAC) has launched the Market Access Upgrade Programme (MARKUP) to support member countries improve market access of agro-food products to the EU and regional markets. The main purpose of this project is to contribute to the economic development of Kenya by increasing the value of both extra and intra-regional agricultural exports in selected horticulture sub sectors; (snow peas and peas, mango, passion fruit, chilies, herbs and spices, and nuts [macadamia nuts and groundnuts]). According to MARKUP, agriculture (crop and livestock production) contributes to an average of 27.3% of the national GDP and provides a source of livelihood to most Kenyans. It also contributes about 26% indirectly to GDP through linkages with other sectors such as agro-based manufacturing, transport, wholesale and retail trade. This programme (MARKUP) is structured around two intervention levels: the EAC Regional Window and the Partner States National Window with country specific projects. United Nations Industrial Development Organization (UNIDO) is the implementation partner for the Kenya-Partner States window.

MARKUP requested KALRO expertise in developing procedural manuals for the production of clean planting materials for mango, passion fruit, groundnuts and macadamia nuts. The process involved a detailed analysis of the sectors in question and identifying the various roles played by KALRO and other partners and Competent Authority (CA) bodies such as Agriculture and Food Authority (AFA) under the Nuts & Oil Crops Directorate (NOCD), Kenya Plant Health Inspectorate Service (KEPHIS), among other players. The analysis identified the strength and weaknesses of the sector and what needs attention.

The agricultural sector growth is critical for transforming Kenya's economy and catalyzing rapid economic growth. It is the largest sector contributing towards development, provides raw materials for agribusiness and livelihood for over 70% of the population. The building blocks and foundation of agriculture are high quality planting materials. Seeds/seedlings are the most important input in all crop based agricultural value chains.

Mango (*Mangifera indica* L.) was ranked 2nd after banana in terms of value amongst fruits in 2020. This fruit is an important cash crop in Makueni, Machakos and Embu Counties. It is produced for both local and export markets. During the last 20-30 years, commercial mango production has developed based on locally adapted and newly imported cultivars. This has seen the area under mango cultivation in Kenya rise from 500 ha in 1970 to approximately 56,437 ha in 2020 (source: HCD 2021). It is a source of foreign exchange for the country and a source of employment for a seasonal labour force.

The project observed that most of the fruit tree nurseries are not registered or certified by the requisite authorities and thus poses health risks to producers. The development of an

efficient and sustainable nursery system of certified and registered nurseries for supplying mango farmers in potential areas with high quality mango planting material of commercial varieties is needed. Varieties planted in the wrong agro-ecological zones have contributed to low quality fruit and market prices.

The mango procedural manual describes the principles and practices in nursery production of quality and superior varieties mango planting material from seed to seedlings. The manual equips the nursery operators, farmers and institutional nurseries with the knowledge and techniques of plant propagation, establishment of small-scale nurseries and managing mango orchards. It also enable participants to translate such knowledge and skills into entrepreneurial action projects.

The mango business plan guides entrepreneurs to adherer to structures that will assure production of quality seedlings as per the existing standards and protocols for different plants propagated from seeds or vegetative materials. Thus, the procedural manual and business plan address shortfalls and interventions required in the mango seed system.

This procedural manual has been developed from extensive information from research and background data by KALRO. The business plan is meant to be used together with the procedural manual to ensure that both technical and business considerations are met during the production process. The design takes into consideration all the information that a nursery operator and extension service provider would need to develop and produce high quality clean mango seedlings for use by nursery operators and extension service providers across the country and beyond. I am greatly indebted to the KALRO commodity experts who participated in the preparation of the Business Plan, which is expected to epitomize a new way of operating propagation units where in addition to the technical considerations, the business aspects are also incorporated to ensure sustainability.

It is hoped that these manuals reach the intended users as Kenya strives towards sustainable quality mango seedling propagation that triggers increased production and productivity and subsequently improves livelihoods for the communities served by this crop system. Given its utility, KALRO recommends that this manual is translated into Kiswahili and several vernacular languages to benefit a wider section of the mango farming community.

Prof. Lusike Wasilwa, PhD,
Director Crop Systems
For Director General, KALRO

ABBREVIATIONS AND ACRONYMS

AFA	Agriculture Food & Authority
CAN	Calcium ammonium nitrate
DAP	Diammonium phosphate
EU	European Union
GAPs	Good Agricultural Practices
HCD	Horticultural Crops Directorate
HCDA	Horticulture Crops Development Authority
HHN	High Health Nursery
KALRO	Kenya Agricultural & Livestock Research Organization
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KES	Kenya Shilling
KRA	Kenya Revenue Authority
MARKUP	Market Access Upgrade Programme
MoAL	Ministry of Agriculture, Livestock, Fisheries & Cooperatives
PCPB	Pesticide Chemical Products Board
PHI	Postharvest interval
PPP	Public Private Partnerships
UNIDO	United Nations Industrial Development Organization

DEFINITIONS

	Term	Definition
1	Compost	Mixture of ingredients prepared by decomposing plant and food waste with recycled organic materials used to fertilize soil
2	Farm Yard Manure	Decomposed mixture of dung from farm animals mixed with roughage or fodder
3	Graft Union	This is the point where the scion and rootstock unite
4	Grafting	Joining together of plant parts and let to grow
5	Nursery bed	An area used to grow certain seed
6	Organic matter	A source composed of natural compounds that have come from remains of plants and animals
7	Pathogen	An organism that causes diseases to plants
8	Pruning	To cut off some the branches of a tree that are not necessary to make it grow better
9	Rootstock	A stem with a well-developed root system to which a bud from another plant is grafted
10	Scion	A young shoot or twig of a plant used for grafting
11	Symptoms	Is a visible effect of disease on the plant
12	Vegetative	A process in which plants reproduce from stems, roots and leaves

INTRODUCTION

The importance of good quality planting material as an initial investment and a well realized factor for persons engaged in horticulture enhances market promotion of the produce. This manual entails to provide nursery managers and operators with the information necessary to run the nurseries and avail high quality mango seedlings at a reasonable price.

Purpose of the Manual

This manual describes the principles and practices in the nursery production of quality and superior mango planting material from seed to seedlings. The manual equips the nursery operators, farmers and institutional nurseries with the knowledge and techniques of plant propagation, establishment of small scale-nurseries and mango orchards. This manual is designed to facilitate the learning process by incorporating practical activities that provide better and clearer understanding of the principles involved in nursery establishment and management and to enable participants to translate such knowledge and skills into entrepreneurial action projects.

Nursery Site

To select a suitable nursery site, many factors must be considered the most important being mother block, size, water, soil, slope and access. This determines the success or failure of a plant nursery:

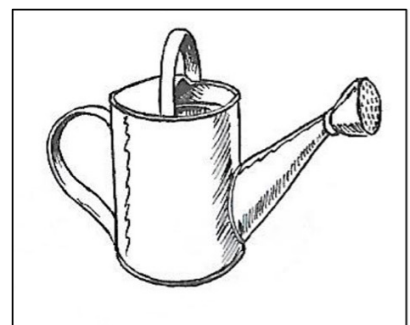
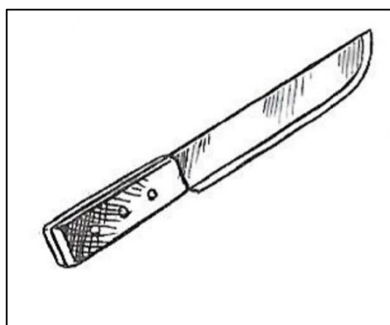
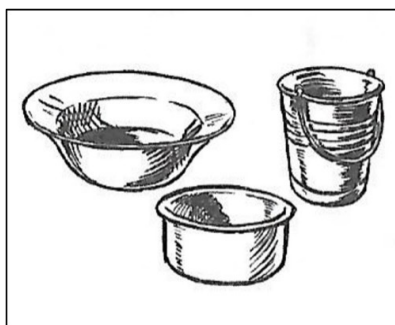
- A nursery should be isolated as far as possible from existing commercial planting and should be accessible
- Movement of vehicles and personnel through the nursery should be limited
- No foreign materials should be allowed into the nursery without proper precautions
- Tools and equipment should frequently be sterilized
- The nursery should be built on a gentle slope to avoid flooding
- Water should be available and free of harmful pathogens, nematodes and fungi

Size of the Nursery

This depends on a number of factors:

- Seedlings to be raised annually and the production system, whether grown as bare root or in containers
- The space available for establishing the nursery
- Whether the seedlings will be grown in pots or in beds
- The amount of water that is available to maintain seedlings

NOTES

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SEEDLING PRODUCTION

Selection and Management of Mother Plants

Prior to seed collection, one needs to select and mark good mango mother trees to use as sources of high quality seed and scions. The major characteristics of a good mother tree are:

- Mature
- Free of pests and diseases
- Vigorous
- True-to-type
- High yielding



Fig 1: Healthy mango mother-block orchard (Source of pictures: Grace Watani and Lusike Wasilwa)

The mother plants should be maintained through regular watering, fertilization, pruning, pest and disease management. It is strongly recommended that a nursery should have a mother block comprising popular plant varieties.

Choice of Rootstocks

Only poly-embryonic seeds are used as rootstocks.

- Seedlings derived from such seed will be true to type and uniform in growth and production habits
- Mono-embryonic seeds are not suitable as stem burst often results from such rootstocks
- Peach and Sabre seeds perform well as rootstocks in mid-altitude areas.
- Local varieties for rootstocks, such as Batawi, Kitovu or Kimji are well adapted to the climatic conditions of the coastal region
- Poly-embryonic seeds from which rootstocks are grown, must be taken from ripe fruits
- They should be fresh as possible at the time of planting
- The hard, woody endocarp is removed by cutting it open at the narrow end of the seed and forcing it off
- The seed itself is then still covered with a loose-fitting parchment layer which must also be removed



Remove all the flesh from the mango seed



It is safer to use secateurs to remove the husk. Start from the distal end (part of fruit that is attached to the tree)



When removing the husk, the fragile seed coat can be peeled off or it breaks away



Prop open the husk to remove the seed



Freshly extracted mango seed



Mango seed-size differs based on variety

Fig. 2. Steps for removing mango seed from fibrous husk (Source of pictures: Lusike Wasilwa)

- The seeds are then examined and those damaged by the mango weevil are discarded (since this insect penetrates the young fruit and seed as a small larva, there is usually no sign of its presence on the outside of the fruit or seeds)
- Partially damaged seeds may, if necessary, be planted, since there will normally be enough undamaged embryos left (Fig. 3)
- In such a case it is advisable to cut right into the healthy tissue to make sure that all the damaged parts are removed, since the dead and rotting tissue is potential source of secondary fungal infection or can facilitate the entry of such fungi
- For the same reason thorough seeds treatment should be applied to these seeds
- The possible presence of the mango weevil necessitates the removal of the hard, woody endocarp and the parchment layer, and it should be borne in mind that the removal of these layers also speed up germination
- The extracted seed can either be planted in a sand bed for germination and then transferred into pot or can be planted directly in pots



Bad or damaged seed must be discarded because of low germination



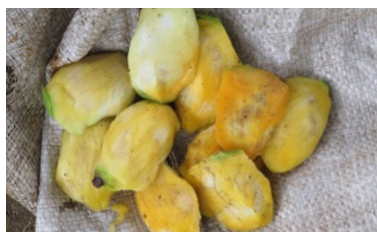
Mango seed infested with mango seed weevil. In this picture larva is visible

Fig. 3. Seed-health is a very important factor in mango propagation
(Source of pictures: Lusike Wasilwa)

- The seeds sown in sand 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
- Seeds germinate and seedlings emerge 10 – 14 days after planting
- About 4-5 weeks after emergence, seedlings have 5 to 6 reddish/coppery leaves, 10 cm high and ready for transplanting (Fig. 4)
- 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) with holes at the base at least 15 cm deep



Mango fruit for rootstock are harvested when fully mature



The seed is extracted using a knife



Allow the seed to dry for three days



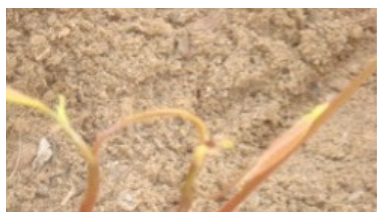
Extract mango seed from parchment



Healthy seed extracted from the husk/parchment



The seed can be planted in a seed bed with sand media



Germinated mango seedling



A healthy young mango rootstock seedling



Mango seed can be planted directly into potting bags



Cover completely with media and gently compact



The seed germinates between 4 to 5 weeks



Healthy seedlings in a high health (HH) nursery

Fig. 4. Propagation of mango rootstock seed
Source of pictures: Grace Watani and Lusike Wasilwa

Nursery media treatment

- Many plant pathogens reside in the soil. These pathogens can contaminate “soilless” mixes
- Using pathogen-free potting media is an essential starting point for producing seedlings that are pathogen-free
- Diseased plant material can introduce pathogens from the nursery to a new site
- Some pathogens can spread and affect other plants
- Soil-borne pathogens are very expensive and sometimes difficult to control
- Treatment for media can be - chemical fumigation/ sterilization using hot steam normally referred to as steam pasteurization or sunlight (solarization)
- Metham sodium can be used for soil fumigation when available but is very expensive
- Note that heat-treated media can readily become re-contaminated with soil-borne plant pathogens in many ways including:
 - Placing treated media into contaminated equipment, vehicles, bins, or pots
 - Handling treated media with contaminated farm implements or hands
 - Planting pathogen-contaminated seeds or propagules
 - Using contaminated water for irrigation
 - Placing treated soil on the ground directly or in pots that have been on the ground or on contaminated surfaces
- Excessive soil heating may increase chances of phytotoxicity due to soluble salts, manganese toxicity, and toxic organic compounds
- Soil mixtures high in readily decomposable organic matter (manure, leaf mold, compost) are most likely damaged when exposed to excessively high temperatures

Potting Media

- 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 10:4:1 (top soil/manure/sand) to ensure that it is well-draining

- A proper mix of soil and sand with organic material is common practice to prevent the root ball from disintegrating when the container is removed at time of planting
- Heavy clays should be avoided because of poor drainage and compaction
- Sand is added to improve on aeration and porosity

Note:

- Before use, the soil should be screened through a coarse sieve with a 1 cm mesh. Fig. 5. illustrates two simple methods of screening soil
- After screening, the soil is mixed, if necessary with sand and/or organic matter and appropriate fertiliser if required
- Rest the growing media for at least two weeks after preparation to allow unwanted weeds to germinate and be removed
- Care should be taken to avoid sub-soil which is often available in large quantities at construction sites

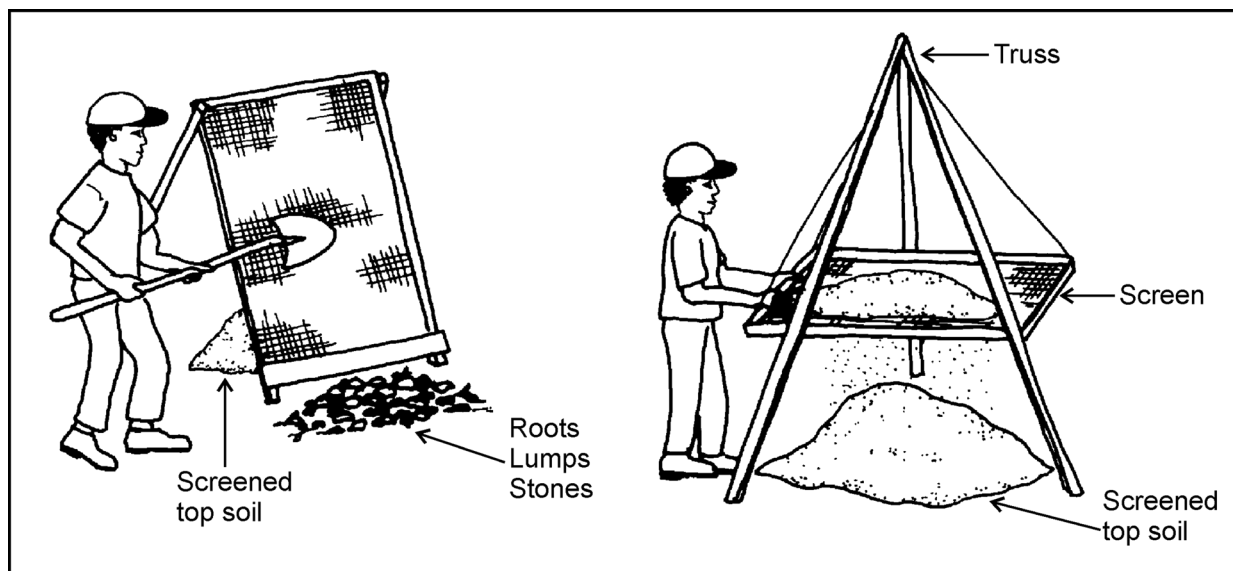


Fig 5: Two simple methods of screening soil (Source: Keats C.)

Direct Planting of Mango Rootstock Seed

- Seeds can also be planted directly into polybags
- Fill the polybags 6" x 9" or bigger and shake mixture to settle
- Put the seed with the broad side upwards or put it upright until it's covered slightly
- Put water until it is sipping from the lowest perforation
- Repeat water application at least thrice a week
- Seedlings will take about 6 – 7 months before grafting

NOTES

[illegible]

MANGO GRAFTING

Grafting tools for mango propagation

A nursery operator requires several tools and equipment to enable mango propagation including a tree pruner/pruning saw, secateurs for harvesting scions, grafting knife, and grafting tape for binding the graft union (Fig. 6).



Potting spade (trowel)



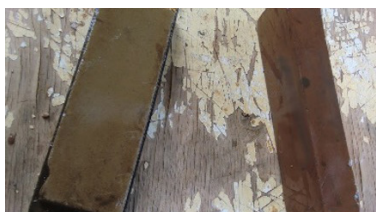
Potting bag



Watering can



Budding knife



Knife sharpening stones



Grafting knife



Secateurs



Pruning saw



Grafting tape



For immediate use, mango scions are placed in placed in an open container



Polybag or seran wrap is used for storage of scions to prevent them from drying

Fig. 6: Mango propagation tools and equipment (Source of pictures: Lusike Wasilwa)

Grafting mango is recommended to:

1. Shorten time to production
2. Obtain true to type plants
3. Obtain dwarf plants for ease management

Mango are propagated by grafting a recommended scion onto a rootstock (pencil size) using either top-wedge, side wedge, whip or bark graft methods. Seedlings are grafted when they are about 6 – 7 months. Recommended rootstocks such as Peach, sabre and local varieties are used.

NOTES

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GRAFTING METHODS

Top Wedge or Cleft Grafting

Scions for top wedge grafting should be obtained from new wood (current season flushes). The scion should be pencil-size with 3 to 4 nodes. A few leaves below the graft union enhances success.

- A wedge-like slanting cut is made at the base of the scion with a sharp grafting knife. A vertical incision is made at the top of the rootstock. The two pieces are fitted together, wrapped firmly with a grafting tape and then sealed with grafting wax

Procedure:

- Remove soil or debris adhering on the stem of the rootstock
- Cut rootstock at the point where the stem is actively growing i.e. has a greenish-brown color
- Leave at least four to six leaves below the cut or graft area
- Choose a scion (10 to 15 cm long) whose diameter is the same size as the rootstock and cur a smooth wedge of about 2 cm long

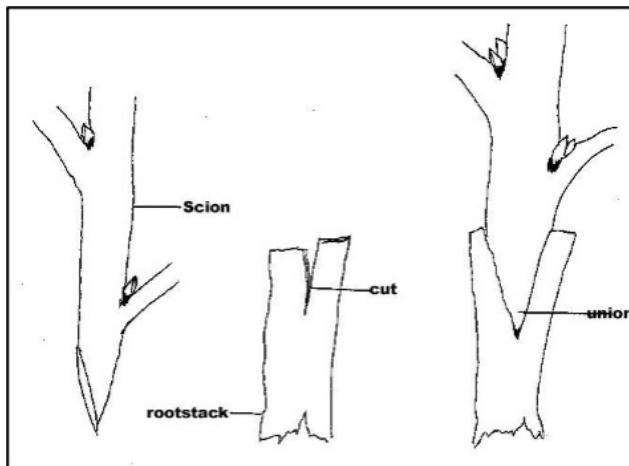
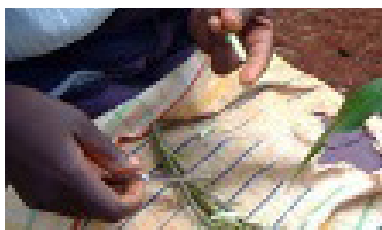


Fig. 7: Top wedge grafting (Source or drawing: Evans Kalangi)

- Make a vertical cut at the middle of the rootstock, deep enough so that the wedge of the scion fits
- Insert the scion into the rootstock and secure it with polyethylene plastic strip. This should be tied firmly to avoid entry of water which can eventually cause rotting of the graft union (Fig. 8)
- Wrap the entire scion with a polyethylene plastic strip to minimize loss of water
- A polyethylene plastic bag can be used to cover the scion if grafting is undertaken during the rainy season to avoid rotting of the graft point
- Maintain the grafted plants under the shade until new shoots develop and then transfer them to an open area



Scions are harvested and placed on a moist clean cloth or paper towel



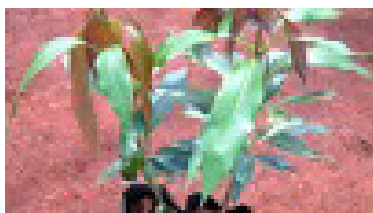
Prepare the scion by removing leaves and branches



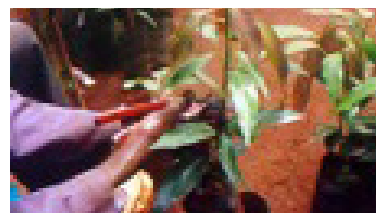
A wedge-like slanting (1 – 1.5 cm) cut is made at the base of the scion with a sharp grafting knife



Mango scion ready for grafting. Note the "pencil" shaped end



Select health rootstocks with pencil-size diameter



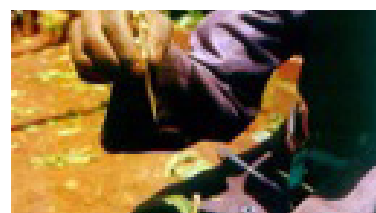
Use secateurs to cut rootstock 15cm from soil-level



Remove leaves from the rootstock that are close to the soil-level



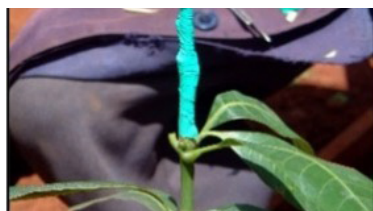
Make a vertical incision 1 – 1.5 cm deep into the top of rootstock



Select scion that is the same size as the rootstock



Insert the scion into rootstock ensuring that the two pieces are aligned.



Use grafting tape to wrap the graft union in firmly place



For a successful graft buds will sprout three weeks later

Fig. 8. Steps for top-wedge grafting of mango (Source of pictures: Lusike Wasilwa)

Whip and Tongue graft

Procedure

- Make a 1 to 2-inch slanting cut into the rootstock and “tongue” cut 1 inch from center of slant. Repeat this with scion (Fig. 9a and 9b)
- Fit the scion and rootstock and align scion and rootstock cambium (Fig. 9c)

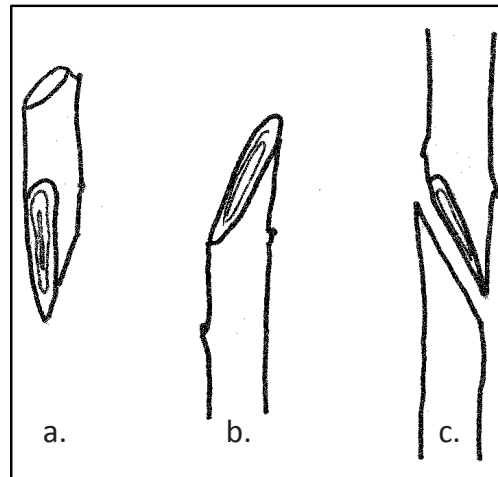


Fig 9: Whip Graft

- Tie and wrap the graft union with plastic wrap. A plastic bag may be used to cover the scion and graft to prevent desiccation (Fig. 9)

Side Wedge graft

- Make a 5cm sloping cut on one side of the scion (Fig. 10a)
- Make a 5cm cut into the rootstock exposing the cambium (Fig. 10b)
- Fit scion and rootstock (Fig. 10c)

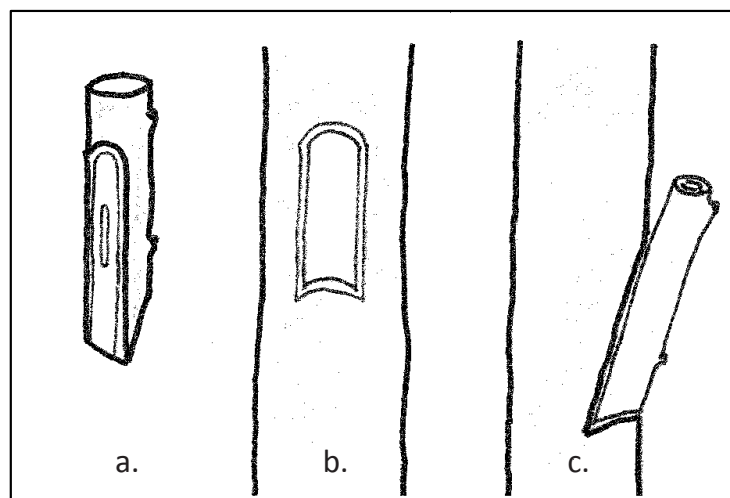


Fig. 10: Side Wedge graft

Top- working or Bark Grafting

Mature trees of inferior mango varieties are top-worked to better cultivars using either side-grafting or crown-grafting the trunk or main branches. When top-working a mango tree, leave at least two fully leafed branches intact (Fig. 11). Such trees need protection from sunburn until the graft affords shade. Top-worked trees will bear in 2 to 3 years.

Procedure

Saw off branch or trunk at right angle to the grain. Split the bark using a heavy knife and hammer to split the stock about 4cm deep into the branch through the center (Fig. 11). Use a screwdriver or a chisel to drop open the split. Use pencil-size one-year-old scions that are knot- free with at least three buds. Make a long (1 to 1-1/2 inches long) smooth cut towards the base from the lowest bud. Perform this operation on the other side creating a wedge with a blunt tip.



Top-worked young seedling with scion wrapped with grafting tape



Successful top-worked tree with grafting tape only at graft union



Successfully top-worked grafted tree

Fig. 11: Top Working mango under field conditions (Source of pictures: Muo Kasina)

Insert the scion (usually two scions) and align the cambiums. Remove the screwdriver. Wax all the cut surfaces and ensure that there no cracks are evident a few days after grafting.

Management of Grafted Seedlings

- 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 when necessary
- Pest and disease control operation are regularly carried out
- 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

NOTES

[illegible]

MANGO VARIETIES/CULTIVARS

Mango varieties in Kenya are mainly classified based on areas they thrive best.



Vandyke






Kent





Apple



Fig. 12. Mango tree varieties (Source of pictures: Grace Watani)





A. Low Altitude Cultivars

<p>Apple</p> <ul style="list-style-type: none"> - Tree spreading - Fruit is round in shape - Ripen to a rich yellow orange to red colour - Excellent flavour - Fruit is fibre-free 	
<p>Ngowe</p> <ul style="list-style-type: none"> - Tree spreading - The most popular for export market - The fruit is large and long with excellent flesh quality - It is fibre-free - The colour is deep yellow 	
<p>Boribo</p> <ul style="list-style-type: none"> - Tree spreading - Fruit is long and large - The flesh is deep orange-red - Fruit is fibre free and sweet 	

<p>Kitovu</p> <ul style="list-style-type: none"> - Oval medium fruit with flat cheeks - The seed is polyembryonic - Recommended rootstock for coastal lowlands - Size of fruit: small - Fruit colour is green - Flesh colour is orange and fibrous - The tree habit: Small - Harvesting season is late - June/July 	
<p>Kimji</p> <ul style="list-style-type: none"> - Size of fruit: small - The seed type is polyembryonic - Recommended rootstock for coastal lowlands - The tree habit: small - Flesh yellow and fibrous - Harvesting season is late - June/July and December/January 	

B. Medium Altitude Cultivars

<p>Tommy Atkins</p> <ul style="list-style-type: none"> - Tree full, dense - Fruit medium to large (500g) - Fruit is regular ovate with thick skin - Orange-yellow covered with red and heavy purple bloom - Firm, juicy, medium fibre - Flavour poor when over fertilized and irrigated - Resists anthracnose and black spots - Early and regular yielder - Prone to jelly seed abnormality 	
<p>Van Dyke</p> <ul style="list-style-type: none"> - The tree large with an open canopy - Very attractive bright red colour - Fruit is small (300g) and flattened laterally - Very prominent nose - Susceptible to black spot - Poor yielder 	

<p>Haden</p> <ul style="list-style-type: none"> - Tree spreading - Fruit large and ovate - Yellow almost covered with red - Flavor mild - Little fibre - Susceptible to anthracnose 	
<p>Kent</p> <ul style="list-style-type: none"> - Tree upright - Fruit large and ovate (500-600g) - Greenish yellow with red shoulder - Flesh rich - The fruits are sweet - Fibreless - Strong flavored - Have a long shelf life. - Late season variety that comes into bearing in late February-April - Highly Susceptible to black spot 	
<p>Sabre</p> <ul style="list-style-type: none"> - Polyembryonic - Fruit ripen over a long period - Tolerant to black spots - Fruit slightly fibrous, long and S shaped - Yields are good - A good rootstock but also suitable for local market 	
<p>Peach</p> <ul style="list-style-type: none"> - Polyembryonic - Tree big - Produce consistent high yield - Fruit is fibrous - Fruit is of medium size (300-400g) - Has attractive orange-yellow colour - A rootstock tolerant to black spot - Has good shelf-life - A good rootstock but also suitable for local market 	





<p>Turpentine</p> <ul style="list-style-type: none"> - Seed is polyembryonic - Variety is used as a salt-tolerant (highly alkaline soils) rootstock - Fruit is small, roundish to ovate in shape - Flesh is yellow and highly fibrous - The tree has vigorous growth with a thick canopy 	
<p>13-31</p> <ul style="list-style-type: none"> - Is a salt-tolerant (highly alkaline soils) rootstock - Has a good root system - A small tree - High graft compatibility - Does well in the highlands 	
<p>Keitt</p> <ul style="list-style-type: none"> - Fruit large and ovate (400-600) - Green - Flesh rich - Fibre around seeds - Resists mildew - Late - Excellent keep quality - Susceptible to black spot 	
<p>Kensington</p> <ul style="list-style-type: none"> - Polyembryonic - Tree round and vigorous - Fruit medium to large - Fruit is almost round with pink blush - Flavour sweet - Mid –season variety 	

Fig. 13. Commercial mango varieties and recommended rootstocks in Kenya
(Source of pictures: Lusike Wasilwa)

NOTES

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MANGO ORCHARD ESTABLISHMENT

Planting

- Dig holes 60 x 60 x 60 cm at a spacing from 9 x 9 m to 13 x 13 m depending on growth characteristic of individual variety
- Mix one debe of well decomposed manure and 120g of DAP with top soil and return this to the hole

Transplanting

- 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
- Plant the young tree into the hole and fill the hole and press the soil around the stem firmly
- Irrigation is necessary in absence of adequate rainfall for proper establishment of the young trees. Mulching around the tree is recommended to smother weeds and to conserve moisture
- Trees should be top dressed with 250g of CAN per tree at the beginning of each rainy season after attaining a height of 1 metre. However, soil analysis is recommended.

Pruning

Formative pruning

- Allow the planted seedling to grow to a height of 1m
- When the plant is partially dormant, remove the apical bud in order to stimulate growth of lateral buds
- This would result in growth of several laterals (5-6buds)
- Select three of these lateral that are well placed on all sides of the main stem and remove all the rest
- When these lateral have grown to about 30cm they are tipped again to stimulate more lateral to grow
- Allow three of those lateral growing to the outside to grow and remove all those growing towards the centre of the tree
- This process is repeated five times until the canopy is properly established

Maintenance pruning

Should be done after harvesting period is over (March-April) before the main flush in May.

Procedure

- Open the tree centre by removing all the branches growing towards it
- Remove all the branches crisscrossing and those which are shaded

- Remove die bark and dried twigs
- Remove branches growing downwards such that the lowest branch should be at least 1m above the ground
- One should be careful not to over open the centre-the open space should be about 1/4 of the canopy

Flower Induction

- Mango in Kenya is available from November to April and off season crop in July. Because of less competition better prices are fetched in Europe and Middle East between November and December. Other advantages of flower addition are to fill the gap of under supply and having fruits during the dry spell with little or no fungal diseases.
- These are several ways that can be used to induce flowering.

Cultural Methods

- Smudging (moist organic material – grass, leaves etc. is slowly burnt under the tree canopies and the resulting smoke induces flowering)
- Ringing the tree branches
- Pruning the roots
- Applying salts on the roots

Chemical Methods

- Application of Potassium Nitrate (1%) Solution mixed with a sticker agent (adhesive) on the tree totally drenching its terminals and leaves
- If the timing is right, flowering will emerge 10-14 days after application
- The readiness of the tree to flower is an important factor for a successful operation. Best results are achieved on trees with leaves that are dull green or greenish-brown and brittle when crushed by hand. The tree should have an appearance of suspended growth or be dormant
- Auster or Culter (Paclobutrazol) - New product in Kenya. Also regulate production and one gets much higher yields

NOTES

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CROP PROTECTION

Insect Pests

Mango seed weevil

(*Sternuchus* (Cryptorhynchus) *mangiferae*)

- The female cuts the fruit into which it inserts a single egg
- The larva on hatching bores through the pulp into the seed (Fig. 14)
- Pupation takes place into the seed
- The entire life cycle takes 40-50 days



Fig. 14. Damaged young mango fruit & seed and ripe mango fruit

(Source of pictures: Grace Watani)

Symptoms

- Partly eaten embryos inside the husk of the seed
- Small, white and legless grubs can be seen inside the husk. There are no outside signs of damage on the fruits

Control

- Seed destruction by burning. Infected mango seed are collected, placed on a wire mesh and burnt (Fig. 15).



Fig. 15. Damaged young mango fruit & seed and ripe mango fruit

(Source of pictures: Grace Watani)

- Trunk banding using Dursban has been proven to be very effective. A mixer of Dursban (40ml/l) and white wash is used for banding (Fig. 16). This prevent weevils from climbing up.



Fig. 16. Trunk Banding (Source of picture: Grace Watani)

- Banding should be done at the beginning flowering

Mango fruit fly (Ceratitis spp)

- A number of them infest mango fruits causing considerable damage
- In Kenya, the below three species (Fig. 17) are considered most important
- The female fly pierces the ripening fruit and insert its eggs just below the skin surface
- Maggots feed on the fruit pulp causing premature ripening and fruit drop
- Damage by this pest can be as high as 30%



Ceratitis coryra



Ceratitis capitata



Bactrocera invadens

Fig. 17. Types of fruit fly pests of mango (Source of pictures:

<https://www.cphdforum.org/index.php/2015/06/03/about-mediterranean-fruit-fly/>

<https://infonet-biovision.org/PlantHealth/MinorPests/Fruit-flies-5>)

Symptoms

- Causes premature ripening on the fruit
- The flesh under the skin in the ovipositional site becomes liquid due to secondary infections
- Widespread fruit drop is a common characteristic



Fig. 18. Mango fruit fly entry spot



Mango damage by fruit flies

(Source of pictures: Grace Watani)

Control

- Collect all fallen fruits, put them in a drum of water with one inch of oil for two weeks. After this burn or bury the fruit
- Spray trees with an insecticide like Decis. Control is enhanced if the insecticide is mixed with attractant such as buminal, sugar or molasses

Gall midges

The adult oviposit on tender leaves. These are characterized by occurrence of numerous “pimples” become necrotic and the leaves may drop.



Fig. 19. Galls (“pimples”) on and under leaves of a mango tree
(Source of pictures: Grace Watani)

Control

- Under normal conditions, control is not instituted
- If the need arises, timing of pesticide application is important
- Should be carried out during the new flush
- Apply either Decis or folimat as soon as new shoots and leaves appear

Scale insects

A number of scale insects (both armoured and soft-scales). The feeding sites are either the fruits, leaves or both depending on the population density.



Fig. 20. Mealybugs on leaves

Mealybugs on fruit

(Source of pictures: Grace Watani)

In most cases, these are minor problems but occasionally lower the fruit quality and may warrant control.

Control

Scale insects are effectively controlled by use of DC-Tron plus (Caltex oil) which act by suffocating the pests.

N.B. For chemical control, read the label attached to the pesticide container and use the manufacturer's recommendations. It is important to observe postharvest interval (PHI). This applies to all the above mentioned pest control products.

Mango Diseases and their Control

Powdery mildew

This disease is caused by fungus *Oidium mangiferae* Breth. Spores are disposed by the wind from the neighboring early infected trees and survive from season from season in dormant buds. Infection is favored by cool, cloudy weather, but reduced by rainfall.

Symptoms

Infected flowers, flower stalks, young fruits and leave are coated with the white, powdery growth of fungus. The flowers and young fruits turn brown and shed. In severe attacks, the entire blossom panicle may be infected and the fruits fail to set.



Fig. 22. Powdery mildew on leaves



Powdery mildew on flowers

(Source of pictures: Grace Watani)

Control

The only effective method of control is by use of foliar sprays with fungicides. Thiovit or Bayleton applied at an interval of 2 weeks are effective.

N.B. For chemical control, read the label attached to the pesticide container carefully and use the manufacturers recommended rate.

Anthracnose

This disease is caused by the fungus *Colletotricum gloeosporioides* perr. The principal source of infection is old infected twigs, on which the fungal spores are produced in abundance during damp weather. Spores are principally splash dispersal. Thus rainy weather during blooming and early fruit set is particularly important in disease development.

Symptoms

The disease attacks all parts of the tree and is especially severe on flowers, young fruits and leaves.

It appears as small black spots on stems, leaves and flower stalks. On flowers and flower stalks, the infection spreads quickly and causes death of individual flowers or often the entire flower stalk. This causes flower abortion and reduces fruit set. Young fruits are susceptible until they are about half developed. The affected skin areas are usually cracked and slightly depressed.



Fig. 23. Symptoms of anthracnose on fruit
(Source of pictures: Grace Watani)

The importance of this disease is particularly post-harvest as on mature fruits the black spots enlarge and a black rot penetrates the flesh. Although the fruit is still edible, it looks unattractive and has reduced market value.

Control

Cultural

- Prune dead branches and twigs to reduce disease reservoirs
- Where feasible, fruits should be stored in cool (10-12°C) room.

Chemical

The disease can be controlled by foliar sprays of copper based fungicides.

Physiological disorders

The physiological disease that most often afflicts mango fruits is termed “internal breakdown” the appearance of which can take various forms like soft-nose or jelly seed (Fig. 24).

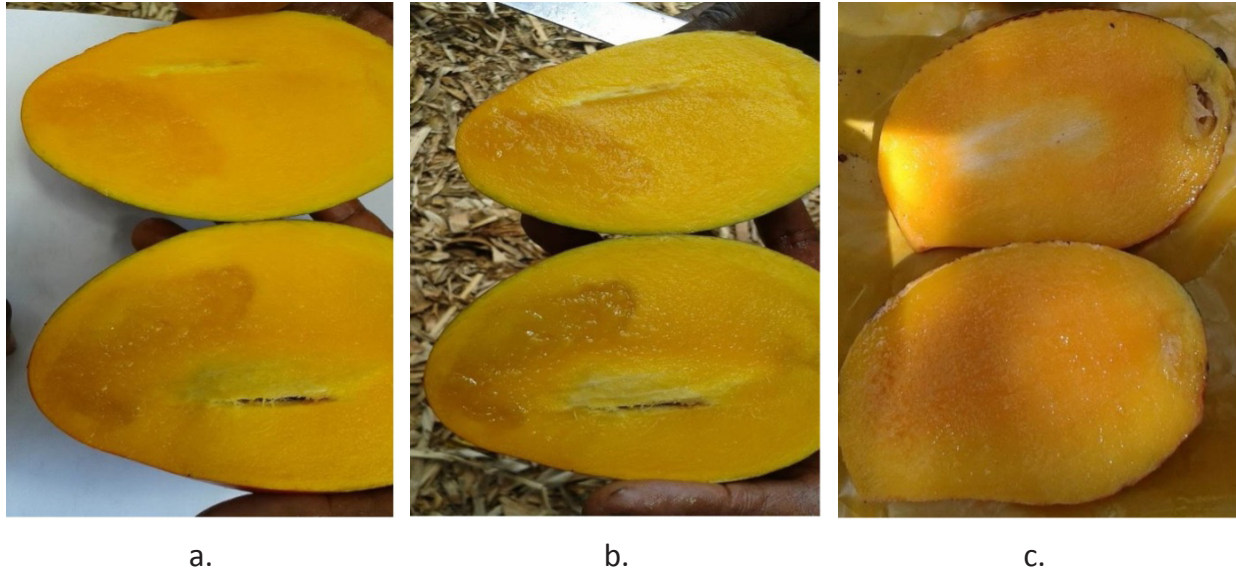


Fig. 24. Mango seed jelly at 33% (A), 66% (B) and 100% (C) damage
(Source of pictures: Kori Njuguna)

Control

- Early harvest when fruit have reached physiological maturity but before they ripen
- Repeated spraying of CaCl_2 and leaf dressing. 700g of CaCl_2 per 100L water. 3-4 spraying each season beginning after the fruit set
- Correction of soil micronutrients
- Reduction of Nitrogen application
- Liming the soil with Gypsum (CaSO_4) or muriate of potash reduces the problem

NOTES

This image shows a full page of blank white paper with horizontal blue or grey ruling lines, typical of notebook paper. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

REFERENCES

1. PCPB (2021). Pest control products registered for use in Kenya. 15th edition. Pest Control Products Board. Nairobi, Kenya.
2. Nyaga A., Watani G., Gatambia E., Njeru E., Muriuki S. J. N., Wandera F., Ringera E., Macharia E., Otipa M., Finyange P., Too A., Gitahi M., Mutiso A., Wario F., Okoko N., Kwambai T., Fullerton B. and Wasilwa L. (2017). Good Nursery Management Practices Manual. KALRO Headquarters

Appendix 1: Template for Costing Seedling Propagation

Template for Costing a seedling eg Mango						
Item No	Item of cost	Units	Quantity	Rate per unit	Total	Cost per seedling
			(A)	(B)	(A*B)	(A*B)/C6
1	COST OF ROOTSTOCK PRODUCTION					
1.1	LABOUR					
	Seed fruit/stone loading/offloading	Mandays	1	433	433	0.433
	Seed extraction and processing	Mandays	2	433	866	0.866
	Seed/stone planting in beds	Mandays	2	433	866	0.866
	Forest soil collection	Mandays	2	433	866	0.866
	watering	Mandays	2	433	866	0.866
	spraying	Mandays	0.5	433	216.5	0.217
	weeding	Mandays	0.5	433	216.5	0.217
	soil potting and planting	Mandays	2	433	866	0.866
	Sub-total				5196	5.196
1.2	MATERIALS					
	Seed fruit/stone	bags	1000	2	2000	2.000
	Forest soil	tons	0.5	300	150	0.150
	Farm yard manure	tons	0.33	1,000	330	0.330
	Sand	tons	0.167	1,000	167	0.167
	Budding knives	pieces	1	500	500	0.500
	Seceatur	pieces	1	1,500	1	0.001
	Sub-total				3148	3.148
1.3	FERTILIZERS					
	DAP	kgs	1	85	85	0.085
	CAN	kgs	1	60	60	0.060
	UREA	kgs	1	60	60	0.060
	Foliar feed	litres	1	100	100	0.100
	Sub-total				305	0.305
1.4	CHEMICALS					
	Fungicides	gms/ml	1	60	60	0.060
	Insecticides	ml/gm	1	50	50	0.050
	Sub-total				110	0.110
1.5	POTTING PAPERS					
	Size 6*9	packets	5	1000	5000	5.000
	Sub-total				5000	5.000
1.6	TRANSPORT OPERATION					
	Forest soil collection	kms	40	40	1600	1.600
	Fruit seed/stone collection	kms	300	40	12000	12.000
	Purchase of stores	kms	200	40	8000	8.000
	Sub-total				21600	21.600
1.7	TRAVELLING AND ACCOMODATION					
	Forest soil collection	persons	2	1000	2000	2.000
	Fruit seed/stone collection	persons	2	1000	2000	2.000
	Sub-total				4000	4.000
1.8	Rootstock watering	Cubic mt	100	50	5000	5.000
	Sub-total				5000	5.000
2	Total costs per rootstock				44359	44.359

3	COST OF PROPAGATING THE SEEDLING					
3.1	LABOUR					
	Grafting	Mandays	10	433	4330	4.330
	watering	Mandays	1	433	433	0.433
	spraying	Mandays	0.5	433	216.5	0.217
	weeding	Mandays	1	433	433	0.433
	scion /buds cutting	Mandays	2	433	866	0.866
		Sub-total		2165	6278.5	6.279
3.2	MATERIALS					
	grafting strips	rolls	1	600	600	0.600
	scions	nos	1000	10	10000	10.000
	Wheels	pcs	1	500	500	0.500
	Hose Pipe		1	250	250	0.250
	Knapsack Sprayer		1	1000	1000	1.000
	Grafting Knife		1	300	300	0.300
	Labelling Wool	boll	1	100	100	0.100
		Sub-total			12750	12.750
3.3	FERTILIZERS					
	CAN	kgs	1	60	60	0.060
	UREA	kgs	1	60	60	0.060
	Foliar feed	litres	1	6.5	6.5	0.007
		Sub-total			126.5	0.127
3.4	CHEMICALS					0.000
	Fungicides	grams	1	60	60	0.060
	Insecticides	litres	1	50	50	0.050
		Sub-total			110	0.110
3.5	TRANSPORT OPERATION					0.000
	Scion /buds collection	kms	200	40	8000	8.000
		Sub-total			8000	8.000
3.6	TRAVELLING AND ACCOMODATION (Advisory services per year)					
	Scion /buds collection	persons	2	1000	2000	2.000
		Sub-total			2000	2.000
3.7	Seedling watering	Cubic mt	60	50	3000	3.000
	Sub total				3000	3.000
4	Total cost of grafting one mango seedling				32265	32.265
5	Total cost of grafted seedling (rootstock + grafting cost)				76624	76.624
6	OVERHEAD COSTS (CROSS CUTTING COSTS)					
6.2	Storage costs at 1% of nursery costs				766.2	0.766
6.5	Building maintainance and other renovations at 1.5% of nursery costs				1149.4	1.149
6.6	Staff wages at 10% of nursery costs				7662.4	0.077
6.7	Losses due to seedling mortality a t10% of the production cost				7662.4	0.077
		Sub-total			17240.4	2.1
7	Total unit Propagating cost of mango seedling (RS, Grafting, Overheads)					78.693
7.1	Gross profit of seedling @ 38.8% of Total unit cost					44.388
7.2	Selling price of the seedling Mango Seedling					130

Appendix 1: Acceptable Irrigation Water Quality

Characteristics	Quantity
pH	6.0 - 8.3
Salinity	0 - 1.5mmhos/cm
Calcium	40 - 120mg/l
Alkalinity	0 - 300mg/l
Sodium	0 - 50mg/l
Boron	0.2 – 0.8mg/l
Magnesium	6 – 24mg/l
Chloride	0 – 140mg/l
Sodium Absorption Ratio	0 - 4

Appendix 3: Management for Efficient Composting

Symptoms	Problem	Solution
Bad odour (foul smell)	No enough air or too wet	Turn the compost and add more dry material and cover with soil
Dampness and warm in the middle	Too small substrate	Add new material and mix with the old material
The heap is damp, sweet smelling but not heated up	Lack of Nitrogen	Turn the compost, add mineral Nitrogen fertilizer or organic manure, mix the material and cover with soil
High production of not decomposed material	Short composting period	Allow decomposition to proceed for a longer time
Center of heap is too dry	No enough water	Apply water to moisten, mix the heap and cover with soil
Extreme wetness/water logging	Use fibrous material only	Alternate layers with of cut-soft material with coarse fibrous material

Appendix 4: Application form for Horticultural Crop Nursery Registration



AGRICULTURE FOOD AUTHORITY (AFA) HORTICULTURAL CROPS DIRECTORATE

Nairobi Horticultural Centre next to JKIA, P.O. Box 42601 – 00100 Nairobi, Telephone: 020-2088469, 020-2131560 Email: md.hcda@gmail.com / Website: www.agricultureauthority.go.ke

Application form for Horticultural Crop Nursery Registration

(The Agriculture Act (Cap 318) HCDA Legal No 190 paragraph 29(1))

1. Full Name/Group of applicant.....
2. National Identification No. (ID).....
3. Kenya Revenue Authority Pin No.....
4. Physical business location.....
5. Postal address.....
6. Telephone mobile No.....
7. E-mail address.....

A. Source of Propagation Material

- i). Copy of Receipt for Seed acquisition
- ii). Certified Copy of HCDA Mother-block registration
- iii). A Phytosanitary Certificate of seed and Mother-block

B. Fruit tree Nursery Source

1. Conventional

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Tissue Culture

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____

C. Vegetable Seedlings Nursery**1. Conventional**

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Tissue Culture

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

D. Ornamental Seedlings Nursery**1. Conventional**

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Tissue Culture

Crop	Variety	No. of Seedling
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

I Certify that I shall abide by the regulations and ensure that all scion materials and all seedlings are Certified by the horticultural inspectors before they are sold.

Applicant Signature Date:

FOR OFFICIAL USE ONLY

Recommended/ Not recommended

District Horticultural Crops Officer

{Site must be inspected}

{Horticultural Crops Development Officer}

Date: _____ District: _____

Approved/ Not Approved _____ Date: _____

.....

DIRECTOR

Horticultural Crops Directorate

CONDITIONS

1. This Certificate is Valid for 1 year from date of issue.
2. This Certificate is not Transferable to any other person, or nursery site.
3. All Certified planting materials which are not distributed during the certification's period will be subject to re-inspection.

Note: This form shall be accompanied by a non-refundable fee of Kshs.500.00 payable to Horticultural Crops Directorate

Appendix 5: Table showing contacts of KEPHIS Regional Office

	MAIN KEPHIS OFFICES	LOCATIONS/ REGIONS COVERED
1	KEPHIS Headquarters P.O. Box 49592-00100, Nairobi Cell: 0709 891 000 Tel: 020 661 8000 Email: director@kephis.org , kephisinfo@kephis.org	Nairobi, Machakos, Makueni, Kitui, Tharaka Nithi, Kiambu, Thika, Maragwa, Nyambene, Muranga and Kajiado
2	Plant Quarantine Station P.O. Box 49421-00100 Nairobi PH: 020-3597204/5 Cell:0722-209505 0734-330017 VOIP-YELLO 7730592/3 Fax: 020-3536176 Email: pqs@kephis.org	Nairobi, Machakos, Makueni, Kitui, Tharaka Nithi, Kiambu, Thika, Maragwa, Nyambene, Muranga and Kajiado
3	Plant Inspection Unit Jomo Kenyatta International Airport P.O. BOX 19164-00501 Nairobi. PHONE: 254-020-822768 Cell:0722-209504/0734-330016 Fax: 254-020-3597206/7 Email: kephisiu@kephis.org	Nairobi, Machakos, Makueni, Kitui, Tharaka Nithi, Kiambu, Thika, Maragwa, Nyambene, Muranga and Kajiado
4	Nakuru Regional Office P.O. Box 1679 Nakuru TELEFAX: 020-3536170 Cell:0722-209503 0734-330020 Email: kephishnakuru@kephis.org	Samburu, Nakuru, Laikipia, Baringo, Kericho, Koibatek, Bomet, Narok, Transmara, Nyandarua, Kuria, Migori, Isibania, Nyamira, Homa Bay, Suba, Rachuonyo and Gucha
5	Kitale Regional Office P.O. Box 249 Kitale PH: 254-054-30908 020-3536173/3597211 Cell:0722-209502 0734-330019 Fax: 254-054-31971 kephiskitale@kephis.org	Trans Nzoia, West Pokot, Uasin Gishu, Bungoma, Mt. Elgon, Teso, Ungari, Butere, Vihiga, Nyando, Bondo, Siaya, Turkana, Keiyo, Malaba, Suam, Marakwet and Nandi
6	Mombasa Regional Office P.O. Box 80126 Mombasa PH: 2316002/3 020-3536174/3587523 Cell:0722-209501 0734-330018 Fax: 254-041-316002 Email: kephis_mombasa@kephis.org	Kwale, Kilifi, Mombasa, Taita Taveta, Lamu, Tana River, Garissa, Wajir and Mandera
7	Kisumu Regional Office P.O. Box 7094-40100 Kisumu PH: 254-057-2024776 020-3597209 Cell:0728-607098 Fax: 254-057-2024727 Email: kephiskisumu@kephis.org	Kisumu, Kakamega, Busia, Kuria, Migori, Gucha, Kisii, Nyamira, Homabay, Suba, Rachuonyo, Nyando, Bondo, Vihiga Siaya and Butere-Mumias

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MARKUP

EU-EAC MARKET ACCESS UPGRADE PROGRAMME



Contacts

United Nations Industrial Development Organization (UNIDO)

P.O. Box 41609-00100

United Nations Avenue

UN Gigiri Complex, Block N, Ground Floor

Nairobi, KENYA

Tel: +254 20 7624369; +254 20 624388;

Email: office.kenya@unido.org

Website: <https://www.unido.org/>