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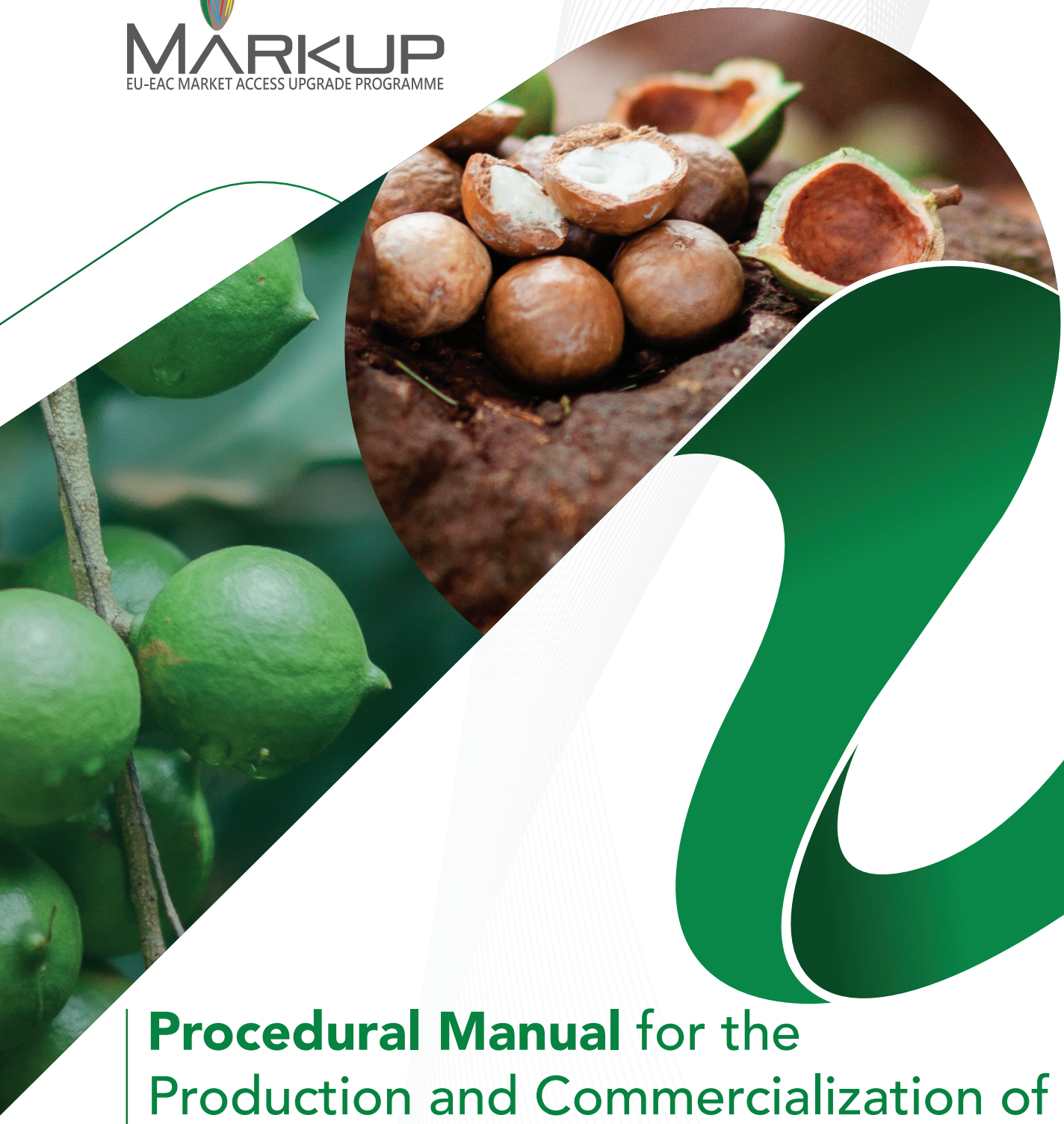

Procedural Manual for the Production and Commercialization of Macadamia Clean Planting Material

MARKUP PROJECT MACADAMIA

Republic of Kenya
Ministry of Industrialization,Trade and Enterprise Development

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Procedural Manual for Clean Macadamia Propagation Material Production

A manual developed by KALRO to guide in the production of clean planting materials by nursery operators and extension service providers for macadamia nuts for increased marketability, yield and export potential

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Figure 1: Macadamia nut seedlings tunnels
Source of picture: Lusike Wasilwa, KALRO

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ACRONYMS

AFA	Agriculture Food Authority
HCA	Competent Authority
HHN	High Health Nurseries
KALRO	Kenya Agricultural & Livestock Research Organization
KARI	Kenya Agriculture Research Institute
KES	Kenya Shilling
KEPHIS	Kenya Plant Health Inspectorate Service
MOALF	Ministry of Agriculture Livestock and Fisheries
MSB	Macadamia Stink Bug
MT	Metric tonnes
NIS	Nuts in Shell
NOCD	Nuts and Oil Crops Directorate
PCPB	Pesticide Control Products Board
Ph	Hydrogen Potential
HCD	Horticultural Crops Directorate

DEFINITIONS

Term	Definition
Adventitious roots	A root that arises from any point other than the radicle or the root axis
Biological control	A reduction of pest populations by natural enemies and typically involves an active human role
Cambium	A thin formative layer between the xylem and phloem of most vascular plants that gives rise to new cells and is responsible for secondary growth
Callus	In living plants, callus cells are those cells that cover a plant wound
Certified	In the case of seedlings, the Quality of the seedlings is approved by an official mandated organization (in the Kenyan case, the Competent Authority is KEPHIS)
Chlorosis	Extreme yellowing of plants leaf tissue, usually at Nursery or juvenile phase, distinctly different from Nitrogen and other nutrient deficiencies
Clone	A plant or an animal that is produced naturally or artificially from the cells of another plant or animal and is therefore exactly the same as its parent
Compost	Mixture of ingredients prepared by decomposing plant and food waste with recycled organic materials used to fertilize soil
Field sanitation	Collection and disposal of fallen diseased fruits, leaves and vines
Graft union	This is the point where the scion and rootstock unite
Grafting	Joining together of plant parts and let to grow
Heterozygous	Does not breed true to type usually leading to two different gene compositions in the same location and consequently different phenotypic expression
High health nursery	Is a special production system that prevents or reduces infection by soil-borne diseases
Kernel recovery	Percentage by weight of the Kernels to the total weight of the Nut(s)
Lesions	It is any damage or abnormal change in the tissue of an organism, usually caused by disease or trauma
Mother tree	A genetically characterized source of Scion materials for propagation for maintenance of True ton Type Ness
Organic matter	A source composed of natural compounds that have come from remains of plants and animals
Pathogen	An organism that causes diseases to plants
Pest	A pest is any organism harmful to humans or human concerns. The term is particularly used for organisms that damage crops, livestock, and forestry (lately includes both arthropod pests and diseases)
Phenotype	Physical (visible) expression of traits dictated by the genes and the environment

Pruning	To cut off some the branches of a plant that are not necessary to make it grow better
Rootstock	A stem with a well-developed root system to which a bud from another plant is grafted
Sand beds	Specially prepared propagation bed with sand as the medium
Satire	In nuts, a small line or mark running on one side of the nut indication where the opening will occur on germination
Scion	A young shoot or twig of a plant used for grafting
Symptoms	Is a visible effect of disease on the plant
Tissue culture	It is an artificial method of culturing plants. A small part of the plant is used to grow cells in a nutrient solution in the sterile condition of the laboratory. Tissue culture is a very fast technique. The new plantlets can be grown in a short period of time and "en-mass"
True-to-type	Where the progeny is an exact true replica both physically and genetically (Usually though vegetative propagation)
Vegetative propagation	A process in which plants reproduce from stems, roots and leaves

ACKNOWLEDGMENTS

This work was carried out as part of the European Union funded EAC-MARKUP Programme – Kenyan window – implemented by UNIDO, which aims at creating awareness and promoting the use of clean planting material of the marketable varieties of certain crops, like mangoes, passion fruit, macadamia and ground nuts. This was based on the need, as identified by farmers/growers, for clean planting mat4rial that would ensure better yield, compliant produce and marketability. This work was primarily carried out and written by experts from the Kenyan Agriculture Research and Livestock Organization (KALRO), namely: Grace Watani (Mango), Nasambu Okoko (Groundnuts), John Ndungu (Passion Fruit) and Antony Nyaga (macadamia). The KALRO experts work under the direct supervision of Lusike Wasilwa (PhD) who coordinated and documented all their activities. The work was sanctioned by UNDO-MARKUP expert Ali Abbas Qazilbash (PhD), International Expert QI & SPS Compliance and Stefano Sedola, Chief Technical Advisor-MARKUP and facilitated by Michael 'Maina' Karuiru, National Program Coordinator of the MARKUP-Kenya project. The guide and manuals developed by the KALRO experts was used as training material for the nursery staff and extension officers at county level. The experts then imparted this knowledge at the designated counties as identified under the MARKUP project.

Special acknowledgment to the MARKUP communication team, led by Christine Misiko, (Knowledge Expert), Rachel Kibui and Brian Muriuki who used the material to develop awareness campaigns and design the communication materials and publications linked to the work carried out the experts.

In addition, the support provided by Christine 'Kiki' Mulindi in organizing the trainings and logistic support to help ensure the smooth conduct of activities linked to these activities is gratefully acknowledged.

FOREWORD

Procedural Manual for Macadamia 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.

For macadamia nuts subsector, lack of adequate clean planting materials has been identified as one of the sectors major drawback limiting its growth, despite the high market potential and undersupplied global market. This is as a result of lack of inadequate information on good agricultural practices by both nursery operators, extension service providers and other industry players. Other challenges include long propagation cycles (18 -24 months), low regulatory capacity of CA bodies, high cost of seedlings (the cost of buying quality macadamia seedlings has remained high subsequently a high investment cost), hard-woodiness nature of the crop, poor callus formation and high mortality rates of graft unions, among others.

This procedural manual has been developed from extensive information from research and background data by KALRO. 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 macadamia seedlings for use by nursery operators and extension service providers across the country and beyond. The manual is meant to be used together with the developed business plan that guides on how the nursery operators can operate their production units and at the same time ensuring cost effective clean planting materials.

I am greatly indebted to the KALRO commodity experts who participated in the preparation of the manual, which is expected to epitomize a new way of delivering technical information and training content in a changing agricultural environment.

Lusike Wasilwa, PhD
Director Crop Systems
For Director General KALRO

1 INTRODUCTION

Macadamia (*Macadamia integrifolia* Maiden and Betsche and *Macadamia tetraphylla* L.A.S Johnson) is one of the most important nut crops in Kenya, mostly produced in Eastern, Central, Rift Valley and Western parts of the country. It is produced by resource-poor farmers as a complimentary cash crop to coffee, tea and banana, with an annual production of estimated at about 40,000 metric tons (MoALF, 2015). The contribution of macadamia nut is 38.8% of the overall nut value in Kenya (AFA, 2017). Value addition associated with the crop is leading to a growing agro-processing industry that targets niche markets in Europe, America, Japan and China (Wilkie, 2008). Being a low-input tree crop, macadamia is grown by smallholder farmers who produce about 70% of the total production while 30% is produced by about 1000 large-scale growers with at least 1000 trees each (Quiroz *et al.*, 2020). The area under macadamia production has increased over the years and in 2014, macadamia nuts were produced on 6,059 Ha with a production of 42,160 metric tons valued at KES 3.3 billion (MOALF, 2015). Furthermore, macadamia can be intercropped with other cash crops such as coffee, tea and food crops such as beans and bananas thus enhancing income and livelihood of smallholder farmers (Gitonga *et al.*, 2009). Area currently covered by the macadamia crop is estimated at 9,707 acres and directly supports about 6,472 farmers (NOCD, 2016).

Despite its economic importance, macadamia production has been on slow decline in Kenya due to both biotic and abiotic constraints (Mbaka, 2011). The scope for increasing the production of crop exists, especially through increased acreage. However, despite the research undertaken on the crop over the years, good planting materials, pest and diseases and marketing are still a limiting factor (Quiroz *et al.,* 2020)

BACKGROUND INFORMATION

Macadamia is a large spreading evergreen tree that grows to between 10 and 15 m high and has a canopy that spreads 10-15 m. The inflorescence is a pendant raceme with 250-300 flowers. The fruit has a very hard seed coat that is enclosed in green fibrous husk that splits open when the nut matures. Natural hybridisation occurs when M. integrifolia and M. tetraphylla are intercropped particularly at high altitudes (Nyaga *et al*, 2006).

Macadamia belongs to the family Proteaceae. There are 3 edible species of this crop, namely *Macadamia integrifolia*, *M. tetraphylla* and *M. ternifolia*, of which only the former 2 are of economic importance. Macadamia originated from Queensland, Australia and gained importance as a commercial crop and is currently grown in Hawaii, Australia, Kenya, Brazil, Guatemala, Costa Rica, Malawi and South Africa among other countries. It was introduced in Kenya from Australia by Bob Harries in 1946 and macadamia planting as a complimentary cash crop to coffee begun in the then Central, Eastern and Coast (Taita/Taveta District) Provinces. Most of these trees were propagated from seeds and resulted in a wide variation among the original plants.

The crop though introduced in the mid-1940s did not flourish due to several constraints including low yields (5-10 kg/tree/season), poor quality nuts (< 70% oil content) due to lack of adapted varieties and poor marketing infrastructure. These discouraged farmers from growing the crop with some of them uprooting the initial planted trees.

ADAPTABILITY AND SCOPE

Macadamia grows well at altitudes between 1,000 to 2000 metres above sea level, in the coffee tea zone, marginal and main coffee zones, and is grown in the central highlands, Machakos, Taita Taveta and most recently to the Rift Valley, Western and Nyanza regions. It is small-scale farmer grown crop with only a few large-scale farmers having orchards with more than 1000 trees.

Kenya exports more than 95% of its production amounting to about 5,000 MT dried kernels against a production of about 40,000 MT NIS. The farm-gate prices for the nuts in shell has risen from KES 70 in 2013 to the current prices of KES 200 (2019). This has resulted to increased demand for seedlings for new plantings.

ECONOMIC IMPORTANCE

Global Macadamia nuts production is estimated at 211,000MT with Kenya producing approximately between 40,000-45,000MT annually. Kenya is the 3rd largest producer of macadamia nuts in the world after South Africa (54,000MT) and Australia (46,000MT).

Production and earnings from Macadamia has increased tremendously over the years. Production increased from 1,839 MT in 1992 to about 45,000 MT in 2018. The earnings increased from KES. 935,910 to about KES 6.052 billion during the same period. The number of local processing factories has also increased from 5 in 2008 to 26 currently having contracts with 133 registered marketing agents who supply them the produce (NOCD 2019).

The production area for macadamia has steadily grown from 633 Ha in 1992 to 44,883 ha in 2018. Currently, massive uptake of the nut crop in the non-traditional growing regions is taking place.

The commercial varieties in Kenya are MRG-20, KMB-3, EMB-1 and KRG-15. These varieties are high yielding and differently suited to different ecological conditions. However, the cost of the seedlings remains high (KES 350 - 500 per seedling as at 2019). There is also limited number of certified nurseries most of which are located in the Mount Kenya region. The crop is estimated to support directly about 7,000 farmers and provides an opportunity to improve their livelihoods from the increased prices, as the world markets are largely undersupplied. Macadamia provides raw materials for processing facilities thereby providing additional employment.

Macadamia is also known to contribute towards the increase of the forest/green cover to the 10% target set by the government. Macadamia nut is considered by many to be a prime edible nut. The kernel can be eaten raw or roasted, or is used as a desert, and in the confectionery industry, making chocolates and biscuits. Macadamia nuts are 75% fat by weight, 80% of which is mono-saturated fatty acids. These fatty acids have a high percentage of palmitoleic acid that lowers blood cholesterol levels to reduce the cardiovascular disease risk factor.

The oil extracted from macadamia nuts is similar in composition to olive oil. The high content of palmitoleic acid in the oil also makes a desirable ingredient in cosmetics especially skincare products. The seed cake that remains after oil extraction is used as a constituent of livestock feed.

OPPORTUNITIES IN THE MACADAMIA INDUSTRY:

(i) Unsaturated global macadamia market

Macadamia (Macadamia integrifolia) is the world most popular nut due to its health benefits and its demand globally has been rising. The world market supply for the nut is about 20% undersupplied and therefore this creates a ready market for production in any corner of the globe.

(ii) Potential increase of macadamia growing regions

The potential for growth in the non-traditional areas of the Rift Valley, Western and Nyanza regions is high. This is evident by increased demand for the planting materials in the region. The regions have vast suitable land where macadamia production can be done on large scale.

(iii) Adequate processing capacity

Processing firms are currently operating below capacity. This presents an opportunity for processing even when the production increases. There is need for a corresponding increase in number of trees planted to increase production to utilize the installed processing capacity.

Notes

2 ROLE OF KALRO IN THE PRODUCTION AND COMMERCIALIZATION OF CLEAN MACADAMIA PLANTING MATERIAL

Kenya Agricultural Livestock & Research Organization (KALRO) and its predecessor KARI has been engaged in the development of technologies for macadamia since its introduction as a commercial crop. Macadamia being a new crop, farmers solely on extension services for guidance. The technologies developed include scion varieties, rootstock varieties, agronomic packages, vegetative propagation methods and techniques as macadamia does not breed true-to-type. However, despite of all the research work that has been put into the crop, the uptake by the end users has been slow, particularly in the identification of the correct varieties for the different agro ecological zones, correct agronomic packages, propagation techniques, harvesting and postharvest practices.

KALRO has developed and registered four varieties for Kenya and developed training guides for nursery operators wishing to propagate macadamia. However, most nursery operators have not been trained and end up producing planting materials that are deceased, weak and unsuitable for planting by farmers.

DEVELOPMENT AND REGISTRATION OF MACADAMIA NUT VARIETIES

In 1985, 6 Macadamia integrifolia clones (MRG-20, EMB-2, KRG-1, KRG-3, KRG-4 & KRG-15) and 1 hybrid (KMB-3) were tentatively recommended for cultivation in the eastern, central and western highlands of Kenya (Hirama et al., 1987; Kiuru et al., 2004; Nyaga and Tominaga, 1996; Wasilwa, 1988) (Table 1). Varieties MRG-20, KRG-15 and EMB-1 and one hybrid (KMB-3) are recommended for commercial production. Adaptability studies for clones ttw-1, ttw-2, HAES 508, HAES 333, KMB-4, EMB-2, EMB-A, EMB-H, MRG-25, MRU-24 and MRU-25 are ongoing.

Notes

Table 1. Recommended zones for growing different varieties of macadamia nuts

Altitude (m)	Zones	Rainfall (mm)	Temp (°C)	Variety
> 1750	Coffee-tea	1600	17.5-19	KMB-3 (EMB-1, MRG-20, EMB-H, MRU-24, MRU-25)
1550-1750	Main coffee	1200	18.5-20	EMB-1, KRG-15 (KMB-4, EMB-2, EMB-H, MRG-20, MRG-25, HAES)
1400-1550	Marginal coffee	850	20-21	MRG-20 (KMB-4, MRG-25, TTW-2)
<1400	Sunflower-maize			(KRG-15, EMB-1, MRG-20)

**Clones in brackets are moderately suitable for the said areas as more research is still being done*

RELEASED MACADAMIA VARIETIES IN KENYA

There are four approved varieties of macadamia nut in Kenya today. They are classified according to their characteristics and the agro ecological zone they are suitable for.

1. MRG—20

This is a pure *Macadamia integrifolia* variety suitable for the marginal coffee zones of altitudes between 1500—1600 metres above sea level. Its distinct features include while flowers and rounded leaves with no distinct leaf apex (fig.2)

- Expected yield at 15yrs of age = 55kg/tree/yr
- Harvesting months = All year round (peak May—June)
- Kernel recovery% = 33%
- First grade ratio = 91%
- Twin nut ratio = 2.16%
- Cluster size = 13, Cluster count =6
- Shell thickness = <3.0mm

Figure 2. Characteristics of MRG-20

Source of pictures: KALRO

2. EMB-1

A pure *Macadamia integrifolia* variety suitable for the main coffee zones of altitudes between 1550—1650 metres above sea level with precipitation above 1200 mm pa with white flowers, curly leaves with few spines. The Nuts are perfectly smooth and round. Trees are cone shaped (Fig. 3).

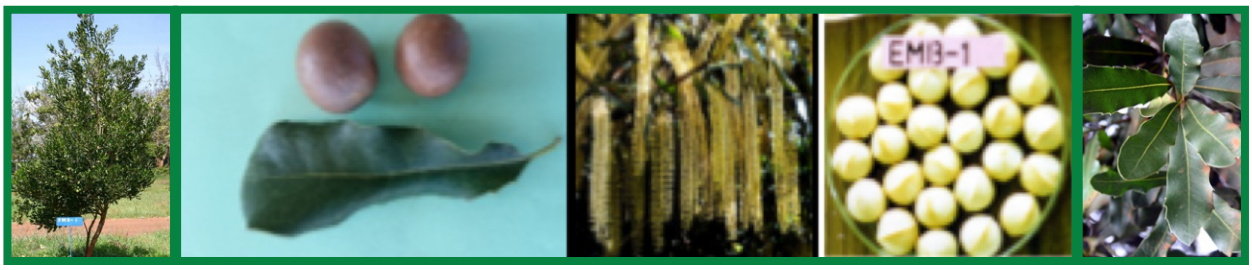


Figure 3 Characteristics of EMB-1

Source of pictures: KALRO

- Expected yield at 15yrs of age = 70kg/tree/yr
- Harvesting months = All year round (peak May—June)
- Kernel recovery% = 35%

- First grade ratio = 93%
- Twin nut ratio = 2.41%
- Cluster size = 5 cluster count = 17
- Shell thickness = <3mm

3. KRG-15

A pure *Macadamia integrifolia* variety suitable for the main coffee zones of altitudes between 1550—1650 metres above sea level with precipitation above 1200 mm pa. The tree has white flowers with open tree formation. Leaves are moderately spines with an apex (Fig. 4).

Figure 4. Characteristics of KRG-15

Source of pictures: KALRO

- Expected yield at 15yrs of age = 80kg/tree/yr
- Harvesting months = All year round (peak May—June)
- Kernel recovery% = 39%
- First grade Ratio = 91%
- Twin nut ratio = 0%
- Cluster size = 8 cluster count = 11
- Shell thickness = <3mm

4. KMB-3

A pure a Hybrid variety suitable for the coffee-tea zones of altitudes between 1650– 1900 metres above sea level, with precipitation above 1500 mm pa. It has distinct pink shoots and flowers and long leaves with many spines and a pronounced apex (Fig. 5).

Figure 5. Morphological Characteristics of KMB-3

Source of pictures: KALRO

- Expected yield at 15yrs of age = 60kg/tree/yr
- Harvesting months = Once a year (May—August)
- Kernel recovery% = 35%
- First grade ratio = 90%
- Twin nut ratio = 0.1%
- Cluster size = 5 cluster count = 13
- Shell thickness = <3mm

SUITABLE AREAS FOR MACADAMIA CULTIVATION

KALRO has Tested the suitability of the cultivation in the various agro-ecological zones of Kenya and recommendations made as in Table 2 and suitability mapped as in Fig 6.

Table 2. Suitability Classification for Macadamia Nut in Kenya

Crops	Soil and environmental conditions	Suitability classification	Spatial extent in Kenya (ha)
Macadamia	• Altitude: >2,000 m • Mean annual temperature: 20 < °C • Mean annual rainfall: >2000 mm • Organic matter content: >3% • Soil depth: >1.0 m • Imperfectly drained to poorly drained • Sandy clay to clay • pH: >6.0 or <7.0	Moderately suitable (S4)	Tea-Dairy zone??
	• Altitude: 2000 m asl • Mean annual temperature: 25°C • Mean annual rainfall: 2000 mm • Soil depth>1.0 m • Well drained soils • pH 6.5 • Organic matter content: >2.5%	Highly suitable (S2)	Coffee –tea zone
	• Altitude: 1500 m asl • Mean annual temperature: 20°C • Mean annual rainfall: 1250 mm • Soil depth: 0.8 m • Moderately drained • pH: 6.0 or 7.5 • Organic matter: 2%	Highly suitable (S1)	Main coffee zone
	• Altitude: <1250 m • Mean temperature: <20°C • Mean annual rainfall: <1250 mm • Soil depth: <0.8 m • Marginally drained • pH: <6.0 or >7.5 • Organic matter content: <2.0%	Marginally suitable (S3)	Marginal coffee zone

Notes

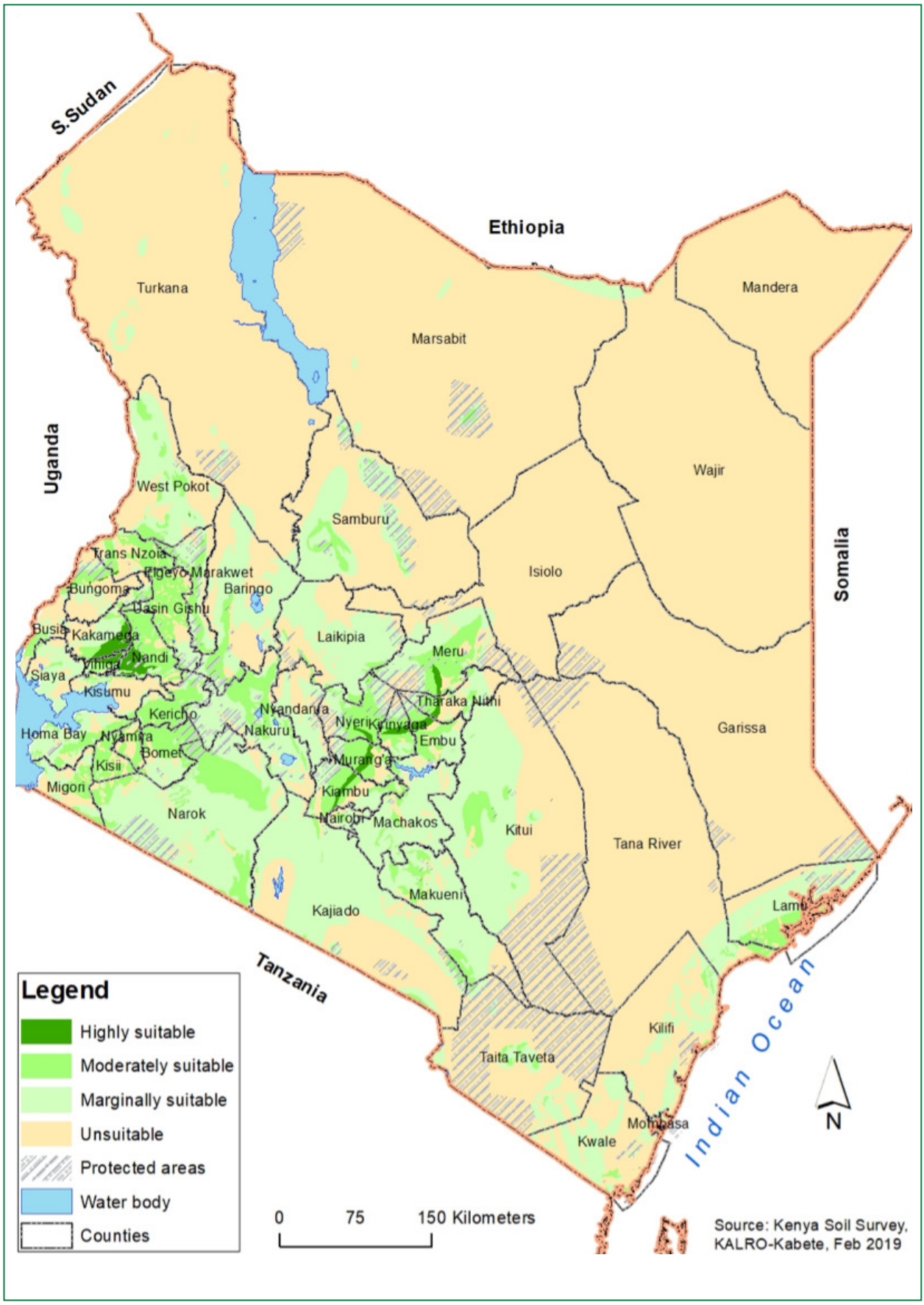


Figure 6. Macadamia nut suitability map for Kenya

Source: Kenya Soil Survey KALRO-Kabete

Notes

3 MACADAMIA PROPAGATION PROCEDURES

The stages in macadamia propagation include

a) Seed selection and establishment
b) Raising the rootstocks (increase in size)
c) Grafting/budding
d) Callus formation and graft union (in tunnels)
e) Hardening
f) Field establishment

SELECTION AND MANAGEMENT OF MOTHER PLANTS

Prior to seed and scion collection, one needs to select and mark good mother trees to use as sources of high-quality seed and scions (Fig 7). The major characteristics of a good mother tree are:

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

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. When establishing new mother blocks, it is recommended that one obtains plants from certified sources.

Figure 7. A well-managed macadamia mother block
Source: KALRO

ROOTSTOCK SELECTION

Macadamia is easily propagated using seed. However, the resultant progeny takes 8-12 years to start bearing nuts, usually bears less than 10kgs, quality of nuts is unpredictable as far as quality is concerned. This is because macadamia nuts are highly heterozygous and do not breed true-to-type. Grafting is therefore necessary in order to obtain true-to-type materials (clones) and hasten reproductive maturity.

The rootstock should be raised from seed of recommended variety and the scions be picked from a strong healthy mother tree. Several methods including top-wedge, side-wedge, splice, veneer or bark-grafting can be used. Selection of rootstocks for macadamia is as important as the scion used for grafting. Previous recommendations were that *Macadamia tetrapylla* was the best for use as rootstocks as it is much more resilient to adverse conditions and has better germination rates, regularity, among other characteristics. However, research has shown (Nyaga and& Yamada, 1992) that using this type of rootstock leads to severe graft complications such as scion overgrowth, scion/rootstock incompatibility, rootstock overgrowth among others.

It is therefore recommended that hybrids such as KMB-3, KMB-9, EMB-H and KMB-4, among others are best suited for grafting the selected Kenyan varieties. Where hybrids are unavailable, it is recommended that any integrifolia lines may be used.

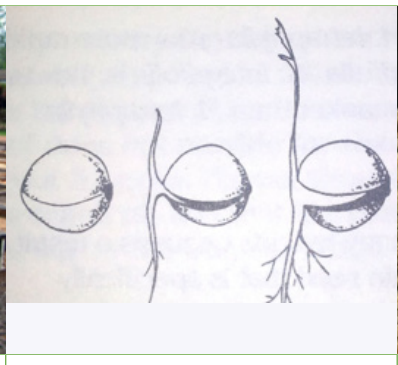
ROOTSTOCK ESTABLISHMENT

Mature nuts will fall on the ground and should be collected as soon as possible to avoid fungal attack. The nuts are de-husked and best germination is achieved where nuts are seeded fresh. Heavier seeds produce stronger seedlings than the lighter ones. The best nuts are obtained by putting the bulk of the nuts in a container with clean water. All the floaters should be discarded.

Although the seed coat (shell) is hard and thick, the nuts should be planted without any pre-treatment. Boiling or cracking will completely ruin the seed. Filing is not recommended either. Soaking seed nuts in cold water for 72 hours before seeding in sand enhances rapid and uniform germination. The water should be changed every day.

Sand beds are pre-treated with a copper-based fungicide to control soil-borne pathogens. Under normal conditions, germination occurs in 3-4 weeks after seeding. The sand beds should be watered regularly to prevent drying (Fig. 8).

Nuts are seeded on the sand beds after soaking for 72 hrs



Nuts are seeded with the satire facing sideways or downwards

Transplanting is done at the 3 leaf stage. Lifting is done using a trowel

Figure 8. Steps in rootstock establishment in macadamia nuts

Source: KALRO

RAISING OF ROOTSTOCKS

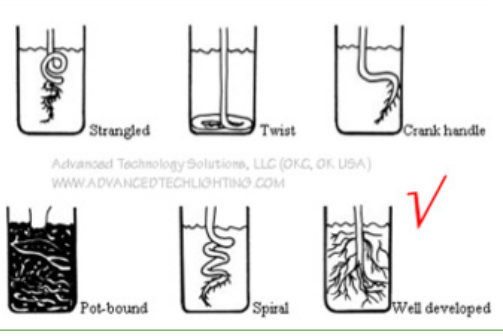
After germination, the rootstocks stay on the sand bed until they achieve 3 - 4 true leaves before transplanting into potting bags. Soil media for transplanting should consist of 10 parts of topsoil, 3 parts of manure, 3 parts of compost, 1-3 parts of sand at a ratio of 10:3:3:1-3 (v/v) and 300g of compound fertiliser (17:17:17) per mixture. The rootstocks are lifted carefully (Fig. 8) to avoid damaging roots), placed in a bucket of water and potted in polybags.

These seedlings have a long tap-root with many strong and short adventitious roots. The most appropriate procedure to transplant is (Fig.9);

i) Half fill the potting bag with the soil mixture
ii) Moisten the mixture
iii) Take care that the period between lifting the seedling out and planting it in the roots are kept moist
iv) Cut the tap root at the length of 100 mm (if it is longer than this)
v) Hold the seedling in a vertical position above the soil while filling the bag on either side of the tap-root with the soil mixture
vi) The planting depth must be maintained at the same level as it was in the seedbed
vii) Water immediately

- Drying out of the roots is fatal and the two attached cotyledons should not be removed or damaged. The time taken between uprooting and transplanting must therefore be kept as short as possible.
- The seedlings should be maintained under high shade, allowing only 40-50% sunlight for about 2 months before transferring to open area where they are maintained for 6-12 months before grafting.

Hold seedling upright above the potting bag and pour the soil while ensuring the roots are straight



Do not pot any rootstocks with deformed root systems

Newly transplanted rootstocks are kept under shade until new growth appears

Rootstocks then placed outside in the open area for growth

Rootstocks that have achieved pencil thickness are selected for grafting

Figure 9. Steps in propagating macadamia nuts

Source: KALRO

Notes

GRAFTING:

The most appropriate rootstocks are those that are vigorous in growth and have attained a girth of pencil thickness at least 6 – 8) inches (10 – 15 cm above the soil level on the potting bag.

There are several grafting methods than can be used, although the most common is the top wedge (cleft) method (Fig 10).

(i) **Top-wedge grafting** is used for rootstocks with 4-6 mm diameter and a scion of the same size. A wedge-like slanting cut is made at the base of the scion (Fig. 10 & 13) with a sharp knife or scalpel. A vertical incision is made at the top of the rootstock. The 2 pieces are fitted together aligning the cambiums, wrapped firmly with grafting tape as shown in Fig. 12a & 12b.

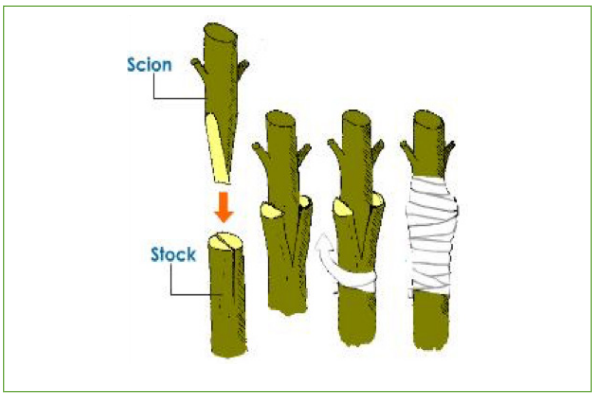


Figure 10. Process of Top wedge (cleft Method)

Source: www.mazra3a.net/vb/showthread.php?t=12066

Figure 12a. Photo scion inserted on cleft

Source - KALRO

Figure 12 b: Taping of the grafts

The process of Top Wedge (cleft) grafting method

Scions are collected from healthy vigorous disease & pest free trees	Scion (of the same size/ diameter) and cut into a wedge	The rootstock spliced (scion & rootstock must be the same size)

Figure 13. Steps in propagating macadamia nuts using top wedge grafting

Source: KALRO

(ii) Splice or Whip grafting is used for overgrown rootstocks. A simple slanting cut of the same length and angle is made on both the rootstock and the scion (Figures 14a and b). They are aligned (Fig. 14c) and the graft union is wrapped with the grafting tape and sealed with wax as shown in Fig. 14c.

Figure 14. a, b & c showing the different stages of splice grafting

Source: KALRO

(iii) Side-wedge grafting (also called veneer grafting) is used in rootstocks with a larger diameter than the scion (Fig. 15). A 3-cm deep cut is made on the scion at 20-30° and a tapered cut on the rootstock. The scion is inserted into the side of the rootstock and wrapped with grafting tape and waxed.

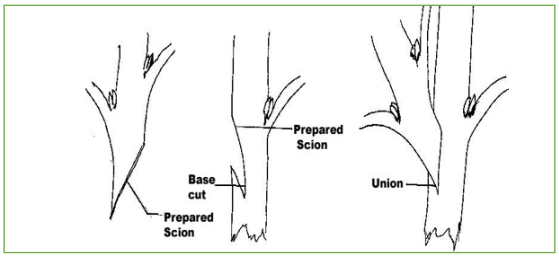


Figure 15. Side wedge/Veneer grafting

(iv) Top-working (also called bark grafting) is used to change clones in an established orchard. It is conducted using the cleft graft. Young trees may be top-worked on the trunk whereas for older trees, branches less than 5 cm diameter are used. Upright branches in exposed regions of the tree should be used.

The branch or trunk should be sawn off at right angle to the grain. Split the bark using a strong knife and a hammer to split the stock about 4 cm deep into the branch through the Centre (Fig. 16). Use a screwdriver or a chisel to prop open the split. Use pencil-size one-year-old scions that are knot-free with at least 3 buds. Make a long (1-1½ inch long) smooth cut towards the base from the lowest bud. Perform this operation on the other side creating a wedge with a blunt tip. Insert the scions (usually 3) and align the cambiums. Remove the screwdriver. Wax all the cut surfaces and ensure that there are no cracks that may promote drying, few days after grafting.

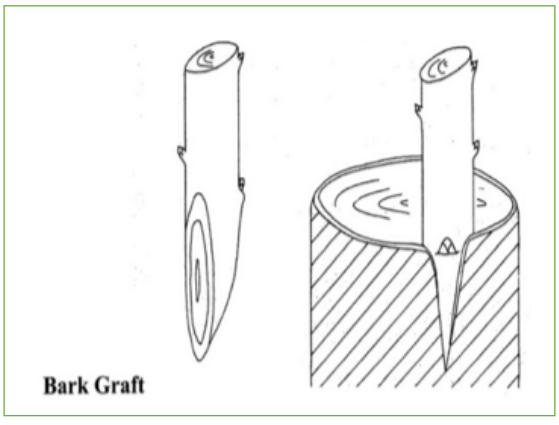


Figure 16. Bark grafting also called Top working

(a) Graft union formation (in tunnels)

Grafted seedlings should be maintained in tunnels (Fig. 17) or individual polybags in a greenhouse with shade or just tunnels under shade at 25-28°C and 90% humidity for 2-3 months before they are taken out for hardening in a shade-house at 40-50% light intensity. Wax and grafting tape should be removed from the graft union one month after removal from greenhouse/tunnel.

Figure 17. Macadamia in tunnels

(b) Hardening

Macadamia seedlings should be hardened for 2-3 months before transplanting in the field (Fig 18). Top dress once with calcium ammonium nitrate (CAN) every month while still in the hardening shade.

Figure 18. Macadamia seedlings in a hardening shade

Notes

(c) Approach Grafting

This is the process of joining the rootstock and the scion while the scion remains attached to the mother tree. Once the graft union has taken the grafted seedling is detached from the mother tree by severing the scion from the mother tree (from the side t is attached to the mother tree - Fig 19).

Figures 20 – 24 show the different stages of approach grafting in a KALRO Centre.

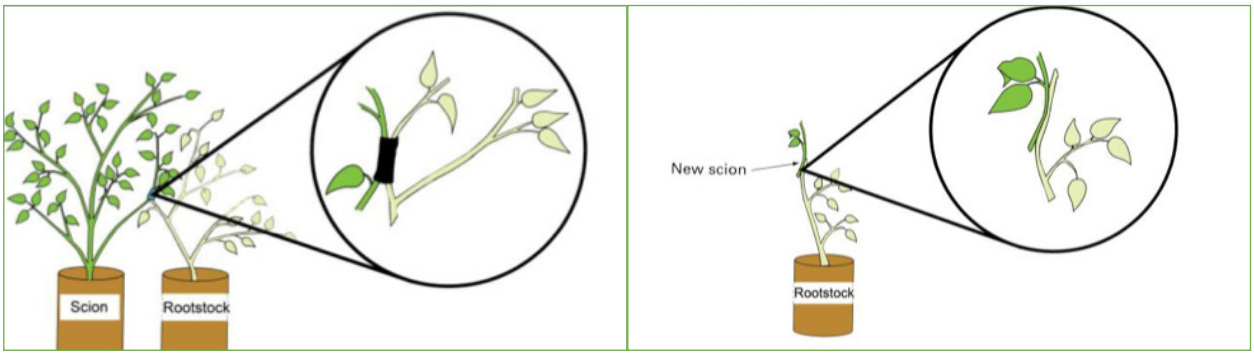


Figure 19. Illustration of Approach grafting procedure
Source: https://propg.ifas.ufl.edu/06-grafting/02-graftingtypes/01-grafting-approach.html

Grafting Procedure

Figure 20. Two stems – one in the potted rootstock, and the other one is the scion stem in the mother orchard. The two are of similar thickness.
Source: KALRO

Figure 21. Bark is removed leaving an elongated oval shape on both rootstock and scion stems
Source: KALRO

The two stems are joined and wrapped using a banding tape. A single scion plant can have several scion stems. This means that several rootstocks can be grafted onto one scion plant.

Figure 22. Scion plant with a potential of grafting two potted rootstock plants
Source: KALRO

Figure 23. Note that staking done to encourage sprouting of multiple scion shoots
Source: KALRO

Figure 24. A section of harvested approach grafted seedlings ready for field planting
Source: KALRO

Notes

4 IMPORTANT PESTS AND DISEASES IN MACADAMIA NUT NURSERY

Table shows illustrates the main pests and diseases of Macadamia nuts including those of the Nursery.

Table 3. Pests and diseases of macadamia nut

Diseases	Symptoms	Management
Phytophthora Root Rot *(Phytophthora cinnamomi)*  **On seedling in nursery**  **A young seedling in the field**	- This disease is caused by a fungus - It is spread by water and infested planting material - Phytophthora can cause up to 40% loss in the nursery - This disease reduces vigour and productivity of macadamia nut, and subsequent tree death	- **Certified planting material:** Use clean planting material from high health nurseries (HHN) - **Cultural control:** Ensure good drainage. - *P. cinnamomi* is greater in soils with poor drainage, or low-lying areas where water collects - **Genetic resistance:** *M. integrifolia* variety MRG-20 has a high level of resistance to *P. cinnamomi* (Mbaka et al., 2011). - **Chemical control:** The seedlings could be drenched with Ridomil (Metalaxyl); use of phosphite following manufacturers guidelines

Diseases	Symptoms	Management
Macadamia stem/trunk canker *(Phytophthora cinnamomi)*   **Advanced truck canker** *Source: Jesca Mbaka, KALRO*	- This disease is caused by a fungus - Wounds appear at the base of the plant that may have gum exudation (gummosis), - A general tree decline is observed - Cankers can cause stunting and eventually girdle the trunk leading to death - Low lying macadamia nurseries promote spread of stem canker - Fields with poor drainage	- **Cultural control:** Prevent injuring the stems field operations - **Certified planting material:** Obtain seedlings from a high health nursery - Graft on tolerant rootstocks - **Chemical control:** use copper based fungicides on canker following manufacturers guidelines
Scab  **Scab on macadamia husk** *Source: Abel Too, KALRO*	- This disease is caused by a fungus - The husk is covered with a rough, corky surface - This eventually impacts on the colour of shell and nut quality	- **Field sanitation** – Keep the orchard clean. Plant debris are a source of inoculum for this disease. - **Cultural control:** implement good field sanitation practices - Remove and burn infected leaves, flowers, and nuts - **Host resistance** – Plant tolerant varieties (these have not been identified in Kenya)

Diseases	Symptoms	Management
 **Early stage of scab**		
Anthracnose *(Colletotrichum gloeosporiodes)* 	- This disease is caused by a fungus - Black spots (lesions) form on leaves and subsequently merge to form dark coloured areas - The lesions from leaves spread to nuts - When severe, anthracnose can cause premature nut drop - Shells from infected husks may have different colours and the oduor impact negatively on nut quality - Anthracnose softens the husk tissue, which distinguishes it from husk spot	- **Cultural control:** - Avoid tree stress or wounding - **Crop management (pruning):** - reduce high canopy humidity - Field sanitation: Remove dead and dying branches from the canopy and nuts that have dropped on the orchard floor - **Crop management:** Control insects to reduce wounding of the husk tissue - Compost the husks before use as mulch
Husk spot *(Pseudocercospora macadamiae)*  **Lesions on husks** *Source: Andre Drenth, ResearchGate*	- Black spots can expand up to 1cm diameter and eventually join to form a rapidly spreading dark coloured, greasy decay of the entire husk within 10 to 14 days - Shells within infected husks can turn from a healthy brown colour to an ashey grey	- **Field sanitation:** - Maintain high orchard hygiene - Remove past or off season nuts that fail to drop on maturity - **Chemical control:** Use a mixture of carbendazim and copper based fungicides in early development

Diseases	Symptoms	Management
Postharvest mould  **Mould on husks due to prolonged postharvest removal**	- Mold occurs inside the husk within after harvesting - The oduor from the mold is absorbed but the nut thus negatively impacting on kernel taste	- **Cultural control:** - Postharvest management: Remove the husks within 48 hours of harvesting and dry nuts down to at least 12% moisture
Pests		
Macadamia stink bug (MSB) *(Bathycoelia bequarti Schoutedn)*  *(Source: Samuel J.N. Muriuki, KALRO)* 	- This is the most destructive pest of macadamia in Kenya. It occurs in all regions where this crop is grown and causes up to 55-70% nut loss especially in the coffee zone. - The infested kernels become spongy with or without brown pit-like depressions. Such kernels shrivel, become soft, distasteful and become translucent, unlike the normal white appearance - The adult female lays eggs on the underside of leaves, dead twigs, branches and main trunks in batches of fourteen.	- **Biological control:** - MSB is naturally controlled by several egg parasitoid wasps including Tetractrichus spp. Tamarixia dryi, Approstocetus spp. and Anastatus spp. - Under field conditions egg parasitization of between 70% and 85% can be achieved.

Diseases	Symptoms	Management
Macadamia nut borers *(False codling moth Cryptophlebia leucotreta [Myrick] and Warehouse moth Ephestia spp.)*   **Macadamia husk with nut borers** *Source: Samuel J.N. Muriuki, KALRO*	- Nut borer damage to nuts is most serious in higher altitudes (coffee-tea zone). - Larva bore through green husks measuring about 3 mm thick into nuts measuring about 10-15 mm in diameter - Infested kernels and husks are pre-disposed to fungal and bacterial infections which cause rotting and the kernel to blacken. In the marginal coffee zone the damage on the kernel is 1-2 and 5-7% in the coffee/tea zone.	- **Cultural control:** Dehusk the nuts immediately after harvesting. - Field sanitation: Burn husks in which the larvae and the pupae dwell immediately after dehusking - Storage areas must be cleaned regularly. - Store nuts for less than one month - Collect nuts regularly from the field at least twice a week. - **Biological control:** Use of blue sticky traps to control the pests
Vertebrate Pests		
Ground and tree squirrels  **Damaged nuts by ground squirrel** *Source: Samuel J.N. Muriuki, KALRO*	- Macadamia shells showing damage by ground squirrels. This pest eats fallen nuts - The tree squirrel will mostly "harvest" nuts before they fall down	- The loss attributable to these pests has not been quantified and no control measures have ever been envisaged in Kenya.

Diseases	Symptoms	Management
Nutrient and water constraints		
 **Water stress**	- Water stress symptoms are evident during the dry season - Young leaves become chlorotic	- Ensure adequate watering of seedlings in periods of low rainfall
 **Seedling chlorosis**	- These symptoms are sporadic	- Use forest soil or soils high in organic matter to propagate seedlings
 **Water quality**	- Poor water quality can produce chlorotic leaves	- Check the water quality and ensure that the pH is close to neutral

Source of pictures: Lusike Wasilwa, KALRO unless where indicated

Chemical control - Other products can be sourced from Pest Control Products Board (PCPB) list of registered products (www.pcpb.co.ke).

If the problem persists, seek immediate technical advice from a KALRO Centre nearest you.

Other quick sources of help

1. Plant Clinic nearest you
2. County Agriculture Office nearest you
3. Write to: info@kalro.org

Notes

5 CHALLENGES/ CONSTRAINTS IN THE MACADAMIA SUBSECTOR

- Inadequate varieties for all suitable areas (There are no commercial varieties for the production of the nut crop in the coastal lowlands)
- High cost of seedlings (The cost of buying quality macadamia seedlings has remained high subsequently a high investment cost)
- Inadequate supply of quality planting materials (particularly in the non-traditional growing regions due to few nurseries. There are also no nurseries in Taita Taveta and Machakos Counties leading to farmers planting poor material)
- Inadequate information on good agricultural practices (lack of information by both the farmers and the extension officers has led to poor agricultural practices especially in selection of the varieties)
- Poor market structure (many intermediaries exploit macadamia farmers. The farm gate price in some areas is half the processors price)
- Inadequate volumes of processing (the potential for the production of the nut crop in Kenya has not been achieved leading to a deficit in the installed processing capacity)
- Lack of policy guidelines/support (there are no adequate policy guidelines in the macadamia industry)
- Low regulatory capacity (since the nuts and oil crops regulations have not been gazetted, there is a deficit in regulating the intermediaries)
- Low domestic consumption (the local consumption remains low where more than 95% of the Kenyan nuts are exported)
- Hard-woodiness nature of the crop
- Long propagation cycles (18 months)
- Poor callus formation
- High mortality rates of grafts
- Low knowledge of grafting techniques by most nursery operators
- Low adoption of released or introduced varieties by farmers
- Inadequate planting materials
- Non predictability of market demand especially for the export market
- Lack of enough capital for expansion of plant nursery

Notes

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7 APPENDICES

APPENDIX 1. TEMPLATE FOR COSTING MACADAMIA NUT SEEDLING PROPAGATION

BUSSINESS CASE COSTING FOR MACADAMIA NUTS PROPAGATION MATERIALS							
Costing Target Number = 1000 seedlings							
Item		**Cost Details**	**Unit Description**	**Quantity**	**Unit Cost**	**Total Cost**	**Derived Cost per seedling**
1		**Rootstocks Generation**					
1.1		CASUAL LABOUR					
		Digging & loading of soil	Mandays	4	650	2,600.00	2.60
		Harvestng of seed	Mandays	2	650	1,300.00	1.30
		Dehusking of nuts	Mandays	3	650	1,950.00	1.95
		Seed bed preparation	Mandays	4	650	2,600.00	2.60
		Soil mixing	Mandays	3	650	1,950.00	1.95
		Seed sowing	Mandays	4	650	2,600.00	2.60
		Transplanting	Mandays	4	650	2,600.00	2.60
		watering	Mandays	8	650	5,200.00	5.20
		spraying	Mandays	2	650	1,300.00	1.30
		weeding	Mandays	4	650	2,600.00	2.60
		Arranging of Seedlings	Mandays	6	650	3,900.00	3.90
		Guardiing (Night& Weekends)	Mandays	3	650	1,950.00	1.95
			Sub-total			**30,550.00**	**30.55**
1.2		MEDIA INPUTS					
		Seed nuts	kgs	20	200	4,000.00	4.00
		Forest soil	tons	2	300	600.00	0.60
		Farm yard manure	tons	0.7	1000	700.00	0.70
		Fine ballast	Tons	0.3	450	135.00	0.14
		River Sand	tons	0.03	1000	30.00	0.03
			Sub-total			**5,465.00**	**5.47**
1.3		FERTILIZERS					
		DAP	kgs	1	85	85	0.085
		CAN	kgs	0	60	0	0
		UREA	kgs	1	60	60	0.06
		Foliar feed	litres	1	6.5	6.5	0.0065
			Sub-total			**151.5**	**0.15**
1.4		PESTICIDES					
		Assorted Fungicides	Kgs/Lt	1	1200	1,200.00	1.20
		Assorted Insecticides	Kgs/Lt	1	1200	1,200.00	1.20
			Sub-total			**2,400.00**	**2.4**
1.5		POTTING BAGS					
		Size 7*12	Pcs	3	2000	6,000.00	6
			Sub-total			**6,000.00**	**6**
1.6		TRANSPORT OPERATION					
		Forest soil collection	kms	300	25	7,500.00	7.5
		Seed nut collection	kms	100	25	2,500.00	2.5
		Purchase of stores	kms	100	25	2,500.00	2.5
			Sub-total			**12,500.00**	**12.50**

1.7		TRAVELLING AND ACCOMODATION					
		Forest soil collection	persons	2	1000	2,000.00	2
		Seed nut collection	persons	2	1000	2,000.00	2
			Sub-total			**4,000.00**	**4**
1.8		Cost of water for watering	Cubic mt	200	50	10,000.00	10
			Sub-total			**10,000.00**	**10**
		Total rootstock Costs				**71,066.50**	**71.0665**
2		**GRAFTING COSTS**					
2.1		LABOUR					
		Grafting	Unit Cost	2000	15	30,000.00	30
		watering	Mandays	24	650	15,600.00	15.6
		spraying	Mandays	12	650	7,800.00	7.8
		weeding	Mandays	12	650	7,800.00	7.8
		scion /buds cutting	Mandays	6	650	3,900.00	3.9
			Sub-total			**65,100.00**	**65.1**
2.2		**GRAFTING MATERIALS**					
		Grafting tapes	rolls	1	1500	1,500.00	1.5
		scions	nos	2000	5	10,000.00	10
			Sub-total			**11,500.00**	**11.5**
2.3		**FARM INPUTS**					
		CAN	kgs	10	60	600.00	0.6
		UREA	kgs	10	60	600.00	0.6
		Foliar feed	litres	10	100	1,000.00	1
			Sub-total			**2,200.00**	**2.2**
2.4		**PESTICIDES**					
		Fungicides	grams	10	60	600.00	0.6
		Insecticides	litres	10	60	600.00	0.6
			Sub-total			**1,200.00**	**1.2**
2.5		**TRANSPORT OPERATION**				-	0
		Scion /buds colletion	kms	100	25	2,500.00	2.5
		Forest Soil Collection	kms	400	25	10,000.00	10
			Sub-total			**12,500.00**	**12.5**
2.6		**SUBSISTENCE COSTS**					
		Scion /buds colletion	persons	4	1200	4,800.00	4.8
			Sub-total			**4,800.00**	**4.8**
3.7		Costs for Water (for watering)	Cubic mt	300	50	15,000.00	15
		Sub total				**15,000.00**	**15**
		Total cost of grafting one macadamia seedling				**112,300.00**	**112.3**
		Total cost of grafted seedling (rootstock + grafting cost)				**183,366.50**	**183.3665**

		Overhead Costs					
		Marketing and promotion costs at 0.5% of nursery costs				916.83	0.92
		Storage costs at 1% of nursery costs				1,833.67	1.83
		Administrative costs at 1.5% of nursery costs				2,750.50	2.75
		Seedling issues studies at 1.5% of nursery costs				2,750.50	2.75
		Building maintainance and other renovations at 1.5% of nursery cos				2,750.50	2.75
		Staff wages at 10% of nursery costs				18,336.65	18.34
		Losses due to seedling mortality a t10% of the production cost				18,336.65	18.34
		Electricity bill PM =500; 24 months = 12000				12,000.00	12.00
			Sub-total				**29.34**
		Total unit Propagating cost of macadamia seedling (R/Stock, Grafting, Overheads)					**212.71**
		Gross profit of seedling @ 41% of Total unit cost					**87.29**
		Selling price of the seedling					**300.00**

APPENDIX 2. 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 3. 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 TELFAX: 254-020-3597206/7 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: kephisnakuru@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

8	**Embu Regional Office** P.O. Box 2129 Embu PH: 254-068-31593 l020-3597208 Cell:0728-600092 Fax: 254-068-31592 Email: kephis_embu@kephis.org	Mandera, Moyale, Marsabit, Wajir, Isiolo, Garrisa, Meru North, Meru Central, Meru South, Tharaka, Embu, Mbeere, Mwingi, Kirinyaga and Nyeri

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