# Macadamia Growing Guide

# 1. INTRODUCTION

## 1.0.1 Origin

Macadamia belongs to the family Proteaceae and is native to south-eastern Queensland, Australia where it grows in the wild. Macadamia was introduced in Kenya from Australia in 1946 by Bob Harris at Karamaini estate in Kiambu County. The Ministry of Agriculture initiated planting seedlings by small-scale farmers in 1964, mainly in Eastern and Central Provinces (Hamilton, 1971; Harris, 2004). Macadamia is the most popular nut in the world today. In Kenya, it is grown as an additional cash crop to coffee and tea. The crop is mainly grown by small-scale farmers (Hirama and Ondabu, 1987; Kiuru *et al.*, 2004, Nyaga *et al* 2007) the counties of Meru, Embu, Kirinyaga, Nyeri, Muranga, Kiambu, Machakos and Taita Taveta. The crop has also lately spread to Bungoma, Busia, Kakamega, Transnzoia, Uasingishu, Kericho, Nandi, Kisii, Baringo and other areas. It is a major foreign exchange earner and provides employment and income at household level. It can be consumed as roasted nuts or used in making confectionery. It is a nutritious nut with ample amounts of Vitamin B complex and carbohydrates. Until the late 1970s, there was no market for macadamia nuts in Kenya.

The main growing countries are USA (Hawaii), Australia, South Africa, Guatemala, Malawi, China and others.

## 1.0.2 Distribution

In the late 1960's, Seedlings propagated at the Bob Harris Nursery and were distributed in the central and eastern highlands and later the western highlands through the ministry of Agriculture. The majority of seedlings planted were of two species, *Macadamia integrifolia* Maiden and Betche or

*M. tetraphylla* L. S. Several hybrids of *M. integrifolia* and *M. tetraphylla* have been identified in the central and eastern highlands and these formed the bulk of the macadamia improvement research program which was launched in the early part of 1980, by the Ministry of Agriculture. Since then, 30 superior clonal lines of the initial materials planted in the 1960s have been selected and evaluated in various trial orchards located in different agro ecological zones of Kenya. Most of the recently planted orchards are constituted by seven clones that yield between 50 to 100 kg of nuts annually, with four of these (KMB-3, KRG-15, EMB-1 & MRG-20) finally being recommended and registered as approved varieties. In addition, five high-yielding macadamia varieties (508, 333, 666, 660 & 246) from Hawaii were also introduced in Kenya for evaluation in the early 1980s. To date over 90% of the cultivated macadamia trees in Kenya are either *M. integrifolia* or hybrids of *M. integrifolia* and *M. tetraphylla*, and is grown in about thirty counties.

### 1.0.3 Classification

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. Although there are 10 species, only 2 (*Macadamia integrifolia* Maiden & Betche, also called the smooth-shelled type) and *Macadamia tetraphylla* L. Johnson commonly referred to rough-shelled type) are of economic importance

Taxonomical classification of Macadamia is shown in Table 1 below.

**Table 1. Classification**

| |
|---|
| Kingdom Plantae – Plants |
| Subkingdom Tracheobionta – Vascular plants |
| Super division Spermatophyta – Seed plants |
| Division Magnoliophyta – Flowering plants |
| Class Magnoliopsida – Dicotyledons |
| Subclass Rosidae |

| |
|---|
| Order Proteales |
| Family Proteaceae – Protea family |
| Genus *Macadamia* |

The inflorescence in Macadamia is a pendant raceme with 250-300 flowers (Fig 1). The fruit has a very hard seed coat that is enclosed in green fibrous husk that splits open when the nut matures (Fig 2). Natural hybridisation occurs when *M. integrifolia* and *M. tetraphylla* are intercropped particularly at high altitudes.

Fig. 1: Flower of Macadamia nut

Fig 2: Anatomy of Macadamia

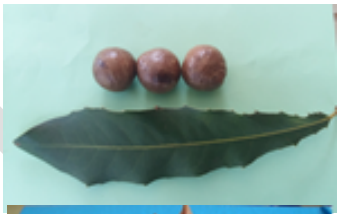
## 2. VARIETIES OF MACADAMIA

There are four varieties recommended for growth in Kenya. These are KMB-3, KRG-15, EMB-1 and MRG-20

### 2.1 KIAMBU - 3 (KMB – 3):

A Hybrid variety suitable for the coffee-tea zones of altitudes between 1650– 1900 Metres above sea level, with precipitation above 1500 mm pa

- 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



### 2.3 KIRINYAGA 15 (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

- 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

## 2.3 EMBU -1 (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

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

- First Grade Ratio = 93%
- Twin nut Ratio = 2.41%
- Cluster Size = 5 Cluster count = 17
- Shell Thickness = <3mm

## 2.4 MURANGA-20 (MRG - 20):

This is a pure Macadamia integrifolia variety suitable for the marginal coffee zones of altitudes between 1500—1600 Metres above sea level.

- 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

**Table 3: Recommended zones for the various Macadamia Varieties**

| Alt (m) | Zones | Rainfall (mm) | Temperature (°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, TTW-2)* |
| 1400–1550 | Marginal coffee | 850 | 20 – 21 | MRG-20 (KMB-4, MRG-25, TTW-2)* |
| <1400 | Sunflower - maize | | | (KRG-15, EMB-1, MRG-20)* |

*Secondary variety for the zone from recommended varieties or lines under adaptability tests

**Source: Nyaga & Tominaga, 2007**

## 3. ECOLOGICAL REQUIREMENTS FOR MACADAMIA

Macadamia can grow in most of the Kenyan agro ecological zones that do not experience frost and have suitable soils, rain fall and optimum temperatures necessary for its establishment.

### 3.1.1 Altitude

Macadamia grows well between 1500 – 1850m above sea level.

### 3.1.2 Temperature

The optimum temperature for the crop ranges from 18 - 21 $^{o}$C. Areas that experience frost should be avoided. The difference between minimum and maximum daily temperatures (diurnal) must be at least 7º during the flowering months.

### 3.1.3 Rainfall / Irrigation

Macadamias can withstand periods of drought, but the harvests will be small and of low quality. Macadamia requires a minimum annual rainfall of 1200mm well distributed. This can be supplemented with irrigation, particularly during certain critical periods in the crop cycle such as flowering, nut set, nut filling and the vegetative growth period during the drier months. The actual amount depends on the soil type and water retention capacity. Young trees have comparatively higher water requirements than mature trees which have a higher resistance to water stress. In general, it is important to water macadamias regularly and deeply during dry periods.

### 3.1.4 Soil

Macadamia will perform on a wide range of soil types from open sandy, loams and clay loamy soils, as long as they are well drained. The crop however does best in rich, deep (at least 100 cm) well drained soils with a pH range of 5.5 to 6.5. Macadamias will not tolerate soils or water with high salt concentrations.

### 3.1.5 Wind protection

After choosing a suitable site, it is recommended to establish a windbreak especially in areas with strong winds. The brittle branches in macadamia are easily damaged by wind, especially when laden with a heavy crop of nuts. Macadamia is not deep rooted leading to lodging under strong windy conditions. Windbreaks should be planted at least one year before the macadamia seedlings are transplanted. They should be perpendicular to the direction of the wind (fig …). Trees like cypress, pine, wattle and grevillea are used as wind breaks, although bananas can also be used.

## 4.0 PROPAGATION

Although macadamia is easily propagated using seed, the progeny takes 8-12 years to start bearing nuts. The nut quality is also unpredictable because the crop is highly heterozygous. Grafting is 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 trees. Several methods including top-wedge, side-wedge, splice, veneer or bark-grafting can be used.

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

### (a) Seed selection and 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. Filling is not recommended either. Soaking seed nuts in cold water for 72 h 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. Varieties KMB-3 (hybrid) and EMB-1 (M. integrifolia) have the best germination percentage of 50-60% and are recommended for rootstock production.

**(b) Raising the rootstocks (Increase in size)**

After germination, the rootstocks stay on the sand bed until they achieve 3 - 4 hard 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 fertilizer (17:17:17) per mixture. The rootstocks are lifted carefully (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;

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.

**(c) 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.

**(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. 3) with a sharp knife or scapel. A vertical incision is made at the top of the rootstock. The 2 pieces are fitted together, wrapped firmly with grafting tape as shown in Fig. 4a & 4b.

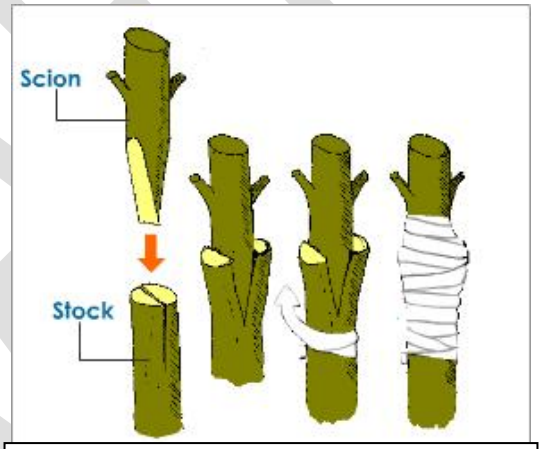



**Fig 3: Process of Top wedge (cleft Method)**
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Fig 4a: Photo scion inserted on cleft

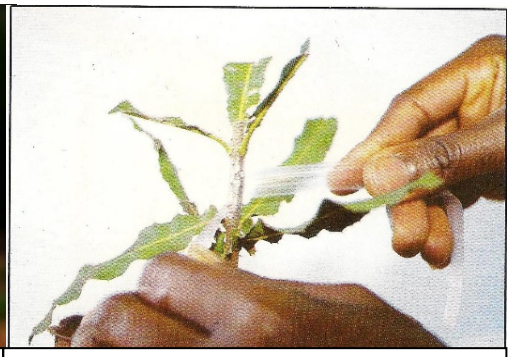


Fig 4b: Taping of the grafts

**(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 5a and b). They are aligned (Fig. 5c) and the graft union is wrapped with the grafting tape and sealed with wax as shown in Fig. 5d.


Fig. 5 a, b & c showing the different stages of splice grafting

**(iii)** **Side-wedge grafting** (also called veneer grafting) is used in rootstocks with a larger diameter than the scion (Fig. 6). A 3-cm deep cut is made on the scion at 20-30° and a tapered cut on the

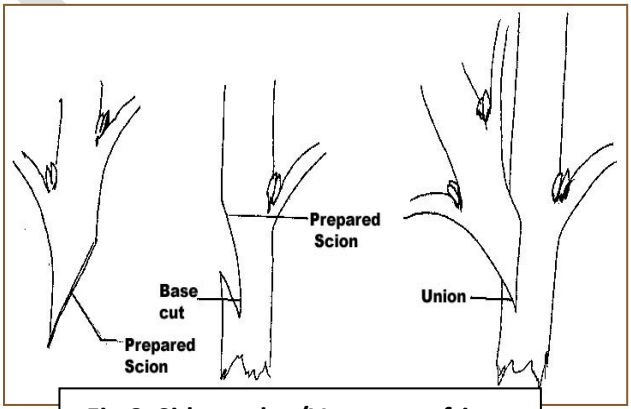



**Fig 6: Side wedge/Veneer grafting**

rootstock. The scion is inserted into the side of the rootstock and wrapped with grafting tape and waxed.

**(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.

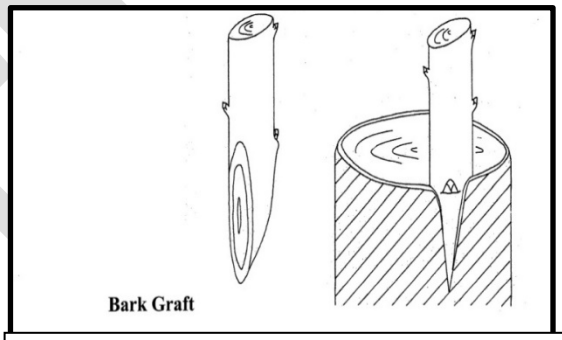



**Fig 7: Bark grafting also called Top working**

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. 7). 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.

**(d) Graft union formation (in tunnels)**

**Fig 8: Macadamia in Tunnels**

Grafted seedlings should be maintained in tunnels 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.

**(e) Hardening**

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

**Fig 9: Macadamia seedlings in a hardening shade**

## 5.0 ORCHARD ESTABLISHMENT AND MANAGEMENT PRACTICES

### .5.1 Land preparation

The land should be prepared well in advance during the dry season. The first and second ploughing should be done followed by harrowing. The land should be prepared to a fine tilth.

### 5.2 Spacing

The planting distance depends on the topography and the land use e.g. intercropping. The recommended minimum spacing under pure stand establishment is 7.5 x 7.5m for the upright varieties and up to 10 x 10m for the spreading types.

### 5.3 Transplanting

Planting holes should be 60 x 60 x 60 cm and should be prepared at the onset of rains. When preparing the hole, topsoil and the subsoil should be kept separately. Backfill the hole with the topsoil mixed with 2 debes of well-decomposed manure and a handful (300g) of compound fertilizer NPK 20:10:10: or its equivalent.

The seedling bags are then opened carefully by making a vertical shallow incision with a blade. The soil covering the roots should remain intact.

The seedling is then placed in the hole and covered with the topsoil and firmed. A basin around the seedling for holding water is made (Fig.…). If

the soil pH is below 4.5, 120 g of lime (calcium carbonate [CaCO3)] and 60 g single superphosphate (SSP) should be mixed with soil at each planting hole. The transplanting is more successful when carried out during the long rains, April-June.

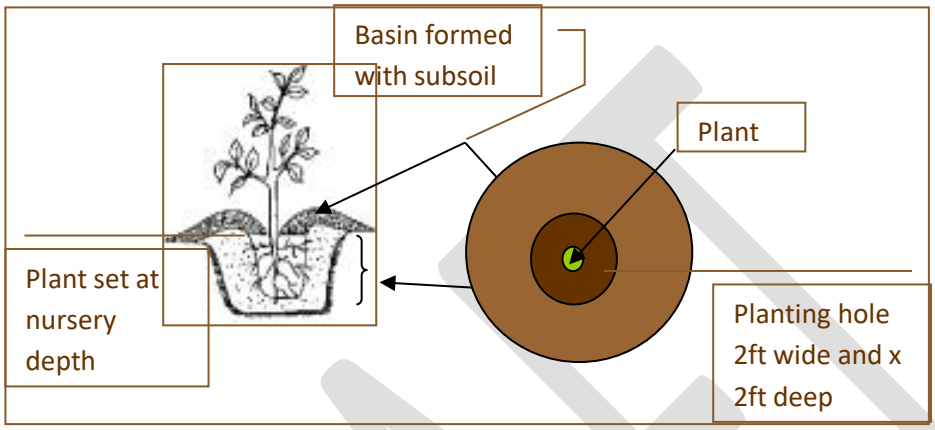



Fig:How to plant a macadamia seedling. The cross section defines the layout of the hole

### 5.4 Fertilization

The fertilizer should be applied in 2 splits applications just before the short and long rains i.e. March – April and September – October. The fertilizer should be applied under the canopy, along the drip line and away from the trunk (Fig ….). It should be gently incorporated into the surface of the soil to avoid runoff and volatilization. The rate of fertilizer application increases as the tree increases in size and age till a maximum of ten years. However specific areas may differ and soil analysis before planting is recommended.

**Table 1 Fertilizer Application Guide**

| COMPOUND FERTILIZER, 20:10:10 IN GRAMS PER TREE | | | |
|---|---|---|---|
| YEAR | APRIL-JUNE | OCT – DEC | TOTAL |
| 1 | 30 | 30 | 60 |
| 2 | 30 | 30 | 60 |
| 3 | 83 | 83 | 166 |
| 4 | 115 | 115 | 230 |
| 5 | 300 | 300 | 600 |
| 6 | 600 | 600 | 1200 |
| 7 | 900 | 900 | 1800 |
| 8 | 1200 | 1200 | 2400 |
| 9 | 1350 | 1350 | 2700 |
| 10 | 1350 | 1350 | 2700 |

Manure is much more preferred for nutrient replenishment. A mature tree should receive approximately 2 debes of manure every year or 2.7 kg of fertilizer (Table 4). Too much nitrogen may result in the vegetative growth of the tree at the expense of fruiting. Micronutrient deficiencies are common in some areas, but these can be corrected with foliar feed sprays.

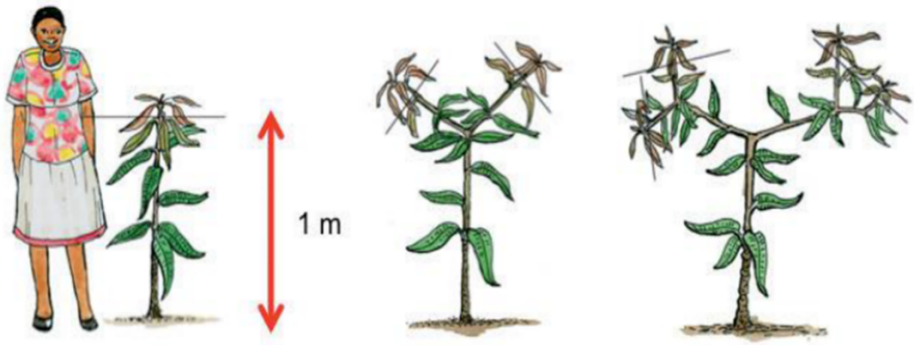
### 5.5 Training and Pruning

The purpose of training is to develop strong and well-balanced low branching trees with only one trunk or leader (central leader system) and several sets of main branches forming wide angles with the trunk (Figs. 10). The trees must be trained within 3 years of transplanting. Untrained trees produce several leaders and uneven branches spaced along the trunk. Such trees are prone to breakage by wind. The branches should be cut close to the laterals or the main trunk.

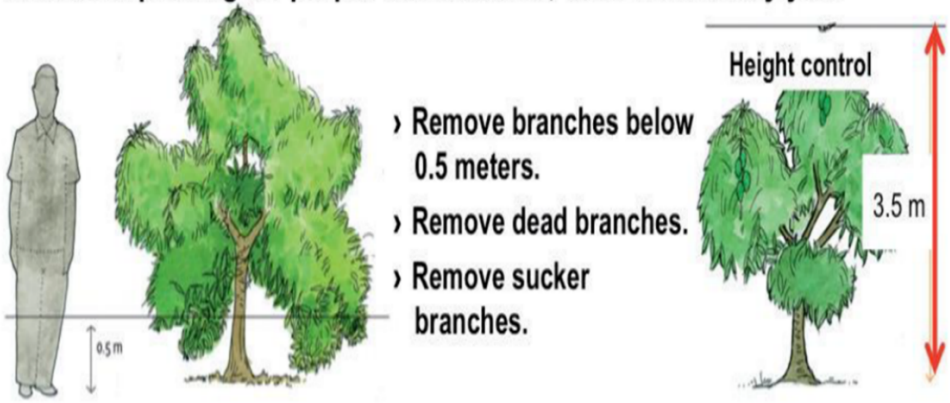
**Wide clotch angles**

**Narrow clotch angles (Undesirable)**

## Formative pruning to achieve the desired shape




## Structural pruning for proper maintenance, to be done every year




- Remove branches below 0.5 meters.
- Remove dead branches.
- Remove sucker branches.

## 5.6 Intercropping

The purpose of intercropping macadamia and other crops is to increase the gross margin per unit area and to obtain maximum utilization of the land. As a general rule, perennial crops and the grass family should not be intercropped with macadamia. This is to avoid competition for nutrients and space. The most popular intercrops are legumes and other short crops that may include, French beans, green peas, common bean, passion fruit, irish potatoes, sweet potatoes, ground nuts and ornamental flowers. As the canopy expands with age, intercropping will eventually diminish if the spacing was close for pure stand. In most instances, farmers intercrop macadamia with other crops under mixed farming system and usually, the spacing between a trees is wide as desired by the famer and other enterprises. However, Macadamia should not be intercropped with crops such as *Prunus Africana* that are attacked by same pests.

## 5.7 Harvesting & Post Harvest Handling

### 5.7.1 Field Harvesting

Macadamia nuts drop from the tree when fully mature and should be collected within 2-3 days to prevent deterioration (physiological) or damage by rodents. Picking or forcing nuts to fall is discouraged because it is not possible to distinguish mature from immature ones. Physiologically mature nuts contain 30% moisture in husk and 25% moisture in the kernel. The nuts should be spread in layers of about 15 cm on mats or meshed trays under a shade until they are dehusked. For efficient collection, the area under the canopy should be free of weeds and dry leaves so that the nuts are clearly visible. The yield ranges from 3-5 kg for the 1st harvest after 3 years and 40-75 kg of nuts after 15 years.

### 5.7.2 Dehusking

Dehusking is the removal of the green outer cover of nuts which is usually slightly open when nuts drop.

Dehusking should be done within 2 days after harvest or the nuts should be spread on trays or floor sheltered from the rains in layers of 6-7 cm to avoid mould infection.

The nuts should continuously be turned. It is recommended not heap or store nuts in sacks before dehusking. The husks should be removed by cutting with knives, secuters or by carefully pounding in specially designed containers to avoid cracking. Although machines can be used to dehusk, large nuts are damaged and may crack slightly.

### 5.7.3 Drying

In-shell nuts can be air-dried in a shade as direct sun causes nuts shells to crack, which serve as entry points for fungi and other organisms that cause deterioration of kernels. Nuts can be dried on meshed trays, mats,

or in bins with hot air at 55-65°C.

They should be dried to moisture level of 3.5% before storage. Nuts for processing should be dried to a moisture level of 2.0%. The nuts should be cracked after a curing for 1-3 weeks.

The kernels are then dried, roasted or deep-fried at 127-150°C for 12-15 min with the different grades roasted in separate batches. Dry-roasted and deep-fried kernels are graded and pack.

### 5.7.4 Storage

Dried nuts should be stored in a cool dry place free from oduors as they pick up flavours/ odours from the surroundings. The store should be inaccessible to rodents and observe all the food standards & handling guidelines.

Where long term storage is necessary, use of jute/sisal bags is recommended. Where storage is at farm level before low moisture content drying, net bags are most appropriate.

Fig. 13. Macadamia nuts stored in mesh bags on a slated shelf

### 5.7.5 Grading

After shelling, kernels are sorted and graded into size and quality depending on usage.

#### (i) Size Grading

The basic guidelines for size grading are;

- Premium (AA), minimum 90% whole and size 15-25 mm
- Popular (A), minimum 50% whole and size 10-17 mm
- Medium (BP), minimum 10% whole and size less than 45 mm

#### (ii) Kernel Quality Grading

Quality grading is based on oil content of the kernels. The grade classifications are as follows:

Grade 1 = more than 72% oil content

Grade 2 = 66% - 71% oil content

Grade 3 = 54% - 65% oil content

This method of grading is for more specialized uses or niche client markets that require specific oil contents. The general guidelines are that at least 90% of a sample taken should be grade 1.

#### (iii) General Kernel Quality Guidelines

In either of the grading methods, nuts should yield a high percentage of whole nuts. Whole kernels fetch better prizes than halves or chippings. This is influenced by nuts handling/treatment, moisture content at cracking, maturity, inherent nuts shell thickness, stick-on characteristics and others factors.

Standard quality requirements of macadamia nut kernels are:

- High oil content, of not less than 67%
- Low sugar content of not more than 6%. The sugar content of the kernels varies inversely with oil content. Kernels with high sugar content tend to carbonize at roasting, leading to off colours that do not appeal to consumers.
- The kernels should be plump and not shriveled
- Free from mechanical and insect damage
- Be fresh, free from rancidity, staleness, mouldy off-flavours and bitterness
- They should have intense flavour, creamy white, tan brown or golden brown and uniform size when roasted

### 5.7.6 Packaging

Macadamia nuts are usually packed in containers that do not allow air to enter. Vacuum packaging or use of inert gasses such Nitrogen and Co2 is commonly used using the general food safety guidelines. Packaging should prevent oxygen and moisture which influences microbial growth. Packing under inert gases and under vacuum or $CO^2$ extends shelf life (usually used on packed raw kernels).

### 5.7.7 Uses of macadamia nuts

Macadamia nuts can be eaten as dried or roasted and salted kernels. They are used industrially in ice-cream making, as ingredient in food processing and in confectionery for manufacture of chopped pastries, cookies, chocolate, cakes (Okello, 1992).

The resultant cake from oil extraction is used as livestock feed and for making high protein food formula for human beings.

The oil is used as a salad oil, in the manufacture of cosmetics and as carriers in medicine.

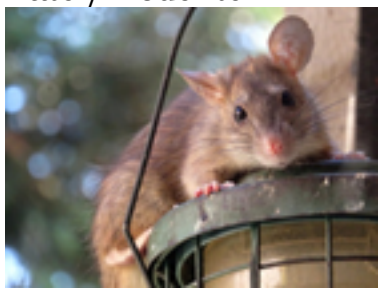
The shells can be used as fuel, for making ornaments and decorations, and for making charcoal and other carbonized media.

## 6.0 Pests and diseases

The table below shows a summary of common pests and diseases

**Table Macadamia Pests and Diseases**

| Pest/disease | Type of Damage | Symptoms | Control |
|---|---|---|---|
| Macadamia Stinkbug  | Insects that causes Sunken lesions on the kernels and also causes flower and fruit drop<br>In low altitudes (1400 – 1550) damage can reach 75% if unchecked under plantation conditions |  | • Biological control using parasitic wasps<br>• Cultural methods of burning obnoxious weeds under<br>• Bagging clusters after fruit set<br>• Chemical control method |
| Nut borer  | Damage is by the larva stage of false codling moth that lays its eggs on the husks of young nuts before they harden. The hatched caterpillars do all the damage.<br>Entry holes in husks of nuts are visible with Shallow dimple-like depressions.<br>Infected nuts drop from the tree |  | (a) Field sanitation - destruction of husks by burning<br>(b) Regular nut collection -.<br>(c) Avoid Intercropping - with crops that are alternative hosts to nutborers. These include maize, guava and citrus<br>(d) No need to intervene in lower elevations |

| | | | |
|---|---|---|---|
| Rats / Rodents<br>  | Damage of developing nuts and mature fallen nuts.<br>They open the shells by chewing through it |  | • Harvest nuts promptly<br>• Use rodent traps<br>• Remove all food sources for rats<br>• Keep the land free from weeds<br>  |
| Phytophthora root rot<br>  | Phytopthora root rot causes the death of roots leading to yellowing and subsequent death of the plant<br>Most prevalent in water logged conditions |  | • Plant only disease free seedlings<br>• Plant seedlings on well drained soils<br>• Avoid wounds on the trunks of the trees |
| Anthracnose | Fungus | • Black lesions on leaves, husks and stem<br>• Decay of nuts on the ground | • Avoid stressing trees by providing adequate irrigation and fertilization |

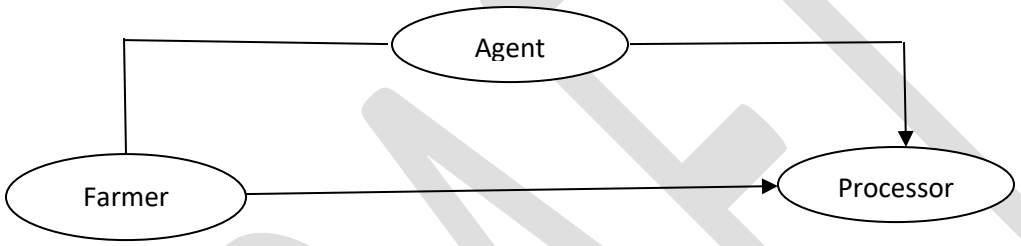
| | | | |
|---|---|---|---|
| | | • Shells of the infected nuts may turn brown-gray but the kernel inside remains unaffected | • Prone out dead or dying limbs from the tree canopy<br>• Control insect pests |
| Raceme bright | Fungus | • Small brown spots on the flower petals which spread to racemes (flower stock)<br>• Racemes turn black and fall | • Use of fungicide |
| Husk spot | Fungus | • Chlorosis on husks | Use of fungicide |
| Slow and quick tree decline | Fungus | • Yellowing and browning of some leaves on the tree<br>• Death of the tree | Remove the affected trees from the field carefully avoiding wounding the tree |

In the control of pests and diseases, always consider the stage of the crop when choosing the chemical to use. When almost harvesting, avoid those chemicals with long pre-harvest interval, although these can be used earlier in the season.

## 7.0 Marketing

More than 90% of the Kenyan macadamia is exported. Despite remarkable local production and increasing number of processing companies, the local market remains underserved of the processed macadamia nuts. Only three nut processing companies' supply to the local market; Kenya Nut Company, Eureka nuts and Equatorial Nut Processors Company.

Marketing of mature macadamia nuts from the farmer uses two different channels. The channels are;




### 7.1 Farmer-Processor Channel

This is a channel that is most common on contract farming. Farmers sign contract with the processor to supply macadamia nuts for a specific period of time. With this channel, processors are able to monitor the operations of the farm through their field officers. In some areas such as Kirinyaga, farmers have formed farmer groups that sign contract with the processor who collects macadamia on specified days at a designated collection center.

#### 7.1.1 Advantages of farmer-processor channel

1. Reduced farmers exploitation by illegal middlemen
2. Reduced cases of immature harvesting
3. Easy to arbitrate in case one of the parties breaches the contract

### 7.1.2 Disadvantages of farmer-processor channel

1. Price of macadamia remains as per the contract or agreement even when the prices go high. To avoid these, most of the farmers sign contracts without a definite figure of the price and assign price as the prevailing market price.

### 7.2 Farmer-agent channel

This is a channel where registered middlemen act on behalf of the processors. The agents buy directly from the farmer and then sell to the processors. Such agents should have a license and a badge to show that they are genuine.

These channel has been used as a blame for most of the challenges that face the macadamia industry.

### 7.3 Cost Benefit Analysis

Cost of establishment

**Table 2**

| **Item** | **Cost** | **Total Cost** |
|---|---|---|
| Seedlings | 70X400 | 28000 |
| Fertilizer | 0.06X70X120 | 500 |
| Manure | 25x70 | 1750 |
| Labor | 50x70 | 3500 |
| **Total** | | **33750** |

Yearly production up to 15years per acre

**Table 3**

| Year | 1-4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | 0 | 70 | 350 | 840 | 1400 | 2100 | 3150 | 3500 | 3850 | 4130 | 4480 | 4900 |

Yearly returns vs cost

**Table 4**

| Year | Returns | Cost | Difference |
|---|---|---|---|
| 1. | 0 | 33750 | -33750 |
| 2. | 0 | 4000 | -4000 |
| 3. | 0 | 4894 | -4894 |
| 4. | 0 | 5432 | -5432 |
| 5. | 7000 | 8540 | -1540 |
| 6. | 35000 | 13580 | 21420 |
| 7. | 84000 | 18620 | 65380 |
| 8. | 140000 | 23660 | 116340 |
| 9. | 210000 | 26180 | 183820 |
| 10. | 315000 | 26180 | 288820 |
| 11. | 350000 | 26180 | 323820 |
| 12. | 385000 | 26180 | 358820 |
| 13. | 413000 | 26180 | 386820 |
| 14. | 448000 | 26180 | 421820 |
| 15. | 490000 | 26180 | 463820 |

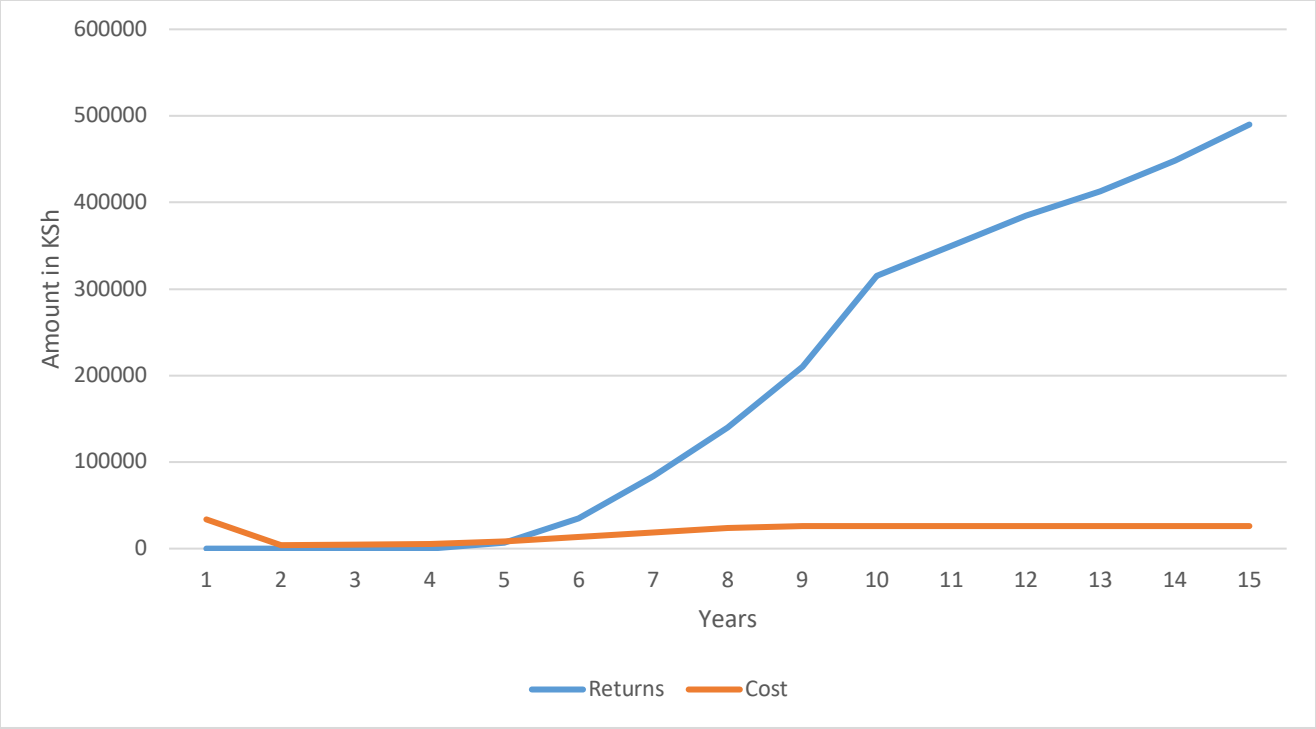



**Figure 2**

GROSS MARGIN/Ha

| Item | Unit | Qty | Unit Price | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yield (A) | Kg | | | - | - | - | 144.00 | 1,152.00 | 2,016.00 | 2,880.00 | 3,744.00 | 5,184.00 |
| Price (B) | Ksh/kg | | | - | - | - | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Gross Output (A x B) | Ksh | | - | - | - | - | 14,400.00 | 115,200.00 | 201,600.00 | 288,000.00 | 374,400.00 | 518,400.00 |
| **Total Variable Costs** | | | | **-** | | | **14,400.00** | **115,200.00** | **201,600.00** | **288,000.00** | **374,400.00** | **518,400.00** |
| Ploughing | Ha | 1 | 5,000.00 | 5,000.00 | - | - | - | - | - | - | - | - |
| Harrowing | Ha | 1 | 3,000.00 | 3,000.00 | - | - | - | - | - | - | - | - |
| Preparing Holes for planting | Hole | 178 | 15.00 | 2,670.00 | - | - | - | - | - | - | - | - |
| Purchasing Seedlings | no. | 178 | 350.00 | 62,300.00 | - | - | - | - | - | - | - | - |
| NPK fertiliser | kg/bag | 1 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 6,300.00 | 6,300.00 | 6,300.00 | 14,600.00 | 14,600.00 | 14,600.00 |
| Manure | Ton | 1 | 3,560.00 | 4,984.00 | - | 10,680.00 | - | 10,680.00 | - | 6,680.00 | 6,680.00 | 6,680.00 |
| Seedlings planting/ replacement | Seedling | 178 | 15.00 | 2,670.00 | 5,400.00 | - | - | - | - | - | - | - |
| Weeding | MD | 15 | 300.00 | 4,500.00 | 4,500.00 | 4,500.00 | 9,000.00 | 9,000.00 | 9,000.00 | 9,000.00 | 9,000.00 | 9,000.00 |
| sisal twine | | 1 | 350.00 | 350.00 | - | - | - | - | - | - | - | - |
| watering | MD | 15 | 330.00 | 4,950.00 | 9,600.00 | 4,500.00 | - | - | - | - | - | - |
| Chemicals- Pesticides | Lt | 1 | | - | 1,500.00 | 1,500.00 | 3,000.00 | 3,000.00 | 3,000.00 | 6,000.00 | 6,000.00 | 6,000.00 |
| Prunning | | | | - | - | 2,500.00 | - | - | - | - | - | - |
| Harvesting& Grading/packing | Kg | | | - | - | - | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 | 3,000.00 |
| **Subtotal** | | | | **93,424.00** | **24,000.00** | **26,680.00** | **18,300.00** | **28,980.00** | **18,300.00** | **36,280.00** | **36,280.00** | **36,280.00** |
| **GROSS ANNUAL FLOW** | | | | **-93,424.00** | **-24,000.00** | **-26,680.00** | **-3,900.00** | **86,220.00** | **183,300.00** | **251,720.00** | **338,120.00** | **482,120.00** |