Coffee (Coffea arabica & Coffea canephora) Production and Utilization in Kenya

Authors:
Introduction

Coffee History
Ethiopia is the ancestral home of cultivated Arabica coffee with wild Coffea arabica L., being the parental shrub growing naturally in the moist forest. With continuous active selection and breeding activities, many varieties like Batian and Ruiru II in Kenya have emerged with improved disease and pest tolerance coupled with high yields potential.

Coffee consumption has existed for more than 1,000 years leading to the current status of being the most consumed drink to water with over 33.33 Billion cups per month and most traded commodity after oil as per 2017 statistics. Coffee propagation culture commenced in Arabia as early as 575 in Yemen and later in the 16th century in Persia. Coffee drinking was appreciated in Europe in 1615, after being brought by traders, later Germans, Frenchmen, and Italians who introduced in their colonies. The Dutch introduced botanical garden of Amsterdam that made and triggered increase in drinking and defining culture of the Europeans. Netherland and France experiences led to expansion of the coffee cultivation to other European colonies due to readily available European market.

Coffee sustains over 100 million people globally and is rated among the largest export commodities in the world. Coffea arabica (arabica or highland coffee) and Coffea canephora (Robusta or lowland coffee) are the main coffee species that are commercially grown, however there are 124 coffee species existing and which have been named to date. Coffee Arabica contributes 70% of produced coffee while Robusta contributes 30% (ICO, 2016). Coffee is to date planted in over 11 million hectares in the world spread over 60 countries in the tropics. In Kenya, coffee was first planted in 1893 at Bura in Taita hills thereafter it was grown in Kibwezi in 1900 followed by Kiambu in 1904, since then coffee growing was expanded to several areas of Central Kenya, Meru, Kisii, Machakos, Mount Elgon and Rift Valley.

Agricultural production
The fast increasing population is the greatest challenge to the agriculture sector and natural resource management and sustainability. It is estimated that each year the population increases by an average of 90 million individuals. Agriculture sector is meant to feed the population and improve the well-being of the farmers.

Kenyan economy depends heavily on agriculture with over 75% of rural livelihood depending on it and about 28% on the national GDP contribution level out which coffee contributes 0.2%. Agriculture sector in Kenya utilize over 70% of labour force, giving 25% of the total national GDP, 60 % total export earnings, over 75 % of raw materials for the industries and contributes to 45 % of total government revenue. Coffee is the fifth largest foreign exchange earner in Kenya after tourism, tea, horticulture and diaspora remittances. Furthermore, Coffee is mainstay of about 800,000 households most of whom are in the rural areas and hilly terrains. Rural areas are characterized by high level of poverty, low income, low education levels and key resources available that needs management.

Vision 2030 outline agriculture as an important pillar to the national development plan, in fact development and agriculture in Kenya are synonymous as it is in other countries like Brazil, India
and Ethiopia. Harmonization of information, data and procedure for improved coffee production is key in the sustainability of coffee production and consistency in the livelihood for coffee value chain dependants. Guided coffee production gives positive results in terms of agricultural production quantities, community nutrition, poverty reduction and environmental management.

**The coffee Sector in Kenya**

Kenya’s agriculture cannot be complete without mentioning good climatic conditions which are favourable for coffee production of high quality sought product especially in the rural areas where over 70% of the world’s poor live. Coffee performance determines the livelihoods and economic status of over 800,000 households in rural areas of Kenya. This therefore means that an improved coffee performance translates to improved rural development.

**Coffee production**

Coffee production is an important economic venture world over for example in 1830 Brazilian business men shifted their business from gold to coffee basically for local consumption. This shift triggered infrastructural development including an approximate of 7,000 km railroad between 1860 and 1885 which further transportation of labour to work in the country especially the State of Rio de Janeiro and São Paulo which has favourable climate, soils, and terrain. Coffee opened Brazil to immigrants from Portuguese, Italian, Spanish, German, and Japanese nationals who were looking for better economies. The gains made by coffee trade have created a sustained economic growth in the coffee growing countries. Coffee exports are closely related to various developments in many countries namely Brazil, Colombia, Costa Rica, Côte d'Ivoire and Kenya.

The coffee sector in Kenya is a key economic undertaking in terms of income generation, employment creation, foreign exchange earnings and tax revenue. Even politics at all levels cannot ignore or be ignored by coffee, not least in the race for well-paying jobs, sinecures, and contracts in the various institutions that serve as gravy trains in the coffee sector fiscal and monetary system.

Kenya coffee production is categorized into two systems namely the estate and smallholder with a total of about 4000 estates and over 800,000 smallholder producers who operate and process their coffees in about 550 cooperative societies. Cooperative sector made of smallholder’s farmers account for 75% of total acreage with less than half of total production. There is high production in the estate sub sector due to increased adoption of technologies demand driven extension approaches working on it hence utilization of appropriate fertilizers, agrochemicals and water supplementation at the right timing.

It is estimated that five million people depend on coffee for their livelihood along the value chain which include the nursery operators, growers, agrochemical industry, millers, marketers, transporters, roasters, packers, financial institutions, insurance companies and coffee houses. Owing to its immense contribution to the economic growth of our country, coffee is one among the crops selected for commercialization in Kenya’s **The Big 4 Agenda**.
Figure 1. Map of Kenya showing the coffee growing areas
# Varieties, Areas Grown and their Attributes

**Table 1. Commercial Coffee Varieties Grown in Kenya**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Areas Grown</th>
<th>Spacing and population density</th>
<th>Attributes</th>
</tr>
</thead>
</table>
| Batian  | All coffee growing areas | 2.1 x 2.5 m (7 x 8ft) 1905 trees/ha | • Tolerant to CBD and CLR  
• Early maturing (18 months)  
• Cost effective - reduces costs by 30% |
| Ruiru 11 | All coffee growing areas | 2 x 2 m (6.6 x 6.6ft) 2500 trees/ha | • Hybrid variety  
• Resistant to CBD and CLR  
• Early maturing (18 months)  
• Cost effective - reduces costs by 30%  
• Compact growth amenable to high density planting |
| SL 34   | High altitude with good rainfall | 2.74 x 2.74 m (9 x 9 ft) 1330 trees/ha | • Susceptible to Coffee Leaf Rust and Coffee Berry Disease |
| SL 28   | Medium to high altitude coffee zones less prone to Leaf Rust | 2.74 x 2.74 m (9 x 9 ft) 1330 trees/ha | • Susceptible to Coffee Leaf Rust and Coffee Berry Disease |
| K7      | Low altitude | 2.74 x 2.74 m (9 x 9 ft) 1330 trees/ha | • Tolerant to Coffee Leaf Rust  
• Tolerant to drought |
Propagation
The main methods of coffee propagation are:
1. Seeds
2. Cuttings
3. Grafting
4. Tissue culture

Propagation by seed

- Coffee seeds are acquired from Coffee Research Institute
- With proper management, 1kg of coffee seed produces between 3000-4,000 seedlings.
- To ensure high germination rate, seeds should be sown immediately after collection. If not sown, the seeds should be kept in cool dry place and not for more than one day.
- Use 5-7cm (2-2.75 inches) deep pure clean river sand (without soil) as propagation media.
- To reduce germination period, de-husk the seed by use of hands just before sowing
- Sow the seeds at a spacing of 2.5cm by 2.5cm (1inch X 1inch) and a depth of 1cm. The centre cut should face up
- The seeds are then thinly covered with sand and moistened with water using a watering can.

- Cover the propagator with a 1000 gauge translucent UV treated polythene sheet to maintain ideal temperature and humidity. The propagators should be shaded.
- Apply adequate clean water regularly (ensure adequate moisture by using a finger to check for wetness)
- Regularly uproot any emerging young weeds
- The pre-germs usually emerge after 6 – 8 weeks
- Pre-germs are ready for potting when they have a pair of cotyledons leaves This takes about 2 -2 ½ months

Sowing – centre cut

Pre-germs ready for potting
Vegetative propagation

Vegetative propagation is a method of producing planting materials using plant vegetative parts instead of seeds. The materials produced vegetatively are genetically identical to the mother plant. This is done predominantly on the disease resistant hybrid cultivar Ruiru 11.

Clonal mother plants

- These trees are derived from seedlings which have undergone a pre-selection test for Coffee Berry Disease (CBD) and Coffee Leaf Rust (CLR) resistance.
- The selected mother trees are established in the field at a spacing of 1m by 1m.
- After 12-18 months, the primary branches are removed and the stems bent and pegged down in a horizontal position to encourage growth of orthotropic (vertical) shoots.
- Suckers grow from the dormant buds at each node, and are ready for harvesting after six months.

Propagation by cuttings

- Harvesting of suckers should be done early in the morning when the atmospheric relative humidity is relatively high.
- Single node cuttings are prepared by making a cut at an angle below the node but retaining the pair of leaves.
- The cuttings are planted in the propagators at a depth of 2 to 4 centimeters and at a spacing of 4cm by 4cm.
- Callus formation begins 3 weeks after planting and is complete in 5-6 weeks.
- Root development follows after 8-10 weeks.

Propagation by grafting

- This is the successful heeling of the union between the scion and root-stock.
- Grafting requires 10-12 months old seedlings (or pencil thick) to be used as root-stock.
- Root-stocks of other commercially existing Arabica coffee varieties are compatible with Ruiru 11.
• The graft union is tied with a polythene tape and the entire seedling is placed in a propagator to heal

Propagation by Tissue culture
• This is the generation of plantlets using plant parts such as leaves by use of growth hormones.
• The method is limited to highly specialized facilities/laboratories and therefore cannot be adopted at the farm level

Potting media and transplanting
• The recommended potting mixture consists of three parts top soil, two parts sand and one-part manure (top soil: sand: manure=3:2:1). For example, to fill 125 polybags of 5 by 9 inches, use 3 deben of sieved top soil, 2 deben of sand, one debe of well decomposed manure, 25gms TSP or 50gms SSP
• Put the mixture in National Environment Management Authority (NEMA) compliant potting materials, place them in rows in the shaded beds and water thoroughly.
• Make a hole in the centre of the pot using a pointed stick and insert the pre-germ to the level of the stem crown. For pre-germs, transplanting is done after the two cotyledons unfold, which is about 8 weeks after sowing. Weak pre-germs or those with twisted roots are discarded
• For cuttings, transplanting is after 8-10 weeks following propagation
• Carefully firm the mixture around the stem
Poly bags with potting mixture
Pre-germs transplanted

Maintenance of seedlings

- Water seedlings regularly depending on prevailing weather conditions. Avoid overwatering which predisposes seedlings to damping-off. Other factors that may cause damping off includes; poor potting mixture, over shading and acidic soils
- Regularly uproot any emerging young weeds
- Apply foliar feed as recommended after 4 months following transplanting
- Control diseases such as damping-off and Brown eye spot by using 0.5% copper solution.
- Control the common insect pests like green scales, giant looper and leaf miners as they occur

Hardening of seedlings

- Gradually reduce shade and the watering frequency to harden the seedlings at 7-8 months after potting.
- Completely remove the shade one month before planting
- Ideally, seedlings are ready for transplanting they have 1-2 pairs of primary branches. This is around 8-10 months after potting

Land preparation

- Prepare the land well in advance, digging out all tree stumps, roots, bushes and grasses. Land cleared of trees within 6 months should not be used for coffee planting because of the risk of Armillaria, a fungal disease which causes root rot
- Ensure soil analysis is done to determine the inherent soil condition
- Make terraces or other soil conservation structures where the land has steep slopes
- Protect bench terraces by planting grasses e.g. Blue grass (*Paspalum notatum*) on the bench faces

Layout and preparation of planting holes

- Layout and peg the planting points along the contours at the appropriate spacing
• Space holes at 2.74m x 2.74m (9ft x 9ft) for SL 34, SL 28 and K7; 2m x 2m (6.6 ft x 6.6 ft) for Ruiru 11 and 2.1m x 2.5m (7ft x 8 ft) for Batian variety.
• Dig the planting holes during the dry season, at least three months before planting/onset of rains
• Planting holes should measure 60cm x 60cm x 60cm (2ft x 2ft x 2ft)
• Place top-soil (first 15cm or 6 inches) and sub-soil (15cm-60cm or 6”-24”) separately.
• 1 month before planting fill the holes with the top soil mixed with a minimum of 1 "debe" (20 litre bucket) of well decomposed manure or well-rotten coffee pulp, 100g TSP or 200g SSP. If the soil pH is below 4.4, add 100g of lime to the mixture, otherwise add as per soil test results.
• Slightly mound the mixture in the holes to allow for settling
• Place pegs at the centre of the holes and align appropriately

Field planting
• Obtain coffee seedlings from KALRO - CRI or any licensed coffee nursery
• Select seedlings that are about 30 - 40 cm tall, with 1 - 2 pairs of primary branches and that should have undergone sufficient hardening
• Plant the seedlings at the start of the main rain season after the soil has become wet up to about 60cm (2ft) deep
• Remove the pot carefully to avoid disturbing the root system
• Open the soil mound sufficiently at the top centre to accommodate the tap root and other roots and plant the seedling without burying the stem crown
• Fill in the soil and press firmly without compacting and avoid stepping on it
• Avoid deep planting as this usually interferes with nutrient uptake leading to stunted growth

![Deep planting](image1.png) ![Correct planting](image2.png)

**Field maintenance of young coffee**

**Mulching**
• Young coffee requires mulching in order to conserve moisture, suppress weeds and moderate soil temperatures
• Apply the mulch around the stem and ensure that it does not come into contact with it to avoid incidences of insect pest attack

![Mulching in young coffee](image3.png)

**Watering**
• During dry spells, water the seedlings at least two times a week until they are well established.
• Avoid over-watering to encourage proper root development.
Weed Management
- Undertake hand weeding around the young trees. Use implements like the half-moon jembe to weed in between the rows
- In the event that there are stubborn weeds like couch grass, cover the seedlings (with a bucket or bag) before spraying the weeds with a suitable herbicide

Nutrition
- Apply 50g of CAN per seedling six months after planting
- After one year, apply 80g of NPK e.g. 17:17:17 per tree
- one and half year apply 100g of CAN
- At two years, apply NPK at 125g per tree. Subsequent applications should be as per the recommendations.
- For the first two years, abort the flowers to encourage vegetative growth

Intercropping
- Intercropping can be undertaken within the first two years after establishment. Suitable intercrops include short leguminous crops such as Field beans, tomatoes and Irish potatoes
- Plant the intercrops using a recommended fertilizer preferably NPK fertilizer such as 17:17:17
- Plant the intercrop at the middle of the inter rows at least 2 feet away from the coffee rows/stem.

Young coffee intercropped with field beans
Crop Management

Coffee Nutrition
For high yields and quality, there is need for adequate and timely supply of both macro and micro nutrients. The nutrients can be supplied from various sources such as fertilizers, manures or composted plant materials. Fertilization programs are based on established inherent soil fertility characteristics and expected production level.

Essential nutrients in coffee
- Macronutrients – elements required in large quantities. They consist of the primary macronutrients required in relatively higher quantities such as Nitrogen (N), Phosphorous (P) and Potassium (K) and the secondary macronutrients required in moderately high quantities such as Calcium (Ca), Magnesium (Mg), and Sulphur (S)
- Micronutrients - elements required in very small quantities but are essential for plant growth. They include Zinc (Zn), Copper (Cu), Boron (B), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Chlorine (Cl)

Role of macro and micronutrients and deficiency symptoms

Importance of macronutrients
Nitrogen (N)
- Essential for vegetative growth
- Increases tree bearing capacity
- Enhances bean size

Phosphorus (P)
- Essential for roots and bearing wood development
- Promotes early berry maturity
- Increases bean density

Potassium (K)
- Crucial in glucose transportation from the chlorophyll to storage tissues – roots, stems and branches
- Promotes healing of injured plant tissue especially after picking, pruning and hail storm damage
- Essential for berry development – enhances bean size (berry length) hence raises the proportion AA and AB grades
- Regulates evapotranspiration pull i.e. the opening and closing of stomata thus the loss of water through the stomata and the uptake from the soil
- Enhances mucilage formation and ripening

Magnesium (Mg)
• A major constituent of chlorophyll which facilitates the making of plant glucose which in turn makes all the biochemical constituent of the plant – starch, amino acids, vitamins and the plant tissues
• Enhances bean colour (Bluish-Green colour)
• Initiates root formation

Calcium (Ca)
• Facilitates growth of apical and root terminal points – intensifies flowering density
• Essential for vegetal and floral bud formation – it’s a constituent
• Manages the lyophilic series - directs the overall ratios of nutrients uptake
• Plays a key role in bark formation – its constituent of the bark tissue

Deficiency symptoms

Nitrogen deficiency

Phosphorous deficiency

overbearing die-back due to of N deficiency
Importance of micronutrients

**Zinc (Zn)**
- Boosts flower initiation and formation
- Enhances fruit set and leaf size
- Sets the inter-nodal spacing on the branch and the stem
- Enhances phosphorus uptake and utilization
- Determines the leaf symmetry

**Boron (B)**
- Enables flower fertilization by facilitating pollen germination through the stigma to the ovary. Consequently, optimal flowering and fruit set are realized i.e. it minimizes flower abortion
- Manages the utilization of water in the plant together with potassium. Consequently, it regulates the uptake of water from the soil together with potassium
- Promotes shoot and root growth
- Facilitates protein and sugar synthesis from glucose

**Iron (Fe) and Sulphur (S)**
- Helps in the production of chlorophyll which is required in glucose formation
- Promotes bean colour (lack of iron leads to amber beans)
- Together with copper, iron facilitates energy transfer processes during photosynthesis

**Molybdenum (Mo)**
- Facilitates translation of pinheads to expanding berries without abscission i.e. abnormal drop of the pinheads

**Deficiency symptoms**
Sources of macro and micronutrients

Inorganic fertilizers

Compound Fertilizers (NPK)
- These are granular, mechanically mixed homogeneous fertilizers with multiple nutrients. Examples of compound fertilizers are 17:17:17 and 20:10:10
- If two or more nutrients are limiting in the soil, it’s economical to apply a compound fertilizer. One of the annual N-fertilizer applications should be replaced with a compound fertilizer at a rate sufficient to supply the same quantity of Nitrogen

Nitrogenous Fertilizers
- Sources include Ammonium Sulphate (AS), Calcium Ammonium Nitrate (CAN), and Urea
- The choice of Nitrogen fertilizer depends on the soil reaction (pH)

Phosphate Fertilizers
- Common sources include Single Super Phosphate (SSP), Di-Ammonium Phosphate (DAP), Triple Super Phosphate (TSP) and Phosphoric/phosphorous acid
- The choice of a Phosphatic fertilizer depends on the soil reaction (pH)
- DAP contains both Phosphorous and Nitrogen but has an acidifying effect. It is only recommended for use in soils with high pH and high levels of potassium. Continuous use of DAP without soil analysis can lead to big cherries without beans. Avoid using DAP unless recommended after soil analysis

Potassium Fertilizers
- Sources include Muriate of Potash, Sulphate of Potash and organic manure (coffee pulp, Napier grass and cattle manure)

Foliar Fertilizers
- These are formulations of soluble fertilizers usually applied on the foliage of the coffee tree to supplement soil applied fertilizers with the aim of:
  - Correcting nutrient deficiency
Supplementing nutrient availability where soil nutrient uptake is impeded during dry weather or cold spells
Apply when evaporation is low, preferably mornings or evenings, when it is not hot

**Organic fertilizers**
Consist of manures, mulches and composts

- Boma manures are livestock organic waste made from accumulated dung from cattle pens and bomas
- Farmyard manure (FYM) is made from a mixture of farm plant residues and daily accumulation of dung. Periodic turnings of the boma and FYM leads to a fine livestock manure. The latter is often richer in potassium.
- Compost is made from decomposed organic materials derived from plant residue
- Mulches are plant materials applied directly on the soil surface
- The benefits of all these include:
  - Improvement of soil structure
  - Improvement of soil porosity/aeration - ability of the soil to hold optimal water and air
  - Lowered soil bulk density hence improved P uptake
  - Moderation of top soil temperatures
  - Minimization of top soil moisture loss
  - Increment of microbial activity
  - Suppression of weed/insect pests
  - Soil erosion control

- To avoid inducing nutrient imbalances, the mulching material to be used should be guided by the soil nutrient status. Examples of manures and the nutrients they supply:
  - Cattle manure - rich in Nitrogen and Potassium
  - Poultry manure - rich in Phosphorus and Nitrogen
  - Coffee pulp - rich in Potassium and Nitrogen
  - Sisal waste - rich in Calcium

- The amount of nutrients released to crops depends on:
  - Nature and origin of materials
  - Level of decomposition
  - Weather conditions
  - Storage condition - exposing the manure to direct sun or rain leads to loss of Nitrogen.

**Fertilizer Application**
Appropriate fertilizer types and rates depends on overall fertility status of the soil and can be determined by undertaking soil analysis.

**N.P.K application**
Apply 6 months before the main flowering (April for October/November flowering and October for March/April flowering) at the rate of 250g/tree to allow the plant to absorb adequate amount of P. P absorption is a slow process for dicots
• Apply 2 weeks after the onset of rains to allow the feeder roots to develop
• Apply on at most 20cm wide ring along the drip line and incorporate shallowly in the soil. Alternatively, scoop some soil, apply then cover shallowly (1 – 2 inches) with soil. The latter is more efficient

Boron/Zinc application
• Apply a foliar mixture of Zinc and Boron at the rate of 2 - 3kg of each per Ha (40 - 60 g of each/20 litres of water) 2 – 3 months before the main flowering

Nitrogen application
• Apply Nitrogen fertilizer (CAN/ASN) after the main flowering, two weeks after the onset of rains at the rate of 300g/tree per year
• For East of Rift Valley, apply in 2 equal splits at 3 - 4 weeks’ interval (150g per application)
• In West of Rift Valley, apply in 3 equal splits at 3 - 4 weeks’ interval (100g per application)
• Apply the fertilizer in at least a 30cm wide ring starting from the drip line towards the stem
• If trees are carrying a heavy crop, apply a foliar fertilizer rich in Nitrogen during the dry or cold spell. For example, apply Urea 46% N at the rate of 10kgs/ha (10kgs in 1000 lts of water or 200g per 20lts of water) or other foliar formulations rich in Nitrogen. A better practice will be to use a foliar rich in NPK

Manure application
• Apply 1 - 2 debes of well decomposed manure/coffee pulp once a year during the dry weather, a month before the rains
• Dig a shallow furrow ring (4 – 6” deep), 30cm wide, starting from the drip line towards the stem. Apply the manure and mix with soil

COMPOSTING PROCEDURE

Compost is made from on-farm plant residues such as postharvest remains, weeds, tree litter fall, fodder/forage crops, coffee pulp, kitchen waste and other biodegradable materials. To assist in composting, EM (Effective Micro-organisms) can be used. This is a culture of micro-organisms that aids rapid breakdown of organic materials to release nutrients. The stock culture is termed as EM1 and is used to generate the working culture - EM2 as follows:

• Mix 1 litre of EM1 with 1 litre of Molasses and 20 litres of water. Let the mixture ferment for 7 days
• 2 litres of EM2 can be mixed with 100 litres of water for use in compost making
• For large scale compost, prepare ground of 100ft by 4ft wide. This should be done in areas free from flooding and run-offs
• Line the composting depression with a strong polythene sheeting
- Stack the materials into 2ft thick layers
- Apply the diluted EM2 solution and repeat the layering until approx. 4ft high
- Wet each layer with adequate amount of water
- Compress the layers and cover with polythene sheet and apply a thin layer of soil on top
- Incubate for 3 weeks. After 3 weeks, start and continue turning and rewetting biweekly to aerate the mixture evenly
- Poke in a thermocouple regularly to monitor the compost temperatures or use a stick to feel the temperatures
- The decomposition process is complete when the mixture no longer feels hot
- Let the process continue for two months after which the compost will be ready for application to the field
- The end point is determined by a 66% reduction from the original volume
- Apply 5 -10kg of the compost per tree depending on the canopy size
- For small scale compost, make a hole 5ft by 5ft but the horizontal length depends on the availability of the composting materials and undertake the process above
- Apply the compost from the first hole after two months and restart filling all over gain
- To ensure a continuous supply, undertake the procedure repeatedly
- EM is readily available at Agrochemical shops

**Fertilizer application schedule for late main crop areas**

<table>
<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
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<th>Jun</th>
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<tbody>
<tr>
<td>NPK</td>
<td>CAN</td>
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The key areas for the late main crop are – Central region, Upper Embu and West of Rift Valley.

Note: NPK application in West of Rift valley should be done in August or September depending on the start of rains.
Fertilizer application schedule for early main crop areas

<table>
<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
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Main flowering | Initial Crop Expansion | Final expansion/maturation

- CAN
- NPK
- Zinc sulphate
- Solubor
- Lime
- Manure

The key areas for the early main crop are – Meru, Machakos, Taita, and Oloitoktok regions

**Note:** Trees carrying a heavy crop should be supplied with adequate nitrogen. The application of nitrogen should be based on expected production. The table below gives a guideline on the amount of nitrogenous fertilizer to be applied for various levels of production.

**Fertilizer application rates based on production**

<table>
<thead>
<tr>
<th>Amount of crop estimated in the current season</th>
<th>Kg N/ha per year</th>
<th>Grams of fertilizer/tree</th>
<th>Kg of fertilizer/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg N/ha per year</td>
<td>21% N</td>
<td>26% N</td>
<td>21% N</td>
</tr>
<tr>
<td>Less than 1000 kg clean coffee per hectare (5 kg of cherry per tree)</td>
<td>80</td>
<td>330</td>
<td>260</td>
</tr>
<tr>
<td>1000-1500 kg clean coffee per hectare (5 – 7 kg of cherry/tree)</td>
<td>100</td>
<td>358</td>
<td>290</td>
</tr>
<tr>
<td>1500–2000 kg clean coffee per hectare (7– 10 kg of cherry/tree)</td>
<td>100 – 150</td>
<td>358 - 538</td>
<td>290- 434</td>
</tr>
<tr>
<td>Over 2000 kg clean coffee per hectare (over 10 kg of cherry /tree)</td>
<td>Up to 200</td>
<td>716</td>
<td>578</td>
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</table>

4.6 Soil sampling and analysis

Soil sampling entails collecting representative samples (random sampling) from the whole farm for the purpose of analysis. It should be done during the dry season

- When sampling, ensure you have two containers, a fork jembe or a panga and packaging bags (for the sample)
- Take samples from the various parts of the farm. Collect samples outside the tree canopy between 4 trees
- At the sampled point, dig out and place the top soil (first 6”) separately from the sub soil (6 – 18”). Mix the top soil and the sub soil separately and take 1 or 2 handfuls from each and put in separate containers. Repeat this at the other sampled points
- Thoroughly mix the soil in each of the containers and take a sample of about 1kg of top soil and 1kg of subsoil
- Put the topsoil and subsoil in separate packages and label appropriately giving your name, location and address (Postal and email). Send the samples to CRI
- At least 5 sampling holes (cores) should be dug for a small farm of 1 acre and below. For larger farms add 2 – 3 cores per every additional acre
- Undertake soil analysis every 2-3 years in order to determine the type and quantities of fertilizers to apply

**Soil sampling tools and process**

**Liming**

- Apply lime as advised in the soil analysis report
- Where soil analysis has not been done and there is an indication of high acidity (e.g. presence of fern and poverty grass), apply lime at 250g/tree each year in order to attain a suitable soil pH (4.4 – 5.4)
- Broadcast the lime along the rows during the dry weather
Irrigation in Coffee

Irrigation is the artificial application of controlled amounts of water to soil at predetermined intervals in order to make up for inadequate rainfall for the purpose of increasing the cropping level. It is done to supplement rainfall especially when the tree is carrying a heavy crop. Irrigation may be done through drip, overhead, basin, under tree or bottle irrigation.

Benefits of irrigation

- Increases production by up to 50% especially when rains are below normal
- Increases the bean sizes hence the proportion of premium grades and thus enhances quality
- It can be used to induce flowering
- It protects the tree from damage arising from overbearing when there is drought
- It allows ground fertilizer application in case of rain failure

Types of irrigation

- Drip irrigation – this is the most preferred type of irrigation since it is economical in water usage. Water is delivered through laid out drip lines that have equally spaced openings
- Overhead irrigation – the use of sprinklers to apply water above the coffee bushes. It is the most uneconomical in water usage and predisposes the coffee trees to disease attacks. It is also expensive to run
- Basin irrigation – holes are dug between the coffee trees and water is applied into holes
- Under tree irrigation – This is preferred where CBD is severe to avoid wetting the canopy. It involves use of small sprinklers to apply water under the trees
- Bottle irrigation – This is ideal for small scale farmers and involves the use of bottles to apply water under the tree canopy
Critical periods to irrigate

Coffee needs to be irrigated when:

- Moisture content is inadequate for the young coffee
- Flower buds are fully formed but there are no rains
- Pinheads are breaking dormancy (7th week from fruit set) but there is moisture deficit
- Rains fail during the ripening stage
- Trees are under stress due to drought

Note:
Moisture deficit testing kit (cobalt chloride disc method) is used to determine whether to irrigate or not. On average, if time taken by the disc to change from blue to pink is 5 minutes or more, there is need for irrigation.
Important aspects of irrigation

- Irrigate fields that are weed free
- Calibrate the amount of water being applied by collecting water from the discharge point for a given period of time
- Repair leaking pipes and joints
- Ensure the pump and the whole irrigation system is working properly – check the foot valves, sluice valves and the return valves

Canopy Management in Coffee

Canopy management is the overall process of ensuring optimal production of the bearing wood in order to maximize annual regular cropping. It includes pruning, tree training, handling, desuckering and change of cycle.

Benefits of Canopy Management

- Maintains a suitable crop: leaf ratio
- Opens the tree to sunlight which stimulates flowering
- Encourages growth of new stems and crop producing branches
- Reduces pests and disease susceptibility
- Helps to reduce over-bearing and dieback
- Reduces biennial cropping
- Maintains an appropriate tree shape
- Rejuvenates the coffee tree

Coffee Tree Training Systems

There are two training systems in coffee namely capped and uncapped (free growth) system:-

- The capped system involves cutting the heads at a height not exceeding 6 feet from the ground while in the uncapped system, the apical stem growth is maintained
- The free growth is appropriate for smallholder, small estates and medium estate farmers while the capped system is appropriate for the mechanized plantations
Benefits of uncapped tree system
- It is cheap, simple and quick to manage.
- Good for crop control and prevention of over-bearing.
- Stems replacement and change of cycle is easy.
- It bears crops mostly on primaries which give bigger beans of higher quality.

Limitations of uncapped tree system
- Tree breakages are common especially with delayed change of cycle.
- Picking and spraying is difficult on tall trees.
- Irregular growth of trees in a field.
- Rotting of stumps with age.

Benefits of capped tree system
- Easy picking and spraying at convenient uniform height.

Limitations of capped tree system
- Pruning is complicated, slow and requires skilled labour.
- Top branches liable to scorching without shade

Pruning
Pruning is a process through which undesired branches are removed in order to concentrate growth on the wanted branches and it is normally carried out after the main harvesting. Unhealthy trees due to die-back should be pruned only after new vegetative growth.
6.4.1 How to prune coffee under the uncapped system (free growth)

- Remove all primary branches touching the ground
- Open the centre by removing all the secondary branches within 9 inches (22.8cm) for traditional varieties and 6 inches (15cm) for Ruiru 11 from the main stem.
- Remove all the interlocking primaries
- After the third main harvest, maintain a bearing height: 5.5 feet for coffee in the coffee-tea zones, 5 feet for main coffee zones and 4.5 feet for marginal coffee zones.
- Remove the old primaries below the above recommended bearing height
- Allow 4 non-cropping secondary branches per primary and 2 more bearing ones for medium and low altitudes
- Remove the interlocking primaries spirally, one from each alternate head especially for Ruiru 11
- Remove all the dry branches
- Remove all secondary branches growing upwards, inwards and downwards
- Cut back primaries to ensure they do not grow beyond 3 feet
- Maintain 2 or 3 bearing heads per stem
How to prune coffee under the capped system

- Has a fixed bearing head, hence the crop is mostly borne on the secondary branches and tertiaries.
- Capping is done at 1.83 metres (6ft) from soil level.
- Cut back primaries to maintain a length of 2.5 feet. Primaries carrying a crop should not be more than one metre long.
- Cut off secondary branches, tertiaries and laterals which have carried two crops to encourage new laterals.
- Leave 4 bearing secondary branches and 2 non-bearing ones on one Primary.
- If possible leave only one secondary on each node on alternate sides of primary.
- Remove secondary branches and laterals growing upright or within 15cm (6 in) towards the main stem.
- Always remove suckers unless wanted for change of cycle.
- For capped multiple stem remove all inside primaries.

Handling and de-suckering

- Handling involves thinning out of the young shoots that develop after rains or irrigation.
- De-suckering is the removal of suckers on main stems and at the base of the trunk.
- Handling can be done at any time but mainly at the end of the rain season.
- De-suckering can be done at any time but at least every 3-4 months for the uncapped system and every 2 months for the capped system.
- Replace the non-bearing secondary branches which have matured with young shoots. Do not remove those carrying a crop.
- Do not allow suckers to grow unless they are for change of cycle or replacement of broken bearing head(s).
Change of cycle
A process of rejuvenation (renewal) of the old bearing heads with new ones. This can be done through gradual replacement or clean stumping. This should be preferably done after every 5 major main crops

Uncapped (free growth)
- Start preparing for change of cycle 18 to 24 months before heads are to be cut off.
- Cut off the inside primaries leaving those within 1.5-2.5 feet from the top. This will make the heads to bend outwards.
- Allow suckers to grow in the main stem at about 12 to 18 inches from the ground.
- When suckers are about 18 inches high, select 4 strong, health and well-spaced suckers and cut off the rest.
- Just before the long rains, cut off 1 sucker leaving 3 to develop into new heads.
- One year before cutting the old stems, prune off all the primaries inside the main stems.
- Remove one head each year starting with the one on the sunrise side. Cut off at an angle of 45° slanting outwards.
- Change of cycle can be done by clean stumping where all stems are cut to allow for regeneration of new suckers. The suckers are progressively selected to allow for development of up to 3 bearing heads.

Change of cycle in a capped system
- Change of cycle is done after 5 cropping years.
- In case there are 3 heads per stem start the process by removing the head facing the sunrise side.
- Side prune the remaining heads on the sunrise side to allow adequate light at the base of the stem.
- Allow suckers to grow in the main stem at about 12-18 inches from the ground.
- The rest of the procedure is as for the uncapped.
- Undertake stem surgery whenever necessary to remove the dead wood and create space for sucker expansion.

New suckers developing
Top-working
Top-working is varietal conversion that involves converting disease susceptible mature trees of Arabica coffee into Ruiru 11/Batian without uprooting and replanting.

Methods used in top-working
- Side wedge grafting that leaves the upper portion of the root stock as a breather -gives rise to weak stems
- Whip and tongue grafting done on pencil thick suckers and is the most common method
- Bark grafting -done on the side of the main stem and gives rise to weak stems which can easily break off

Top-work during cool and wet weather to achieve best results

How to top-work
Top working procedure:
- Induce sucker growth on the trees to be converted by side pruning in September to October or January to February
- When the suckers are six months old, they will be approximately pencil thick, hardened and suitable for grafting
- Select 3 to 4 healthy suckers per stem originating from as near the ground as possible (4-6 inches) and graft with single node scions of Ruiru 11 or Batian bearing a pair of leaves
- Tie the graft union with a tape to keep the scion in place and to prevent fungal infections
- Lower a milky tube to enclose the grafted sucker and tie the lower open end tightly just below the graft union
- Pour a little water (approximately 50ml) carefully into the polythene bag maintaining its level below the graft union. The water helps to maintain a high relative humidity for enhanced healing
- Remove the bag when the graft union is completely healed (after about 6 months)
- Remove the tape tying the graft union
- Remove the old stems when the grafted suckers start bearing
- Infill with the selected variety to achieve the recommended plant population for the new variety
Benefits of top-working

- There is no interference with normal cropping pattern
- The farmer saves on the cost of uprooting old bushes and establishment
- The well-established root system of old stumps prevents lodging which may occur when young trees carry a heavy crop
- Gets into production faster than through uprooting and replanting
- Increased plant population per unit area especially where compact varieties are used
- It leads to high returns as a result of foregone fungicide costs
**Weed Management in Coffee**

Weeds compete with coffee for nutrients, light and moisture. This leads to production of less yields and low quality coffee grades like C, T, TT and defects like lagged beans and pods. Weeds also act as alternate host to some coffee pests making their management difficult in un-weeded fields.

There are two types of weeds, annual and perennial. Their management includes mechanical, cultural, chemical and integrated weed management strategies.

**Economic importance of weeds**

A weed is plant that grows where it is not wanted. It has the following effects on coffee:-

- Competition for moisture, nutrients and light
- Lowers quality and quantity
- Serves as alternate host for coffee pests
- Interferes with field operations

**Timeliness in weeding**

Effective weed control depends on timely application of the control methods that should be done before:-

- Weeds get too big and the root system makes them difficult to pull out
- Weeds can seed adding to the weed problem (fourth leaf stage)
- Fertilizer is applied which would otherwise be taken up by weeds
- Mulching is done

**Common types of weeds**

Weeds are classified either as annual or perennial weeds.
Annual weeds
- These are weeds that complete their vegetative cycle within one year and are easy to control e.g. gallant soldier, black jack and Mexican marigold

Perennial weeds
- These are weeds that persist over seasons and are difficult to control e.g. Kikuyu grass, nut grass, wandering jew, oxalis and couch grass

Methods of weed control
Weed management in coffee can be achieved through mechanical, cultural, chemical or a combination of any two or more strategies hereby referred to as Integrated Weed Management (IWM).

Mechanical
This involves:
- Hand hoeing - done shallowly to avoid damaging root hairs by using a hoe (jembe) or a panga.
- Forking - should be done every 2 – 3 years mainly to break hardpans and enhance soil aeration. This is best done during the dry season to aid in management of difficult weeds
- Slashing - appropriate when the soils are too wet and the use of a hoe is difficult. Care must be taken not to injure the trees as this would predispose them to Fusarium infection.
- Tractor drawn mower – this is economical on large scale operations

Cultural
This involves use of traditional practices such as mulching, close spacing and cover crops.

Chemical
This entails use of herbicides which are either systemic or contact in their mode of action.
- Systemic herbicides control both annual and perennial weeds
- Contact herbicides control the annual weeds
- Chemical control should be applied only as the last option

For effective chemical control, it is important to use recommended spray equipment, motorised sprayers or knapsack sprayers and most importantly the selection of nozzles. The nozzles should be wedge shaped as opposed to cone shape. These will cover large swathes as well as ensuring chemical does not drift to coffee plant. Sometimes it is important to use a shield to avoid any chemical drift.

Integrated Weed management
This is a combination of any two or more of the methods mentioned above. It is most effective, cost friendly and efficient as it is directed by the weed spectrum present in a particular coffee farm.
Disease Management in Coffee

Classification of coffee diseases in Kenya

Some diseases are major while others are minor. The main coffee diseases in Kenya include

- Coffee Berry Disease (CBD)
- Coffee Leaf Rust (CLR)
- Bacterial Blight of Coffee (BBC)
- Fusarium bark disease (FBD)
- Fusarium root disease (FRD)

Minor diseases are Armillaria root rot, Botrytis Warty disease, Root rot, Brown eye spot, Leaf blight and stem die back.

Major Coffee diseases

Coffee Berry Disease (*Colletotrichum kahawae*)

Symptoms

- On flowers: Dark brown blotches/streaks on the petals. Flowers may be destroyed but loses from flower infection are generally not serious
- On green berries: Small dark sunken patches/lesions which spread rapidly and may cover the whole berry. Infected berries may be shed or remain on the trees in a black shrivelled condition
- On ripe berries: Dark sunken lesions with black dots spreading rapidly on the ripe berries (late Blight)
- On leaves: Brown marginal spots. However, leaf infection is not common
- Severe infections may cause the die-back of twigs and branches

CBD infected berries

Late-blight

Conditions favouring high disease incidences

- Cool temperatures – 18-20°C
- High humidity - encourages spores production
• Rainfall – rain droplets disperse the spores to the rest of the tree. After the dispersal, at least 5 hours of wetness on the berries are required for the spores to germinate. Rainfall occurring in the late afternoon is therefore likely to provide suitable conditions for infection.

Management of CBD
• **Cultural control** – Proper and timely pruning, handling and de-suckering, and regular change of cycle. This reduces the initial disease inoculum.
• **Chemical control** – Correct and timely use of recommended fungicides. It is advisable to complete the recommended CBD control program for it to be effective and to avoid development of resistance by the pathogen. Farmers should start spraying before the rains and continue until the rains and the cold spells are over.
• **Resistant varieties** – New planting of disease resistant varieties or conversion of susceptible varieties to resistant ones through top working.

Coffee Leaf Rust (*Hemileia vastatrix)*

**Symptoms**
- Pale yellow spots appear on the underside of the leaves at the onset of infection
- The spots later change to yellow/orange powdery masses
- Affected leaves fall off prematurely in case of severe infection. This condition may cause dieback if not controlled.

![Coffee leaf rust](image)

**Conditions favouring high disease incidences**
- Warm and wet conditions
- Wind and or rain – disperses the spores
- After the dispersal of spores, at least 3 hours of wetness on the leaves are required for them to germinate. Only germinating spores on the lower surface of a leaf can penetrate and cause infection.
Management of Leaf Rust

- **Cultural control** - Proper and timely pruning and regular change of cycle

- **Chemical control** - This entails the use of recommended Copper-based fungicides. Timing is critical for the control of leaf rust and the sprays should be applied before the commencement and during the early period of the rainy season. For effective management:
  - Start the 1st round of sprays just before the short rains and repeat 3 weeks later
  - Start the 2nd round of sprays before the onset of long rains and do 2 more at 3 weeks interval
  - In case the infection is severe (20% of leaves have rust), it is necessary to use a systemic fungicide such as Alto or Bayleton. Do not spray more than 2 times a year as it affects production of plant hormones leading to hormonal imbalance such as the balance between floral and vegetal inducing hormones. This may affect flowering and thus production
  - Adhere to the spray programme. Improper use of fungicides may lead to development of resistance by the pathogen

- **Resistant varieties** - Planting of disease resistant varieties or conversion of susceptible varieties to resistant ones through top-working

**Bacterial Blight of coffee (Pseudomonas syringae pv. garcae)**

**Symptoms**
- On leaves: black soaked lesions. Leaves eventually dry out, roll inwards and turn brown but do not shed
- On twigs and shoot tips: die back syndrome as infection extends downwards from the terminal bud
- On flowers and pin head stage: If attacked, pin heads appear water soaked. Both the flowers and pin heads shrivel, turn black and the entire crop may be lost
- On internodes of young branches: Dying of branches above the area of infection. Infection may start at the internodes of young succulent branches or green stems as a result of hail damage or through wounds caused by sucking insects

Bacterial Blight of Coffee
Conditions favouring high disease incidences
- Cool and wet weather
- Injuries as a result of hailstorms and insect attack

Management of BBC
- **Cultural control** - proper pruning, minimising use of high N foliar feed formulations, splitting ground N application, sterilising pruning tools (e.g. with Kerol 1% or Lysol 3% or methylated spirit), cutting off and burning infected twigs and branches, frequent desuckering and avoiding transportation of seedlings from BBC prone areas
- **Chemical control** - use of bactericides (Copper based products are most effective). During the wet weather use Kasumin Bordeaux (Copper Sulphate plus Lime at 1:1 ratio). A single spray after hailstorm to protect fresh wounds from infections is necessary

Fusarium Bark Disease (*Fusarium stilboides*)
There are 3 distinct forms namely Storeys bark disease, Collar rot and Scaly bark.

**Symptoms**
- Yellowing and wilting of leaves and eventual death of the tree
- For Storeys bark - suckers are attacked at the base forming lesions that girdle the stem forming a bottle neck at the base
- For Collar rot - a cankerous lesion develops causing a constriction at the base near the ground level
- For Scaly bark – Rising up and flaking of the bark on mature stem especially at the point where a primary has been cut off. On old trees, this may be difficult to recognize. However, when seen on young wood or associated with cankerous regions around the base of branches or suckers, it is most likely Fusarium. Unless cankerous areas develop or dieback begins, affected stems and branches may survive

Storeys bark  Collar rot  Scaly bark

Conditions favouring high disease incidences
- Poor nutrient status of soil
- Weak trees as a result of poor establishment, drought or scorch
• Scars on trees due to pruning, careless slashing of weeds and herbicide damage on green suckers
• Excessive weed growth and mulching too close to the stem causing a warm moist micro climate around the base
• Failure to destroy affected trees

Management of Fusarium Bark Disease
• Cultural control
  o Avoid deep planting
  o Keep soil pH at optimum (4.4-5.4)
  o Proper application of mulch (6” from the stump) to avoid Collar rot
  o Sterilising of pruning tools with methylated spirit
  o Eliminate wood boring insect pests e.g. yellow headed borer. This can be done by maintaining soil potash at optimal level as per soil analysis recommendations
  o Uproot and burn all infected trees having die bark from Collar rot

• Chemical Control
  o In case of storey bark disease cut off and burn affected suckers or heads. Paint the scars with a fungicidal paint (1 teaspoonful of Captan plus 150ml vegetable oil).
  o In disease prone areas, spray suckers raised for conversion fortnightly with Captan at 40gm in 10 litres of water from emergence until wood bark matures to about 30 cm (1 foot) from the base
  o For scaly bark, no action need to be taken as long as no further signs of disease develop

Fusarium Root Disease (*Fusarium solani*)

Symptoms
• Sudden wilting of leaves and death of the tree
• Infected trees may remain alive for several years but disease symptom appears once the tree is subjected to water stress. At this stage a cross-section of the stem near the soil level reveals a pink-purplish colouration, sometimes with dry rot at the centre depending on severity of infection on the tree.

Conditions favouring disease incidences
• Injury at the time of planting
• High acidity in soils
• Chemical or mechanical injury to the roots
• Water logging

Management of FSD
• Cultural control
  o Uproot and burn infected trees. Leave the hole exposed for at least six months before replanting
  o Avoid damaging the roots of seedlings during planting
• **Chemical control**
  - Sterilise the planting holes with a soil fumigant such as Basamid at a rate of 150gm per hole

**Minor Coffee Diseases**

**Armillaria root rot** (*Armillaria heimii*)

This is a fungal disease commonly associated with new establishments where trees have been uprooted leaving residual lateral roots. The residual roots contain food substrates for Armillaria fungi to multiply. These fungi eventually infect the developing coffee roots.

**Symptoms**

- Wilting and death of the leaves
- Death of the verticals (shoots, suckers and the stem)
- Subsequent death of affected trees
- In advanced stage of the disease, the wood of the affected tree is decomposed into a white wet mass with characteristic black zone lines running through the wood tissue

**Conditions favouring high disease incidences**

- Clearing of forest without first ring barking the trees

**Management of Amillaria**

- Where coffee has to be planted in newly cleared forest land, it is recommended that ring-barking of the forest trees be done 2 to 3 years earlier
- Removal of forest tree stumps and roots
- The infected tree(s) should be uprooted and replanting delayed for 2 years

Other minor coffee diseases include Botrytis Warty disease, Root rot, Brown eye spot, Leaf blight and stem die back. However, these are not of major economic importance.
Insect Pest Management in Coffee

Globally, about 1000 insect pest species infest coffee of which 35 are known to attack coffee in Kenya. Of these, some are major while others are minor. The pests attack coffee flowers, berries, leaves, branches, stems and roots leading to reduction in yield and quality.

Pests Scouting and IPM

- Pest scouting refers to random survey of pest presence and population level and is critical in pest management.
- For effective pest management, it is important to take into consideration the economic threshold levels (ETL) i.e. the pest population level beyond which if not controlled is likely to cause crop loss which exceeds the cost of control with an insecticide.
- To manage the pests, it is recommended that an integrated pest management (IPM) approach be practiced
- IPM entails combining several pest control methods such as biological (use of biological control agents), cultural and chemical (use of insecticides and bio-pesticides)

It is important to avoid unnecessary insecticide sprays in order to conserve the beneficial insects or natural enemies

Classification of Insect pests

Major insect pests
The major coffee insect pests are Antestia Bug, Coffee Berry Borer (CBB), Thrips, Coffee Scales (Green scales, Mealy bugs), Stem Borers (White Stem Borer, Yellow headed Borer), Berry moth, Leaf miner, Root mealybug, and Giant Loopers.

Minor insect pests
Minor insect pests include Capsid bugs, Systates weevil, White Waxy scales, Brown scales Mites and Cottony scales among others

Prevalent insect pests
Antestia Bug
It is a broad insect, up to 6mm long (¼ inch long), dark brown in colour with orange and white markings

Symptoms and damage
- buds leading to abortion
- Rotting of beans within the berries
- Fan branching and short internodes on terminal growth
- Characteristic zebra pattern on beans that grow to maturity causing the beans to be of low quality
Management
- **Cultural control**
  - Timely pruning, handling and de-suckering

- **Chemical control**
  - Spray when the pest population reaches 2 bugs per tree for East of Rift Valley and 1 bug per tree for West of Rift Valley using any of the recommended insecticides

**Coffee Berry Borer (CBB)**

**Symptoms and damage**
- One or two small round holes appear near the apex of mature green or ripe berries.
- Adult females and the larvae cause damage by feeding inside the mature berries causing the inside of the fruit to rot.
- Damaged beans has distinctive blue-green stains and may contain up to 20 larvae of different sizes.
Management

- **Cultural**
  - Regular Pruning
  - Practice field hygiene by collecting infested fallen berries to avoid the berries becoming breeding reservoir for CBB
  - Strip all the remaining berries at the end of the harvest season. If infested, bury or burn them
  - Avoid over-shading in order to enhance searching capacity of natural enemies on CBB. 30% shading level is sufficient

- **Chemical**
  - Ensure timely spraying twice at 3 weeks' interval (15th and 18th week from the main flowering) using any of the recommended insecticides. This to apply where infestation was too severe in the previous season.

- **Integrated method**
  - Use of pheromone traps (Brocap traps) – The traps contain ethanol-methanol (50:50)+ acid fuchsine +Britex 80ppm mixture that attract the CBB
Thrips

**Symptoms and damage**
- White silvery patches with minute black spots on leaves, berries and green shoots
- Heavy infestation, cause death of leaves or total leaf fall

![Thrips damage](image)

**Management**
- **Cultural control**
  - Mulching, shading and irrigation
  - Use of sticky traps
- **Chemical control**
  - Spray using a recommended insecticide at ETL of 1-2 per leaf when there is drought and 2-3 when there are rains.

**Green scales, Mealy bugs and other scales**
The management of Green scales, brown scales, white waxy scales and the Kenya mealy bugs is similar. Scales suck the plant sap causing reduction in coffee production and quality.

**Symptoms and damage**
- Rows of flat oval Green scales along main leaf veins and near tips of green shoots
- Mealy white masses of insects (Mealy bugs) between clusters of berries and/or flower buds
- Sticky honey dew and sooty mould growing on leaves
- Presence of attendant ants climbing on infested coffee trees
Green scales  Lady bugs

Kenya mealy bugs

Management

- **Cultural control**
  - De-suckering and removal of branches touching the ground
  - Proper weeding to avoid weeds becoming bridges for the ants

- **Biological control**
  - Natural enemies such as parasitoids, parasites, predators and fungal pathogens attack the Scales thus affecting their infestation

- **Chemical control**
  - Under severe infestation, spray the infested trees (spot spraying) with mineral oil e.g. white oil or DC-Tron plus (100ml in 20 litres of water)

- **Integrated method**
  - Combines the cultural, biological and chemical methods. Coffee trees infested by scales are banded (Chemical control) 6 inch at the base of the trunk with a recommended insecticide. Followed by removal of any branches (cultural control) touching the ground that act as the bridges for attendant ants. This creates favourable conditions for natural enemies (Biological control) to attack the scales.
White Stem Borer

Symptoms and damage
- Wood shavings extruded by larvae burrowing in the stem
- Ring barking at the base of the trunk
- Oblong holes visible on the trunks left by larvae after entering the trunk
- Visible round holes on trunks left by emerging adults
- Yellowing of foliage and eventual death of trees

Management
- **Mechanical control**
  - Kill the larva(e) that is already in the stem by inserting a wire/spoke into the tunnel
  - Physically collect and kill the beetle at the onset of rains
- **Chemical control**
  - Paint or spray a 90 cm band above the ground on coffee trunk with a recommended insecticide. Repeat after one year and every second year.
  - Insert a cotton ball soaked in an insecticide through the tunnel in incidences where the larva has entered into the stem.

Yellow headed borer

Symptoms and damage
- Wilted tips of primary branches
- Ejected frass (Sawdust like) visible on the ground
- Series of holes on the underside of primary branches and on the main stem
- Breaking of branches especially when trees carries a heavy crop
Management

- Cultural control
  - Cut off infested primaries and burn them
  - Kill the larva(e) already in the stem by inserting a wire/spoke at the last hole downwards
  - Remove and burn the heavily infested heads

- Chemical control
  - Enlarge the lowest hole and use a pen filler or an oil can to squirt in any recommended insecticide

Berry moth

The larva is a reddish caterpillar 12mm (1/2 inch) long when fully grown.

Symptoms and damage

- Webbed berry clusters with one or more berries being brown, dry and hollow
Management
- **Cultural control**
  - Remove infested berries. Destroy them by burning or deep burying

- **Chemical control**
  - Spray with a recommended insecticide and repeat 5-6 weeks later if buds or young berries are being infested. Scout for the pest soon after main flowering.

**Leaf Miner**
The pest is most common in the East of the Rift Valley.

**Symptoms and damage**
Irregular brown blotches on the upper side of the leaves, covering white caterpillars of size 12 mm (½ in) long within the “mine”.

Management
- **Chemical control**
  - Use recommended systemic insecticides that are ground/soil applied
  - Foliar spray Biological insecticides (Insect Growth Regulators- IGR’s)

**Root Mealy bug**
Symptoms and damage
- Wilted and yellowish Leaves
- Stunted Roots that are encased in clusters of greenish and white fungal tissue
- White mealy bugs visible after peeling off the fungus.

Management
- Cultural control
  o Uproot infested trees, leave the holes open for 3 months and replant as recommended under coffee establishment

- Chemical control
  o Apply the recommended insecticide during establishment and/or infilling
  o Ground application along the dripline of infested coffee trees with recommended insecticides. This to be applied when soils are wet

Capsid Bug
This is a common coffee pest in all coffee growing regions.

Symptoms and damage
- Blackening of flower buds due to death of stamens and petals.
- Club shaped elongated style with pale green shaft and black head.

Management
- Chemical control
  o Use any recommended insecticides

- Biological control
  o The nymphal stages are attacked by endo-parasites

Giant Looper
Giant Looper is a widely distributed pest. It is associated with heavy use of Organo-phosphates. The caterpillars are Pale grey to dark brown in colour and they resemble the twigs. They measure 5 cm (2 in) when fully grown. They move with looping motion.

Symptoms and damage
- Young caterpillars perforate pits on the leaf surface usually on the upper side.
- Jagged edge leaf margins eaten by older caterpillars.
- Caterpillars prefer young leaves but they also feed on berries and large flower buds.

Management
• **Chemical control**  
  o Spray the infested coffee trees with recommended bio-pesticides

• **Mechanical/Physical control**  
  o Manually, collect and kill the caterpillars

• **Biological control**  
  o The caterpillars are attacked by various predators and parasitic wasps

**Other coffee insect pests**

Other coffee insect pests that are not of much economic importance include, Jelly grub, Green Loopers, Dusty Brown Beetle, Fruit fly, Yellow, Green and Red Tortrix, Black Borer, Fried Egg scales, White Waxy scales, Mites, Lacebug, Tip borer, Black borer, Leaf Skeletonizer, Systates weevil, Tailed caterpillar, Stinging caterpillar, Berry butterfly and Cottony scales. These pests occur sporadically and are associated with indiscriminate use of insecticides which leads to elimination of natural enemies such as Ladybird beetles. Consequently, the pest population increases to a level warranting chemical control.

**Primary Coffee Processing**

Proper coffee processing is important as it sustains bean quality and thus assures better prices to growers. There are two methods of coffee processing namely wet and dry methods. Wet processing is the pre-dominant practice in Kenya. The process involves a series of stages and each must be undertaken in the right manner and with facilities which are in good order. The stages are:

**Cherry harvesting**

- Ensure timely and selective picking of bright red cherry. Avoid picking green and under-ripe berries which may cause pulping and fermentation problems
- Use clean harvesting bags, baskets or tins
- Avoid dropping cherry on bare ground during picking
- The harvested cherry should be kept under shade to protect it from direct sun
- Cherry should be transported in clean containers/bags
- Transportation of cherry to the factory should be done on the same day of harvesting
Cherry harvesting – pick only the red ripe

Cherry sorting
- Spread the cherry on a clean material/floor to avoid contamination
- Remove the green, under/over ripe, dry, insect infested/diseased berries, twigs, leaves and any other foreign materials such as stones
- Weigh and record the sorted cherry
- Process the sorted out lower grade cherry (under ripes, over ripes and greens) by the dry method as Buni

Pulping and pre-grading
- Pulping involves the removal of the outer red skin (pulp) of the cherry
- The pulping machine used should be clean, in good mechanical order and well-adjusted depending on the size of beans
- Control the cherry feed rate to avoid overfeed that may cause too much pulp in the parchment
• Pulping should be done on the same day of cherry harvesting
• Processing water must be clean, free from colour and odours
• During pulping, pre-grade coffee parchment into heavy and light beans
• Re-circulate processing water to enhance subsequent fermentation. Dispose off the re-circulated water every day after pulping
• Flush the pulping system with clean water immediately after pulping

Fermentation and intermediate washing
• This is done to break down the mucilage into simple non sticky substances which are easily washed off from the coffee beans
• Mucilage attracts dust, taints coffee, inhibits drying and is a media of mould growth, all of which affect bean quality. Its removal is therefore important for drying
• Place the different grades of parchment in separate fermentation tanks. The tanks should be shaded to protect the parchment from direct sunlight and rainfall
• The depth of parchment in fermentation tanks should not exceed 1 metre
• Drain all water and leave the parchment for at least 16 hours (depending on the weather conditions and whether re-circulated water is used or not). Undertake intermediate washing (after about 16 hours or so), then 4 to 6 hours of further dry fermentation if necessary
• Fermentation is complete when parchment feels gritty and is no longer slippery upon pressing between fingers. To test, put some fermented parchment in a bowl, add enough water, wash and check for grittiness
• Always ensure that the fermentation tanks are free from cracks and are well painted with appropriate paints which are acid resistant and compliant to health standards

Final washing and grading of parchment
• Once fermentation is complete, fill the tank with clean water, stir vigorously with paddles, drain off the water and repeat several times to assist in detaching the mucilage from the parchment
• Wash the parchment thoroughly on well painted concrete channels using clean water and rubber paddles/squeezers
• Push the parchment against a stream of water to clean and grade it into parchment 1, 2, 3 and lights (PL)
• Take Parchment 3 and lights to the skin drying tables
• Put parchment 1 and 2 under water in separate soak tanks overnight. Thereafter, wash and take the parchment to the skin drying tables
• If the drying tables are inadequate, one may soak for longer periods, changing the water daily but usually not more than 7 days

Parchment drying
Skin drying of parchment (55 – 45% MC)

• This is the removal of surface water and that between the parchment hull and the bean. It should be executed within the shortest time possible (2-3 hrs in a normal day). Parchment should not be left on the skin drying tables overnight
• Maintain a parchment layer of approximately 1 inch for even drying
• Frequently stir the parchment to enhance water removal and prevent parchment cracking
• Mechanical drying is also recommended
• Sort out defective beans since they are easily distinguishable during this stage
• Transfer the parchment to the final drying beds when the skin of the parchment is free of surface moisture as well as beneath the hull
• Maintain drying tables in clean condition and absolutely flat for even drying
• Clear all leftover beans on the beds before placing new wet parchment

White stage (45-30% M.C)

• The beans are white when the parchment skin is removed
• Place the parchment on drying beds lined with sisaltex, hessian cloth, tilder/shade net maintaining a parchment depth of about 2.5 cm
• Practice slow and cool drying to avoid cracking
• Spread the parchment in a thin layer and stir regularly during the morning hours and in the evening
• Ideally, in the hot part of the day, a raised shade cover should be put in place to allow free air movement. Else, pile coffee into a ridge of about 4-5 inches deep along the centre of the table and stir regularly
• Finalise the sorting out of the damaged and defective beans
• In the evening and during rainy weather, cover the parchment with both hessian cloth and nylex
• Avoid dropping parchment on bare ground or on the grass. Any parchment collected should be put in the parchment light category
Soft black stage (30 -20% M.C)
- At this stage the beans are soft and translucent
- The parchment depth can be increased to about 5cm
- Expose the parchment to sunlight for a period of at least 2 days of actual sunshine (about 50hrs)
- Sun light is essential in the formation of the final bluish-green colour of the bean at this stage. Mechanical drying is not recommended

Medium black stage (20 -16% M.C)
- The beans are fairly dark and hard
- In case of congestion, temporary storage in ventilated bins is permitted
- Parchment can be dried rapidly without loss of quality and mechanical driers can be used

Hard black stage (16 -11% M.C)
- Fully hard beans and dark in colour
- Can be dried rapidly without loss of quality

Conditioning (11-10.5% M.C)
- This is normally done in ventilated stores or bins to even out moisture level
- The parchment is ready for storage when it has a moisture content of 11 to 10.5%. Use a well calibrated moisture meter to measure the moisture content in order to avoid over or under-drying
The semi-washed processing method

- This process combines pulping and mechanical removal of mucilage by friction or attrition in one operation by use of eco-pulpers
- The mucilage is removed immediately after pulping using a demucilager
- Wash off any mucilage mixed with the parchment and soak the parchment under water overnight to improve the quality of the beans
- Grading can be done before the soaking to separate the different parchment grades. Soak P1. P2 can also be soaked if space allows

Processing at small and medium estate farms

- In small and medium estate farms hand and motorized pulpers can be used for pulping
- Fermentation can be done in hard plastic containers. Fill the parchment up to ¾ depth to enable intermediate washing and final washing.
- The pulping yields mixed grades of parchment. After the fermentation, grading can be done if the farmer has grading channels. Soak P1 and P2 under water overnight before drying. Else, soak the whole lot.
Storage of parchment

- Store bulk coffee in well ventilated bins or on wooden floors and stir regularly
- Place coffee bags on wooden pallets 15cm from walls and floors
- The coffee store must be well ventilated and corrugated iron sheet roof adequately insulated to minimize heat transfer
- Avoid storing coffee parchment in the same store with buni
- Avoid pro-longed storage as this leads to quality loss. Over stored parchment becomes “woody” after six months of normal storage in the factory
- In the event that sorting was not adequately done during the skin drying and white stage, it is important to sort the coffee before bagging and final delivery to the mills

N/B
Avoid the use of herbicides as a means of weed control at the wet mills
Important considerations in coffee processing
- Fermentation tanks should be roofed to avoid direct sun
- Clean water can be harvested from the roofs during the rainy season and used for soaking P1 and P2
- Store the water used in final washing for pulping cherry the same day
- In cool, dull weather concentrates on drying the wettest coffee
- Nearly dry coffee (Medium black stage) can be placed in store to give space for wet coffee. Do not forget to take out this coffee when drying conditions improve
- Always wash your hands before handling the coffee
- Do not allow animals in the coffee processing area to avoid off-flavours

Factory Hygiene and maintenance
- All the factory operators, equipment and materials must be clean
- The recommended maintenance procedures e.g. painting, repair of channels and cherry hoppers should be strictly adhered to.
- Wash the pulper immediately after pulping
- Ensure no berries are left out from previous days pulping on the processing lines to avoid formation of stinkers
- Clean the stores at the beginning of the season – remove dirt and old parchment
- Do not store any chemicals or fuels in a coffee store. Coffee beans can absorb odours thus affecting quality negatively

Coffee waste management
- Channel the waste water to the seepage/soak pits which should be located away from water bodies
- Minimize water usage by re-circulating pulping water and using the final grading water for pulping
- Remove the sludge from the bottom and sides of the seepage pits annually
- Pulp and waste water should not be left to flow to water bodies
- The pulp should be composted and used in farms. Alternatively, the pulp can be used to produce bio-gas
Buni drying (dry processing)

- Although wet processing is the most common practice in Kenya, dry processing is done for overripe, under ripe, stripping and in situations where wet processing facilities are not available.
- Start drying cherry on a clean and well drained surface after harvesting. E.g. on a concrete surface.
- Dry buni on raised surfaces or drying tables and cover with rain proof materials when there is rain to avoid re-wetting. This prevents mould growth.
- Avoid mixing freshly picked or sorted out cherry with the drying ones. Each batch of buni should be dried separately to avoid mixed drying.
- Ensure buni is properly dried to a moisture content of 12%.
## Common errors on pulper settings and their remedies

<table>
<thead>
<tr>
<th>Error</th>
<th>Causes</th>
<th>Remedies</th>
</tr>
</thead>
</table>
| Unpulped cherry passing through the pulper / repasser | Knives / Plough too far from the disc  
Too small beans                                        | Adjust plough closer  
Proper sorting                                            |
| Nipping of beans                           | Knives / plough too close to disc  
Under-ripes, over-ripes                                 | Adjust the plough / knife wider  
(a used hacksaw blade size)  
Check and replace bearings                               |
| Whole cherry lost with pulp                 | Knife set too far from the disc                               | Adjust knife setting as above                          |
| Excess pulp in pulped coffee               | Worn out disc surfaces  
Too high cherry feed rate into pulper                      | Re-spray discs  
Reduce feed rate                                             |
| Intermittent ringing sound coming from pulper | Knives set too close to Loose disc shaft  
Cover plates touching disc  
Hard object trapped between disc and plough disc           | Reset Knives correctly  
Check shaft bearings  
Correct by adjusting  
Remove the object                                           |
Secondary Coffee Processing, Quality Assessment and Marketing

After the primary processing, the next step in the coffee value chain is secondary processing as a preparation for marketing of coffee. Quality assessment precedes determination of price.

Secondary processing

Secondary coffee processing entails parchment milling, grading and classification of clean coffee. Prior to delivery of coffee for milling, a grower should ensure that a signed milling agreement has been registered at the coffee directorate. The milling agreement should clearly indicate what the parties have negotiated and agreed on, in terms of milling charges and other charges associated with milling process.

Preparations

- Booking Slip
  - This is a document obtained from the mill confirming the date of intended coffee delivery
- Movement Permit
  - This is a document issued by the Coffee Directorate authorizing coffee movement within a specified time as specified in the booking slip. It is a must for this document to be issued before any coffee deliveries are made
- Bagging
  - Before bagging, the parchment should be confirmed dry. This enables the husk to be removed more easily
  - Use clean, odor free sisal or jute bags for coffee
  - Avoid using bags that have been used for chemicals or for animal feed
- Weighing
  - Weigh the parchment using a calibrated weighing machine before delivery
  - Take into account the weight of the empty bag
- Grower delivery notes
  - This document details the type and quantity of parchment to be transported to the mill by a vehicle at a time.
  - It is filled in duplicate at the farm/factory before transportation - one copy to the mills while the other remains at the farm/factory.

Transportation

- The vehicle must be visibly clean, dry and free of odours before loading
- Ensure there is a good tarpaulin to cover the parchment against rain and dust.
- The body of the vehicle to be used for parchment transportation should not have protrusions that may cause bag damage resulting in spillage
- Sisal or jute bags are recommended for maintenance of quality
• Insurance cover is important to consider while coffee is on transit

Weighbridge tickets
• When a vehicle transporting coffee arrives at the mill it is weighed before proceeding to the off-loading bay. A second reading is taken when the vehicle has been off-loaded. The empty parchment delivery bags are weighed separately

Sampling
• At the off-loading bay, a sample (1 kg) is taken from different bags to determine the pre-milling conditions of the coffee including the moisture content (MC)
• The ideal final moisture content is 10.5-11%. Moisture content lower than 10.5% leads to loss of weight. If the moisture content is higher than 11%, the parchment will undergo further drying by either the miller at a cost or taken back by the grower for further drying. After drying, the coffee is re-weighed to establish the final weight of the coffee delivered by the grower
• Upon confirmation that the MC is conducive for milling, the consignment is weighed and entered into the tracking system of the mill by being assigned a unique identification number called an outturn number
• Based on the pre-milling analysis, a milling order is given considering a millable lot of 50 bags of parchment. Below the millable lot, coffee is bulked based on its cup profile and green bean analysis.

Pre-cleaning
• This is done to protect the equipment and ensure a clean product is obtained. It entails the removal of all foreign objects such as stones, nails, hair, etc

Milling
• Milling involves hulling, polishing and sorting of defects. Hulling is the removal of husk while polishing is the removal of silver skin from the clean/green bean surface. Milling yields a mixture of beans of various sizes, shapes and density
Grading

- Grading is the mechanical separation of clean coffee beans into different grades depending on size, shape and density. It's done to facilitate trade and roasting.

- Kenya coffee is graded into seven categories by use of mechanically agitated sieve graders as follows:
  
  - E: Normally referred to as elephant grade. It is rare and only appears in very small quantities. It is retained in screen size 21.
  - AA: Flat beans, retained on screen number 18 with an aperture diameter 7.2mm.
  - AB: Flat beans, retained on screen number 16 with an aperture diameter of 6.3mm.
  - TT: These are beans extracted from AA and AB grades by density.
  - Pb: Pea shaped beans.
  - C: Small flat beans retained on screen number 10.
  - T: Smallest grade consisting mainly of broken fragments pass through screen number 10.

- Others include:
  
  - HE: Broken hulled ears from grade E.
  - UG1 and UG2: ungraded coffee comes from P3 and PL coffee.
  - MH & ML: from Buni hulling.
**Storage/warehousing**

- Coffee Warehouse means any building, structure or other protected enclosure duly licensed by the relevant authority to be used for the storage or conditioning of coffee for the purposes of trading at the Exchange.
- It is specifically designed to ensure that the quantity, quality and safety of the coffee is maintained. Good storage should ensure that the commercial value is maintained for as long as possible.
- The clean coffee is bagged into 61.2kg per bag. Bags are stacked on wooden pallets 0.5ft above ground level and 0.5ft away from the walls. Maximum care is taken to make sure that the coffee does not absorb moisture. This storage is done for a maximum of 6 months.
- Warehouses store coffee on behalf of the marketing agents and play the role of coffee warrants preparation - legal titles of coffee under their custody.
- Clean coffee is stored in the warehouse depending on the grade.

**Quality assessment**

Coffee classification in Kenya is done through cupping (liquoring). Cupping is a method used to systematically evaluate the aroma and the taste characteristics of coffee through taste sense (organoleptic method). This is the Devonshire method of classification.

**Attributes considered in quality assessment**

In a coffee sample, several attributes are considered in order to determine the overall quality. These are;

- The raw bean quality – the size of the beans, the color and the defects
  - The size of bean is determined by the feeding regime
- Color ranges from bluish green to brown. It depends on geographical origin, age, processing, storage conditions and maturity of cherry at harvest.

- The quality of the roast - The type of roast, the center cut and defects present. Good quality beans have a white center cut.

- The cup quality - Acidity, body, flavor, off-flavors
  - Acidity - Pleasing brightness or sharpness of coffee like for lemons, limes and orange. Acidity can be intense or mild.
  - Body - The sense of weight or heaviness that coffee exerts in the mouth.
  - Flavor - The simultaneous sensation in the palate of aroma and taste. Good flavors includes:
    - Fine - coffee with distinct quality characteristics e.g. acidity body and flavor
    - Pointed - fine acid sharpness
    - Sweet - a nice clean soft coffee free of any harshness
  - Off-flavors - defect transmitted to taste properties of flavor. This constitutes the poor cup quality as a result of poor processing and husbandry practices. They include:
    - Coarse - coffee lacking fineness
    - Flat - lifeless coffee lacking in any acidity
    - Fruity - strong overripe taste prevalent in beans left too long in the cherry
    - Grassy - greenish flavor prevalent in coffee harvested when premature
    - Sour - a sharp excessively acidic biting flavor
    - Thin - flat lifeless coffee lacking in body or acidity
    - Woody - hard wood like flavor found in old coffee which has been stored for too long.
    - Onion flavor - delayed skin drying
    - Potato flavour - Antestia and berry borers damaged beans
    - Musty - beans stored in wet places
    - Earthy - wet earth flavor - coffee that had contact with the soil

**Quality descriptors**

Several descriptors are used in determination of quality. These are;

- Raw beans
Coffee liquoring procedure

- Coffee liquoring is done by roasting about 100 to 300 g of clean coffee sample using a standard roaster to medium brown and allowed to cool for about 5 minutes before grinding to medium size particles.

- About 10gm of ground coffee is placed in the cup, smelled and aroma noted.

- Boiling water is then added to coffee in the cup and smelled again to note the aroma emanating from the cup while stirring gently.

- Ground coffee particles are skimmed from the surface of the beverage and the froth discarded.

- To perceive the taste, one makes a rapid seep of the liquor so that it spreads over the whole tongue uniformly.
During tasting, the back of the tongue detects bitterness, the sides detect the sour and saltiness taste while the front detects the sweetness.

**Roaster**

**Human tongue**

**Coffee defects**

- Amber beans which have yellowish appearance and usually due to iron deficiency.
- Antestia damaged beans which have zebra stripes on the parchment when dried.
- Black beans which have the surface and the interior partly black, which may arise from faulty drying or poor storage.
- Diseased beans which arise from infections particularly from coffee berry disease and other fungal infection in the farm or storage.
- Faded coffee which has whitish pale appearance due to mould growth on the surface. This defect occurs when under dried coffee above 11% moisture content is stored in humid conditions.
- Foxy beans that have a brownish silver skin that results from wet processing of over ripe cherry.
- Green water damaged beans that have a dark seaweed colour with brown and partly black patches. They appear shrunken and small in size. They arise from beans exposed to prolonged moisture in the drying stage. It's a pre-condition stage for the black beans development.
- Stinkers - beans from previous lots which were left on the sorting yard, pulper, fermentation tanks, washing channels or pulping area.
- Onion flavor coffee that occur as a result of heaping coffee at skin drying stage or prolonged fermentation.
- Poor body that arise in coffee that lacks phosphorus in the soil.
- Pulper damaged is due to poor setting of pulpier discs, pulping of under ripe and diseased coffee
- Coated - beans are covered with too much silver skin results from drought or overbearing conditions
- Discolored - beans that came in contact with metal. To avoid this, paint all metal surfaces before season commences

**Defects originating from the farm**

Insect damaged beans

Amber beans

Pods
Defects originating from primary processing

<table>
<thead>
<tr>
<th>Defect</th>
<th>Causes</th>
<th>Remedies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ragged beans</td>
<td>Lack of Nitrogen / Phosphorus, drought, weeds, poor pruning, low pH</td>
<td>Proper nutrition, weeding, pruning, water management and pH correction</td>
</tr>
<tr>
<td>Pods</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Foxy beans</td>
<td>Delayed harvesting/pulping</td>
<td>Timely harvesting and pulping</td>
</tr>
<tr>
<td>Diseased beans</td>
<td>Brown Blight (late CBD attack)</td>
<td>CBD control</td>
</tr>
<tr>
<td>Insect damage</td>
<td>Berry borer attack, etc.</td>
<td>Manage insect pests</td>
</tr>
<tr>
<td>Damage Type</td>
<td>Cause/Issue</td>
<td>Control Measures</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
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<tr>
<td>Antestia damage</td>
<td>Antestia attack</td>
<td>Control Antestia bugs</td>
</tr>
<tr>
<td>Pulper damage</td>
<td>Poor setting of pulper discs</td>
<td>Proper setting of pulpers</td>
</tr>
<tr>
<td>Amber beans – causes pales in a</td>
<td>Iron deficiency</td>
<td>Correct soil pH and spray iron sulphate</td>
</tr>
<tr>
<td>roast (Quakers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over-fermented beans</td>
<td>Prolonged fermentation</td>
<td>Use the “gritty feel” principle to determine when fermentation is complete</td>
</tr>
<tr>
<td>Stinkers</td>
<td>Severe over fermentation, Old beans mixing with fresh coffee</td>
<td>Ensure no beans are left in fermentation tanks, soak tanks channels, or drying beds</td>
</tr>
<tr>
<td>Green-water damage</td>
<td>Rewetting</td>
<td>Shelter drying coffee from rain and dew</td>
</tr>
<tr>
<td>Black beans</td>
<td>Severe Rewetting</td>
<td></td>
</tr>
<tr>
<td>Onion flavour</td>
<td>Prolonged fermentation</td>
<td>Use the “gritty feel” principle and maintain a parchment</td>
</tr>
<tr>
<td></td>
<td>Delayed skin drying due to heaping of coffee at skin drying stage</td>
<td>Place coffee at a depth of approx. 2.5 cm and stir constantly</td>
</tr>
<tr>
<td>Potato flavour</td>
<td>Insect damage - Antestia damage</td>
<td>Sort coffee at skin drying or white stage</td>
</tr>
<tr>
<td>Earthy flavour</td>
<td>Coffee coming into contact with soil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over-ripe cherry</td>
<td>- Sort coffee on canvas or nylex</td>
</tr>
<tr>
<td></td>
<td>Over fermentation</td>
<td>- Avoid dropping coffee on the ground while harvesting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Pulp coffee picked from the ground separately</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cover coffee during transportation to avoid dust</td>
</tr>
<tr>
<td>Fruity</td>
<td>Over-ripe cherry</td>
<td>Process over-ripes separately</td>
</tr>
<tr>
<td></td>
<td>Over fermentation</td>
<td>Monitor fermentation</td>
</tr>
<tr>
<td>Musty flavour</td>
<td>Heaping under dried coffee and rewetting</td>
<td>Maintain proper parchment depth during drying and avoid rewetting</td>
</tr>
<tr>
<td>Woody flavour</td>
<td>Prolonged storage</td>
<td>Deliver coffee to the mills immediately after drying</td>
</tr>
<tr>
<td>Poor body</td>
<td>Lack of phosphorus in the soil</td>
<td>Soil analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Application of Phosphorous</td>
</tr>
<tr>
<td>Grassy - greenish flavor</td>
<td>prevalent in coffee harvested when not fully ripe</td>
<td>Harvest only red ripe cherry</td>
</tr>
<tr>
<td>Softs</td>
<td>Under drying of coffee</td>
<td>Dry coffee to correct moisture content</td>
</tr>
<tr>
<td></td>
<td>Pops during roasting</td>
<td></td>
</tr>
</tbody>
</table>
Coffee marketing

There are two coffee marketing channels in Kenya - direct sales and the auction system at the Nairobi Coffee Exchange (NCE). Participants at the two marketing channels are the commercial coffee marketing agents, coffee dealers/traders and the growers.

Appointment of marketing agents

- This is a requirement under the Crops Act and should be done before the beginning of the season. The marketing contract is distinct from the Milling contract.
- Some of the key considerations in choosing a marketing agent are fees and services offered such as market access, production support, whether certified or not etc.

Reserve prices

- Set by Marketing Agents in consultation with the grower.
- Referenced on prevailing prices at the New York Coffee Exchange.
- Based on the qualities of coffee on offer.

Sale of noted coffees

- Noted coffees are those coffees whose final bid price is below the reserve price.
- The rules allow for the marketing agents to revert to the final bidder and negotiate an a price or Re-offer the coffee in a space of 2 auctions after the 1st offer.

Direct sales

- Should be facilitated by the appointed Marketing Agent.
- Requirements:
  - A valid sales contract should exist.
  - The prices should be higher than the prevailing NCE (Auction) average.
  - Must be registered with Coffee Board of Kenya.

Kenya Coffee mark of origin
To enhance the visibility of Kenya’s coffee in the world, the G.o.K through the Coffee Directorate developed the Kenya coffee mark of origin to be used for promotion of Kenya Coffee locally and internationally. Its tagline is “so Rich, so Kenyan”

- The Mark is awarded to coffee products that
  fulfil the specific standards as prescribed by
  Agriculture and Food Directorate.
- Stakeholders who wish to brand their coffee with this mark must meet the following minimum requirements:
  - They must have a valid registration by the Authority
  - The coffee must be 100% of Kenyan origin as demonstrated by the firm and verified by the Authority or its appointed agents
  - The coffee must be manufactured and packaged in accordance with coffee industry code of practice, KS 2366:2013
  - The coffee complies with other regulatory, as well as statutory requirements which are covered by other monitoring mechanisms

Sustainable Coffee Production
Sustainable coffee farming refers to the growing of coffee in a way that does not jeopardise the future generations’ ability to derive similar benefits. It is a system of farming that ensures high yields and quality, meets consumer demands, conserves the environment by avoiding environmental pollution, gives better returns to farmers and guarantees food security through crop diversification. It employs practices such as minimizing water usage, preventing processing effluent from returning to rivers, planting shade trees in coffee and avoiding cutting of trees and charcoal burning.

Dimensions of sustainability in coffee farming
Sustainability has three pillars (dimensions)
- Environmental - taking care of the environment where coffee is grown
- Social - Taking care of the people or the humanity within and around the coffee farms
- Economic - Economic accountability/prudent management of finances
Environmental pillar
Aspects of the environment that are impacted upon by coffee producers include Flora, Fauna, Wildlife, Soil, Air and Water. Various activities at the farm level might impact negatively on the environment and need to be addressed. For example, lack of soil conservation measures leads to loss of soil and water through surface run off.

Environmental sustainability entails
- Protection of water sources
- Conservation of soil
- Protection of biodiversity
- On farm energy conservation
- Environmental management

Protection of water sources
Sources of water include rivers, springs, boreholes, lakes and wetlands. To protect these sources;
- Do not interfere with the natural vegetation within at least 10m on both sides of the water resources e.g. alongside a river measured from the highest water mark level. This avoids contamination through soil sedimentation fertilizers, chemicals and wastes residues
- Recycle farm waste e.g. by composting
- Take water samples of the river, borehole etc for chemical analysis regularly
- Minimize water consumption. Do not extract more water than needed
- Dump waste at least 100 metres away from water sources in seepage pits
- Do not apply agrochemicals within 10 metres of any water body i.e. rivers, springs
- Rinse the pesticide containers thrice and puncture before disposal
- Protect stream crossings with bridges, culverts, etc
Conservation of soil
Soil erosion results in the loss of productive top soil and introduces contamination into nearby water bodies. Erosion results from high rainfall on sloppy land devoid of soil conservation measures. Decline in the organic matter content and earth mineral base saturations also has major contribution to increase in the soil erosivity

- **Soil erosion can be controlled by:**
  - Undertaking bench terracing where the land has a slope of more than 5% and planting stabilizing grass on the face of the terraces such as blue grass (Makarikariensis sp)
  - At lower gradients, other soil conservation measures can be undertaken e.g. mulching, contour planting, planting cover crops and grass strips and conservation tillage (tilling after 2 – 3 years)
  - Water conservation measures include recycling of water used in coffee processing, harvesting of roof water, harvesting of run-off water, use of eco-pulpers in coffee processing and construction of weirs and dams
  - Use of shade trees to accumulate litter that improves soil structure
  - Provision of drainage along the roads and planting grass on the edges to reduce water runoff
  - Avoiding cultivation on slopes of more than 60%. Instead, plant grass or woodlots. Else, establish spaced strips of grass or woodlots along the contour to interrupt water runoff
  - Slashing weeds at ground level in extreme wet weather instead of tilling
  - Planting grass along waterways and gulleys to slow down run-off and eventually fill up the gulleys

- **Maintenance of soil productivity - can be done by:**
  - Accumulating pruning biomass as trash lines which will eventually decompose to raise soil fertility
- Planting appropriate leguminous shade trees which fix nitrogen. e.g. the tall Pigeon pea, Cordia absynica, Grevillea spp, Leucaena spp, Albizia spp etc
- Reducing fertilizer use gradually as you step up the frequency of applying organic manure and mulch
- Taking soil samples for analysis every two to three years
- Using appropriate fertilizer recommendations

Bench terrace planted with grass to control soil erosion on sloppy land

**Protecting biodiversity**
Biodiversity (biological diversity) is a variety of fauna and flora in a particular habitat. To maintain and promote that natural biodiversity and the ecosystem within and adjacent to coffee production areas;

- Develop agro-ecosystems that will eventually mature to naturally maintain pests, pathogens and weeds at equilibrium levels. e.g. avoid indiscriminate use of insecticides, using IPM and raising the levels of K in the soil
- Maintain the indigenous trees as shade trees within the coffee farm - avoid cutting of indigenous trees
- Plant shade trees e.g. Grevillia, Albizia, Sesbania Sesban etc
- Support natural wildlife by preventing hunting through erecting barriers, placing signs and patrolling the farm
- Knowledge of the species of wildlife within the area should be consolidated by sound biodiversity practices.
- Maintain an inventory of the wildlife in the area
- Special attention should be directed towards endangered species to ensure that there is no extinction
- Dedicate a portion of the farm for maintaining indigenous vegetation e.g. an indigenous woodlot

**13.3.4 On-farm energy conservation**
This is the reduction in the amount of energy consumed in a process, system, organization or society through economy, elimination of wastage and rational use. This can be achieved by conserving electric and fossil energy, utilizing renewable energy and use of energy conserving technologies.

- **Conserving electric and fossil energy**
  - Use sun drying instead of mechanical driers
  - Ensure irrigation systems are efficient by keeping irrigation engines well serviced and tuned
  - Replace old large motors with high efficient smaller ones to reduce energy consumption
  - Install motion detectors to control security lights so as to keep them off most of the time
  - Use energy saving bulbs
  - Maintain trucks and tractors properly

- **Use of renewable Energy**
  - This is energy generated from replenishable natural resources including sunlight, wind, rain, geothermal and biogas
  - Farmers can develop renewable energy for their use by installing biogas, solar and wind systems, and growing/converting biofuel crops for farming operations e.g. oilseed
  - Utilize coffee husks to make charcoal briquettes

- **Energy conserving technologies**
  - Energy conserving jikos – jiko koa, clay lined jikos, kuni moja e.t.c
  - Fireless cookers
  - Install biogas systems as an alternative to fossil energy

**Environmental management practices**
- Use the integrated pest management programme to manage insect pests
- Record pests and diseases incidences noted on the farm
- Apply pesticides on sport basis on the infested areas only
- Keep a record of agrochemicals used on the farm i.e. date, product and quantity applied
- Keep agrochemicals in a safe place and avoid possibility of spillage
- Test the representative soil samples for the essential nutrients
- Ensure the chemical stores are secure and able to avoid accidental spillage
- Train farmers on biological and cultural methods of managing insect pests, weeds and diseases
- No burning of wastes or uncontrolled dumping in the open
Environmentally friendly primary processing practices

- Install a water recirculation system to minimize water use
- Monitor water usage by use of water meters
- Compost pulp for use in coffee farms
- Dispose water in soak pits
- Plant bamboo trees around the soak pits to help dissipate the waste water in a clean biological manner

Social pillar
This refers to the social aspects touching on workers welfare including wages, working hours, housing, provision of clean portable water and sanitary facilities
There is need for a structured and documented policy on child labour, safety at work, discrimination, gender equality, sexual harassment and worker’s rights. Social sustainability entails appropriate practices in:
- Hiring and employment
- Workers conditions
- Safety in work place

Hiring and employment - This practice ensures:
- No discrimination during hiring and workers are provided with working contracts
- Workers are paid at least the minimum recommended by the Kenyan labour laws or the Collective Bargain Agreement (CBA)
- Workers are regularly paid as agreed upon hiring
- Working hours do not exceed the limit stipulated in the national labours laws or ILO
- Workers are paid accurately for worked overtime as provided for by the law
- Overtime should be voluntary and must be compensated as per the national labour laws or ILO, whichever is stricter.
- No employment of persons less than 18 years of age - no children are hired
• Employees have access to records of their earnings
• No sexual harassment
• Workers are free to be union members
• No financial disciplinary measures are imposed on employees
• Permanent employees are allowed sick-offs
• No use of forced labour

Workers conditions - This entails:
• Encouraging education of children and workers
• Having a care plan in case of sickness
• Providing workers with clean drinking water
• Having separate toilets for both men and women adequate for the population use

Safety at work place
It’s important to ensure:
• All moving parts of machines have safety guards
• Protective clothing and gear are provided and used appropriately e.g. masks, gloves, goggles, gumboots
• Workers are trained on safety issues in the workplace
• Farms have occupational health and safety programs to reduce the risk of accidents
• Pregnant women are not being exposed to handling, moving or applying chemicals
• Availability of fire extinguishers in the factories
• The building structures are user friendly with high enough roofs to ensure safety of workers
• Medical check-ups to be carried out on people who handle agrochemicals.

Economic pillar
• This refers to transparency in financial activities such as purchasing commodities at prudent prices, avoiding unnecessary expenses, equity in the distribution of income realized among others
Financial viability- is it a financially sustainable venture/society

Food security
Food security is a situation where all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets the dietary needs and food preferences for an active and healthy life.

Kenya’s long-term goal of food self-sufficiency (producing everything consumed in the country) remains unmet.

Measures for ensuring food security in coffee growing areas
- Intercropping
- Diversification

Intercropping of food crops in coffee
- To increase the level of proteins, vitamins and minerals in the diets, coffee farmers are advised to intercrop coffee with suitable crops. Such crops are early maturing, non-climbing and not alternate host to coffee diseases and pests.
- These includes legumes e.g. beans, pigeon peas, cow peas, dolichos (njahi) and green grams (ndengu) as well as onions and Irish potatoes
- This can be done at specific stages of coffee production cycle to increase economic benefits without affecting yields and quality.
- The stages are: during establishment of coffee, during change of cycle by clean stumping and when the coffee is under rehabilitation.

Diversification in coffee farming
- This is a system of farming that encompasses several concurrent enterprises aimed at spreading risks, increasing income and enhancing food security at the household level.
- On separate fields, plant fruits such as guava, paw paws and tree tomatoes that are rich in vitamins. Local vegetables e.g. pumpkins, amaranth (terere) and black night shade (managu) are good food security and nutrition crops as they are rich in vitamin C and iron. They grow fast and can be planted in small plots that satisfy the family’s food needs.

- Diversification can also entail:
  - Producing Horticultural crops for the domestic and export market. Coffee growing areas are well suited for production of a wide range of horticultural crops. Farmers can plant horticultural crops in separate portions of land
  - Livestock farming - indigenous cows can be bred with exotic breeds to improve milk yields
  - Fish farming (Aquaculture) - Farmers in areas with streams or rivers can utilize the water to create fish ponds. Fingerings can be obtained from various fishery departments e.g. at Sagana.
- Bee keeping (Apiculture)
- Poultry farming