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

“Changing Farmers’ Mindset from “Grow and Sell” to ”Grow to Sell””

BANANA PRODUCTION

Prepared by SHEP PLUS
To provide basic information on production, post-harvest handling, and marketing of Bananas

Specific Objective:

- To provide basic information on production, post-harvest handling, and marketing of Bananas

Contents:

1. Introduction: Background, Common Varieties and Optimal Ecological Requirements
2. Pre-Cultivation Preparation 1 – 4
3. Cultural Practices 1- 7
4. Harvest
5. Post-Harvest Handling
6. Cost & Income Analysis
7. Post-Training Evaluation Exercise

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Disclaimer

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The cited agrochemicals are in accordance with “Pest Control Product Registered for Use in Kenya 11th Edition, 2018”. The registered agrochemicals are subject to change. Please refer to the latest registered agrochemicals by Pest Control Products Board.
1. Introduction:

1.1 Background

[Image: Banana (Ndizi)]
1. Introduction:  
1.1 Background  

- Banana is mainly cultivated for its fruit which can either be eaten ripe (dessert) or cooked.  
- The ripe fruit is a good source of vitamins A, B₆, C and potassium, while cooked one is rich in carbohydrates.  
- Can also be processed into flour, canned slices, jam, jelly, puree, vinegar, wine and beer.  
- The popularity of the crop makes it a good cash crop for smallholder farmers.  
- The foliage and pseudo-stems are used as cattle feed during drought.  
- The banana leaves are also used as packing and roofing material.

Banana (Ndizi)
1.2 Common Varieties

“Giant Cavendish”

“Chinese Dwarf”
1.2 Common Varieties

**“Giant Cavendish”**
- A tall variety
- Resistant to fusarium wilt (Panama Disease)
- Susceptible to Black Sigatoka Disease
- Has a strong pseudo-stem
- The plant requires propping

**“Chinese Dwarf”**
- A short variety
- The plant does not require propping
- Grow in areas with altitude as high as 2,100 m
- Resistant to fusarium wilt (Panama Disease)
- Susceptible to “Cigar-end Rot” and Black Sigatoka
1.2 Common Varieties Cont’

“Grand Naine”

“Williams Hybrid”

Photos: SHEP PLUS
1.2 Some Common Varieties Cont’

“Grand Nain”
- A cultivar of Cavendish type
- Tolerant to environmental stress
- Produces good quality bunches with fruits which are uniformly yellow in color
- Mature fruits have good shelf life
- Requires propping

“Williams Hybrid”
- Produces large bunches with fruits which have excellent flavor, aroma, and taste when ripe
- Ripe fruits have short shelf life

“Valery”
- A tall variety and has good taste
- Strong pseudo-stem

FHIA Hybrids: “FHIA-17, 18, 23, 25”
- Varieties which have been developed by International Institute of Tropical Agriculture
- Resistant to “Black Sigatoka”
- Used for cooking and dessert
- Produce heavy bunches with an average weight of 50 kg
- The plants require support to prevent lodging

Other varieties include:
- Ngombe, Lacatan, Apple (Sweet), Gross Michel, Poyo, Kisii Matoke, Muraru, Sweet/ Sukari, Bogoya, Kampala, Kisigame, Manyoke, Kiganda & Mutahato
### 1.3 Optimal Ecological Requirements

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<td><strong>Altitude</strong></td>
<td>0-1,800 metres above sea level</td>
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<tr>
<td><strong>Rainfall</strong></td>
<td>1,000 – 2,000 mm of rainfall annually</td>
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<td><strong>Growing Temperature</strong></td>
<td>20 – 30 °C</td>
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<td><strong>Soils</strong></td>
<td>• Deep well drained soils</td>
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1.3 Optimal Ecological Requirements

Banana is one of the most grown crops in Kenya. The followings are the optimal ecological requirements.

- **Altitude:** Hot and humid conditions are ideal. These conditions are found in altitudes between 0 and 1,800 m above sea level.
- **Rainfall:** 1,000 – 2,000 mm/year is required. To achieve good yields, 200 – 220 mm/month, well distributed throughout the year.
- **Temperature:** Optimal temperature for growth is about 27 °C.
- **Soil:** Deep friable loam soils rich in organic matter with pH range of 6.0 – 7.5.
- **Wind:** Bananas are sensitive to strong wind which causes tearing of leaves and lodging of plants hence need for protection from strong winds by establishing wind breaks.
2. G20 technologies

1. Market survey
2. Crop planting calendar
3. Soil testing
4. Composting
5. Use of quality planting materials
6. Recommended land preparation practices
7. Incorporating crop residues
8. Basal application of compost/manure
9. Recommended practices of seedling preparation/seedlings from registered nursery
## 2. G20 technologies

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**G20 Technologies**
Make sure to support farmers carry out G20 techniques for any crop
2. G20 technologies

10. Recommended spacing
11. Recommended fertilizer application rate
12. Supplementing water
13. Timely weeding
14. Top-dressing
15. IPM practices
16. Safe and effective use of pesticides
17. Use of harvesting indices
18. Appropriate post harvest handling containers
19. Value addition techniques
20. Keeping farm records
2. G20 technologies

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**[G20 Technologies]**
Make sure to support farmers carry out G20 techniques for any crop
2.1 Quality Planting Materials

Tissue Culture
banana seedlings

Sword suckers
2.1 Quality Planting Materials

2.4 Quality Planting Materials (GHCP&PHHT20: Q5)

- Bananas in Kenya are propagated vegetatively using tissue culture and sword suckers.

- **Tissue Culture**: these are normally disease & pest-free plantlets that are multiplied under controlled conditions (laboratories) before being transferred to nurseries for hardening before sale.

- **Sword Suckers**: the commonly used method by most smallholder farmers (Hot water treatment before planting).
2.1.1 Tissue Culture Seedlings

Tissue culture hardening nursery

Tissue culture banana seedlings ready for transplanting
2.1.1 Tissue Culture Seedlings

Tissue culture hardening nursery

Tissue culture banana seedlings ready for transplanting

2.4.1 Tissue Culture Seedlings

- The planting material should be sourced from registered nurseries that are known to sell Tissue Culture seedlings e.g. KALRO, JKUAT & some private companies, such as Genetic Technologies, Africa Harvest Biotech Foundation & Aberdare Technologies Ltd.

- Advantages of using tissue culture seedling are the elimination of risks of pests & diseases, production of uniform banana crop and higher yields.
2.1.2 Sword Suckers

Banana sword suckers
2.1.2 Sword Suckers

Most farmers use sword suckers obtained from own farm or from neighbors to extend existing or establish new banana orchards.

The common farmer practice of using infected sword suckers has continuously perpetuated the spread of banana diseases and pests.

To mitigate this problem, suckers need to be disinfected before planting.

2.4.2 Sword Suckers

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- To mitigate this problem, suckers need to be disinfected before planting.
2.1.3 Suckers Disinfection through Hot Water Treatment

Sword suckers

Disinfection of Banana Suckers

Photos: SHEP PLUS
2.1.3 Suckers Disinfection through Hot Water Treatment

In the absence of Tissue Culture banana seedlings, sword suckers can be used as the propagation material. Sword suckers are shoots with narrow leaves with height of about 1 m and 15 cm diameter at the base. Sword suckers are sourced from existing banana orchards therefore it is necessary to treat the suckers with hot water to eliminate nematodes & banana weevils. This process involves the following:

1. Trimming of all the roots
2. Cutting off 1 cm of tissue around the corm until you get clean white tissue
3. Prepare hot water
4. Immerse the trimmed corm in the hot water bath at 50 – 55 °C for 20 minutes

Note: In farm situation where there is no thermometer, the suckers can be dipped in boiling water for 0.5 minute (30 seconds).
3. Cultural Practices:

3.1 Land Preparation

Weighing manure
3. Cultural Practices:
3.1 Land Preparation

3. Cultural Practices:
3.1 Land Preparation Practices (GHCP&PHHT20: Q6)

- Before planting, deep soil cultivation by ploughing & harrowing is recommended
- The field should be free of trees, bushes and especially perennial weeds
- A planting hole measuring 60 cm x 60 cm x 60 cm is recommended although this may vary depending on water availability
- In dry & semi-arid areas, it is recommended to use holes measuring 90 cm x 90 cm x 90 cm
- Bananas cannot withstand stagnant water hence soil should have good drainage

3.1.1 Recommended Spacing (GHCP&PHHT20: Q10)

- Short Varieties: 3 m x 3 m (444 plants/acre)
- Medium Varieties: 3 m x 4 m (333 plants/acre)
- Tall Varieties: 4 m x 4 m (250 plants/acre)

3.1.2 Fertilizer Application Method & Rates (GHCP&PHHT20: Q11)

- The top soil and sub soil should be kept separate
- Mix the top soil with 2-3 “debes” (about 20-30 kg) of well decomposed manure and 200 g of Triple Super Phosphate (TSP)
- Refill the hole with the top soil first followed by the sub soil
- Allow it to settle for at least 2 weeks before transplanting
3.2 Transplanting

Banana seedlings after transplanting
3.2 Transplanting

3.2.1 Appropriate Time

- Transplanting should be done when tissue culture seedlings are about **30 cm** and have produced **at least 5 healthy leaves**
- To ensure **good anchorage**, a sucker or seedling should be placed **30 cm** deep in the planting hole
- A **heavy cover of mulch** should be placed around each plant to conserve soil moisture
- Under rain fed conditions, planting should be carried out only at the **onset of the rains**
- However, if irrigation water is available, planting can be done throughout the year
3.3 Crop Management

3.3.1 De-suckering

Poorly managed banana stools

Well managed banana stools
3.3 Crop Management

3.3.1 De-suckering

- Process of removing unwanted suckers from one stool so that at any moment a stool has only 3 suckers:
  - One bearing sucker (mother plant)
  - One half-grown sucker (daughter plant)
  - One sprouting sucker (grand daughter plant)

- The surplus suckers are dug out with corm, and can be used as planting material

- In order to prevent sprouting: Insert a peg on the growing part

- The process should start 2 months after planting and be repeated every 45 days till the plant flowers

Poorly managed banana stools

Well managed banana stools
3.3.2 Propping

Propped up banana plants
3.3.2 Propping

It is the process of supporting banana plants which have mature or immature bunches to prevent them from lodging/ falling over.

A pole with a V-shape end is placed under the bunch to support it.

The prop should be placed carefully to avoid fruit injury.

The major varieties which require propping are: Grand Nain", Williams, Valery, Giant Cavendish, FHIA series etc.

Propped up banana plants
3.3.3 Trimming of Old Dried Leaves

Neglected stool with dried leaves

Well managed orchard without dried leaves
3.3.3 Trimming of Old Dried Leaves

Neglected stool with dried leaves

Well managed orchard without dried leaves

3.3.3 Trimming of Old Dried Leaves

• This activity is useful since it ensures light penetration in the orchard and helps reduce certain leaf diseases and reduces injury caused to banana by the dry leaves during windy periods

• All dry/dead leaves which hang down the sides of the pseudo-stem need to be removed at least twice a year (Each pseudo-stem should have 7 leaves at any one time)

• Trimming:
  – Ensures light penetration in the orchard
  – Helps reduce certain leaf diseases
  – Reduces injury caused to banana fruits by the dry leaves during windy periods

• After harvesting, the pseudo-stem should be cut off at ground level, and chopped into small pieces to avoid banana weevil infestation
3.3.4 Removal of Male Bud & Bagging

Before removal

After removal
3.3.4 Removal of Male Bud & Bagging

• The male bud or navel should be removed after bunch formation is complete.
• The advantages of removing the male bud include increase in yield, faster maturing of bunches and reduced thrips attack.

Note: Tools used during removing male buds and pruning need to be disinfected.

3.3.5 Bunch Covering (Bagging)
• A process of covering banana bunches with special polybag in order to protect them from being attacked by thrips and other insects.

Before removal

After removal

Photos: SHEP PLUS
3.4 Water Requirement

Banana orchard under irrigation

Photo: SHEP PLUS
Banana orchard under irrigation

3.4 Water Requirement

- Banana plants require a minimum of 1,000 mm of rainfall annually
- Irrigation is therefore necessary where the rainfall received is less than this amount
- Water is critical at flowering
- Therefore, in drier areas, supplemental irrigation may be necessary during this time 40-60 litres/plant per week split into 20L (in two splits)
3.5 Managing of Weeds

Weed management through mulching
3.5 Managing of Weeds

Weed management through mulching

3.5 Managing of Weeds (GHCP&PHHT20: Q13)

- Orchards should be kept weed-free through either 
  **hoeing** or **mulching**
- Since Bananas are **shallow-rooted**, care should be taken during weeding to avoid root injury
- A well maintained heavy mulch cover will **suppress weed growth**, **retain moisture** & **provide humus** for a good soil structure
- The orchard can also be kept weed-free through **inter-cropping**
- **Use of herbicide** such as Paraquat Dichloride (Gramoxone®, HERBIKILL®) or Glufosinate - Ammonium (Basta®) is also effective
3.6 Top-dressing

Fermenting green manure (Day 3)  
Top-dressing using green manure

Photos: SHEP PLUS
3.6 Top-dressing

3.6 Top-dressing (GHCP&PHHT20: Q14)

3.6.1 Top-Dressing using “Green Manure”

How to prepare “Green Manure” (15 litres):

- **Materials:**
  - 6 kg of fresh cattle dung
  - 9 litres of water
  - 4 kg of green weed called “Tithonia”

- **Procedures:**
  - Chop the 4 kg of “Tithonia” into small pieces
  - Mix all materials together in a bucket, and cover with a piece of cloth or news paper
  - Keep the bucket under a shade for 1 – 2 weeks depending on weather
  - When the mixture stops releasing bubbles and smell ceases, the green manure is ready

- **How to apply the “Green Manure”**
  - Apply 3 litres of ready green manure per stool once in three months

3.6.2 Top-Dressing by Fertilizer

- 200 g of CAN should be distributed around each stool per year, or, with 250 g of Mavuno Banana (N:P:K=10:3:20+TE) applied every 6 months
- The top-dressing fertilizer should be applied in a band 60 cm away from the plant
- 2 – 4 “debes” of decomposed farmyard manure is applied per stem per year before the rains. This is applied on the outer diameter of the canopy and incorporated into the soil carefully to avoid root damage
3.7 Pests & Diseases Control:
3.7.1 Major Pests

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Photo: Scot Nelson (CC BY 2.0)
https://www.flickr.com/photos/scotnelson/27755734515/in/photolist-Jb53fP-JhFoSP
3.7.1 Major Pests

• The following are the important pests of Banana in Kenya:
  A. Burrowing Nematode
  B. Banana Thrips
  C. Banana Weevil Borer
  D. Moles
3.7.1.A: Burrowing Nematode

Photo: © A.A. Seif, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Bananas (9 Dec 2016)

Burrowing nematodes on banana roots
3.7.1.A: Nematode

Nematodes are the most damaging pests causing over 70% loss of the crop.

Damages:
- Lesions and tunnels within the rhizome
- Root destruction leads to toppling of mature plant, especially when the wind blows or during bearing stage

Control:
- Use of clean planting material (Tissue Culture or by hot water treatment)
- Use “Tithonia” and “Mexican Marigold” in banana farm as green manure
- Apply farmyard manure or poultry manure
- Use of nematicides such as Azadirachtin (Achook®), Ethoprophos (MOCAP GR 10®)
3.7.1.B: Banana Thrips

Damage on banana fruits by thrips

Photo: Scot Nelson (CC BY 2.0)  https://www.flickr.com/photos/scotnelson/27755734515/in/photolist-Jb53fP-JhFoSP
3.7.1.B: Banana Thrips

Damage on banana fruits by thrips

Damages:
- **Silvery patches** on the fruits that later turn **brown**
- The skin of heavily infested fruit may crack permitting secondary infection which results in **fruit rot** making it unattractive hence lowering its marketability

Control
- **Removal of male flowers**
- Covering of bunches/bagging
- Use of **insecticides**, such as
  - **Deltamethrin** (Decis 2.5 EC®)
  - **Pirimiphos-Methyl** (ACTELLIC 25EC®)

Photo: Scot Nelson (CC BY 2.0)
https://www.flickr.com/photos/scotnelson/27755734515/in/photolist-Jb53fP-JhFoSP
3.7.1.C: Banana Weevil Borer

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

Banana weevil adult
3.7.1.C: Banana Weevil Borer

Identification:
- Weevil: A brown-black weevil with a curved hard shell
- Borer (grub) form irregular tunnels in the rhizome reducing it to a mass of rotten tissue

Damages:
- The leaves of infested plants turn yellow, wither and die prematurely
- Infested plants are easily blown over the ground by wind

Control:
- Use clean planting material for propagation (Tissue Culture or hot water treatment)
- Do NOT leave suckers and other planting materials over night in the field, as the weevils may lay eggs on them
- After harvest, cut stems at the ground level and cover the cut surface with a layer of earth to prevent entry of the weevil
- Cut harvested stems into very small pieces to allow faster drying and rotting

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

Adult banana weevil
3.7.1.D: Moles

A Mole making tunnels at the base of banana stool

Photo: By Scapanus_latimanus.jpg: Sarah Murray derivative work: WolfmanSF (Scapanus_latimanus.jpg) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons
https://commons.wikimedia.org/wiki/File%3AScapanus_latimanus2.jpg (9 Dec 2016)
3.7.1.D: Moles

Identification:
- Moles are small cylindrical mammals
- They have velvety fur; tiny or invisible ears and eyes; and short, powerful limbs with large paws oriented for digging
- Forms mounds of soil (shaped like a volcano) and/or surface tunnels

Damages:
- Stools fall over from damage on the roots

Control:
- Keep the basin of the banana stools always moist as moles do not like living on wet grounds
- Do NOT heap/mount soil around the basin of the banana stool as this might become a hide out for the moles
- Use traps with baits
- Field sanitation

A Mole making tunnels at the base of banana stool
3.7.2 Major Diseases
3.7.2 Major Diseases

- The following are the major diseases of bananas in Kenya:
  a. Panama Disease (Fusarium Wilt)
  b. Black Sigatoka / Black Leaf Streak
  c. Cigar-end Rot
  d. Banana Bacterial Wilt
3.7.2.a: Panama Disease

Banana plant with collapsed dry leaves (left) and infected banana pseudo-stem (right)
3.7.2.a: Panama Disease

General Descriptions:
- A soil-borne disease also known as “Fusarium Wilt”
- Fungus attacks roots and blocks vascular system causing wilts

Symptoms:
- The older leaves turn yellow and collapse while still green at the base
- The leaves fall in order, from the oldest to the youngest until they hang around the pseudo-stem like a skirt, and dry up
- The emerging heart leaf may die while the stem remains erect till it decays and falls over
- Diseased plants fail to produce normal fruit and die before the fruit stalk is fully developed
- Apple and Gross Michel/Kampala are highly susceptible to this disease

Control:
- Use of resistant varieties, such as Giant Cavendish, Lacatan or FHIA hybrids
- Use disease-free materials (Tissue Culture and clean suckers)
- Observe quarantine
3.7.2.b: Black Sigatoka / Black Leaf Streak

A Banana leaf with symptom of “Black Sigatoka” infection

Photo: ©Scot Nelson (CC: BY 2.0) https://www.flickr.com/photos/scotnelson/29608954871
3.7.2.b: Black Sigatoka / Black Leaf Streak

General Descriptions:
• A fungal disease that destroys banana leaves also called Leaf Streak Sigatoka
• It can seriously reduce crop yield

Symptoms:
• First symptoms are narrow, rusty, reddish-brown streaks on the underside of leaves
• These become dark brown or black spots on both surfaces and develop yellow margins & grey centres
• It causes significant reduction in leaf area, premature ripening and yield loss of up to 50 % or more

Control:
• Cultural practices such as removal of affected leaves, adequate spacing of plants and efficient drainage within orchards
• Use of resistant cultivars e.g.) FHIA 17, 18, 25, some Cavendish varieties like Williams and Grand Nain
• Use chemicals such as:
  – Mancozeb (DITHANE M-45®)
  – Thiophanate-Methyl (TOPSIN M Liquid®)
3.7.2.c: Cigar-end Rot

“Cigar-end Rot” damage on a banana fruit

Photo: ©Scot Nelson (CC: BY 2.0) https://www.flickr.com/photos/scotnelson/5670474991
3.7.2.c: Cigar-end Rot

**General Descriptions:**
- The fungus invades the dry flower parts and penetrates into the skin
- Favoured by **high humidity** due to overcrowded orchard or stool, and abundant leaf trash

**Symptoms:**
- Tips of the attacked **banana fingers** undergo a dry rot with an **ashy gray appearance** that look like a **cigar**

**Control:**
- Field hygiene and removal of excess suckers
- **Male flower bud should be removed** when it is **15 cm** below the last hand
- **Use of fungicides**, such as
  - Propineb (**Antracol WP70®**)
  - Thiophanate-Methyl (**Topsin M Liquid®**)
  - Mancozeb (**Dithane M-45 WP®**)
3.7.2.d: Banana Bacterial Wilt

**Xanthomonas** Wilt-infected banana pseudostem

Banana fruit infected with **Xanthomonas** “Bacterial Wilt”
### 3.7.2.d: Banana Bacterial Wilt

**General Descriptions:**
- The disease is easily spread by use of infected planting materials and farm tools.
- Transmitted by insects including bees through the male bud.
- **Lacatan** is a very susceptible variety.

**Symptoms:**
- Withering of flowers, wilting of leaves and premature ripening of fruits.
- The leaf sheath turns dull green, scalded & breaks at petiole, then all leaves collapse at pseudo-stem.
- Cross section of the pseudo-stem when cut reveals yellow discoloration bacterial ooze.
- Un-even and premature ripening of fruits.

**Control:**
- **Field Sanitation:**
  - Disinfecting farm tools after use and washing hands e.g.) use of jik 1:5 water.
  - Uprooting, destroying, and burying affected plants.
  - **Disbudding of male flower buds** after fruiting.
  - Observe quarantine.
  - Use of clean planting materials.

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**Xanthomonas Wilt-infected banana pseudostem**

**Banana fruit infected with Xanthomonas “Bacterial Wilt”**
4. Harvest

Harvested banana directly placed on the ground

A harvested bunch of banana on display
4. Harvest

Harvested banana directly placed on the ground

A harvested bunch of bananas on display

4. Harvest
4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Fruit Size**: length and volume of fruit increases as fruit matures
- **Fruit Shape**:
  - At early stages of development, individual fruits are angular in **cross-section**
  - As the fruit matures, the fingers become more rounded
- **Peel and Pulp Color**:
  - During maturation, the color of the peel changes from **deep green** to **light green** or **yellow**
  - The pulp color changes from **cream** to **orange yellow**
- **Harvesting** involves:
  - **Cutting the bunch** from the **pseudo-stem**
  - For tall varieties, the pseudo-stem may be cut **half-way** to allow the bunch to be reached and thereby prevent it from falling on the ground
- Harvesting starts **9 – 18 months** after planting
- Banana comes to full production in **2 – 3 years**
- Average yield in Kenya has been **6 tons/acre**
- Under good management yields of **20 tons/acre** can be achieved
5. Post-Harvest Handling

Banana bunch being weighed before selling
5. Post-Harvest Handling

5.1 Containers & Packaging Materials (G20: Q18)
- Bunches must be handled gently to avoid bruising
- Farmers usually transport and market bananas in bunches
- This form of handling exposes the fruits to mechanical damage thereby reducing their quality
- In order to reduce this damage it is advisable to remove the hands and pack in reusable plastic containers

5.2 Value Addition Techniques: Cleaning, Sorting, Grading, & Processing (G20: Q19)
- Sorting: Remove undesirable fruits e.g. with thrips & rust damage, severe latex staining
- Processing:
  - Some products include flour, juices, puree, chips, crisps, jams/jelly, sweets, vinegar and wine

Banana bunch being weighed before selling