"*KAMISHIBAI*"

- The "*KAMISHIBAI*" is a Kenya SHEP training material provided to **extension workers**.
- **Extension workers** use them to train farmers during **farmer group training (In-field Training)**.

SHEP PLUS Training Manuals/Materials

"*KAMISHIBAI*" Cont'

Characteristics of the "*KAMISHIBAI*"

- Photos and diagrams are widely used
- Each material consists of front page and back page
- Front page consists of title & photos/diagrams
- Back page has same photos/diagrams (smaller ver.) and notes for the trainer
- The "*KAMISHIBAIs*" are laminated for ease of use by extension workers during training sessions and are more durable as compared to other written materials

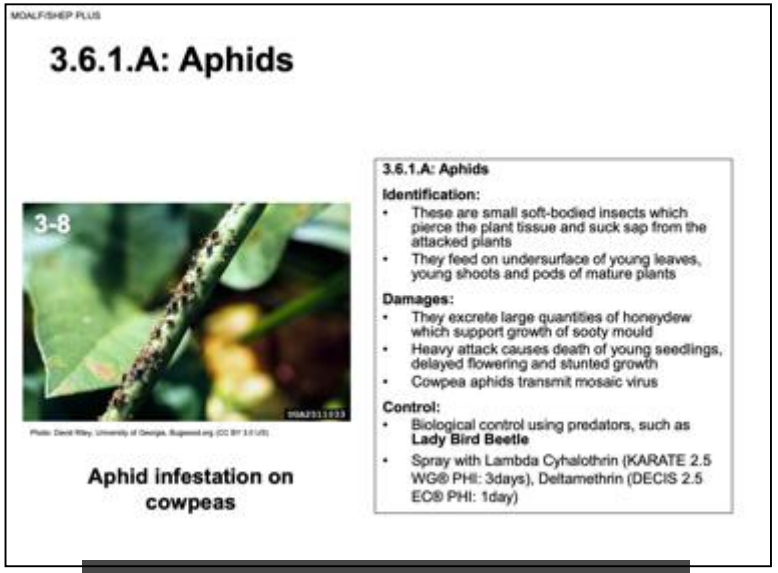
"*KAMISHIBAI*" Cont'

General Format of the "*KAMISHIBAI*"

- Each material consists of front and back page

Front Page

Title & photos/diagrams



Back Page

Same photos/diagrams as front (smaller ver.) and notes for the trainer

"*KAMISHIBAI*" Cont'

How to use the "*KAMISHIBAI*" - Examples

- **Extension workers** bring the "*KAMISHIBAI*" corresponding to the topic of the farmers' training.
- Front page is shown to the farmers. It helps clear understanding by farmers.
- Back page has same photograph with notes for explanation. It helps extension workers to provide detailed explanation to the farmers.

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture, and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

Photo: SHEP PLUS

Training Title: **Banana Production**

Objective: **To provide a guideline on production of Bananas**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling; and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

Banana Production, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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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

1-1

Photo: SHEP PLUS

Banana (Ndizi)

1. Introduction:
1.1 Background

Photo: SHEP PLUS

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**, **B_6** & **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**

1.2 Common Varieties

“Giant Cavendish”

“Chinese Dwarf”

Photos: SHEP PLUS

1.2 Common Varieties

“Giant Cavendish”

“Chinese Dwarf”

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

“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

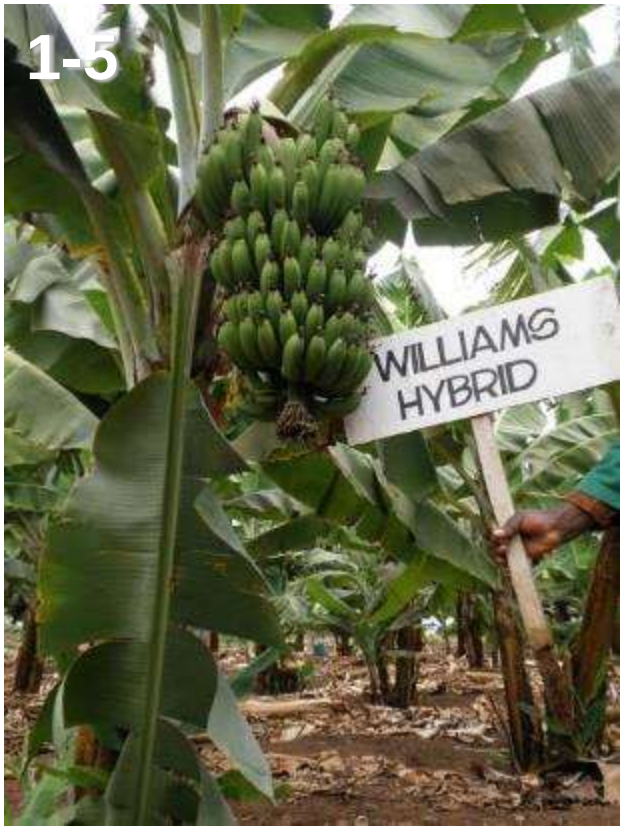
“Chinese Dwarf”

- 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

Photos: SHEP PLUS

1.2 Common Varieties Cont’

“Grand Naine”



“Williams Hybrid”

Photos: SHEP PLUS

1.2 Common Varieties Cont'

"Grand Naine"

"Williams Hybrid"

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

Photos: SHEP PLUS

1.3 Optimal Ecological Requirements

Altitude	**0-1,800 metres above sea level**
Rainfall	**1,000 – 2,000 mm of rainfall annually**
Growing Temperature	**20 – 30 ^{0}C**
Soils	• **Deep well drained soils** • **pH range 6.0 – 7.5**

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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 ^{0}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

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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

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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

Tissue Culture Bananas seedlings

Sword suckers

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

Photos: SHEP PLUS

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

Photos: SHEP PLUS

2.1.2 Sword Suckers

Photo: SHEP PLUS

Banana sword suckers

2.1.2 Sword Suckers

Photo: SHEP PLUS

Banana sword suckers

2.4.2 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

2.1.3 Suckers Disinfection through Hot Water Treatment

Sword suckers

Disinfection of Banana Suckers

Photos: SHEP PLUS

2.1.3 Suckers Disinfection through Hot Water Treatment

Disinfection of Banana Suckers for nematode/weevil control

2.4.3 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 ^{0}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)**

Photos: SHEP PLUS

3. Cultural Practices:
3.1 Land Preparation

Photos: SHEP PLUS

Weighing manure

3. Cultural Practices:
3.1 Land Preparation

Weighing manure

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

Photos: SHEP PLUS

3.2 Transplanting

Banana seedlings after transplanting

3.2 Transplanting

3-3

Photo: SHEP PLUS

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

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

3.3.2 Propping

Propped up banana plants

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.

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

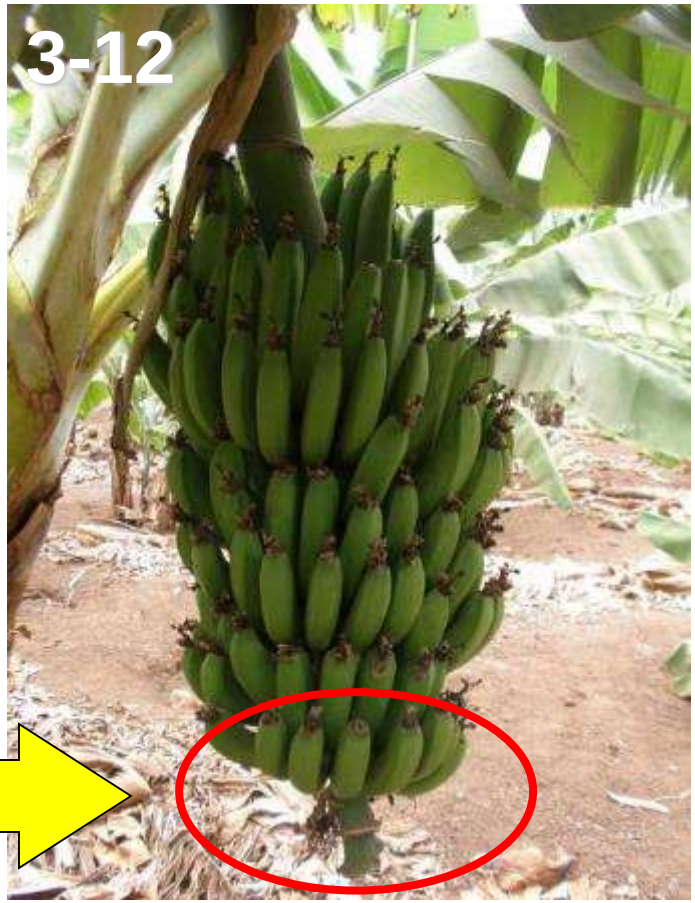
Neglected stool with dried leaves

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**

Photos: SHEP PLUS

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

Photos: SHEP PLUS

3.4 Water Requirement

Banana orchard under irrigation

Photo: SHEP PLUS

3.4 Water Requirement

Banana orchard under irrigation

3.4 Water Requirement (GHCP&PHHT20: Q12)

- 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)**

Photo: SHEP PLUS

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

Fermenting green manure (Day 3)

Top-dressing using green manure

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

Photos: SHEP PLUS

3.7 Pests & Diseases Control:
3.7.1 Major Pests

Photo: © A.A. Seif, icipe
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Photo: Scot Nelson (CC BY 2.0)
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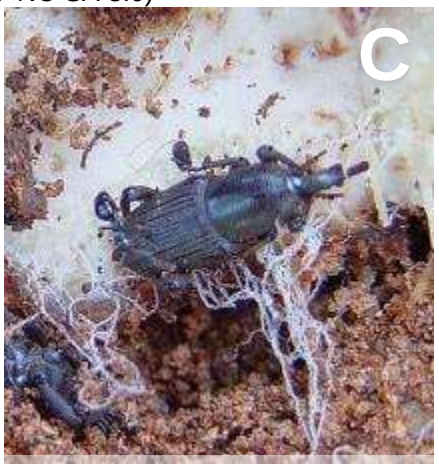

Photo: © A.M. Varela, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Crops/Bananas(9 Dec 2016)

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https://commons.wikimedia.org/wiki/File%3AScapanus_latimanus2.jpg (9 Dec 2016)

3.7.1 Major Pests

3.7 Pests & Diseases Control:
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

Burrowing nematodes on banana roots

3.7.1.A: Nematode

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

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

Damage on banana fruits by thrips

3.7.1.B: Banana Thrips

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

Damage on banana fruits by thrips

3.7.1.B: Banana 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®)**

3.7.1.C: Banana Weevil Borer

Banana weevil adult

3.7.1.C: Banana Weevil Borer

Adult banana weevil

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

3.7.1.D: Moles

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)

A Mole making tunnels at the base of banana stool

3.7.1.D: Moles

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)

A Mole making tunnels at the base of banana stool

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**

3.7.2 Major Diseases

Photo: SHEP PLUS

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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

3-24a

3-24b

Banana plant with collapsed dry leaves (left) and infected banana pseudo-stem (right)

3.7.2.a: Panama Disease

Banana plant with collapsed dry leaves

infected banana pseudo-stem

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

3.7.2.b: Black Sigatoka / Black Leaf Streak

A Banana leaf with symptom of "Black Sigatoka" infection

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

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“Cigar-end Rot” damage on a banana fruit

3.7.2.c: Cigar-end Rot

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https://www.flickr.com/photos/scotnelson/5670474991

"Cigar-end Rot" damage on a banana fruit

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

Photo: © Rose Kamau, MOALF 2019

***Xanthomonas* Wilt-infected banana pseudostem**

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Banana fruit infected with *Xanthomonas* "Bacterial Wilt"

3.7.2.d: Banana Bacterial Wilt

Photo: © Rose Kamau, MOALF 2019

***Xanthomonas* Wilt-infected banana pseudostem**

Photo: © IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/6755031667/in/photostream/

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

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

Banana bunch being weighed before selling

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**

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

BLACK NIGHTSHADE PRODUCTION

Photo: © Victor Omari HCD, 2019

Prepared by SHEP PLUS

Training Title: **Black Nightshade Production**

Objective: **To provide a guideline on production of Black Nightshade**

Specific Objective:

- **To provide basic information on production, post-harvest handling, and marketing of Black Nightshade**

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

Black Nightshade Production, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

Editors: James Arim, Stephen Kioko, Collins Otieno, Calistus Efukho, Grace Mbuthia, Florence Mangoli, Zablon Oirere, Elizabeth Mbuthia, Fransisca Malenge, Jiro Aikawa, Kiyoshi Kita, Harue Kitajima, Yasuhiro Takashina, Taku Seo

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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 Product Board.

1. Introduction:
1.1 Background

Photo: © Victor Omari HCD, 2019

Black Nightshade
(Mnavu, Managu, Osuga, Rinagu etc.)

1. Introduction:
1.1 Background

Black Nightshade (Mnavu, Managu, Osuga, Rinagu etc.)

1. Introduction:
1.1 Background

- The term **"Nightshade"** refers collectively to a wide ranging group of plants including poisonous, medicinal and edible species (from the genus Solanum)
- There are several species with black berries, but the most popular ones are those with orange berries belonging to **"*Solanum Villosum*"**
- This group of species is often erroneously referred to as **"*Solanum Nigrum*"**, a poisonous plant from Europe that is not usually grown in Africa (AVRDC, 2003)
- Some Solanum varieties are preferred for their **bitter taste** while others are considered **sweet/tastier**, particularly after being boiled and the water discarded
- It is rich in **proteins**, **calcium**, **iron**, **phosphorus** and **magnesium, *Beta*-Carotine**, Vitamin **E**, **Folic** acid and **Ascorbic** acid
- Black Nightshade is gaining popularity due to its **nutritional value** and ready market in major urban centers

1.2 Common Varieties

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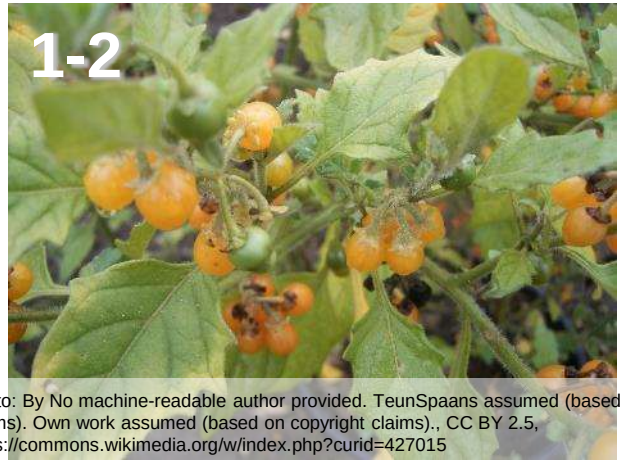
Photo: By David Eickhoff from Pearl City, Hawaii, USA - Solanum americanumUploaded by Tim1357, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=22702159

"Solanum Villosum"

"Solanum Americanum"

1.2 Common Varieties



"Solanum Villosum"

"Solanum Americanum"

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

"*Solanum Villosum*"

- Grows well in **low altitude areas**
- Produces **orange colored fruits** which are edible

"*Solanum Americanum*"

- Produces **very small fruits** which are **black**
- Grows well in **hot and humid areas**, such as Coastal areas

1.2 Common Varieties Cont’

Photo: By Caroline Léna Becker - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=20085916

“*Solanum Scabrum*”

1.2 Common Varieties Cont'

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"Solanum Scabrum"

1.2 Some Common Varieties Cont'

"*Solanum Scabrum*"

- Bigger in size
- Produces **bigger leaves** and **fruits** which are **black in color when ripe**
- Grows well in **medium altitude areas** which receives a lot of rainfall
- It is unpopular in Kenya

"*Solanum Eldoreti*"

- Broader leaves compared to *Solanum Villosum*
- Grows well in **high altitude areas**
- Produces **small greenish** to **purplish fruits**

1.3 Optimal Ecological Requirements

Altitude	**0 – 2,400 metres above sea level**
Rainfall	**500 – 1,200 mm of rainfall**
Growing Temperature	**Warm Temperatures**
Soils	• **Well drained soils** • **High organic matter content**

1.3 Optimal Ecological Requirements

Altitude	**0 – 2,400 metres above sea level**
Rainfall	**500 – 1,200 mm of rainfall**
Growing Temperature	**Warm temperatures**
Soils	• **Well drained soils** • **High organic matter content**

1.3 Optimal Ecological Requirements

- **Altitude:** The optimum altitude ranges **0 – 2,400 m** above sea level depending on the species:
  - "*Solanum Villosum*" grows **up to 2,400 m.a.s.l**
  - "*Solanum Americanum*" is mainly found at **low altitudes** and in coastal areas
  - "*Solanum Scabrum*" grows **up to 2,000 m.a.s.l**
- **Rainfall:** Requires low to medium rainfall, **500 – 1,200 mm** per year, which is well distributed
- **Temperature:** Does well in warm temperatures
- **Soil:** Black Nightshade requires **well drained soils** and **high in organic matter content** since they require large quantities of nitrogen and other nutrients.

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

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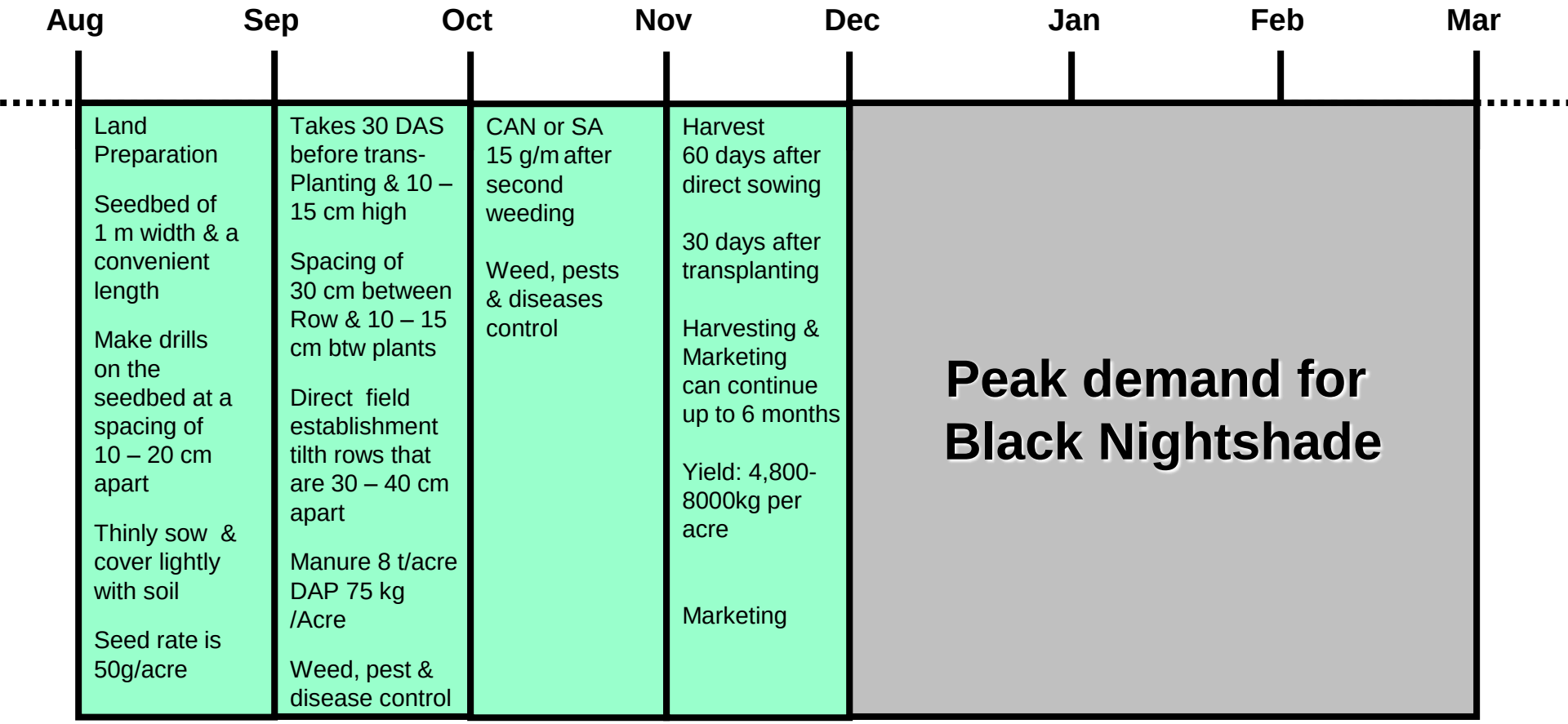
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

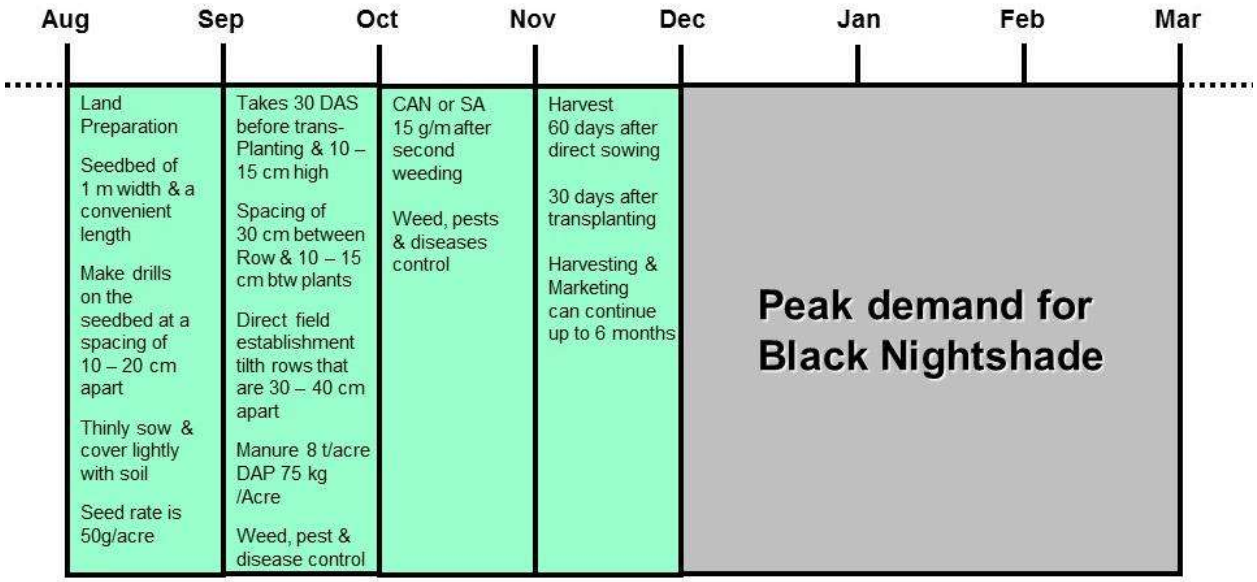
2.1 Crop Planting Calendar

A Sample of a BNS Planting Calendar



2.1 Crop Planting Calendar

A Sample of a BNS Planting Calendar



A Sample of a Black Nightshade Planting Calendar: Targeting a peak market demand beginning just after December

2.1 Crop Planting Calendar (GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Black Nightshade
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Manure preparation through composting

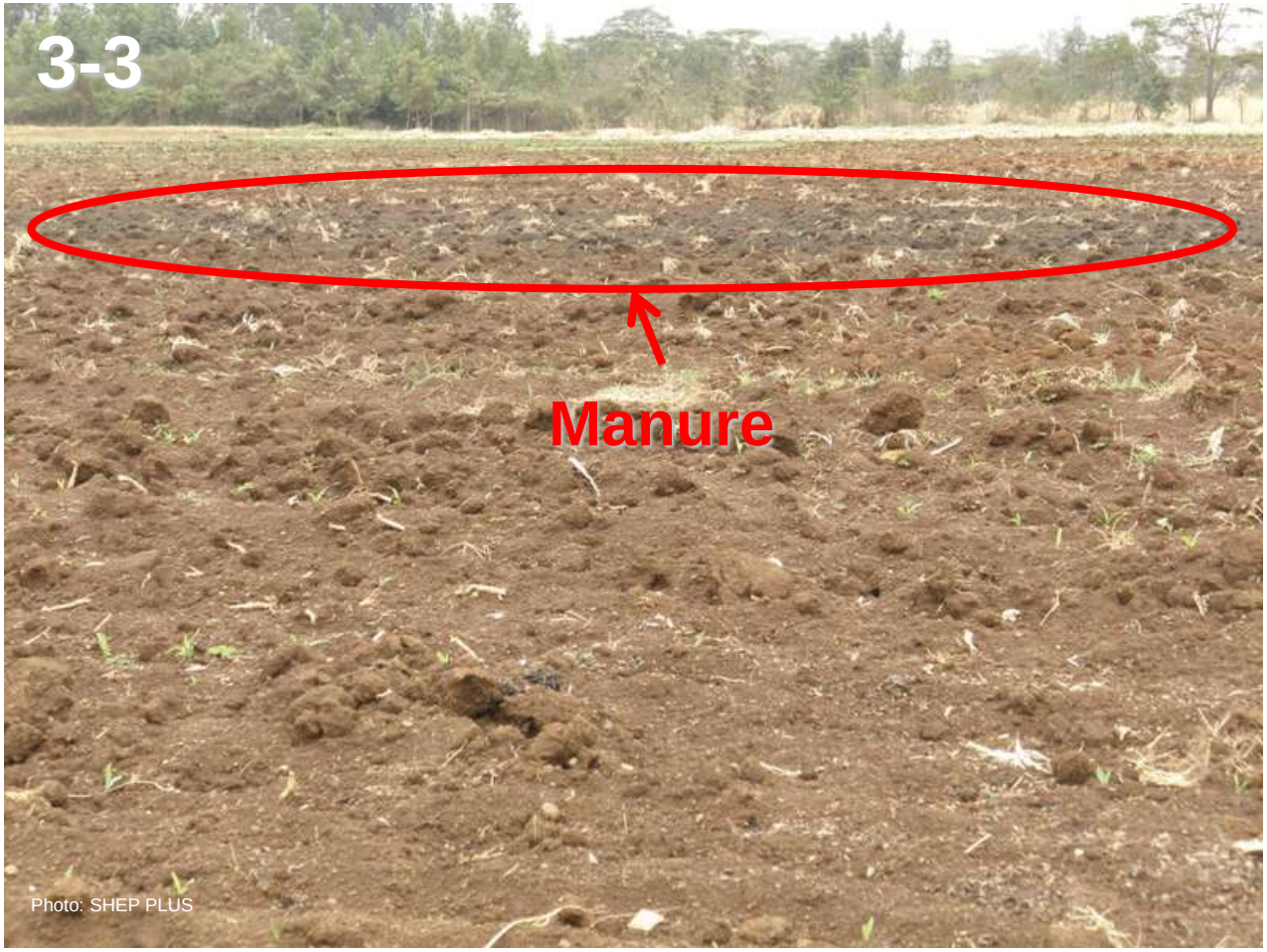
2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- Compost manure has been found to:
  - Be cheaper than inorganic fertilizers
  - Improve soil productivity by readily providing soil nutrients and improving soil structure
  - Increase the water retention capacity
- Black Nightshade like most **leafy** vegetables is a heavy feeder and does well in soils with high organic content (manure/compost)
- Based on the results of the soil analysis, prepare adequate compost for application; the recommended rate of application ranges from **5 – 8 tons per acre**

3.1 Basal Application



Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- To be based on soil analysis results
- Pre-plant phosphorus (**P**) can be applied in form of fertilizer (**DSP**) at the rate of **75 kg per acre**
- Manure/compost should be applied **1 – 2 weeks before** transplanting and incorporated into the soil
- The manure/compost should be broadcasted (**8 tons per acre**) then worked into the soil (incorporated) preferably using a hoe

3.2 Raising Seedlings

Nursery bed of Black Nightshade

3.2 Raising Seedlings

Nursery bed of Black Nightshade

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Use of clean seed is recommended due to high incidences of seed borne diseases
- **Seed Rate:** 50 g per acre

Nursery Site Selection:

- The nursery should be located in a plot that has not been planted with crops in the ***Solanaceae*** family for at least **three (3) years**

Note:

- Trays can also be used for raising seedlings

Nursery Establishment:

- Involves **site preparation**, **construction of nursery infrastructure** and **basic nursery tools**
- Nursery soil should be **loosened** and **enriched** with well decomposed manure
- Make drills at a spacing of **10 – 20 cm apart**; thinly sow the seeds in the drills and cover lightly with soil

Management of Nursery:

- **Adequate watering** is essential for proper growth
- **Water** the nursery **regularly**
- The nursery should be **mulched** to conserve moisture

3.3 Transplanting

Recently transplanted BNS seedlings

3.3 Transplanting

Recently transplanted BNS seedlings in Khwisero Sub-county

3.3 Transplanting

3.3.1 Appropriate Time

- Seedlings are transplanted **30 days after sowing** or when having **5** – **6 true leaves** and have attained **a height of 10 – 15 cm**

3.3.2 Recommended Spacing (GHCP&PHHT20: Q10)

- Seedlings are planted at spacing of **30 cm** between the row and **10 – 15 cm** between plants
- For the direct seeded, seeds are drilled thinly in fine tilth rows that are **30 – 40 cm apart**
- To ensure uniform distribution, mix the seed with the soil or sand at a ratio of **1:15** or **1:20**, respectively
- Direct seeding enables the plant to establish well and faster which leads to faster production of bigger leaves
- Seed germination takes place between **4 – 7 days**
- Thin seedlings to attain a spacing of **15 cm** between the plants after **30 days**

3.3.3 Fertilizer Application Rates (GHCP&PHHT2: Q11)

- To be based on **soil analysis**
- Manure alone: **8 tons per acre** or,
- Manure and DAP: **8 tons manure per acre** together with **40 kg DAP per acre** or,
- **DAP 75 kg per acre**

3.6 Water Requirement

(G20: Q12)

Photo: © Victor Omari HCD, 2019

Black Nightshade under drip irrigation

3.6 Water Requirement (G20: Q12)

3-5

Photo: SHEP PLUS

Black Nightshade under drip irrigation

3.6 Water Requirement (G20: Q12)

- Frequent irrigation is needed to avoid **water stress** and have optimum growth and yield
- Irrigation interval of the crop **depends on the soil types**
- It is recommended that sandy soil be irrigated **three times a week**, sandy loam **twice a week**, clay loam and loam soils **once a week,** respectively

Irrigation Methods:

- **Drip** and **sprinkler irrigation** can be used but drip irrigation is recommended to save water

3.4 Top-dressing

Photo: SHEP PLUS

Top-dressing using the placement method

3.4 Top-dressing

Photo: SHEP PLUS

Top-dressing using the placement method

3.4 Top-dressing (GHCP&PHHT20: Q14)

- Research indicates that **Nitrogen** is one of the most important nutrient that is required by the crop in fairly large quantities
- Calcium ammonium nitrate (CAN) or Sulphate of ammonia (SA) should be applied at **15 g** (**3 tea spoonfuls**) **per m²** after **second weeding**
- Application of **foliar fertilizer** is beneficial to this crop

Notes:

- **Soil Fertility**
  - Recommendations for supplemental **organic matter**, **fertilizer**, **lime** or **manure** should be based on a soil test and a nutrient management plan
  - Nutrient management plans balance the crop requirements and nutrient availability, with the aim to **optimize crop yield** and **minimize ground water contamination**, while improving soil productivity

3.5.1 Major Pests

Photo: A. M. Varela, icipe
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Photo: A. M. Varela, icipe
http://www.infonet-biovision.org/PlantHealth/Pests/Cutworms
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Photo: By Bob Peterson from North Palm Beach, Florida, Planet Earth! - Metallic blue flea beetles (Altica sp.)Uploaded by Jacopo Werther, CC BY-SA 2.0,
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Photo: © Magnus Gammelgaard
http://www.infonet-biovision.org/PlantHealth/Pests/Aphids (CC BY-NC-SA 3.0)

3.5.1 Major Pests

Photo: By Bob Peterson from North Palm Beach, Florida, Planet Earth! - Metallic blue flea beetles (Altica sp.) Uploaded by Jacopo Werther, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=24649912

Photo: © Magnus Gammelgaard
http://www.infonet-biovision.org/PlantHealth/Pests/Aphids
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3.5.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Black Nightshade in Kenya:

A. Root-Knot Nematode
B. Cutworm
C. Flea Beetle
D. Aphid

3.5.1.A: Root-Knot Nematode

Photo: A. M. Varela, icipe
http://www.infonet-biovision.org/PlantHealth/Pests/Root-knot-nematodes (CC BY-NC-SA 3.0)

“Root-knot Nematode” infection

3.5.1.A: Root-Knot Nematode

“Root-knot Nematode” infection

3.5.1.A: Root-Knot Nematode

Damages:

- Root-Knot Nematodes induce characteristic **swellings of the roots** which are commonly referred to as **galls**
- This deformation of the root system inhibits the translocation of water and mineral salts thus resulting in **stunted plant growth**

Control:

- Crop rotation
- **Keep weed free** land fallow for one or two seasons
- Intensive use of manure

3.5.1.B: Cutworm

A Cutworm larva

3.5.1.B: Cutworm

A Cutworm larva

3.5.1.B: Cutworm

- Cutworms are often found **hiding in soil** near the cut seedlings

Damages:

- **Grey to black caterpillars** feed at night, either bite out the side of the stem at ground level causing the plant to **fall over** or may **cut it** completely

Management/control

- **Hand removal** since the pest is easily found near the damaged plant, especially at the beginning of infestation
- **Early weeding** destroys sites for egg laying

3.5.1.C: Flea Beetle

Photo: By Bob Peterson from North Palm Beach, Florida, Planet Earth! - Metallic blue flea beetles (Altica sp.)Uploaded by Jacopo Werther, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=24649912

A Flea Beetle on a leaf

3.5.1.C: Flea Beetle

Photo: By Bob Peterson from North Palm Beach, Florida, Planet Earth! - Metallic blue flea beetles (Altica sp.)Uploaded by Jacopo Werther, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=24649912

3.5.1.C: Flea Beetle

Damage:

- Feed on leaves where they create **big holes** on the **foliage**
- The damage is serious in **young plants**

Control:

- Keep fields **weed-free**
- **Destroy plant debris**

A Flea Beetle on a leaf

3.5.1.D: Aphid

Aphids on a leaf

3.5.1.D: Aphid

Aphids on a leaf

3.5.1.D: Aphid

- Most destructive pest for this crop especially during the dry season

Identification:

- Aphids are **pale green** and are usually covered with **a light dust of mealy powder**
- They suck plant sap from the central part of the plant and near the base of leaves

Damages:

- Aphid attack results in **curled** and **distorted leaves**

Control:

- Use of **ash**
- **Use of pesticides**, such as
  - **Karate 2.5 WG®** (a.i. **Lambdacyhalothrin. PHI 3days**)

3.5.2 Major Diseases

Photo: By Forest & Kim Starr, CC BY 3.0,
https://commons.wikimedia.org/w/index.php?curid=6109049

Photo: © A. M. Valera, icipe (CC BY-NC-SA 3.0)
http://infonet-biovision.org/PlantHealth/Crops/African-Nightshade

3.5.2 Major Diseases

Photo: By Forest & Kim Starr, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=6169049

Photo: © A. M. Valera, icipe http://infonet-biovision.org/PlantHealth/Crops/African-Nightshade

3.5.2 Major Diseases

- Disease infestation leads to reduction in quality and quantity of produce
- The following are the major diseases of Black Nightshade in Kenya:

  a. Bacterial Blight
  b. Early Blight

3.5.2.a: Bacterial Blight

Photo: By Forest & Kim Starr, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=6109049

Symptoms on a Black Nightshade leaves

3.5.2.a: Bacterial Blight

Symptoms on a Black Nightshade leaves

3.5.2.a: Bacterial Blight

Symptoms:

- The disease is characterized by **small**, **round**, **water-soaked spots**, which eventually turn **dark brown to black** and become **hard and dry**

Control:

- Once the soil has been infected with the disease, it is advisable not to plant Black Nightshade for **at least 4 years**
- Use **certified disease-free seeds**
- When using own seeds, do hot water treatment

3.5.2.b: Early Blight

Symptoms on a Black Nightshade leaves

3.5.2.b: Early Blight

Symptoms on a Black Nightshade leaves

3.5.2.b: Early Blight

General Description:

- Early Blight thrives best under **warm wet conditions**
- Controlling Early Blight once it has established is **very difficult**

Symptoms:

- Leaf spots of early blight are **circular**, up to **1 cm in diameter**, **brown**, and often show a **circular pattern** which distinguishes this disease from other leaf spots
- Leaf spots first appear on **the oldest leaves** and **progress upwards** on the plant
- Entire plant could be **defoliated** and **killed**

Control:

- **Crop Rotation** with other crops, like **Amaranth** is essential
- **Do Not rotate** with **Tomato**, **Potato** or **Capsicum** as these belong to the same family and susceptible to the same diseases
- In areas with high humidity, **wider plant spacing** should be used
- Practice **good field hygiene**
- **Remove infected leaves** during the growing season, **discard all badly infected plant debris** at the end of each season
- Use **certified disease-free seeds**
- When using own seeds, treat with **hot water**

4. Harvest

Farmers Harvesting Black Nightshade

4. Harvest

Harvested Black Nightshade

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Maturity Period: 60 days** after direct seed sowing in the field or **30 days** after transplanting
- **Harvesting Method:**
  - The most common way of harvesting is regular plucking of leaves (multiple harvesting), twice per week
  - **14 days after transplanting**, cut the growing point of the plant to encourage branching; and **2 weeks later** start plucking the young shoots and continue harvesting **every 1 to 2 weeks** for **3 to 4 months**
- Harvest the fruit when it turns into **a black/purple** colour if the crop is for **seed production**
- Another method is **once-over harvesting** where the whole plant is removed by uprooting
- This is done either as **thinning** or if there is close spacing
- **Plucking method** determines the longevity of harvesting
- **Regular removal of flowers** ensures longer harvesting period
- **Yields:** Range from **4.8 tons to 8 tons of foliage per acre** depending on the variety and management

5. Post-Harvest Handling

Black Nightshade at a market

5. Post-Harvest Handling

Black Nightshade at a market

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- The crop can be harvested and placed on **plastic sheets** or **banana leaves**
- Blanched leaves can be **dried** and **stored** in **plastic containers**

5.2 Value Addition Techniques: Sorting, Cleaning & Grading (GHCP&PHHT20: Q19)

- **Sorting:**
  - Black Nightshade should be sorted to **remove insects** and **yellow** or **damaged leaves** before packing
  - Airing of the harvested leaves is done to **remove field heat**
- **Cleaning:** Leaves should be **thoroughly washed** with portable water
- **Grading:** Grade the leaves by **size**, bunching those of the same size and **tying in small bundles** before packing in well ventilated container for transportation to markets

5.3 Storage

- Fresh leaves should be stored in the refrigerator or stored in cool place

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

BULB ONION PRODUCTION

Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **Bulb Onion Production**

Objective: **To provide a guideline on production of Bulb Onions**

Specific Objective:

- **To provide basic information on production, post-harvest handling, and marketing of Bulb Onion**

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

Bulb Onion Production, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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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 Product Board.

1. Introduction:
1.1 Background

Photo: SHEP PLUS

Bulb Onion (Kitunguu Maji)

1. Introduction:
1.1 Background

Photo: SHEP PLUS

Bulb Onion (Kitunguu Maji)

1. Introduction:
1.1 Background

- Bulb Onion is one of the **most widely grown** & **consumed vegetables** in Kenya
- It is a biennial plant but considered an annual because it is harvested in its first growing stage
- It is a profitable crop. However, it requires a lot of labour during transplanting and weeding
- It is an important spice for foods when cooked or served raw
- Used to make pickles or chutneys
- It is rich in **Calcium**, **Iron**, **Potassium**, **Vitamin B6 & B9**, **Vitamin E** and has **medicinal properties**

1.2 Some Common Varieties

Photo: SHEP PLUS

“Bombay Red”

Photo: SHEP PLUS

“Red Creole”

1.2 Some Common Varieties

“Bombay Red”

“Red Creole”

1.2 Some Common Varieties

- **“Bombay Red”** and **“Red Creole”** are the most common varieties in Kenya

“Red Creole”:

- A popular variety which produces **red**, **flat-round**, **globular bulbs**
- It has **very** pungent **taste**
- **Maturity: 150 days** after **transplanting**
- Excellent in **storage**
- **Yield Potential: 16,000kg** per acre

“Bombay Red”:

- Variety for dry and warmer conditions
- Produces **small to medium** sized bulbs, which are **globe shaped, Deep purple red** colour and very pungent
- **Maturity: 150 days** from **transplanting**
- **Yield Potential: 16,000kg** per acre

1.2 Some Common Varieties

1-4

Photo: https://www.easeed.com/2015-07-16-12-56-29/vegetables/vegetables-6-137

“Red Star F1”

1-5

Photo: Amiran seed catalogue

“Neptune F1”

1.2 Some Common Varieties

1-4

Photo: https://www.easeed.com/2015-07-16-12-56-29/vegetables/vegetables-6-137

“Red Star F1”

1-5

Photo: Amiran seed catalogue

“Neptune F1”

1.2 Some Common Varieties

- **“Bombay Red”** and **“Red Creole”** are the most common varieties in Kenya

“Red Star F1”

- Matures in **110-120 days** after transplanting
- Very high yielding **25,000kg** per acre
- **Globe shape, uniform medium to big bulbs**
- Excellent bulb colour; **deep dark red**
- **Good field holding capacity**
- Stores up to **5 months**
- Tolerant to **neck rot** and **purple blotch** diseases

“Neptune F1”

- **High yielding**
- Firm **shinning red bulbs**, **good pungency**
- Good for salads, red-skin, **flattened globe-shape**
- **Mid-late maturing**,(110 -120 days)
- , **5-6 months** storage period
- **Pink root resistant**

1.2 Some Common Varieties Cont’

Information Source: http://www.royalseed.biz/onions.php

“Texas Grano”

Source: http://www.easeed.com/index.php/2015-07-16-12-56-29/vegetables/onion-red-tropicana-f1

“Tropicana F1”

1.2 Some Common Varieties Cont'

1-6

Information Source: http://www.royalseed.biz/onions.php

"Texas Grano"

1-7

Source: http://www.easeed.com/index.php/2015-07-16-12-56-29/vegetables/onion-red-tropicana-f1

"Tropicana F1"

1.2 Some Common Varieties Cont'

"Texas Grano":

- **White colour** with golden exterior
- **Bulbs large**
- Maturity **120 days** from transplanting
- **Does Not store well**.
- It has **mild pungency,** which is good for salad
- **Yield: 21,000kg** per **acre**

"Tropicana F1":

- **Very productive** and produces **large red**, **thick flat bulbs** with firm pungent taste
- **Yield Potential: 25 tons per acre**
- Maturity **90 -100days** after transplanting

Other varieties grown in Kenya:

"Jambar F1":

- **Dark red globe bulbs easy to cure**
- Can be grown in **open field** and **greenhouses**
- **Yield: 23,000kg** per **acre**

"Red Passion F1":

- **Deep red**
- Stores up to 5 months
- Tolerant to **Pink Root** and **Purple Blotch**
- **Yield Potential: 23,000kg per acre**

"Red Pinoy F1"

- **Deep red** attractive bulbs
- Maturity only **90 days** from transplanting
- **Strong pungency**
- Long shelf life of up to **6 months** at room temp
- Tolerant to **Downy Mildew** and **Purple Blotch**
- **Yield: 30 tones** per **acre**

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,900 metres above sea level**
Rainfall	**500 – 700 mm of rainfall annually**
Growing Temperature	**15 – 30 ^{0}C**
Soils	**• Fertile and well drained soil** **• pH range 6.0 – 6.8**

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,900 metres above see level**
Rainfall	**500 – 700 mm of rainfall annually**
Growing Temperature	**15 – 30 ^{0}C**
Soils	• **Fertile and well drained soil** • **pH range 6.0 – 6.8**

1.3 Optimal Ecological Requirements

- **Altitude:** Onion can be cultivated up to **1,900 m** above sea level
- **Rainfall:** Onions require **well-distributed rainfall** of between **500** and **700 mm** during the growing period. Dry spell is needed at maturity.
- **Temperature:** The optimum temperature for growth is **15 – 30 ^{0}C**. If the temperature exceeds **30 ^{0}C**, maturity is hastened & small bulbs are produced, consequently lowering the yields. When the temperature is low, growth is slowed or the plant may result to **flowering**. **Cold weather** is also associated with increased leaf diseases.
- **Soil:** Onions require **fertile** and **well-drained soil**. The optimum pH range is **6.0 – 6.8**. Sandy to silty loams with **fine tilth** are adequate.

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

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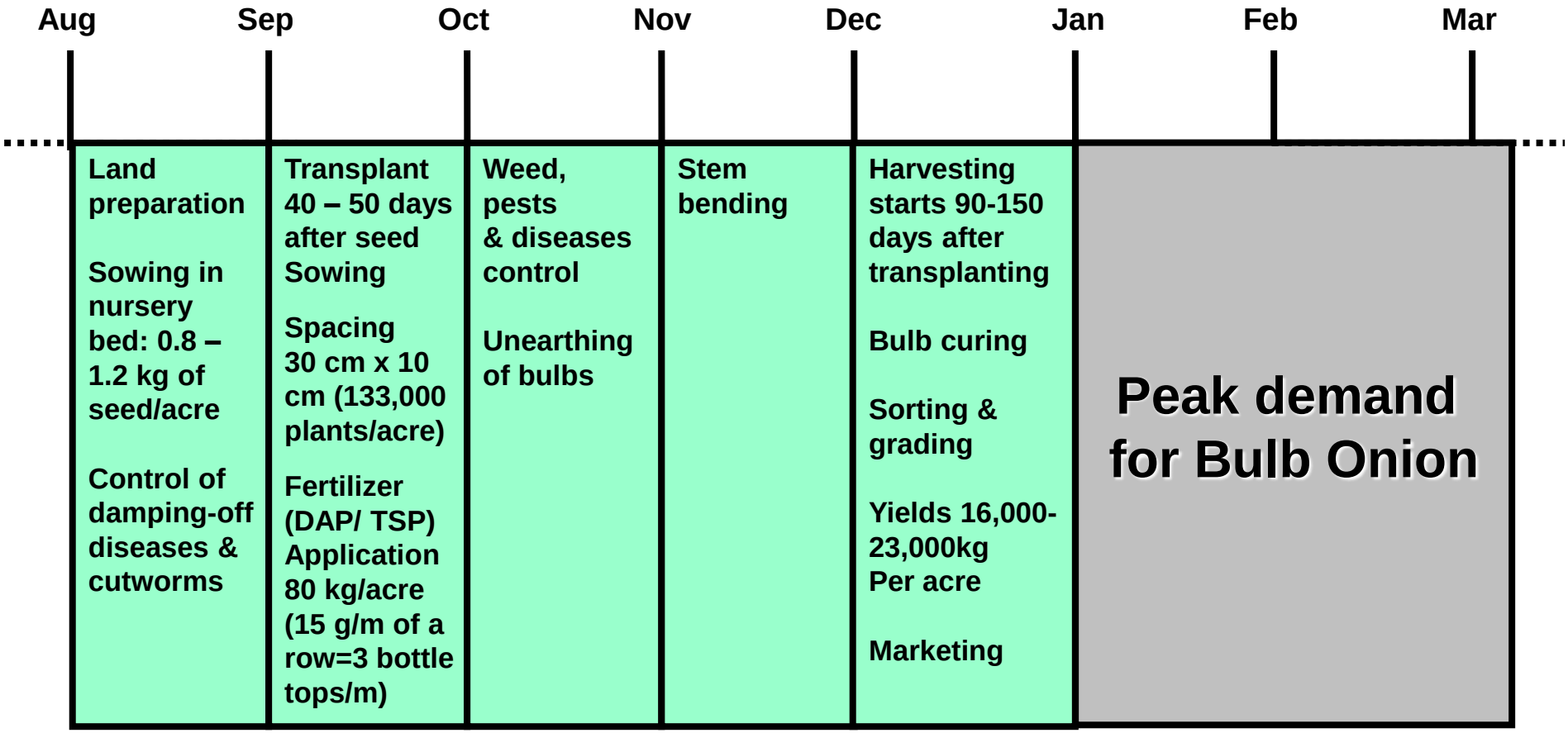
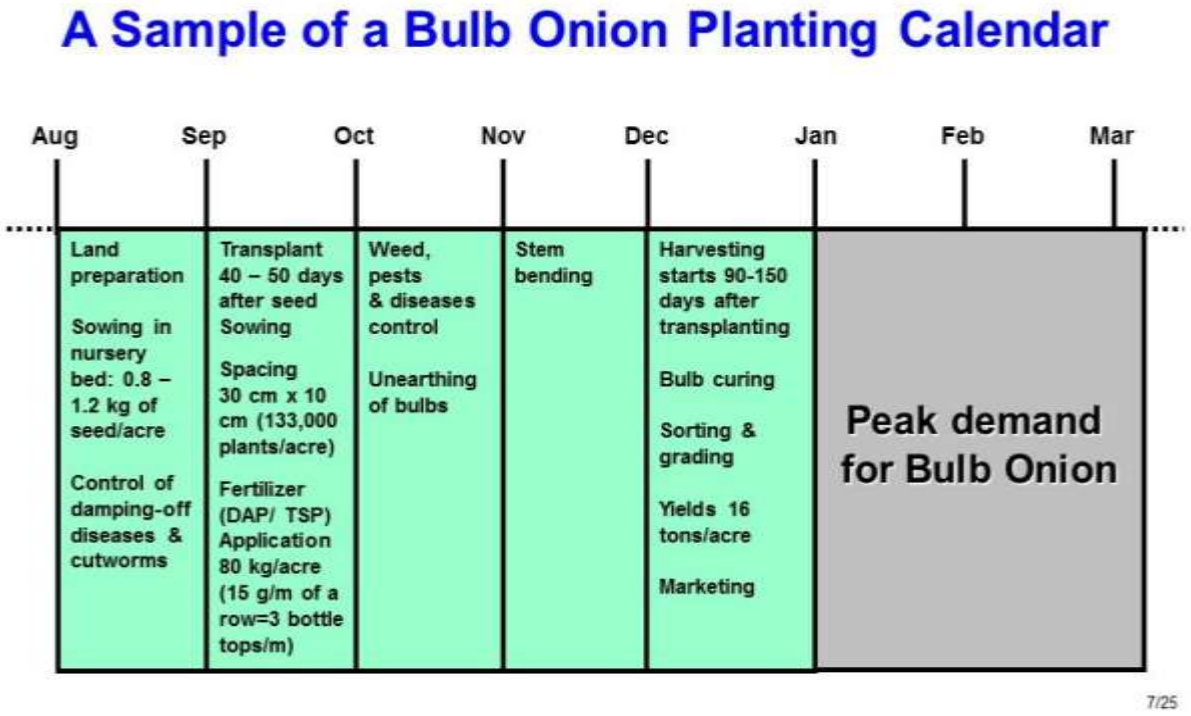
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

2.1 Crop Planting Calendar

A Sample of a Bulb Onion Planting Calendar



2.1 Crop Planting Calendar



A Sample of a Bulb Onion Planting Calendar: Targeting a peak market demand beginning just after the beginning of January

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Bulb Onion
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need of supplemental irrigation

2.2 Composting

Photo: SHEP PLUS

Manure preparation through composting

2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- Bulb Onion is a heavy feeder and does well in soils with high organic content (manure)
- Based on the results of the soil analysis, prepare adequate compost for application
- The recommended rate of application ranges from **10 – 16 tons per acre** for Bulb Onion

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application: (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted (**10 – 16 tons per acre**) then worked into the soil (incorporated) preferably using a hoe
- Manure/compost should be applied at least **1 – 2 weeks before transplanting** the Bulb Onions
- Onions respond very well to well decomposed organic manure

3.2 Raising Seedlings

Photo: SHEP PLUS

A Bulb Onion nursery

3.2 Raising Seedlings

Photo: SHEP PLUS

A Bulb Onion nursery

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Onion is **propagated by seed (fresh)**
- Seed rate is **0.8 – 1.2 kg per acre** and is sown in a nursery under a mulch cover

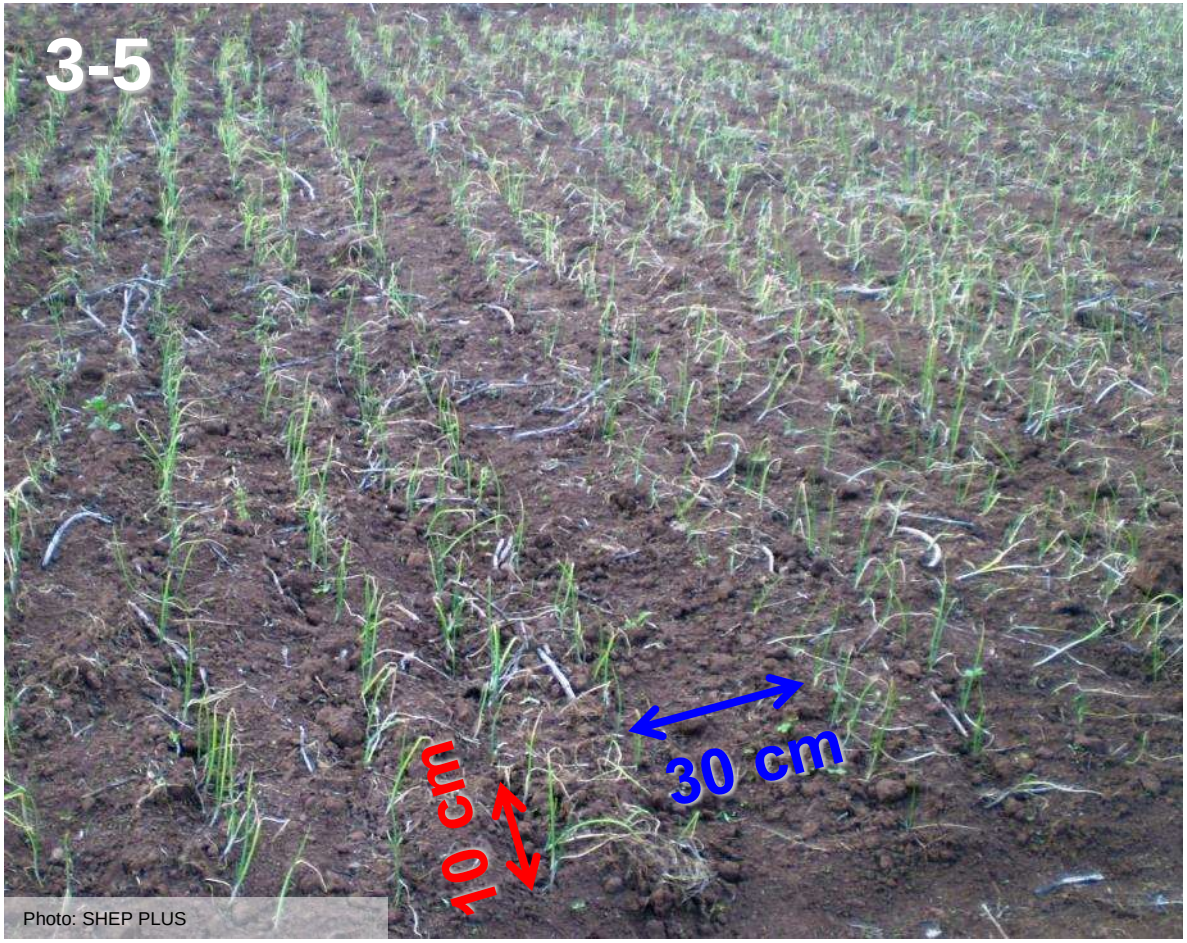
Nursery Establishment:

- Prepare beds maximum **1 m wide** and incorporate well-decomposed compost /FYM **20 kg/m^2 and add DAP/TSP 20 g/m^2**
- Make rows about **15 cm apart**, drill the seed thinly in **1cm** furrows and cover **lightly with soil** and **mulch**
- **Germination takes 7-10days**

Nursery Management:

- Irrigate the nursery bed regularly
- After the seed emerges, remove the **mulch**
- Prepare a **raised cover**
- Manage weeds, pests and diseases

3.3 Transplanting



Recently transplanted Bulb Onion seedlings

3.3 Transplanting

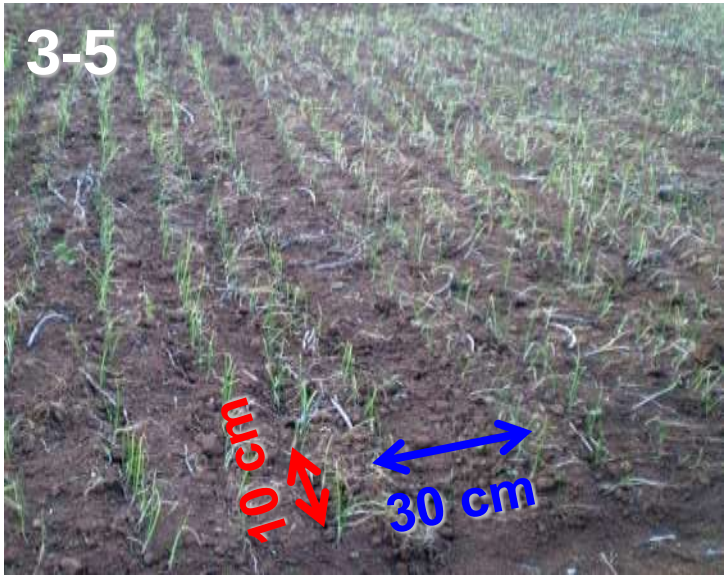


Photo: SHEP PLUS

Recently Transplanted Bulb Onion seedlings

3.3 Transplanting

3.3.1 Appropriate Time

- Seedlings are transplanted **6 – 8 weeks** after sowing or at 3-5 well formed leaves when **base** is pencil thick

3.3.2 Recommended Spacing (GHCP&PHHT20: Q10)

- The seedlings are transplanted in **2.5 – 3 cm** deep trenches at a spacing of **30 cm** between rows and **8 – 10 cm** between plants (when using furrow irrigation)

3.3.2 Transplanting Method

- Soil analysis results should be used to determine the nutrient requirements of the soil prior to planting
- Irrigate the seedbed prior to pulling out the seedlings
- Apply **80 kg/acre of TSP**
- Irrigate field well a day before transplanting
- Carefully pull out the seedlings to avoid damage
- Cut off 50 per cent of the green tops to hasten take off
- When planting onion sets, don’t bury them more than one inch under the soil

3.4 Water Requirement

Photo: SHEP PLUS

Bulb Onion Seedlings Under Irrigation

3.4 Water Requirement

Photo: SHEP PLUS

Bulb Onion Seedlings Under Irrigation

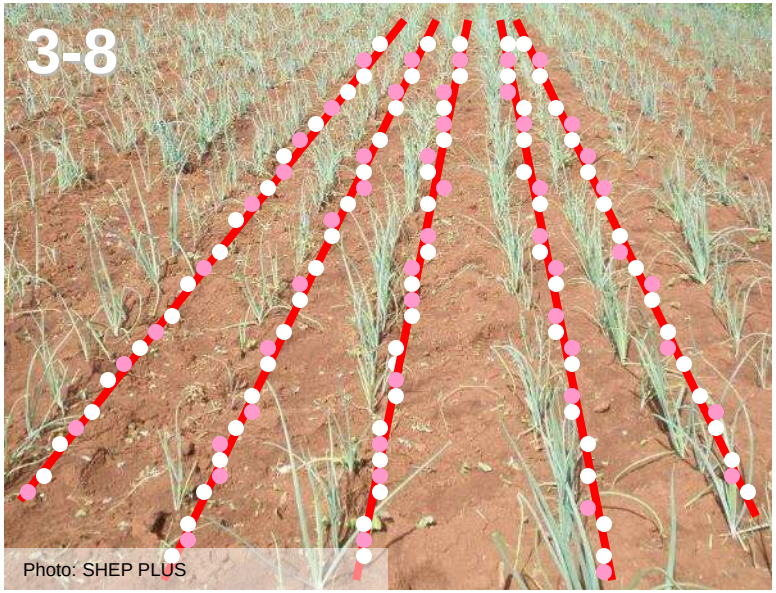
3.4 Water Requirement (GHCP&PHHT20: Q12)

- Onions require light and frequent irrigation:
  - **At the growing stage: excessive moisture** must be avoided
  - **At the bulbing stage:** need a substantial amount of water
  - Watering should be **reduced**/discontinued towards bulb maturity
- Lighter soils need more frequent water applications, but less water applied per application
- Increase the water application as plants and roots increase in size
- Proper moisture management is important in
  - Alleviating **"Pink Root"** problems (Refer to the **page No. 21/26**)
  - General root health
  - Vigorous bulb growth
- Drought stress will cause splitting or formation of double/ multiple bulbs

3.5 Top-dressing

Strip/banding top-dressing of Bulb Onions

3.5 Top-dressing



Strip/banding top-dressing of Bulb Onions

3.5 Top-dressing (GHCP&PHHT20: Q14)

- Soil analysis results should be used to know the nutrient requirements of the soil prior to planting
- Top-dressing can be done in 2 splits
  - 1st Top-dressing: **30 days** after transplanting at **40 kg/acre of CAN**
  - 2nd Top-dressing: **45 days** after transplanting at **80 kg/acre of CAN**
- Strip/banding method is preferred over broadcasting as it is more effective
- Too much nitrogen results in thick necks
- Top-dressing should be completed before initiation of bulbing

Unearthing:

- **Unearthing** is removal of excess soil around the bulb/loosening soil **to allow the bulb to expand** or **develop well**
- **Unearthing** can also facilitate the **colouring and curing**
- If the soil is hard during bulb formation, loosen the soil to allow bulbs to develop well
- Unearthing is carried out **during 2nd** and **subsequent weeding** and is done by removal of the soil from the bulbs by hand
- Watch out not to damage or expose the roots

3.6.1 Major Pests

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

3.6.1 Major Pests

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

3.6.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Bulb Onion in Kenya:
  - **A. Onion Thrips**
  - **B. Onion Fly**

3.6.1.A: Onion Thrips

Damage by Onion Thrips on Bulb Onion leaves

3.6.1.A: Onion Thrips

Onion Thrips on Bulb Onion leaves

3.6.1.A: Onion Thrips

Identification:

- Adult thrips are **small** (**0.5 – 2.0 mm**), **slender** and **winged**
- Wings are long, narrow and fringed with long hairs
- Nymphs are **white or yellow**
- Both adults and nymphs feed on the base of the plant within the leaf sheaths

Damages:

- Attacked leaves have **sunken silvery patches**
- Under severe attack, the entire plant appears **silvery** and later the leaves **wither**, **dry up** and **die**
- The pest excreta appears as **black spots** on the silvery leaves

Control:

- Keep plants well irrigated since water stressed plants are more susceptible to thrips damage
- Maintain weed-free plots
- Rogue heavily infested plants
- Neem extracts can be sprayed on attacked plants
- Spray with insecticide, such as **Spinosad (Tracer®)**, Abamectin + Acetamiprid **(AMAZING TOP 100 WDG® PHI:21days),** Acephate (ASATAF SP® PHI: 3-7days)

3.6.1.B: Onion Flies

Damage by an onion fly larva

3.6.1.B: Onion Flies

Photo: © Jarmo Holopainen
http://infonet-biovision.org/PlantHealth/Crops/Onion (CC BY-NC-SA 3.0)

Damage by an onion fly larva

3.6.1.B: Onion Flies

Identification:

- The onion fly maggots measure **8 mm long** and are **white cream in color**
- They are the most destructive stage of the fly

Damages:

- They eat the lateral roots causing tunnels into the taproot, plants become **shriveled** or eventually **die**
- They are also found inside developing onion bulbs and their feeding exposes the plant to infection by diseases like **Bacterial Soft Rot**

Control:

- Practice crop rotation
- Use well decomposed manure/compost
- Practice field sanitation: remove and destroy infested plants
- Carefully plough in crop residues immediately after harvest

3.6.2 Major Diseases

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

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

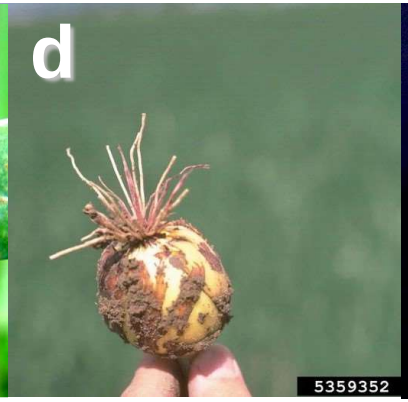
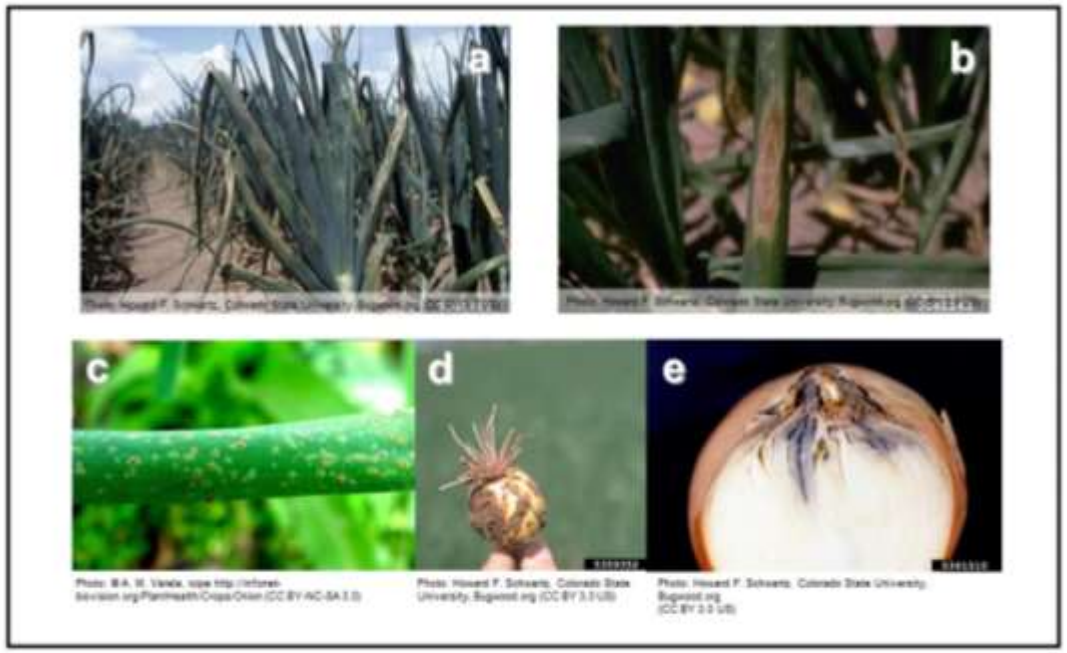


Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org
(CC BY 3.0 US)

3.6.2 Major Diseases



3.6.2 Major Diseases

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases of Bulb Onion in Kenya:
  a. **Onion Downy Mildew**
  b. **Purple Blotch**
  c. **Rust**
  d. **Pink Root**
  e. **Neck Rot**

3.6.2.a: Onion Downy Mildew

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Symptoms of “Onion Downy Mildew” infection on a Bulb Onion leaf

3.6.2.a: Onion Downey Mildew

Symptoms of "Onion Downy Mildew" infection on a Bulb Onion leaf

3.6.2.a: Onion Downey Mildew

General Descriptions:

- The disease is caused by **a fungus**
- It is prevalent in **cool**, **humid and poor drainage conditions**

Symptoms:

- **Formation of lesions** near the tips of the older leaves,
- **Yellow patches covered with grey wet fields**
- **Leaf tips shrink**, **turn pale brown** and later **die**

Control:

- Field hygiene
- Crop rotation
- Use tolerant varieties e.g. Red Pinoy F1
- Use of fungicides e.g.) **Mancozeb** (**Cadilac®**, **Dithane M45®** etc.)

3.6.2.b: Purple Blotch

Source: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Symptoms of “Purple Blotch” infection on a Bulb Onion leaf

3.6.2.b: Purple Blotch

Source: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Symptoms of "Purple Blotch" infection on a Bulb Onion leaf

3.6.2.b: Purple Blotch

General Description:

- The disease is caused by **a fungus**

Symptoms:

- **Small white spots** on the foliage
- Under moist condition, the spots rapidly increase to **large purplish blotches** often surrounded by a **yellow to orange border**
- Lesions extend to girdle the leaf which leads to its collapse
- Infection may spread to the **bulb**, where it may cause a **wet**, **orange rot** starting at the neck

Control:

- Use resistant varieties e.g. **Red Passion F1** and **Red Pinoy F1**
- Crop rotation
- **Field Sanitation:** remove crop remains after harvest, do not leave volunteer plants in the field
- Avoid over fertilization
- Recommended spacing and good drainage to decrease humidity in the plant stand
- Use of fungicides such as **Mancozeb** (**Dithane M45®**) **Difenoconazole** (**Domain 25% EC®**),
- **Propineb + Cymoxanil** (**Milraz WP 76®**)
- **Eugenol** (e.g. **Explorer 0.3 SL®**)

3.6.2.c: Rust

Symptoms of “Rust” infection on a leaf of Bulb Onion

3.6.2.c: Rust

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

Symptoms of "Rust" infection on a leaf of Bulb Onion

3.6.2.c: Rust

General Description:

- The disease is caused by **a fungus**
- **High humidity**, **high temperatures** and **dense plant population** favor the disease development

Symptoms:

- Small reddish dusty spots (pustules) on leaves
- Heavily infected leaves **turn yellow** and **die** prematurely

Control:

- Crop rotation
- Application of proper agronomic practices: proper nutrition and spacing
- **Use of fungicides**:
  - **Mancozeb** (**Dithane M45**)
  - **Difenoconazole** (**Domain 25% EC®**)
  - **Eugenol** (**Explorer 0.3 SL®**)

3.6.2.d: Pink Root

Symptoms of “Pink Rot” infection on Bulb Onion roots

3.6.2.d: Pink Root

Symptoms of “Pink Rot” infection on a Bulb Onion roots & leaves

3.6.2.d: Pink Rot

Symptoms:

- Similar to **nutrient deficiencies** or **stress** associated with extremely **dry conditions**
- Light pink to **yellowish-brown** discoloration on **roots** that becomes **dark pink** then red and eventually **purple**
- Under advanced stages, **roots** eventually **shrivel,** become **brittle** and **die**

Control:

- Good management practices that **reduce** plant **stress**
- Crop rotation
- Use tolerant cultivars e.g. **Red Passion F1** (Refer to **page No. 3/26**)

3.6.2.e: Neck Rot

Symptoms of “Neck Rot” infection on Bulb Onion

3.6.2.e: Neck Rot

3-16

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Symptoms of “Neck Rot” infection on a Bulb Onion

3.6.2.e: Neck Rot

General Descriptions:

- Disease visible when onions are in store
- Caused by a **fungus** which enters the onions through wounds or cracks in the fleshy neck part of the bulb.

Symptoms:

- Top part of the bulb will turn browner and the skin will be darker brown.
- Top of the bulb will be softer than the lower parts.
- Grey mold and sometimes speckled with small black spots will appear, and the bulbs will deteriorate even further.

Control:

- Use fungicide treated seeds or sets
- Avoid damaging onion bulbs at or during harvest
- Don't bend over foliage to hasten drying out
- Only harvest onions when the necks have ripened and fallen over on their own accord.
- Avoid using high nitrogen fertilizers
- Crop rotation at least 3 years
- Dry the bulbs out thoroughly after harvest
- Good ventilation is important in the drying process than sun.
- Store only bulbs with dried out thin necks
- Store bulbs in a cool and dry place
- Sort out bulbs which show signs of rot.

4. Harvest

Harvested Bulb Onions

4. Harvest

Harvested Bulb Onions

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Harvesting can be done **90 – 150 days** after transplanting depending on the variety
- Bulb Onions are ready for harvesting when **the leaves collapse** or when **75 % of the tops of the crop have dried and fallen over**
- Leaf tops begin to **discolor**, **bend** and **dry** towards the ground
- **Reduced thickness of sheath leaves** surrounding the bulbs (papery membranous cover)

5. Post-Harvest Handling

5.1 Curing

Photos: SHEP PLUS

Field Curing

5. Post-Harvest Handling
5.1 Curing

Field Curing

5. Post-Harvest Handling
5.1 Curing

What is "Curing"?

- Curing is **a process** intended to **dry** off the **necks** and **outer leaves** of bulbs
- The main objective is to **prolong shelf life** by **preventing moisture loss** and **attack by diseases**
- It can be done **in the field** or **in a protected environment** away from adverse weather conditions, such as rain or direct sunlight

5.1.1 Field Curing

- Curing can be done in the field if the maturity and harvesting coincides with dry months
- Harvested onions are placed in rows with leaves partially covering the bulbs to prevent **sunburn** or **greening**
- Onions are then left in the field **until the outer leaves and neck are completely dry** and **papery**
- Field curing can take **2 – 3 weeks** depending on the environmental condition

5.1.2 Protected Curing

Drying of Onions in a protected environment

- Curing is done in a **warm**, **dry** and **well ventilated location** protected from **direct sunlight and rain**
- The process involves the following:
  - Removal of excess soil
  - Trimming of foliage leaving 2.5cm of section of stem at neck
  - Placing onions in single layer in large flat tray
- Onions can also be cured by **tying tops** of bulbs in bunches and **hanging** on a **horizontal pole** in well **ventilated** shade

5.2 Value Addition Techniques

Photo: SHEP PLUS

Bulb Onions packed in the nets

5.2 Value Addition Techniques

Photo: SHEP PLUS

Bulb Onions packed in the nets

5.2 Value Addition Techniques (GHCP&PHHT20: Q19)

5.2.1 Sorting

- Before storage, Bulb Onions are sorted to remove the following:
  - **Onions with thick necks**
  - **Onions which have bolted**
  - **Injured onions**
  - **Decayed onions**
  - **Doubles and small bulbs**

5.2.2 Grading

- Grading should be done **before** & **after storage**
- For domestic market onions are put into **3 Grades: large**, **medium** and **small**
- Bulbs must be:
  - Intact with firm flesh which is not exposed
  - Clean and free from visible foreign matter
  - Sufficiently dry with the first two outer skin and stem fully dry
  - Free from abnormal external moisture
  - Free from foul smell

5.2.3 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- **Store/package Bulb Onions** in well ventilated containers such as **onion nets**

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

CABBAGE PRODUCTION

Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **Cabbage Production**

Objective: **To provide a guideline on production of Cabbage**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

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 Product Board.

1. Introduction:
1.1 Background

Cabbage (Kabeji)

1. Introduction:
1.1 Background

Cabbage (Kabeji)

1. Introduction:
1.1 Background

- Cabbage is a member of the ***Brassicaceae* (*Cruciferae*) family** which includes crops such as **Kale**, **Cauliflower**, **Broccoli** and **Radish**
- Three main types: **Green**, **Red** and **Savoy**
- One of the most **widely grown**, **popular** and **nutritious vegetables** in Kenya mainly for the domestic market
- Grown by both small and medium scale farmers
- Contains **Calcium**, **Iron**, **Vitamin A**, **C** & **E**, **Minerals**, **Riboflavin**, **Nicotinamine** and **Ascorbic Acid**
- Cabbage has cleansing effect of stomach and intestinal tract if consumed raw without salt due to high sulphur and chlorine content

1.2 Common Varieties

“Gloria F1”

“Copenhagen Market”

Photos: http://thekenyan.co.ke/farming/cabbage-growing-in-kenya/

1.2 Common Varieties

“Gloria F1”

“Copenhagen Market”

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

“Gloria F1”

- A medium-late maturing variety ready for harvesting 90 days after transplanting. Has solid blue green color and thick waxy layer. It is not prone to splitting and keeps well after harvesting.
- Tolerant to **Black Rot** and resistant to **Fusarium yellows**
- **Plant Spacing: 60 cm x 60 cm**
- **Maturity: 90 days** after transplanting (**medium-late maturing**)
- Plant population: **11,111 per acre**
- **Average head weight 3-5 kg**
- **Yield: 30,000-50,000kg per acre**

“Copenhagen Market”:

- Requires a cool/warm climate
- **Plant Spacing: 60 cm x 45 cm**
- Plant population**: 14,800 per acre**
- **Maturity: 65 – 70 days** after transplanting (**early maturing**)
- **Head:** small to medium round shape with uniform size, weighing **2 – 2.5 kg**
- **Yield: 20,000 – 30,000kg per acre**

Photos: http://thekenyan.co.ke/farming/cabbage-growing-in-kenya/

1.2 Common Varieties Cont’

Photo: http://www.seminis.com/global/us/products/Pages/CabbageBlueDynasty.aspx

“Blue Dynasty F1”

Photo: http://www.easeed.com/index.php/2015-07-16-12-56-29/vegetables/cabbage-baraka-f1

“Baraka F1”

1.2 Common Varieties Cont'

"Blue Dynasty F1"

"Baraka F1"

1.2 Some Common Varieties Cont'

"Blue Dynasty F1"

- Good tolerance to **Black Rot**, **Cabbage Ring Spot**, **Diamond Back Moth (DBM)** & **Fusarium Yellows**
- Can do well in warm areas
- **Plant Spacing**: **60 cm x 60 cm**
- Plant population: **11,111 heads per an acre**
- **Maturity: 80 – 85 days** after transplanting (**medium-late maturing**)
- **Head:** round compact shape, weighing **4 – 5 kg**
- **Yield: 45,000 – 68,000kg per acre**

"Baraka F1":

- High yielding bluish green round heads weighing **4 – 6 kg**
- **Maturity:** 75 days
- Good field holding capacity
- High tolerance to **Black Rot**, **Ring Spot** & **Cabbage Yellows**
- Good ground clearance
- **Yield: 40,000 – 50,000kg per acre**

1.2 Common Varieties Cont’

Photo: http://www.seminis.com/global/in/products/Pages/GreenChallenger.aspx

“Green Challenger F1”

Photo: http://profyseeds.com/products/cabbage-pruktor-f1-hybrid-80-seeds_130.html

“Pruktor F1”

1.2 Common Varieties Cont'

Photo: http://www.seminis.com/global/in/products/Pages/GreenChallenger.aspx

"Green Challenger F1"

Photo: http://profyseeds.com/products/cabbage-pruktor-f1-hybrid-80-seeds_130.html

"Pruktor F1"

1.2 Some Common Varieties Cont'

"Green Challenger F1"

- Blue green colour with rich creamy internal colour
- Tolerance to **Diamond Back Moth (DBM)**, **Black Rot** & **Fusarium Yellows**
- **Plant Spacing**: **30 x 30 cm/60 x 60 cm**
- **Plant Population:11,111-44,444 per acre**
- **Maturity: 60 days** after transplanting (**early maturing**)
- **Head:** round shape with compact size, weighing **2.5 – 3 kg**
- **Yield: 40,000 – 50,000kg per acre**

"Pruktor F1":

- **Plant Spacing**: **60 cm x 60 cm**
- **Population: 11,111 per acre**
- Sweet flavor
- Tolerant to **Black Rot** and **Diamond Back Moth (DBM)**
- Tolerant to **low night temperatures**
- **Maturity: 80 days** after transplanting
- **Head:** uniform size, weighing **5 – 6 kg**
- **Yield: 50,000 – 60,000kg per acre**

1.2 Common Varieties Cont’

Information Source: http://egv.aparte.dk

“Riana F1”

1.2 Common Varieties Cont'

"Riana F1"

1.2 Some Common Varieties Cont'

"Riana F1"

- **Plant Spacing: 60 cm x 60 cm**
- Both heat and cold tolerant, blue green, white internal color
- Resistant to splitting when irrigated or rain fed
- **Maturity: 90 – 100 days** after transplanting
- **Head:** Round and compact, weighing **1.5 – 2.5 kg**
- Tolerant to **Black Rot** and **Tip Burn**
- **Yield: 15,000 – 30,000kg per acre**

"Amigo F1":

- Tolerant to **Black Rot** and **Diamond Back Moth (DBM)**
- Green and semi round heads **4 – 6 kg**
- Requires warm/cool areas, **Maturity**: 90 – 100 days
- **Yield: 45,000 – 68,000kg per acre**

Other varieties grown in Kenya are:

- Prize Drumhead
- Glory of Enkhuizen
- Golden Acre
- Sugar Loaf
- Fortuna
- K-Y Cross
- Early Market F1
- Super Master F1
- Oxylus
- Star 3308 F1
- Santa F1
- Rotan F1
- Field Winner F1
- Globe Master Hybrid F1
- Queen F1
- Fanaka F1
- Tristar

1.3 Other types of Cabbages

Photo: http://www.condorseed.com/vegetables/cabbage/cabbage-red-acre/C

“Red Acre”

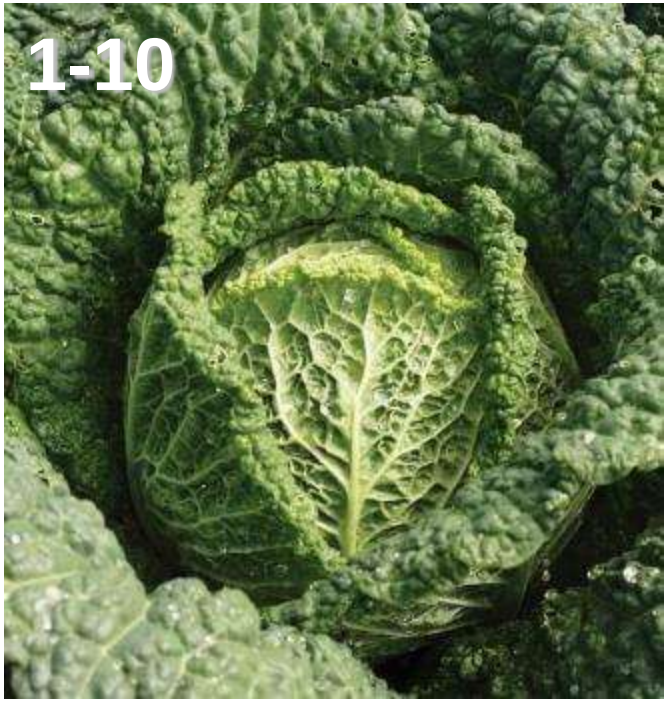

Photo: https://www.westcoastseeds.com/shop/vegetable-seeds/cabbage-seeds/savoy-capriccio/

“Savoy Cabbage”

1.3 Other types of Cabbages

Photo: http://www.condorseed.com/vegetables/cabbage/cabbage-red-acre/C

“Red Acre”

Photo: https://www.westcoastseeds.com/shop/vegetable-seeds/cabbage-seeds/savoy-capriccio/

“Savoy Cabbage”

1.3 Other types of Cabbages

1. Red Type

- Red Cabbage (*Brassica oleracea var*, *capitata fruiticosa rubra*) is just another form within same species and has much in common with Green Cabbage
- Red Cabbage has **twice** as much **Vitamin C** as Green Cabbage
- Grown varieties in Kenya are **“Mammoth Red Rock** (1.2-2.0kg/ head)**”**, **“Red Acre** (1.2-2.0kg/ head)**”**, “**Red Dynasty** (4-5kg/ head, 45-56t/ acre)”**“Ruby Ball”** etc.

2. Savoy Type

“Savoy Cabbage”:

- Savoy Cabbage (*Brassica oleracea var. sabauda.*) has **deeply crinkled and ruffled textured leaves**
- Savoy Cabbage is milder and tastier than Red and Green Cabbages and has **beta-carotene**

1.3 Optimal Ecological Requirements

Altitude	**700 – 2,200 metres above sea level**
Rainfall	**At least 500 mm**
Growing Temperature	**16 – 20 ^{0}C**
Soils	**• Well drained sandy or silty loam soils** **• High organic matter content** **• pH range 6.0 – 6.5**

1.3 Optimal Ecological Requirements

Altitude	**700 – 2,200 metres above sea level**
Rainfall	**At least 500 mm**
Growing Temperature	**16 – 20 ^{0}C**
Soils	• **Well drained sandy or silty loam soils** • **High organic matter content** • **pH range 6.0 – 6.5**

1.3 Optimal Ecological Requirements

- **Altitude:** Cabbage can be grown in altitudes ranging from **700 – 2,200 m** above sea level. At low altitude the crop should be grown during the cool months of the year.
- **Rainfall:** Cabbage has a **high water requirement** and at least **500 mm** of rainfall well distributed throughout the growing period is required.
- **Temperature:** Cabbage performs better under **cool temperatures** and the **optimum temperature** range for production is **16 – 20 ^{0}C**. Temperatures above **25 ^{0}C** hamper head formation.
- **Soil:** Cabbage requires **well drained sandy** or **silty loams** with high organic matter content and high water holding capacity. The optimal soil pH range is **6.0 – 6.5**.

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

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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

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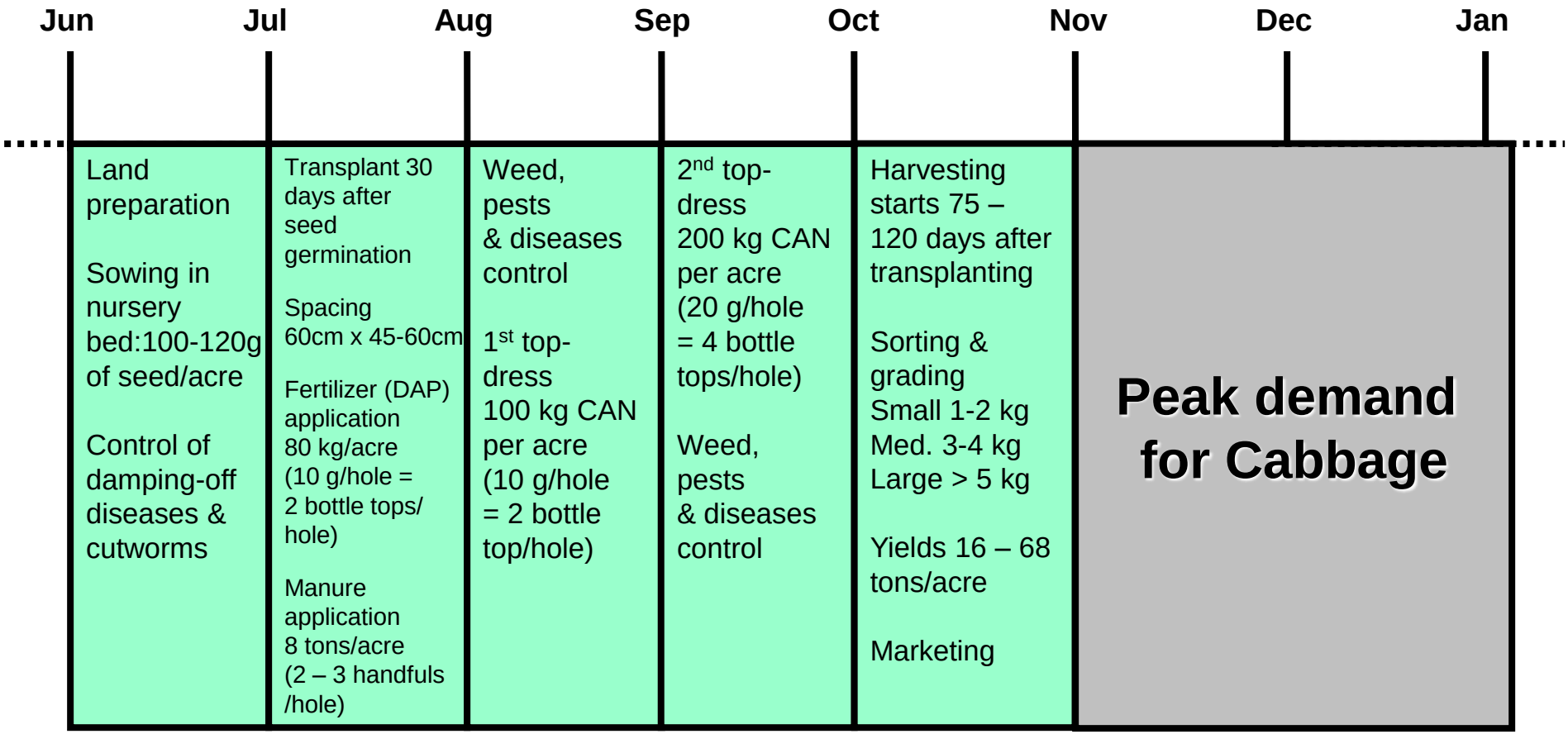
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

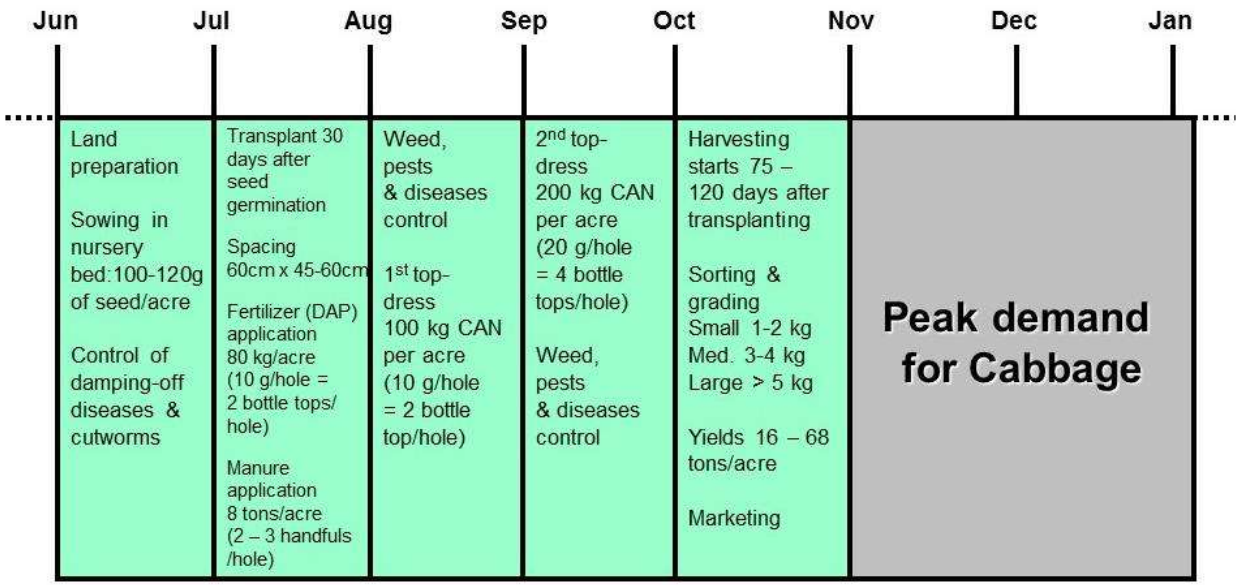
2.1 Crop Planting Calendar

A Sample of a Cabbage Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Cabbage Planting Calendar



A Sample of a Cabbage Planting Calendar: Targeting a peak market demand beginning just after November

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Cabbage
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need of supplemental irrigation

2.2 Composting

Manure preparation through composting

2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- Cabbage, like most leafy vegetables, is a heavy feeder and does well in soils with high organic content
- Based on the results of the soil analysis, prepare adequate compost for application
- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- The recommended rate of application ranges from **5 – 8 tons/acre**

3.1 Basal Application

3-3

Manure prepared for basal application

3.1 Basal Application

3-3

Manure prepared for basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted (**5 – 8 tones/acre**) then worked into the soil (incorporated) preferably using a hoe
- Manure/compost should be applied **1 – 2 weeks** before transplanting

3.2 Raising Seedlings

A Cabbage nursery

3.2 Raising Seedlings

A Cabbage nursery: seedlings 2 weeks after germination at an interrow spacing of 15 cm

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Use certified seed with special attributes, such as tolerance/resistance to pest and diseases and high yielding
- The seed rate is about **100-120 g/acre (depending on variety (F1/OP) and spacing)**

Nursery Site Selection:

- Avoid setting up the nursery in fields previously having a Cabbage crop

Nursery Establishment:

- Prepare a seedbed of **1 m width** and of a convenient length
- Make drills on the seedbed at a spacing of **10 – 20 cm apart**
- Thinly sow the seeds in the drills and cover lightly with soil

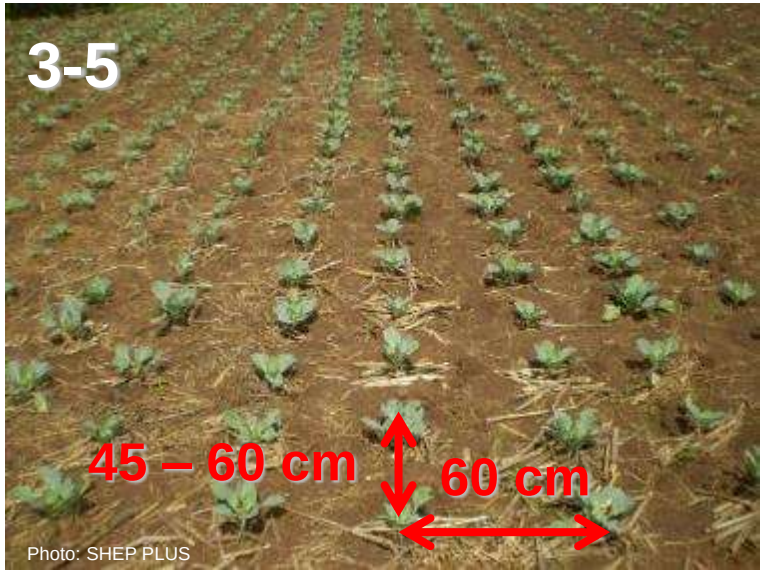
Management of Nursery:

- Water thoroughly after transplanting and regularly
- However, avoid **over-watering** which can lead to **"Damping-off"** disease
- Start hardening the seedlings **1 – 2 weeks** before transplanting by reducing the frequency of watering and the shade over the nursery
- Mulching is important to provide favourable environment for seedlings

3.3 Transplanting

Cabbage crop 2 weeks after transplanting

3.3 Transplanting



Cabbage crop 2 weeks after transplanting

3.3 Transplanting

3.3.1 Appropriate Time

- Seedlings are transplanted **30 days** after seed germination
- It is recommended that transplanting should be done either early in the morning or late in the evening

3.3.2 Recommended Spacing (GHCP&PHHT20: Q10)

- The recommended spacing is **60 cm between rows** and **45 – 60 cm between plants** depending on the variety
- Plant population: **11,000 – 14,800 plants/acre**

3.3.3 Fertilizer Application Rates (GHCP&PHHT2: Q11)

- Apply **2 – 3 handfuls** of manure per planting hole (**8 tons/acre**) and 2 half-litre water bottle tops (**10 g**) of DAP per planting hole (**80 kg/acre**)

[Note]

- **DAP** should not be applied on acid soils, use **DSP**, **TSP** or **NPK**
- Only thoroughly decomposed manure should be used to avoid possible introduction of cutworms in the field
- The **DAP** fertilizer should be mixed thoroughly with the soil to avoid possible scorching of the seedlings

3.4 Water Requirement

Photo: © Victor Omari HCD 2019

Cabbage under drip irrigation

3.4 Water Requirement

Cabbage under drip irrigation

3.4 Water Requirement
(GHCP&PHHT20: Q12)

- The optimal amount of rainfall required for Cabbage during the growing period is **500 mm**
- Regular watering ensures uniform head formation, prevents **head splitting** and increases the size of the head
- Watering should be reduced as crop matures
- Excessive watering increases water logging hence deficiencies of **Magnesium** and **Phosphorus**
- Use potable water for irrigation for food hygiene

Irrigation Methods:

- Irrigation can be **overhead**, **drip** or **furrow**

3.5 Top-dressing

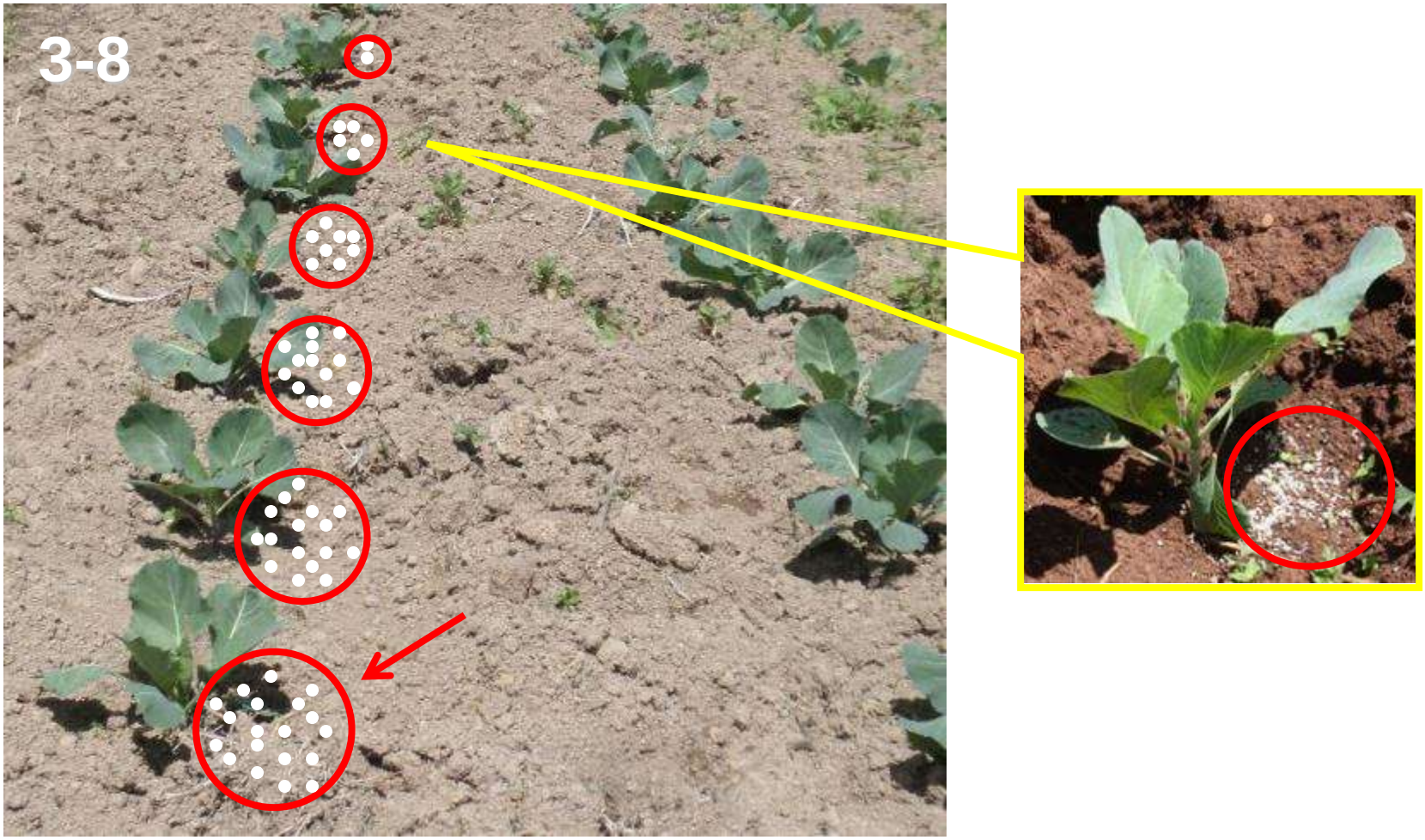
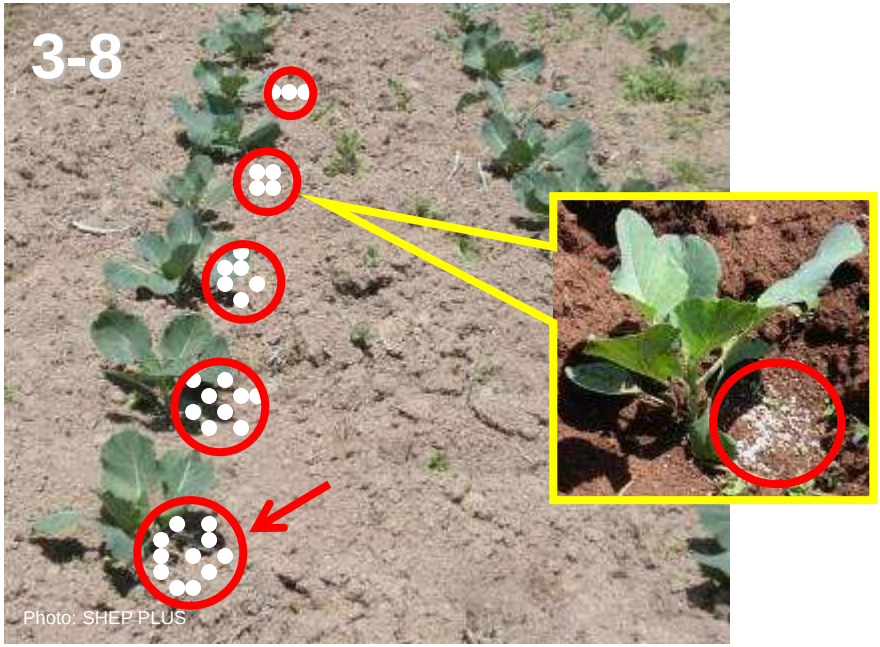


Photo: SHEP PLUS

Top-dressing using the placement method

3.5 Top-dressing



Cabbage top-dressed with CAN using the placement method

3.5 Top-dressing (GHCP&PHHT20: Q14)

- The crop should be top dressed with **CAN fertilizer** in **2 splits** to avoid nutrient loss through leaching as well as excessive soil salinity
- The first split is applied at a rate of **10 g/plant** (**100 kg/acre**) **2 – 3 weeks** after transplanting
- The second split is applied at a rate of **20 gm/plant** (**200 kg/acre**) at the onset of head formation (*KARI & The Rockefeller Foundation, 2005*)
- **Placement method** is preferred over broadcasting as it is **more effective** and **economical**

3.6.1 Major Pests

Photo: SHEP PLUS

Photo: © A. M. Valera, icipe

http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

Photo: SHEP PLUS

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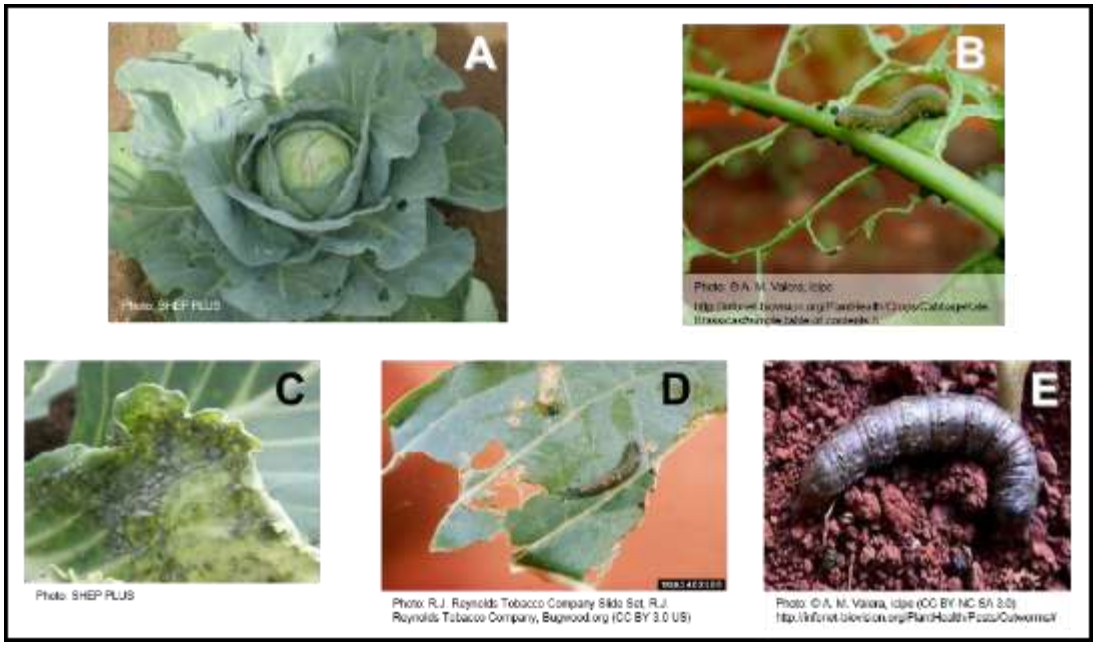
Photo: © A. M. Valera, icipe (CC BY-NC-SA 3.0) http://infonet-biovision.org/PlantHealth/Pests/Cutworms#

3.6.1 Major Pests



3.6.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Cabbage in Kenya:

A. Diamond Back Moth (DBM)
B. Cabbage Sawfly
C. Aphids
D. Slugs
E. Cutworms

3.6.1.A: Diamond Back Moth (DBM)

Photo: SHEP PLUS

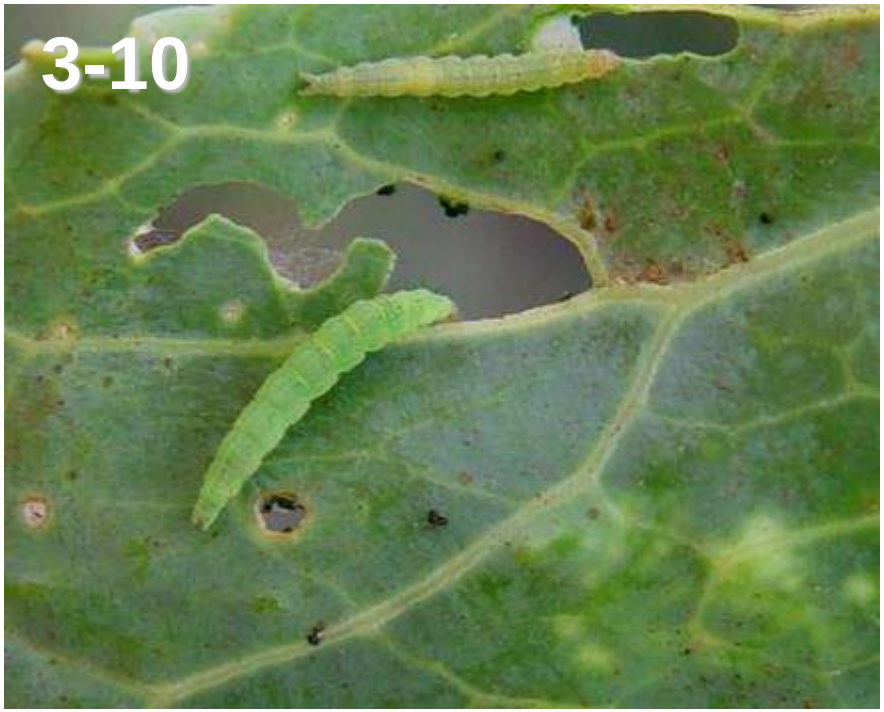


Photo: A. M. Varela, icipe (CC BY-NC-SA 3.0)

http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

Cabbage plant damaged by the DBM larvae

3.6.1.A: Diamond Back Moth (DBM)

Photo: SHEP PLUS

Photo: Am. M. Varela, icipe (CC BY-NC-SA 3.0)
http://infonet-biovision.org/PlantHealthyCrops/CabbageKale-Brassicasthsimple-table-of-contents-5

Cabbage plant damaged by the DBM larvae (inset)

3.6.1.A: Diamond Back Moth (DBM)

Identification:

- Male adult is **small grayish moth** with **diamond pattern on its back** when wings are closed
- **Eggs** laid on upper surface of leaves (one female can lay 400 eggs)

Damages:

- The **pale green larvae** feed on the underside of leaves making **"windows"**
- Pupation takes place into a silken gauze-like cocoon at underside of leaf
- Infestations are normally serious **in drier months**
- **Failure to form heads** if infested early

Control:

- Use of bio-insecticides such as ***Bacillus thuringiensis*** **(Bt)** (**DELFIN 6.4W.G®** and **HALT 50WP®**)

3.6.1.A: Diamond Back Moth (DBM) Cont’

Photo: By Indiaphotoblog at en.wikipedia, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=17047173

“Indian Mustard”: Trap Crop to reduce DBM destruction on Cabbage

3.6.1.A: Diamond Back Moth (DBM) Cont'

Photo: By Indiaphotoblog at en.wikipedia, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=17047173

"Indian Mustard": Trap Crop to reduce DBM destruction on Cabbage

3.6.1.A: Diamond Back Moth (DBM) Cont'

Control Cont':

- **Intercropping with other crops** which act as **repellants** (e.g. **Tomato**) or **trap crops** (e.g. **Indian Mustard**) reduces DBM destruction on Cabbage
- When Tomato is used as a repellant, Cabbage is planted **30 days after Tomato**
- **Use of parasitic wasp (*Diadegma spp*.)**
- Use of neem products, such as **azadirachtin (Neemraj Super 3000®)** etc.
- **Use of pesticides**, such as
  - **Chlorantraniprole 200g/L (CORAGEN 20 SC®)**
  - **Indoxcarb (AVAUNT 150 EC®)**
  - **Malathion (FEDOTHION 50 EC®)**
  - **Flubendiamide 480g/L (BELT 480 SC®)**
  - Methoxyfenoxide (RUNNER 240 SC)

3.6.1.B: Cabbage Sawfly

Photo: © A. M. Valera, icipe

http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

A “Cabbage Sawfly” larva and damage on a Cabbage leaf

3.6.1.B: Cabbage Sawfly

A “Cabbage Sawfly” larva and damage on a Cabbage leaf

3.6.1.B: Cabbage Sawfly

Identification:

- Adult **is a wasp with dark thorax** and **blight yellow abdomen**
- Adults fly slowly above the crop
- Eggs laid singly inside the leaf
- The **grayish green larvae** with fleshy warts along the body feed on the blade of the leaves: often leaving **only the main veins** and **midrib**
- Larvae drop to the ground if there is slight disturbance
- Pupation takes place **inside the soil**
- Spin tough silken cocoons

Control

- **Destruction of wild plants** of the ***Brassicaceae*** **family**
- **Use of pesticides**, such as
  - **Methoxyfenozide (RUNNER 240SC®)**
  - **Imidacloprid (MURCLOPRID 25 WP®)**
  - **Trichlorfon (DIPTEREX 95 SP®)**

3.6.1.C: Aphids

Underside of a Cabbage leaf infested with Aphids

3.6.1.C: Aphids

Underside of a Cabbage leaf infested with Aphids

3.6.1.C: Aphids

Important Types:

- Mealy Cabbage Aphid
- False Cabbage Aphid
- Green Peach Aphid

Identification of <u>Mealy Cabbage Aphid</u>:

- They are **pale green** and usually covered with **a light dust of mealy powder**
- They suck plant sap from the central part of the plant and near the base of leaves

Damage:

- Aphid attack results in curled and distorted leaves which in turn leads to **poor head formation**

Control:

- **Field hygiene** through removal and destruction of crop residue
- Natural enemies (**Parasitic Wasps**)
- **Use of Biopesticide products**, such as
  - **Azadiractin (NEEMRAJ SUPER®, ACHOOK 0.15% EC®)**
- **Use of insecticides**, such as
  - **Imidacloprid (EMERALD Gold®**)
  - **Lambdacyhalothrin (KARATE 2.5WG®**)
  - **Thiocyclam 50% w/w of thiocyclam-hydrogenoxalate (EVISECTS®**)

3.6.1.D: Slugs

Photo: R.J. Reynolds Tobacco Company Slide Set, R.J. Reynolds Tobacco Company, Bugwood.org (CC BY 3.0 US)

Cabbage plant damaged by slug

3.6.1.D: Slugs

Cabbage plant damaged by slug

3.6.1.D: Slugs

Identification:

- Found under the leaves

Damage:

- Reduced **quality** and **marketability**

Control:

- Cultural control by drowning the slugs in water (bury tins at ground level and fill with water) and **add yeast** to attract the slugs
- **Use slug pellets**

3.6.1.E: Cutworms

A Cutworm larva

3.6.1.E: Cutworms

Photo: © A. M. Valera, icipe (CC BY-NC-SA 3.0) http://infonet-biovision.org/PlantHealth/Pests/Cutworms#

A Cutworm larva

3.6.1.E: Cutworms

Identification:

- They are **grayish black larvae** that partially or completely bite the stem at ground level **causing the plant to fall over**
- They are often found hiding in soil near the cut seedlings

Control:

- **Hand removal** since the pest is easily found near the damaged plant, especially at the beginning of infestation
- **Early weeding** destroys sites for egg laying
- **Ploughing** exposes the pest to its predators and desiccation
- **Use of appropriate insecticides**, such as
  - Beauviera bassiana/ biological insecticide (BIOPOWER 1.5®)
  - Lambda Cyhalothrin (TATA UMEME 2.5EC®)
  - Acephate (ASATAF SP®)

  (Drenching should be done in the evenings)

3.6.2 Major Diseases

Photo: SHEP PLUS

Photo: SHEP PLUS

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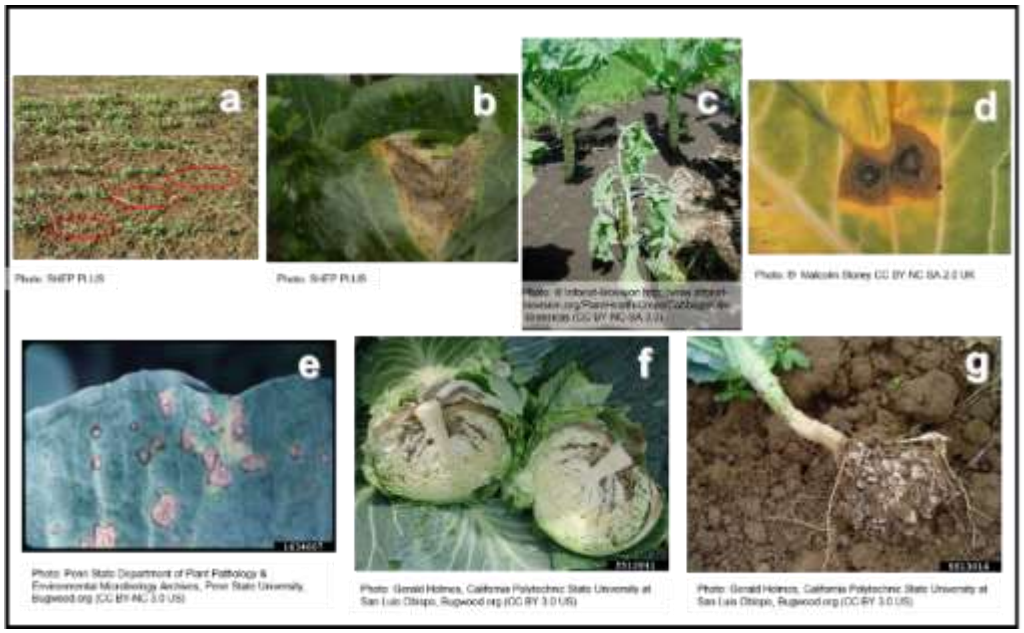
3.9.4 Major Diseases



3.6.2 Major Diseases

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases of Cabbage in Kenya:

a. Damping-off
b. Bacterial Black Rot
c. Black Leg (Dry Rot Canker)
d. Ring Spot
e. Alternaria Leaf Spot
f. Bacterial Soft Rot
g. Club Root

3.6.2.a: Damping-off

Photo: SHEP PLUS

Symptom of “Damping-off”

3.6.2.a: Damping-off

Photo: SHEP PLUS

Symptom of "Damping-off"

3.6.2.a: Damping-off

General Descriptions:

- The disease is caused by the **fungi**
- Common problem at the **nursery stage**
- More likely prevalent during **rainy season**
- **Too much moisture** will dispose the crop to the disease

Symptoms:

- **Seedlings rot** at the base of the stem thus falling over to the ground

Control:

- Avoid **dense sowing** which cause damp conditions
- Avoid **excessive watering** and **fertilization**, particularly with nitrates
- Avoid fields with a history of the disease
- Practice **crop rotation**
- Use **certified disease-free seed**
- **Solarization of seedbed** where feasible
- Use of appropriate fungicide such as Metalaxyl-M+Mancozeb (AMIDIL 68WG®)

3.6.2.b: Black Rot

Early symptom of “Black Rot” on the edge of a Cabbage leaf

3.6.2.b: Black Rot

Early symptom of "Black Rot" on the edge of a Cabbage leaf

3.6.2.b: Black Rot

General Descriptions:

- This is a **seed-borne bacterial disease**, spread through **soil + Infected debris**
- Black rot infection and spread is favored by **wet conditions** and **high temperatures** (**26 – 30 ^{0}C**)
- Crowded plants provide conditions that are ideal for bacterial spread to nearby plants

Symptoms:

- Yellow **V-shaped lesions** on the leaf margins which later turn **brown** as the leaf veins in the affected area become **black**
- A cross sectional cut of infected stem reveal a characteristic **black ring**
- In later stages, affected heads turn **black** and soft
- The rotten heads give a characteristic **offensive odour**

Control:

- Use certified seeds
- Field sanitation (burn crop residues)
- Use of resistant/tolerant varieties, e.g.) **Green Challenger**, **Amigo F1**
- Crop rotation (at least 3 years)
- Use of copper based fungicide such as AMICOP 50WP® (should be sprayed at early stage of disease infestation)

3.6.2.c: Black Leg (Dry Rot Canker)

Photo: © Jack Kelly Clark, courtesy University of California Statewide IPM Program

Photo: © Infonet-Biovision http://www.infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas (CC BY-NC-SA 3.0)

A stem infected with “Black Leg” (Left) and Blackleg infected kale wilting (Right)

3.6.2.c: Black Leg (Dry Rot Canker)

3-18

Photo: © Jack Kelly Clark, courtesy University of California Statewide IPM Program

Blackleg lesions can girdle the basal part of the stem

3-19

Photo: © Infonet-Biovision http://www.infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas (CC BY-NC-SA 3.0)

Blackleg infected kale wilting

3.6.2.c: Black Leg (Dry Rot Canker)

General Descriptions:

- This is a **seed borne fungal disease**
- Spread through **movement of infected seedlings**, **garden tools** and **crop debris**
- It is destructive in **wet soil**

Symptoms:

- Leaves have **light brown spots** which may be circular and which later develop ash **grey centres with many black spots**
- Stem has **dark cankers** extending below the soil level that kills the roots
- Destroys the **fibrous root system**
- Affected plants **wilt abruptly** and **die** or **topple** over as heads enlarge

Control:

- Use of **certified seed**
- **Field sanitation** (hygiene)
- **Crop rotation** for 1-2 years
- **Good drainage**
- Diseased plant parts should not be fed to animals if manure is to be used on fields
- Ploughing
- Application of Iprodione (ROVRAL 250 FLO ®) (spray on the base of the plants. Do not apply more than twice)

3.6.2.d: Ring Spot

A Cabbage leaf infected with “Ring Spot”

3.6.2.d: Ring Spot

A Cabbage leaf infected with "Ring Spot"

3.9.4d: Ring Spot

General Descriptions:

- This is a **seed borne fungal disease**
- Spread by **wind** or **use of compost** made from infected crop residues

Symptoms:

- **Circular brown grey spots** on the leaves which are often bordered by **a green margin** and with **black – specked concentric zones**

Control:

- Use of **certified seeds**
- Crop rotation for at least 2 years
- **Use of fungicides**, such as
  - **Tebuconazole (ORIUS 25EW, WARRIOR 25EW)**
- Maintain field hygiene

3.6.2.e: Alternaria Leaf Spot

Symptom of *Alternaria* Leaf Spot

3.6.2.e: Alternaria Leaf Spot

Symptom of

"*Alternaria* Leaf Spot"

3.6.2.e: Alternaria Leaf Spot

General Descriptions:

- **A fungal disease** that can severely damage cabbage if uncontrolled

Symptoms:

- Initial symptoms are **small**, **circular dark spots** on older leaf surfaces
- As the spots enlarge, **concentric rings** develop within lesions surrounded by **a yellow halo**
- The lesions eventually fall out, producing a hole or under wet conditions, may be covered with masses of black spores
- In storage, **spots enlarge** and soft rot bacteria may enter lesions

Control:

- Use **disease free transplants**
- Remove infected plant debris or destroy it after the season
- **Crop rotation**

3.6.2.f: Bacterial Soft Rot

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org (CC BY 3.0 US)

Symptom of the “Bacterial Soft Rot” on Cabbages

3.6.2.f: Bacterial Soft Rot

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org (CC BY 3.0 US)

Symptom of the "Bacterial Soft Rot" on a Cabbage stem

3.6.2.f: Bacterial Soft Rot

General Descriptions:

- It is **a soil borne disease**
- **High temperature** (**32 – 33 ^{0}C**) favour disease development
- The disease is spread rapidly by **rain splash** on lower leaves
- It is mainly **a post-harvest problem**

Symptoms:

- The head becomes **soft** and has **watery rot** which develops an **offensive smell**
- When the stem of the affected plant is cut, a **very bad smell** is generated

Control:

- Maintain field hygiene
- **Crop rotation** with legumes, cereals
- **Avoid harvesting when it is wet**
- Remove from the field or plough crops deeply immediately after harvesting so that the residues decompose as quickly as possible
- Handle produce carefully and store in a **cool**, **well-ventilated area**
- Foliar sprays with **copper based fungicides** such as Copper Oxychloride 50% metallic copper (COBOX 50 WP®) and (ISACOP®) at early stage of head formation
- **Use of bactericide such as Bronopol 27%** w/w **(ENRICH BM)**

3.6.2.g: Club Root

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Galls on root of Cabbage affected by the fungus

3.6.2.g: Club Root

Galls on root of Cabbage affected by the fungus

3.6.2.g: Club Root

General Descriptions:

- Extensive **galling**, **swelling** and **distortion of roots**

Symptoms:

- Galled roots often invaded by secondary rot organisms, such as soft rot bacteria resulting in rapid decay of roots
- Fungus persists as thick walled viable spores for **over 10 years**
- Fungus dispersed by surface water, movement of infected plant or soil

Control:

- **Crop rotation**
- **Field hygiene**
- Lime application creates soil condition **unfavorable** for spore formation

4. Harvest

Cabbage crops ready for harvest

4. Harvest

Cabbage crops ready for harvest

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Maturity Period: 2.5 – 4 months** after transplanting depending on variety and location
- **Maturity:** When the **head becomes firm**
- Harvest the heads **before** they **pass the prime stage** to avoid **cracking** or **splitting**
- Cut heads at the base and leave **the outer leaves** to protect the head and keeping it fresh
- Avoid bruising the head as it encourages rotting
- **Yields: 15 – 68 tons per acre** (depending on the variety and crop husbandry)
- **Varieties with firm solid heads** have good storability

5. Post-Harvest Handling

Use of appropriate crates in post-harvest handling

5. Post-Harvest Handling

Photo: https://pxhere.com/en/photo/652820 CC0 Public Domain

Use of appropriate crates in post-harvest handling

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Packed in **clean well ventilated containers/crates** and transported in covered vehicles

5.2 Value Addition Techniques: Sorting, Cleaning & Grading (GHCP&PHHT20: Q19)

- **Sorting:** Damaged and diseased heads are discarded
- **Grading:** Cabbages are graded depending on the head size: **small** (**1 – 2 kg**), **medium** (**3 – 4 kg**), **large** (**over 5 kg**)

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

CAPSICUM PRODUCTION

Prepared by SHEP PLUS

Photo: SHEP PLUS

Training Title: **Capsicum Production**

Objective: **To provide a guideline on production of Capsicum**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

Capsicum Production, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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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 Product Board.

1. Introduction:
1.1 Background

Capsicum (Pili Pili Hoho, Pili Pili Mboga)

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- Capsicum belongs to solanaceae family
- It has **a mild flavor,** is **not hot**
- It is rich in **Vitamin A** and **C**
- It also has **nutritive elements** such as **Potassium** and **Phosphorus**
- Its fruits are consumed **fresh**, **dried** or **processed** form as table vegetable or spice
- Is eaten raw in salads or cooked in food seasonings

1.2 Common Varieties

1-2

Open Field Variety

1-3

Greenhouse Production

1.2 Common Varieties

Open field variety

Greenhouse production

1.2 Some Common Varieties

There are two main types: determinate (open field) and Indeterminate (greenhouse) varieties.

- Determinate varieties: are bushy with defined growth and development period. Examples include Yolo Wonder and California Wonder
- Indeterminate varieties: achieve growth through single apical stem with few secondary branches. Examples Commandant F1, Admiral F1, Nemalite F1, Green Bell F1

1.2 Common Varieties Cont'

Photo: http://www.burpee.com/vegetables/peppers/pepper-sweet-california-wonder-prod000825.html

"California Wonder"

Photo: http://www.neseed.com/Pepper-Seeds-Yolo-Wonder-p/32400.htm

"Yolo Wonder"

1.2 Common Varieties

Photo: http://www.burpee.com/vegetables/peppers/pepper-sweet-california-wonder-prod000825.html

“California Wonder”

Photo: http://www.reseed.com/Pepper-Seeds-Yolo-Wonder.p/32400.htm

“Yolo Wonder”

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

“California Wonder”:

- Suitable for home and market gardening
- Fruits are **thick walled**, **4 lobed**, **blocky** and **compact**
- **Yield: 6,000kg per acre**

“Yolo Wonder”:

- A popular variety for **export** and **local market**
- Fruits are **shiny dark green**, **3 – 4 lobed**, **firm** and **blocky**
- It is **vigorous**, **compact** and **high yielding**
- **Yield: 6,00kg per acre**

1.2 Common Varieties Cont’

Photo: https://www.syngenta.co.ke/product/seed/

“Commandant F1”

Photo: https://www.syngenta.co.za/admiral

“Admiral F1”

1.2 Common Varieties Cont’

1-6

Picture: https://www.syngenta.co.ke/product/seed/

“Commandant F1”

1-7

Photo: https://www.syngenta.co.za/admiral

“Admiral F1”

1.2 Some Common Varieties Cont’

“Commandant F1":

- Can be grown in open field and greenhouse
- Has resistance to Potato virus, Tomato mosaic and Tobacco mosaic, pepper mild mottle and bacterial spot
- Has long harvesting period: 10 weeks and 4-6 months for open field & greenhouse respectively
- Fruits can be harvested green (75 days) or red (90 days)
- Yield: 25,000-30,000kg per acre (open field), 50,000-60,000kg per acre (green house)

“Admiral F1”:

- Can be grown in open field and greenhouse
- Has similar characteristics to Commandant F1
- Fruits can be harvested green (75 days) or yellow (90 days)
- Yield: 25,000-3,000kg per acre (open field), 50,000-60,000kg per acre (green house)

1.3 Optimal Ecological Requirements

Altitude	**0 – 2,000 metres above sea level**
Rainfall	**600 – 1,200 mm of rainfall annually**
Growing Temperature	**18 – 30 ^{0}C**
Soils	**•Well-drained loamy soils** **•pH 5.5 – 6.8** **•High organic matter**

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1.3 Optimal Ecological Requirements

- **Altitude:** Capsicum can be cultivated up to **2,000 m** above sea level
- **Rainfall:** Capsicum performs well in areas that receive **600 – 1,200 mm** of rainfall annually which is well distributed throughout the growing period is required
- **Temperature:** Capsicum performs well in **warm climatic conditions**. The optimal temperature range is **18 – 30 ^{0}C**
- **Soil:** Capsicum requires **well drained loamy**, or **heavy cracking clay soils** with high organic matter. The optimal soil pH range is **5.5 – 6.8**

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

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[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

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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

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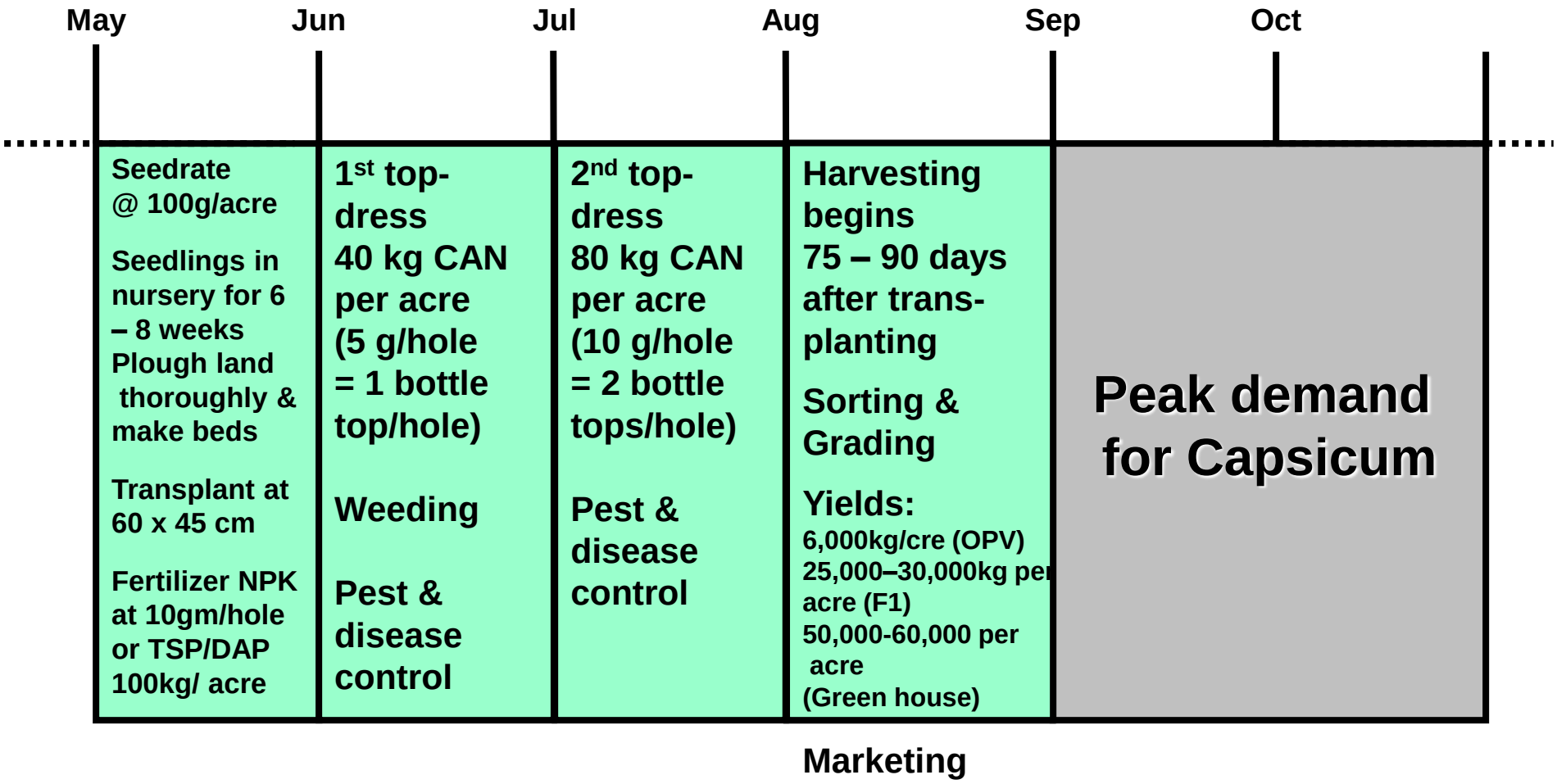
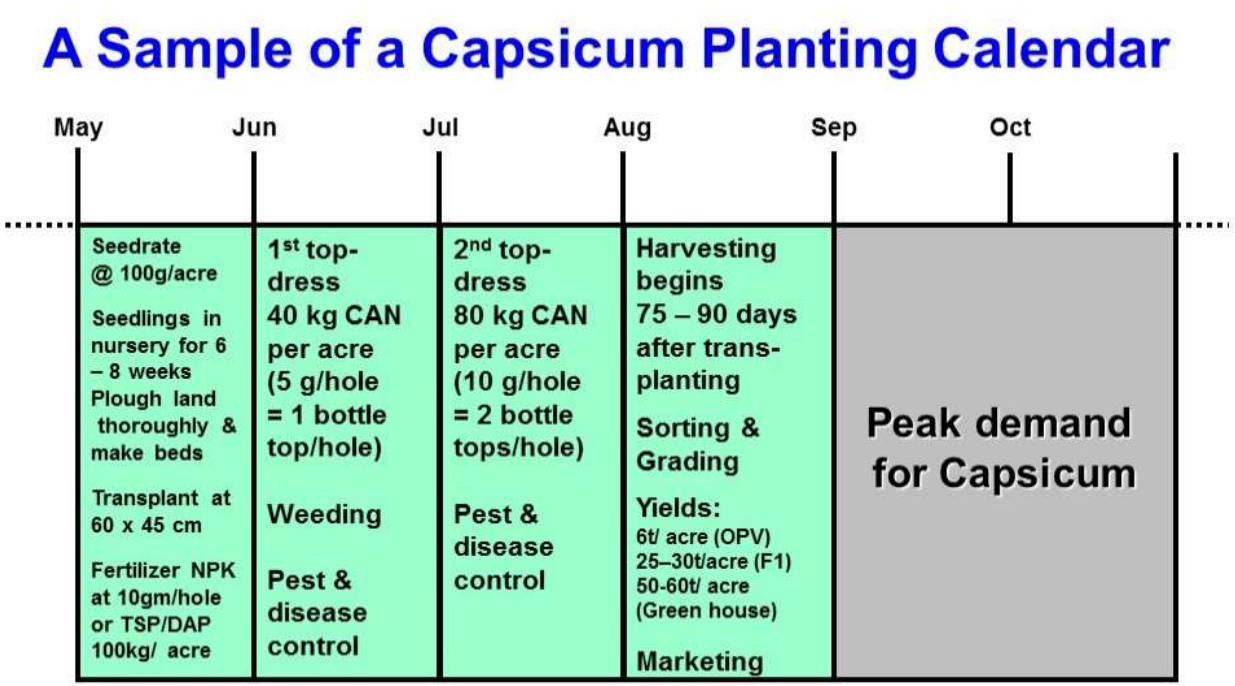
2.1 Crop Planting Calendar

A Sample of a Capsicum Planting Calendar



2.1 Crop Planting Calendar



A Sample of a Capsicum Planting Calendar: Targeting a peak market demand beginning just after September

2.1 Crop Planting Calendar (GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Capsicum
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Manure preparation through composting

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Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- Capsicum requires well composed manure to avoid soil borne diseases
- Application rate of **4 – 8 tons per acre** of manure required depending on the soil organic matter content. This is equivalent to **1 – 2 handfuls of manure per sowing hole**
- It should be mixed thoroughly with the soil in the planting hole

3.1 Basal Application

Manure incorporation as a basal application

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Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- Capsicum thrive best if supplied with a generous amount of manure/compost
- Recommendation is to supply **4 – 8 tones per acre** of organic matter
- Apply **100 kg per acre of Double Super Phosphate (DSP)/ Triple Super Phosphate (TSP)** fertilizer at sowing time
- It is however vital to confirm soil nutrients through soil analysis
- This will determine the type of fertilizer to use

3.2 Raising Seedlings

Photo: SHEP PLUS

Raising seedlings in nursery bed

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Photo: SHEP PLUS

Raising seedlings in nursery bed

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Capsicum is normally raised in nursery & transplanted but it can also be directly sown
- Capsicum can also be raised in seed trays
- Seed Rate: **100g per acre**

Nursery Site Selection:

- The nursery should be sited in a plot that has not been planted with a member of ***Solanaceae*** **family** for the last **3 years**
- The nursery site should be well drained

Nursery Establishment:

- Prepare a nursery bed of **1 m width** and of a convenient length
- Make drills on the seedbed at a spacing of **10 – 20 cm apart**
- Thinly sow the seeds in the drills and cover lightly with soil
- Water the nursery regularly
- Prepare shade and cover with organic materials such as dry grass
- The shade protects young seedlings from exposure to sun

Management of Nursery:

- Water the nursery regularly
- Harden the seedlings **1 – 2 weeks before transplanting** by reducing the frequency of watering and gradually exposing the seedlings to direct sunlight
- Control of whiteflies is important since they transmit viruses to young Capsicum plants
- These insects can be blocked from reaching the seedlings by using **an insect proof net**

3.3 Transplanting

Photo: SHEP PLUS

Transplanted Capsicum plants in the field

3.3 Transplanting

3-5

Photo: SHEP PLUS

Transplanted Capsicum plants in the field

3.3 Transplanting

3.3.1 Appropriate Time

- Seedlings are transplanted out in the field **at the 4 – 6 true leaf stage**, usually **6 – 8 weeks after sowing**
- Hardy transplants can be produced by restricting water and removing shade protection **1 week before transplanting**
- It is recommended that transplanting should be done either **early in the morning** or **late in the evening**

3.3.2 Recommended Spacing (GHCP&PHHT20: Q10)

- **Plant Spacing: 60 cm × 45 cm** or **70 cm × 30 cm** depending on the variety
- **Plant Population per Acre:** range from **14,814** to **19,047**
- Appropriate spacing produces short sturdy plants with good root system

3.3.3 Fertilizer Application Rates (GHCP&PHHT20: Q11)

- The type of fertilizer and amount needed depend on soil analysis results
- Apply **100 kg per acre** of DSP/TSP during transplanting
- The fertilizer should be mixed thoroughly with the soil

3.4 Top-dressing

Top-dressing using the placement method

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Top-dressing using the placement method

3.4 Top-dressing (GHCP&PHHT20: Q14)

- Capsicum crop should be top-dressed with organic and inorganic chemical fertilizers to produce high yields
- **1st top-dressing** is done with **40 kg per acre** of **CAN 2 – 3 weeks** after transplanting
- **2nd top-dressing** is done with **80 kg per acre** of **CAN 4 – 6 weeks** after transplanting
- During flowering high amounts of nitrogenous fertilizer should be avoided

3.5 Crop Management
3.5.1 Training & Staking

Photo: Darbie Granberry, University of Georgia, Bugwood.org (CC BY 3.0 US)

Well trained & staked Capsicum field

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3.5.1 Training & Staking

Photo: Dariac Granberry, University of Georgia, Bugwood.org (CC BY 3.0 US)

Well trained & staked Capsicum field

3.5 Crop Management
3.5.1 Training and Staking

- **Staking** keeps the plants upright and also keep the fruit away from the soil
- Staking materials: **Wood stakes**, **bamboo** or any **sturdy material**
- **Strings, plastic strips** or other material can be used for **training** the plant to the stake
- It keeps the canopy intact, thus preventing sunscald on the fruit
- It also prevents the plant from splitting during a heavy fruit load
- Staking can help minimize lodging

3.5.2 Pruning

3-13

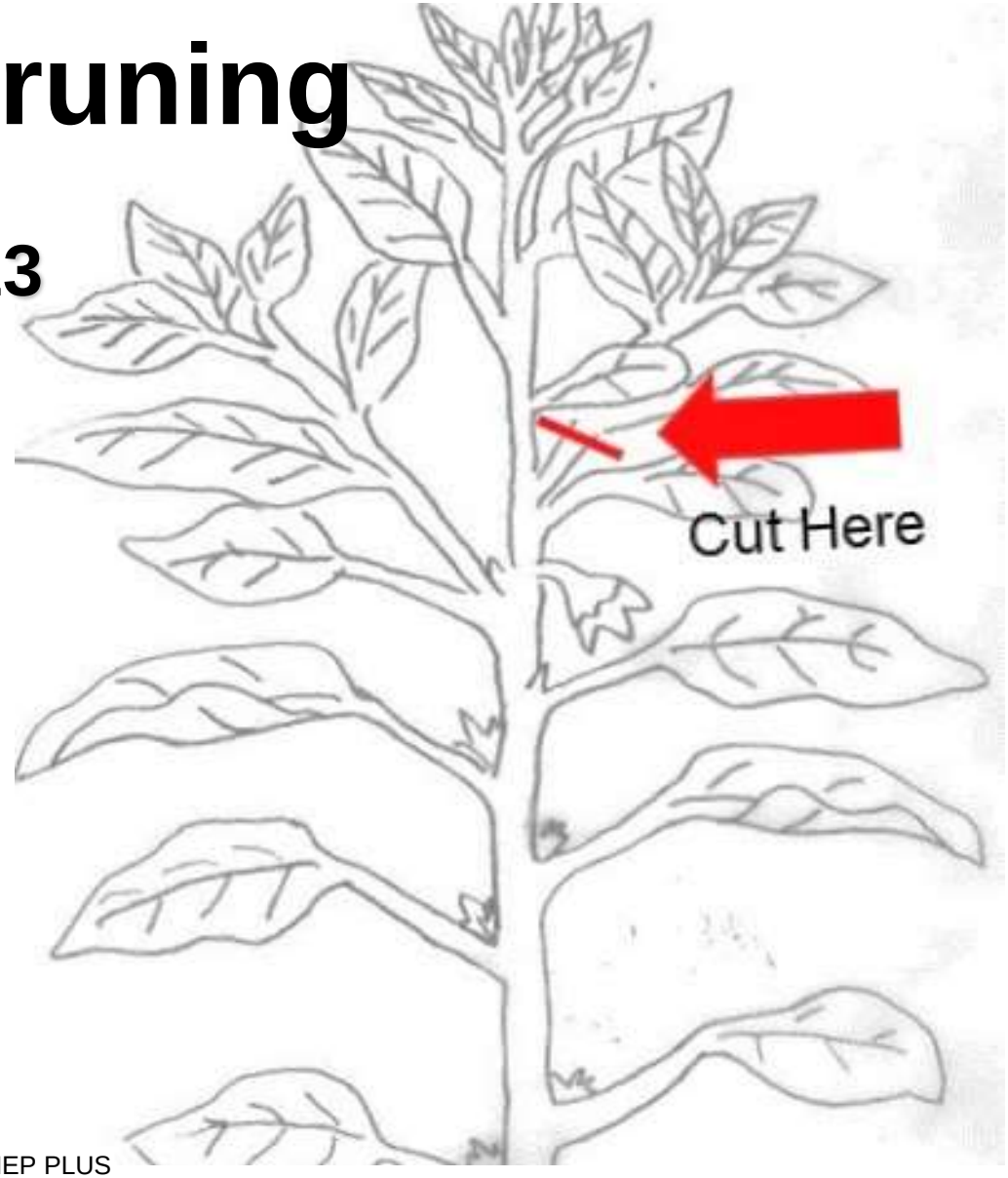
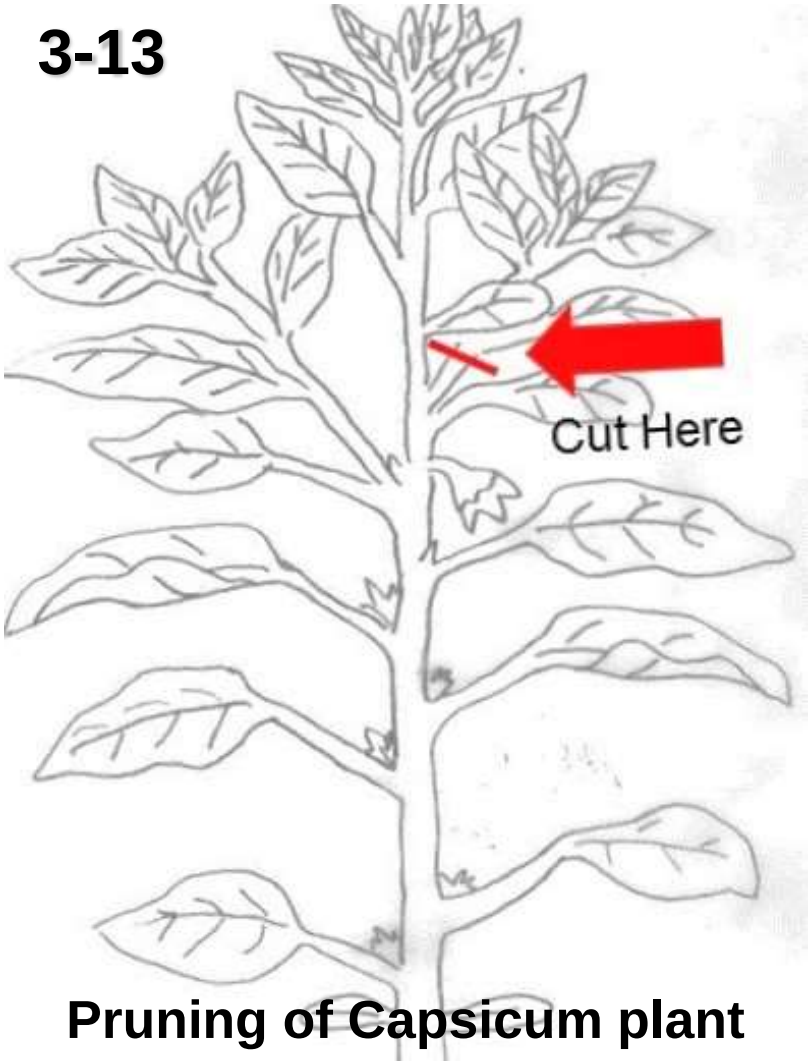


Diagram: SHEP PLUS

Pruning of Capsicum plant

3.5.2 Pruning

3-13



Pruning of Capsicum plant

Diagram: SHEP PLUS

3.5.2 Pruning

- Capsicum plants initially develop **one single stem**
- Later more shoots develop
- Each shoot will branch further after one or two leaves, while producing flower buds at the point of division
- The most common way of growing Capsicum is to facilitate development of **two main shoots**
- If three or four main shoots are required, the third and fourth must normally be **taken from the second branching**
- Side shoots should have equal vigour

3.5.3 Control Flower Load

A capsicum flower

3.5.3 Control Flower Load

A capsicum flower

3.9.3 Control Flower Load

- Capsicum plant starts flowering **about 2 – 3 weeks** after planting
- **The first flower must be removed**
- Later flowers may develop into fruit
- Sufficient leaf area must have developed for one to allow the plants to carry the fruits
- Plants with **3 or 4 axils** above the branching are big enough to be allowed to set fruit
- Young plants fruit load must be controlled by the grower, in order to achieve **a reasonable fruit weight**

3.6.1 Major Pests

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

Photo: Whitney Cranshaw, Colorado State University, Bugwood.org (CC BY 3.0 US)

Photo: John C. French Sr., Retired, Universities:Auburn, GA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

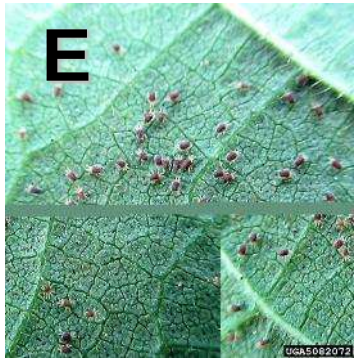


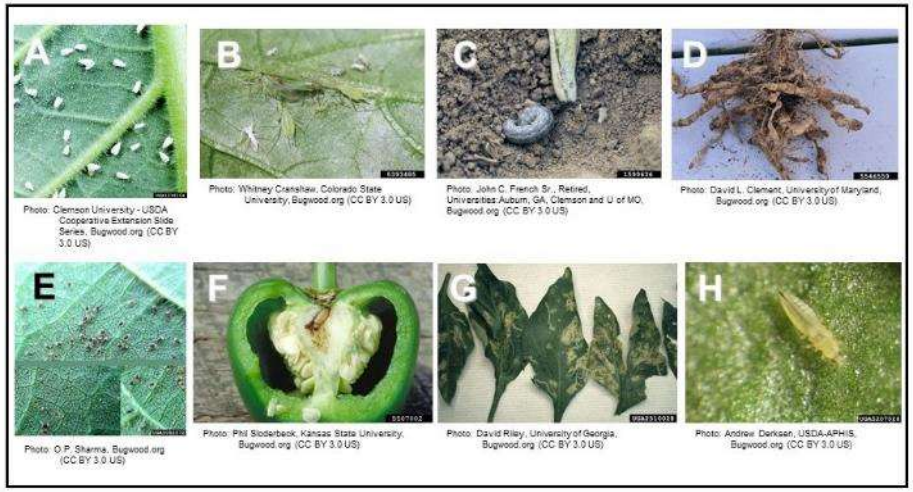
Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

Photo: Phil Sloderbeck, Kansas State University, Bugwood.org (CC BY 3.0 US)

Photo: David Riley, University of Georgia, Bugwood.org (CC BY 3.0 US)

Photo: Andrew Derksen, USDA-APHIS, Bugwood.org (CC BY 3.0 US)

3.6.1 Major Pests



3.10.3 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Capsicum in Kenya:

A. White Fly
B. Root-Knot Nematode
C. Aphid
D. Cutworm
E. Spider Mite
F. Fruit Borer
G. Leaf Miner
H. Thrips

3.6.1.A: White Fly

White Flies on a leaf

3.6.1.A: White Fly

White Flies on a leaf

3.6.1.D: White Fly

Identification :

- Whiteflies are **soft-bodied**, **winged insects** closely related to aphids
- They can be as small as 1/12 of an inch, and are often found in **clusters on the undersides of leaves**
- They are **active during daytime**
- Whiteflies are **capable of over wintering** and reproducing throughout the year **in warmer climates**

Damages:

- Whitefly immature stages (nymphs) and adults suck sap from leaves producing **chlorotic spots on infested leaves**
- Nymphs excrete **a clear sugary liquid** known as **honeydew**, which proliferates the growth of a **black sooty mould**, affecting photosynthesis
- Whiteflies are **vectors of important viral diseases**, such as **Chili Leaf Curl virus**

Control:

- Keep the seedlings protected under **a fine meshed insect netting** until they are ready for transplanting
- Make sure the netting is always properly closed
- **Use of traps** with yellow polyethylene with a sticker to attract the insects
- **Conserve natural enemies:** Parasitic Wasps, Predatory Mites, Ladybird & Lacewings
- **Spray with insecticides**, such as
  - **Lambada Cyhalothrin 106** g/kg +**Thiamethoxam** 141 g/kg (LEXUS 247 SC)

3.6.1.B: Root-knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

Symptom of “Root-knot Nematode” on roots

3.6.1.B: Root-knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

Symptom of roots damaged by "African Bollworm"

3.6.1.A: Root-knot Nematode

- Nematodes are **soil inhabitants** easily spread by infested seedlings, soil washed down the slopes or by implements
- Root–knot Nematodes are most serious on **light sandy soils**

Identification:

- **Small lumps** or **galls** develop on the infested roots
- The galls on Capsicum are much smaller than those on cucurbits or Tomato

Damages:

- Wilting of plants
- The plant roots can be seen to be **distorted**, **swollen** and bearing **galls** (**knots**)
- The infested roots eventually **rot** and **affected plants die**

Control:

- **Crop rotation**
- Mixed cropping with **African Marigold**
- Maintaining **high levels of organic matter** in the soil
- Use some bio products e.g.) **Neem extracts (Nimbecidine®, Achook EC®)**

3.6.1.C: Aphid

Photo: Whitney Cranshaw, Colorado State University, Bugwood.org (CC BY 3.0 US)

Aphids on a leaf

3.6.1.C: Aphid

Photo: Whitney Cranshaw, Colorado State University, Bugwood.org (CC BY 3.0 US)

Aphids on a leaf

3.6.1.B: Aphid

Identification:

- Aphids occur in **colonies** initially around tender plant parts and on the lower leaf surface
- When numerous, they can be found on all above ground parts of the plant

Damages:

- Aphids damage plants by sucking their sap, excreting **a sticky substance** (**honeydew**) that coats the plants, or/and by **transmitting viral diseases**
- **Curling**, **wrinkling**, or **cupping** of young leaves, **chlorotic spotting**, **mottling of older leaves**, **stunting** and **wilting** of plants
- Growth of sooty mould on honeydew excreted by aphids reduces photosynthesis and **affects fruit quality**

Control:

- **Naturally controlled by predators**, such as ladybird, beetles, hoverflies, anthocorid bugs, spiders and lacewings and by fungal diseases
- Indigenous natural enemy
  - Parasitic wasp (Aphitech®)
- **Spray with insecticides**, such as
  - **Acetamiprid 200g/Kg (PRESENTO 200SP®)**
  - **Alpha cypermethrin (DEGREE 100EC®)**
  - **Lambdacyhalothrin + Thiamethoxam (LEXUS 247SC®)**

3.6.1.D: Cutworm

Photo: John C. French Sr., Retired, Universities:Auburn, GA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

A cutworm larva

3.6.1.D: Cutworm

Photo: John C. French Sr., Retired, Universities-Auburn, CA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

A cutworm larva

3.6.1.C: Cutworm

- Cutworms are **the caterpillars of various moths**
- They drop to the soil where they live until pupation
- They hide during the day in the soil around the base of the plants and climb into plants **at night**

Damages:

- Young caterpillars feed on leaves making **small holes**
- **Cutting stems of young seedlings** at the level of the soil

Control:

- **Eliminate weeds early**, well before transplanting
- **Plough and harrow the field** to expose Cutworms to natural enemies and desiccation **3 – 4 weeks** before transplanting is done
- Dig near damaged seedlings and destroy them
- **Conserve natural enemies: Parasitic wasps** and **ants** are important in natural control of Cutworms
- Application of Azadirachtin 0.03% (NIMBECIDINE EC®) and Imidacloprid 17.8% (TATA MIDA 200SL®)

3.6.1.E: Spider Mite

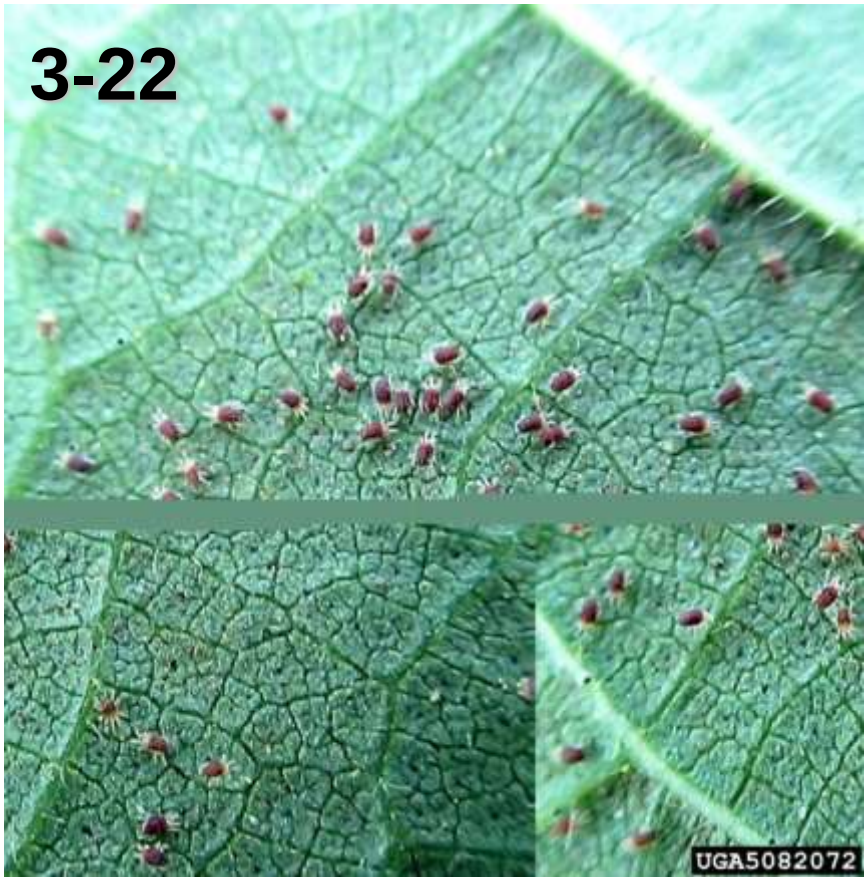


Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

Spider mites on a leaf

3.6.1.E: Spider Mite

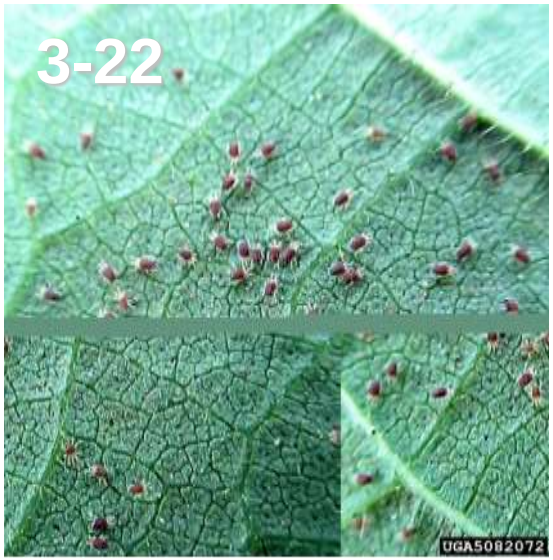


Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

Spider mites on a leaf

3.6.1.E: Spider Mite

Identification:

- Adults are **oval** and have **eight legs**
- They are **very tiny** (0.5 mm) resembling **tiny moving dots**
- They **vary in colour** depending on the species
- Many of the species are bright red in colour, others are yellowish, greenish, pinkish, orange or reddish
- The Two-spotted Spider Mite has **a large dark blotch** on each side of the body

Damages:

- Spider Mites suck the sap of the plants, **causing mottling of the upper leaf surface**
- Infested leaves first show **a white to yellowing speckling**, and then eventually **turn bronze** and **fall off** as the infestation becomes heavy
- Spider Mites prefer **the lower surface of the leaves**, but in severe infestations occur on both leaf surfaces as well as on stems and fruits
- High infestations cause **defoliation**

Control:

- **Field hygiene** is important for the management of Spider Mites
- **Conserve natural enemies**, such as **Predatory Mites**
- Chemical sprays using **miticides**, such as
  - **Oxydemeton-Methyl 250g/L (HATTRICK EC®)**
  - **AMBLYTECH® (predatory mite)**
  - **PHYTOTECH® (predatory mite)**

3.6.1.F: Fruit Borer

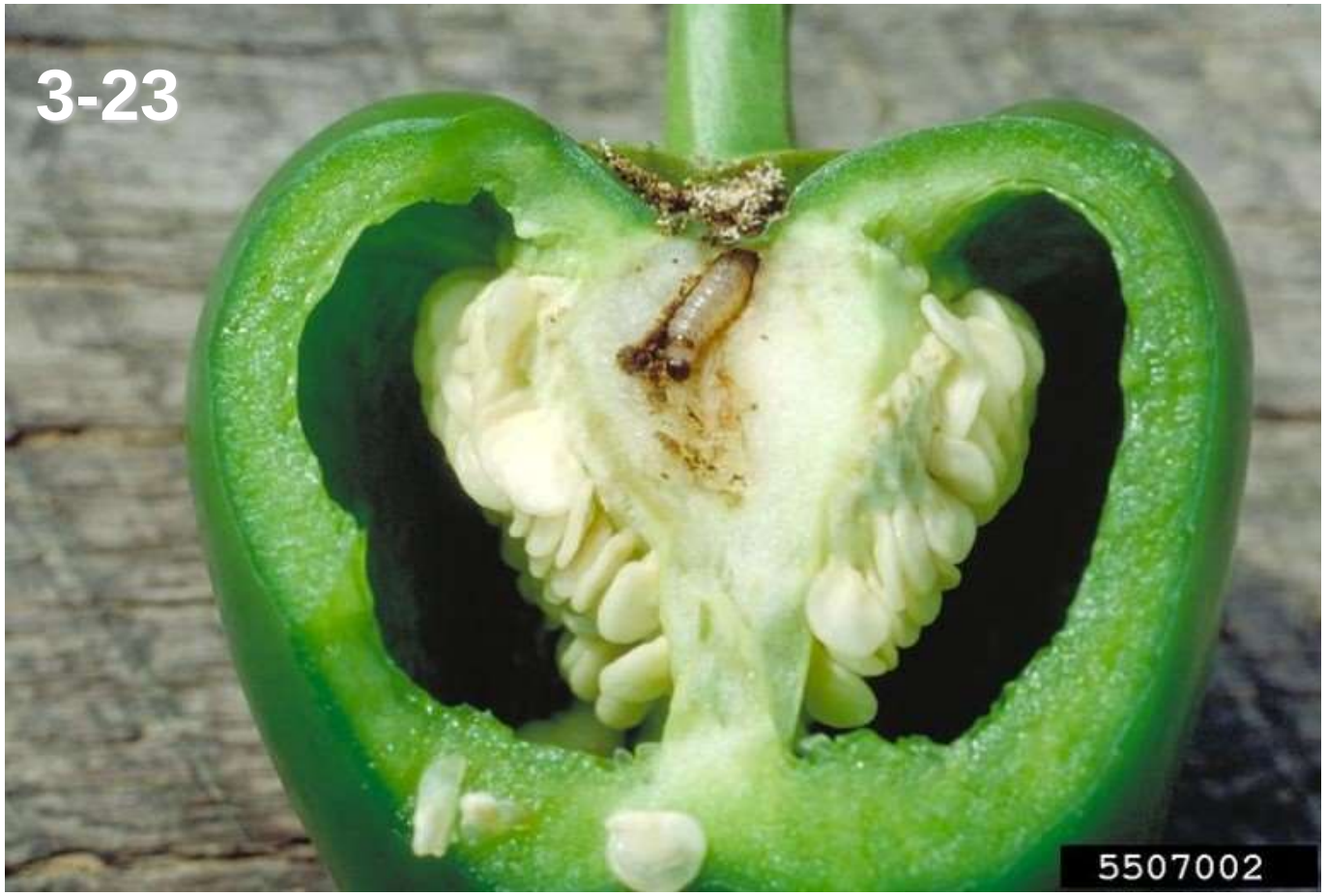


Photo: Phil Sloderbeck, Kansas State University, Bugwood.org (CC BY 3.0 US)

Fruit Borer larvae in a capsicum fruit

3.6.1.F: Fruit Borer

Fruit Borer larvae in a capsicum fruit

3.6.1.F: Fruit Borer

Identification:

- Fruits Borers (Bollworms) are **about 2 – 3.5 cm long**
- Moths are active at dusk and at night
- Moths of Fruit Borers, **feed on nectar** and **lay eggs on leaves**

Damages:

- Some species feed on leaves causing **defoliation** and **slow plant growth**
- Attack on flower buds results in **flower abortion**
- Caterpillars usually bore holes in fruits, causing **extensive damage** and **promoting decay** from secondary infection by diseases

Control:

- Check the crop regularly (**scouting**)
- **Plough the soil before planting**
- Handpick and destroy damaged fruits, eggs and caterpillars
- **Conserve natural enemies:** Parasitic Wasps, Ants, Pirate Bugs etc.
- Scouting the crop in order to detect eggs or larvae before they bore into the fruit
- **Use trap crops**, such as tasseling maize for ovipositing adult females
- Use bio-pesticides, such as **Bacillus thuringinesis (Bt)**, **neem products** or other plant extracts
- Spray **insecticides**, such as
  - **Lambda Cyhalothrin** (**Karate 2.5 WG®)**

3.6.1.G: Leaf Miner

Photo: David Riley, University of Georgia, Bugwood.org (CC BY 3.0 US)

Leaves infested by Leaf Miner

3.6.1.G: Leaf Miner

Leaves infested by Leaf Miner

3.6.1.G: Leaf Miner

Identification :

- Female flies make **numerous small**, **whitish tunnels (mines)** on the foliage when feeding and depositing eggs
- Full-grown maggots come out of the mines to pupate in the soil beneath the plants or on the foliage
- Maggots are **the most destructive stage**

Damages:

- The females lay eggs that hatch into **tiny yellow maggots** which feed on leaf tissues leaving **a wandering track** (**whitish tunnels**) known as **mines**
- The mines may **reduce photosynthetic activity**, affecting development of flowers and fruits
- These tunnels can serve as **entry points** for disease-causing organisms
- Completely mined leaves might **dry up** and **fall off prematurely**
- Wilting of plants leading to **fruit sunscald**, **death of the young plants** and **yield loss**

Control:

- **Ploughing and solarization** can help in exposing pupae to desiccation and natural enemies
- **Conserve natural enemies**
- **Neem products** are effective for controlling Leafminers
- Use of Systemic chemicals and observe PHI
- **Spray insecticides**, such as

– **Thiocyclam 50% w/w(EVISECT S®)**
– **Spinosad 480Gg/L(TRACER 480SC®)**

3.6.1.H: Thrips

Photo: Andrew Derksen, USDA-APHIS, Bugwood.org (CC BY 3.0 US)

Photo: Bruce Watt, University of Maine, Bugwood.org (CC BY 3.0 US)

Thrips and damage on capsicum leaves

3.6.1.H: Thrips

Photo: Andrew Derksen, USDA-APHIS, Bugwood.org (CC BY 3.0 US)

Photo: Bruce Watt, University of Maine, Bugwood.org (CC BY 3.0 US)

Thrips and damage on capsicum leaves

3.6.1.H: Thrips

Identification:

- Often concealed **under the calyx**
- Thrips usually feed on all above ground parts of plants preferring **the underside of young leaves**, **flowers** and **fruits**

Damages:

- Thrips puncture leaves and suck the exuding sap
- At the initial stage of infestation, leaves have a **silvery sheen** and show **small**, **dark spots of faecal material** on the underside
- Later leaves **curl upward**, **wrinkle** and finally **dry up** leading to fruit sunscald
- Damaged leaves, buds and fruits turn **rusty in colour**
- **Wilting**, **retardation of leaf development** and **distortion of young shoots** resulting in stunted plants
- Attack on fruits causes **deformation** and **scarring** of the fruits
- Thrips transmit the **Tomato Spotted Wilt virus** and **Leaf Curl disease**

Control:

- **Conserve natural enemies**, such as **Anthocorid Bugs**, **Predatory Mites** and **Spiders**
- **Spray insecticides**, such as
  - **Spinosad 480g/L (TRACER 480 SC®)**
  - **Thiocyclam 50% w/w (EVISECT S®)**

3.6.2 Major Diseases

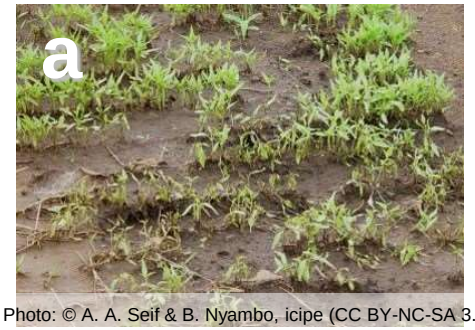


Photo: © A. A. Seif & B. Nyambo, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Pests/Damping-diseases

Photo: Seth Dale, 127103, Bugwood.org (CC BY 3.0 US)

Photo: Ontario Crop IPM, © Queen's Printer for Ontario, 2009
http://www.omafra.gov.on.ca/IPM/english/peppers/diseases-and-disorders/bacterial-soft-rot.html

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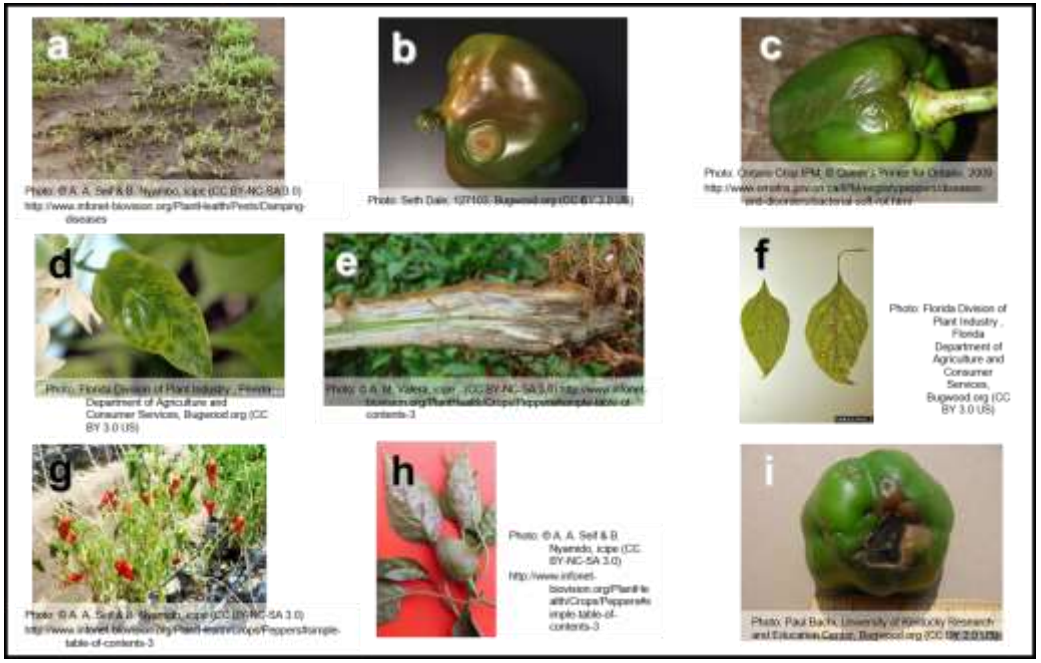
http://www.infonet-biovision.org/PlantHealth/Crops/Peppers#simple-table-of-contents-3

Photo: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org (CC BY 3.0 US)

3.6.2 Major Diseases



3.10.4 Major Diseases

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases of Capsicum in Kenya:
  a. **Damping-off**
  b. **Anthracnose**
  c. **Bacterial Soft Rot**
  d. **Viral Diseases**
  e. **Bacterial Wilt**
  f. **Leaf Spot**
  g. **Fusarium Wilt**
  h. **Powdery Mildew**
  i. **Blossom End Rot**

3.6.2.a: Damping-off

Capsicum seedlings showing symptoms of Damping-off

3.6.2.a: Damping-off

Capsicum seedlings showing symptoms of Damping-off

3.6.2.a: Damping-off

General Descriptions:

- This disease is **soil borne** caused by fungi
- There are **2 two types** of Damping-off:
  - Seedlings fail to emerge (**Pre-emergence Damping-off**)
  - Small seedlings collapse (**Post-emergence Damping-off**)

Symptoms:

- Seedlings are **stunted** through **root rot** and/or **collar rot**
- Nursery beds show **irregular patches**
- **Leaves:** lesions, abnormal colours, abnormal forms, wilting, fungal growth
- **Roots:** lesions
- **Seeds:** rot, discolorations
- **Stems:** external discoloration, canker, abnormal growth, mycelium visible
- **Whole plant:** plant death, dieback, damping-off

Control:

- Growing certified disease-free seed
- Nursery beds be located on **well drained sites**, not previously under vegetable production
- **Proper watering regime**
- Use of **appropriate fungicides** as spray or soil drench, such as
  - **Metalaxyl + Mancozeb (AMIDIL 68WG®)**

3.6.2.b: Anthracnose

Photo: Seth Dale, 127103, Bugwood.org (CC BY 3.0 US)

Capsicum fruits affected by Anthracnose

3.6.2.b: Anthracnose

Photo: Seth Dale, 127103, Bugwood.org (CC BY 3.0 US)

Capsicum fruits affected by Anthracnose

3.6.2.b: Anthracnose

General Descriptions:

- **Anthracnose** is caused by Colletotrichum spp.
- Spores dispersed by **water-splash**, **air currents**, **insects** or **other forms of contact**
- **Transmitted through seed**, but also through **infected plant parts**
- Persists on and in the **seed**, **crop residues**, and **weed hosts**

Symptoms:

- **Dark**, **sunken spots** up to **2.5 cm** across on Capsicum
- The **spots** on green and ripe fruits surface may be covered with salmon-pink mass of spores in moist weather

Control:

- Use certified disease-free seeds
- **Practice field sanitation** (removal of crop debris after harvest)
- Application of **registered fungicides**, such as
  - **Propineb (ANTRACOL WP 70®)**

3.6.2.c: Bacterial Soft Rot

Photo: © Marita Cantwell, UC Davis vegetable Produce facts English. Bell Pepper : Recommendations for Maintaining Postharvest Quality. http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=5&ds=799 (Accessed on March 20, 2019)

Bacterial Soft Rot on a Capsicum fruit

3.6.2.c: Bacterial Soft Rot

Photo: © Marita Cantwell, UC Davis vegetable Produce facts English. Bell Pepper : Recommendations for Maintaining Postharvest Quality.

http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=5&ds=799 (Accessed on March 20, 2019)

Bacterial Soft Rot on a Capsicum fruits

3.6.2.c: Bacterial Soft Rot

General Descriptions:

- The bacteria are **soil-borne**
- Soft Rot is primarily **a post-harvest problem**
- The disease is **serious during rainy periods** because the bacteria are splashed from the soil onto the fruit, which are more susceptible due to their high moisture content
- The disease begins in the **peduncle** and **calyx tissues** of harvested fruit

Symptoms:

- Fruit infected on the plant **collapses** and **hangs on the plant** like **a water-filled bag**
- When the contents leak out, a dry shell of the fruit remains

Control:

- **Crop rotation** with pulses and cereals
- **Control of insects** that cause injury to fruits
- **Post-harvest decay** can be reduced by harvesting fruits when dry
- **Minimize injury** during handling
- **Store at cool temperatures**

3.6.2.d: Viral Diseases

Photo: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org (CC BY 3.0 US)

Cucumber Mosaic Virus infection

3-35

Photo: William M. Brown Jr., Bugwood.org (CC BY 3.0 US)

Alfalfa Mosaic virus infection

3.6.2.d: Viral Diseases

3-34

Photo: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org (CC BY 3.0 US)

Cucumber Mosaic Virus infection

3-35

Photo: William M. Brown Jr., Bugwood.org (CC BY 3.0 US)

Alfafa Mosaic virus infection

3.6.2.d: Viral Diseases

General Descriptions:

- **Cucumber Mosaic Virus (CMV)** is the most important world wide
- Other viral diseases include **Alfalfa Mosaic Virus (AMV)**, **Tobacco Mosaic Virus (TMV)**, **Tomato Spotted Wilt Virus (TSWV)**, **Pepper Mottle Virus (PeMV)**, **Potato Virus Y (PVY)**, **Tobacco Etch Virus (TEV)**
- Most of these viruses are **transmitted by insects such as aphids**, **infected seed** and **a few mechanically**

Symptoms:

- Difficult to firmly diagnose by symptoms as they can be altered by factors like **cultivar**, **age of host plant**, **environmental conditions**, **host plant nutrition** and **viral strains**, not to mention the occurrence of virus mixtures
- Some symptoms are; **mosaic patterns on leaves**, **yellowing**, **ring spots**, **leaf deformation** or **distortion**, **curling of leaves**, and/or **stunting of plants**
- Also, **reduction of fruit size**, **distortion**, and/or **ring patterns** could be seen

Control:

- **Rogue out and burn affected plant (including alternative hosts) immediately**
- **Use barrier crops** to minimize virus spread
- **Use oil sprays** to reduce virus transmission by **Aphids**
- **Use reflective mulches (silver colored)** to repel **Aphids** and **Thrips**
- **Field hygiene** & **Crop rotation**
- **Control** the insect **vectors**
- Use certified seeds

3.6.2.e: Bacterial Wilt

Bacterial Wilt symptoms on capsicum plants

3.6.2.e: Bacterial Wilt

3-40

Photo: © A. M. Valera, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Crops/Peppers#simple-table-of-contents-3

Bacterial Wilt symptoms on capsicum plants

3.6.2.e: Bacterial Wilt

General Descriptions:

- The bacteria attack **a wide range of crops** and solanaceous weeds and **can survive in the soil for long periods**
- It is favoured by **wet**, **warm conditions**
- Cross sectional cut from roots and lower stems of diseased plants exude **milky streams of bacteria** from the vascular system when suspended in water

Symptoms:

- **Wilting of the entire plant** with no leaf yellowing

Control:

- **Roguing of infected plants**
- **Control Root-knot Nematodes** since they could facilitate infection and spread of **Bacterial Wilt**
- **Soil amendments** (organic manures)
- **Crop rotation** to avoid continuous planting of Solanaceous crops
- **Proper irrigation management**

3.6.2.f: Leaf Spot

Photo: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org (CC BY 3.0 US)

***Cercospora* Leaf Spot symptoms on a leaf**

3.6.2.f: Leaf Spot

Photo: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org (CC BY 3.0 US)

***Cercospora* Leaf Spot symptoms on a leaf**

3.6.2.f: Leaf Spot

General Descriptions:

- The fungus survives **on seeds** and **in crop debris**
- The disease is favored by **prolonged periods of wetness**

Symptoms:

- **Spots on leaves** are **brown** and **circular** with small to large light grey centers and **dark brown margins**
- **Spots on stems**, **petioles** and **peduncles** are typically elliptical with same characteristic colour

Control:

- Use **certified seeds**
- **Maintain adequate soil moisture**, especially **at fruit development stages**
- **Carry out soil liming** in calcium deficient soils
- **Top-dress with CN** and ensure adequate soil moisture
- Maintain **field sanitation**
- **Spray the crop with calcium chloride, Mancozeb (Dithane M45WP®)**

3.6.2.g: Fusarium Wilt

Fusarium Wilt on crops in the field

3.6.2.g: Fusarium Wilt

3-43

Photo: © A. A. Seif & B. Nyamido, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Crops/Peppers#simple-table-of-contents-3

Fusarium Wilt on Capsicum plants in the field

3.6.2.g: Fusarium Wilt

General Descriptions:

- The fungus lives **indefinitely in the soil**
- It is spread by **irrigation water**
- It is very susceptible to changes in temperature and soil moisture
- It is serious **in poorly drained fields**

Symptoms:

- **Drooping** and **yellowing** of lower leaves followed by **wilting** of the entire plant
- Leaves on infected plants remain attached and the vascular system of the plant is discoloured, particularly in the lower stem and roots

Control:

- Crop rotation
- **Lime the soil** (soil pH 7.0 – 7.5 reduces fusarium wilt disease)
- Ensure the soil has **a good drainage**

3.6.2.h: Powdery Mildew

http://www.infonet-biovision.org/PlantHealth/Crops/Peppers#simple-table-of-contents-3

Leaves showing the initial sporulation

3.6.2.h: Powdery Mildew

Leaves showing the initial sporulation

3.6.2.h: Powdery Mildew

General Descriptions:

- The disease is caused by **a fungus**
- It is favoured by **warm**, **humid** and **dry weather**

Symptoms:

- **Yellowish blotches** appear on upper surface, **spots** with **a white to grey powdery fungal growth** appear on the lower leaf surface
- The disease progresses **from the older to younger leaves** shedding the foliage
- Leaf defoliation leads to **reduction in size and number of fruits**

Control:

- Apply **preventive fungicides**, such as
  - **Sulphur (Cosavet DF®)**
- **Remove and destroy crop debris** after harvest

3.6.2.i: Blossom End Rot

Photo: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org (CC BY 3.0 US)

Advanced Blossom End Rot symptoms on Capsicum fruits

3.6.2.i: Blossom End Rot

Advanced Blossom End Rot symptoms on Capsicum fruits

3.6.2.i: Blossom End Rot

Symptoms:

- The end of the fruit becomes **off-whitish** to **brown in colour** and takes on a **"sunken" appearance**
- As the fruit matures, these symptoms become **more pronounced** and the colour of the rot becomes **dark brown** to almost black

Control:

- Boost the soil with calcium by adding **lime**, **Calcium Nitrate**, **dolomite**, **gypsum** or **composted animal manures** before planting the seedlings
- **Water regularly:** Capsicum continue to flower and bear fruit for prolonged periods of time, so ensure the soil around their roots is kept moist
- **Avoid fertilizers with a high nitrogen content:** Nitrogen fertilizers will promote leaf growth at the expense of fruit, allocating calcium to the leaves instead of to the fruit

4. Harvest

Photo: OakleyOriginals (CC BY 2.0) https://www.flickr.com/photos/oakleyoriginals/3616117273/

Capsicums at harvesting stage

4. Harvest

Capsicums at harvesting stage

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Maturity periods range between **2 – 3 months** after transplanting
- Capsicum fruits can be harvested when they are **harvestable-green** or developed full colour
- Green fruits are incapable of ripening after removal from the plant
- The right stage for red fruit is when they have reached **full colour**, **filled out**, **still firm**, **sticky** and **thick walled**

Harvesting Method:

- Since Capsicums have soft pliable thin flesh, **care should be taken during harvesting**
- Use clean **knife** or **scissors** to harvest the fruits
- Fruits should be harvested **early in the morning** when it is cool since the fruit temperature is low
- Harvested fruits should be kept in a **cool**, **shaded** and **ventilated area** in order to minimize heat gain
- **Yield Potential: 6t/ acre** (OPV), **25–30t/ acre** (F1) open field and **50–60t/ acre** (F1) greenhouse depending on the variety and crop husbandry

5. Post-Harvest Handling Cont’

Photo: SHEP PLUS

Harvested Capsicums

5. Post-Harvest Handling Cont'

Photo: SHEP PLUS

Harvested Capsicums

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Harvested Capsicum peppers are packed into plastic crates then transported to markets
- Peppers are sensitive to ethylene and should not be stored with fruits that produce ethylene such as bananas and avocados

5.2 Value Addition Techniques: Cleaning, Sorting, Grading, & Processing (GHCP&PHHT20: Q19)

Sorting:

- Eliminate all fruits harvested with defects

Grading:

- Grade Capsicum based on its **uniform color**, **maturity**, **shape** and **size**

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

COWPEA LEAVES PRODUCTION

Photo: © Victor Omari, HCD 2019

Photo: SHEP PLUS

Prepared by SHEP PLUS

Training Title: **Cow Pea Production**

Objective: **To provide a guideline on production of Cow Pea**

Specific Objective:

- **To provide basic information on production, post-harvest handling, and marketing of Cow Pea leaves**

Contents:

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  Kilimo House, Cathedral Road, P.O. Box 34188-00100, Nairobi, KENYA, Tel: 020-2718870
- **Agriculture and Food Authority (AFA), Horticultural Crops Directorate (HCD):**
  Airport Road, Opp. JKIA, P.O. Box 42601-00100, Nairobi, KENYA, Tel: 020-2131560/3597356
- **Japan International Cooperation Agency (JICA) Kenya Office:**
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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in the cases. But where applicable, it is recommended that the instructions issued be given due consideration.

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 Product Board.

1. Introduction:
1.1 Background

Cowpea (Kunde)

1. Introduction:
1.1 Background

Photo: © Victor Omari, HCD 2019

Cowpea (Kunde)

1. Introduction:
1.1 Background

- **Cowpea** is one of **the most important crops** in the dry lands of Kenya, but it is gaining popularity across the country
- It is grown as pure stand or **intercropped with Maize and Sorghum**
- It's **drought tolerant**, performs well in a wide variety of soils, and being a legume, replenishes low fertility soils when the roots are left to decay
- Grown both as a **leafy vegetable** and for its **grain**
- Plant types can be classified as **erect**, **semi-erect** or **trailing types**
- **Rich in calcium, iron, zinc, and vitamin B complex**

1.2 Common Varieties

“Machakos 66 (M 66)”

“Katumani 80 (K 80)”

1.2 Common Varieties

“Machakos 66 (M 66)”

“Katumani 80 (K 80)”

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

“Machakos 66 (M66)”:

- A dual purpose bushy **semi-spreading variety**
- Flowers **55 – 60 days** after germination
- Grown in higher altitude of **1,200 – 1,500 m.a.s.l.**
- Tolerant to yellow mottle virus and scab and partly to aphid and thrips damage
- Moderately tolerant to **Septoria Leaf Spot** and **Powdery Mildew**

“Katumani 80 (K80)”:

- A dual purpose variety (vegetable & grain) with **sprawling growth habit**
- Flowers **50 days** after emergence
- Tolerant to **Aphids**, **Thrips**, **Pod borers** and **Leafhoppers**
- Susceptible to **Cowpea Yellow Mosaic Virus (CYMV)**

1.2 Common Varieties Cont’

“KVU 27-1”

1.2 Common Varieties Cont'

"KVU 27-1"

1.2 Some Common Varieties Cont'

"KVU 27-1":

- A dual purpose variety with **a semi-spreading habit**
- Moderately tolerant to **Aphids**, **Thrips**, **Pod borers** and **Leafhoppers**
- Moderately resistant to **fungal diseases** and **mosaic virus**

- The 3 varieties above are for arid and semi-arid areas

Other varieties grown in Kenya:

"Kenkunde":

- A reddish brown pea which is drought tolerant but is bitter

Others:

- **KVU 419**, **Kunde 1**, **KCP 022**, **Ngombe**
- **Local Varieties:** these differ from one area to another and is defined by among other aspects, seed colour **e.g.)** white seed, black seed, growth habit or whether it's drought tolerant or does well in wet season

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,500 meter above sea level**
Rainfall	**200 – 700 mm annually**
Growing Temperature	**20 – 35 ^{0}C**
Soils	**•Well drained sandy loams or sandy soils** **• pH range 5.5 – 6.5**

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,500 meter above sea level**
Rainfall	**200 – 700 mm annually**
Growing Temperature	**20 – 35 ^{0}C**
Soils	• **Well drained sandy loams or sandy soils** • **pH range 5.5 – 6.5**

1.3 Optimal Ecological Requirements

- **Altitude:** Cowpea can be cultivated up to **1,500 m** above sea level
- **Rainfall:** Minimum rainfall of **200 mm per growing season** is required for most varieties. The crop does well in rainfall up to 700 mm. Rainfall should be well distributed throughout the growing period.
- **Temperature:** The optimum temperature for growth and development is **20 – 35 ^{0}C**. It tolerates heat and dry conditions. Colder temperatures slow down germination
- **Soil:** Cowpea performs well in a wide variety of soils and soil conditions. Well drained sandy loams or sandy soils are suitable. Soil pH range is **5.5 – 6.5**

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

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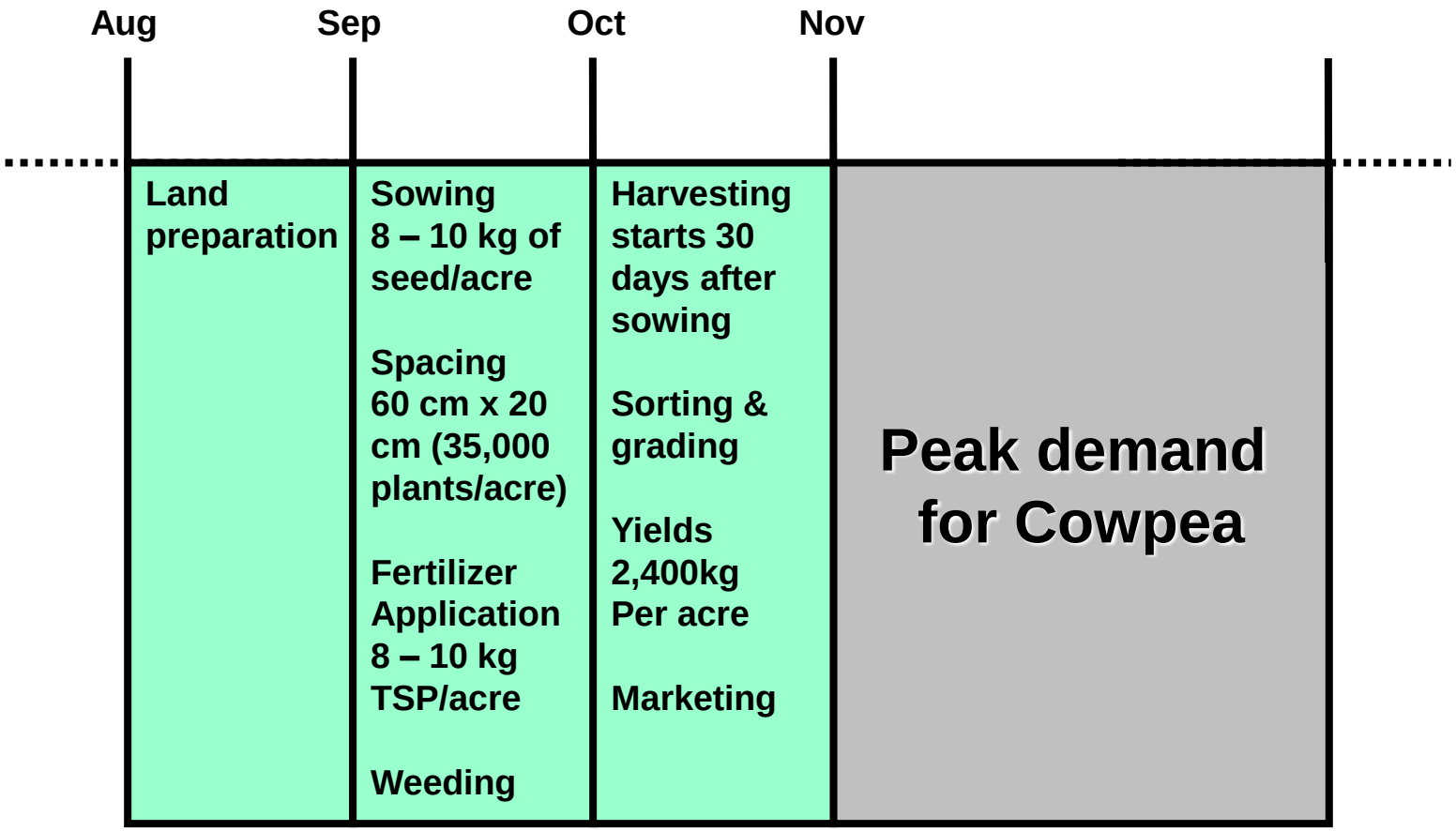
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

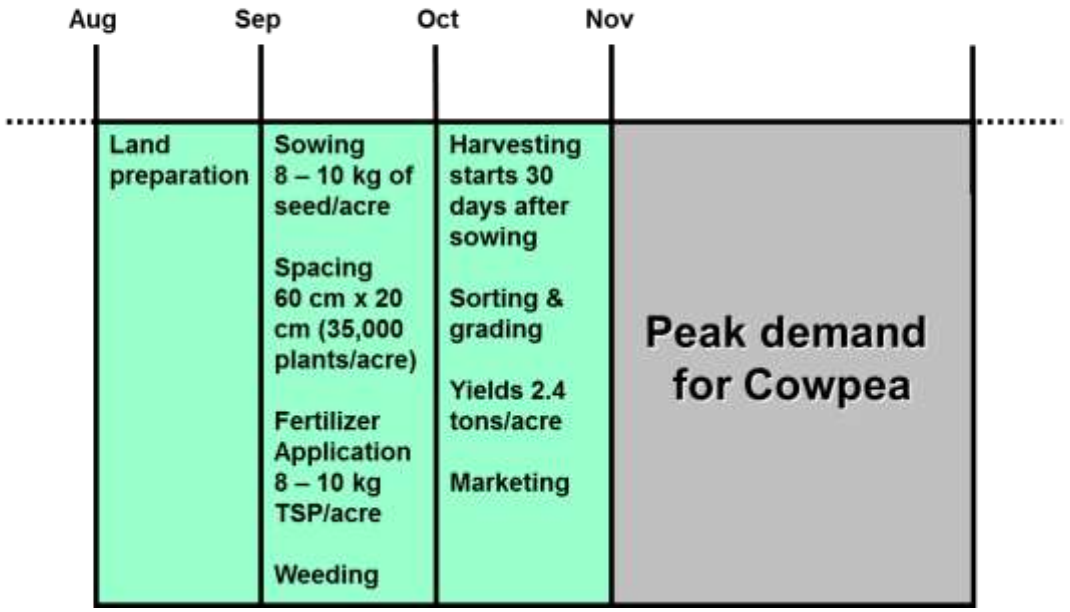
2.1 Crop Planting Calendar

A Sample of a Cowpea Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Cowpea Planting Calendar



A Sample of a Cowpea Planting Calendar: Targeting a peak market demand beginning just after November

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Cowpea
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Photo: SHEP PLUS

Well composted manure ready for use

2.2 Composting

Photo: SHEP PLUS

Well composted manure ready for use

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter needs to be covered to prevent leaching of nutrients
- Based on the results of the soil analysis, prepare adequate compost for application
- Where soils are highly eroded, an application of **2 tons per acre** of dry compost or manure is beneficial
- Generally, Cowpea is more tolerant to infertile soils than many other crops

3.1 Basal Application

Photo: SHEP PLUS

Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- Pre-plant phosphorus (**P**) can be applied in form of fertilizer (**TSP**) at the rate of **8 – 10 kg** (17-22kg TSP) **per acre**
- Manure/compost should be applied **1 – 2 weeks before** planting and incorporated into the soil
- The manure/compost should be broadcasted (**2 tons per acre**) then worked into the soil (incorporated) preferably using a hoe

3.2 Planting

Young cowpea seedlings

3.2 Planting

Photo: © IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/6938018228/

Young cowpea seedlings

3.2 Raising Seedlings
(GHCP&PHHT20: Q9)

- Cowpea is directly grown from seed
- The seed can be inoculated with *Rhizobium* (e.g. Biofix) which boosts the positive effects of nitrogen fixation

3.2.1 Appropriate Time

- Early planting after **30 mm** of rainfall is received
- **Seed rate: 8 – 10 kg per acre** and **3 – 4 seeds per hill**
- Seed should be planted at **4 – 5 cm deep**
- Seedlings are thinned to one **after 2 weeks**

3.2.2 Recommended Spacing (GHCP&PHHT20: Q10)

- The seeds are planted at a spacing of **60 cm** between rows and **30 cm** between plants for both **vegetable** and **grain production**
- Plant Population: **22,222 per acre**

OR

- **30 – 40 cm** between rows and **8 – 10 cm** between plants purely for **vegetable production** (uprooting at **3 – 5 true-leaf stage**)
- Plant Population: **166,666-100,000** per acre

3.3 Fertilizer Application

Triple Super Phosphate (TSP)

3.3 Fertilizer Application

Photo: Di Rasbak - Opera propria, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1734539

Triple Super Phosphate (TSP)

3.3 Fertilizer Application

- Cowpea does not require too much nitrogen fertilizer because it fixes its own nitrogen from the air using the nodules in its roots
- Cowpea requires more phosphorus than nitrogen to help the plant nodulate well and fix its own nitrogen from the air
- Single or **Triple Super Phosphate** fertilizer should be applied at a rate of **17-22kg per acre**

3.4 Water Requirement

Photo: © Victor Omari HCD 2019

Drip irrigation

3.4 Water Requirement

Photo: © Victor Omari HCD 2019

Drip irrigation

3.4 Water Requirement
(GHCP&PHHT20: Q12)

- Cowpea is a more drought-tolerant crop compared to many other crops. It grows under rainfall ranging from **200 – 700 mm** per annum
- Cowpeas utilize soil moisture efficiently than other crops
- It reacts to serious moisture stress by limiting growth (especially leaf growth) and reducing leaf area by changing leaf orientation and closing stomata
- Cowpeas are usually grown **under dryland** rather than irrigated conditions (For continuous production, irrigation is required)

3.5 Managing of Weeds

Photo: SHEP PLUS

Weed-free field of Cowpea

3.5 Managing of weeds

Weed-free field of Cowpea

3.7 Managing of Weeds (GHCP&PHHT20: Q13)

- Cowpea has a deep root system.
- Weeding is done once or **twice in the growing season**
  - **First Weeding:** 2 weeks after emergence
  - **Second Weeding:** as need arises
- This can be done through use of appropriate weeding tools
- Cowpeas may also be affected by the parasitic weed ***Striga* spp**. This is controlled by hand weeding before it sets seeds
- Where this weed is a problem, soil fertility improvement is important
- Use of manure and/or small quantities of fertilizer may reduce infestation, when combined with weeding of plants before seed setting

3.6.1 Major Pests

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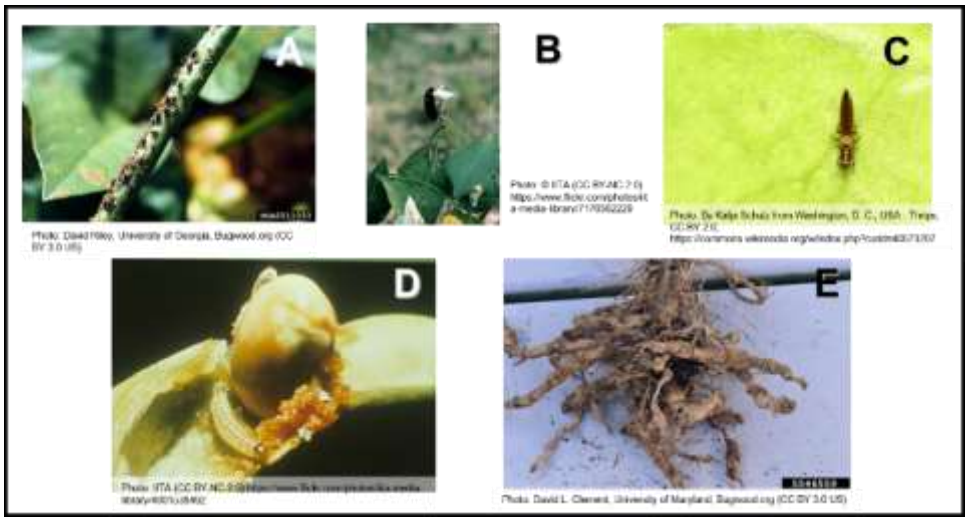
Photo: © IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/7176562229

Photo: By Katja Schulz from Washington, D. C., USA - Thrips, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=40573207

Photo: IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/4901538492

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

3.6.1 Major Pests



3.8.3 Major Pests

- Pests damage causes a reduction in quality and quantity of produce
- The following are the major pests of Cowpea in Kenya:

A. Aphid
B. Blister Beetle
C. Thrips
D. Pod Borer
E. Root-knot Nematodes

3.6.1.A: Aphids

Photo: David Riley, University of Georgia, Bugwood.org (CC BY 3.0 US)

Aphid infestation on cowpeas

3.6.1.A: Aphids

Photo: David Riley, University of Georgia, Bugwood.org (CC BY 3.0 US)

Aphid infestation on cowpeas

3.6.1.A: Aphids

Identification:

- These are small soft-bodied insects which pierce the plant tissue and suck sap from the attacked plants
- They feed on undersurface of young leaves, young shoots and pods of mature plants

Damages:

- They excrete large quantities of honeydew which support growth of sooty mould
- Heavy attack causes death of young seedlings, delayed flowering and stunted growth
- Cowpea aphids transmit mosaic virus

Control:

- Biological control using predators, such as **Lady Bird Beetle**
- Spray with Lambda Cyhalothrin (KARATE 2.5 WG® PHI: 3days), Deltamethrin (DECIS 2.5 EC® PHI: 1day)

3.6.1.B: Blister Beetle

Blister beetle feeding on Cowpea flower

3.6.1.B: Blister Beetle

Blister beetle feeding on Cowpea flower

3.6.1.B: Blister Beetle

Identification:

- Adults are medium to large sized beetles (**2 – 5 cm long**) usually black and yellow or black and red in colour

Damages:

- The adults feed on flowers and cause reduced pod set
- Adult beetles are attracted to maize pollen

Control:

- In rare occasion when large numbers of beetles are found on flowering crops, control measures can be applied
- Hand picking is commonly done. However, care should be taken because when disturbed, the beetles release a liquid that burn the skin. Wear gloves to protect the hands.

3.6.1.C: Thrips

Adult thrips on a leaf

3.6.1.C: Thrips

Adult thrips on a leaf

3.6.1.C: Thrips

Identification:

- Adult thrips are shiny black minute insects with a short life cycle that takes **14 – 28 days**
- Eggs are laid on flower buds and on hatching, nymphs feed on the flower buds. They pupate in the soil or debris close to the host plants

Damage:

- During pre-flowering stage, the nymphs and adults feed on and damage the terminal buds. However, the main damage is on the flower buds and flowers. Attacked flower buds turn brown and eventually fall off, leaving behind dark red scars
- Damaged flowers are distorted and malformed, show discoloration and may fall off
- Infested pods are malformed

Control:

- Intercropping cowpea with maize or sorghum
- Plant resistant/tolerant varieties e.g. **K80** & **KVU 27-1**
- Eliminate **alternative host** plants
- Maintain **field hygiene**
- Use of **pesticides**, such as
  - Lambda Cyhalothrin (**KARATE 2.5** WG 25g/Kg. PHI: 3days)

3.6.1.D: Pod Borer

Photo: IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/4901538492

Legume Pod Borer Feeding inside the Pod

3.6.1.D: Pod Borer

Photo: IITA (CC BY-NC 2.0) https://www.flickr.com/photos/iita-media-library/4901538492

Legume Pod Borer Feeding inside the Pod

3.6.1.D: Pod Borer

Identification:

- Adult moth has whitish markings on its forewings
- Larva are dull to yellow white & reach a length of **1.8 cm**
- Each segment has dark spots that form a distinct series along the length of the body
- Head is dark brown to black
- The moths lay eggs on leaf and flower buds, flowers and terminal shoots

Damages:

- Young caterpillars feed on any part of the flower or foliage
- Older caterpillars are highly mobile and feed continuously on flowers and newly formed pods, causing severe damage to the crop

Control:

- **Use of pesticides**, such as
  - **Lambda-cyhalothrin (Karate 2.5WG®. PHI: 3days)**

3.6.1.E: Root-Knot Nematode

Roots showing severe damage by Root-Knot Nematodes

3.6.1.E: Root-Knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

Roots showing severe damage by Root-Knot Nematodes

3.6.1.E: Root-Knot Nematode

Identification:

- Roots of affected plants have knots or galls
- The root galls formed by nematodes can be distinguished from the nodules containing *Rhizobium*, which are **small, spherical and pink inside**

Damages:

- Affected plants appear nutrient deficient, wilting and have stunted growth
- Can cause premature death of plants as a result of damage to the roots
- Attack by **Root-knot Nematodes** make plants susceptible to **Fusarium Wilt**

Control:

- Crop rotation with nematode resistant or tolerant crops e.g.) **Cereals**, **Onions**
- After harvest, uproot entire plants and destroy crop debris
- Tops can be composted but any infested roots should be burned since nematodes may survive the relatively low heat of compost heap

3.6.2 Major Diseases

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http://www.infonet-biovision.org/PlantHealth/Crops/Cowpea

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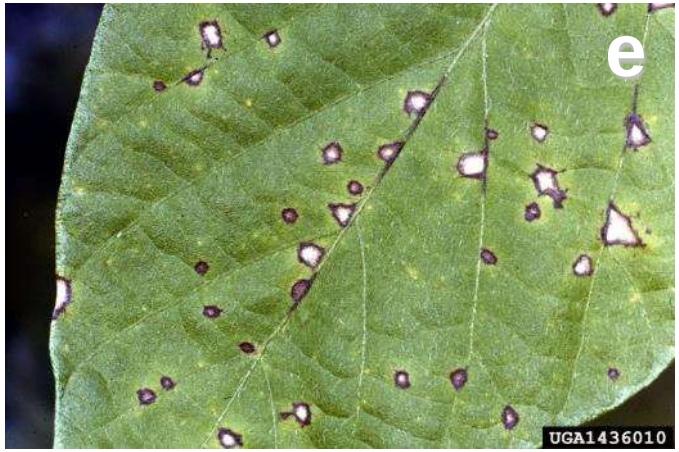
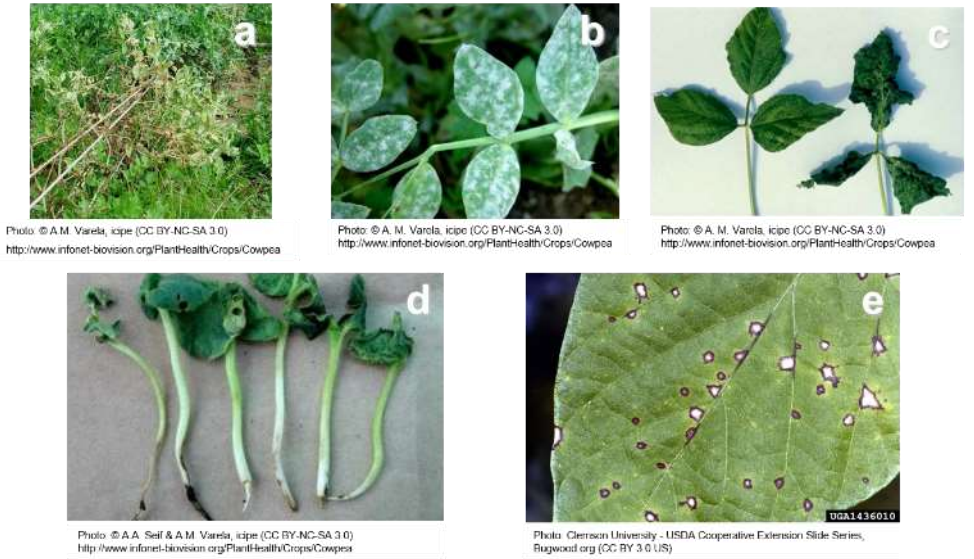


Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

3.6.2 Major Diseases



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http://www.infonet-biovision.org/PlantHealth/Crops/Cowpea

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http://www.infonet-biovision.org/PlantHealth/Crops/Cowpea

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

3.8.4 Major Diseases

- Disease infestation leads to reduction in quality and quantity of produce
- The following are the major diseases of Cowpea in Kenya:

a. Fusarium Wilt
b. Powdery Mildew
c. Cowpea Mosaic Virus
d. Damping-off
e. Cercospora Leaf Spot

3.6.2.a: Fusarium Wilt

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

Fusarium Wilt on a Legume Crop

3.6.2.a: Fusarium Wilt

Fusarium Wilt on a Legume Crop

3.6.2.a: Fusarium Wilt

General Descriptions:

- The disease is caused by **a fungus**
- It attacks water and nutrient conducting tissues of the plants

Symptoms:

- Wilting of lower leaves, or whole plant
- Browning of stem tissues
- Stunted growth

Control:

- Control root-knot nematodes since nematodes increase plants susceptibility to **Fusarium Wilt**

3.6.2.b: Powdery Mildew

Powdery Mildew on a legume crop

3.6.2.b: Powdery Mildew

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

Powdery Mildew on a legume crop

3.6.2.b: Powdery Mildew

General Descriptions:

- The disease is caused by **a fungus**

Symptoms:

- A light grayish and powdery growth on the leaves and pods
- It causes yellowing and defoliation of infected plants
- Heavy application of nitrogen-based fertilizer tend to increase disease severity

Control:

- Field hygiene
- Avoid very close spacing
- Use tolerant varieties e.g.) **M66**
- Use recommended fungicides, such as
  - **Azoxystrobin (Ortiva SC®. PHI: 3days), Sulphur (a.i. Cosavet DF ® PHI: 3days)**

3.6.2.c: Cowpea Mosaic Virus

Cowpea Mosaic Virus (CpMV)

3.6.2.c: Cowpea Mosaic Virus

Cowpea Mosaic Virus (CpMV)

3.6.2.c: Cowpea Mosaic Virus

General Descriptions:

- The disease is caused by **a virus** which is transmitted by aphids

Symptoms:

- Curling of leaves
- Infected leaves are smaller than healthy ones
- Infected plants may be dwarf and become bushy with reduced yields

Control:

- Control **aphids**
- Plant clean/**certified seeds**
- Crop rotation with none-legumes such as cereals
- Remove **alternative hosts** of virus diseases (legumes)

3.6.2.d: Damping-off

Young seedlings symptoms of Damping Off

3.6.2.d: Damping-off

Young seedlings symptoms of Damping Off

3.6.2.d: Damping-off

General Descriptions:

- The disease is caused by a fungi and causes high seedling mortality
- It is favoured by **cool**, **wet** or **water logged soils conditions**

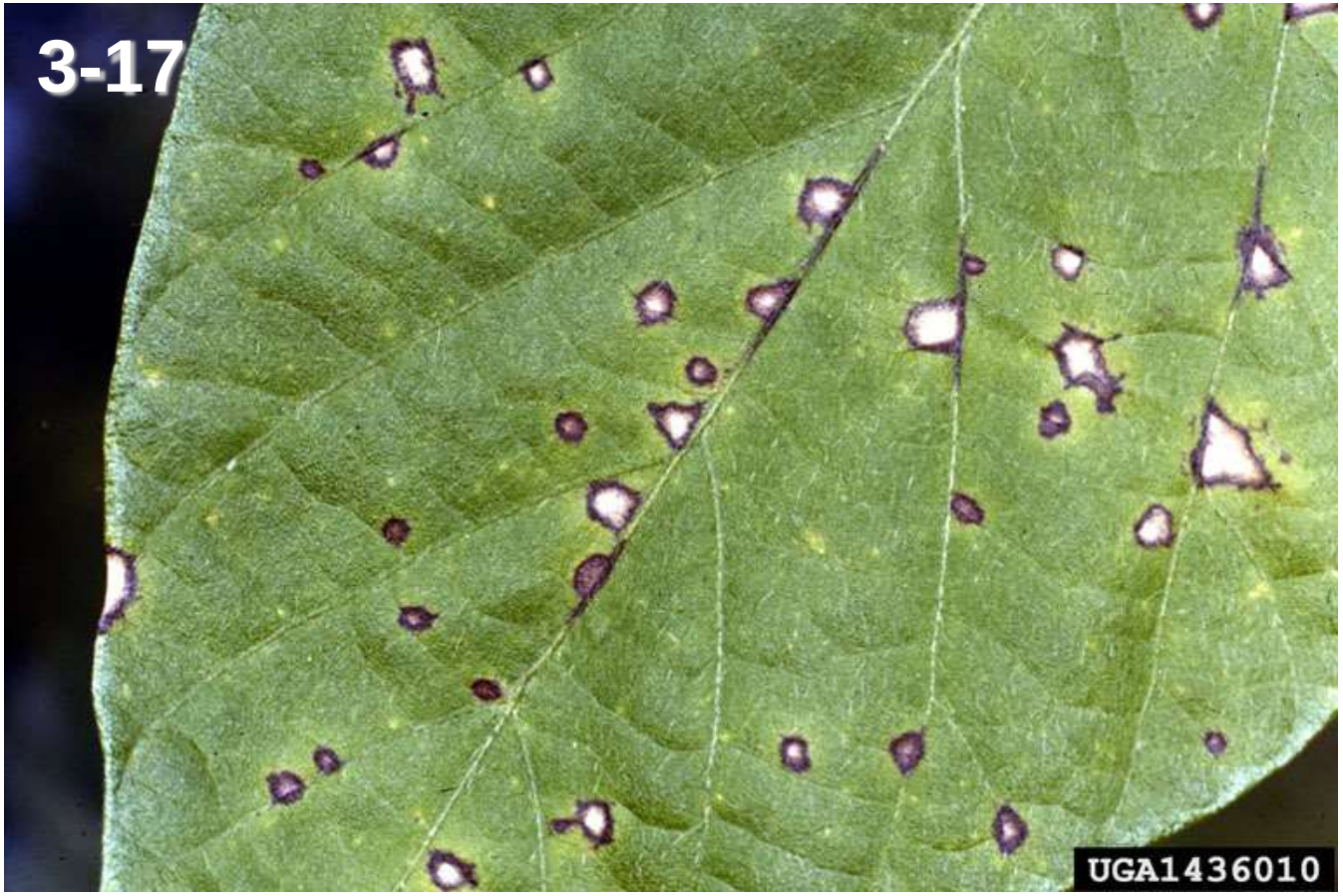
Symptoms:

- The emerging seedling collapses, often submerged in a mass of white fungal growth **3 weeks** after sowing

Control:

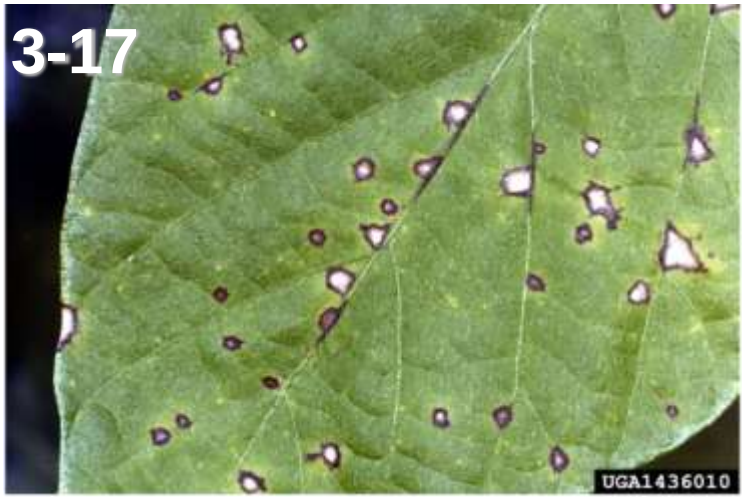
- Crop **rotation**
- **Avoid** water **logging**
- Use recommended fungicides such as Metalaxyl-M+Moncozeb (**AMIDIL 68WG®. PHI: 5days)**

3.6.2.e: Leaf Spot



Cercospora Leaf Spot

3.6.2.e: Leaf Spot



Cercospora Leaf Spot

3.6.2.e: Leaf Spot

General Descriptions:

- Leaf spots vary in size and are often yellowish, brown or purple in colour
- The disease is most serious during periods of prolonged moist weather and on late plantings

Symptoms:

- The spots normally first develop on the lower leaves
- Cercospora leaf spot appears as dark mouldy growth and develops on the lower surface of the leaf corresponding to the spot
- Severe leaf spotting results in defoliation with subsequent yield reduction

Control:

- Practice crop rotation with non-leguminous plants
- Avoid cultivation when foliage is wet
- **Use of fungicides**, such as
  - **Azoxystrobin (Ortiva SC® PHI:3days**)

4. Harvest

Photo: SHEP PLUS

Farmers harvesting cowpea leaves

4. Harvest

Photo: SHEP PLUS

Farmers harvesting Cowpea leaves

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Maturity period for leaf harvesting is **3 – 4 weeks** after planting

Harvesting Methods:

- **Leaf harvesting**
  - Leaves are picked when they are young and tender
  - In other cases, whole plants are harvested by uprooting
- **Leaf and grain harvesting**
  - The leaf vegetable yields are significantly affected by leaf harvesting frequency
  - When harvesting frequency is shorter, higher yields are realized but yield of grain decreases
  - **Leaf Yields: 2,400kg per acre** are achieved

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

KALE PRODUCTION

Prepared by SHEP PLUS

Photo: SHEP PLUS

Training Title: **Kale Production**

Objective: **To provide a guideline on production of Kale**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

Disclaimer

Kale Production, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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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 Product Board.

1. Introduction:
1.1 Background

Photo: SHEP PLUS

Kale (Sukuma Wiki, Sukuma Siku)

1. Introduction:
1.1 Background

Kale (Sukuma Wiki)

1. Introduction
1.1 Background

- Kale is a member of the ***Brassicaceae*** **family** which includes crops such as **Cabbage**, **Cauliflower**, **Broccoli**, and **Radish**
- A popular **leafy vegetable** in Kenya grown mainly for the domestic market
- Valuable source of **vitamins (A, B, Folate)** and **minerals (Ca, K, Mg)**
- Other vitamins present include Riboflavin and Niacin
- A source of income for most smallholder farmers
- Has **a lower cost of production** compared to other horticultural crops

1.2 Common Varieties

“Collards”

“Thousand Headed”

Photos: SHEP PLUS

1.2 Common Varieties

“Collards”

“Thousand Headed”

1.2 Some Common Varieties

- “Collards” and “Thousand Headed” are the most common varieties

“Collards”:

- Tolerant to **Soft Rot** and **Black Rot**
- Widely adapted even to warmer areas
- Flowers after **a short period of harvesting**
- **Yield: 15,000kg per acre**

“Thousand Headed”:

- A popular variety with succulent leaves
- Extended **production period of up to 3 months**
- **Yield: 15,000kg per acre**

Photos: SHEP PLUS

1.2 Common Varieties Cont’

Photo: By Goldlocki - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3128541

“Marrow Stem”

Photo: National Farmers Information Service http://www.nafis.go.ke/vegetables/kales/

“Moss Curled Kale”

1.2 Common Varieties Cont'

Photo: By Goldlocki - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3128541

"Marrow Stem"

Photo: National Farmers Information Service http://www.nafis.go.ke/vegetables/kales/

"Moss Curled Kale"

1.3 Other varieties grown in Kenya are:

"Marrow Stem"

- Dark green leaves with sweet taste and little fibre
- Good digestibility
- Low dry-matter content
- **Yield:** 15,000kg **per acre**

"Moss Curled Kale" (Sukuma Siku)

- Dark curly leaves that are very tasty
- Not a commonly grown variety
- **Yield: 15,000kg per acre**

1.2 Common Varieties Cont’

Photo: AVRDC https://avrdc.org/ethiopian-kale-brassica-carinata/

“Ethiopian Kale (Kanzira)”

1.2 Common Varieties Cont'

Photo: AVRDC https://avrdc.org/ethiopian-kale-brassica-carinata/

"Ethiopian Kale (Kanzira)"

1.3 Other varieties grown in Kenya Cont':

"Ethiopian Kale (Kanzira)"

- This is a traditional crop of the western and coastal communities though it has gained popularity in major towns
  - Smaller leafed varieties are mainly collected in form of shoots whereas larger leaved varieties one plucks the individual leaves
- Very perishable unlike other varieties

"Mfalme F1"

- A prolific variety of long harvesting period of more than a year.
- Harvesting starts 45 days after transplanting.
- Has uniform dark bluish green leaves.
- Has soft tender leaves that are easy to cook.
- Very sweet taste, non-acidic and highly palatable.
- Yield: 15,000-20,000kg per acre depending on level of management.

1.3 Optimal Ecological Requirements

Altitude	**800 – 2,200 metres above sea level**
Rainfall	**750 mm of rainfall**
Growing Temperature	**17 – 30 ^{0}C**
Soils	**• Well drained loam soils** **• High organic matter content** **• pH range 5.5 – 7.0**

1.3 Optimal Ecological Requirements

Altitude	**800 – 2,200 metres above see level**
Rainfall	**750 mm rainfall**
Growing Temperature	**17 – 30 ^{0}C**
Soils	• **Well drained loam soils** • **High organic matter content** • **pH range 5.5 – 7.0**

1.3 Optimal Ecological Requirements

Kales can grow almost anywhere in Kenya. The following are the optimal ecological requirements.

- **Altitude:** The optimum altitude range is **800 – 2,000 m** above sea level. In lower or higher altitudes, use the recommended varieties
- **Rainfall:** A high water requirement throughout the growing period and **750 mm** of rainfall is considered optimal. Rainfall should be well distributed throughout the growing period is required.
- **Temperature:** Kale perform well under cool temperatures & the optimum temperature range for production is **17 – 30 ^{0}C**
- **Soil:** Kale requires **fertile**, **well-drained loam soils** with high organic matter content and high water holding capacity. The optimal soil pH range is **5.5 – 7.0**

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

2. G20 technologies

1. Market survey
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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

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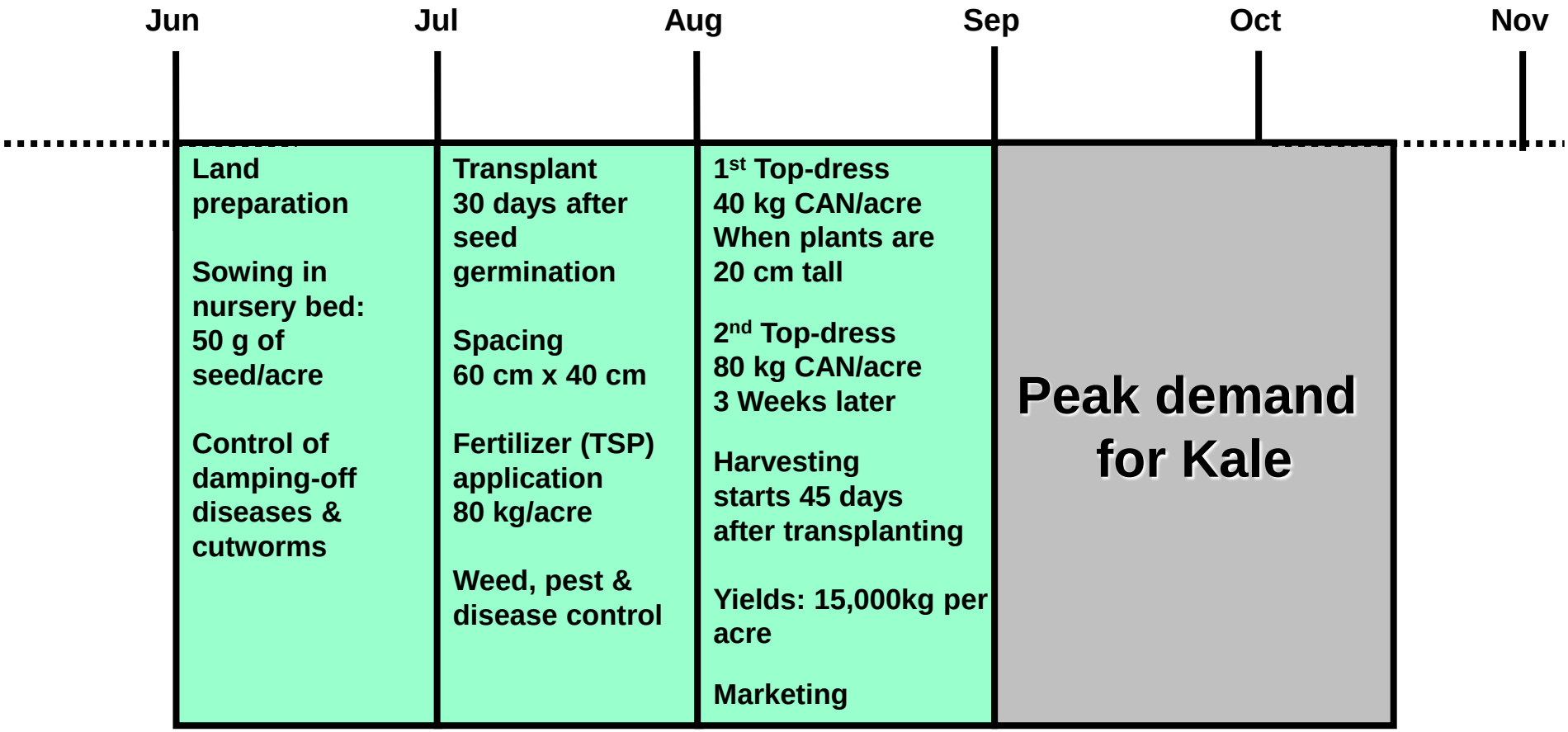
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

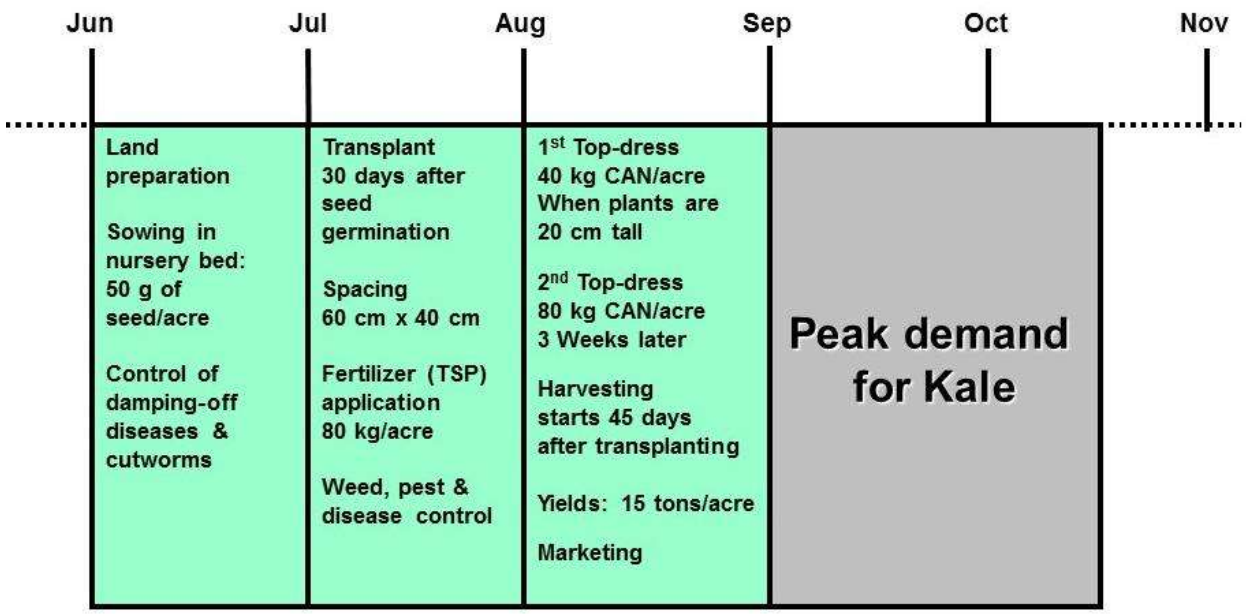
2.1 Crop Planting Calendar

A Sample of a Kale Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Kale Planting Calendar



A Sample of a Kale Planting Calendar: Targeting a peak market demand beginning just after September

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Kale
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need of supplemental irrigation

2.2 Composting

Photo: SHEP PLUS

Manure preparation through composting

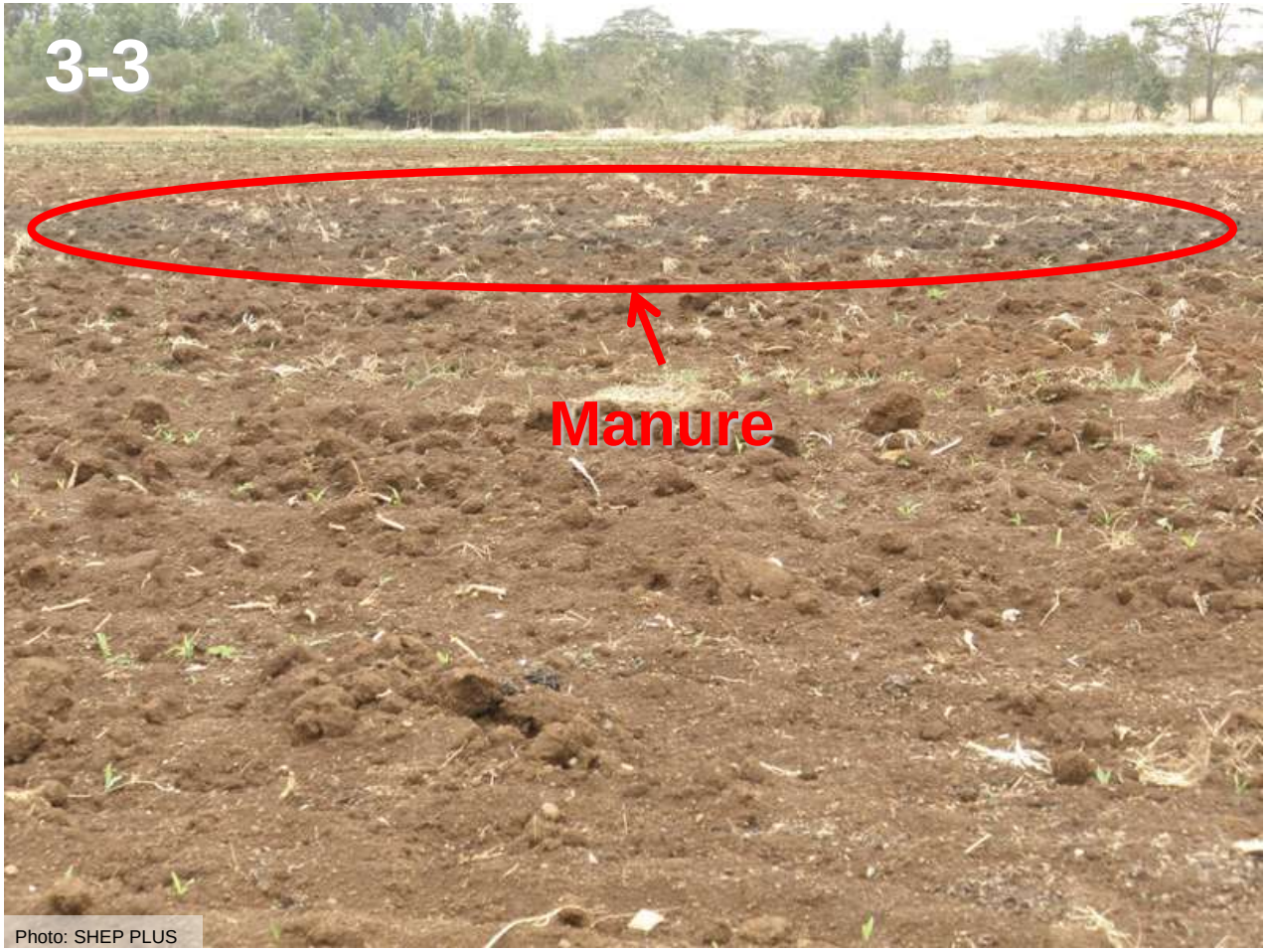
2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- Kale like most leafy vegetables is a heavy feeder and does well in soils with high organic matter (manure)
- Based on the results of the soil analysis, prepare adequate compost for application; the recommended rate of application ranges from **5 – 8 tons/acre** for Kale

3.1 Basal Application



Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted (**5 – 8 tons/acre**) then worked into the soil (incorporated) preferably using a hoe
- Manure/compost should be applied **1 – 2 weeks** before transplanting the Kale

3.2 Raising Seedlings

Photo: SHEP PLUS

Kales nursery established by a farmer

3.2 Raising Seedlings

Kales nursery established by a farmer

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Use certified seed with special attributes, such as tolerance/resistance to pest and diseases and high yielding
- The seed rate is about **50 g per acre**

Nursery Site Selection:

- The nursery should be located in a plot that has not been planted with crops in the ***Brassicaceae*** **family** for at least three (3) years

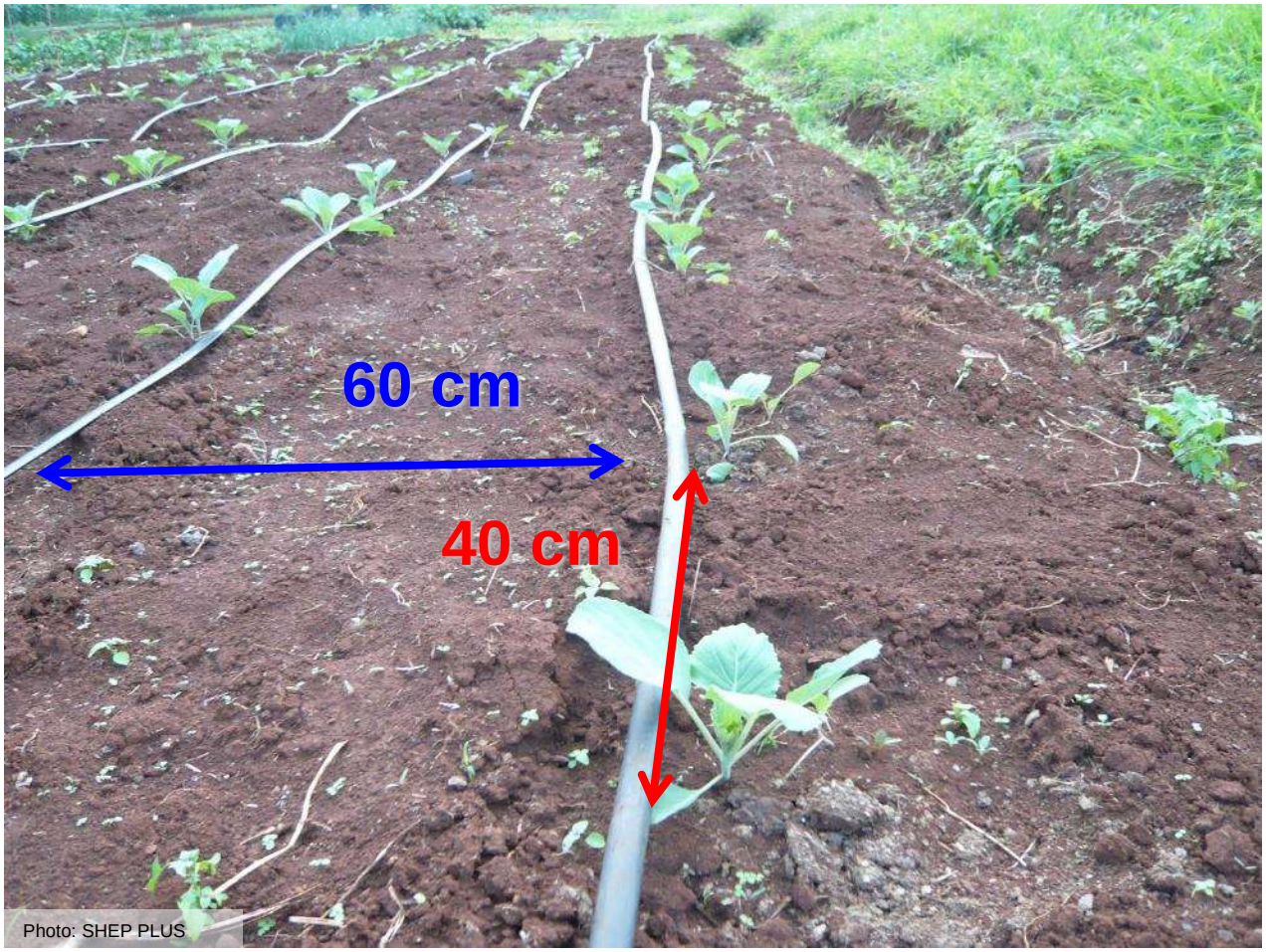
Nursery Establishment:

- Prepare a seed bed of **1 m** width and of convenient length
- Make **2 cm deep drills** on the seed bed at a spacing of **10 – 15 cm** apart
- Thinly sow the seeds in the drills and cover lightly with soil
- **Mulch** seedlings in the seedbed, if possible

Management of Nursery:

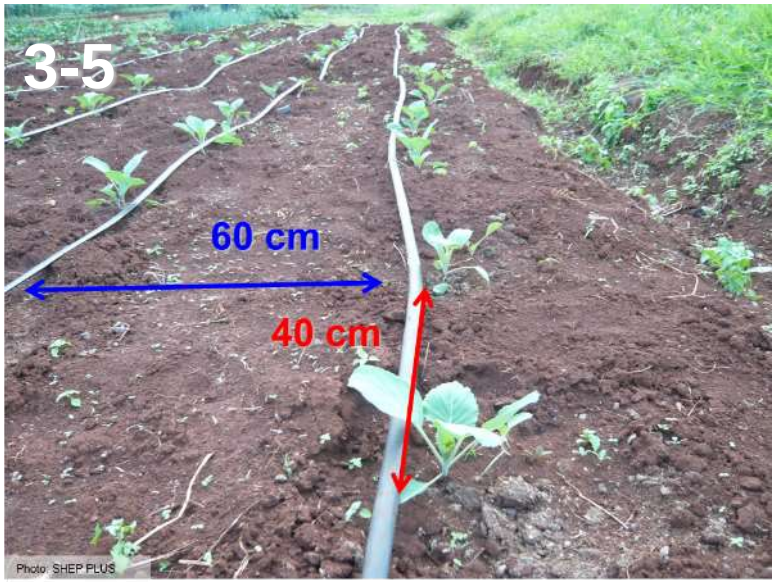
- Water the seedlings regularly
- Avoid over-watering which can lead to **"Damping-off"** disease
- Start hardening the seedlings **1 – 2 weeks** before transplanting by reducing the frequency of watering and the shade over the nursery
- **Notes:** It may be effective to raise seedlings in pots (potting) in order to avoid overgrowing in the nursery

3.3 Transplanting



Transplanted kales seedlings

3.3 Transplanting



Transplanted kales seedlings

3.3 Transplanting

3.3.1 Appropriate Time

- Seedling should be transplanted **30 days** after seed germination
- Transplanting should be done either **early in the morning** or **late in the evening**
- In case farmers did potting, the seedlings can be transplanted **more than 30 days after germination**

3.3.2 Recommended Spacing (GHCP&PHHT20: Q10)

- Transplant the seedling at a spacing of **60 cm** between rows and **40 – 60 cm** between plants **depending on the variety**
- **Plant Population: 11,111-16,666 per acre**

3.3.3 Fertilizer Application Rates (GHCP&PHHT20 Q11)

- In case manure/compost is to be applied during transplanting, apply **1 – 2 handfuls** per hole (**5 – 8 tons/acre**)
- Apply **80 kg/acre (1 teaspoonful/hole)** of **TSP** in the planting holes

[Note]

- Soil testing to determine the type and amount of fertilizer
- Only thoroughly composted manure should be used to avoid possible introduction of pests and diseases in the field
- The TSP should be mixed thoroughly with the soil to avoid possible scorching of the seedlings

3.4 Water Requirement

Photo: SHEP PLUS

Supplementing Kale water requirement through irrigation

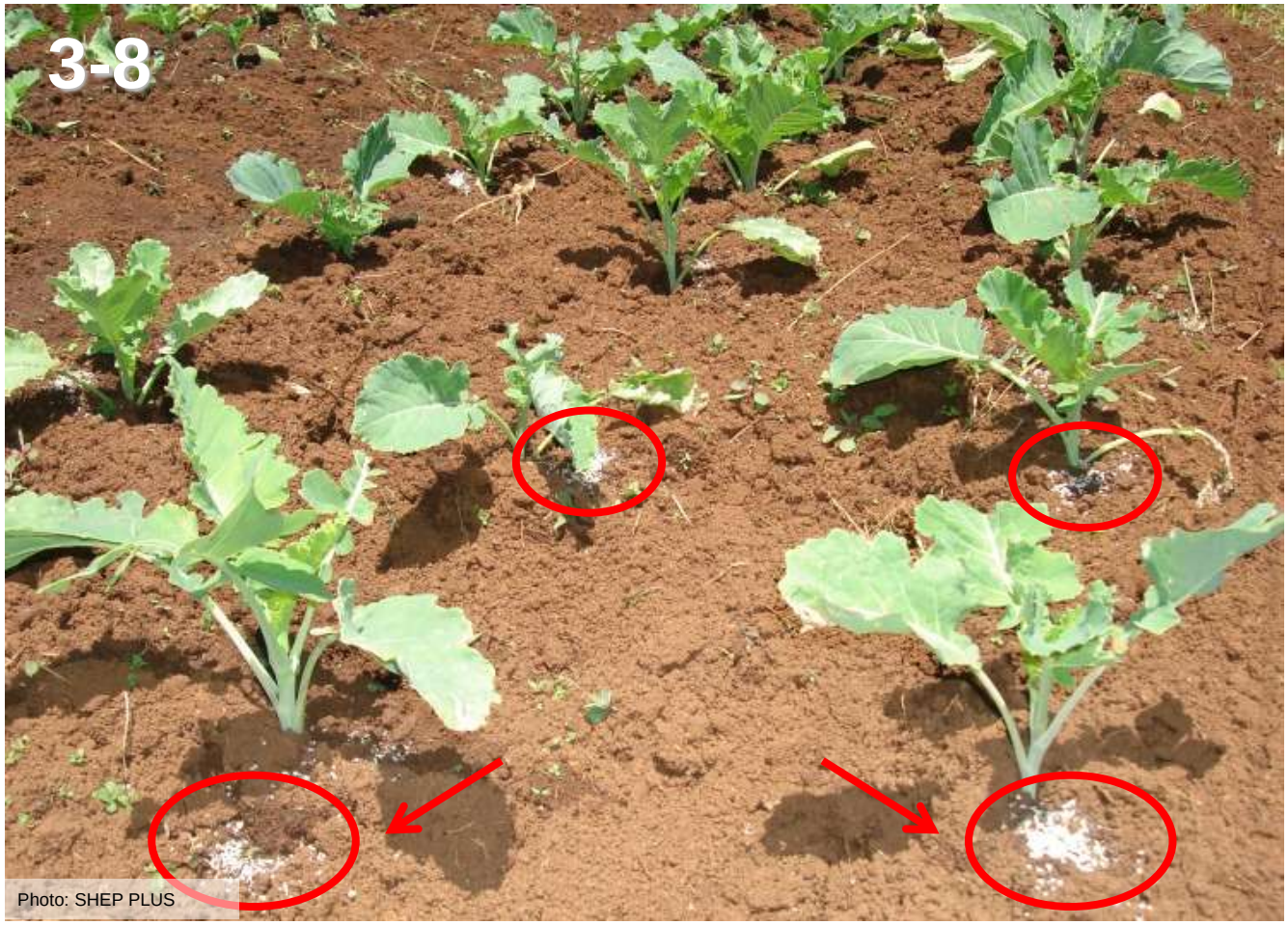
3.4 Water Requirement

Supplementing Kale water requirement through irrigation

3.4 Water Requirement (GHCP&PHHT20: Q12)

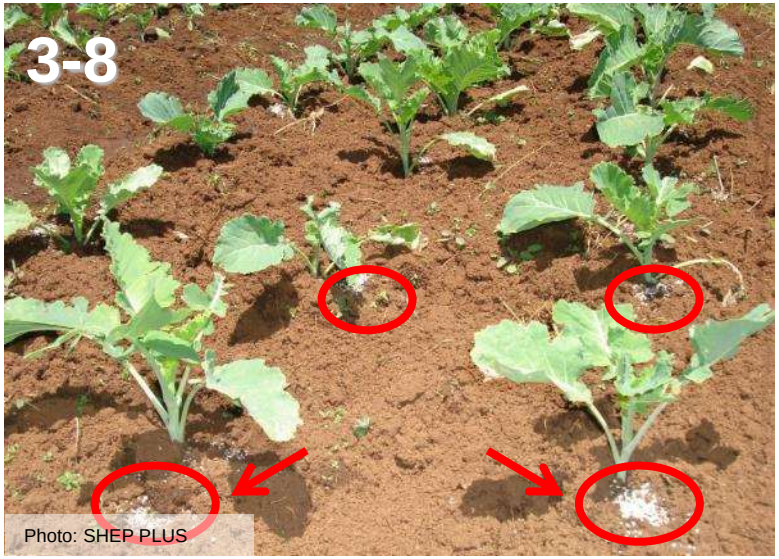
- Kale requires an optimal amount of **750 mm** of rainfall during the growing period
- In areas with lower rainfall, water deficit problems should be addressed through irrigation

3.5 Top-dressing



Top-dressing by placement method

3.5 Top-dressing



Top-dressing by placement method

3.5 Top-dressing (GHCP&PHHT20: Q14)

- Two (2) split applications of CAN are recommended to replenish soil nutrient status
- First split is applied at a rate of **40 kg per acre** (20 g CAN per plant) when plant is 20 cm tall
- Second split application is applied at a rate of **80kg per acre** 3 weeks later
- Placement method is recommended as it is more effective and economical

3.6.1 Major Pests

Photo: Am. M. Varela, icipe (CC BY-NC-SA 3.0)

http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

Photo: © A. M. Valera, icipe (CC BY-NC-SA 3.0)

http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

Photo: SHEP PLUS

Photo: John C. French Sr., Retired, Universities:Auburn, GA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

3.6.1 Major Pests

3.6.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- Kale is generally more pest & disease resistant than other crops in the ***Brassicas*** **family**
- The following are the major pests of Kale in Kenya:
  - **A. Diamond Back Moth (DBM)**
  - **B. Cabbage Sawfly**
  - **C. Aphids**
  - **D. Cutworms**

3.6.1.A: Diamond Back Moth (DBM)

Photo: Am. M. Varela, icipe (CC BY-NC-SA 3.0)
http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#simple-table-of-contents-5

“Windows” caused by DBM larvae on a leaf

3.6.1.A: Diamond Back Moth (DBM)

“Windows” caused by DBM larvae on a leaf

3.6.1.A: Diamond Back Moth (DBM)

Identification:

- The adult is a small grey moth whose wings form a characteristic diamond pattern at the back when closed
- Larvae are **pale yellowish-green** to **green caterpillars** covered with fine, scattered, erect hairs
- When disturbed, the larvae will wriggle backward violently and may drop from the plant, suspended by a silken thread

Damages:

- **Windows** on leaves from feeding by larvae
- If larvae are numerous, they may eat **the entire leaf**, leaving only the veins
- Infestations are normally **serious in drier months**

Control:

- **Crop rotation**
- **Use of pesticides**, such as
  - **Bacillus thuringiensis: Bt. (DELFIN 6.4 W.G®) PHI:1day**
  - **Lambdacyhalothrin (TATA UMEME 2.5 EC®) PHI:3days**
  - **Lufenuron 50 g/L (MATCH 50 EC®) PHI:14days**
- **Intercropping: Intercropping with repellants** (e.g. **Tomato**) or **trap crops** (e.g. **Indian Mustard**) reduces DBM destruction on Kale. The mustard is then sprayed with a pesticide. Tomato repels DBM.
- **Natural enemies:** Egg parasitoids of genera Trichogramma and larval parasitoids in the genera Diadegma are some of the predominant and effective natural enemies.

3.6.1.B: Cabbage Sawfly

A “Cabbage Sawfly” larva feeding on a Kale leaf

3.6.1.B: Cabbage Sawfly

A "Cabbage Sawfly" larva feeding on a Kale leaf

3.6.1.B: Cabbage Sawfly

Identification:

- Adult insect resembles a fly except for the presence of 2 pairs of membraneous wings with dark head and thorax and bright abdomen
- Eggs are laid singly inside the leaf
- The **grayish green larvae** with a black head and more than six pairs of legs

Damage:

- Windows on leaves from feeding by larvae
- They feed on the blade of the leaves often leaving only the main veins and midrib

Control:

- Destruction of wild plants in the Cruciferae
- Use of appropriate pesticides such as Methoxyfenozide 240 g/L (RUNNER 240 SC PHI: 10days), Pyrethrins 40g/L (PYAGRO 4 EC)

3.6.1.C: Aphids

Underside of a leaf infested with Aphids

3.6.1.C: Aphids

Underside of a Kale leaf infested with Aphids

3.6.1.C: Aphids

Identification:

- Aphids are **pale green** or light green to yellowish green and are usually covered with **a light dust of mealy powder.** But some types of aphids do not form mealy powder
- They suck plant sap from the central part of the plant and near the base of leaves

Damages:

- Aphid attack results in **curled, discoloured** and **distorted leaves**
- Large colonies of aphids are found on the underside of Kale leaves during drought causing stunted growth

Control:

- **Field hygiene** through removal and destruction of crop residue and alternative wild hosts
- **Use of insecticides**, such as
  - **Lambdacyhalothrin (KARATE 2.5WG®) PHI: 3days**
  - **Thiamethoxam (ACTARA 25 WG®) PHI: 7day**
  - **Deltamethrin (DECIS 2.5EC®) PHI: 1day**

3.6.1.D: Cutworms

Photo: John C. French Sr., Retired, Universities:Auburn, GA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

A Cutworm larva

3.6.1.D: Cutworms

Photo: John C. French Sr., Retired, Universities Auburn, GA, Clemson and U of MO, Bugwood.org (CC BY 3.0 US)

A Cutworm larva

3.6.1.D: Cutworms

Identification:

- The **grayish black larvae** that curl up tightly when disturbed
- They are often found **hiding in soil** near the cut seedlings

Damage:

- They **girdle** and **cut-off young seedlings at ground level** during the night dragging them into the tunnel in the soil and feed on them during the day

Symptoms:

- Cut stems
- Attacked plant **wilt** and **die**

Control:

- **Hand removal** since the pest is easily found near the damaged plant, especially at the beginning of infestation
- **Early weeding** destroys sites for egg laying
- Flooding of the field for a few days before sowing or transplanting can help kill cutworm caterpillars in the soil
- Chemical control: **(drench at the base in the evenings)**
  - Lambda-cyhalothrin 25g/L (TATA UMEME 2.5EC®(PHI: 3days), Halothrin 2.5EC® (PHI: 3days))
  - Alpha-cypermethrin (ALPHA CYMBA 10EC®(PHI: 3days))

3.6.2 Major Diseases

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http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#overlay=node/27240/edit

Photo: © Jack Kelly Clark, courtesy University of California Statewide IPM Program

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3.6.2 Major Diseases

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20/26

3.6.2 Major Diseases

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases of Kale in Kenya:
  a. **Black Rot**
  b. **Black Leg (Dry Rot Canker)**
  c. **Ring Spot**
  d. **Downey Mildew**
  e. **Powdery Mildew**

3.6.2.a: Black Rot

Photo: A. M. Varela, icipe (CC BY-NC-SA 3.0) http://infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas#overlay=node/27240/edit

Symptom of “Black Rot” on a leaf

3.6.2.a: Black Rot

Symptom of "Black Rot" on a leaf

3.6.2.a: Black Rot

General Descriptions:

- This is a **seed borne bacterial disease**
- Black rot infection and spread is favored by **wet conditions** and **high temperatures** (**20 – 30 ^{0}C**)
- Crowded plants provide conditions that are ideal for bacterial spread to nearby plants

Symptoms:

- In early stage, **yellowish brown V-shaped lesions** are observed on the leaf margins of affected plants
- On the margins of mature leaves, the veins become distinctly **black**
- The lesions extend into the leaf, **killing large areas of affected leaves**
- A cross sectional cut of infected stem reveals a characteristic **black ring**
- Seedlings that are infected systemically become **yellow**, **drop lower leaves**, and **may die**

Control:

- Use certified planting material
- Use of tolerant varieties e.g.) **Collards**
- Field sanitation (hygiene)
- Minimum two year crop rotation
- Spray **copper** fungicide **(AMICOP 50WP, COBOX 50WP®)** when the first symptoms are seen

3.6.2.b: Black Leg (Dry Rot Canker)

Photo: © Jack Kelly Clark, courtesy University of California Statewide IPM Program

Photo: © Infonet-Biovision http://www.infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas (CC BY-NC-SA 3.0)

Blackleg lesions can girdle the basal part of the stem (Left) and Blackleg infected kale wilting (Right)

3.6.2.b: Black Leg (Dry Rot Canker)

3-14

Photo: © Jack Kelly Clark, courtesy University of California Statewide IPM Program

A stem infected with “Black Leg”

3-15

Photo: © Infonet-Biovision http://www.infonet-biovision.org/PlantHealth/Crops/CabbageKale-Brassicas (CC BY-NC-SA 3.0)

Blackleg infected kale wilting

3.6.2.b: Black Leg

General Descriptions:

- This is a **seed borne disease** caused by a **fungus**
- The inoculum is spread by **infected plants**, **garden tools** and **crop debris**

Symptoms:

- Leaves have **light brown spots** which may be circular and which later develop **ash grey centres with many black spots**
- Severe stem infection results in **a dark dry rot** above the soil line which extends below and kills the roots
- Affected plants **wilt abruptly** and **die**

Control:

- Use of certified seed
- Avoid use of **side shoots**
- Avoid nursery beds where Kales and related crops have previously been planted
- Field sanitation (hygiene) by removing and destroying infected material
- **3 – 4 year crop rotation**

3.6.2.c: Ring Spot

Symptom of “Ring Spot” on a leaf

3.6.2.c: Ring Spot

Symptom of "Ring Spot" on a leaf

3.6.2.c: Ring Spot

General Descriptions:

- This is a **seed borne fungal disease**
- **Infected compost** is the source of the innoculum and it is spread by **wind**

Symptoms:

- **Circular brown grey spots** on the leaves which are often bordered by **a green margin** and with **black – specked concentric zones**

Control:

- Use of certified seeds
- Field sanitation-remove and destroy infected plants
- Crop rotation for at least 2 years
- **Use of fungicides**, such as **Copper Oxychloride (COBOX 50 WP®)PHI: 3days**

3.6.2.d: Downy Mildew

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

“Downey Mildew” symptom on Kale

3.6.2.d: Downey Mildew

“Downey Mildew” symptom on Kale

3.9.4d: Downey Mildew

General Descriptions:

- This is **a seed borne fungal disease**
- Spread by **wind**, **rain**, and **overhead irrigation**
- It is severe at **high elevations** where the conditions are **cool and wet**

Symptoms:

- **Fluffy fungal growth** on the underside of leaves which later produce **brown to black spots** on the upper surface

Control:

- Nursery and field sanitation
- Crop rotation
- Follow **recommended spacing** to reduce the risk of incidence
- **Use of pesticides**, such as
  - Metalaxyl+Mancozeb (**METACOZEB 72 WP)** PHI: 7days

3.6.2.e: Powdery Mildew

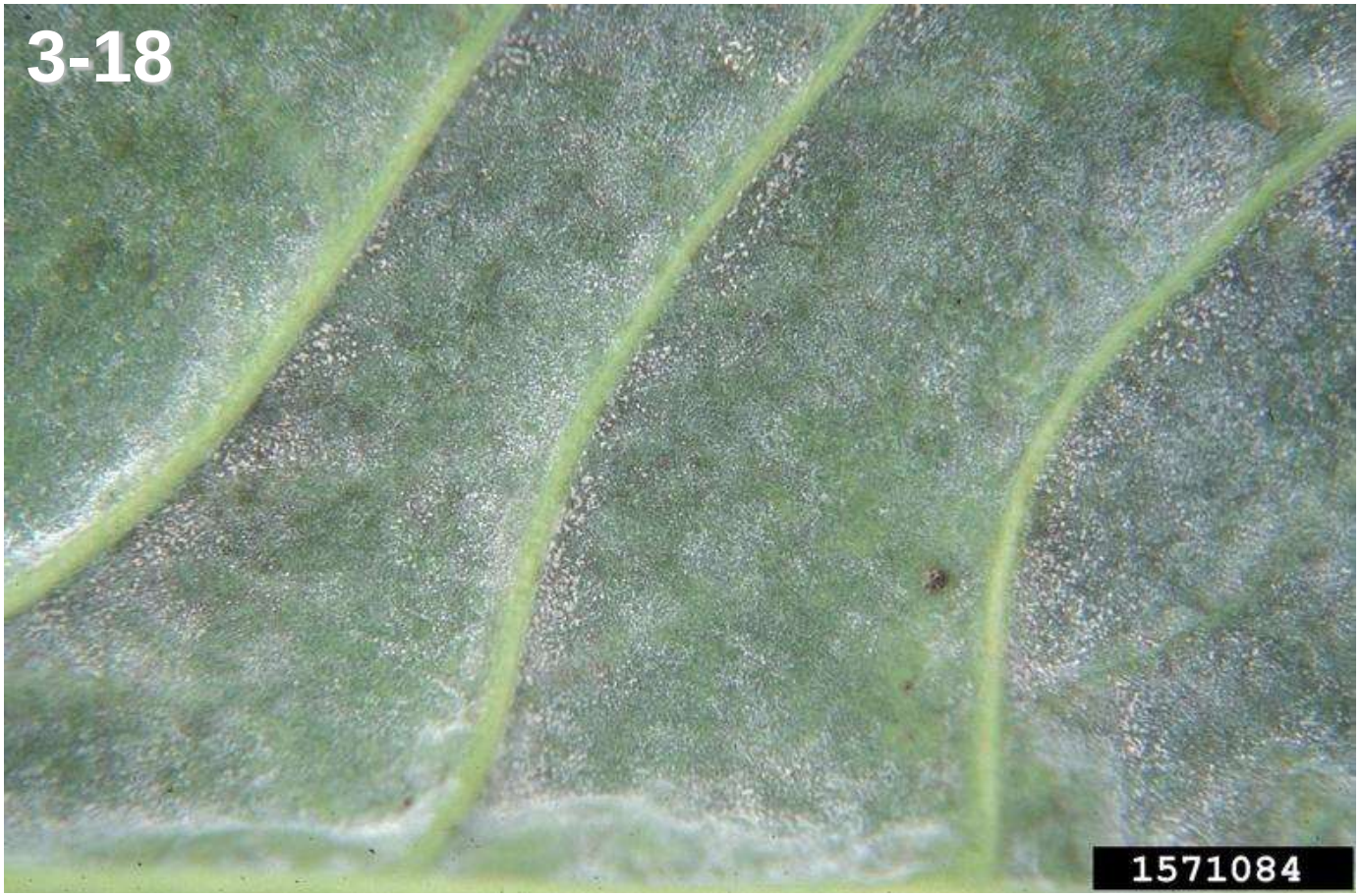

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

“Powdery Mildew” symptom on Kale

3.6.2.e: Powdery Mildew

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

"Powdery Mildew" symptom on Kale

3.6.2.e: Powdery Mildew

General Descriptions:

- This is **a fungal disease** that affects a wide range of plants
- Powdery Mildews are severe in **warm**, **dry climates**

Symptoms:

- Appears as **white**, **powdery spots** that may form on both surfaces of leaves
- Leaves infected with Powdery Mildew may gradually turn completely **yellow**, **die**, and **fall off**

Control:

- Crop rotation
- **Cultural Control:** Remove infected leaves to reduce the spread
- **Chemical Control:** Use of **fungicides**, such as Sulphur (**COSAVET DF)** PHI: 3days Sulphur 800g/L (**FLOSUL PLUS)** PHI: 3days)

4. Harvest

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Harvesting Kales

4. Harvest

Harvesting Kales

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Harvesting Period:** Begins 6 weeks after transplanting and can last for 4 – 6 months
- **Harvesting Method:**
  - Kale is hand harvested either as a whole plant, shoots or leaves
  - A picker should look for kale with firm, deeply coloured leaves and moist hardy stems
  - Plucking the lower leaves; each time leaving 3 – 4 top leaves
  - When harvesting the leaves, always leave part of the stalk attached to the stem
- **Yields: 15,000kg per acre**
- The **frequency** and **total duration of harvesting** depends on management practices; for instance, irrigation and additional application of CAN shortens the harvesting interval and prolongs the harvesting duration

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

POTATO PRODUCTION

Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **Potato Production**

Objective: **To provide a guideline on production of Potato**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

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 Product Board.

1. Introduction:
1.1 Background

Photo: SHEP PLUS

Potato (Viazi)

1. Introduction:
1.1 Background

Potato (Viazi)

1. Introduction:
1.1 Background

- Herbaceous perennial cultivated as an **annual crop**
- The crop is grown for its **tuber**- an underground stem
- **Rich in starch** (**8 – 28 %**) but **low in protein** (**1 – 4 %**)
- It is also **rich in Vitamin C**
- **2nd most important food crop** after maize; and a valuable cash crop to many smallholders
- Can be utilized **boiled**, **baked**, **mashed** or **fried** into chips or crisps among other uses

1.2 Common Varieties

1-2

1-3

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“Tigoni”

“Asante”

1.2 Common Varieties

“Tigoni”

“Asante”

Photo: © A.A. Seif (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Potato-Seed-Production

1.2 Some Common Varieties

Released varieties (1998 by KARI-Tigoni):

“Tigoni”:

- Tall variety with upright stem
- Produces white flowers and tubers are long oval with white smooth skin
- Has poor tuber storage and short tuber dormancy
- Optimal production altitude: **1,800 – 2,600 m**
- Maturity Period: **3 – 4 month**
- **Tolerant to Late Blight**
- Has high dry matter content
- **Yield: 14,000 – 18,000kg per acre**
- Use: chips, mashing, boiling, baking, roasting

“Asante”

- Stems are upright to semi-upright of medium height
- Tubers are round and have pink smooth skin
- Tuber dormancy is short
- Optimal production altitude: **1,800 – 2,600 m**
- Maturity Period: **3 – 4 month**
- Has high dry matter content
- **Fairly tolerant to Late Blight**
- **Yield: 14,000 – 18,000kg per acre**
- Use: chips, mashing, roasting, baking

1.2 Common Varieties Cont’

Shangi

1.2 Common Varieties Cont'

1.2 Some Common Varieties Cont'
Other Indeterminate varieties grown in Kenya:
"Shangi"
-Highly prolific, versatile use
-About 1m high, upright growth
-Broad leaves, light in colour
-Abundant flowers,
-Oval tubers, uniform in grading, white flesh
-Medium to deep eye with pink pigmentation
-Very short dormancy
-**Matures in 3-4 months**
-Yield 30,000-40,000kg per acre
-Moderately susceptible to late blight
-Good for mashing, boiling, Roasting,chips
-Altitude range 1500-2800m asl

Released varieties (2010 by KARI-Tigoni):
"Kenya Mpya":
•Tall plant (about 1 m) with good ground cover
•Flowers are white
•Tubers have Cream white skin color with pink shallow eyes
•Optimal production altitude: **1,400 – 3,000 m**
•Resistant to **Late Blight**
•**Early tuberization:** large size, oval/round tubers
•Good storability
•Short dormancy
•Maturity Period: **3 – 3.5 month**
•Yield: **14,000 – 18,000kg per acre**
•Use: boiling, roasting, mashing, chips

Shangi

"Sherekea":
-Medium sized plant which produces abundant light purple flowers
-Tubers are oblong/round and have red skin
-High number of tubers per plant
-Good storability
-Long tuber dormancy
-Optimal production altitude: 1,800 – 3,000 m
-Maturity Period: 3.5 – 4 month
-Yield: 16,000 – 20,000kg per acre
-High resistant to Late Blight and viruses (PVY and PLRV)
-Use: boiling, roasting, mashing, chips, crisps

"Purple Gold":
-Medium sized plant with purples flowers
-Tubers are round and have dark purple skin with white flesh eyes
-Has long tuber dormancy
-Has excellent crisping quality
-It is predominantly grown in **Narok** but can be grown in other areas
-Moderate resistance to late blight, PLRV but susceptible to PVY
-Tolerant to most soil borne diseases
-It is resistant to greening and has good storability
-Yields 10,000 – 14,000kg per acre
-Uses: mashing, boiling, roasting and chips

1.2 Common Varieties Cont’

Photo: © A.A. Seif (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Potato-Seed-Production

Other Varieties

1.2 Common Varieties Cont'

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http://www.infonet-biovision.org/PlantHealth/Crops/Potato-Seed-Production

1.2 Some Common Varieties Cont'

Other varieties grown in Kenya:

"Kerr's Pink" (also known as "Mew Pink")

-Tall plant with white flowers

-Tubers have oval shape with red skin

-Tolerant to drought but susceptible to late blight

-Maturity:2-3 months

-Yields: 10,000-12,000kg per acre

"Dutch Robijn"

-Medium plant height with upright stem which produces white flowers

-Tubers are round and red skin in colour with good storage and long dormancy

-Yield: 14,000-16,000kg per acre

"Nyayo", "Roslin Tana"

Varieties released in 2002 with yield potential of **14,000 – 18,000kg per acre** include Kenya Sifa, Kenya Karibu, Kenya Faulu and Kenya Mavuno

Other varieties include: Ambition, Annet, Arizona, Arnova, Caruso, Desire, Destiny, Mayan Gold, Saviola, Toluca

Note:

- Maturity period is dependent on the **cultivar** and **climatic conditions**
- The national average yield is **3,100kg per acre**
- With use of **disease free-seed** and **good management**, yield potential can rise to **8,000kg per acre**

1.3 Optimal Ecological Requirements

Altitude	**1,500 – 2,800 meters above sea level**
Rainfall	**850 – 1,200 mm of rainfall**
Growing Temperature	**15 – 20 ^{0}C**
Soils	**• Well drained medium loams** **•pH range 5.5 – 7.5**

1.3 Optimal Ecological Requirements

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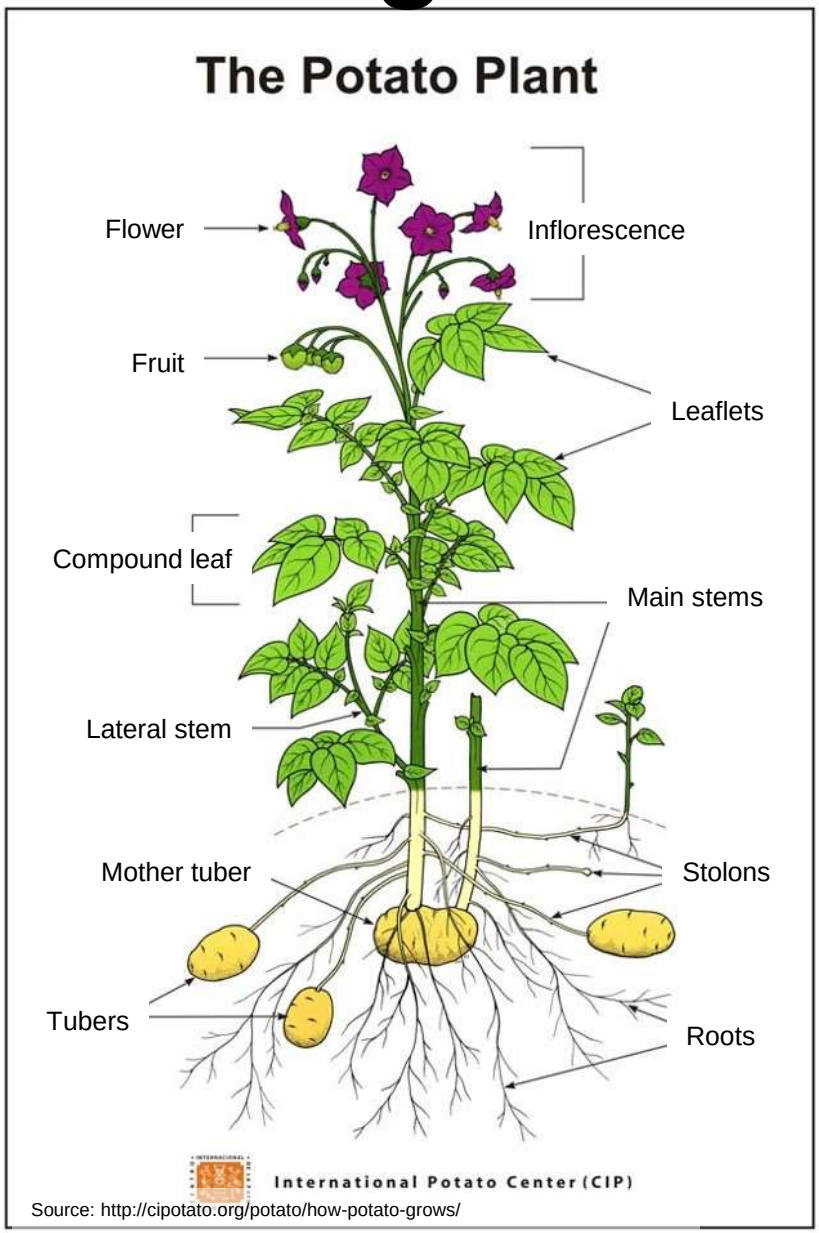
Growing Temperature	**15 – 20 ^{0}C**
Soils	• **Well drained medium loams** • **pH range 5.5 – 7.5**

1.3 Optimal Ecological Requirements

- **Altitude:** Potatoes are cultivated between **1,500 – 2,800** m.a.s.l.
- **Rainfall:** Well distributed rainfall of between **850 – 1,200** mm is required during the growing period
- **Temperature:** Potatoes perform well in cool climatic conditions and the optimum temperature range is **15 – 20^{o}C**. The temperature for tuberization is **15^{o}C**.
- **Soil:** Free draining fertile medium loams are preferred since heavy clays restrict tuber growth. The optimal soil pH range is **5.5 – 7.5**

1.4 Growth Stage

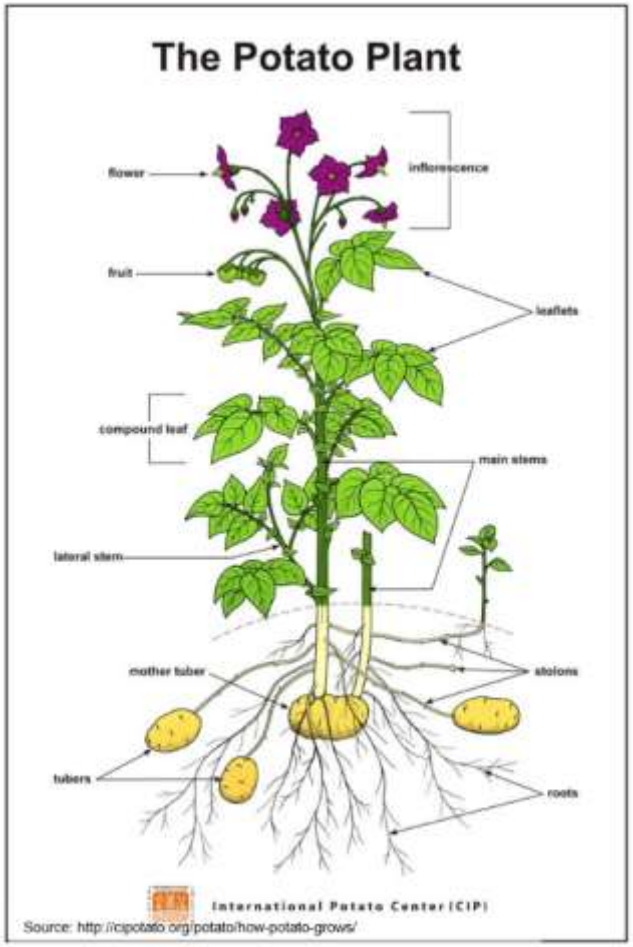
1-5



Source: http://cipotato.org/potato/how-potato-grows/

1.4 Growth Stage

1-5



1.4 Growth Stage

Growth Stage 1:

- **Sprout development:** Sprout develop from the eyes using energy from the seed tuber (pinch off the first sprout to remove apical dominance)

Growth Stage 2:

- **Vegetative growth:** Development of leaves, branches and stolons (Right time for earthing- up)
- Growth stage 1 and 2 takes roughly **4 – 10 weeks** depending on environmental conditions, physiological age of the tubers & kind of variety

Growth Stage 3:

- **Tuber set (initiation):** Tubers begin to form at the stolon tips but with little enlargement
- Flowering starts at the end of this stage and takes **2 weeks**

Growth Stage 4:

- **Tuber bulking:** Tuber enlargement caused by accumulation of water, nutrients & carbohydrates
- Critical stage for yield & quality
- This stage is the longest and can last **up to 3 months**

Growth Stage 5:

- **Maturation:** Vines turn yellow & tuber growth slows down
- Decline in photosynthesis
- Dry matter content is at maximum
- Dehulm to harden the skin at this stage (very important to ensure good quality produce)

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

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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

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[G20 Technologies]
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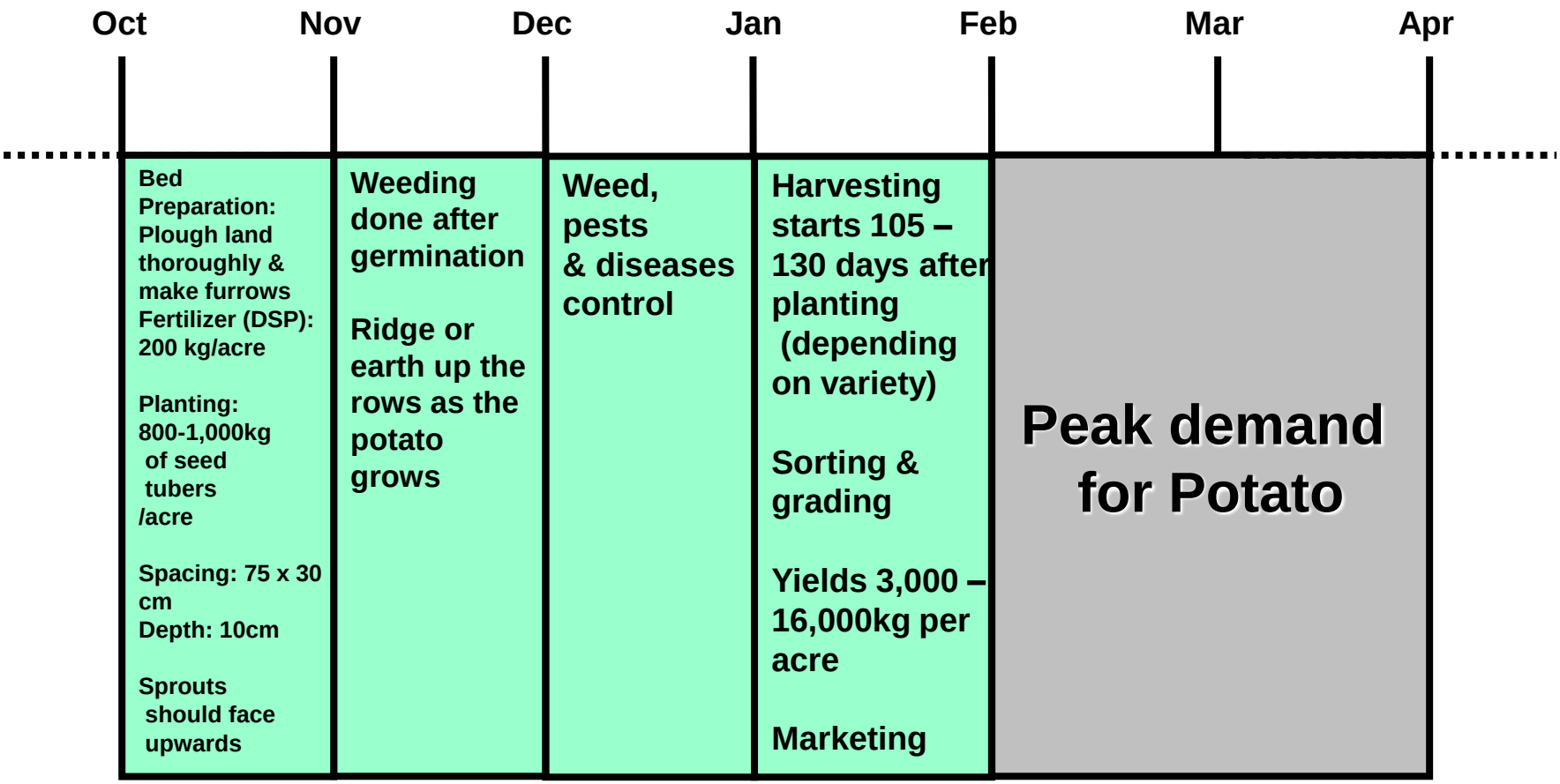
2.1 Crop Planting Calendar

A Sample of a Potato Planting Calendar



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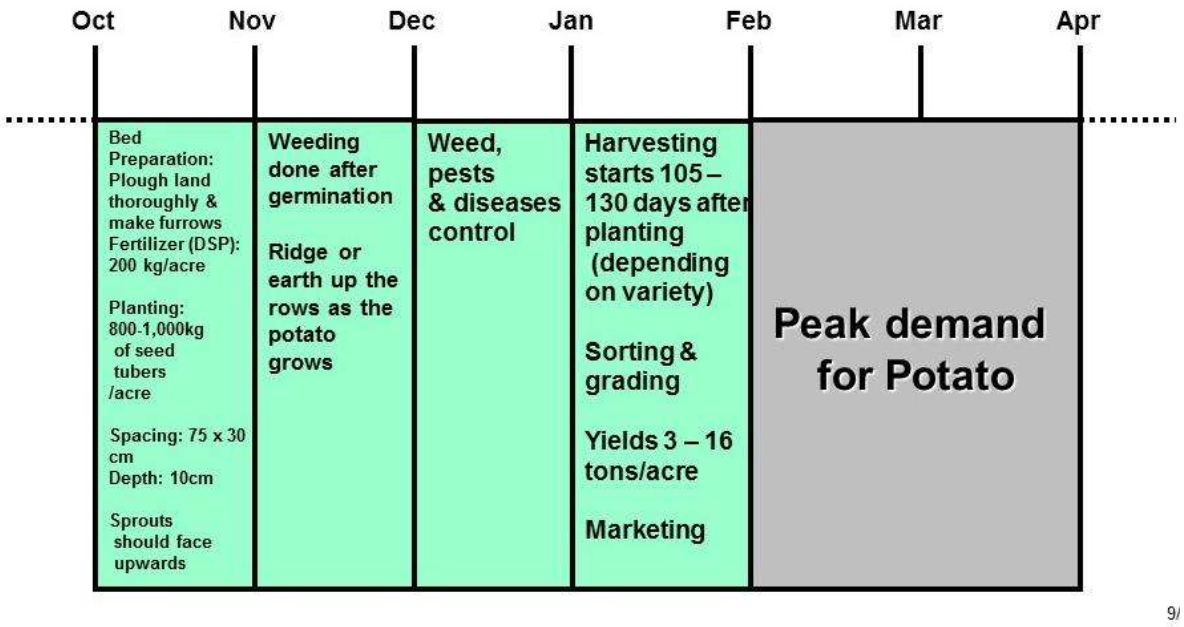
A Sample of a Potato Planting Calendar



A Sample of a Potato Planting Calendar: Targeting a peak market demand beginning just after February

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

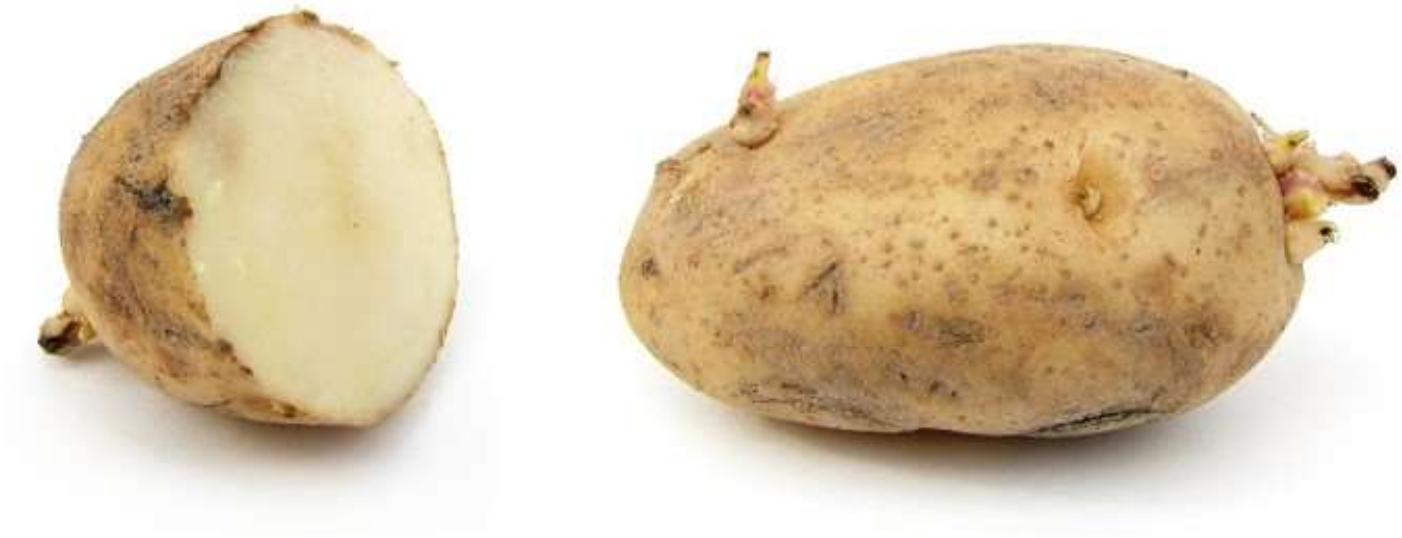
1. Determine from the market survey results (2.1) when there is peak demand for Potato
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Note:

- To meet the peak demand period of the market, there may be need of supplemental irrigation

2.2 Quality Seed/Planting Materials

2-4



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A sprouting seed potato

2.2 Quality Seed/Planting Materials

2-4

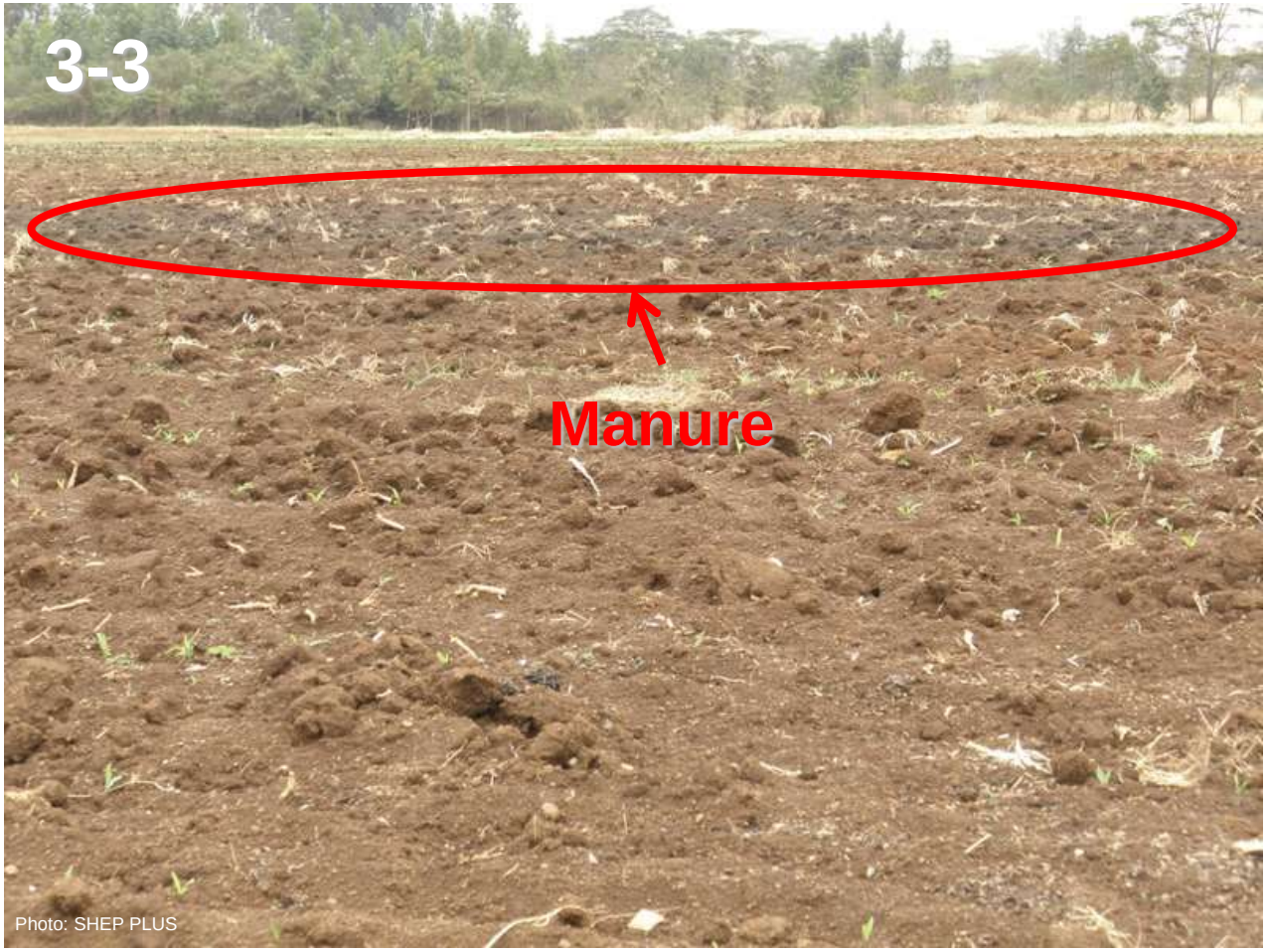
Photo: By ZooFari - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=8870305

A sprouting seed potato

2.2 Quality Seed/Planting Material (GHCP&PHHT20: Q5)

- Use **disease-free** or **certified seed**
- Certified seed potatoes have 3 grades:
  - **Size I:** Small sized seed potatoes (**25 – 35 mm** diameter)
  - **Size II:** Medium sized seed potatoes (**35 – 45 mm** diameter, egg sized tubers). This is the preferred size since it produces a good balance of big sized & small sized seed tubers
- Number of sprouts should be at least 4
- Seed tubers are kept in diffuse light to allow development of short strong sprouts: this is to ensure a uniform stand
- Production of basic seed is undertaken by **KARI Tigoni**
- Bulking of basic seed is done by various organizations such as **ADC Farm in Molo, Kisima Farm in Meru** and **selected individual farmers**

3.1 Basal Application



Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- Potatoes respond well to high soil fertility and manure or compost is needed if the land has been continuously cropped
- However, to prevent excessive production of vegetative part at the expense of tubers, it is recommended to add compost or manure on the crop preceding the potato
- Well-decomposed animal manure or compost is recommended

3.2 Planting

Photos: SHEP PLUS

Planting seed tubers

3.2 Planting

Photos: SHEP PLUS

Planting seed tubers

3.2 Planting

3.2.1 Appropriate Time:

- Planting is done **at the onset of the rains** (long & short) since most production in the country is rain fed and is done **twice a year**
- **Seeding rate: 800 – 1,000 kg/acre**

3.2.2 Recommended Spacing (GHCP&PHHT20: Q10):

- **20-30cm** (intra row) and **60-90cm** (inter row)
- Planting depth is **10 cm** and the sprouts should be placed facing upwards & the seed covered by a layer of soil

3.2.3 Fertilizer Application Rates (GHCP&PHHT20: Q11):

- DAP at **200 kg per acre** (about **1 kg** of **DAP** for **25 m** of furrow)
- On acidic soils, **DSP/ TSP 80kg per acre** & **CAN 120kg per acre** should be used, depending on the result of soil analysis

Note:

- Use of excess nitrogen should be avoided as it encourages vegetative growth at the expense of tuber formation

3.3 Water Requirement

Vigorous potato crop

3.3 Water Requirement

Vigorous potato crop

3.5 Water Requirement (GHCP&PHHT20: Q12)

- Potatoes require **850 – 1,200 mm** rainfall during the growing period
- Low and fluctuating moisture contribute to scab, hollow heart, low dry matter & low tuber set
- Production in Kenya is mainly rain fed and is timed to coincide with **the 2 rainy seasons** (long & short rains)
- Some farmers use furrow irrigation while others use sprinkler irrigation in their Potato crop

3.4 Crop Management:
3.4.1 Ridging/Earthing-up

Potato crop that has been earthed up /ridged properly

3.4 Crop Management
3.4.1 Ridging/Earthing-up

Potato crop that has been earthed up / ridged properly

3.7 Crop Management

3.7.1 Ridging/Earthing-up

- **Ridge** or **earth-up** the rows as the potatoes grow(1st at when crop grows15-20cm tall with weeding, then every after 2weeks for 3times), with the final ridging done **before plant starts to bloom**
- **Do Not** earth-up **when the soil is wet** to avoid compaction
- A well built hill helps to **control weeds**, **prevents greening of tubers**, **reduces attack** by the potato tuber moth

3.5.1 Major Pests

Photo: Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org

Photo: © Magnus Gammegaad (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Potato

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3.5.1 Major Pests

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3.5.1 Major Pests

- Pests damage causes a reduction in quality and quantity of produce
- The following are the major pests of Potato in Kenya:

A. Potato Tuber Moth
B. Aphids
C. Root-knot Nematode
D. Spider Mites
E. Millipedes
F. Mealy Bugs
G. Cutworms

3.5.1.A: Potato Tuber Moth

3-8

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Adult Moth

3-9

Photo: Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org

Potato tuber moth larva and pupa

3.5.1.A: Potato Tuber Moth

3-8

Adult Potato Moth

3-9

Potato tuber moth larva and pupa

3.5.1.A: Potato Tuber Moth

Identification:

- The moth is **small**, **brownish grey** in color with **narrow fringed wings**
- The moths are active mainly at dusk
- The female lays eggs singly or in batches on **leaves**, **stems** & **near eye buds** on exposed tubers in the field or in the store
- The caterpillars are up to **12 mm long**, **whitish** to **pale greenish** in color

Damages:

- Caterpillars burrow in the tubers making **long irregular tunnels** filled with excreta exposing tubers to secondary bacterial and fungal infection
- These tunnels make the potatoes unfit for human consumption
- The pest is transferred with **the harvested tubers** to the potato store, where it can reproduce and infest other tubers

Control:

- Use **healthy** & **clean seed**, since infested seed tubers are the main cause of **re-infestation in the field**
- Plant as deeply as possible (**10cm deep**) and ridge at least **3 times** during the growing season
- Ensure **compact hilling**: very important to prevent moths reaching the tubers to lay eggs
- Store all harvested tubers **before** dusk to avoid moths laying eggs on them
- Don’t leave harvested tubers in the field overnight during dry season
- Spray using appropriate insecticides Dimethoate (AGROTHOATE 40 EC®)

3.5.1.B: Aphids

Aphid on the leaf of a Potato Plant

3.5.1.B: Aphids

Aphid on the leaf of a Potato Plant

3.5.1.B: Aphids

Identification:

- Many aphid species attack the potato including the **green peach aphid**, **potato aphid** & **cotton aphid**
- Aphids are mainly found on young shoots and on the underside of leaves

Damages:

- Feeding by aphids causes **irregular curling of young potato leaflets** and **hinders growth of the leaflets**
- Direct damage caused by aphids sucking sap from the plant is usually of little importance
- Most damage is caused by **honeydew production on foliage** and **virus transmission**
- Aphids are important pests as **vectors of potato viruses**, such as the **Potato Leaf Roll Virus**, a serious disease affecting potatoes

Control:

- Use appropriate pesticides e.g. Thiamethoxam **(ACTARA®)** incorporate a sticker/spreader e.g. **Zipper®** or **Agral 90®,** Imidacloprid 200g/L**(NUPRID 200SC)**
- Control aphids in potato planted for **seed production**
- Keep seed production areas **separated from** commercial potato production

3.5.1.C: Potato Cyst Nematode

3-11a

Photo: Christopher Hogger, Swiss Federal Research Station for Agroecology and Agriculture, Bugwood.org Licensed under a Creative Commons Attribution-Noncommercial 3.0 License

3-11b

Photo: Bonsak Hammeraas, NIBIO - The Norwegian Institute of Bioeconomy Research, Bugwood.org
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Right: Potato cyst nematode damage on potato tuber
Left: Symptoms

3.5.1.C: Potato Cyst Nematode

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Photo: Bonsak Hammeraas, NIBIO - The Norwegian Institute of Bioeconomy Research, Bugwood.org
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3-11a: Potato cyst nematode damage on potato tuber
3-11b: Symptoms

3.5.1.C: Potato Cyst Nematode
Identification:

- Potato Cyst Nematodes (PCN) or potato root nematodes (*Globodera rostochiensis* and are 1-mm long roundworms belonging to the genus *Globodera*.
- They live on the roots of plants of the *Solanaceae* family, such as potatoes and tomatoes

Symptoms:

- PCN cause **growth** r**etardation** and, at very high population densities, damage to the roots and early senescence of plants.
- Reflect those of plants with an inefficient roots system i.e. poor growth, **wilting** during periods of **water stress**, early **senescence, reduced tuber size** and reduced tuber yield up to levels in excess of **80%.**

Control:

- Plant certified seed purchased from recognized, certified-seed producers.
- Avoid sharing equipment with other growers. The most common way of spreading PCN is in soil or on equipment.
- Thoroughly clean all equipment.
- Practice crop rotation.
- Regularly examine your crops for patches of poor or yellow potato plants.

3.5.1.D: Spider Mites

Photo: By CSIRO, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=35432982

Two spotted spider mites & eggs on leaf

3.5.1.D: Spider Mites

Two spotted spider mites & eggs on leaf

3.5.1.D: Spider Mites

Identification:

- To the naked eye, spider mites look like tiny moving dots but can be seen using a hand lens
- They live in colonies, mostly on the **under-surface of the leaves** and spin a silk-like web
- Adults have 8 legs and an oval body with two eye spots on the head end of the body
- Immatures are similar to adults except that newly hatched larvae have 6 legs
- Eggs are spherical & translucent becoming **cream colored** before hatching
- The pest is destructive **during dry weather**

Damages:

- Mites cause damage by sucking cell content from leaves
- At first, the damage shows up as **light dots** on the leaves which at times take a **bronze colour**
- As the feeding continues, the leaves turn **yellow** and **drop off**
- Often, leaves and stems are covered by **a large amount of webbing**
- Damage is usually worse when compounded by **water stress**

Control:

- Grow healthy crops; avoid water and nutrient stress. Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation.
- Keep perennial hedges such as pigeon peas, they are said to encourage predatory mites, which predate on spider mites.
- Uproot and burn infested plants. This can be successful during the early stages of infestation when the mites concentrate on a few plants.
- Keep the field free of weeds.
- Spray Sulphur 80% w/w (KUMULUS DF®)

3.5.1.E: Millipedes

Potato tubers damaged by millipedes

3.5.1.E: Millipedes

Potato tubers damaged by millipedes

3.5.1.F: Millipedes

Damages:

- They tunnel into potato tubers

Control:

- Clear hiding places
- Remove volunteer plants, crop residues, decaying vegetation, dead leaves, grass, compost piles, excess mulch or other similar debris.
- Avoid planting wet areas

3.5.1.F: Mealy Bugs

Mealybugs on a potato plant

3.5.1.F: Mealy Bugs

Mealybugs on a potato plant

3.5.1.G: Mealy Bugs

Damages:

- Mealybugs suck sap from plant phloem, reducing plant vigor
- They excrete sticky honeydew and wax, which reduces plant and fruit quality, especially when black sooty mold grows on the honeydew.

Control:

- Pruning and destroying affected parts.
- Removing and destroying heavily infested plants.
- Ensuring soil fertility. In most cases healthy plants are able to withstand some mealybug attack

3.5.1.G: Cutworms

A Cutworm larva

3.5.1.G: Cutworms

A Cutworm larva

3.5.1.E: Cutworms

Identification:

- The larvae of cutworms stay **buried in the soil** and **cut stems during the night**
- The pest is **destructive during dry weather**

Damages:

- Cutworms feed on **tubers** and **roots**, boring a **wide shallow hole**
- They are also serious pests of **newly sprouted potato plants**, and can leave great empty patches in a potato field

Control:

- Ploughing and hand picking
- Prepare field and **destroy vegetation and weeds 10 – 14 days** before planting
- **Ploughing** exposes caterpillars to predators and desiccation by the sun
- **Flooding of the field** for **a few days before planting** can help kill cutworm caterpillars in the soil
- Use appropriate **insecticide** e.g. Thiamethoxam (**Actara®)**: used to drench when damage by cutworm is evident

3.5.2 Major Diseases

Photo:
https://commons.wikimedia.org/wiki/File%3ALate_blight_on_potato_3.jpg
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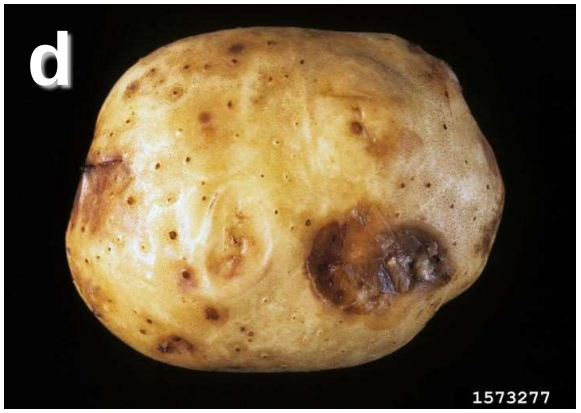

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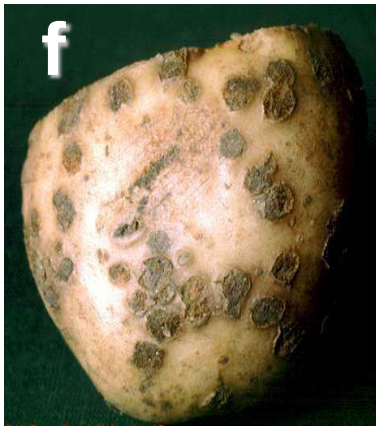
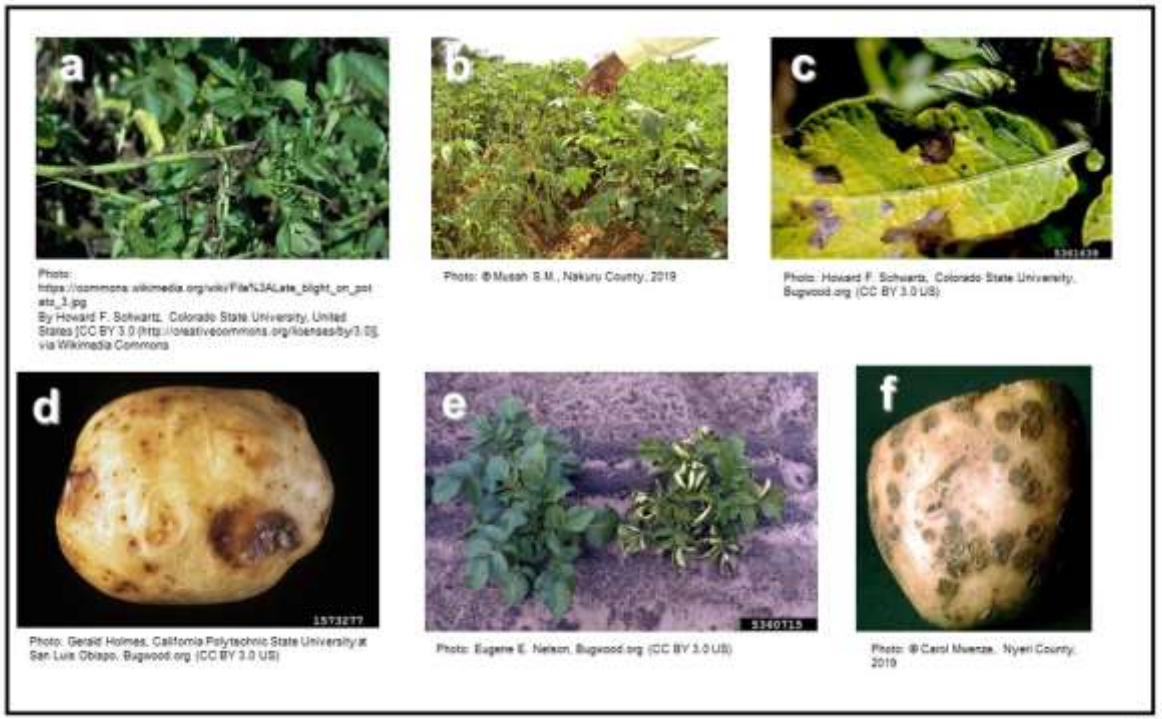


Photo: © Carol Mwenze, Nyeri County, 2019

3.5.2 Major Diseases



21/28

3.8.4 Major Diseases

- Disease infestation leads to reduction in quality and quantity of produce
- The following are the major diseases of Potato in Kenya:
  a. **Late Blight**
  b. **Bacterial Wilt**
  c. **Early Blight**
  d. **Bacterial Soft Rot**
  e. **Potato Leaf Roll Virus (PLRV)**
  f. **Common Scab**

3.5.2.a: Late Blight

Photo: https://commons.wikimedia.org/wiki/File%3ALate_blight_on_potato_3.jpg
By Howard F. Schwartz, Colorado State University, United States [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

Leaves and stem of potato plant infected by Late Blight

3.5.2.a: Late Blight

Leaves and stem of potato plant infected by Late Blight

3.5.2.a: Late Blight

- This is **a fungal disease** which is favored by **cool**, **cloudy wet conditions**
- It is one of the most destructive disease of potato

Symptoms:

- **Water soaked spots on leaves** which enlarge and **turn brown**
- Below the leaf, the fungus produces **white mouldy growth** seen clearly at the edge of the spot
- The affected leaves wither, yet frequently remain attached to the stem

Control:

- **Resistant varieties**, such as **"Tigoni"**, **"Kenya Baraka"**, **"Roslin Eburu"**, **"Annet"** & **"Asante"** are claimed to have some resistance
- Practice **Crop Rotation** with **non-*solanaceaous* crops**
- Practice **good field hygiene by rouging**
- Select only **certified**, **disease-free** seed potatoes
- **Spray with appropriate fungicides both protective & curative, such as**
  - **Antracol WP70® (a.i. Propineb)**
  - **Dithane M45® (a.i. mancozeb)**
  - **Nando 500SC® (a.i. Fluazinam) Ridomil Gold MZ68® (a.i. metalaxyl + mancozeb)**
  - **Milraz WP76® (a.i. Propineb 70 % + Cymoxanil 6 %)**
  - **Victory 72WP® (a.i. metalaxyl + mancozeb)**

3.5.2.b: Bacterial Wilt

3-15

Photo: Plant Protection Service , Plant Protection Service, Bugwood.org (CC BY 3.0 US)

Potato leaves wilting due to Bacterial Wilt infection

3.5.2.b: Bacterial Wilt

Photo: Plant Protection Service , Plant Protection Service, Bugwood.org (CC BY 3.0 US)

Potato leaves wilting due to Bacterial Wilt infection

3.5.2.b: Bacterial Wilt

- The disease is caused by a bacteria known as ***Pseudomonas solanacearum***
- It is **soil borne** and **the most serious disease** which can destroy an entire field
- The bacteria survives in the soil for a long time and enters into the host plant through **wounds on the roots** and **the base of stems**
- The disease is spread by infected tubers, crop residues, contaminated surface water, contaminated soils, and tools

Symptoms:

- **Affected plants wilt** even when there is adequate moisture in the soil
- **Wilting is rapid** and **wipe out** the entire fields in few days
- Slimy continuous white discharge emanate from the eyes of the affected tubers

Control:

- Use of **certified seed**
- Practice **Crop Rotation (5 – 7 years)** roguing volunteer potato plants during rotation
- Destruction of infected plant debris by burning
- Avoid contaminating the field with soil from an affected field
- Avoid cutting of seeds as a way of multiplying seeds when having insufficient seed potato
- Spot treatment with **10 % of Sodium hypochlorite (bleach)**

3.5.2.c: Early Blight

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Early Blight on Potato Leaf

3.5.2.c: Early Blight

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Early Blight on Potato Leaf

3.5.2.c: Early Blight

- This is caused by **a fungus: *Altenaria solani***
- The fungus persist in debris of affected plants **for several years**
- Early Blight thrives best under **warm wet conditions**

Symptoms:

- First, **oval** or **angular dark brown** to **black "target" spots** appear on leaflets
- Usually, **a narrow chlorotic zone** is around the spot which fades into **the normal green**
- Lowest, oldest leaves are infected first, and they **droop** and **dry** as the disease progresses and eventually fall off

Control:

- Use **certified seeds**
- Good field sanitation by rouging
- When using own seeds, carry out **hot water treatment**
- Practice **Crop Rotation**
- Destroy all infected crop residue
- **Spray with appropriate fungicides**, such as
  Antracol WP70® (a.i. **Propineb**)
  Dithane M45® (a.i. **mancozeb**)
  Nando® (a.i. **Fluazinam**)
  Ridomil Gold® (a.i. **metalaxyl + mancozeb**)
  Milraz WP76® (a.i. **Propineb 70 % + Cymoxanil 6 %**)
  Victory 72WP® (a.i. **metalaxyl + mancozeb**)

3.5.2.d: Bacterial Soft Rot

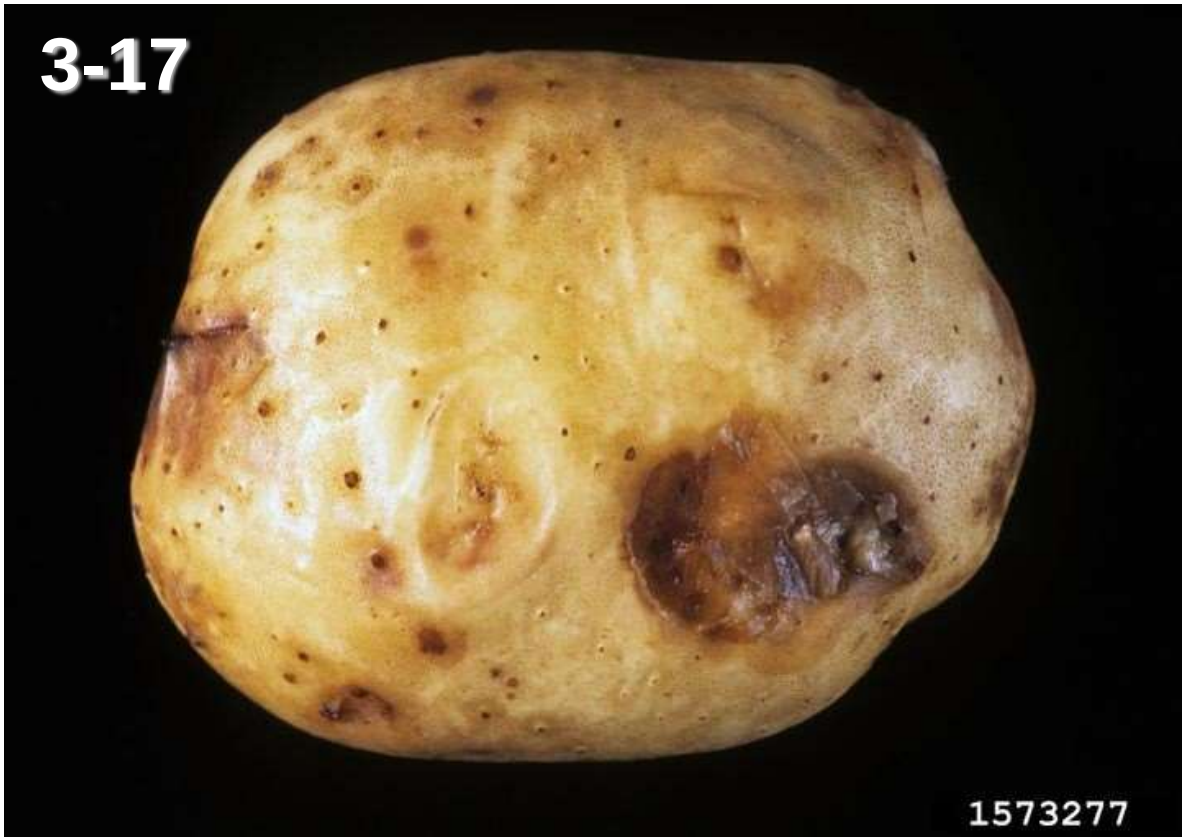


Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Potato tubers infected by Bacterial Soft Rot

3.5.2.d: Bacterial Soft Rot

Potato tubers infected by Bacterial Soft Rot

3.5.2.d: Bacterial Soft Rot

- The disease is caused by **the bacteria: *Erwinia spp.***
- It enters the plant through **wounds** on leaves or **stems** near the soil surface and **young tubers**
- The disease development is favoured by **high temperatures and humidity**
- The bacteria is spread by **rain splash**
- **In poorly drained fields**, tubers decay
- The infected tubers and soils acts as **a source of inoculum in subsequent years**

Symptoms:

- Stems and leaves develop lesions which are **water soaked**, **dark green** and eventually develops to **a soft rot with a foul odour**
- On tubers, **reddish brown spots** form at the lenticels
- The inner parts of the tubers shows **a soft rot** and **a creamy exudate** is seen and may decay during transportation or storage in **poorly ventilated**, **high temperature** and **humidity**

Control:

- Practice crop rotation with crops such as cereals
- Use of **healthy seed tubers**
- Improved **field drainage**
- Store and transport tubers in **dry**, **well ventilated conditions**
- Field hygiene
- Crop rotation
- Sorting before storage

3.5.2.e: Potato Leaf Roll Virus (PLRV)

Photo: Eugene E. Nelson, Bugwood.org (CC BY 3.0 US)

PLRV-infected plant next to an uninfected potato plant

3.5.2.e: Potato Leaf Roll Virus (PLRV)

PLRV-infected plant next to an uninfected potato plant

3.5.2.e: Potato Leaf Roll Virus (PLRV)

- This is an important potato disease which occurs in **all potato growing areas**
- It is transmitted by **aphids.**
- The virus is also spread through **infected tubers** and diseased **volunteer plants**

Symptoms:

- In plants infected through aphid transmission, **the apical leaves roll upwards** and occasionally become **pinkish in colour**
- In plants infected through use of infected seed tubers, **the lower leaves roll upwards** (after sprouting) and becomes **spoon-like**
- Severely affected leaves develop **a tubular shape**
- Plants are **stunted** and plants develop small tubers
- If these tubers are used as seeds, plants are stunted and crop produces very low yields

Control:

- **Use of chemicals to control aphids which can transmit the virus to potato plants**, such as
  - **Nuprid 200 SC** (a.i. **Imidacloprid**)
  - **Karate 2.5WG** (a.i. **Lambda Cyhalothrin**)
- Use of **virus-free seed tubers**

3.5.2.f: Common Scab

Photo: © Carol Mwenze, Nyeri County, 2019

Common scab on a tuber

3.5.2.f: Common Scab

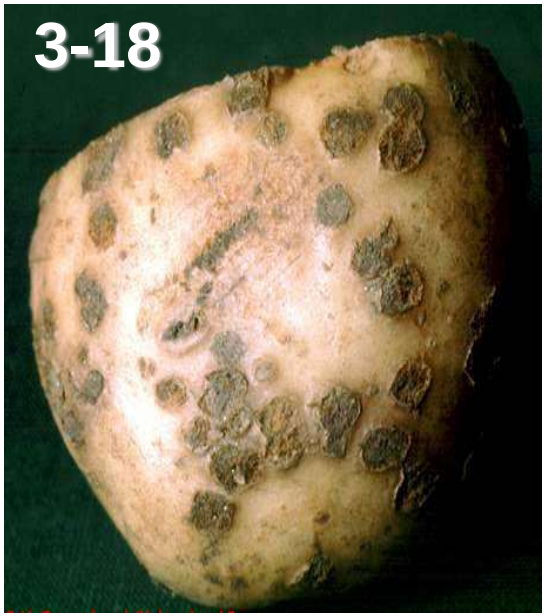


Photo: © Carol Mwenze, Nyeri County, 2019

Common scab on a tuber

3.5.2.f: Common Scab

- Affects the potato skin with pimple-like lesions.
- It may not quantitatively affect yield but the quality of tubers which makes them less attractive in the market and their storability.

Symptoms:

- Lesions are a superficial cork-like layer (russet scab)
- They may be erumpent or cushion-like (raised scab)
- The lesions may extend deep into the tubers (pittedscab)
- Lesions may be circular or irregular in shape - Affected potato skin tissue may be tan or brown

Control:

- Avoid planting scab-infected seed tubers
- Increase the rotation period (2 years or more) for potato planting
- High moisture levels at tuber formation and bulking reduces scab incidence
- Do not reduce the acidity of the soil too much by liming as scab is reduced in acidic soils.

4. Harvest

Farmers harvesting and bagging Potatoes

4. Harvest

4-1

Farmers harvesting and bagging Potatoes

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- **Maturity Period:** Range between **3 – 4 months** after planting depending on the variety
- Tubers harvested while still immature tend to have **low dry matter content** and to suffer **more skin damage**, resulting in easier infection by **fungal and bacterial pathogens**
- However, **seed potatoes are often harvested early**, to avoid virus infection that may occur during the latter part of the growing season

Important Notes:

- Tubers should be **completely covered with soil** to **reduce greening** and **entry of potato tuber moth**
- Cutting vegetative material **2 weeks before harvesting** hardens the skin of tubers **(dehaulming).**
- Hardening of skin tuber reduces **damage of tubers** during harvesting & post-harvest handling
- Dug potato tubers should be stored **clean**, **dry** with mature skins free from **wounds**, **insect pests** and **diseases**

Yields: Average yield in Kenya: **3.2 tons/acre** (Yields potential: **16 tons/acre**)

- **Proper husbandry** and **use of clean planting material** can increase yields to **6 – 8 tons/acre**
- Depending on **variety** and **degree of maturity at harvesting**, potatoes can be kept for **1 – 2 months** before sprouting at room temperature
- Mature Potato can be **dehaulmed** and left in soil for **1– 2 months**

5. Post-Harvest Handling

Photo: Brochure/G.O.K. STRATEGY ON POTATO DEVELOPMENT INDUSTRY

Sorting potatoes

5. Post-Harvest Handling

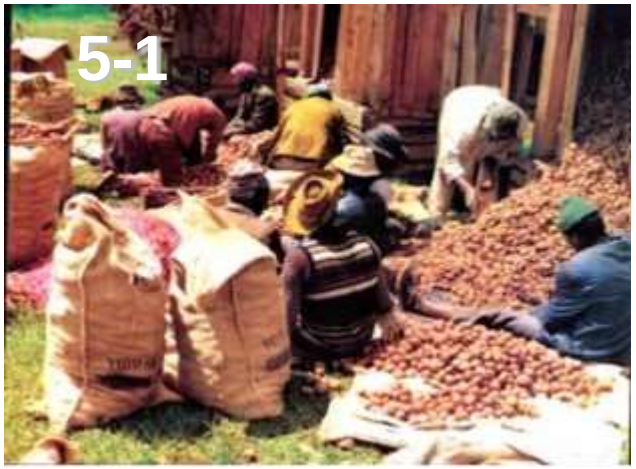


Photo: Brochure/G.O.K. STRATEGY ON POTATO DEVELOPMENT INDUSTRY

Sorting potatoes

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Potatoes are supposed to be sold in the standard **50kg units** in the markets

5.2 Value Addition Techniques: Cleaning, Sorting, Grading, & Processing (GHCP&PHHT20: Q19)

Sorting:

- **Diseased and cut tubers** are sorted out to avoid losses in storage due to rotting

Grading:

- Potatoes are graded depending on **size** and **shape of tuber**
- Malformed tubers are removed
- Tubers of are graded into:
  - Ware: beyond 60 mm gauge
  - Seed: 28 – 60 mm gauge
  - Chatts: Less than 28 mm gauge

  (SEED POTATO PRODUCTION AND CERTIFICATION GUIDELINES, KEPHIS 2016)

Storage:

- **Ware Potatoes**
- Ware tubers should be kept in a dark store to prevent greening
- The store should be cool and well ventilated
- **Seed Potatoes**
- **Seed potatoes** are kept in **a cool store with diffuse light** for **coloured**, **short sprouts** to develop, however, avoid **direct sunlight**

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

TOMATO PRODUCTION

Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **Tomato Production**

Objective: **To provide a guideline on production of Tomato**

Specific Objective:

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

Contents:

1. **Introduction: Background, Common Varieties and Optimal Ecological Requirements**
2. **Pre-Cultivation Preparation 1 – 5**
3. **Cultural Practices 1- 10**
4. **Harvest**
5. **Post-Harvest Handling**
6. **Cost & Income Analysis**
7. **Post-Training Evaluation Exercise**

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

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 Product Board.

1. Introduction:
1.1 Background

Tomato (Nyanya)

1. Introduction:
1.1 Background

Tomato (Nyanya)

1. Introduction:
1.1 Background

- Tomato is a member of the ***Solanaceae*** **family** which includes crops such as **Irish Potato**, **Sweet Pepper**, **Chili** and **Egg Plant**
- One of the most produced and consumed vegetables in Kenya
- Important cash crop for smallholder farmers
- Mainly grown in open fields, however green house tomato production is growing in popularity
- Rich in **Vitamin A, C** and **Lycopene**
- Eaten **fresh,** added to **salads**,cooked as a vegetable or processed into **tomato paste**, **jam**, **sauce**, **puree**, and **juice**

1.2 Common Varieties

1-2

Photo: Flora fields
http://www.florafields.com/index.php?route=product/product&product_id=189

“Rio Grande” (Determinate)

1-3

Photo: seminis,
https://seminis.co.za/product/assila/686

“Assila F1” (Determinate)

1.2 Common Varieties

1-2

Photo: Flora fields
http://www.floralfields.com/index.php?route=product/product&product_id=169

“Rio Grande” (Determinate)

1-3

Photo: semins, https://semins.co.za/product/assila/686

“Assila F1” (Determinate)

Determinate Varieties

“Rio Grande”:

- Fresh market and processing variety
- Plant is slightly bushy and can be staked or left unstaked
- Tolerant to verticillium and fusarium wilt
- **Maturity Period: 75 – 85 days** after transplanting
- **Yield: 18,000kg per acre**

“Assila F1”

- **Determinate** early maturing (**75 days)** variety
- Tolerant to **Tomato Yellow Leaf Curl Virus (TYLCV)** & **nematodes**
- It produces fruits with attractive **red colour** with **oval shape** & **heavy sweet fruits**
- Yield: **23,000kg per acre**
- Good keeping quality & transportability

1.2 Common Varieties Cont’

Photo: Syngenta Kenya, https://www.syngenta.co.ke/tomatoes

“Kilele F1” (Determinate)

Photo: Farm Fresh Seeds
http://www.farmfreshseeds.com/heirloom-tomato-seeds-cal-j.html

“Cal J” (Determinate)

1.2 Common Varieties Cont'

Photo: Syngenta Kenya, https://www.syngenta.co.ke/tomatoes

"Kilele F1" (Determinate)

Photo: Farm Fresh Seeds
http://www.farmfreshseeds.com/heirloom-tomato-seeds-cal-j.html

"Cal J" (Determinate)

Determinate Varieties Cont'

"Kilele F1"

- Medium-early maturing, determinate type
- Suitable for drier or humid areas
- Disease tolerance: **Tomato Yellow Leaf Curl Virus**, **Tomato Mosaic Virus**, **Verticillium**, **Fusarium Wilt** & **Nematodes**
- Fruits: Firm and elongated and has shelf life of 21 days
- **Maturity Period: 75 days** after transplanting
- **Yield: 30,000 – 35,000 per acre**

"Cal J"

- Open pollinated **determinate** variety
- Tolerant to verticilium & fusarium wilts
- The plant produces red blocky shaped fruits
- The fruits store and transport well
- **Maturity Period: 75 - 85 days** after transplanting
- **Yield: 11,000 – 13,000kg per acre**

1.2 Common Varieties Cont’

Photo: seminis, https://seminis.co.za/product/eden/687

“Eden F1”

Photo: Kenya Highlands Seed Co. https://royalseed.biz/tomatoes

“Rambo F1”

1.2 Common Varieties Cont’

Photo: seminis, https://seminis.co.za/product/eden/687

“Eden F1” (Determinate)

Photo: Kenya Highlands Seed Co.
https://royalseed.biz/tomatoes

“Rambo F1”

1.2 Common Varieties Cont’

“Eden F1”

- **Determinate** and vigorous growing variety
- Good tolerance to **Alternaria Canker**, **Verticillium Wilt**, **Fusarium Wilt**, **Nematodes** and **Bacterial Speck**
- Deep red blocky fruits have long shelf life
- **Maturity Period: 75 days** after transplanting
- **Yield: 40,000-50,000kg per acre** (**9 – 10 kg** per plant)

“Rambo F1”

- Determinate, vigorous plant with uniformly set and firm fruits
- Tolerance: Bacterial wilt, Bacterial spot, Fusarium wilt, Verticilium wilt and Nematodes
- **Maturity 75 days** after transplanting
- **Yield: 30,000kg per acre**
- Good shelf life & transport quality

1.2 Common Varieties Cont’

“Anna F1” (Indeterminate)

1.2 Common Varieties Cont’

“Anna F1” (Indeterminate)

1.2 Some Common Varieties Cont’

“Anna F1”:

- **Hybrid** and **indeterminate fresh market variety** that produces blocky oval red fruits that have **a long shelf life**, **tolerance to Fusarium**, ***Verticillium*** **Wilt**, ***Alternaria*** **Stem Canker** and **Nematodes**
- Ideal greenhouse Tomato
- **Maturity Period: 75 days** after transplanting
- **Yield: 64,000kg per acre** (**18 kg** per plant for **8 months**)

Other Determinate varieties grown in Kenya:

- **Fortune Maker F1**
- **Novel**
- **Nuru**
- **Valoria F1**
- **Zawadi F1**

Other Indeterminate varieties grown in Kenya:

- **Nemoneta**
- **Tylka F1**
- **Prostar F1**

1.3 Choice of Varieties

Photo: SHEP PLUS

Tomato crop in the field

1.3 Choice of Varieties

Photo: SHEP PLUS

Tomato crop in the field

1.3 Choice of Varieties

Selection of a variety needs to be based on:

- **Growth Habit:** determinate (bush), indeterminate (climbing) and semi-determinate
- **Disease Resistance/Tolerance:** indicated by initials after variety name e.g.) **"F"** for **fusarium wilt**, **"N"** for **nematodes**
- **Fruit Type (shape, size & color):** Market requirement will determine fruit type.
  - Processing-intense red color & more solids
  - Fresh market- shape, color & size vary
- **Hybrid or Open Pollinated Varieties (OPV):** Hybrid seeds give higher yields but are more expensive

1.4 Optimal Ecological Requirements

Altitude	**0 – 2,000 metres above sea level**
Rainfall	**Over 600 mm of rainfall annually**
Growing Temperature	**20 – 25 ^{0}C (day)** **15 – 17 ^{0}C (night)**
Soils	**•Well drained sandy, loam, and clay loam soils** **•pH range 6.0 – 7.5**

1.4 Optimal Ecological Requirements

Altitude	**0 – 2,000 metres above sea level**
Rainfall	**Over 600 mm of rainfall annually**
Growing Temperature	**20 – 25 ^{0}C (day)** **15 – 17 ^{0}C (night)**
Soils	**• Well drained sandy, loam, and clay loam soils** **• pH range 6.0 – 7.5**

1.4 Optimal Ecological Requirements

- **Altitude:** Tomato can be cultivated up to **2,000 m** above sea level
- **Rainfall:** Tomato performs well in areas that receive over **600 mm** of rainfall annually. It should be **well distributed** throughout the growing season.
- **Temperature:** Tomato performs well in **warm climatic conditions**. The optimal day and night temperature range is **20 – 25 ^{0}C** and **15 – 17 ^{0}C**, respectively
- **Soil:** Tomato requires **well drained sandy loam**, or **clay loam soils**. The optimal soil pH range is **6.0 – 7.5**.

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

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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

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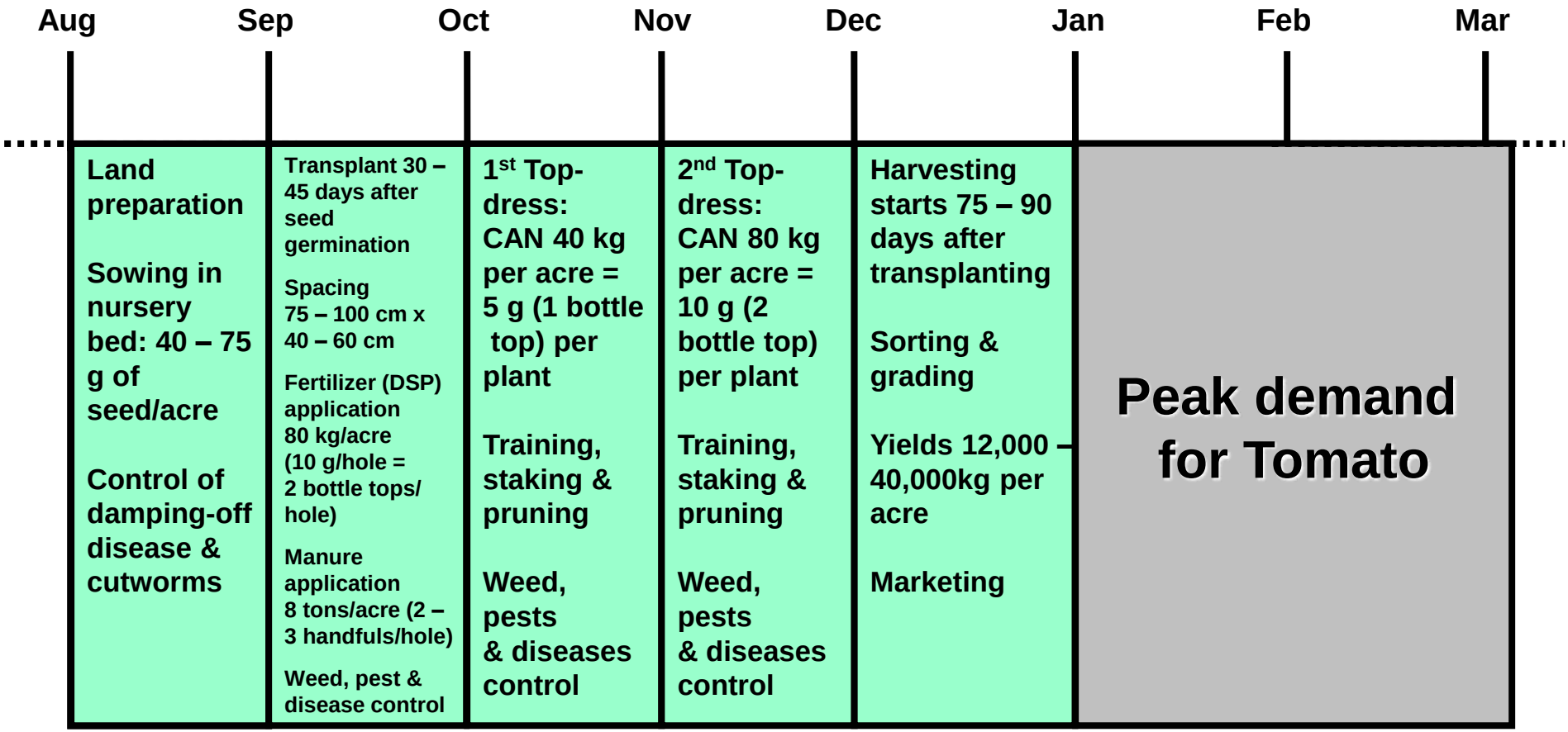
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

2.1 Crop Planting Calendar

A Sample of a Tomato Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Tomato Planting Calendar

A Sample of a Tomato Planting Calendar: Targeting a peak market demand beginning just after January

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Tomato
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak demand as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Manure preparation through composting

2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching and volatilization of nutrients
- Tomato is a heavy feeder and does well in soils with high organic content (manure)
- Based on the results of the soil analysis, prepare adequate compost for application; the recommended rate of application ranges from **5 – 8 tons/acre**

3.1 Basal Application

Manure incorporation as a basal application

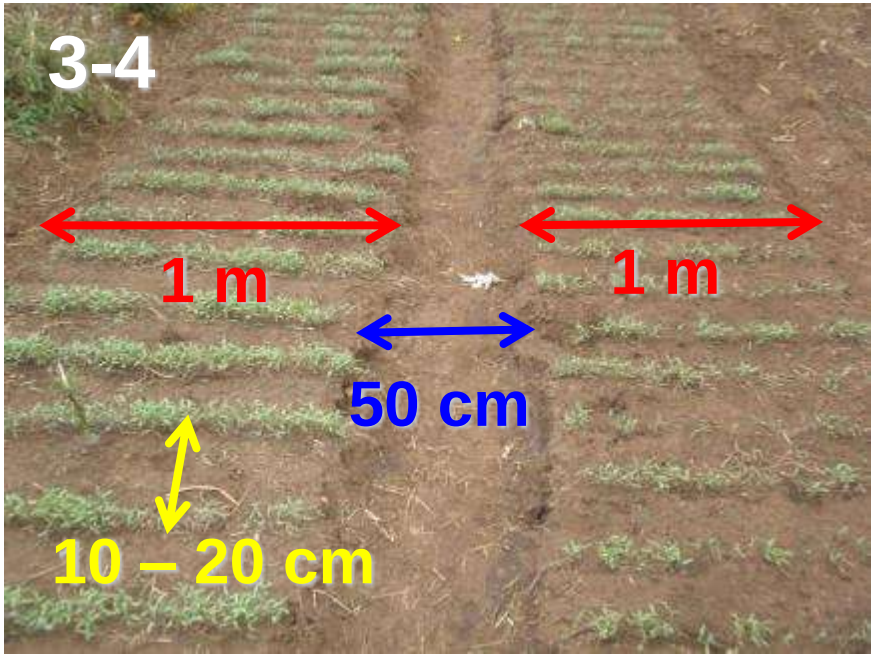
3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- The manure/compost should be broadcasted (**5 – 8 tons/acre**) then worked into the soil (incorporated) preferably using a hoe
- Manure/compost should be applied **1 – 2 weeks** before transplanting the Tomato and incorporated into the soil

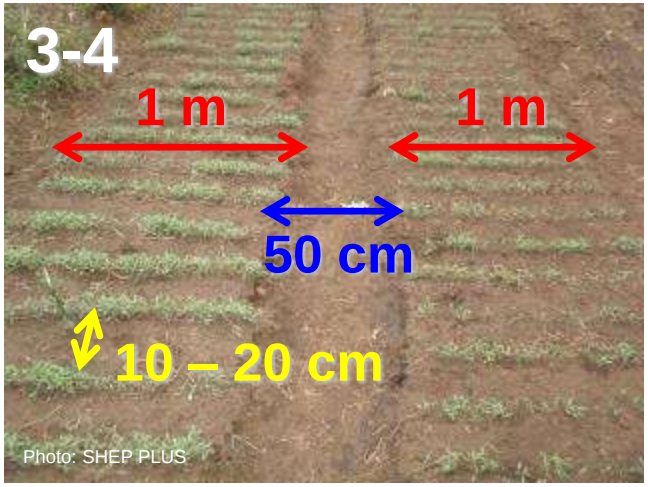
3.2 Raising Seedlings



Photos: SHEP PLUS

Tomato nursery

3.2 Raising Seedlings



Tomato nursery

3.2 Raising Seedlings (GHCP&PHHT20: Q9)

- Tomato can be established through the nursery or directly seeded
- Normally, it is raised in nursery before transplanting
- The seed rate is about **40 – 75 g/acre**
- **Seed trays** can also be used to raise seedlings

Nursery Site Selection:

- The nursery should be sited in a plot that has not been planted with a member of ***Solanaceae* family** for the last **3 years**
- Choose the site with **good drainage**

Nursery Establishment:

- Prepare a seedbed of **1 m width** and of a convenient length
- Make drills on the seedbed at a spacing of **10 – 20 cm apart**
- Thinly sow the seeds in the drills and cover lightly with soil

Management of Nursery:

- Water the nursery regularly
- Harden the seedlings **1 – 2 weeks before transplanting** by reducing the frequency of watering and gradually exposing the seedlings to direct sunlight
- Insects such as whiteflies can transmit viruses to young tomato plants hence should be controlled using pesticides e.g. Amitraz (Mitac 20EC®), Buprofezin (Applaud 40%SC®), Azadirachtin (Nimbecidine®), Imidacloprid (Confidor 70 WG®)
- These insects can be blocked from reaching the seedlings by use of **an insect proof net** (agricultural type)

3.3 Transplanting

Recently transplanted Tomato seedlings

3.3 Transplanting

Recently transplanted Tomato seedlings

3.5 Transplanting

3.5.1 Appropriate Time

- Seedlings are transplanted **30 – 45 days** after seed sowing
- It is recommended that transplanting should be done either **early in the morning** or **late in the evening**

3.5.2 Recommended Spacing

(GHCP&PHHT20: Q10)

- **Spacing:** range from **75 – 100 cm** (between rows) by **40 – 60 cm** (between seedlings) depending on the variety
- **Plant Population per Acre:** range from **6,666 to 13,333**
- Appropriate spacing produces short, stocky plants with good root system

3.5.3 Fertilizer Application Rates

(GHCP&PHHT20: Q11)

- Apply **2 – 3 handfuls** of manure per planting hole (**8 tons/acre**)
- **Apply 2 bottle tops** (**10 g**) of Triple Super Phosphate (TSP) per planting hole (**80 kg/acre**
- Apply Muriate of Potash (**MOP)** to enhance availability of potassium

3.4 Water Requirement

Drip Irrigation in a Tomato field

3.4 Water Requirement

Furrow Irrigation in a Tomato field

3.4 Water Requirement (GHCP&PHHT20: Q12)

- Tomato is sensitive to water deficit:
  - Immediately after transplanting
  - During flowering and fruit development
- Plants should be provided with adequate water
- Tomato plants are sensitive to water logging and flooded fields should be drained within **1 – 3 days**

Irrigation Methods:

- **Furrow** and **drip irrigation** are the most effective methods
- **Furrow irrigation minimizes** spread of fungal diseases, such as “Early Blight”
- **Drip irrigation** on the other hand is **efficient on water utilization**
- **Overhead irrigation encourages** spread of diseases such as “Early Blight”

3.5 Managing of Weeds

Tomato under good weed management

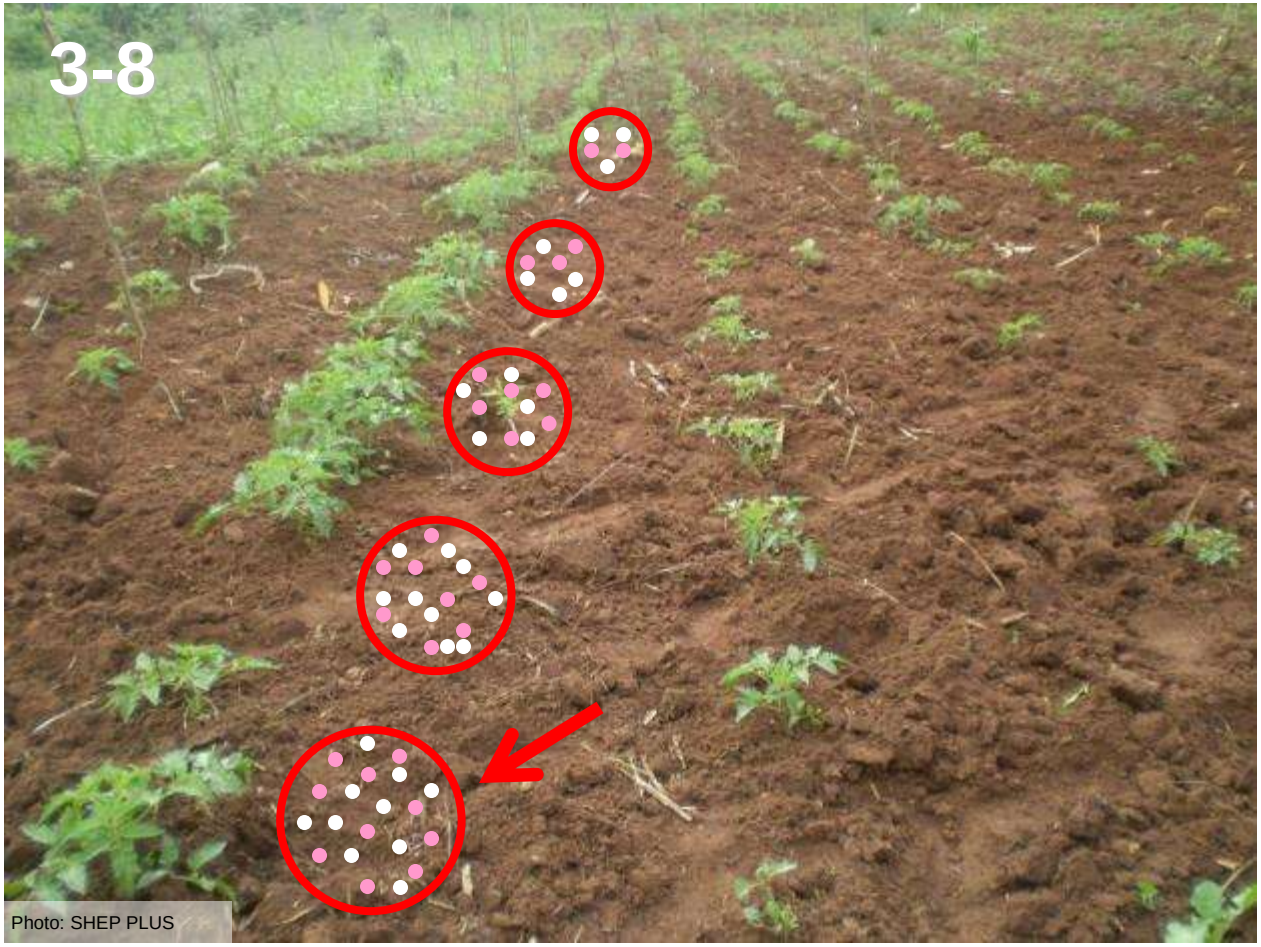
3.5 Managing of Weeds

Tomato under good weed management

3.5 Managing of Weeds (GHCP&PHHT20: Q13)

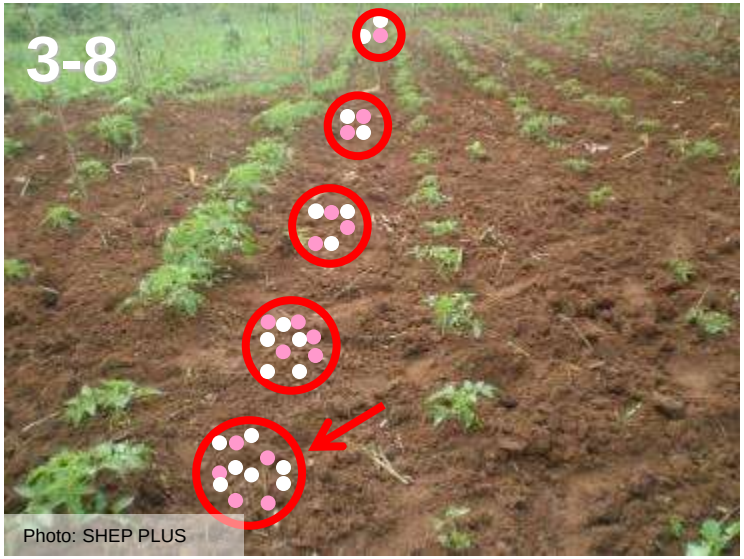
- Avoid bruising the roots during weeding
- This can be done through use of appropriate weeding tools
- Generally, keep the field weed free as much as possible to avoid competition for **nutrients**, **sunlight** and **moisture**
- Weeding Tomato field when the soil is wet can increase the spread of some **bacterial** (Bacterial Wilt) and **fungal** (Fusarium Wilt) **diseases**

3.6 Top-dressing



Top-dressing using the placement method

3.6 Top-dressing



Top-dressing using the placement method

3.6 Top-dressing (GHCP&PHHT20: Q14)

- Tomato crop should be fertilized with organic and inorganic chemical fertilizers to produce high yields
- Top-dressing fertilizer such as CAN should be applied in **2 splits** at **40 kg & 80 kg/acre** at **4 and 8 weeks** after transplanting
- Application method: circular band around the stem
- **Inadequate top-dressing can result into physiological disorders:**
  - Hollow cavities and poor taste in fruits due to potassium deficiency
  - Blossom-end rot due to an imbalance between **Nitrogen**, **Calcium** and **soil moisture**

3.7 Crop Management
3.7.1 Training & Staking

3-9

Photo: SHEP PLUS

Well staked Tomato field

3.7 Crop Management
3.7.1 Training & Staking

3-9

Photo: SHEP PLUS

Well staked Tomato field

3.7 Crop Management
3.7.1 Training and Staking

- Indeterminate varieties need **staking/training** to facilitate pruning, harvesting and other cultural practices
- Determinate varieties may be **staked** in wet season or **mulched** to prevent fruit contact with the soil
- Staking materials: **wooden stakes**, **bamboo** or any **sturdy material**
- **Strings**, **plastic strips** or other material can be used to train the plant to the stake

3.7.2 Pruning

Training of Tomato plants in the field
A side shoot has been pinched

3.7.2 Pruning

Training of Tomato plants in the field

(A side shoot has been pinched)

3.7.2 Pruning

- This practice is necessary for the **indeterminate** varieties
- It involves **removal of side shoots**, **extra flowers**, **fruits and diseased leaves**
- Leads to **early maturity** of fruits and encourages fruits to **increase in size and uniformity**
- **Sterilize** pruning blades by use of chlorine bleach and water at a ratio of 1:1. Use of unsterilized blades, and smoking can lead to spread of diseases e.g. **TMV, Bacterial Wilt**

3.8.1 Major Pests

Photo: SHEP PLUS

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?imgnum=5432149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid=22440495

3.8.1 Major Pests

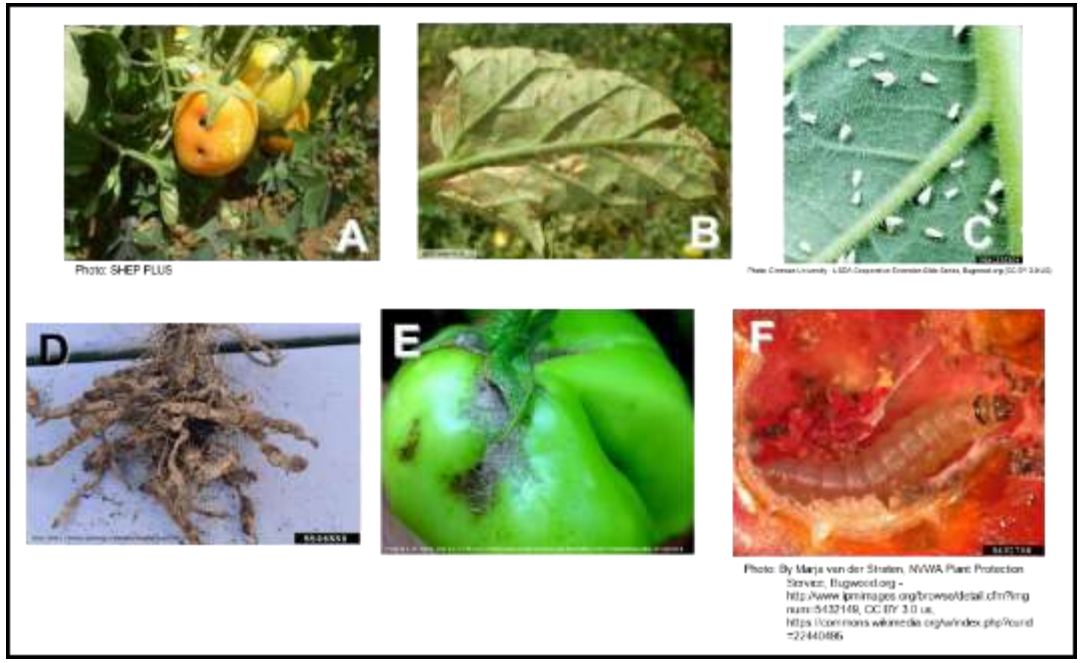


Photo: SHEP PLUS

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?img num=5432149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid =22440886

3.8.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Tomato in Kenya:

A. African Bollworm
B. Red Spider Mites
C. Tobacco Whitefly
D. Root-knot Nematode
E. Thrips
F. Tuta absoluta

3.8.1.A: African Bollworm

Symptom of fruit damaged by “African Bollworm”

3.8.1.A: African Bollworm

Symptom of fruit damaged by "African Bollworm"

3.8.1.A: African Bollworm

Identification:

- Adult moth is **dull yellow** to **brown**
- The female moth lays **tiny round & brownish eggs** near or on flowers or small fruits
- Larvae have alternating **light and dark colored stripes** on either side of the body
- The pupa is **shiny brown**

Damages:

- Caterpillars feed on flowers and green fruits causing **flower abortion** and **sunken necrotic spots**, respectively
- Feeding holes made by the caterpillar serve as entry point for bacteria and fungi which may lead to rotting of fruits

Control:

- **Tilling** & **ploughing** of old tomato field exposes pupa to desiccation and natural enemies
- **Planting of trap crops** (**Cucumber**, **Maize & Africam Marigold**) which attract the pest before it attacks tomatoes (Need to synchronize planting of both maize and tomatoes so that they flower at same time)
- **Use of selective pesticides**, such as microbial control agents:
  - Helocoverpa armigera SNPV Virus (**Helitec SC®)**
  - **Indoxacarb (Avaunt 150SL®)**
  - **Etofenprox 30%(TREBON 30 EC®)**

3.8.1.B: Red Spider Mites

Underside of Tomato leaf infested with “Red Spider Mites”

3.8.1.B: Red Spider Mites

Underside of Tomato leaf infested with "Red Spider Mites"

3.8.1.B: Red Spider Mites

Identification:

- Adult red spider mites are **oval in shape**, appear **reddish** or **greenish** with eight **(8)** legs
- Eggs are very **tiny**, **spherical** and **whitish**; and are laid singly on underside of leaves
- Red spider mites **spin silk threads** which anchor the pest and their eggs to the plant

Damages:

- Infested leaves show **white to yellow speckling**, **later turn pale** or **bronzed**
- **High population causes serious drying** and dropping of leaves (defoliation) which leads to smaller and lighter fruits

Control:

- Use of pesticides (miticides) including:
  - Spiromesifen (**Oberon SC 240®)**
  - Hexythiazox (**Arsur 100 EC®**)
  - Abamectin (**Avirmec 1.8EC®**, **Almectin 1.8%EC®**, **Agrimec 18EC®**)
  - Amitraz (**Mitac 20EC®)**
  - ***Amblyseius californicus*** **(Amblytech®-predatory mite)**
- Spider mites rapidly develop **resistance to pesticides**, especially when they are used **continuously** for **several seasons**
- To avoid development of resistance, farmers need to:
  - Use miticides **with different modes of action and chemical composition/active ingredients- a.i**
  - Avoid **routine spraying**
  - Use the **recommended dosage**

3.8.1.C: Tobacco Whitefly

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

“Tobacco Whitefly” on the Tomato leaf

3.8.1.C: Tobacco Whitefly

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

"Tobacco Whitefly" on the Tomato leaf

3.8.1.C: Tobacco Whitefly

Identification:

- Adult whitefly resembles **small white moth –** like insect which cluster on the underside of upper leaves from which they suck sap
- Eggs are laid in arc or circle on the underside of young leaves
- When eggs hatch they produce **greenish white nymphs** which resemble scales

Damages:

- Suck plant sap and remove nutrients which cause **yellowing of infested leaves**
- The larvae secrete **honey dew** which supports growth of **black sooty mould**
- Transmit viral diseases, especially **Tomato Yellow Leaf Curl Virus (TYLCV)**

Control:

- Keep tomato fields **weed-free**
- Use of **yellow sticky traps** to monitor their **population** levels
- Cover tomato seedling nurseries with **nylon nets or insect proof nets** to protect seedlings from Whitefly infestations
- **Use of insecticides**, such as (**morning** & **ring spray**)
  - **Amitraz (Mitac 20EC®)**
  - **Buprofezin (Applaud 40%SC®)**
  - **Azadirachtin (Nimbecidine®)**
  - **Imidacloprid (Confidor 70 WG®)**
  - **Lambda Cyhalothrin (Karate 2.5WG®)**
  - **Lambda- cyhalothrin + Thiamethoxam (LEXUS 247 SC®)**

3.8.1.D: Root-knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

Root galls: characteristic of “Root-knot Nematode” infestation

3.8.1.D: Root-knot Nematode

Root galls: characteristic of "Root-knot Nematode" infestation

3.8.1.D: Root-knot Nematode

Description:

- Nematodes are **soil inhabitants** easily spread by **infested seedlings**, **soil washed down the slopes** or by farm **implements**
- Root–knot nematodes are most serious on **light sandy soils** under **furrow irrigation**

Damages:

- Plants are **stunted**, become **yellow** and tend to **wilt in hot weather**
- The roots of infested plants are severely **distorted**, **swollen** and **bear galls** or **knots**
- Heavy infestation results in severe loss in yield

Control:

- **Burn the top soil** using waste plant material after seedbed preparation
- **Solarize seedbeds** if possible by covering soil with clear polythene sheet for **2 – 3 months**
- **Manuring** of soil to reduce nematode population
- Fields should be **ploughed deep** and **harrowed followed by dry fallow**
- **Use trap/ repellent crops** such as **Marigold**
- **Use of nematicides** such as
  - **Paecilomyces lilacinus (BIO-NEMATON 1.15% WP®) Azadirachtin (Nimbecidine®, Achook EC®)**
  - ***Paecilomyces lilacinus* (Mytech WP®)**
  - **Metham sodium (Metham sodium®)**
  - **Abamectin (Adventure 5G®)**
  - **Ethoprophos (MOCAP GR 10®)**

3.8.1.E: Thrips

Photo: © A. M. Varela, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Crops/Tomato#simple-table-of-contents-4

Photo: SHEP PLUS

Symptoms of Thrips Damage on Tomato (Left) and TOSPO Virus Symptom (Right)

3.8.1.E: Thrips

Symptoms of Thrips damage on Tomato

Tospovirus symptom

3.8.1.E: Thrips

Identification:

- Adult thrips are **small** (**0.5 – 2.0 mm**), **slender** and **winged**
- Wings are long, narrow and fringed with long hairs
- Nymphs are **white or yellow**
- Both adult and nymphs feed on lower leaf surface, buds, flowers and fruits
- It transmits the **Tomato Spotted Wilt Virus/ Tospovirus** (**"Kijeshi"**)

Damages:

- Attack on leaves causes **speckling** & **small necrotic patches**
- Heavy infestation causes **premature wilting**, **delay in leaf development** & **distortion of young shoots**
- Attack on buds and flowers leads to **abortion**

Control:

- **Ploughing and harrowing** before transplanting to kill **pupae** in the soil
- **Use of insecticides**, such as
  - **Lambda-Cyhalothrin (Karate 2.5 WG®)**
  - **Abamectin** + **Acetamiprid (Amazing Top 100WDG®)**
- Thrips are difficult to control with insecticides because their habits partially offer protection from insecticides (eggs are laid in plant tissue, adults shelter in flowers, and larvae pupate in soil)

3.8.1.F: *Tuta Absoluta*

Photo: By Marja van der Straten, NVWA Plant Protection Service, Bugwood.org - http://www.ipmimages.org/browse/detail.cfm?imgnum=5362149, CC BY 3.0 us, https://commons.wikimedia.org/w/index.php?curid=22430495

***Tuta Absoluta* adult (left) and larva (right)**

3.8.1.F: *Tuta Absoluta*

Tomato Leafminer adult

Tomato Leafminer larva

3.8.1.F: *Tuta Absoluta*

Identification:

- The moth is **grey-brown**, **same size** and **posture** as diamond back moth (DBM) and has long antenna and lays up to 260 eggs
- Newly hatched caterpillars are **small** (0.5 mm) and **yellowish**
- Mature caterpillars (9 mm: fully grown are **yellow-green**, have **pinkish color** on the back and **a black band** behind the head
- Pupae is **light brown** and size is 6 mm
- The larva (caterpillar) is the **damaging stage**
- **Distribution** is through **seedlings, containers, fruits, soil & Green houses**

3.10.3.F: *Tuta absoluta*

Photo: By N3v3rl4nd - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6598872

By Goldlocki - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=228832

Scouting on the leaves: Tomato Leafminer (left) *Tuta Absoluta* (right)

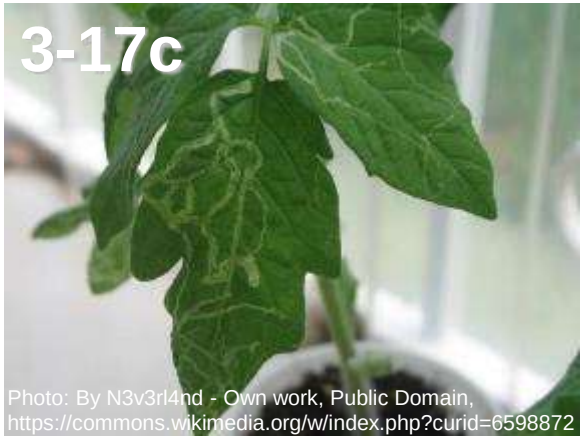
3.8.1.F: *Tuta Absoluta*

Damages:

- The caterpillar burrows (mines**) in the middle of the leaf tissue**
- **Unlike other Leafminers, it feeds indiscriminately** and from a distance, you see as if leaves are “burning”
- Most distinctive symptoms are the **blotch-shaped mines** in the leaves
- **It bores on fruits, leaving symptomatic tiny holes**
- **It also burrows on stems causing breakages**
- **Can lead to 100% crop loss**

Control:

- **Early control** is important before the pest pressure builds up
- Carry out cultural practices like **field hygiene, crop rotation**
- Carry out **regular scouting/monitoring** of pest population
- Use of pheromone traps to attract male insects for both monitoring/surveillance and pest control e.g.) mating disruption, mass trapping ‘lure & kill’ method, such as **Tutrak traps**
- **Use of biological control agents**, such as
  - **Chlorantraniliprole (Coragen®)**
  - **Indoxacarb (Avaunt 150EC®, Merit 150SC®), Spirotetramat + Flubendiamide (Tihan OD®)**
  - **Thiocyclam 50% w/w; Thiocyclam-hydrogenoxalate (Evisect S®) and - Imidacloprid (Grizly 175/30 SC®)**
  - **Flubendiamide (Belt 480SC®)**
- The above pest control tactics should be combined in an **IPM strategy**



3-17c: common leaf miner infesting on leaves which normally does not affect the fruit

3-17d: Leaf-mining pattern of *Tuta Absoluta*

3.8.2 Major Diseases & Physiological Disorders

Photos: SHEP PLUS

Photo: © A. A. Self and A. M. Varela, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Tomato/example-table-of-contents-4

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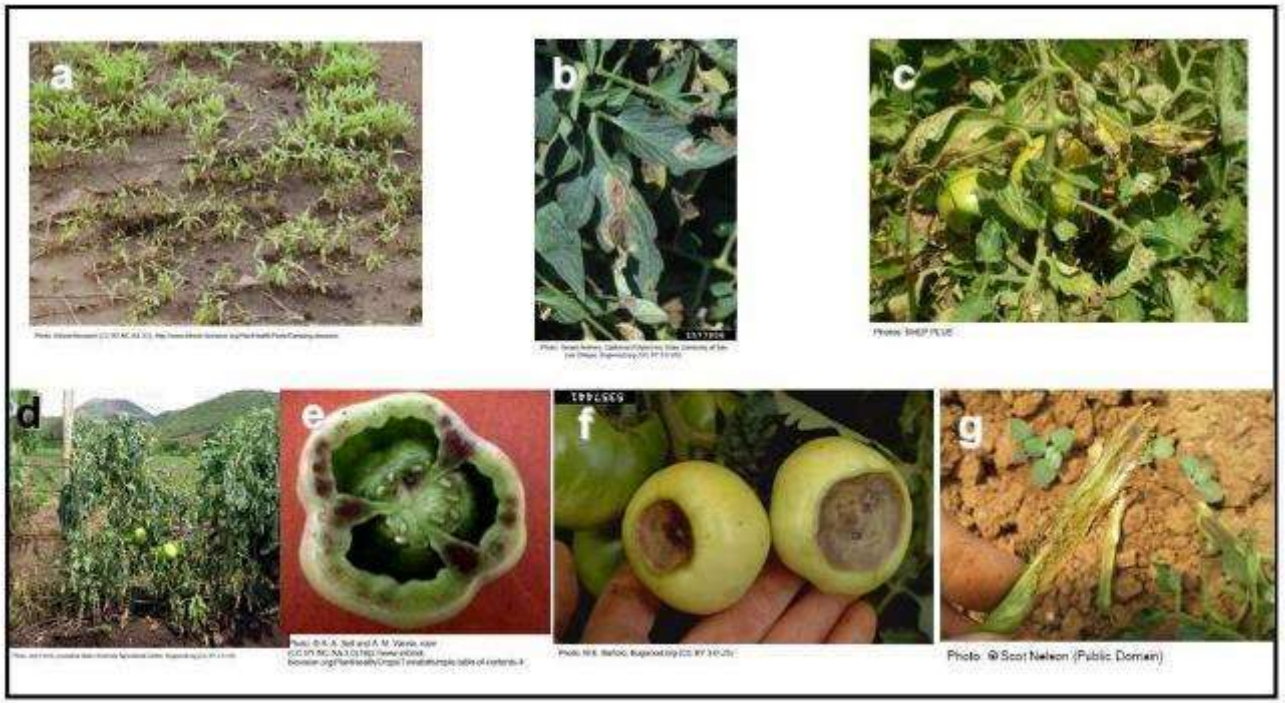
3.8.2 Major Diseases & Physiological Disorders



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3.8.2 Major Diseases & Physiological Disorders

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases and physiological disorders of Tomato in Kenya:

a. Damping-off
b. Late Blight
c. Early Blight
d. Bacterial Wilt
e. Tomato Mosaic
f. Blossom-end Rot
g. Fusarium Wilt

3.8.2.a: Damping-off

Photo: Infonet Biovision (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Pests/Damping-diseases

“Damping-off” symptoms on seedlings

3.8.2.a: Damping-off

Photo: Infonet Biovision (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Pests/Damping-diseases

“Damping-off” symptoms on seedlings

3.8.2.a: Damping-off

General Description:

- This disease is **soil borne**

Symptoms:

- **Decay** of germinating seed
- **Girdling** of stem of young seedling at ground level

Control:

- Use of certified seed
- Avoid locating the seedbed on infested field
- **Avoid excessive fertilizer** application and **watering** to young seedlings while still at nursery bed
- Apply chemicals such as:
  - Metalaxyl + Mancozeb (Amidil 68WG)

3.8.2.b: Late Blight

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Edward Sikora, Auburn University, Bugwood.org (CC BY 3.0 US)

“Late Blight” on foliage and fruits

3.8.2.b: Late Blight

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: Edward Sikora, Auburn University, Bugwood.org (CC BY 3.0 US)

"Late Blight" on foliage and fruits

3.8.2.b: Late Blight

General Descriptions:

- This is a **fungal disease** which affects foliage and fruits
- The development of the disease is favoured by **cool** and **wet conditions**

Symptoms:

- Irregular **greenish-black water** soaked patches on leaves
- The spots on the leaves later turn **brown** and the attacked leaves wither but remain attached to the stem
- Water soaked **brown streaks** on stem
- Grey water soaked spots on fruits – usually the upper half of the fruit with **foul smell**

Control:

- Crop rotation
- Removal of all volunteer crops that are more susceptible to this disease
- **Pruning and staking** in order to improve air circulation and reduce humidity
- **Use of fungicides**, such as:
  - **Metalaxyl** + **Mancozeb (Ridomil Gold MZ68®)**
  - **Propineb** + **Cymoxanil (Milraz WP76®)**
  - **Mancozeb (Dithane M45®)**
  - **Dimethomorph** + **Mancozeb (Acrobat MZ®)**

3.8.2.c: Early Blight

Photo: SHEP PLUS

“Early Blight” on foliage

3.8.2.c: Early Blight

Photos: SHEP PLUS

“Early Blight” on foliage

3.8.2.c: Early Blight

General Descriptions:

- This is a **fungal disease** which affects foliage and fruits
- The fungus is seed borne
- It is well adapted to semi-arid areas; warm wet weather
- The disease is favoured by warm rainy weather

Symptoms:

- **Premature loss** of **lower leaves** is the main symptom
- On leaves, brown circular spots with **dark concentric rings**
- Leaves turn yellow and dry when only a few spots appear
- On fruits, large sunken areas with dark concentric rings appearing velvet

Control:

- Use of certified seeds
- Appropriate spacing
- Avoid overhead irrigation, water in the morning and keep plants healthy/ stress-free
- **Use of fungicides**, such as
  - **Chlorothalonil (Odeon® 82.5WDG)**
  - **Manconzeb (Oshothane®)**
  - **Propineb (Antracol WP70®)**
  - **Mancozeb** + **Cymoxanil (Agromax®)**
  - **Propineb** + **Iprovalicarb (Melody Duo®)**

3.8.2.d: Bacterial Wilt

Photo: Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org (CC BY 3.0 US)

Symptom of “Bacterial Wilt” infection

3.8.2.d: Bacterial Wilt

Photo: Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org (CC BY 3.0 US)

Symptom of "Bacterial Wilt" infection

3.8.2.d: Bacterial Wilt

General Descriptions:

- This is a **bacterial disease** which is **soil-borne**
- It is easily spread by run off water and infested soil

Symptoms:

- **Rapid wilting** and **death** of entire plant **without yellowing or spotting of leaves**
- When the stem of a wilted plant is cut across, the pith has **a darkened water** – soaked appearance
- When stem of wilted plant is squeezed, a **greyish slimy ooze** is produced
- To distinguish this wilt from others when a thin slice is taken from the brown stem tissue and placed inside a glass of water, **a milky ooze** is produced from the cut surface

Control:

- Practice crop rotation with crops such as cereals
- Remove wilted plants, with the soil around roots, from the field and destroy
- **Solarize** planting beds
- Spot treatment with **Sodium Hypochlorite** at 10 % dilution (Jik) or with **lime/ ash**
- Sterilize pruning tools
- Use of Metam sodium (METHAM SODIUM 51 Liquid soluble®), Bronopol (ENRICH BM Wettable Powder®)

3.8.2.e: Tomato Mosaic Virus

3-24

Photo: University of Georgia Plant Pathology , University of Georgia, Bugwood.org (CC BY 3.0 US)

3-25

Photo: © A. A. Seif and A. M. Varela, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealth/Crops/Tomato#simple-table-of-contents-4

Symptoms of “Tomato Mosaic Virus” infection on foliage and fruit

3.8.2.e: Tomato Mosaic Virus

Photo: University of Georgia Plant Pathology , University of Georgia, Bugwood.org (CC BY 3.0 US)

Photo: © A. A. Self and A. M. Varela, icipe (CC BY-NC-SA 3.0) http://www.infonet-biovision.org/PlantHealthyCrops/Tomato#simple-table-of-contents-4

Symptoms of "Tomato Mosaic Virus" infection on foliage and fruit

3.8.2.e: Tomato Mosaic Virus

General Descriptions:

- This is a **viral disease** which is easily transmitted by infected seed and plant debris in the soil
- Mechanically transmitted through transplanting seedlings and pruning tools

Symptoms:

- Mottling of leaves with raised dark green areas
- The shape of young leaves is distorted
- Internal browning of fruits, especially when fruits are affected **at mature green stage**

Control:

- Use certified disease-free seeds
- Remove crop debris and roots from the field
- Do not smoke or touch cigarettes as the virus is transmitted from tobacco leaves even if it is processed

3.8.2.f: Blossom-end Rot

Photo: M.E. Bartolo, Bugwood.org (CC BY 3.0 US)

Tomato fruits affected by “Blossom-end Rot”

3.8.2.f: Blossom-end Rot

Photo: M.E. Bartolo, Bugwood.org (CC BY 3.0 US)

Tomato fruits affected by "Blossom-end Rot"

3.8.2.f: Blossom-end Rot

General Descriptions:

- This is a **physiological condition** caused by **calcium nitrogen imbalance in the soil**, especially when moisture level in the soil is low

Symptoms:

- A rot at the **blossom-end of the fruit**
- The surface becomes **dark brown** and **sunken**

Control:

- **Maintain adequate soil moisture**, especially **at fruit development stages**
- **Soil liming** in calcium deficient soils, **reduce N** and **mulch** the field
- **Top-dress with CN, Mavuno Planting** and ensure adequate soil moisture
- **Spray the crop with calcium chloride**
- Foliar application of **EASY-GRO CALCIUM®**

3.8.2.g: Fusarium Wilt

Photo: © Scot Nelson (Public Domain Mark 1.0)

Symptoms of Fusarium Wilt

3.8.2.g: Fusarium Wilt

Photo: © Scot Nelson (Public Domain Mark 1.0)

Symptoms of Fusarium Wilt

3.8.2.g: Fusarium Wilt

General Descriptions:

- The fungus is both **seed- and soil-borne**.
- It causes most damage on **light, sandy soils**.
- It is most active at temperatures **between 25 and 32^{o}C**.
- The fungus can survive in the soil indefinitely **even when no tomatoes are grown.**
- **It can also survive in fibrous roots of weeds** (e.g. Amaranthus, Digitaria and Malva species).
- **Acidic soils (pH 5.0 to 5.6)** and excessive nitrogen fertilisation promote disease development.

Symptoms:

- **The lower leaves** of the plant usually turn yellow and die.
- Leaflets on one side may be affected while those on the other side are symptomless.
- Diseased leaves readily break away from the stem. When affected stems just above ground level and petioles are cut diagonally, **a reddish-brown discolouration of the water conducting tissues will be observed**.

Control:

- Use resistant tomato varieties (e.g. "Fortune Maker", "Rio Grande", "Tengeru 97", "Roma VFN“, “Eden F1”, “Rambo F1”, “Anna F1”).
- Use **certified disease-free seeds**.
- Do not locate seedbeds on land where Fusarium wilt is known to have occurred.
- Where soil is acidic, raise the pH by applying lime or farmyard manure.
- Avoid excessive nitrogen fertilisation and control root-knot nematodes.

4. Harvest

Photo: SHEP PLUS

Harvesting of Tomatoes

4. Harvest

Harvesting of Tomatoes

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Maturity period range between **3 – 4 months** after transplanting depending on:
  - The variety
  - Environmental conditions
- Tomato can be harvested at different stages depending on the market requirement and distance to the market
- There are **four (4) main harvesting stages:**
  - **Mature-Green Stage**: where the fruit is green but internal gel is well developed
  - **Breaker/turning Stage**: up to **30 %** of fruit surface has definite color break from **green to yellow**
  - **Pink/Light Red Stage**: **30 – 90 %** fruit surface has **pink/red color**
  - **Red/Ripe Stage**: over **90 %** fruit surface has changed to **red color**
- Fruits should be harvested **early in the morning** when it is cool since the fruit temperature is low
- Harvested fruits should be kept in a **cool**, **shaded** and **ventilated area** in order to minimize heat gain
- Where necessary, wipe fruits to remove dirt
- The yields vary from **12,000 – 40,000kg per acre** depending on the variety and crop husbandry

5. Post-Harvest Handling

Photo: SHEP PLUS

Graded tomatoes packed in crates

5. Post-Harvest Handling

Photo: SHEP PLUS

Graded tomatoes packed in crates

5. Post-Harvest Handling

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Tomatoes are normally packed in wooden & plastic crates

5.2 Value Addition Techniques: Cleaning, Sorting, Grading & Processing (GHCP&PHHT20: Q19)

Sorting:

- Sorting is done to remove damaged or diseased fruits.

Grading:

- Tomatoes are graded depending on the uniformity of ripening and fruit size
- There are **tree (3) main tomato grades:**
  - **Grade 1**: big size fruits of uniform color and shape
  - **Grade 2**: medium size fruits of uniform color and shape
  - **Grade 3**: small size fruits with slight variation in color and shape

5. Post-Harvest Handling Cont’

5-2

Photo: SHEP PLUS

Tomatoes in crates ready to be transported to the market

5. Post-Harvest Handling Cont'

5-2

Photo: SHEP PLUS

Tomatoes in crates ready to be transported to the market

5.2 Value Addition Techniques: Cleaning, Sorting, Grading, & Processing Cont' (GHCP&PHHT20: Q19)

Processing:

- Processing Tomatoes into high value products such as **jam**, **sauce**, and **pickles** enables farmers to earn more income

MOALF/SHEP PLUS

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

WATERMELON PRODUCTION

Prepared by SHEP PLUS

Photo: SHEP PLUS

Training Title: **Watermelon Production**

Objective: **To provide a guideline on production of Watermelon**

Specific Objective:

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

Contents:

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Preface

- This training material applies the fundamental practices essential for crop production and successful marketing to put into perspective the case of horticultural crop production.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticulture Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment & Promotion Unit Project (SHEP UP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil sampling & analysis, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, planting/transplanting, fertilizer application); **Crop Management** (water requirement, managing of weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all cases. But where applicable, it is recommended that the instructions issued be given due consideration.

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 Product Board.

1. Introduction:
1.1 Background

Watermelon (Tikiti Maji)

1. Introduction:
1.1 Background

Watermelon (Tikiti Maji)

1. Introduction:
1.1 Background

- Watermelon is a **warm season crop**
- Popular fruit for **fresh consumption** and **agro-processing**, such as juice making
- It contains about **6 % sugar** and **92 % water** by weight
- It is a source of **Potassium, Vitamin A, Vitamin C, Folate and Amino acid.**
- **It contains some of the most important antioxidants in nature- e.g. Lycopene**

1.2 Common Varieties

“Sugar Baby”

“Sukari F1”

1.2 Common Varieties

“Sugar Baby”

“Sukari F1”

1.2 Some Common Varieties

- The following are the common varieties grown in Kenya

“Sugar Baby”

- Round dark green to black fruit with deep red flesh
- Very sweet and juicy
- **Maturity Period: 120 days**
- **Average fruit weight: 4 kg**
- **Yield potential: 20 – 30 tons/acre**

“Sukari F1”

- Early to medium maturing
- Good fruit setting ability
- Fruits are oblong in shape
- Rind color: light green with dark green stripes
- **Maturity Period: 90 days**
- **Average fruit weight:** 7 – 8 kg
- **Yield Potential**: **25 – 35 tons/acre**
- Has good transport and keeping qualities

1.2 Common Varieties Cont’

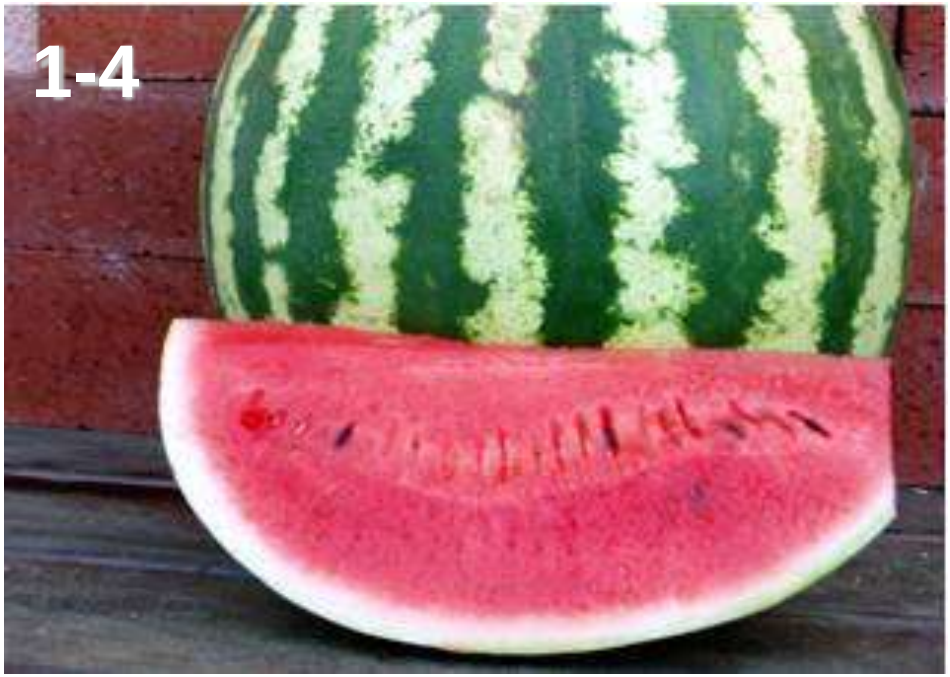

Photo: https://www.royalseed.biz/water-melon.php

“Crimson Sweet”

Photo: https://awhaley.com/seeds/vegetables/watermelon/sweet-dakota-rose-usda-organic

“Sweet Rose”

1.2 Common Varieties Cont'

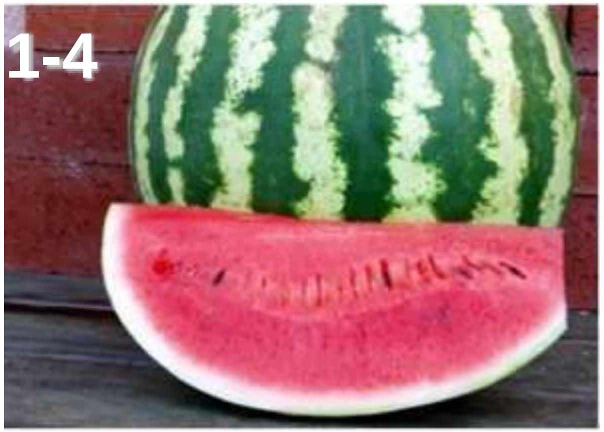

Photo: https://www.royalseed.biz/water-melon.php

"Crimson Sweet"

Photo: https://[illegible]-organic

"Sweet Rose"

1.2 Some Common Varieties Cont'

"Crimson Sweet"

- Has a light green rind with broad dark green stripes
- Has blocky oval shaped with brilliant red flesh
- **Maturity Period: 90 – 120 days**
- **Average fruit weight: 7 – 9 kg**
- **Yield potential: 25 – 30 tons/acre**
- Good shipping quality and resistant to extreme heat and Root-knot Nematodes

"Sweet Rose F1"

- Vigorous with good adaptability
- Fruits are oval to round
- Good keeping quality
- Flesh is deep crimson red with good texture
- **Maturity Period: 80 – 90 days** after transplanting
- **Average fruit weight:** 10 – 12 kg

1.2 Common Varieties Cont’

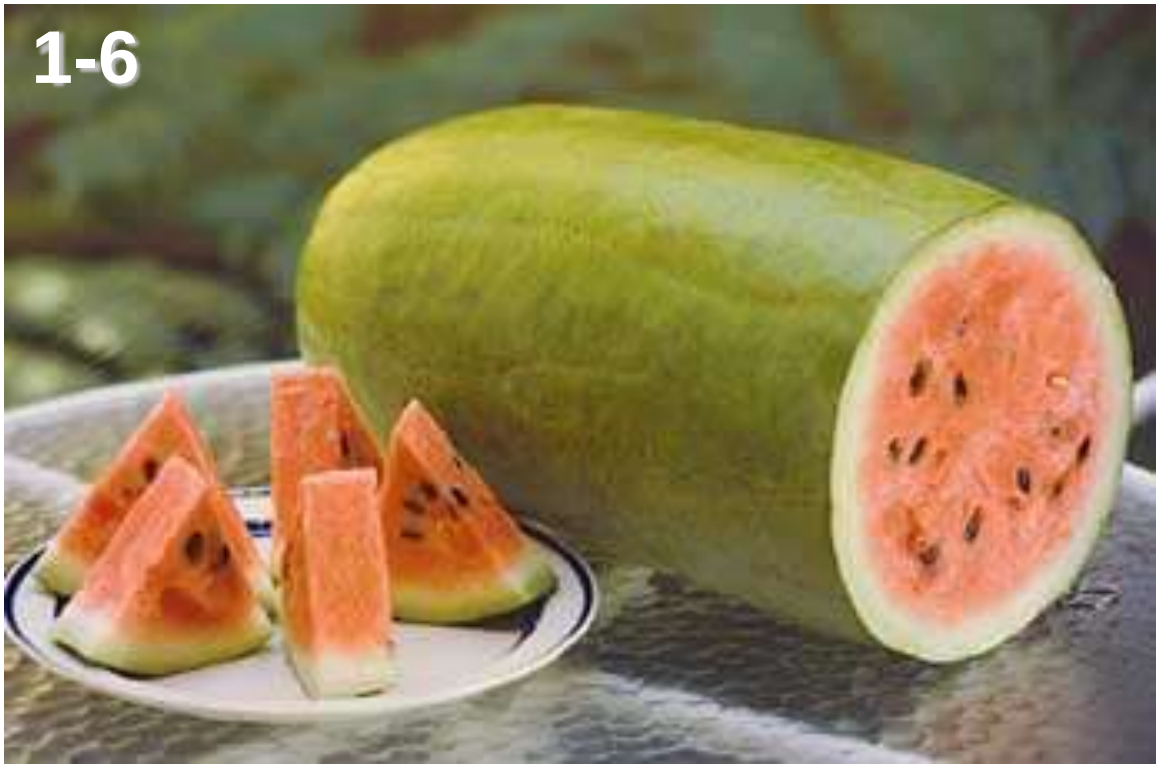

Photo: http://www.farmfreshseeds.com/heirloom-watermelon-seeds-charleston-grey.html

“Charleston Gray”

1.2 Common Varieties Cont’

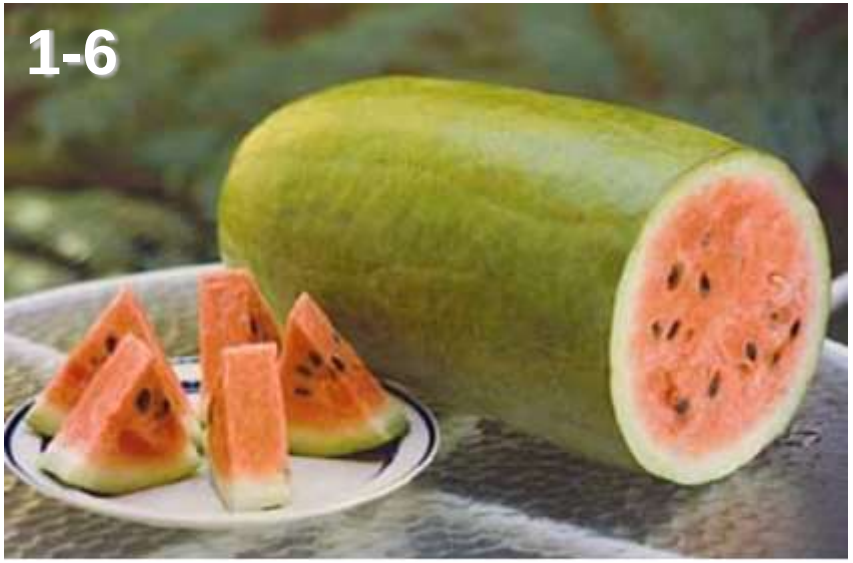

Photo: http://www.farmfreshseeds.com/heirloom-watermelon-seeds-charleston-grey.html

“Charleston Gray”

1.2 Some Common Varieties Cont’

“Charleston Grey”

- Very elongated and oblong
- Light green striped variety with red flesh and hard rind
- At maturity, rind color turns to light green
- Fruits are sweet, juicy and crunchy
- Ideal for fresh market
- Tolerant to ***Fusarium*** and ***Anthracnose***
- **Drought resistant**
- **Maturity Period: 80 – 85 days**
- **Average fruit weight: 8 – 10 kg**
- Able to withstand long transportation

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,500 metres above sea level**
Rainfall	**400 – 600 mm of rainfall annually**
Growing Temperature	**22 – 28 ^{0}C (day)**
Soils	**•Sandy loam** **•Well drained and slightly acidic** **•pH range 6.0 – 6.8**

1.3 Optimal Ecological Requirements

Altitude	**0 – 1,500 metres above sea level**
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Soils	• **Sandy loam** • **Well drained and slightly acidic** • **pH range 6.0 – 6.8**

1.3 Optimal Ecological Requirements

- **Altitude:** Watermelon can be grown in altitudes up to **1,500 m** above sea level
- **Rainfall:** Watermelon has a **high water requirement** and **400 – 600 mm** of rainfall well distributed throughout the growing period is required
- **Temperature:** Watermelon performs better under **warm temperatures** and the **optimum temperature** range for production is **22 – 28 ^{0}C**
- **Soil:** Watermelon requires **well drained sandy loams** with high organic matter content. The optimal soil pH range is **6.0 – 6.8**.

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

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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

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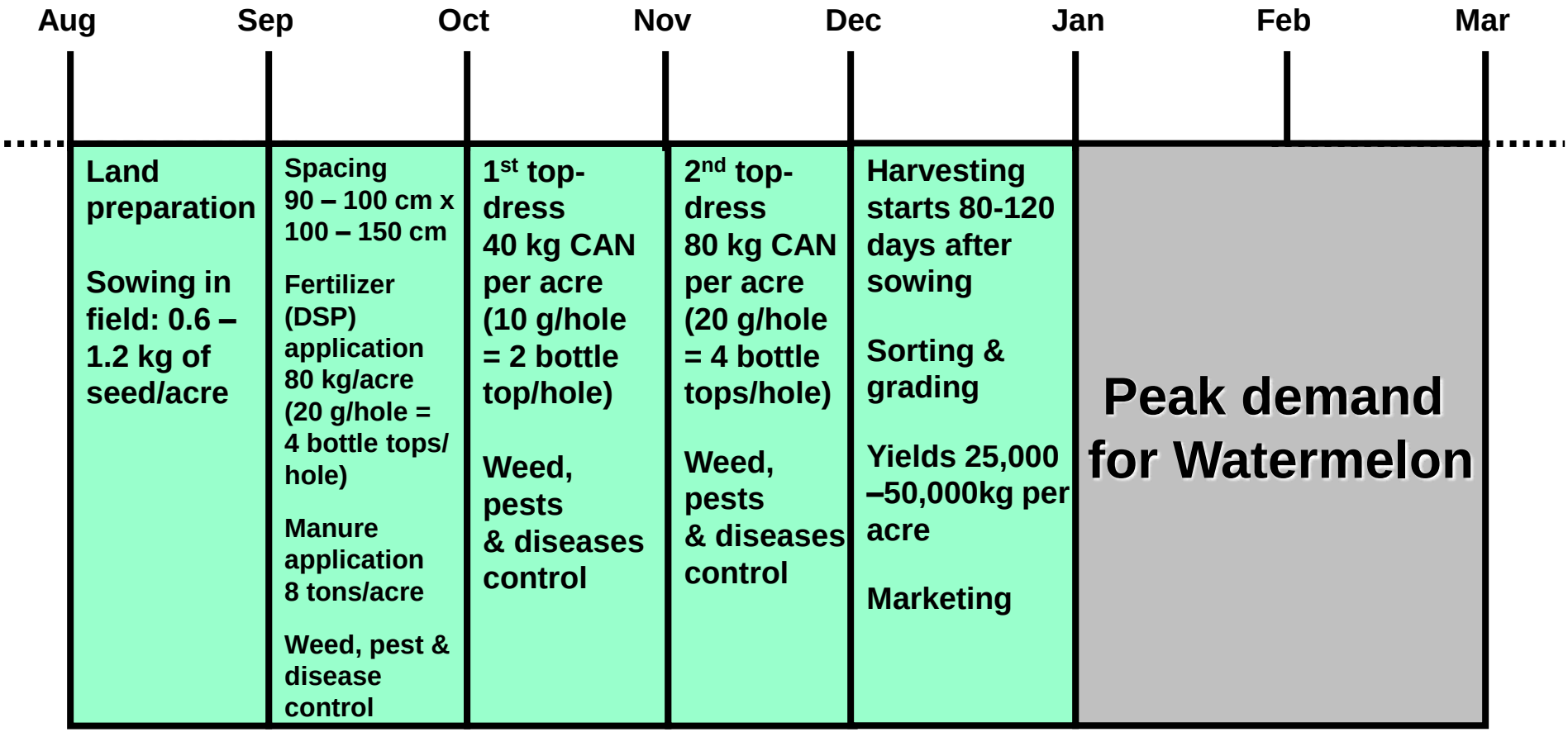
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

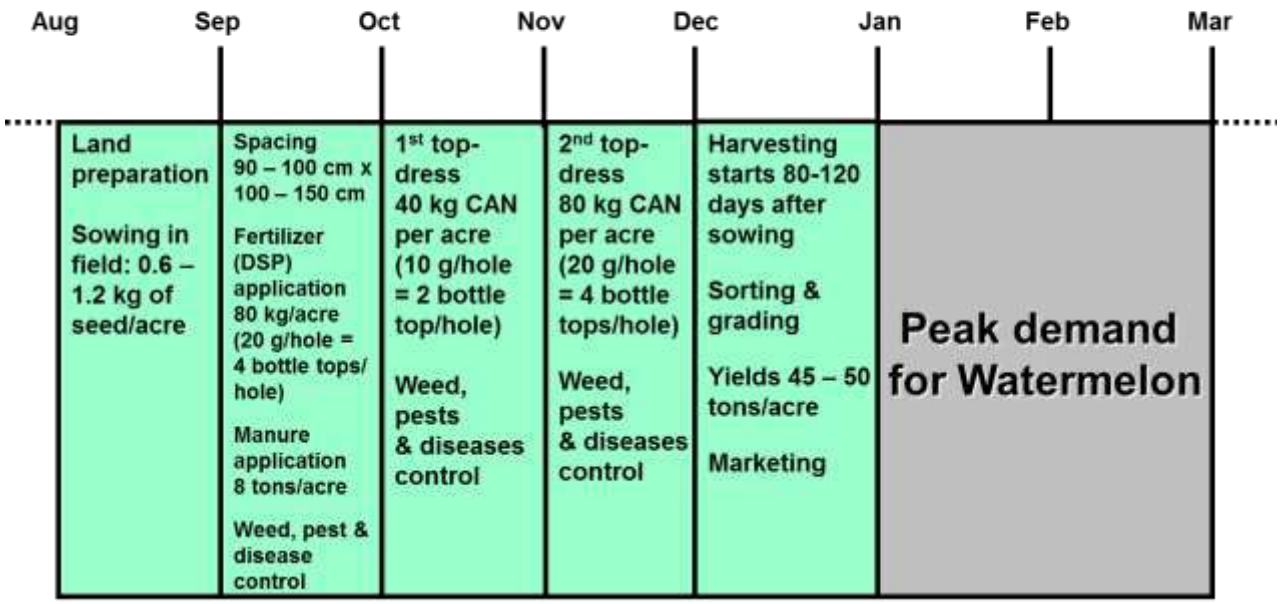
2.1 Crop Planting Calendar

A Sample of a Watermelon Planting Calendar



2.1 Crop Planting Calendar

A Sample of a Watermelon Planting Calendar



A Sample of a Watermelon Planting Calendar: Targeting a peak market demand beginning just after January

2.1 Crop Planting Calendar
(GHCP&PHHT20: Q2)

- A tool used by farmers to plan for production to ensure that marketing coincides with the period of the year when the market price of a produce is highest

Procedure:

1. Determine from the market survey results (2.1) when there is peak demand for Watermelon
2. Work backwards from the month when there is peak demand to prepare a monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

Notes:

- To meet the peak demand period of the market, there may be need for supplemental irrigation

2.2 Composting

Manure preparation through composting

2.2 Composting

Manure preparation through composting

2.2 Composting (GHCP&PHHT20: Q4)

- During compost making, the organic matter need to be covered to prevent leaching of nutrients
- Watermelon is a heavy feeder and does well in soils with high organic content (manure)
- Based on the results of the soil analysis, prepare adequate compost for application
- The recommended rate of application is **8 tons per acre**

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application

Manure incorporation as a basal application

3.1 Basal Application (GHCP&PHHT20: Q8)

- Well composted manure should be broadcasted **(8 tons per acre)** then worked into the soil (incorporated) preferably using a hoe
- Alternatively, apply a **handful per planting hole** before sowing
- Manure/compost should be applied **1 – 2 weeks before sowing** the watermelon and incorporate into the soil

3.2 Planting

Young Watermelon seedlings

3.2 Planting

Photo: SHEP PLUS

Young Watermelon seedlings

3.2 Sowing

Seed Rate:

- About **0.6 – 1.2 kg per acre** depending on variety and spacing
- Soak seeds overnight to hasten germination

3.4.1 Recommended Spacing (GHCP&PHHT20: Q10):

- **100 – 150 cm** between rows
- **90 – 100 cm** between plants
- **Population**: 2,666 - 4,444 per acre

3.4.2 Fertilizer Application Rates (GHCP&PHHT20: Q11):

- **80 kg** per acre of TSP or DSP

3.2 Water Requirement

Photo: SHEP PLUS

Drip Irrigation

3.2 Water Requirement

Drip Irrigation

(GHCP&PHHT20: Q12)

- Water deficit during flowering and fruit development causes serious yield reduction
- Irrigation is important to ensure consistent moisture availability
- Excessive irrigation makes mature fruits to split / crack, tasteless and watery

3.3 Managing of Weeds

3-6

3-7

Photos: SHEP PLUS

A watermelon field with good weed management (left) and field with weeds (right)

3.3 Managing of Weeds

A watermelon field with good weed management

A watermelon field with weeds (right)

3.3 Managing of Weeds (GHCP&PHHT20: Q13)

- Watermelon has a shallow root system therefore care should be taken to avoid bruising the roots during weeding
- The frequency of weeding depends on weed infestation; generally keep the field weed-free as much as possible to avoid competition for **nutrients**, **sunlight** and **moisture**
- This can be done through use of appropriate weeding tools
- Weeding watermelon field when the soil is wet can increase the spread of some bacterial (**Bacterial Wilt**) and fungal (**Fusarium Wilt**) diseases

Photos: SHEP PLUS

3.4 Top-dressing

Top-dressing using the placement method

3.4 Top-dressing

Top-dressing using the placement method

3.4 Top-dressing (GHCP&PHHT20: Q14)

- **CAN** top dressing fertilizer is applied in **2 splits**:
  - **1st split application:** when the plants start to run (**40 kg per acre**)
  - **2nd split application:** when plants are about to flower (**80 kg per acre**)

3.5 Crop Management:
3.5.1 Mulching

Photo: © Victor Omari, HCD 2019

Mulching underneath fruit using organic materials

3.5 Crop Management:
3.5.1 Mulching

Mulching underneath fruit using organic materials

3.5 Crop Management
3.5.1 Mulching

- **Mulching** is a recommended crop management practice for Watermelon production
- Mulching could be done using straw or dry leaves
- Its advantages include:
  - **Moisture conservation**
  - **Weeds suppression**
  - **Prevents fruits** from being in contact with soil and thus prevents pest & disease attack
  - The fruits need to be turned regularly to ensure uniform fruit color development

3.5.2 Pruning

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Control the number of fruits per plants if market demands larger fruits

3.5.2 Pruning

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Control the number of fruits per plants if market demands larger fruits

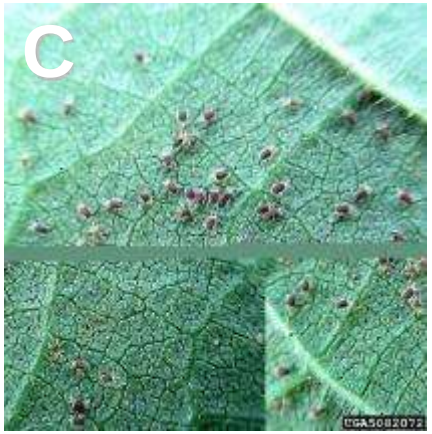
3.5.2 Pruning

- Remove any dead, diseased, yellowing or infested leaves or shoots at the joint where they are connect to the main stem
- Remove **deformed** and **blossom-end rot fruits**
- Maintain 2-3 vines and remove extra vines
- If market demands larger melons leave 3-4 well shaped melons per plant
- **Do not** prune when vines are wet

3.6.1 Major Pests

Photo: SHEP PLUS

Photos: SHEP PLUS



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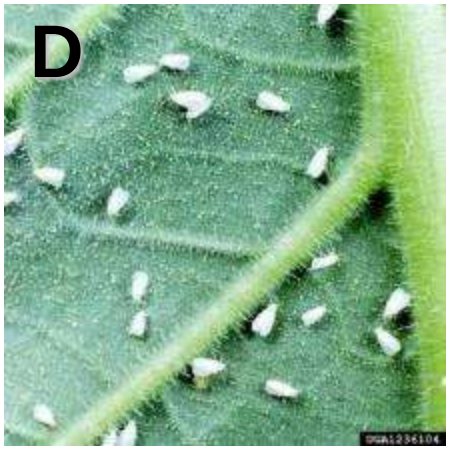
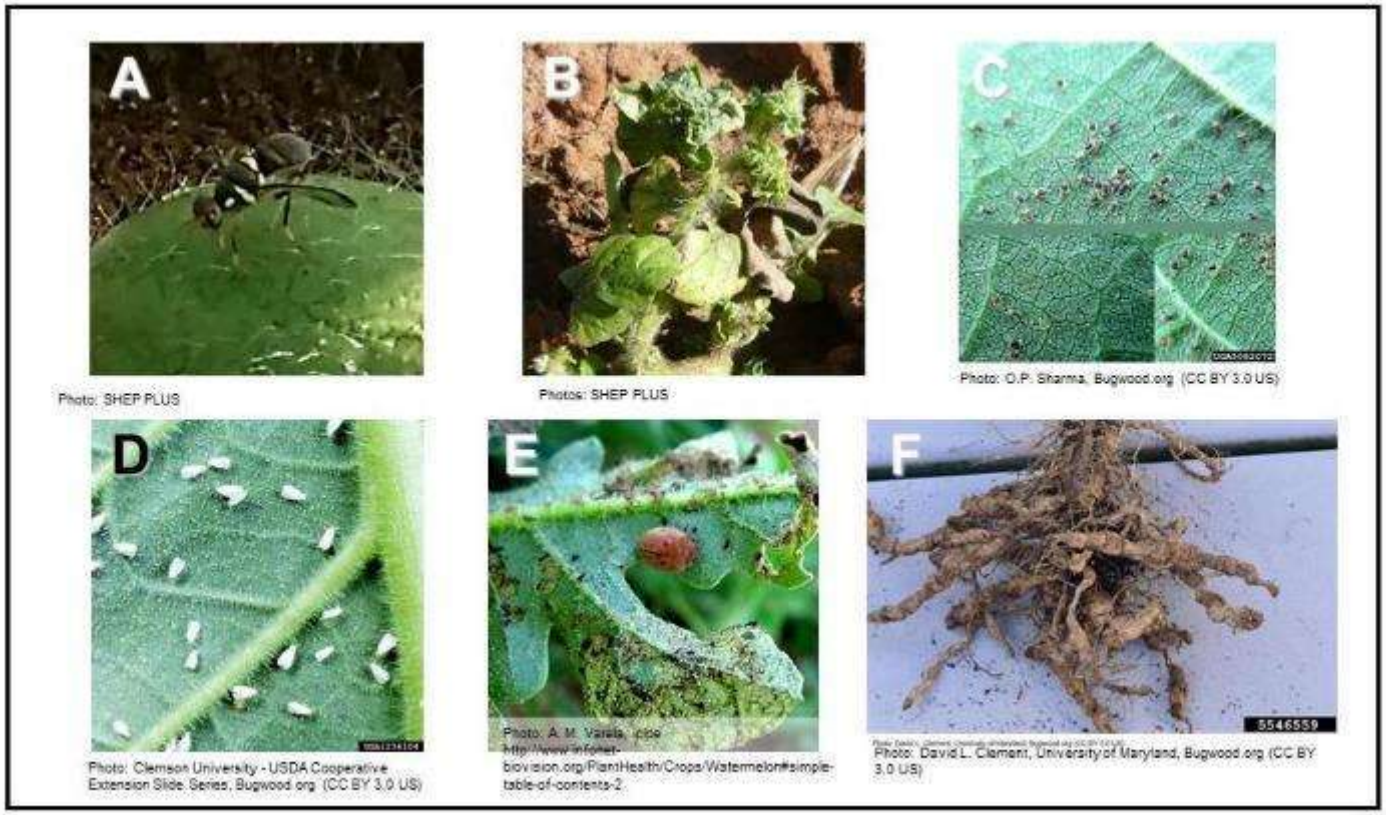


Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

Photo: A. M. Varela, icipe
http://www.infonet-biovision.org/PlantHealth/Crops/Watermelon#simple-table-of-contents-2

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

3.6.1 Major Pests

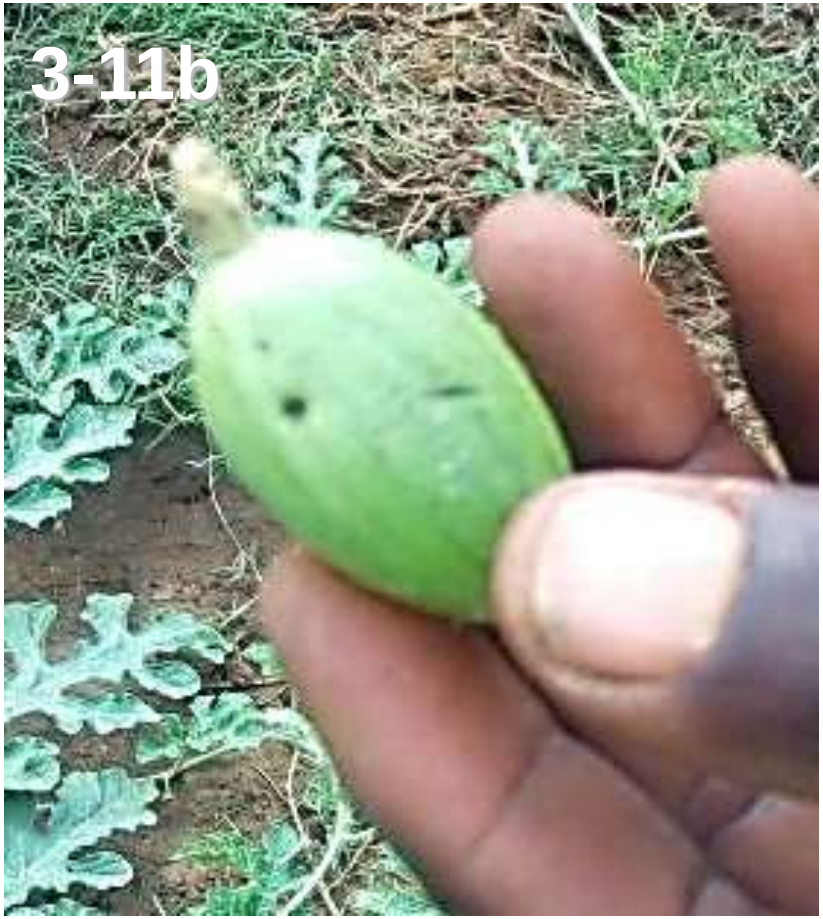


17/32

3.6.1 Major Pests

- Pest damage causes a reduction in quality and quantity of produce
- The following are the major pests of Watermelon in Kenya:
  - **A. Melon Fly**
  - **B. Aphids**
  - **C. Spider Mites**
  - **D. White Flies**
  - **E. Epilachna Beetles**
  - **F. Root-knot Nematode**

3.6.1.A: Melon Fly



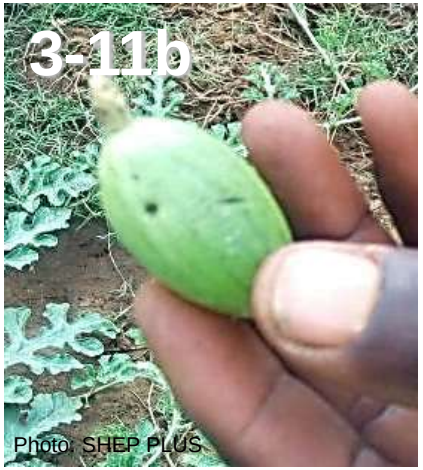
Adult Melon Fly on a fruit

Damage on Fruit

Photos: SHEP PLUS

3.6.1.A: Melon Fly

Adult Melon Fly on fruit



Damage on Fruit

3.6.1.A: Melon Fly

Identification:

- Adult has a yellow stripe in the middle of the thorax between the wings
- A black (often incomplete) T-shaped marking on the abdomen (the rear body section)
- Additional dark patches towards the outer edge of the wings
- Head yellowish with black spots

Damages:

- Larvae usually tunnel into the fruit causing a watery ooze to form on the surface that can later turn brown and resinous
- Exit holes by the larvae (**2 – 3 holes**) are visible on fruit surface
- Affected fruit will rot and often fall from the plant prematurely
- Larvae can also feed on flowers and plant stems

Control:

- **Field Monitoring/ Biological control:**
  - Use of pheromone traps e.g.) **cue lure** baited traps, and **Bactrolure L**® (a.i. **Methyl Eugenol**) used together with **Malathion**
- **Cultural Control:**
  - Wrap fruits with a eco-bags
  - Remove fruits with dimples and oozing clear sap
  - Kill the maggots by burning, burying or tying collected fruits in black plastic bags
- **Chemical Control:**
  - Difficult since larvae feed inside the fruit
  - **Use of pesticides**, such as
    - **Deltamethrin (Decis 2.5 EC**®)
    - **Trichlofon (Dipterex 95 SP**®)

3.6.1.B: Aphids

Photos: SHEP PLUS

Aphids on Watermelon leaves (Left) and damaged leaves (Right)

3.6.1.B: Aphids

Aphids on Watermelon leaves and damaged leaves

3.6.1.B: Aphids

Identification:

- Colonies of **green to blackish** aphids are found on tender shoots
- **Excretion of honeydew**

Damages:

- Attacked leaves are **curled** and **twisted**
- Sooty mould

Control:

- Ensure plants are not water stressed
  - **Use of pesticides**, such as
  - **Azadirachtin (Nimbecidine®)**
  - **Deltamethrin (Decis 2.5EC®)**

Photos: SHEP PLUS

3.6.1.C: Spider Mites

Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

Spider mites on a leaf

3.6.1.C: Spider Mites

Spider mites on a leaf

3.6.1.C: Spider Mites

Identification:

- Mites are tiny spider like pests which spin silk threads for anchoring to the plant
- Their bodies are **yellow-green** to **reddish brown in color**
- They flourish at **low humidity** and **high temperature** (**hot dry conditions**)

Damage:

- Attacked leaves show **white to yellow speckling**
- Where there is high infestation, plant is covered with **orange cloud of mites** and **webs**

Control:

- **Adequate irrigation**
- **Mulching** to conserve water
- **Predatory mite (Phytotech®)**

- Spray with **miticides**, such as:
  - **Bifenthrin (Brigade 25EC®)**

3.6.1.D: White Flies

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

White Fly adults on a leaf

3.6.1.D: White Flies

White Fly adults on a leaf

3.6.1.D: White Flies

Identification:

- **Small soft bodied** insects with wings covered with **white powdery wax**
- Presence of **honeydew** and **sooty mould**

Damage:

- Sucking sap
- Vector of viral diseases (Cucurbit Yellow Stunting Disorder)

Control:

- Use of pesticides such as:
  - **Lamba-cyhalothrin (Karate 2.5WG®)**
  - **Thiamethoxam (Actara 25WG®)**

3.6.1.E: Epilachna Beetles

Photo: A. M. Varela, icipe
http://www.infonet-biovision.org/PlantHealth/Crops/Watermelon#simple-table-of-contents-2

Epilachna Beetles on a leaf

3.6.1.E: Epilachna Beetles

Photo: A. M. Varela, icipe
http://www.infonet-biovision.org/PlantHealth/Crops/Watermelon#simple-table-of-contents-2

Epilachna Beetles on a leaf

3.6.1.E: Epilachna Beetles

Identification:

- Adults resemble lady bird beetles

Damages:

- Feed on leaves leaving fine net of leaves
- Damaged leaves **shrivel** and **dry up**

Control:

- **Spray with insecticides**, such as
  - **Deltamethrin (Decis 2.5EC®)**
  - **Lambda-cyhalothrin (Duduthrin Super EC®)**

3.6.1.F: Root-knot Nematode

Photo: David L. Clement, University of Maryland, Bugwood.org (CC BY 3.0 US)

Root-knot Nematode (*Meloidogyne* sp.) induced galling of Watermelon roots

3.6.1.F: Root-knot Nematode

Root-knot Nematode (Meloidogyne sp.) induced galling of Watermelon roots

3.6.2.g: Root-knot Nematode

General Description:

- Most cucurbits are extremely susceptible to Root-knot Nematodes

Symptoms:

- **Stunting**, **general unthriftiness (**Weak/unhealthy), **premature wilting**, and slow recovery to improved soil moisture conditions
- Root symptoms cause **swollen areas** (**galls**) on the roots of infected plants which result from exposure to multiple and repeated infections
- Leaf **chlorosis** (**yellowing**)

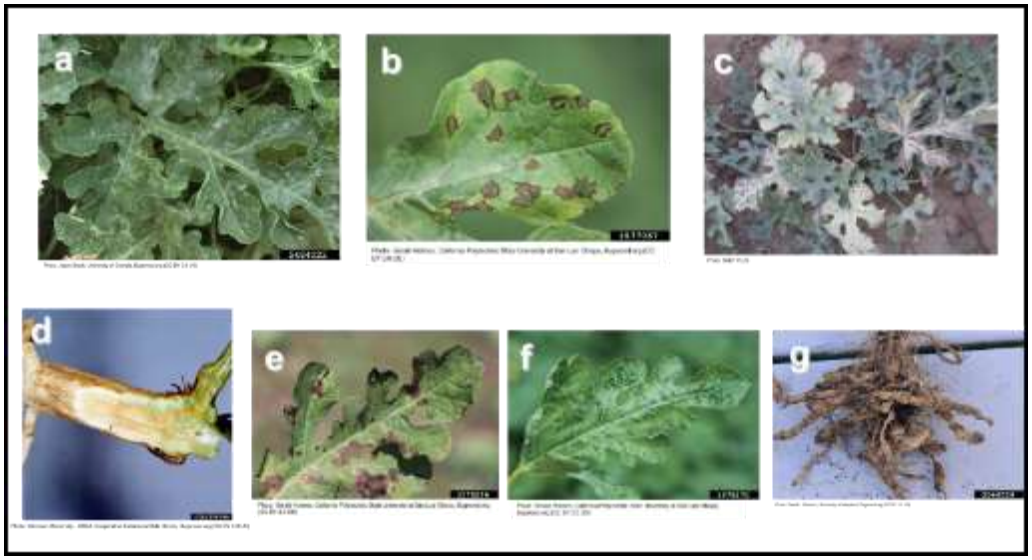
Control:

- **Cultural Control:**
  - **Crop rotation** of less susceptible crops or resistant varieties
  - **Use of resistant varieties** e.g.) **Crimson Sweet**
  - **Use adequate amount of manure**
- **Chemical Control:**
  - Use of Ethoprophos (MOCAP GR10®), Azadirachtin (NIMBECIDINE EC®)

3.6.2 Major Diseases

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

3.6.2 Major Diseases



3.6.2 Major Diseases

- Disease infection leads to reduction in quality and quantity of produce
- The following are the major diseases of Watermelon in Kenya:

a. Powdery Mildew
b. Anthracnose
c. Downy Mildew
d. Fusarium Wilt
e. Gummy Stem Blight (Black Rot)
f. Watermelon Mosaic Virus (WMV)
g. Root-knot Nematode

3.6.2.a: Powdery Mildew

Photo: Jason Brock, University of Georgia, Bugwood.org (CC BY 3.0 US)

Powdery Mildew disease on Watermelon leaves

3.6.2.a: Powdery Mildew

Powdery Mildew disease on Watermelon leaves

3.6.2.a: Powdery Mildew

General Descriptions:

- It is a fungal disease which is favoured by dry condition

Symptoms:

- White powdery growth start on lower leaf surface and later on the upper surface
- At advanced stage necrotic areas develop on the leaves

Control:

- **Use of fungicides**, such as
  - **Sulphur (COSAVET DF®)**
  - **Famoxadime+Cymoxanil (EQUATION PRO®)**
  - **Azoxystrobin + Difenoconazole (AZOXY TOP 325 SC®)**

3.6.2.b: Anthracnose

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Affected Watermelon leaf

Photo: Jason Brock, University of Georgia, Bugwood.org (CC BY 3.0 US)

Affected Watermelon fruit

3.6.2.b: Anthracnose

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Affected Watermelon leaf

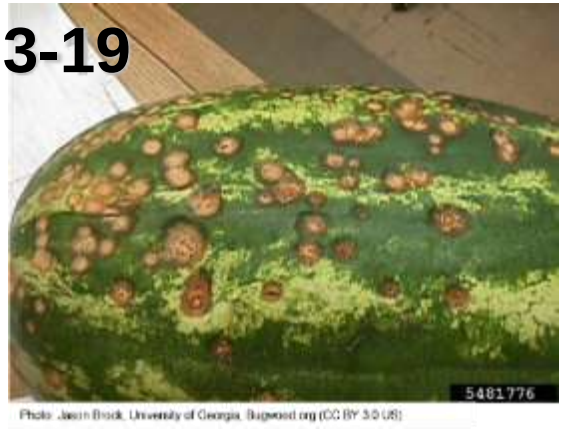


Photo: Jason Brock, University of Georgia, Bugwood.org (CC BY 3.0 US)

Affected Watermelon fruit

3.6.2.b: Anthracnose

General Descriptions:

- This disease is caused by **fungus** and affects **leaves**, **vines** and **fruits**
- Plants can be infected at **any stage**

Symptoms:

- **Round to angular reddish brown spots** on older leaves
- Spots may **dry**, **turn black** and **tear out**
- **Sunken spots** on the rind of fruits which may produce pinkish colored ooze

Control:

- **Cultural Control:**
  - Crop rotation
  - Plant clean seeds
- **Chemical Control:**
  - Use of fungicides, such as
    - **Copper Oxychloride (Samaya Kop 50WP®)** when vines start to run
    - **Mancozeb (Dithane M 45®)**
    - **Azoxystrobin + Difenoconazole (AZOXY TOP 325 SC®)**

3.6.2.c: Downy Mildew

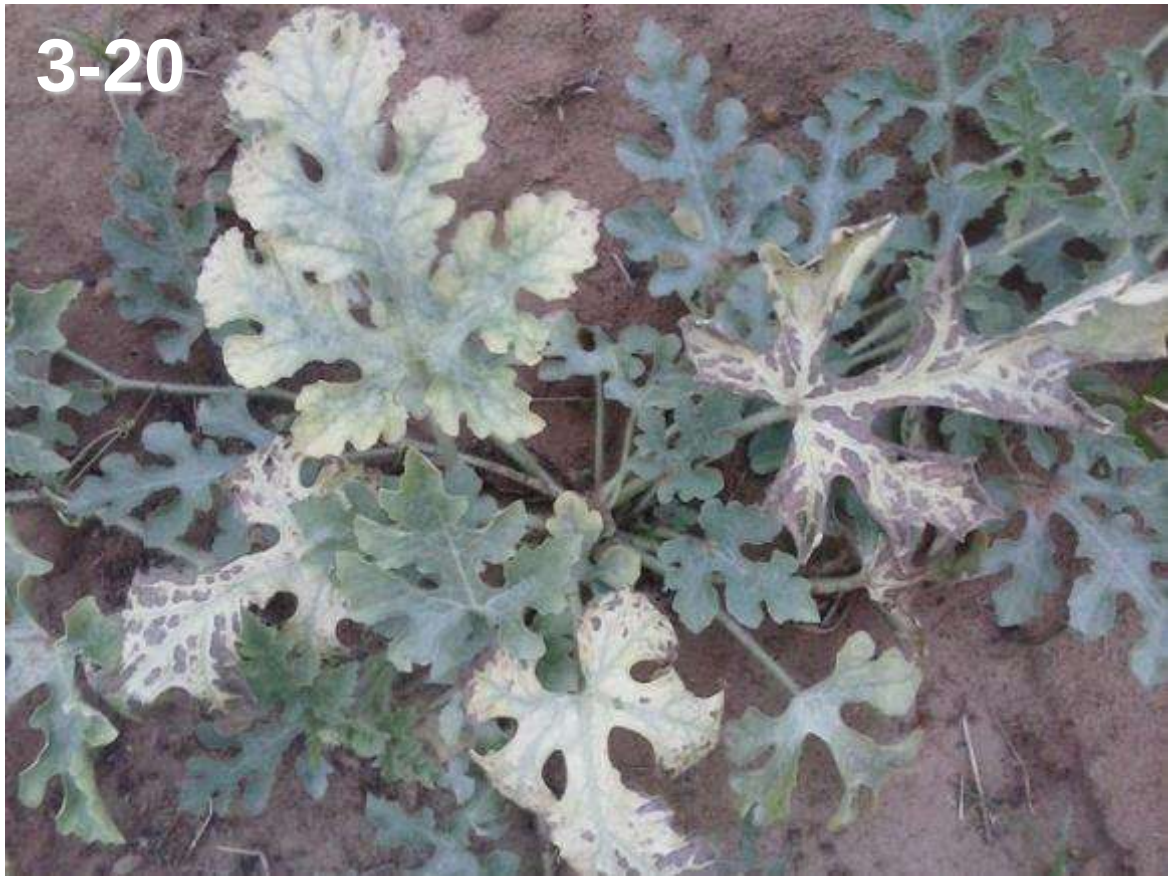


Photo: SHEP PLUS

Downy Mildew on upper leaf surface

3.6.2.c: Downy Mildew

Photo: SHEP PLUS

Downy Mildew on upper leaf surface

3.6.2.c: Downy Mildew

General Descriptions:

- Fungal disease which attacks leaves of Watermelon
- The pathogen is **air borne**

Symptoms:

- Small, irregular, chlorotic spots on upper leaf surface becoming brown and necrotic; entire leaf may become blighted
- Infected leaves tend to curl upward from the margins
- Gray to purple downy growth may be visible on underside

Control:

- **Cultural Control:**
  - Reduce canopy density
- **Chemical Control:**
  - **Mancozeb (Milthane Super®, Penncozeb WP®)**
  - **Propineb + Cymoxanil (Milraz WP®)**
  - **Dimethomorph + Mancozeb (MILLIONAIRE 69% WDG®)**

3.6.2.d: Fusarium Wilt

Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org (CC BY 3.0 US)

Stem section showing effect of Fusarium Wilt

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org (CC BY 3.0 US)

Watermelon plant showing wilting of a few runners

3.6.2.d: Fusarium Wilt

Stem section showing effect of Fusarium Wilt

Watermelon plant showing wilting by few runner

3.6.2.d: Fusarium Wilt

General Descriptions:

- It is **a fungal disease** which can infect crop at any stage of growth
- Pathogen can be spread by **seed**, **soil** or **drainage water**

Symptoms:

- Wilt symptoms develop from **one** or **few runners**
- Vascular tissue of lower stem and roots **brown colouration**

Control:

- **Crop rotation**
- Rouging/removal and destruction of diseased plants
- Plant in well drained soils and avoid water logging
- **Use of certified seed**
- Use of **well decomposed manure** and **compost**

3.6.2.e: Gummy Stem Blight (Black Rot)

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Brown irregular lesion on leaf

Photo: Rebecca A. Melanson, Mississippi State University Extension, Bugwood.org (CC BY 3.0 US)

A stem showing the gummy exudate symptoms

3.6.2.e: Gummy Stem Blight (Black Rot)

Brown irregular lesion on leaf

A stem showing the gummy exudate symptoms

3.6.2.e: Gummy Stem Blight (Black Rot)

General Description:

- The disease affects **leaves**, **stem** and **fruits**

Symptoms:

- **Brown round** or **irregular lesions** on leaves
- Lesions on stem are **brown** and later **turn white**
- Gum oozes from stem cracks
- Affected fruits are **soft** and **discolored**

Control:

Use of chemical, such as Copper Oxychloride (SAMAYA KOP 50WP®, COBOX 50WP®, ISACOP®)

3.6.2.f: Watermelon Mosaic Virus (WMV)

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

WMV symptoms on the leaf

Photo: By Source (WP:NFCC#4), Fair use, https://en.wikipedia.org/w/index.php?curid=37441924

Fruit affected by WMV

3.6.2.f: Watermelon Mosaic Virus (WMV)

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

WMV symptoms on the leaf

Photo: By Source (WP:NFCC#4), Fair use, https://en.wikipedia.org/w/index.php?curid=37441024

Fruit affected by WMV

3.6.2.f: Watermelon Mosaic Virus (WMV)

General Descriptions:

- This disease is transmitted by **aphids**
- It infects **only cucurbit crops**

Symptoms:

- **Mottling of leaves**
- Stunted growth, shortened internodes with bushy erect growth for some runner tips
- **Mottled appearance** on fruit surface

Control:

- **Field sanitation:** removal of weeds (they are potential hosts)
- Control aphids

4. Harvest

Photo: SHEP PLUS

A farmer and his harvested watermelon

4. Harvest

Photo: SHEP PLUS

A farmer and his harvested watermelon

4. Harvest

4.1 Harvesting Indices (GHCP&PHHT20: Q17)

- Tendrils near fruit stem have changed color **from green to brown**
- Ground spot on the belly of the melon has changed **from white to yellow**
- The fruits when thumped with the hand produce **muffled dull tone** (immature fruits produce **clear metallic ringing tone**)
- Leave the stalk attached to the fruit
- Mature fruits have **sweet flavor**, **crisp texture** and **deep red color**
- Sugar content (measured as soluble solids by use of hand held refractometer) of **10 %** or more in the flesh near the center of the melon
- **Yields: 25,000 – 50,000kg per acre**

Main harvesting stages:

- Mature but before full ripeness for **distant markets**
- Mature and ripe for **nearby markets**

Notes:

- Watermelons don't ripen after they are picked so harvest time is important
- If harvested immature, red color will develop but sugar content does not increase after harvest
- Harvesting should be done by **cutting the vine** and **NOT pulling**, **twisting** or **breaking off the vines**

5. Post-Harvest Handling

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: SHEP PLUS

Choose appropriate post harvest handling methods

5. Post-Harvest Handling

Photo: Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org (CC BY 3.0 US)

Photo: SHEP PLUS

Choose appropriate post harvest handling methods

5. Post-Harvest Handling

- **Handling** should **minimize fruit injury** which may be caused by impact or abrasion
- **Shading** is necessary in order **to protect Watermelon from direct sunlight** which causes sunburn

5.1 Containers & Packaging Materials (GHCP&PHHT20: Q18)

- Watermelons are handled as **bulk shipment** or **packed into cartons**
- For bulk shipments in trucks a layer of straw on the floor and between melons and the side walls of the truck needs to be put in place
- Can store for 2 weeks beyond which they lose crispness and colour

5.2 Value Addition Techniques: Sorting, Cleaning & Grading (GHCP&PHHT20: Q19)

Sorting:

- Watermelons are sorted to remove insect-damaged, blossom-end rot, cracked, discolored, without stalk attached

Grading:

- Watermelons are graded according to size (small, medium & large) for each variety

Japan International Cooperation Agency

Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

GENERAL HORTICULTURAL CROP PRODUCTION & POST-HARVEST HANDLING TECHNIQUES (GHCP&PHHT) 20

Prepared by SHEP PLUS

Photo: SHEP PLUS

Training Title: **General Horticultural Crop Production & Post-Harvest Handling Techniques (GHCP&PHHT) 20**
Objective: **To provide a guide on production of horticultural crops using twenty (20) basic techniques**

Specific Objectives:

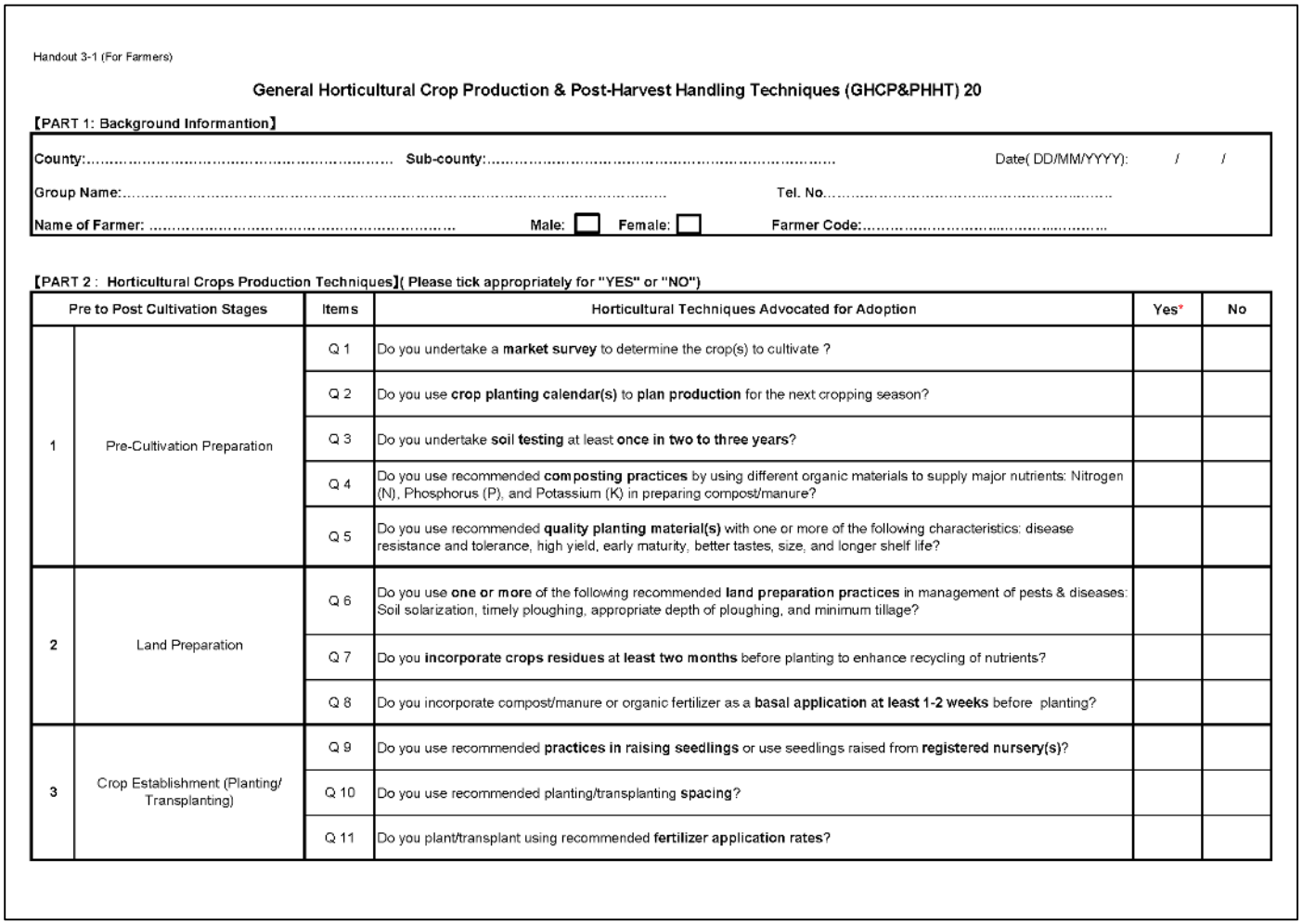
- **To provide basic knowledge & information on production and post-harvest handling techniques of horticultural crops**
- **To provide knowledge & information on 20 techniques as a check list to improve farming techniques of individual farmers**

Contents:

Contacts:

- **Ministry of Agriculture, Livestock & Fisheries (MOALF):**
  Kilimo House, Cathedral Road, P.O. Box 34188-00100, Nairobi, KENYA, Tel: 020-2718870
- **Agriculture and Food Authority (AFA), Horticultural Crops Directorate (HCD):**
  Airport Road, Opp. JKIA, P.O. Box 42601-00100, Nairobi, KENYA
  Tel: 020-2131560/3597356
- **Japan International Cooperation Agency (JICA) Kenya Office:**
  BRITAM Tower, 22nd & 23rd, Hospital Road, Nairobi, KENYA, P.O. Box 50572-00200 Nairobi, KENYA,
  Tel: 020-2775000
- **Smallholder Horticulture Empowerment and Promotion Project for Local & Up-scaling (SHEP PLUS):**
  N.H.I.F. Building, 4th Floor, Ngong Road/Haile Selassie Avenue, Upper Hill P.O. Box 19024-00100, Nairobi, KENYA
  Tel: 0712-504095 /0737-293867,
  E-mail: info.shepunit@gmail.com

1. Introduction: Background



Handout 3-1 (For Farmers)

General Horticultural Crop Production & Post-Harvest Handling Techniques (GHCP&PHHT) 20

【PART 1: Background Informantion】

County:..... Sub-county:..... Date(DD/MM/YYYY): / /

Group Name:..... Tel. No.....

Name of Farmer: ..... Male: ☐ Female: ☐ Farmer Code:.....

【PART 2 : Horticultural Crops Production Techniques】(Please tick appropriately for "YES" or "NO")

Pre to Post Cultivation Stages		Items	Horticultural Techniques Advocated for Adoption	Yes*	No
1	Pre-Cultivation Preparation	Q 1	Do you undertake a **market survey** to determine the crop(s) to cultivate ?		
		Q 2	Do you use **crop planting calendar(s)** to **plan production** for the next cropping season?		
		Q 3	Do you undertake **soil testing** at least **once in two to three years**?		
		Q 4	Do you use recommended **composting practices** by using different organic materials to supply major nutrients: Nitrogen (N), Phosphorus (P), and Potassium (K) in preparing compost/manure?		
		Q 5	Do you use recommended **quality planting material(s)** with one or more of the following characteristics: disease resistance and tolerance, high yield, early maturity, better tastes, size, and longer shelf life?		
2	Land Preparation	Q 6	Do you use **one or more** of the following recommended **land preparation practices** in management of pests & diseases: Soil solarization, timely ploughing, appropriate depth of ploughing, and minimum tillage?		
		Q 7	Do you **incorporate crops residues** at **least two months** before planting to enhance recycling of nutrients?		
		Q 8	Do you incorporate compost/manure or organic fertilizer as a **basal application at least 1-2 weeks** before planting?		
3	Crop Establishment (Planting/ Transplanting)	Q 9	Do you use recommended **practices in raising seedlings** or use seedlings raised from **registered nursery(s)**?		
		Q 10	Do you use recommended planting/transplanting **spacing**?		
		Q 11	Do you plant/transplant using recommended **fertilizer application rates**?		

Fig.1: A check list of the GHCP&PHHT 20

1. Introduction: Background

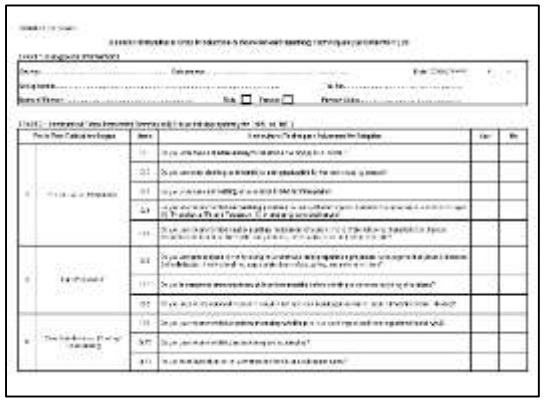


Fig. 1: A check list of the GHCP&PHHT 20 (G20)

- This training material applies the fundamental practices essential for horticultural crop productivity and successful marketing.
- The fundamental practices are categorized into seven (7) broad topics and twenty (20) sub-topics; the twenty sub-topics are referred to as the General Horticultural Crop Production and Post-Harvest Handling Techniques (GHCP&PHHT20). This categorization is based on the Smallholder Horticulture Empowerment Project (SHEP) experience in mitigating production and marketing challenges facing smallholder horticultural farmers.
- The seven (7) broad topics are: Pre-Cultivation Preparation; Land Preparation; Crop Establishment (Planting/Transplanting); Crop Management; Harvest; Post-Harvest Handling: and Cost and Income Analysis.
- The sub-topics under each topic are as follows: **Pre-Cultivation Preparation** (market survey, crop planting calendar(s), soil testing, composting, and quality seed/planting material(s)); **Land Preparation** (land preparation practices, incorporation of crop residues, and basal application); **Crop Establishment** (raising seedlings, spacing, fertilizer application); **Crop Management** (supplemental watering, managing weeds, top-dressing, pests & diseases management practices, and safe & effective use of pesticides); **Harvest** (harvesting indices); **Post-Harvest Handling** (appropriate containers/standard packaging materials, and value addition techniques); and **Cost and Income Analysis** (cost and income analysis).
- The issues outlined in the twenty (20) sub-topics might not necessarily be applicable in all the cases. However, where applicable, it is recommended that the instructions issued be given due consideration.

2. GHCP&PHHT: Pre-Cultivation Preparation: Q1

Farmers conducting a market survey

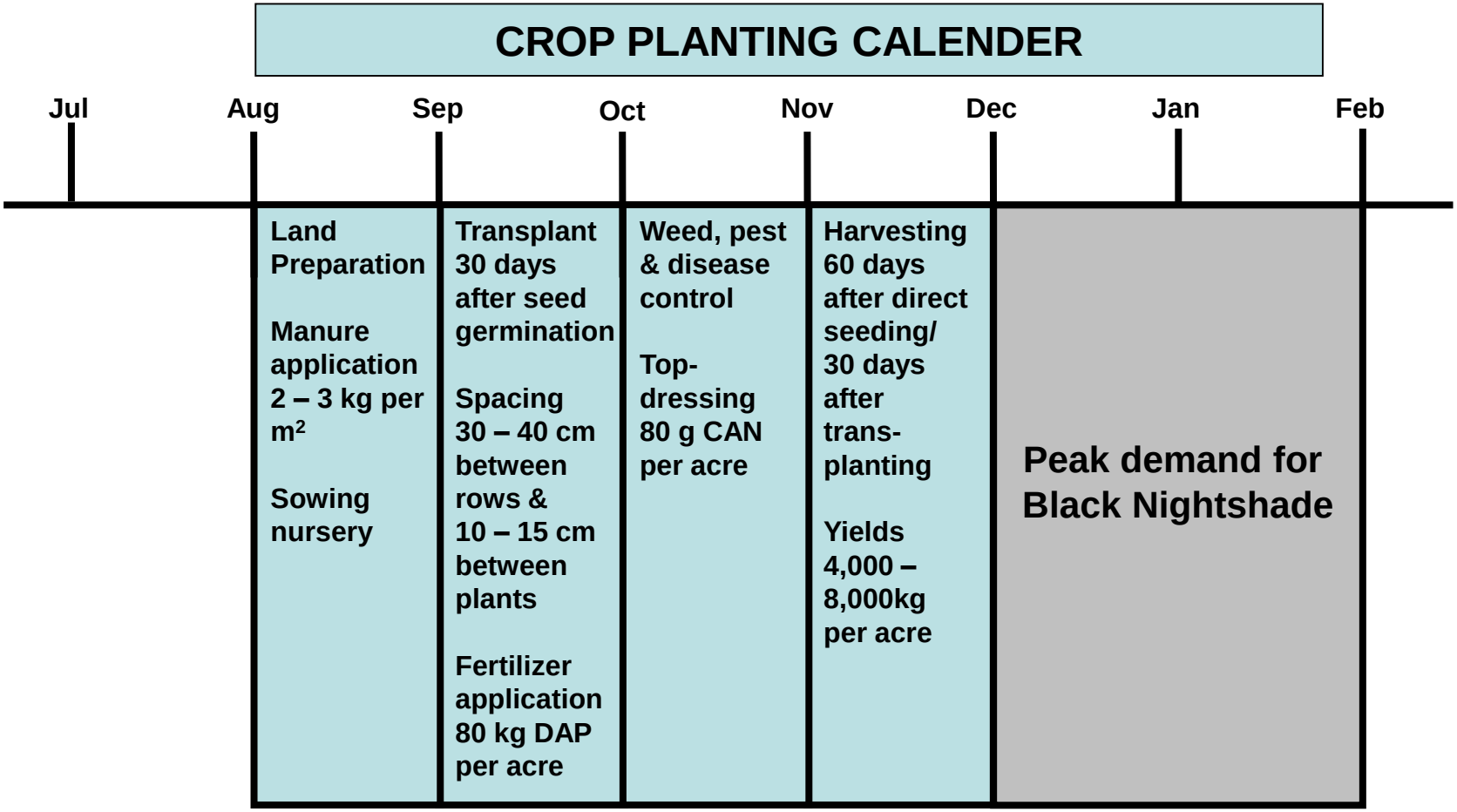
2. GHCP&PHHT: Pre-Cultivation Preparation: Q1 Market Survey

Farmers conducting a market survey

➢ **Market Survey (GHCP&PHHT20: Q1)**
"Do you undertake a market survey to determine the crop(s) to cultivate?"

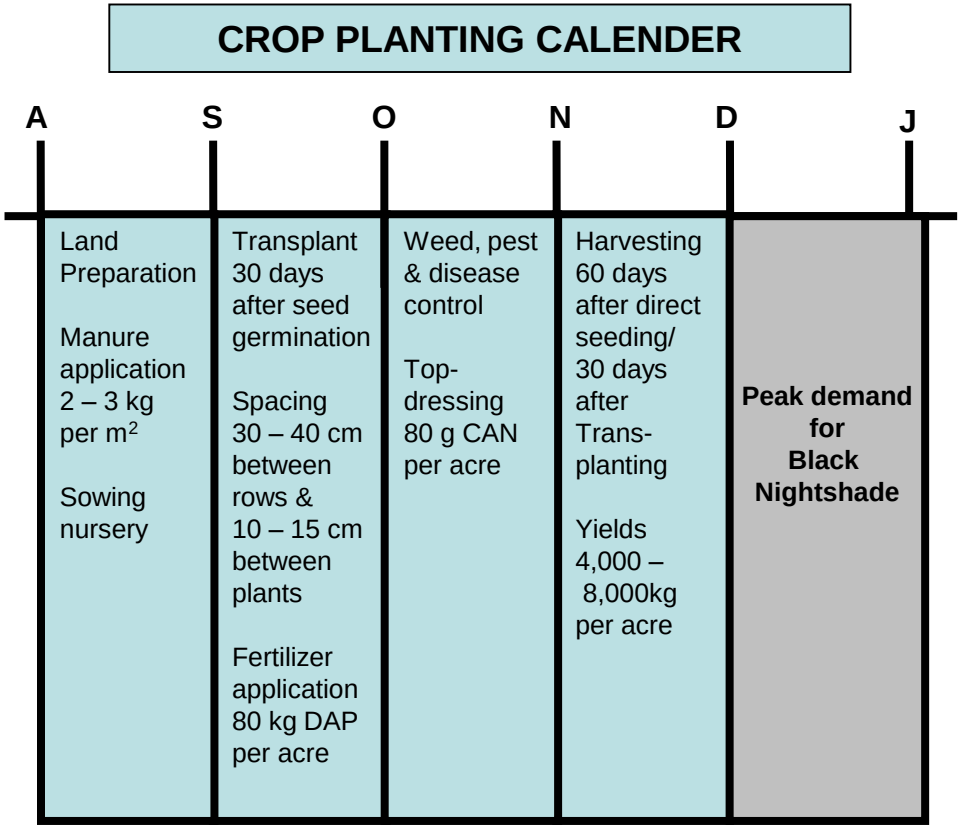
- Most smallholder farmers are not in touch with the present reality about the market. Therefore, they tend to struggle selling what they have produced rather than producing what they can sell.
- Market surveys provide useful information in guiding a producer (farmer) in producing what he/she can sell
- The GHCP&PHHT 20 recognizes market survey as the first fundamental practice that smallholder farmers must undertake regularly in order to realize economic returns from the farming.
- Market surveys need not be cumbersome; farmers should obtain the following information on the crop (s) of their choice:
  - During which month there is **peak demand** for the crop
  - The **price** of the crop during the peak demand
  - The crop **variety** that has the highest demand
  - **Supply requirements** (quantities and frequency)
  - **Quality** of market requirements
  - The **source** of current supply
  - Potential buyers and terms and modes of payment
  - Marketing challenges, trader's willingness to buy from them
- The answers to the above questions determine what the farmer can sell in terms of quality, quantity and the anticipated profit margins

2. GHCP&PHHT: Pre-Cultivation Preparation: Q2



A Black Nightshade Planting Calendar

2. GHCP&PHHT: Pre-Cultivation Preparation: Q2 Crop Planting Calendar



A Black Nightshade Planting Calendar

- **Crop Planting Calendar (GHCP&PHHT20: Q2)**

"Do you use crop planting calendar(s) to plan production for the next cropping season?

- A **crop planting calendar** is a tool for farmers to plan for production to ensure that marketing coincides with the period of the year when the **market price of a produce is highest**

Procedure

1. Determine from the **market survey** results (GHCP&PHHT 20: Q1) when there is **peak demand** for selected crops
2. Work backward from the month when there is peak demand to prepare monthly farm activities preceding the peak period
3. Use the monthly activities preceding the peak as a procurement plan for farm inputs and a guide for farm operations

2. GHCP&PHHT: Pre-Cultivation Preparation: Q3

Collecting soil samples

2. GHCP&PHHT: Pre-Cultivation Preparation: Q3 Soil Sampling & Analysis

Collecting soil samples

- **Soil Sampling & Analysis (GHCP&PHHT20: Q3)**

"Do you undertake soil testing at least once in two to three years?"

- It is recommended to have the soils analyzed for **nutrient availability** and other factors vital to crop production after **every 2-3 years**
- The results of the **soil analysis** should be used to determine **fertilizer** and **manure requirement**
- Establishing the **type** and **quantity** of fertilizer one needs to apply is vital in:
  - **Increase** production
  - Avoiding making the soils either too acidic or alkaline
  - Saving expenditure on inputs thus **reducing** the **cost** of production and increasing the **profitability**

2. GHCP&PHHT: Pre-Cultivation Preparation: Q4

Manure preparation through composting

2. GHCP&PHHT: Pre-Cultivation Preparation: Q4 Composting

Manure preparation through composting

- **Composting (GHCP&PHHT20: Q4)**

"Do you use recommended composting practices by using different organic materials to supply major nutrients: Nitrogen (N), Phosphorus (P), and Potassium (K)? "

- Most smallholder farmers apply either immature or inadequate quantity of manure/compost
- Most smallholder farmers do not have money to purchase adequate amount of inorganic fertilizers
- Due to significant role of manure in increasing crop productivity, farmers need to adopt more efficient methods of preparing the manure.
- Adopting more efficient methods of preparing manure will ensure **optimal application**, thus **increasing productivity**

2. GHCP&PHHT: Pre-Cultivation Preparation: Q5

Photos: SHEP PLUS

Assorted quality seeds

2. GHCP&PHHT: Pre-Cultivation Preparation: Q5 Quality Planting Materials

Photos: SHEP PLUS

Assorted quality seeds

- **Quality Seed/Planting Materials (GHCP&PHHT20: Q5)**

"Do you use recommended quality planting material(s) with one or more of the following characteristics: disease resistance and tolerance, high yielding, early maturing, better tastes, size, and longer shelf life?"

- The fifth fundamental practice of the GHCP&PHHT is the use of quality seed/planting material(s)
- Use of **quality seed/planting material(s**) can positively improve the returns of smallholder farmers for **two (2) major reasons:**
  - **High yields**
  - **Less expenditure** on control of **pests** and **diseases**, since the materials are either resistant or tolerant to the menace
- The overall effect is **higher net income**

3. GHCP&PHHT: Land Preparation: Q6

Land preparation using a hoe (Jembe)

3. GHCP&PHHT: Land Preparation: Q6 Land Preparation Practices

Land preparation using a hoe (Jembe)

➢ **Land Preparation Practices (GHCP&PHHT20: Q6)**

"Do you use one or more of the following recommended land preparation practices in management of pests & diseases: Soil solarization, timely ploughing, appropriate depth of ploughing and minimum tillage?"

- **Land preparation** is critical in **management** of **soil borne pests and diseases** and the recycling of soil nutrients
- One or more of the following practices recommended for management of soil borne pests and diseases should be undertaken where applicable:
  - **Soil solarization** especially in the establishment of the nursery
  - **Timely ploughing** and exposure of pests to desiccation
  - **Minimum movement of soil** to check on the spread of **pests and diseases**
- In addition, the soil should be ploughed to a minimum depth of 30 cm and inverted; it is vital to break the hard pan, thus ensuring proper root establishment; and the recycling of nutrients that tend to get leached.
- Also, minimum tillage could be an option to conserve soil fertility.

3. GHCP&PHHT: Land Preparation: Q7

3-2

Incorporation of crop residues

3. GHCP&PHHT: Land Preparation: Q7 Incorporation of Crop Residues

3-2

Incorporation of crop residues

- **Incorporation of Crop Residues (GHCP&PHHT20: Q7)**

"Do you incorporate crop residues at least two months before planting to enhance recycling of nutrients?"

- **Incorporating crop residues** into the farm is a sustainable means of recycling the soil nutrients and structure
- The crop residues should be incorporated to a depth of **30 cm** at least **2 months** before planting to allow decomposition
- Where need be, the crop residues should be **chopped** into smaller pieces to hasten the decomposition process
- However, diseased material should be discarded to avoid possible risk of disease build-up

3. GHCP&PHHT: Land Preparation: Q8

Basal application of organic manure/fertilizer

3. GHCP&PHHT: Land Preparation: Q8 Basal Application

Basal application of organic manure/fertilizer in the field

➢ **Basal Application (GHCP&PHHT20: Q8)**

"Do you incorporate compost/manure/organic fertilizers as a basal application at least 1-2 weeks before planting?"

- The release of nutrients from manure/compost is a slow process. Therefore, for crops to maximize on nutrient released from manure/compost, it should be applied **1 – 2 weeks before planting** or **transplanting**
- The manure/compost should never be exposed to direct sunlight as the material tend to lose nitrogen through volatilization
- The applied manure/compost should be broadcasted then worked into the soil
- Use of partially decomposed manure/compost should be avoided as this tends to compound the problem of soil borne pests and diseases

4. GHCP&PHHT: Crop Establishment: Q9

Nursery of leafy vegetables

4. GHCP&PHHT: Crop Establishment: Q9 Raising Seedlings

Nursery of leafy vegetables

➢ **Raising Seedlings (GHCP&PHHT20: Q9)**

"Do you use recommended practices in raising seedlings or use seedlings raised from registered nursery(s)?"

- **Raising healthy seedlings** should be the ultimate goal of every farmer
- This should start with appropriate location of the nursery
- The nursery should be located at a site that has not been planted with crops in the family of the seedlings to be raised for at least three **(3) years**
- Sterilization of the nursery site through solarization is a feasible option for smallholder farmers
- Conditions that are likely to predispose seedlings to pest and diseases such as overcrowding, dampness, and excessive shading should be avoided
- Seedlings should be hardened **1 – 2 weeks before transplanting** by reducing the frequency of watering and shading
- Other than on-farm, seedlings should only be sourced from **registered and certified nurseries**
- **Seed dressing** can be an option to **control soil/ seed borne** pests and diseases (Refer to the latest **PCPB list** for specific products appropriate for specific crops)
- Thiamethoxam + Metalaxyl –M + Difenoconazole (APRON STAR®)
- Imidacloprid (MURTANO®, MONCERN®)
- Thiram (THIRAM 80WP®)

4. GHCP&PHHT: Crop Establishment: Q10

Transplanted Black Nightshade seedlings

4. GHCP&PHHT: Crop Establishment: Q10 Planting/Transplanting Spacing

Transplanted Black Nightshade seedlings

- **Transplanting (GHCP&PHHT20: Q10)**

"Do you use recommended planting/transplanting spacing?"

- Seedlings should be transplanted at the **recommended** stage and **spacing** (check the label of the seed packet)
- Right spacing **minimizes** pest and disease i**ncidences**, eases farm operations such as weeding, and has the overall effect of improved productivity
- Avoid transplanting **immature and overgrown** seedlings as they will have poor take off
- **Line planting/transplanting** using a string makes field operations easier

4. GHCP&PHHT: Crop Establishment: Q11

Different types of fertilizers

4. GHCP&PHHT: Crop Establishment: Q11 Fertilizer Application Rates

Different types of fertilizers

- **Fertilizer Application Rates (GHCP&PHHT20: Q11)**

"Do you plant/transplant using recommended fertilizer type and application rates?"

- Adhere to the recommended planting/transplanting fertilizer application **rates**
- Inorganic fertilizers (DAP, CAN, TSP etc.) should thoroughly be mixed with the soil to avoid scorching as this can also lead to poor crop stand
- The **effectiveness** of fertilizers is highly dependent on **soil pH**, therefore, it is recommended to have the **soils analyzed periodicall**y so as to determine the type and quantity of fertilizer to apply

5. GHCP&PHHT: Crop Management: Q12

Drip irrigation

5. GHCP&PHHT: Crop Management: Q12 Water Requirement

Drip irrigation

➢ **Water Requirement (GHCP&PHHT20: Q12)**

"Do you supplement water through one or more of the following irrigation methods: watering can, overhead, drip, basin and furrow?"

- Depending on the rainfall during the growing period of the crop, it might be necessary to supplement rainfall through irrigation
- The type of irrigation to be applied should take into consideration **disease prevalence**. For instance, in areas with high prevalence of "Early Blight" of Tomato, furrow irrigation is preferred to overhead/sprinkler irrigation; the latter favors spread of "Early Blight"
- Overhead/sprinkler irrigation is preferred to furrow irrigation in areas with high prevalence of "Late Blight" of Tomato.
- Other factors to consider when choosing an irrigation system include terrain, soil type, cost, technical know-how, type of crop and climatic conditions
- Besides water utilization efficiency, stage of growth and type of the plant (fruit bearing or vegetative) should be considered
- For fruit bearing and flowering crops, furrow and drip irrigation are preferred over overhead/sprinkler irrigation which causes fruit rot and flower drop
- Irrigation water should be applied as per the recommendations
- **Irregula**r application of irrigation water can lead to defects such as "**Blossom-end Rot**", **toughness, strong flavor, cracking, irregular fruit shape, and poor tip filling**
- Inadequate water leads to **water stressed** crops with **significantly reduced yield**
- In addition, the crops are highly susceptible to pests and diseases

5. GHCP&PHHT: Crop Management: Q13

Weeding Kales using simple tools

5. GHCP&PHHT: Crop Management: Q13 Managing of Weeds

Weeding Kales using simple tools

➢ **Managing of Weeds (GHCP&PHHT20: Q13)**

"Do you ensure timely weeding and use of appropriate weeding practices in managing weeds?"

- Weeds are suppressive to **crop growth**, and **yields**.
- They act as **alternative hosts** to many pests and diseases of economic importance to crops
- More often, smallholder farmers unintentionally aid in weed proliferation by either weeding **seeded** weeds; or **chopping** the **weed** into smaller propagules for the vegetatively propagated weeds
- **Timely** and regular weeding is **important** to suppress weeds
- Avoid weeding in wet condition as it may lead **to soil compaction.**
- Use of **appropriate herbicides** cuts down on labour (costs) and improves farmers' income

5. GHCP&PHHT: Crop Management: Q14

Top-dressed Cabbages

5. GHCP&PHHT: Crop Management: Q14 Top-dressing

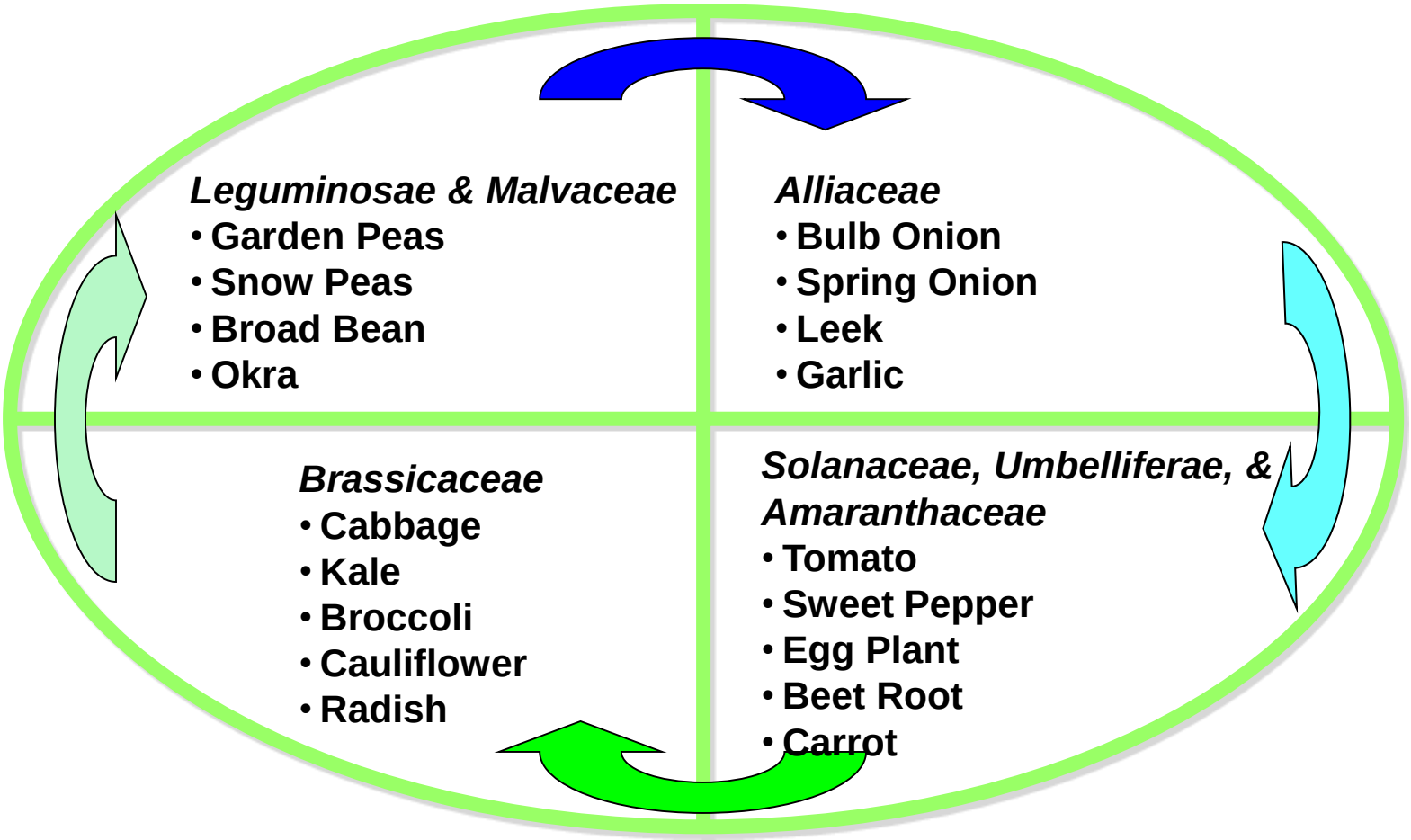
Top-dressed Cabbages

➢ **Top-dressing (GHCP&PHHT20: Q14)**

"Do you undertake appropriate top-dressing practices: timeliness, type, recommended rate of application and method of application?"

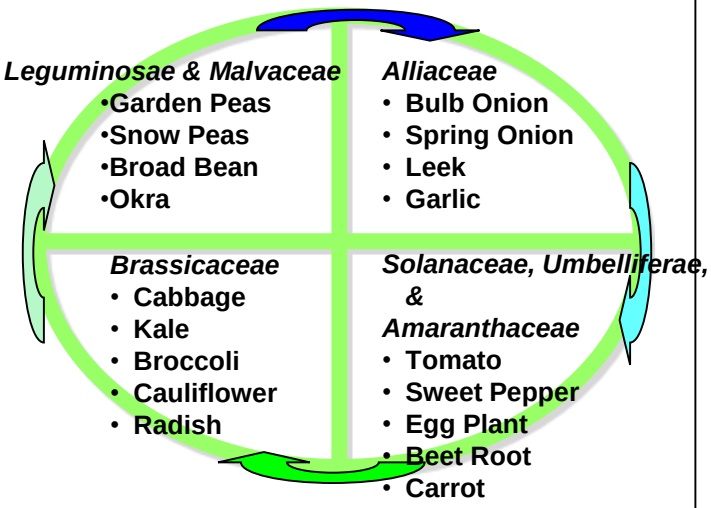
- Top-dressing fertilizers are essential for **vigorous** crop **growth** and better **yields**
- To achieve the desired results, the fertilizers must be applied appropriately in terms of: timing; type and quantity; and the method
- Top-dressing fertilizer should be applied when the **root system** of the seedling is well establish to enable faster uptake by the crop
- Top-dressing fertilizers can be applied through placement methods, and fertigation method
- The effectiveness of fertilizers is highly dependent on soil pH, it is recommended to have the soils analyzed periodically **(2-3 years)** so as to determine the type and quantity of fertilizer to apply

5. GHCP&PHHT: Crop Management: Q15



An example of a Crop Rotation

5. GHCP&PHHT: Crop Management: Q15 Pests and Diseases Control/Management



An example of a Crop Rotation

➢ **Pest and Disease Control/Management (GHCP&PHHT20: Q15)**

"Do you use at least two of the following Integrated Pests Management (IPM) practices: cultural, biological, physical and chemical?"

- Pests and diseases can be managed through either single control strategies or an integration of **two** (2) or **more** methods
- The single control strategies are: cultural; physical; biological; and chemical

Cultural Control:

- Involve managing the environment in which the crop is growing/grows with a view of maintaining pest and disease below the harmful level
- The cultural methods include: field sanitation/hygiene, intercropping, crop rotation, furrowing, flooding, solarization etc.

Physical Control

- Physical control involve use of insect traps, hand picking, screening house, weeding etc.

Biological Control

- This involves use of natural enemies (predators and parasitoids), resistant/tolerant varieties, trap plants, push and pull system, and repellant plants

Chemical Control

- This involves use of pesticides
- Pesticides are preferred because of the quick effect; they have high efficacy
- Pesticide usage has been linked to environmental degradation, development of resistance, and should be used as last resort

Integrated Pest Management (IPM)

- IPM integrates two or more strategies (cultural, mechanical, biological and as a last resort, chemical control) to minimize the crop loss caused by pests and diseases.

5. GHCP&PHHT: Crop Management: Q16

Putting on protective clothing before application of pesticide

Photos: SHEP PLUS

5. GHCP&PHHT: Crop Management: Q16 Safe & Effective Use of Pesticides

Putting on protective clothing before application of pesticide

- **Safe & Effective Use of Pesticides (GHCP&PHHT20: Q16)**

"Do you observe safe and effective use of pesticides: appropriate protective clothing, recommended pesticides, appropriate doses, proper disposal and Pre Harvest Interval (PHI)?"

- Pesticides are harmful both to people and the environment and this has led to restriction and ban of some pesticides
- To minimize the negative effect of pesticides, there is need for smallholder farmers to be sensitized on aspects such as: recommended pesticides; dosage; re-entry interval; Pre-Harvest Interval (PHI); MRLs; appropriate usage of pesticides application devices; protective clothing, storage and disposal of pesticides and their containers.

Photos: SHEP PLUS

6. GHCP&PHHT: Harvest: Q17

Harvesting Cabbages

6. GHCP&PHHT: Harvest : Q17 Harvesting Indices

Harvesting Cabbages

➢ **Harvesting Indices (GHCP&PHHT20: Q17)**

"Do you use at least one of the following harvesting indices: color, size, shape and firmness?"

- The shelf life of a produce is **highly correlated** to the physiological/ horticultural maturity at harvesting
- Therefore, understanding the **unique characteristics** of different produce at physiological maturity is vital in ensuring that **only mature** produce is harvested
- This greatly reduces the **post-harvest losses** associated with produce harvested prematurely
- Below are the harvesting indices for different produce
  - **Color** of the skin & seeds (e.g. Tomato, Chili, and Passion Fruits)
  - **Size** of leaves & fruits (e.g. Kale, Banana, and Pineapple)
  - The **sound** when thumped (e.g. Watermelon, Melon, and Cabbage)
  - **Shape of produce** e.g. mature bananas are more rounded

7. GHCP&PHHT: Post-Harvest Handling: Q18

Tomatoes packaged in wooden crates

Photos: SHEP PLUS

7. GHCP&PHHT: Post-Harvest Handling: Q18 Containers & Packaging Materials

Tomatoes packaged in wooden crates for transportation

- **Containers & Packaging Materials (GHCP&PHHT20: Q18)**

"Do you use post harvest handling containers with the following characteristics: well-ventilated, easy to clean and smooth thus managing damages?"

- Other than the physiological maturity at harvesting, post-harvest handling greatly influences the produce **quality**; **shelf life**; and post-harvest **losses**
- In view of this, there is need for appropriate post-harvest handling of produce in terms of: sorting, grading, cleaning, packaging material(s), transportation, and storage

Photos: SHEP PLUS

7. GHCP&PHHT: Post-Harvest Handling: Q19

7-3

Photo: © Victor Omari HCD 2019

Graded French beans in a pack house

7. GHCP&PHHT: Post-Harvest Handling: Q19 Value Addition Techniques

Graded French beans in a pack house

- **Value Addition Techniques (GHCP&PHHT20: Q19)**

"Do you apply any of the following recommended value addition techniques: sorting, grading, cleaning, packaging or processing of produce?"

- Markets for fresh produce have become increasingly competitive in terms of produce quality
- There is need for farmers to add value to their produce in terms of presentation and processing for the products to be competitive
- Value addition techniques that are compatible with the **cottage industry** should be promoted for **smallholder farmers**.

8. GHCP&PHHT: Cost & Income Analysis: Q20 (1/2)

(A) Input cost & other costs

Date	Type of input/ any other remarks	Quantity	Cost (Ksh)
1st Oct	Tomato Seeds (Cal J)	75g	500
3rd Oct	Fertilizer (DAP)	50kg	2,000
12th Nov	Pesticide (Duduthrin)	200ml	200
.....	.....	.....	....
.....	.....	.....	....
5th Dec	Crates	20	120
Grand Total of Input & Other costs (A)			10,700

(B) Labour cost (should include family labour)

Date	Farm activity	Cost (Ksh)
3rd Oct	Land Preparation	250
6th Oct	Nursery Establishment	1,100
23rd Oct	Transplanting	600
27th Oct	Weeding	300
.....	.....	...
.....	.....	...
19th Dec	Harvesting	1,300
20th Dec	Transportation	350
Grand Total of Labour cost (B)		5,700

Grand Total of Input & Other costs (A) + Grand Total of Labour cost (B) = Total Production Cost (A+B)

10,700 + 5,700 = 16,400

7. GHCP&PHHT: Cost & Income Analysis: Q20 Farm Records (1/2)

(A) Input cost & other costs

Date	Type of input/ any other remarks	Quantity	Cost (Ksh)
1st Oct	Tomato Seeds (Cal J)	75g	500
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19th Dec	Harvesting	1,300
20th Dec	Transportation	350
Grand Total of Labour cost (B)		5,700

Grand Total of Input & Other costs (A) + Grand Total of Labour cost (B) = Total Production Cost (A+B)

10,700 + 5,700 = 16,400

(A) Input cost and other cost

- Keep records of all the expenditure in input cost with Date/ Type of input/ Quantity/ Cost.
- In the last row, sum up all the recorded cost (A)

(B) Labour Cost

- Keep records of all the labour cost which includes family labour with Date/ farm Activity/ Cost.
- In the last row, sum up all the recorded labour cost (B)

(A+B) Total Production Cost

- Add (A) to (B) to find out Total Production Cost

➢ **Cost & Income Analysis (GHCP&PHHT20: Q20)**

"Do you keep farm records to determine the profitability of the enterprise(s)?"

- Viable decisions on any enterprise can only be based on accurate data or information. Such decisions are largely based on the income generated.
- Unfortunately, most smallholder farmers rarely keep records; subsequently, most decisions are abstract and highly subjective. Due to the abstract nature, smallholder farmers decisions are more often not economically viable.
- In view of these, there is need to sensitize smallholder farmers on the importance of keeping accurate farm records in making economically viable decisions.

8. GHCP&PHHT: Cost & Income Analysis: Q20 (2/2)

(C) Production & Sales Record

Date	Total Production (kg) (Yield)	Net Production (kg) (sold&consumed)	Price/ kg (ksh./kg)	Total income (ksh)
1st Dec	80kg	75kg	35	2,625
5th Dec	323kg	309kg	35	10,815
8th Dec	168kg	160kg	35	5,600
10th Dec	13kg	12kg	35	420
.....	.....	.....	.....	...
.....	.....	.....	.....	...
27th Dec	28kg	25kg	45	1,125
Grand total	868kg	772kg		(C) Gross Income 32,424

(D) Net Income

Gross income (C) - Total Production Cost (A+B) = Net Income

KSH 32,424 - KSH 16,400 = KSH 16,024

7. GHCP&PHHT: Cost & Income Analysis: Q20 2/2

(C) Production & Sales Record

Date	Total Production (kg) (Yield)	Net Production (kg) (sold&consumed)	Price/ kg (ksh./kg)	Total income (ksh)
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(D) Net Income

Gross income (C) - Total Production Cost (A+B) = Net Income

KSH 32,424 - KSH 16,400 = KSH 16,024

(C) Production & Sales Record

- Keep records of all the Production & Sales with Date/ Total Production(Yield) (kg)/ Price/kg/ Total income.
- In the last row, sum up all the recorded Total Income (C), which is Gross income

(D) Net Income

- Net income is calculated by

Gross income (C) – Total Production Cost (A+B) (Shown in the previous page) = Net Income

Japan International Cooperation Agency

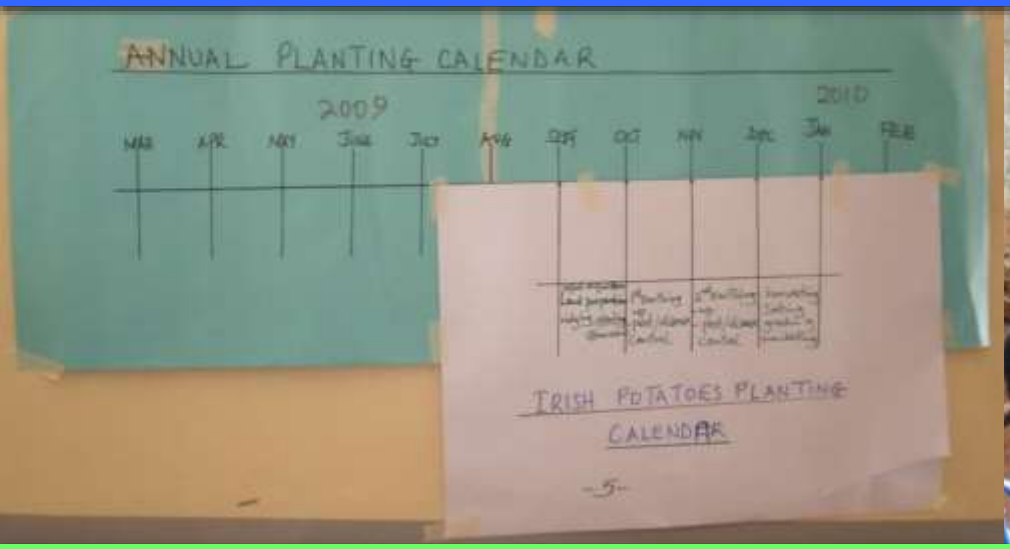
Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

A CROP PLANTING CALENDAR



Prepared by SHEP PLUS

Photos: SHEP PLUS

Training Title: **A Crop Planting Calendar; a Planning tool towards successful marketing of horticultural produce**

Objective: **To assist smallholder farmers in planning their production to optimize their income**

Specific objectives:

- **Assist farmers in preparing and utilizing planting calendar**
- **Guide farmers in resource allocation**
- **Assist farmers in targeting peak market for a produce**

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A CROP PLANTING CALENDAR, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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1. Introduction

A sample of a Bulb Onion Planting Calendar

1. Introduction

Photo: SHEP PLUS

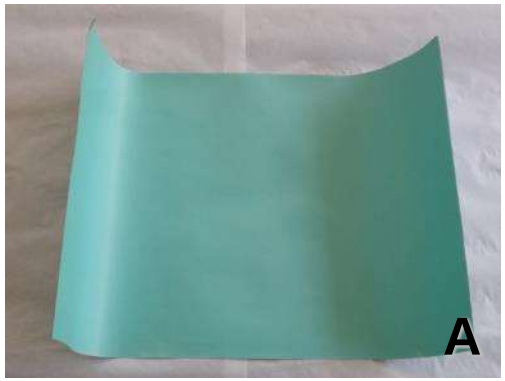
A Sample of a Cabbage Planting Calendar; with land preparation beginning in August and a peak market demand in December

- A crop planting calendar guides farmers on when to plant/sow in order to capture the highest price in the market
- To decide when the planting/sowing should be done, farmers have to undertake a market survey to determine the month when there is peak demand before preparing a crop planting calendar
- In addition, a crop planting calendar is an important planning tool used by farmers to make decisions on when to carry out various farm activities to meet specific market demand
- It is useful for members of farmer groups in synchronizing their farm operations, thus exploiting the economies of scale when purchasing inputs, the bargaining power, and constant supply when marketing the produce

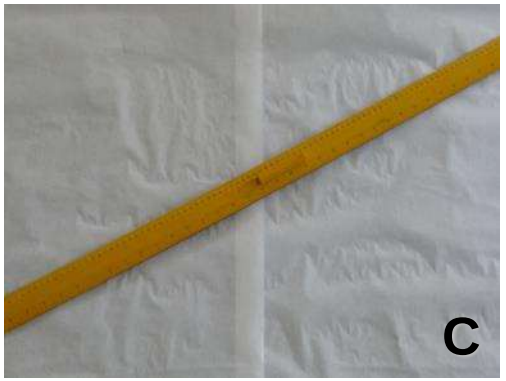
[Note]

- This is a sample calendar for a specific area for a specific crop

2. Materials for Preparing a Crop Planting Calendar


A


B


C

D


E

Or


E’

2. Materials for Preparing a Crop Planting Calendar

Colored Manila Papers (2 pieces): For preparing an annual calendar

White Manila Paper (1 piece): For preparing a monthly activities sheet

Ruler (1 m): For drawing straight lines

Markers: For labeling the annual calendar & the monthly activities sheet

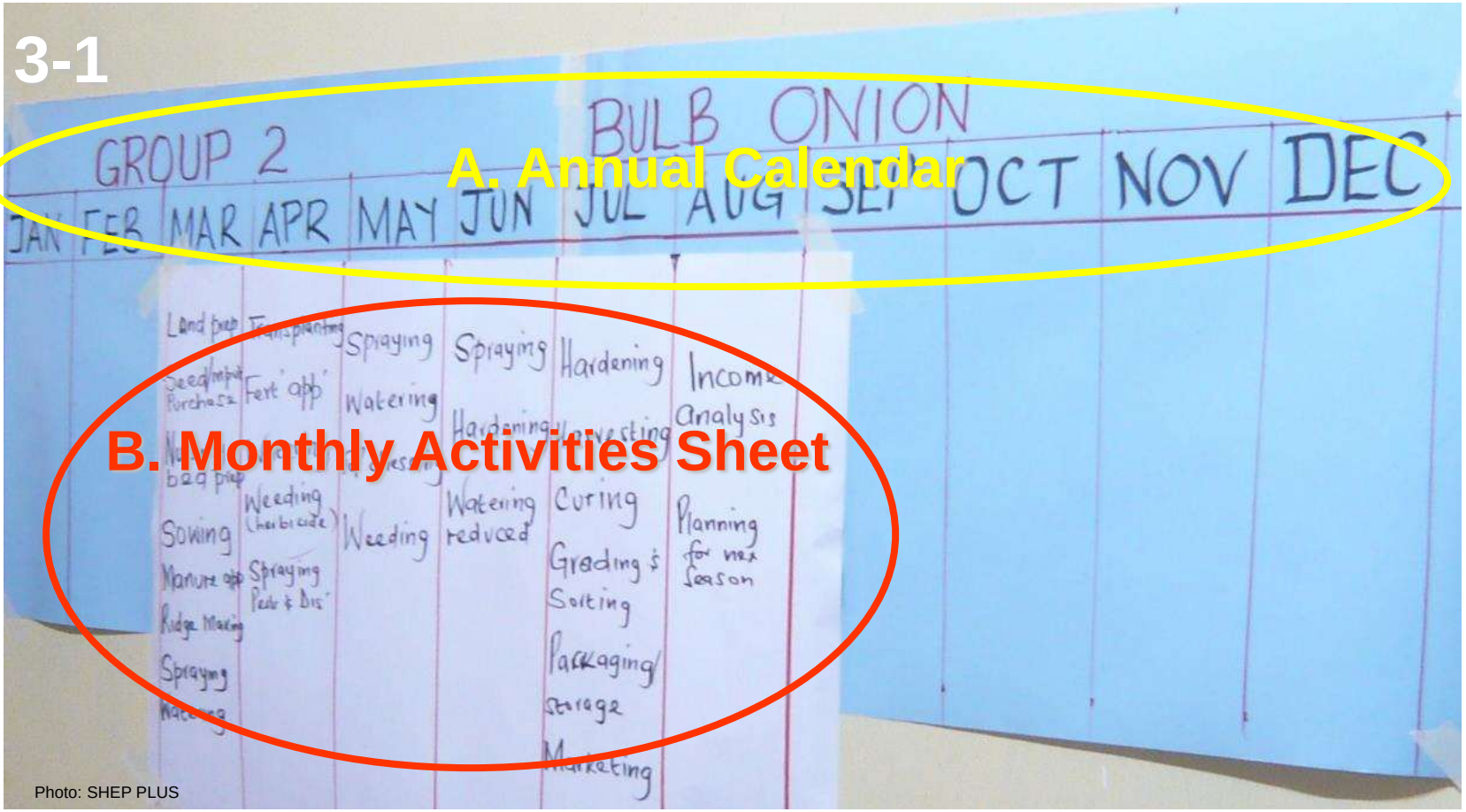
Masking Tape/Cello Tape: For joining the annual calendar & the monthly activities sheet

Or

Glue: For joining the annual calendar & the monthly activities sheet

Photos: SHEP PLUS

3. Parts of a Crop Planting Calendar



A sample of a Bulb Onion Planting Calendar

3. Parts of a Crop Planting Calendar

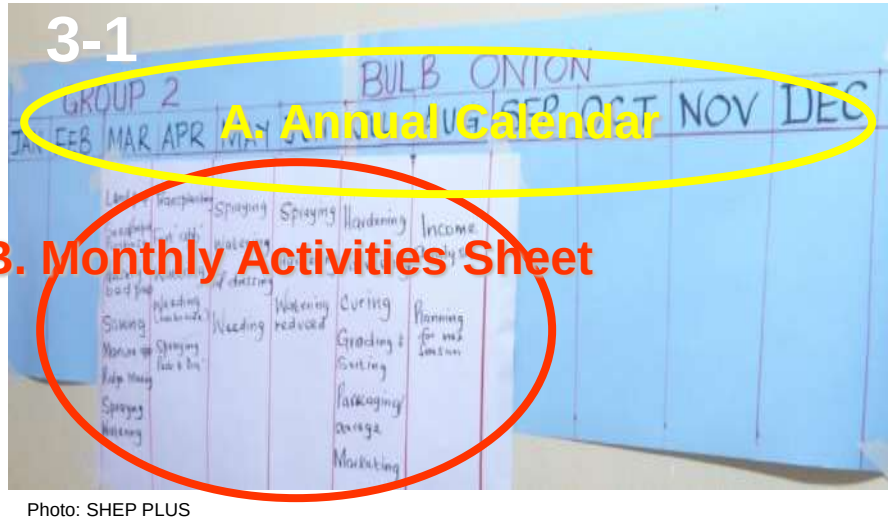
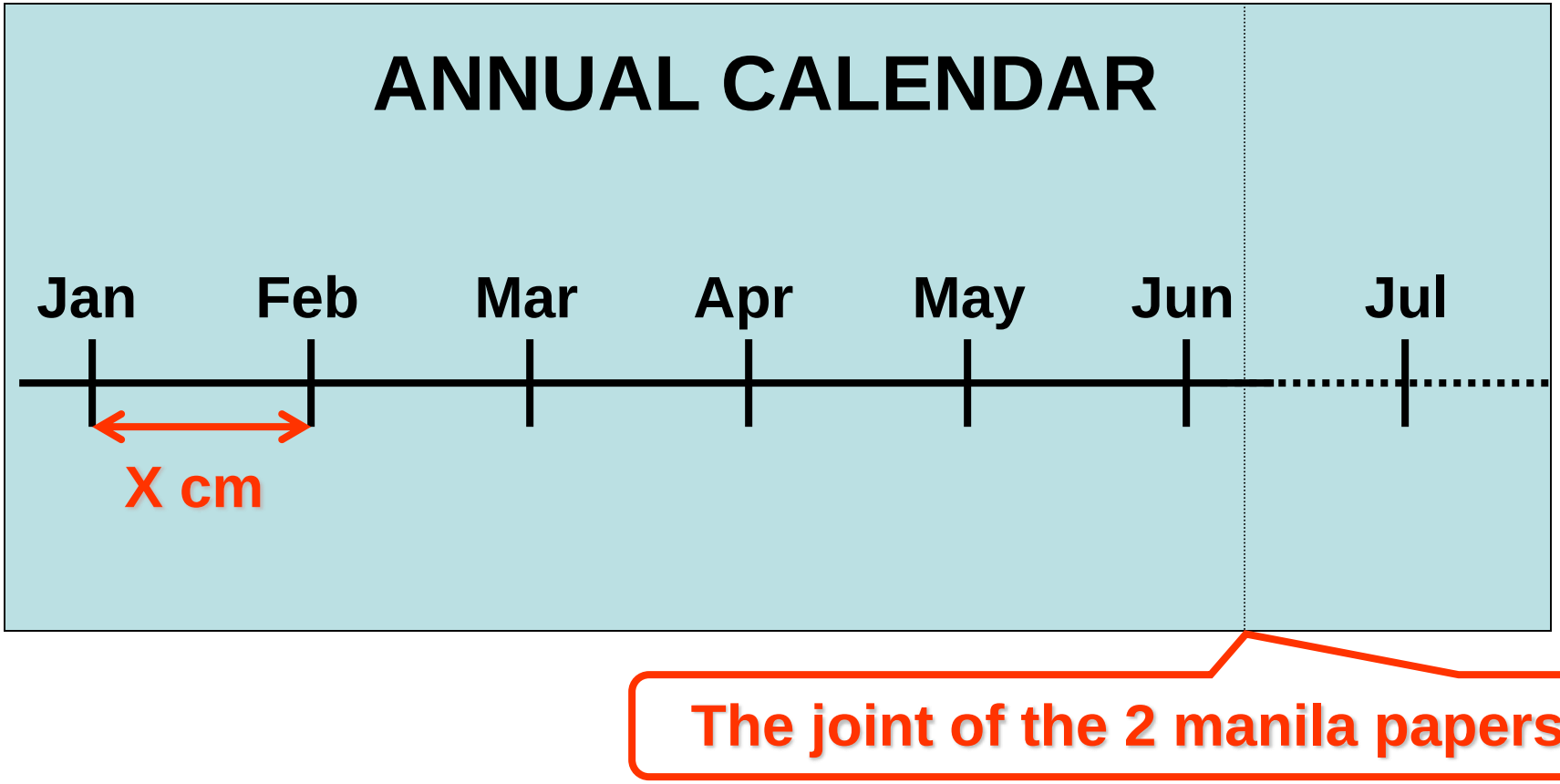


Photo: SHEP PLUS

- A crop planting calendar has two (2) parts:
  - **A. The Annual Calendar** (made by 2 blue manila papers in the photo) without days or dates – indicated by the yellow circle
  - **B. The Monthly Activities Sheet** (made by white manila paper in the photo) indicate the activities for a crop from land preparation to harvesting – indicated by the red circle

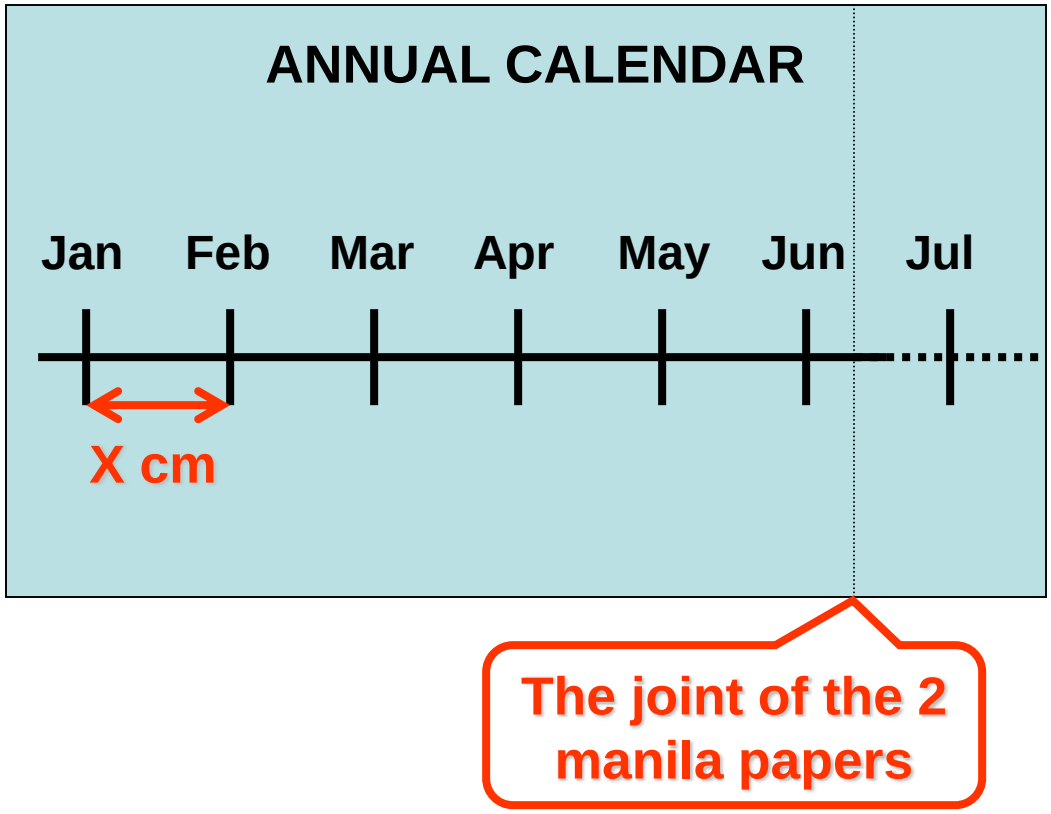
A Sample of a Bulb Onion Planting Calendar

4. Preparing an Annual Calendar



Joined manila papers with calibrated months

4. Preparing an Annual Calendar



A. The Annual Calendar

Procedure for preparing an annual calendar

1. Join two (2) colored manila papers from width to width using a masking tape/cello tape to make one long sheet

2. Using the 1 m ruler, draw a straight horizontal line on the joined manila papers at the centre

3. Subdivide the horizontal line into twelve (12) equal sections (X cm)

4. Label the sections starting from January to December without days or dates (It **DOES NOT** always have to start from January)

Joined manila papers with calibrated month

5.1 Preparing a Monthly Activities Sheet

Land Preparation Nursery Sowing 120 g of seed per acre Control of Damping off Diseases & Cutworms	Transplant 30 days after Seed Germination Spacing 60 x 60 cm^2 Fertilizer Application 10 g DAP per hole (2 bottle tops Per hole) Manure 4 – 8 ton/acre (2 – 3 handfuls)	Weed, Pest & Disease Control 1st Top Dressing 60 kg/acre (5 g/hole or 1 bottle top per hole)	2nd Top-dress 120 kg/acre (10 g/hole) Weed, Pest & Disease Control	Harvesting 75 – 120 days after Transplanting Sorting & Grading Small<1kg Medium 1 – 2 kg Large >3kg Yields 6,000 – 12,000kg per acre Marketing

X cm

A sample of a monthly activities sheet for Cabbage

5.1 Preparing a Monthly Activities Sheet

Land Prepa-ration Nursery Sowing 120 g of seed per acre Control of Damping off Diseases & Cutworms	Trans-plant 30 days after Seed Germi-nation Spacing 60 x 60 cm^2 Fertilizer Appli-cation 10 g DAP per hole (2 Bottle tops per hole) Manure 4 – 8 ton/acre (2 – 3 handfuls)	Weed, Pest & Disease Control 1st Top Dressing 60 kg/acre (5 g/hole or 1 bottle top per hole)	2nd Top dress 120 kg/acre (10g/hole) Weed, Pest & Disease Control	Harvesting 75 – 120 days after Trans-planting Sorting & Grading Small<1kg Medium 1 – 2 kg Large >3kg Yields 6,000-12,000kg per acre Markrting

X cm

A sample of a monthly activities sheet for Cabbage (For a five (5) months maturity period)

B. The Monthly Activities Sheet

- The monthly activities sheet consists of columns
- Each column indicates the monthly activities (activity) to be undertaken and the inputs required

Procedure for preparing the monthly activities sheet

1. Prepare one (1) white manila paper
2. Consider the maturity period of the crop that you are preparing the planting calendar for
3. If the planting calendar is for a crop whose maturity period is five (5) months, draw five (5) columns on the manila paper
4. The width of each column must be equal to that of each section (**X cm**) of the annual calendar
5. Start considering monthly activities and input requirements of the crop
6. Indicate in the appropriate column of the monthly activities sheet the activities and inputs required up to marketing

5.2 Importance of a Monthly Activities Sheet

Indicates resources required towards all the planned activities in every month/ column

Land Preparation Nursery Sowing 120 g of seed per acre Control of Damping off Diseases & Cutworms	Transplant 30 days after Seed Germination Spacing 60 x 60 cm^2 Fertilizer Application 10 g DAP per hole (2 bottle tops Per hole) Manure 4 – 8 ton/acre (2 – 3 handfuls)	Weed, Pest & Disease Control 1st Top Dressing 60 kg/acre (5 g/hole or 1 bottle top per hole)	2nd Top-dress 120 kg/acre (10 g/hole) Weed, Pest & Disease Control	Harvesting 75 – 120 days after Transplanting Sorting & Grading Small<1kg Medium 1 – 2 kg Large >3kg Yields 15,000 – 64,000kg per acre Marketing

X cm

A sample of a monthly Activity Sheet for Cabbage

5.2 Importance of a Monthly Activities Sheet

Indicates resources required towards all the planned activities in every month/ column

Land Prepa-ration Nursery Sowing 120 g of seed per acre Control of Damping off Diseases & Cutworms	Trans-plant 30 days after Seed Germi-nation Spacing 60 x 60 cm^2 Fertilizer Appli-cation 10 g DAP per hole (2 Bottle tops per hole) Manure 4-8 ton/acre (2-3 handfuls)	Weed, Pest & Disease Control 1st Top Dressing 60 kg/acre (5 g/hole or 1 bottle top per hole)	2nd Top dress 120 kg/acre (10g/hole) Weed, Pest & Disease Control	Harvesting 75 – 120 days after Trans-planting Sorting & Grading Small<1kg Medium 1 – 2 kg Large >3kg Yields 15,000 – 64,000kg per acre Marketing

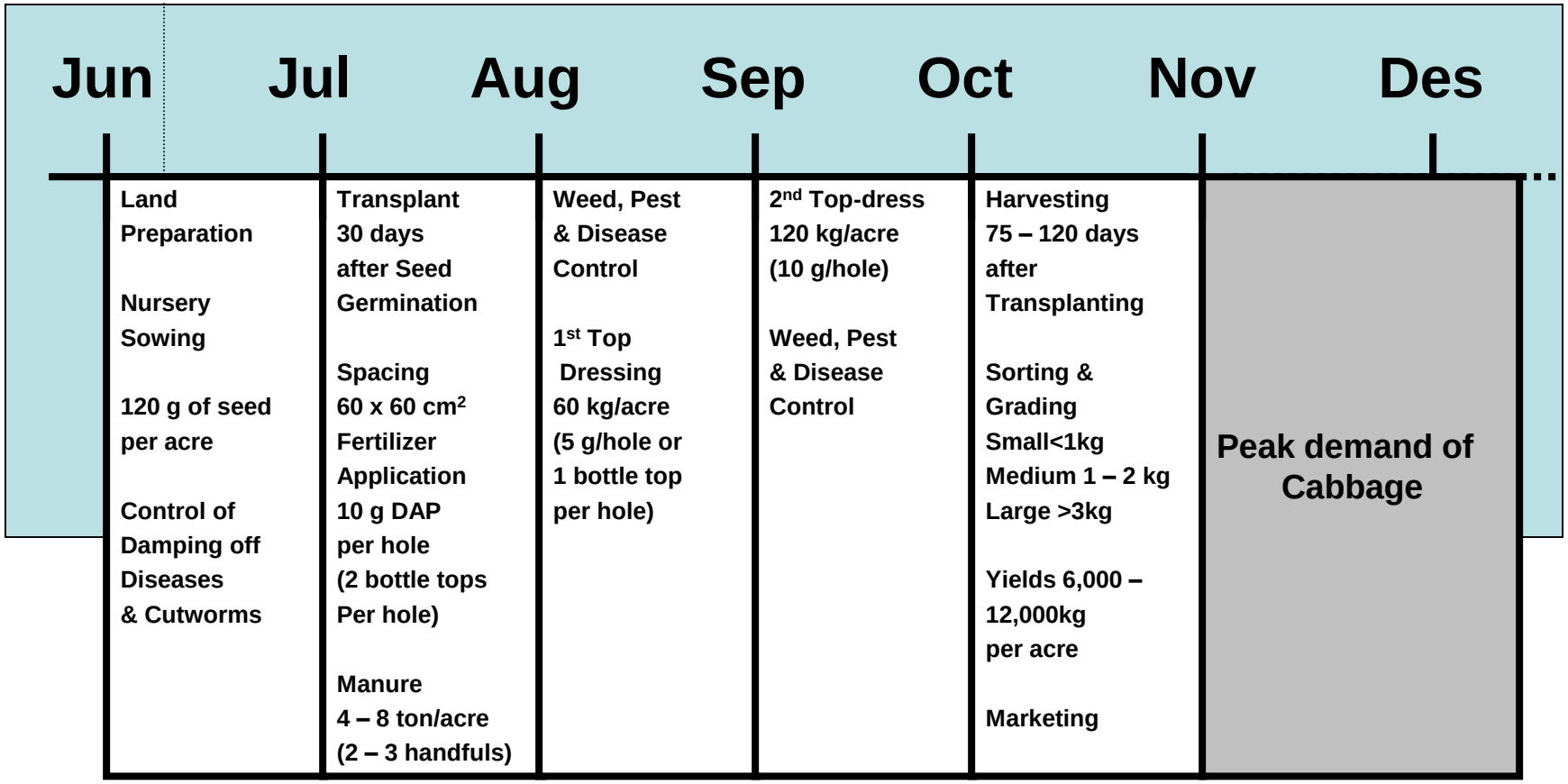
B. The Monthly Activities Sheet

The importance of the monthly activities sheet

- Resources are always scarce more so for smallholder farmers
- However, by using the monthly activities sheet, a farmer can confine his/her resource allocation to immediate needs as indicated by the sheet
- Since the monthly activities sheet indicates the input requirements, farmers working in a group can proportionately pool resources together to meet their monthly input requirements, thus exploiting the economies of scale

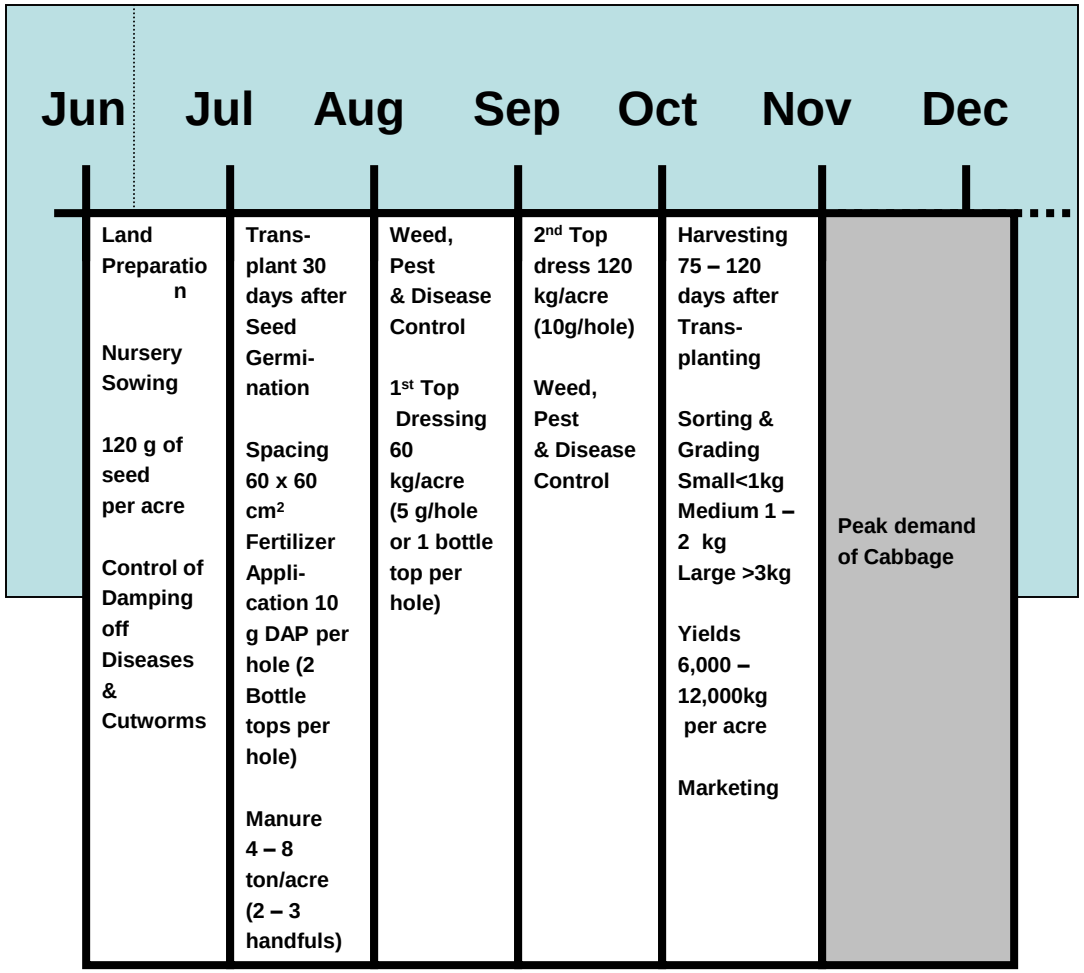
A sample of a monthly Activity Sheet for Cabbage

6. Adjusting a Crop Planting Calendar



Joined crop planting calendar of Cabbage

6. Adjusting a Crop Planting Calendar



Joined crop planting calendar of Cabbage: determining the planting/sowing month for a peak demand in November

How to determine the planting/sowing month for a given peak demand of a produce

- A crop planting calendar provides guidance on which month the planting/sowing should be done in order for harvesting to coincide with the peak market demand for the produce
- Once the month for peak demand on the annual calendar has been determined through the market survey, place the monthly activities sheet against the annual calendar with the last column of the monthly activities sheet (extreme right) directly under the month for peak demand on the annual calendar
- With the superimposition of the annual calendar and the monthly activities sheet as described above, the column of the monthly activities sheet on the extreme left will coincide with the month when the planting/sowing should be done
- The monthly activities sheet is moved along the annual calendar based on market demand

7. How to use a Crop Planting Calendar

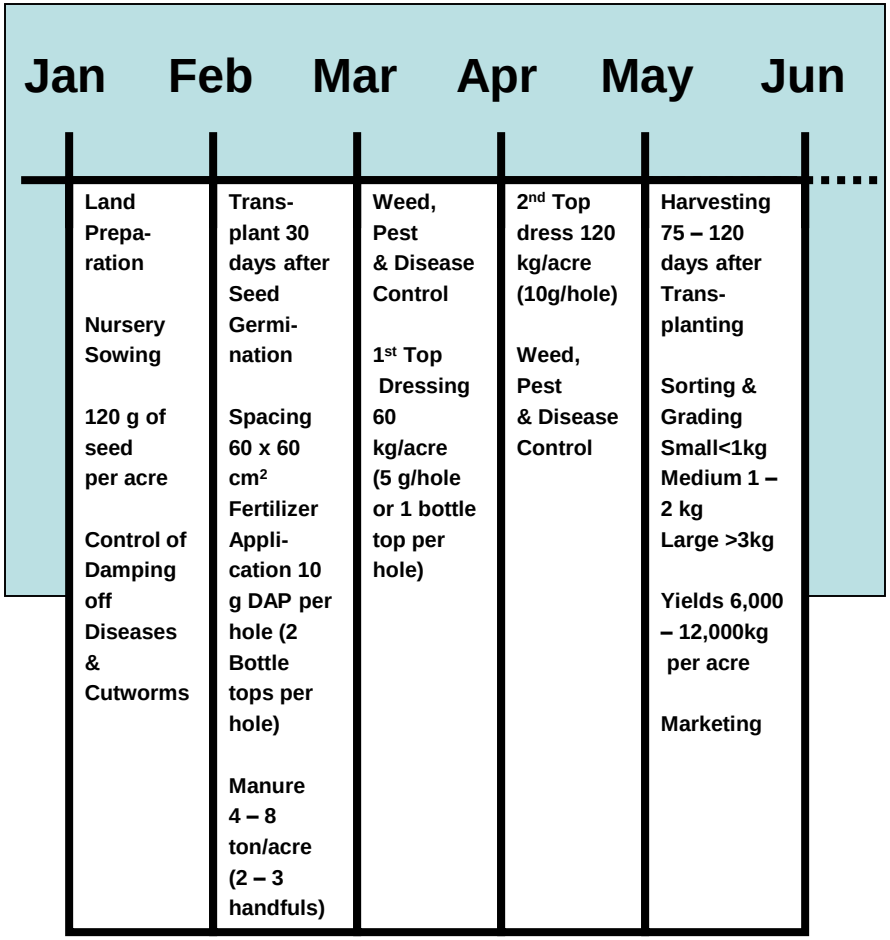


Fig. 1

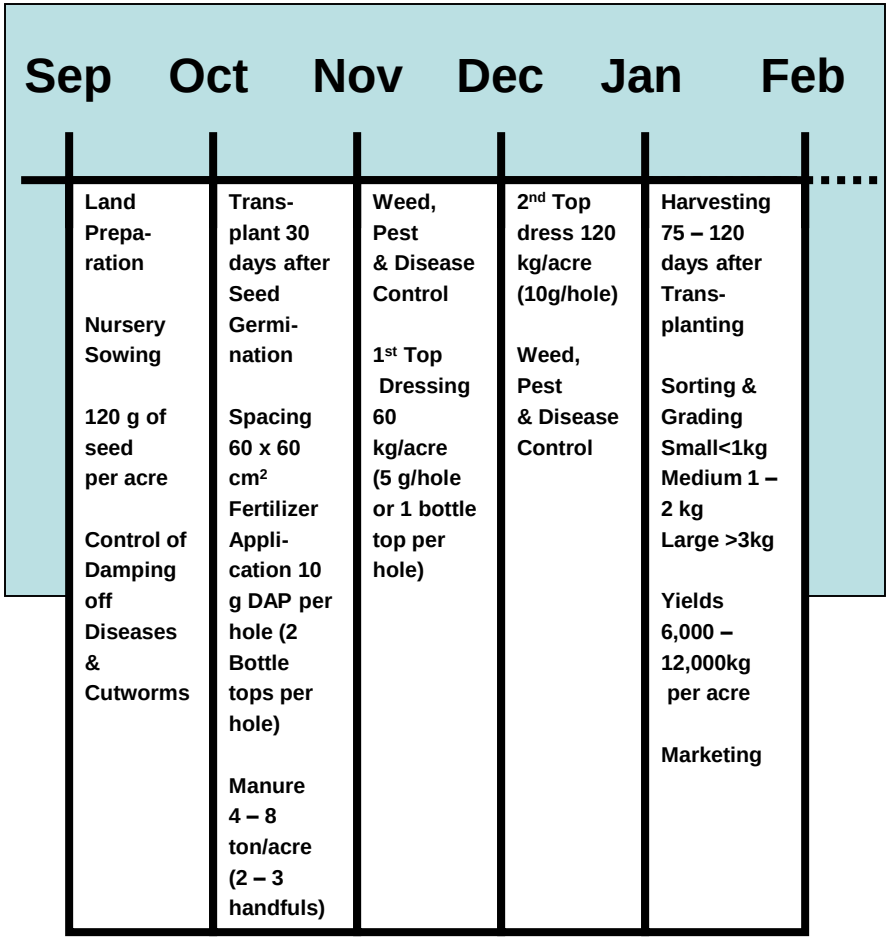


Fig. 2

7. How to use a Crop Planting Calendar

*The figures illustrate how to determine the planting/sowing months for different peak months for produce (cabbage) demand

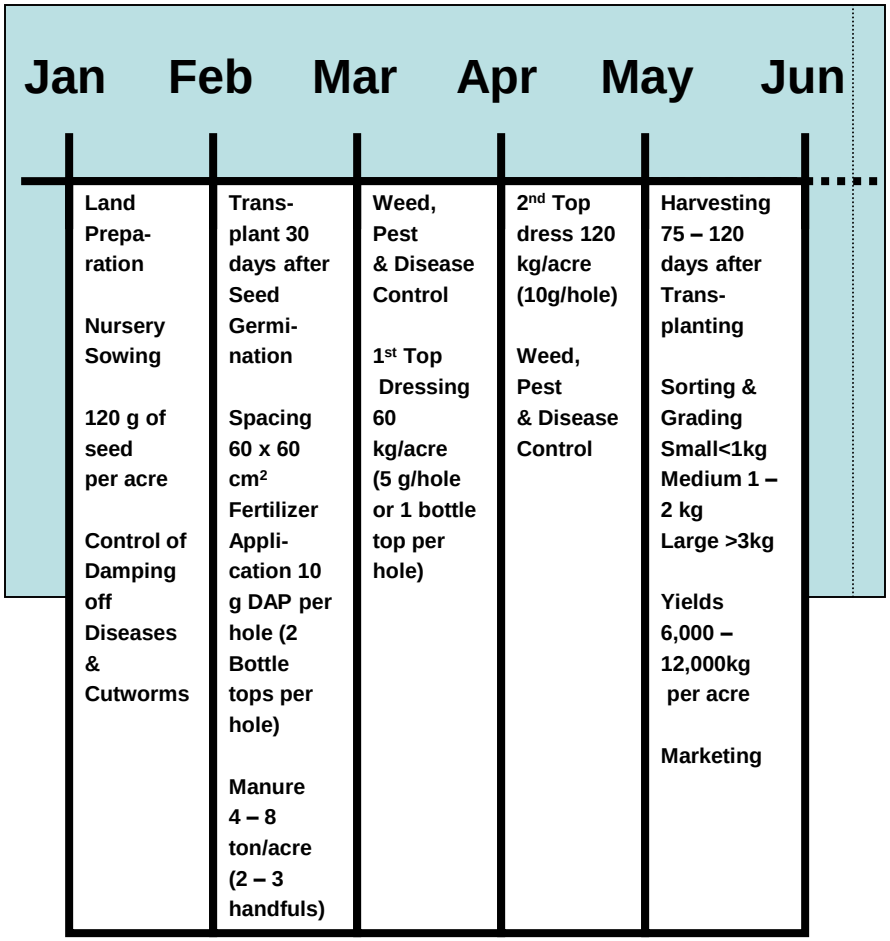


Fig. 1: A planting calendar for Cabbage targeting the peak demands just after June

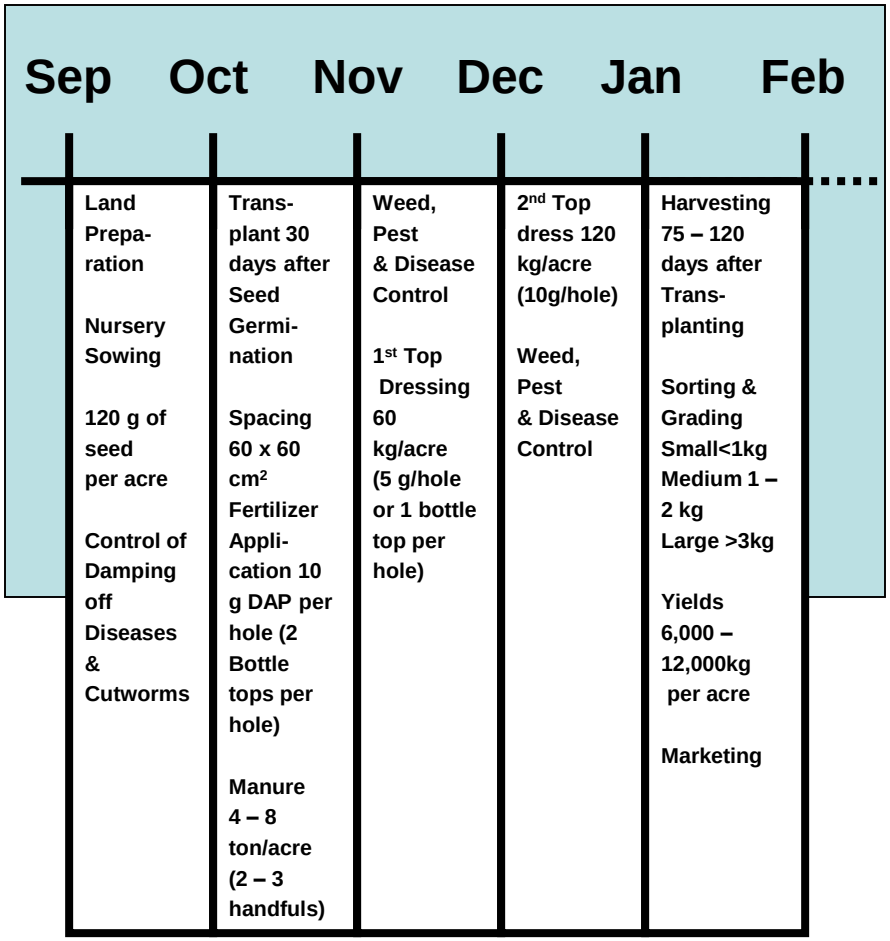


Fig. 2: A planting calendar for Cabbage targeting the peak demands just after February

8. Conclusion

Farmers displaying a crop planting calendar

8. Conclusion

Farmers displaying a crop planting calendar which they have prepared

Conclusion

- A crop planting calendar is a simple and easy tool that can be prepared by farmers
- Farmers can plan future farm activities using the crop planting calendar
- It is a significant planning tool which if properly used can make farming a profitable undertaking

Japan International Cooperation Agency

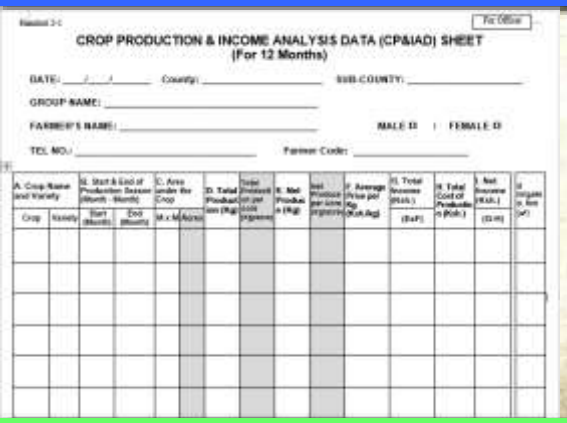
Agriculture and Food Authority
Horticultural Crops Directorate

Ministry of Agriculture, Livestock and Fisheries
State Department for Crop Development & Agricultural Research

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

"Changing Farmers' Mindset from "Grow and Sell" to "Grow to Sell""

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET

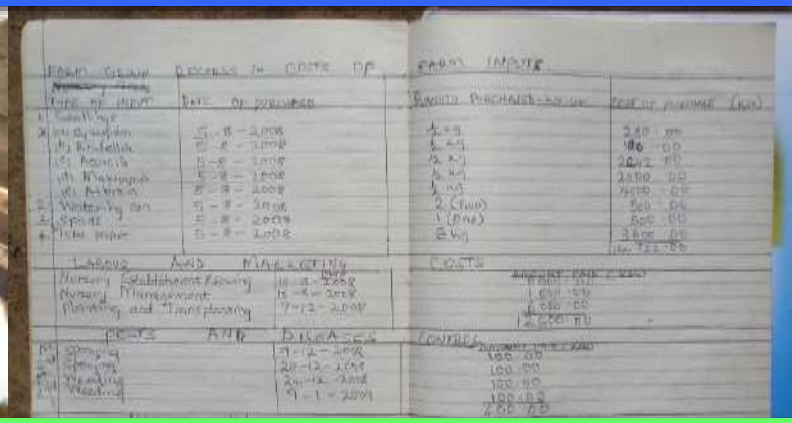

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET
(For 12 Months)

DATE: ____ County: ____ SUB-COUNTY: ____

GROUP NAME: ____

FARMER'S NAME: ____ MALE ☐ FEMALE ☐

TEL NO.: ____ Farmer Code: ____



Prepared by SHEP PLUS

Photo: SHEP PLUS

Training Title: **Crop Production & Income Analysis Data (CP&IAD) Sheet**

Objective: **To provide an effective means of capturing data for income analysis**

Specific objectives:

- **To familiarize extension staff with obtaining production data**
- **To provide a guide on calculating profitability of an enterprise**

Contents:

Contacts:

- **Ministry of Agriculture, Livestock & Fisheries (MOALF):**
  Kilimo House, Cathedral Road, P.O. Box 34188-00100,
  Nairobi, KENYA, Tel: 020-2718870
- **Agriculture and Food Authority (AFA), Horticultural Crops Directorate (HCD):**
  Airport Road, Opp. JKIA, P.O. Box 42601-00100, Nairobi, KENYA
  Tel: 020-2131560/3597356
- **Japan International Cooperation Agency (JICA) Kenya Office:**
  BRITAM Tower, 22nd & 23rd, Hospital Road,
  P.O. Box 50572-00200 Nairobi, KENYA, Tel: 020-2775000
- **Smallholder Horticulture Empowerment and Promotion Project for Local & Up-scaling (SHEP PLUS):**
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  Ngong Road/Haile Selassie Avenue, Upper Hill
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  E-mail: infoshep@shepunit.org

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET,, First published by SHEP in 2009, revised by SHEP PLUS in 2019 (Ver.6)

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This publication was prepared under the Smallholder Horticulture Empowerment and Promotion Project for Local and Up-Scaling (SHEP PLUS) on behalf of Ministry of Agriculture, Livestock and Fisheries (MOALF), and Agriculture and Food Authority (Horticultural Crops Directorate (HCD)) of the Republic of Kenya and Japan International Cooperation Agency (JICA).

1. Background

Farmers identifying appropriate farm records

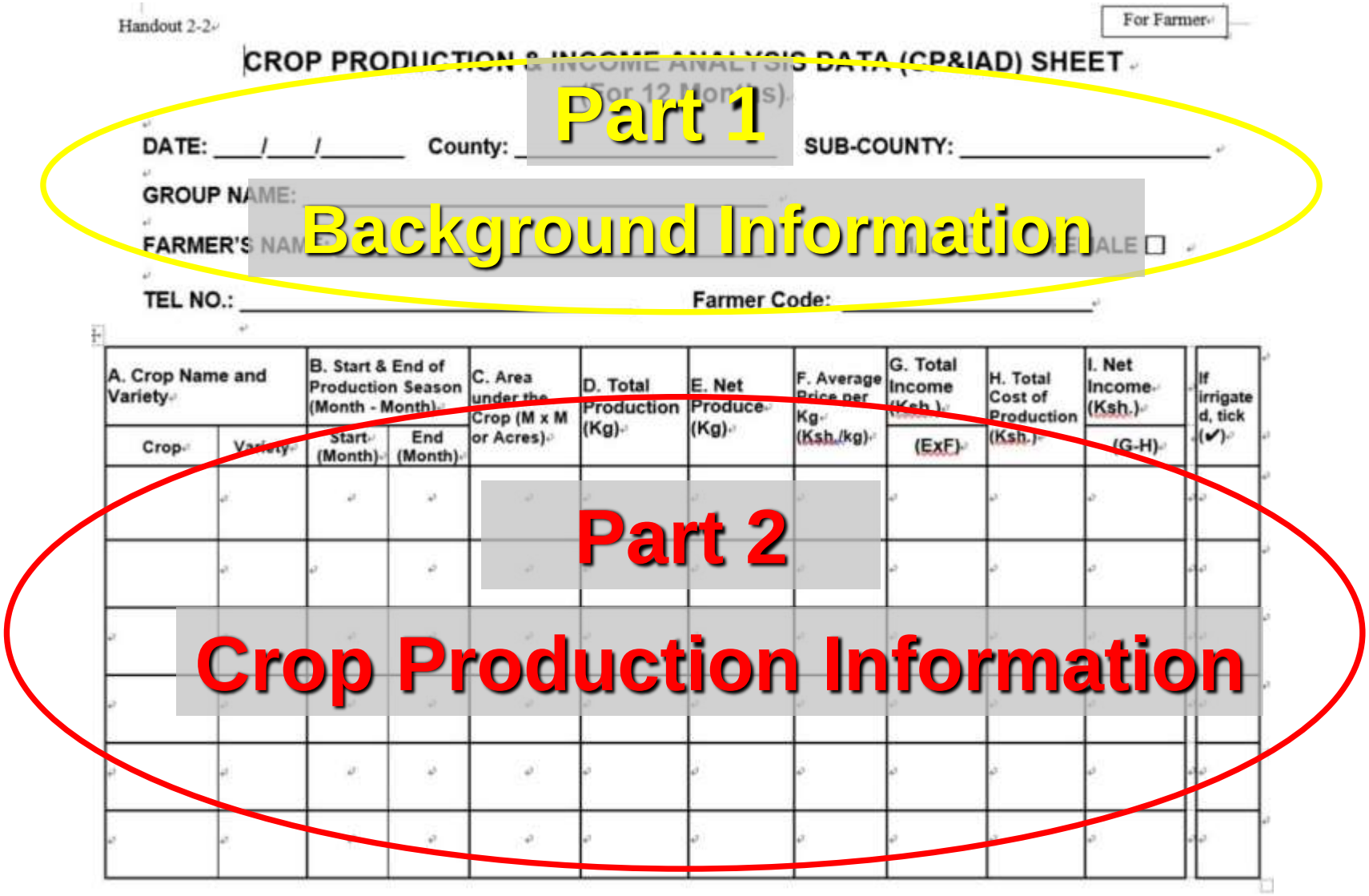
1. Background

Farmers identifying appropriate farm records

1. Background

- Smallholder farmers rarely keep documented farm records. In addition, the records are usually scanty and do not provide any meaningful information for purposes of evaluating the performance of a given enterprise.
- The extension staff face a major challenge in getting farmers to provide accurate information and data due to farmers inability to keep records.
- This training material provides skills to the extension staff and farmers on quick and effective means of obtaining crop production data using a Crop Production & Income Analysis Data (CP&IAD) Sheet.
- Periodic surveys using the Crop Production & Income Analysis Data (CP&IAD) Sheet enables determination of farmers' progress in terms of yield, income, and profit/loss assessment.

2. Introduction (1)



Handout 2-2

For Farmer

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET

(For 12 Months)

Part 1

DATE: ____/____/_____ County: _____ SUB-COUNTY: _____

GROUP NAME:

Background Information

FARMER'S NAME: MALE ☐ FEMALE ☐

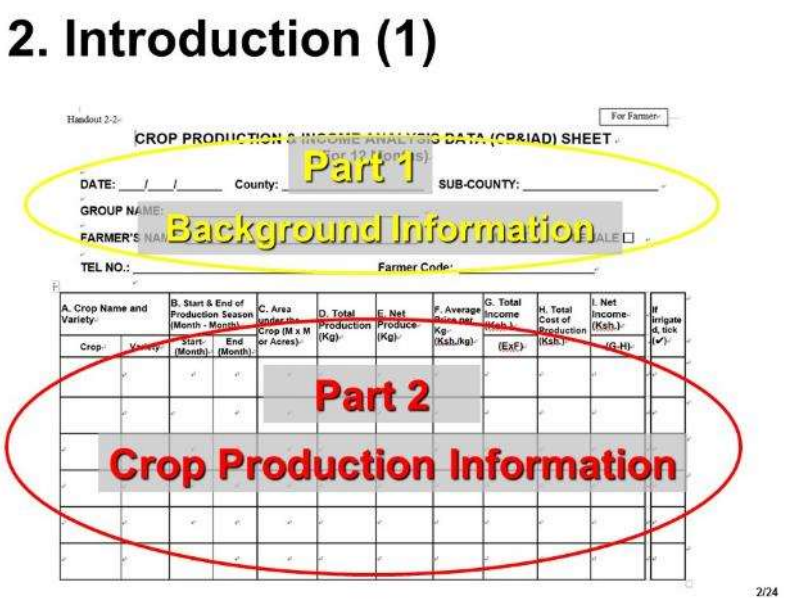
TEL NO.: _____ Farmer Code: _____

Part 2

Crop Production Information

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

2. Introduction (1)



2. Introduction

Parts of Crop Production & Income Analysis Data (CP&IAD) Sheet

The sheet is divided into three (3) parts:

2.1 Background Information

- This part provides information useful for traceability of individual farmers and groups
- It is therefore important for farmers to consistently provide the information during different surveys

2.2 Crop Production Analysis Table

- Each box to be filled by farmers with appropriate information.
- The facilitator must be well acquainted with calibrations of field practices with regard to weights, volume, and lengths **(Please refer to page 4/16)**

2. Introduction (2)

ADDITIONAL INFORMATION:

Please indicate necessary information on data in the box below. e.g.) 1 crate of Tomato = 35 kg, 1 head of Cabbage = 2 kg, 5 pieces of Mango = 1 kg, etc. **In case farmer grows fruit trees, please indicate age of the tree & number of harvestings per year.**

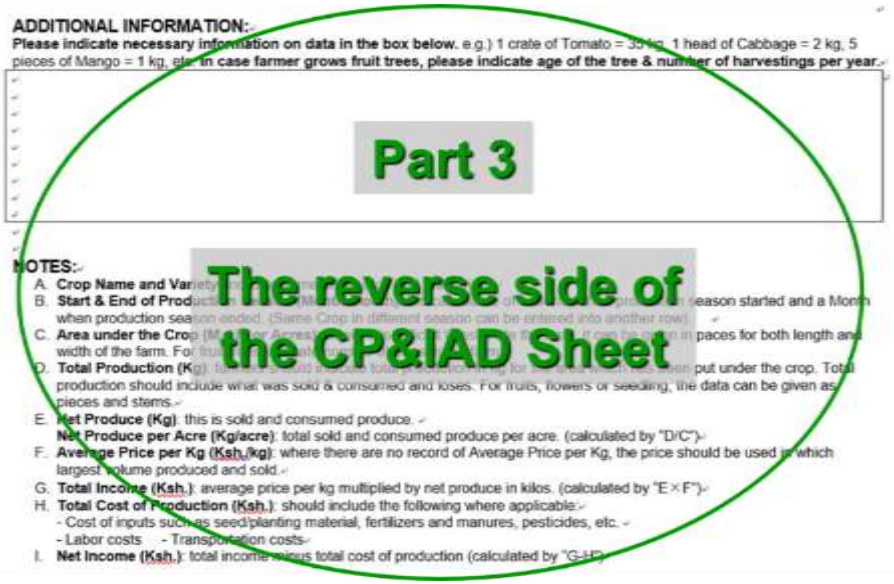
Part 3

The reverse side of the CP&IAD Sheet

NOTES:

A. **Crop Name and Variety** [illegible]
B. **Start & End of Production Season (Month/Month)**: [illegible] production season started and a Month when production season ended. (Same Crop in different season can be entered into another row).
C. **Area under the Crop (M, M or Acres)**: [illegible] it can be given in paces for both length and width of the farm. For fruit trees, [illegible]
D. **Total Production (Kg)**: farmers should indicate total production in kg for the area which has been put under the crop. Total production should include what was sold & consumed and loses. For fruits, flowers or seedling, the data can be given as pieces and stems.
E. **Net Produce (Kg)**: this is sold and consumed produce.
   Net Produce per Acre (Kg/acre): total sold and consumed produce per acre. (calculated by "D/C")
F. **Average Price per Kg (Ksh./kg)**: where there are no record of Average Price per Kg, the price should be used in which largest volume produced and sold.
G. **Total Income (Ksh.)**: average price per kg multiplied by net produce in kilos. (calculated by "E×F")
H. **Total Cost of Production (Ksh.)**: should include the following where applicable:
   - Cost of inputs such as seed/planting material, fertilizers and manures, pesticides, etc.
   - Labor costs - Transportation costs
I. **Net Income (Ksh.)**: total income minus total cost of production (calculated by "G-H")

2. Introduction (2)



2. Introduction
Parts of Crop Production & Income Analysis Data (CP&IAD) Sheet

2.3 Additional Information & Notes

Additional Information:

- Indicate necessary/ additional information on data in a box. In case a farmer grows fruit trees, indicate **age of the trees** & **number of harvestings per year**

Notes:

- Use the notes when you explain the CP&IAD Sheet to farmers

3. Field Practices: Estimation using Household/Farm Equipments

Household/Farm Equipments	Estimated Measure
1. Wheel barrow of manure/compost	40 kg
2. Large wooden box used in trading of Tomato	64 kg
3. Crate used for supplying bread; when full of Tomatoes	35 – 45 kg
4. A gunny bag for 50 kg of sugar; when full of Kale	35 kg
5. A gunny bag for 90 kg of maize; when full of Kale	70 kg
6. Weight of Cabbage – 6a. Small Size – 6b. Medium Size – 6c. Large Size	 1 – 2 kg 3 – 4 kg Over 5 kg
7. A 2 kg container of cooking fat (Kimbo, Cow-boy etc.); when full of DAP, CAN, Urea etc.	3 kg
8. A 20 litre bucket of water; when full of manure/compost	10 – 15 kg
9. Pace factor	1 m

3. Field Practices: Estimation using Household/Farm Equipments

Household/Farm Equipments	Estimated Measure
1. Wheel barrow of manure/compost	40 kg
2. Large wooden box used in trading of Tomato	64 kg
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8. A 20 litre bucket of water; when full of manure/compost	10 – 15 kg
9. Pace factor	1 m

3. Conversion Factors and Estimation

- Smallholder farmers do not readily have access to standard equipment for weights and measures for daily farm operations.
- However, over time, farmers have adopted reusing certain common household packaging containers and farm equipment as units of weights and measures.
- It is therefore imperative that one is conversant with the calibrations of the commonly used household packaging containers and farm equipment.
- The table shows the estimation of some of the most common household containers and farm equipment used by smallholder farmers in regular farm operations.

4. Procedure for Completing the CP&IAD Sheet

Extension staff supporting farmers to complete the CP&IAD sheet

Members of farmer group filling out the CP&IAD sheet

Photos: SHEP PLUS

4. Procedure for Completing the CP&IAD Sheet

Extension staff supporting farmers to complete the CP&IAD sheet

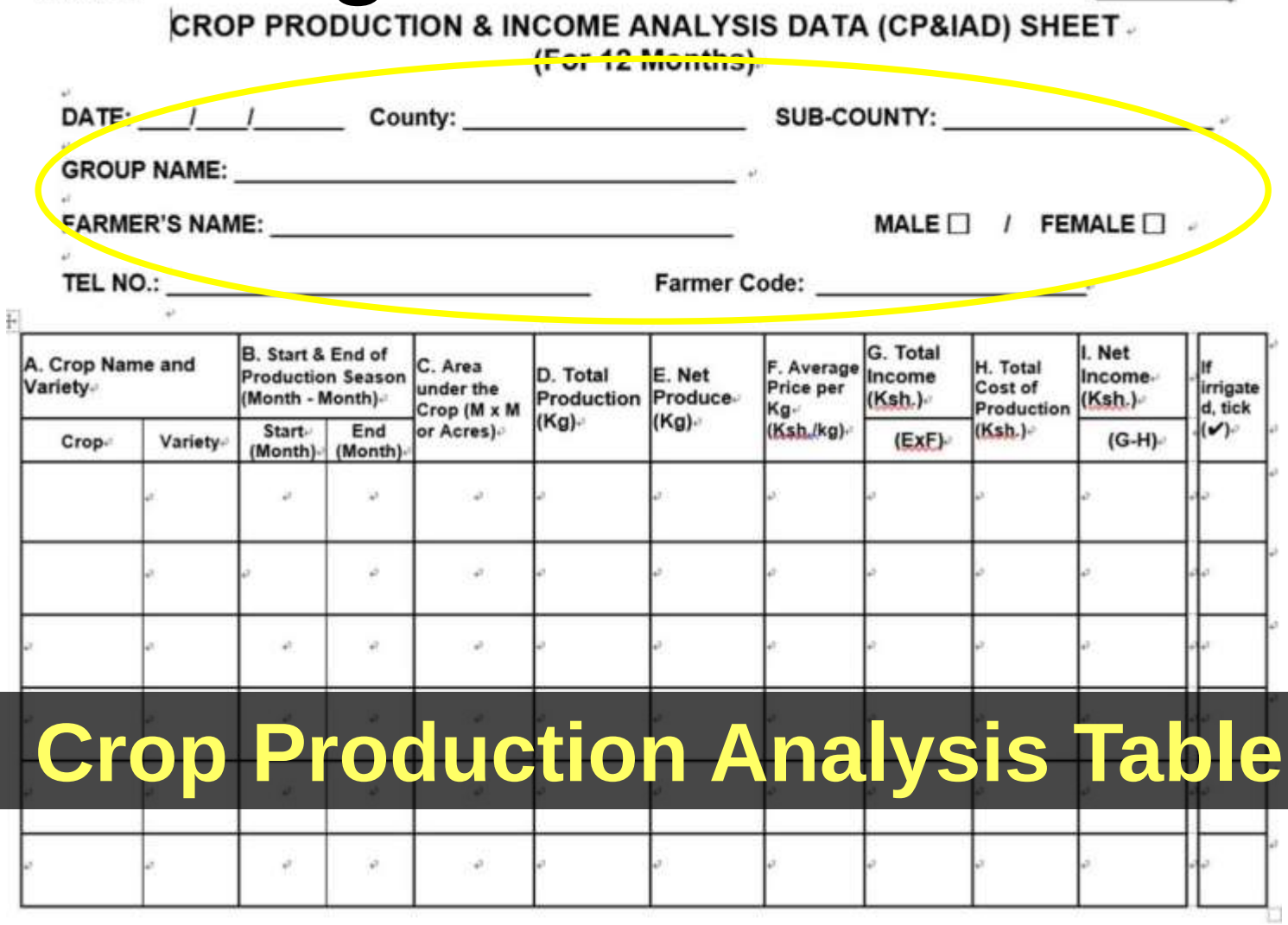
Members of farmer group filling out the CP&IAD sheet

4. Procedure for Completing the Crop Production & Income Analysis Data (CP&IAD) Sheet

- Mobilize and sensitize farmers on importance of the exercise so that they prepare necessary records
- Assemble farmer group members in a venue with sitting facilities
- Provide a flip chart for noting group contributions during deliberation
- Outline the day's programme and the importance of the exercise
- Identify major horticultural crops grown by the members.
- Go through the field practices/calibration sheet with the farmers and build consensus especially on the two (2) priority crops
- Reorganize farmers sitting sequence with a view of ensuring that literate farmers can easily support those who need guidance
- Distribute the sheets, pencils, and erasers
- The facilitator should explain the three (3) parts of the sheet and discuss column by column in a language that is most familiar with the farmers before the filling in of the sheet commences
- Since there is need for consensus when completing the Crop Production and Income Analysis Data (CP&IAD) Sheet, the facilitator has to ensure that all farmers have answered a particular question before proceeding to the next one

Photos: SHEP PLUS

8. CP&IAD Sheet:
8.1 Background Information



CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET
(For 12 Months)

DATE: ___/___/_____ County: _____ SUB-COUNTY: _____

GROUP NAME: _____

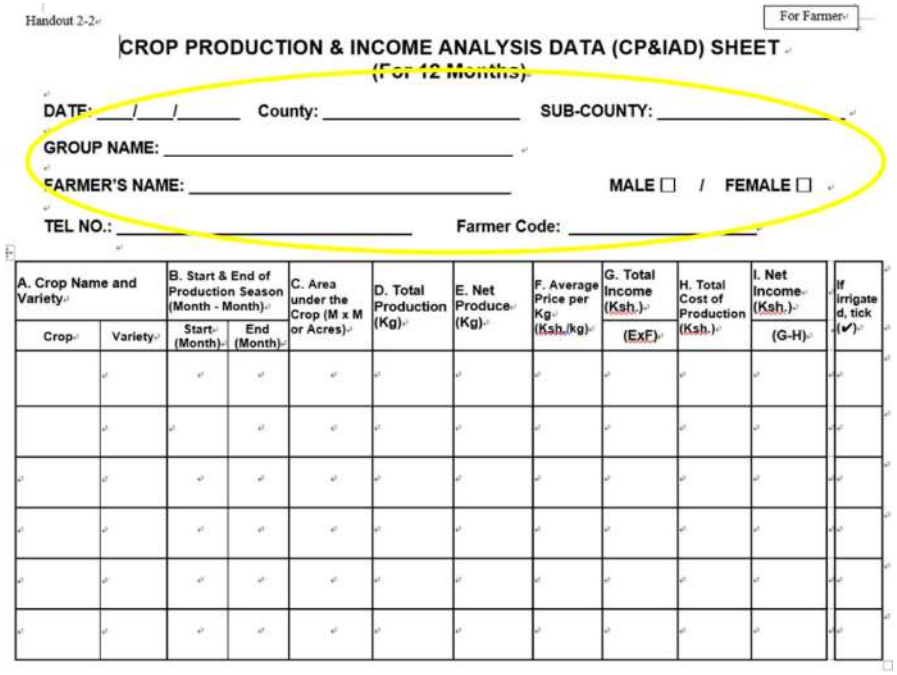
FARMER'S NAME: _____ MALE ☐ / FEMALE ☐

TEL NO.: _____ Farmer Code: _____

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

Crop Production Analysis Table

8. CP&IAD Sheet:
8.1 Background Information



Handout 2-2

For Farmer

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET
(For 12 Months)

DATE: ___/___/_____ County: _____ SUB-COUNTY: _____

GROUP NAME: _____

FARMER'S NAME: _____ MALE ☐ / FEMALE ☐

TEL NO.: _____ Farmer Code: _____

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

5. Crop Production & Income Analysis Data (CP&IAD) Sheet

5.1 Background Information

- Background information is vital for traceability
- Farmers must therefore be consistent when providing this information for different surveys

For Example:

- Date: _____/_____/_____
- County: _____
- Sub-county:_____
- Group Name: _____
- Farmer's Name: _____
- Male/Female: _____
- Telephone No.: _____-_____
- Farmer code : _____

8.2 Crop Production Analysis Table

Handout 2-2

For Farmer

Crop Production Analysis Tables

(For 12 Months)

DATE: ____/____/_____ County: _____ SUB-COUNTY: _____

GROUP NAME: _____

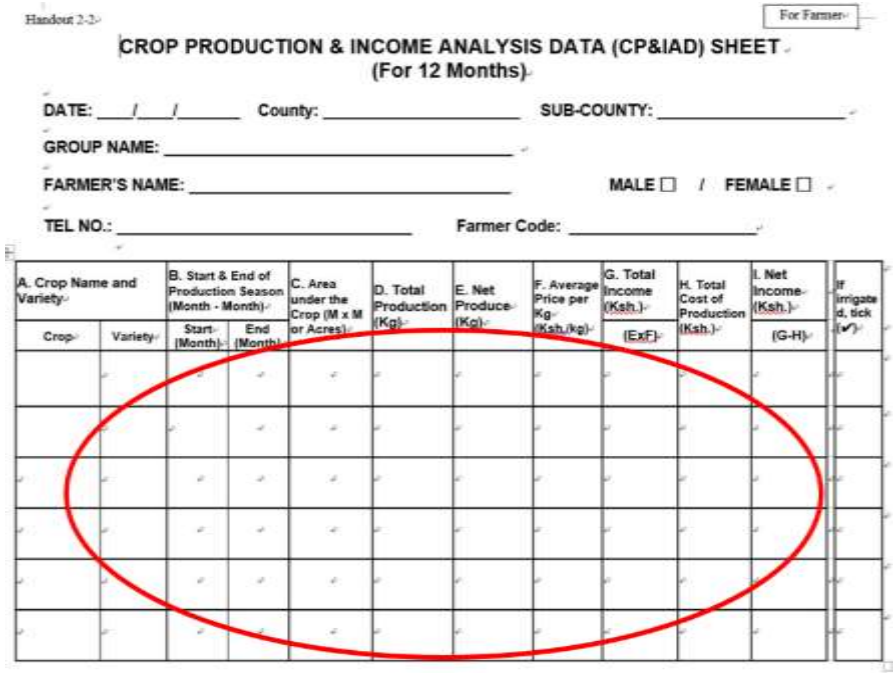
FARMER'S NAME: _____ MALE ☐ / FEMALE ☐

TEL NO.: _____ Farmer Code: _____

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

8.2 Crop Production Analysis Table

Crop Production Analysis Tables



Handout 2-2

For Farmer

CROP PRODUCTION & INCOME ANALYSIS DATA (CP&IAD) SHEET
(For 12 Months)

DATE: ___/___/_____ County: _____ SUB-COUNTY: _____

GROUP NAME: _____

FARMER'S NAME: _____ MALE ☐ / FEMALE ☐

TEL NO.: _____ Farmer Code: _____

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

5. Crop Production & Income Analysis Data (CP&IAD) Sheet

5.2 Crop Production Analysis Table

- Crop Production Analysis Table has ten (10) items with twelve (12) columns.
- Farmers are requested and guided to fill the sheet with correct data.
- Columns that require standardization can be completed manually or through an excel spread sheet back in the office.

9. Crop Production Analysis Table: Column A. (Crop name and variety), B. (Start & End of Production Season) and C. (Area under the crop)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

9. Crop Production Analysis Table: Column A. (Crop name and variety), B. (Start & End of Production Season) and C. (Area under the crop)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

A. Crop Name and Variety: Indicate name of the crop & variety. e.g. Tomato (Rio Grande).

B. Start & End of Production Season (Month – Month): fill the period of the cropping seasons within past 12 months (starting month and ending month)

C. Area under the Crop (M x M or Acres):

- **M x M: Area under the Crop (M x M)**
- **Area under the Crop (Acres)**

9. Crop Production Analysis Table: Column D. (Total production) & E. (Net produce)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

9. Crop Production Analysis Table: Column D. (Total production) & E. (Net produce)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

D. Total Production (Kg): The figure includes sold, consumed (including gifts), and losses/ rejects. The number of harvests and unit of measure must be taken into account.

E. Net Produce (Kg): The amount sold and consumed.

9. Crop Production Analysis Table: Column F. (Average price per kg) & G. (Total income)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

9. Crop Production Analysis Table: Column F. (Average price per kg) & G. (Total income)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

F. Average Price per Kg (Ksh./kg): This is the average selling price of the produce.
e.g. Ksh. 20/kg of Tomato. Where the unit of sale is **NOT** in Kg, make the necessary conversion **(see page 4/16)**.

G. Total Income (Ksh.): The total amount of income from the produce
(**E. Net Produce (Kg)** x **F. Average Price per Kg (Ksh./kg)**.)

9. Crop Production Analysis Table: Column H. (Total cost of production) & I. (Net income)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

9. Crop Production Analysis Table: Column H. (Total cost of production) & I. (Net income)

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

H. Total Cost of Production (Ksh.) include:

- Cost of inputs e.g. seed/planting material, fertilizers/manures, pesticides, tools etc.
- Cost of labour which may include nursery establishment/maintenance, ploughing, manures/fertilizer application, weeding, pest & disease control (spraying), and harvesting.
- Cost of transportation & marketing.

I. Net Income (Ksh.) = (G. Total Income - H. Total Cost of Production)

9. Crop Production Analysis Table: irrigation tick box

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

9. Crop Production Analysis Table: irrigation tick box

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	

If the crop was produced with Irrigation, the boxes in the last column need to be ticked.

10. Example

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	
Tomato	Rio Grande	9	12	40x50	10,000	9,000	20	180,000	28,510	151,490	

10. Example

*** The following are the theoretical data.**

A. Crop Name and Variety		B. Start & End of Production Season (Month - Month)		C. Area under the Crop (M x M or Acres)	D. Total Production (Kg)	E. Net Produce (Kg)	F. Average Price per Kg (Ksh./kg)	G. Total Income (Ksh.)	H. Total Cost of Production (Ksh.)	I. Net Income (Ksh.)	If irrigated, tick (✔)
Crop	Variety	Start (Month)	End (Month)					(ExF)		(G-H)	
Tomato	Rio Grande	9	12	40x50	10,000	9,000	20	180,000	28,510	151,490	

[Note]

Total Cost of Production (column G.)

for 0.5 acre of Tomato (Rio Grande) is **28,510 Ksh.**

Detailed Costs of Production are:

1) Seed 50 g = **400 Ksh.**
2) Fertilizer: 1 bag of DAP = **3,000 Ksh.**
3) Fertilizer: 2 bags of CAN = **4,000 Ksh.**
4) Fungicide: 500 gm of Dithane M45 = **400 Ksh.**
5) Fungicide: 500 gm of Ridomil = **260 Ksh.**
6) Insecticide: 200 ml of Buldock 250 EC = **600 Ksh.**
7) Insecticide: 200 ml of Duduthrin = **200 Ksh.**
8) Ploughing = **1,500 Ksh.**
9) Nursery Establishment & Management = **800 Ksh.**
10) Transplanting = **1,500Ksh.**
11) Weeding = **3,000 Ksh.**
12) Top-dressing = **3,000 Ksh.**
13) Spraying = **1,200 Ksh.**
14) Harvesting = **1,200 Ksh.**
15) Transportation = **3,750 Ksh.**
16) Other Costs = **3,700 Ksh.**

11. Types of Records Supportive to CP&IAD Sheet:

11.1 Input Cost & Other Cost

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Type of Input	Quantity	Cost (Ksh)
1 Oct	Tomato seeds (Rio Grande)	75mg	500 Ksh
3 Oct	Fertilizer (DAP)	50kg	2,000 Ksh
12 Nov	Pesticide (Duduthrin)	200ml	200 Ksh
…	…	…	…
5 Dec	Crates	20	120 Ksh
Grand Total			10,700 Ksh

11. Types of Records Supportive to CP&IAD Sheet: 11.1 Cost of Farm Inputs

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Type of Input	Quantity	Cost (Ksh)
1 Oct	Tomato seeds (Rio Grande)	75mg	500 Ksh
3 Oct	Fertilizer (DAP)	50kg	2,000 Ksh
12 Nov	Pesticide (Duduthrin)	200ml	200 Ksh
…	…	…	…
5 Dec	Crates	20	120 Ksh
Grand Total			10,700 Ksh

11. Types of Records Supportive to CP&IAD Sheet

- To calculate the Total Cost of Production (column I.), there are three (3) types of records that assist farmers. Farmers must strive to keep these records.

11.1 Cost of Farm Inputs Record

- This record sheet captures all purchases of farm inputs.
- The farmer needs to provide the following information for each purchase: **1. Date of Purchase**; **2. Types of Input**; **3. Quantity (kg/gm/ml)**; and **4. Cost (Ksh.)**.

11.2 Labour Cost

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Farm Activity	Cost (Ksh)
3 Oct	Land Preparation	250 Ksh
6 Oct	Nursery Establishment	1,100 Ksh.
23 Oct	Transplanting	600 Ksh.
27 Oct	Weeding	300 Ksh.
…	…	…
19 Oct	Harvesting	1,300 Ksh
20 Oct	Transportation	350 Ksh.
Grand Total		5,700 Ksh.

11.2 Labour Cost

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Farm Activity	Cost (Ksh)
3 Oct	Land Preparation	250 Ksh
6 Oct	Nursery Establishment	1,100 Ksh.
23 Oct	Transplanting	600 Ksh.
27 Oct	Weeding	300 Ksh.
…	…	…
19 Oct	Harvesting	1,300 Ksh
20 Oct	Transportation	350 Ksh.
Grand Total		5,700 Ksh.

11. Types of Records Supportive to CP&IAD Sheet

11.2 Cost of Labour Record

- This record sheet captures all costs of farm activities.
- The farmer needs to provide the following information for each activity: **1. Date**; **2. Farm Activity**; and **3. Cost (Ksh.)**.

11.3 Production & Sales Record

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Total Production (kg) (Yield)	Net Production (kg) (sold & consumed)	Price per kg (Ksh/kg)	Total Income (Ksh)
1 Dec	80kg	75kg	35Ksh	2,625Ksh
5 Dec	323kg	309kg	35Ksh	10,815Ksh
8 Dec	168kg	160kg	37Ksh	5,920Ksh
10 Dec	13kg	12kg	38Ksh	456Ksh
…	…	…	…	…
27 Dec	28kg	25kg	45Ksh	456Ksh
Grand Total	868kg	772kg		32,424Ksh

11.3 Production & Sales Record

Crop: Tomato

Name: John L. Mwanza **Year:** 2015

Date	Total Production (kg) (Yield)	Net Production (kg) (sold & consumed)	Price per kg (Ksh/kg)	Total Income (Ksh)
1 Dec	80kg	75kg	35Ksh	2,625Ksh
5 Dec	323kg	309kg	35Ksh	10,815Ksh
8 Dec	168kg	160kg	37Ksh	5,920Ksh
10 Dec	13kg	12kg	38Ksh	456Ksh
…	…	…	…	…
27 Dec	28kg	25kg	45Ksh	456Ksh
Grand Total	868kg	772kg		32,424Ksh

11. Types of Records Supportive to CP&IAD Sheet

11.3 Production & Sales Record

- This record sheet captures date and quantity harvested, quantity sold and consumed, and amount earned.
- The farmer needs to provide the following information for each harvesting: **1. Date; 2. Quantity Harvested/ Total Production (kg)**; **3. Quantity Sold and consumed/ Net production (kg); 4. Price per kg (Ksh.); and Total Income (Ksh)** (calculated by multiplying Net production with Price per kg).

Disclaimer

These SHEP PLUS Note and KAMISHIBAI were prepared under the Smallholder Horticulture Empowerment and Promotion Project for Local and Up-Scaling (SHEP PLUS) on behalf of Ministry of Agriculture, Livestock and Fisheries (MOALF), and Agriculture and Food Authority (Horticultural Crops Directorate (HCD)) of the Republic of Kenya and Japan International Cooperation Agency (JICA).

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.

For production of the exporting crops, please seek for the advice and follow instructions given by appropriate authorities such as HCD.

Other useful resources

- Ministry of Agriculture, Livestock and Fisheries, Kenya
http://www.kilimo.go.ke/ (external link)

- Infonet Biovision
Crops Fruits and Vegetables
https://www.infonet-biovision.org/crops-fruits-veg (external link)
- Plantwise Knowledge Bank
https://www.plantwise.org/knowledgebank (external link)

- Pests Control Products Board of Kenya (PCPB)
Products for use in Crop Production
http://www.pcpb.go.ke/crops/ (external link)