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:

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 and 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

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)

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

Contributors: Grays Kiplagat, Thomas Mumu, Sarah Ndegwa, Antonina Luta, Peter Orangi, Florence Wambua, Raymond Chelule, Murage Henry, Omari Victor, Jacob Keror, Musah Samuel, Carolyne Mwenze

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).

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)

1. Introduction:
1.1 Background

Capsicum (Pili Pili Hoho, Pili Pili Mboga)

1. Introduction:
1.1 Background

- 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**

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**

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

2. G20 technologies

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

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

2. G20 technologies

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

2. G20 technologies

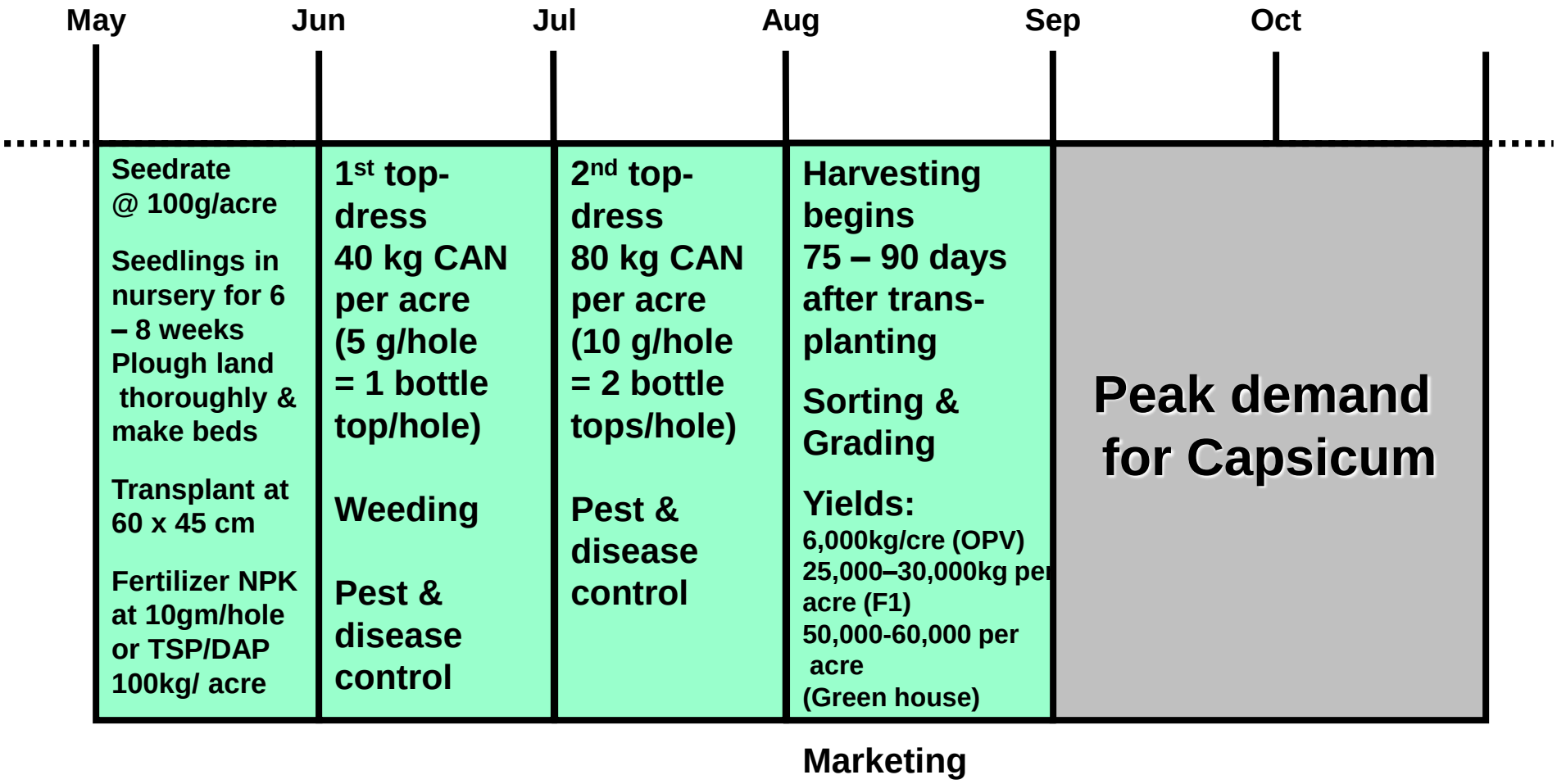
2. G20 technologies

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

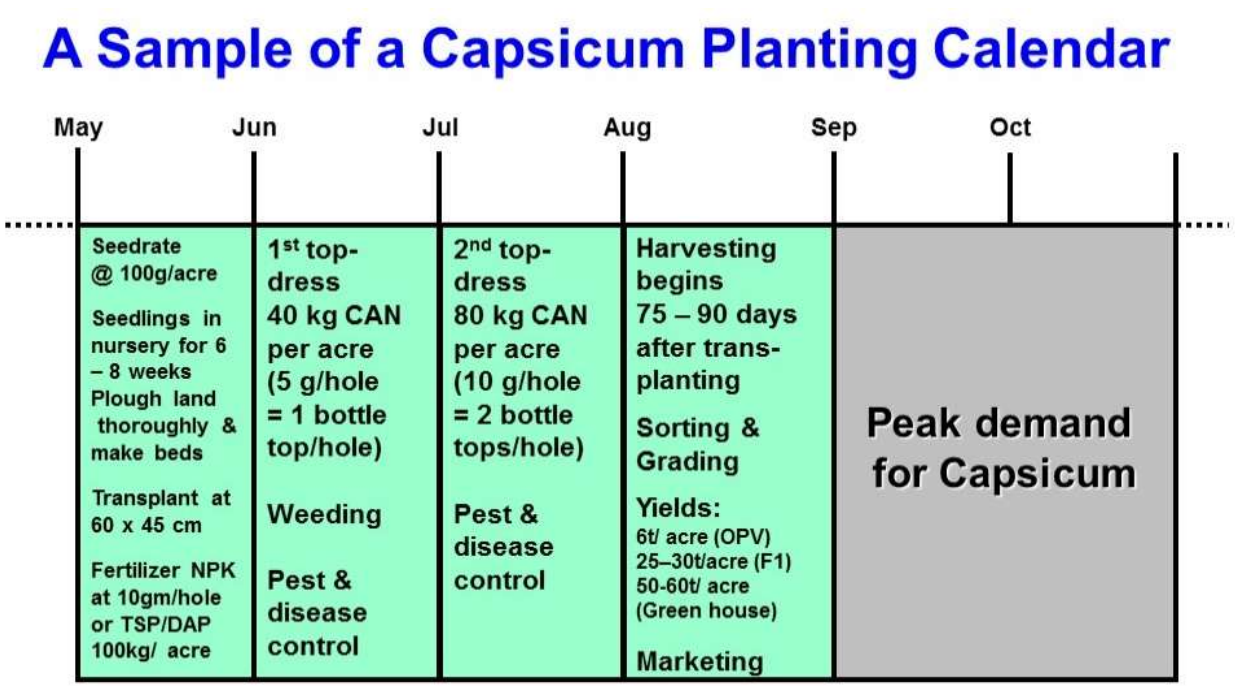
[G20 Technologies]
Make sure to support farmers carry out G20 techniques for any crop

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

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
- 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

3.1 Basal Application

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

3.2 Raising Seedlings

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

3.4 Top-dressing

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

3.5 Crop Management
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

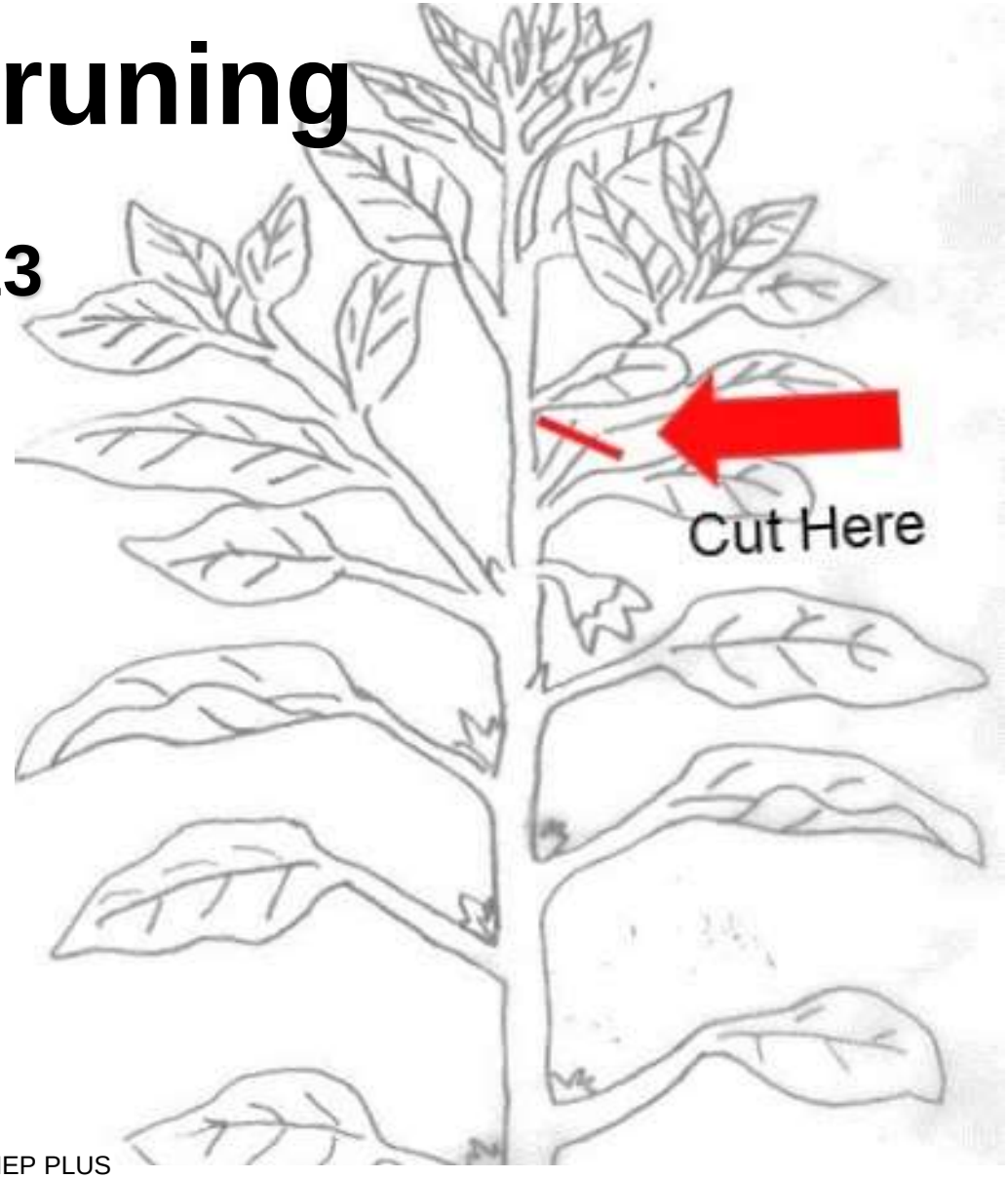
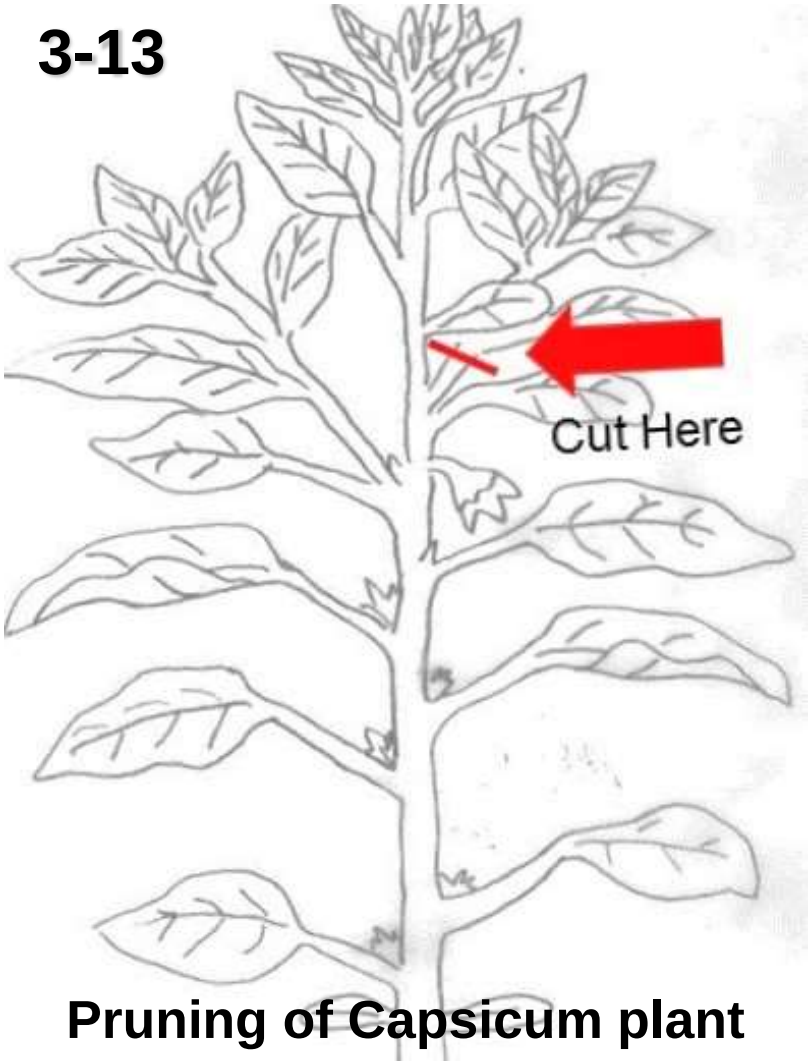


Diagram: SHEP PLUS

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)

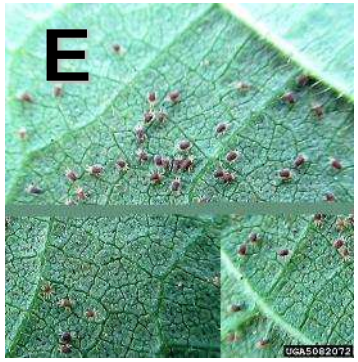


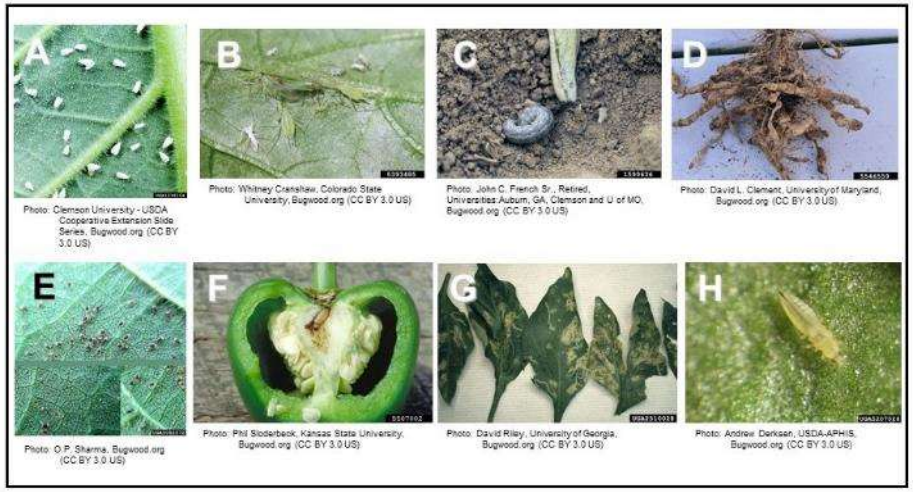
Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

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

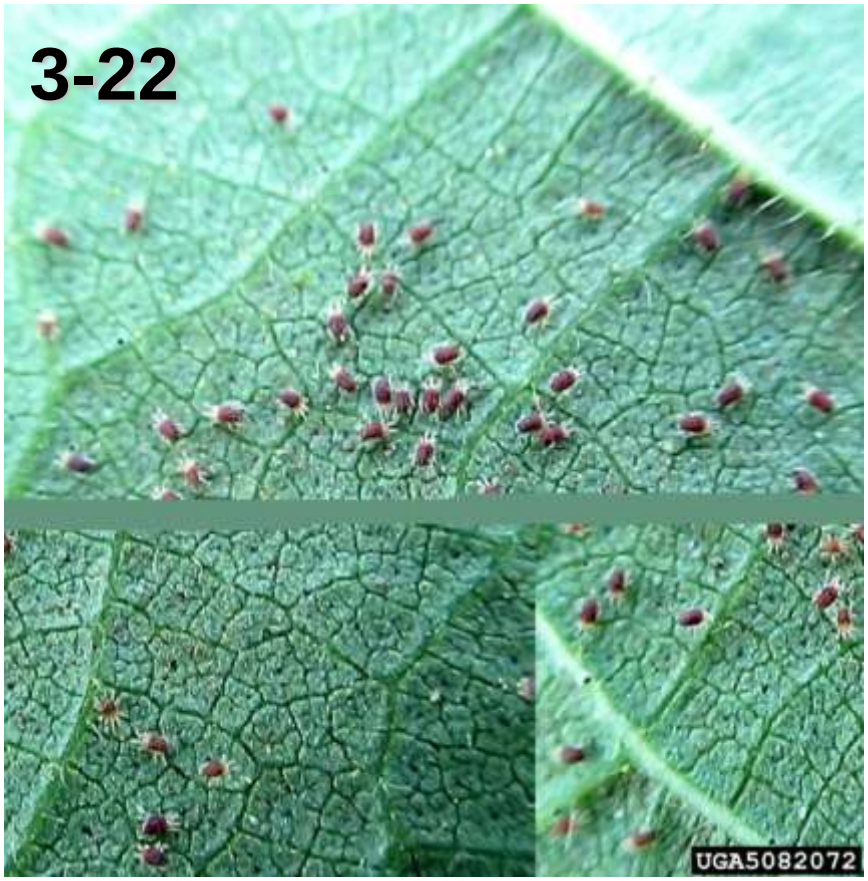


Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

Spider mites on a leaf

3.6.1.E: Spider Mite

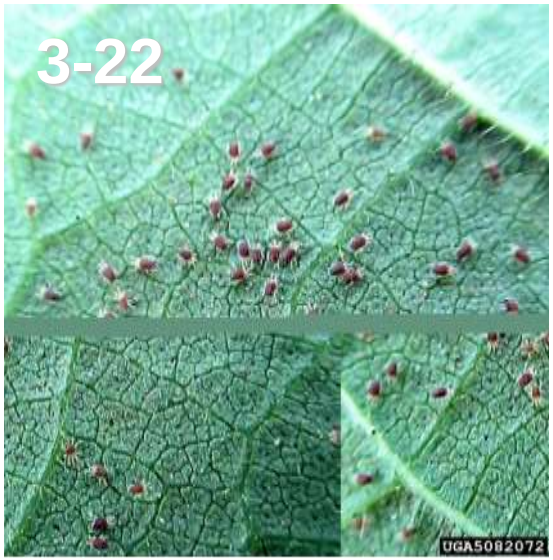


Photo: O.P. Sharma, Bugwood.org (CC BY 3.0 US)

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

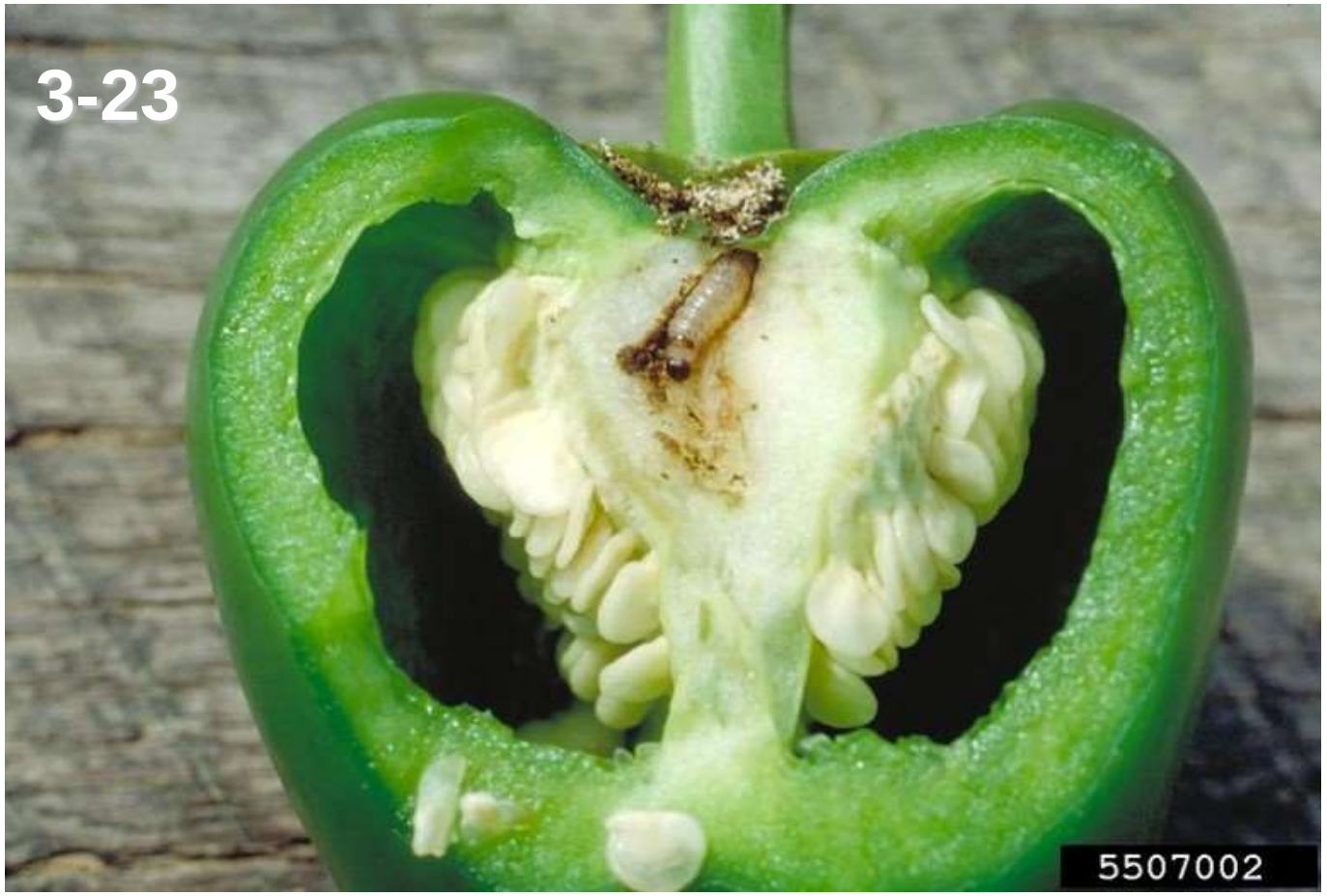


Photo: Phil Sloderbeck, Kansas State University, Bugwood.org (CC BY 3.0 US)

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

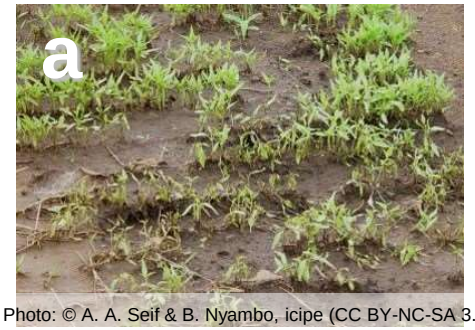


Photo: © A. A. Seif & B. Nyambo, icipe (CC BY-NC-SA 3.0)
http://www.infonet-biovision.org/PlantHealth/Pests/Damping-diseases

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

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

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

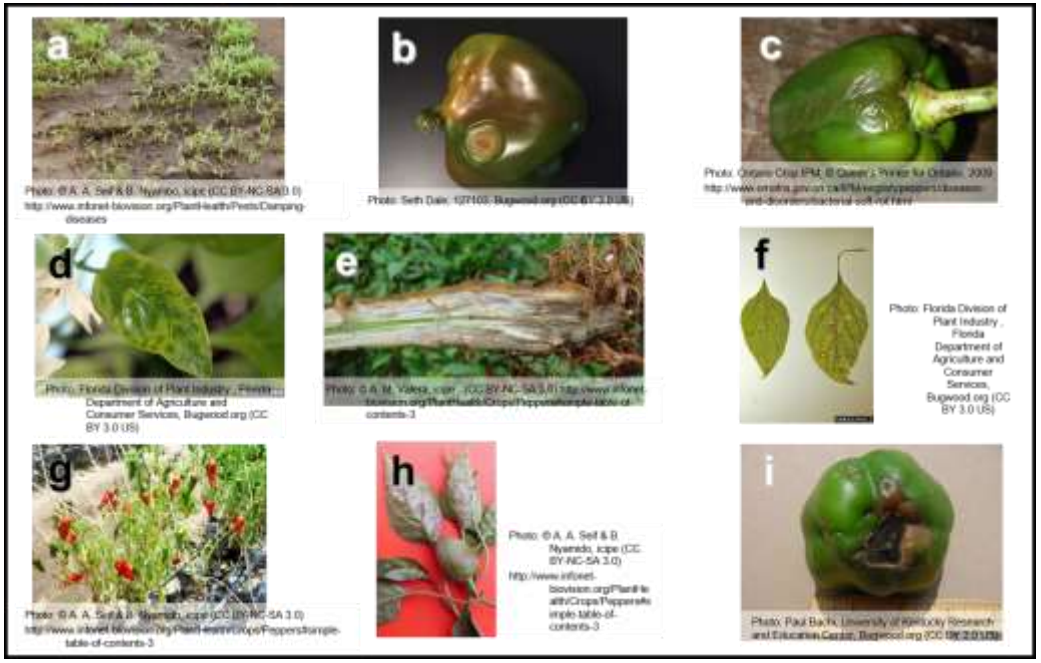
Photo: Florida Division of Plant Industry , Florida Department of Agriculture and Consumer Services, Bugwood.org (CC BY 3.0 US)

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

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

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**