# Smallholder Horticultural Production and Business

## Trainer's Manual

SNV

agritex
Department of Agricultural Technical and Extension Services

Food and Agriculture Organization of the United Nations

ZIMBABWE

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# Acronyms & Abbreviations

| | |
|---|---|
| **AGRITEX** | Agriculture Technical and Extension Services |
| **ABE Chillies** | African Birds Eyes Chillies |
| **AMA** | Agriculture Marketing Authority |
| **HRI** | Horticulture Research Institute |
| **FAO** | Food Agriculture Organization |
| **MoHCC** | Ministry of Health and Child Care |
| **SNV** | Netherlands Development Organization |

# Foreword

The land reform programme (1980-2010) saw significant changes in the Zimbabwe agricultural landscape with effects hitting hard on the horticulture subsector, which was dominated by large commercial farmers (LSCF) land ownership dropping from 34% to 5%. This scenario created a vacuum which demands smallholder farmers to stand up and fill if we want to reclaim our space in the horticulture global sector where during our peak we exported horticultural commodities worth USD142.7 million in 1999 and through the process accounting for 4.5% of the Gross Domestic Product.

Zimbabwe is an agro-based country where 80% of the population, with 70% residing in rural areas, depend on agriculture for a livelihood. With horticultural commodities contributing 7% to agricultural Gross Domestic Product (GDP) and smallholder farmers now being one of the major producers, there is need to address an array of challenges they face as they fill this commercial space. In order for smallholder farmers to effectively supply the formal and informal markets, they need to improve their competitiveness by increasing their production and productivity. Hence to do so we need to continuously build their technical and business skills whilst at the same time upgrading their production practices and technologies.

This Smallholder Horticultural Agronomic and Business manual therefore provides farmers, extension specialists and horticultural advisors with horticultural agronomic and business information which will guide them in decision making and optimising their production.

**Naa-Aku Acquaye-Baddoo**
**SNV Zimbabwe Country Director**

Smallholder horticultural farmers in Zimbabwe currently face myriad challenges ranging from limited access to specialised technical support, business skills, lack of quality and affordable inputs; lack of access to reliable water for cropping and inadequate production and post-harvest technologies and challenges accessing affordable finance.

With government private and developmental agencies joining efforts to commercialize smallholder farmers and integrate them in the formal and informal horticultural market systems, there is need to address their technical and business needs. Furthermore, both formal (including export) and informal markets are now relying on smallholder farmers who are still currently yielding way below the optimum level, government agricultural workers and both private and public horticultural advisors must support smallholder farmers increase productivity and strengthen their business skills in order to feed local, regional and international markets.

In several instances, horticultural agronomic and business manuals are developed and presented separately leaving farmers, extension specialists and horticultural advisors with one side of the puzzle. This Smallholder Horticultural Agronomy and Business manual attempts to bridge this gap as it presents a hybridized manual tackling production, marketing and business issues in key horticultural crops.

Throughout this manual and for the 19 selected horticultural crops, the manual will focus on markets and marketing; enterprise analysis and budgeting; crop agronomy and harvesting, post-harvest handling and value addition. Gross margin budgets included in some specific crops are just shared to serve as guides, extension specialist and horticultural advisors should develop area specific budgets. For each crop, we have included one major pest and one major disease text box which should also help farmers, extension specialists and horticultural advisors in effective pest and disease management.

It is our hope that this manual will complement the already existing horticultural agronomic and business information. By improving the knowledge base, it is our hope also that smallholder farmers will improve productivity and profit margins hence improving their household food and income security whilst at the same time contributing overall horticultural growth locally and internationally.

**Cloffas Nyagumbo**
**SNV Zimbabwe Horticulture Team Leader**

# Overview

## RARP CSF and Horticulture Component

SNV was engaged by the Danish International Development Organisation (DANIDA) to implement the Rural Agriculture Revitalisation Project - Commercialisation of Smallholder Farmers (RARP CSF), an initiative which seek to facilitate commercialisation of smallholder agriculture with a view to promote improved household incomes, employment and food security. The project aim was to reach 280,000 smallholder farming households throughout all eight rural provinces in Zimbabwe.

The development objective of the project was to commercialise smallholder farming in the country by re-instating sustainable commercial input and output marketing channels as well as technical and business development services provision. The RARP CSF was implemented following an integrated value chain development approach that addresses all constraints hindering growth in specific sub sectors.

The project components which include improving small scale farmers' access to the right and high yielding inputs, development of win-win sustainable contract farming arrangements and provision of effective business development services have been designed to facilitate the revitalisation of the horticulture, oil seeds and dairy sub sectors.

**The project's immediate objectives are:**

*1. To facilitate access to credit for intermediaries in the agricultural and food value chains.*

*2. To promote private sector competitiveness through "Matching Grants" that will promote technology upgrades and market development.*

*3. To promote food security through improved access to inputs and output marketing channels and processing services.*

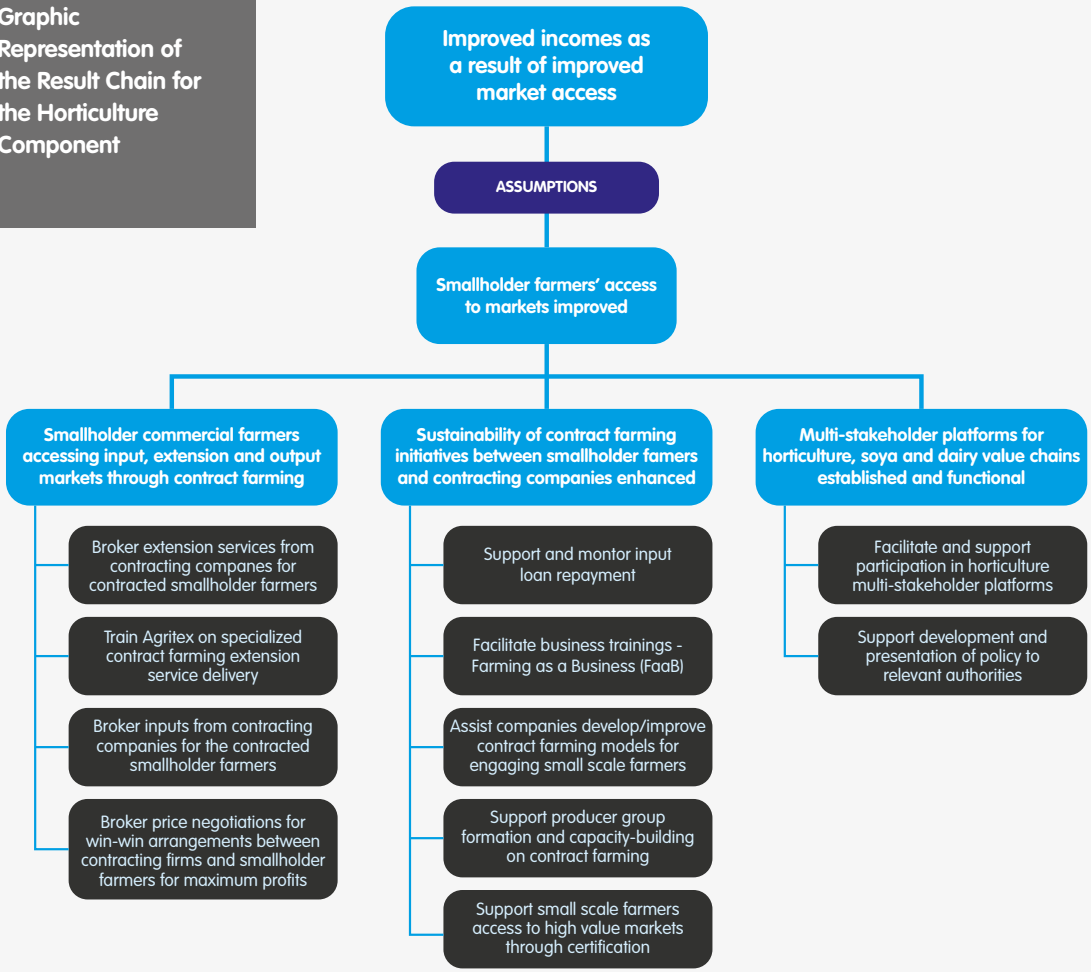
**Within the RARP CSF project was the horticulture component which is briefly explained below.**

| **Programme** | **Rural Agriculture Revitalization Project: Commercialising Smallholder Farming (RARP CSF)** |
|---|---|
| **Component** | Value Chain Development- Horticulture |
| **Crops** | Fruits, Vegetables, Herbs, Spices and Tea |
| **Objectives** | Development of sustainable contract farming arrangements and market linkages for smallholder farmers in Horticulture |
| **Beneficiaries** | 6,000 smallholder farmers |
| **Proposed Implementing Partner(s)** | Private companies, line ministries (Ministry of Agriculture, Mechanisation and Irrigation Development and Ministry of Small and Medium Enterprises and cooperative Development) and Farmer unions |
| **Period** | Jan 2014 – Dec 2015 |

*4. To facilitate smallholder farmers participation in formal markets through development of the dairy, oil seeds and horticulture value chains.*

*5. To consolidate and enhance programme development through studies, pilots and innovation.*

**Graphic Representation of the Result Chain for the Horticulture Component**



Module 1

# Understanding the Horticultural Business

**Unit 1:** Markets & Marketing
**Unit 2:** Enterprise Analysis & Budgeting
**Unit 3:** Production/Agronomy
**Unit 4:** Post-Harvest Handling & Value Addition
**Unit 5:** Area & Yield Estimation

# Unit 1: Markets and Marketing

## 1.0 Introduction

In order to actively participate in any marketing system, one has to take a bird's eye view of the whole marketing ecosystem with market chain actors; their functions (role and responsibilities); key performance factors; relationships; how each market system interconnects with other systems, opportunities and constraints.

### Unit Objectives

- Understand the horticultural market systems – actors and regulators in the horticultural value chain.
- Understand market problems of horticulture produce and possible opportunities.
- Ways that can enhance horticulture produce marketing by using marketing information, market research and survey.
- To comprehend various standards in horticulture produce marketing.
- To understand various marketing channels of horticulture produce.

## 1.1 Market Chain Actors

In horticultural market systems, the key market actors including the input providers, producers, aggregators/traders, wholesalers, retailers, consumers and service providers interact, either directly or indirectly, with horticultural products at various nodes of the chain. The value chain lens diagram below illustrates the position of players:

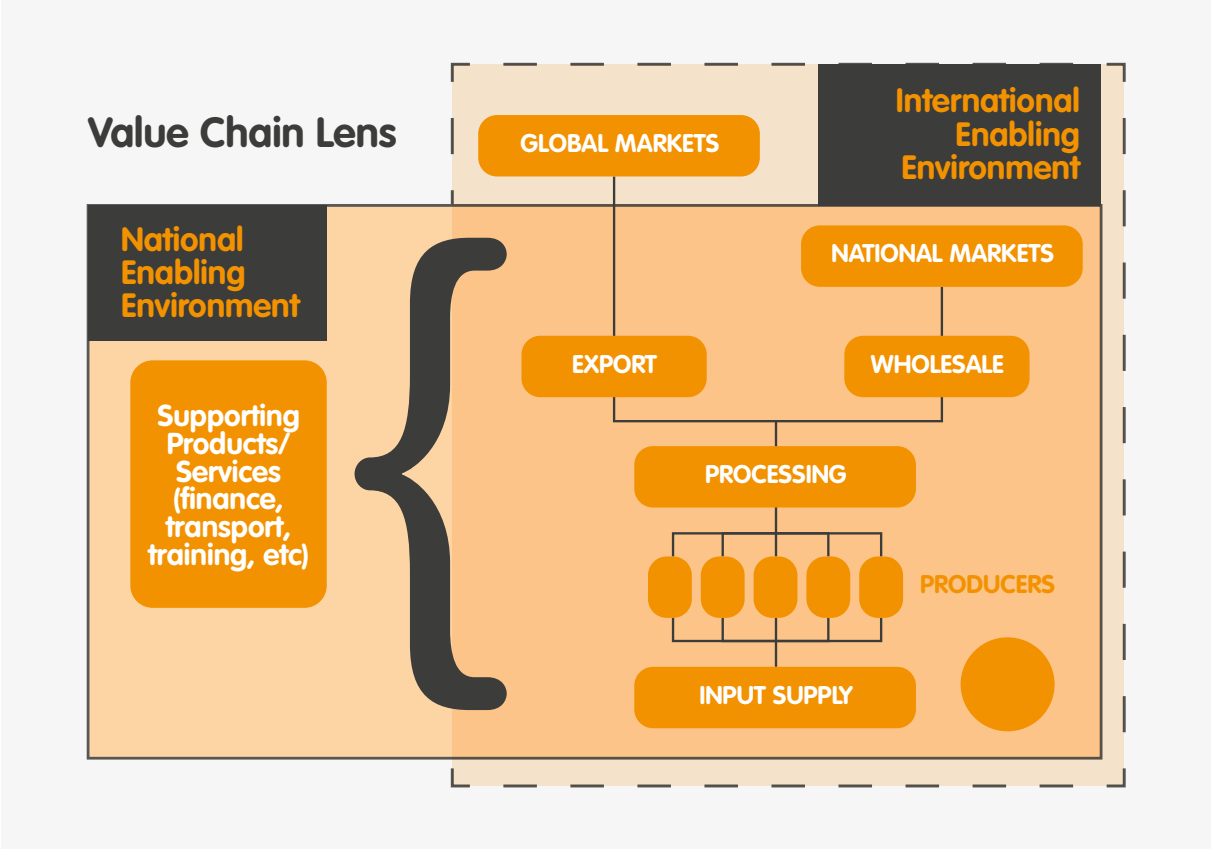



***Figure 1:*** *Value Chain Lens*

## 1.1.1 Market Players' Functions

### Input Providers

Input providers are the "drivers" of horticultural production in Zimbabwe. They buy from input suppliers and distribute seed, agro chemicals and fertilizer amongst farmers (mostly on credit). Examples of input suppliers include seed houses such as Seed Co, Pannar and East West whilst fertilizer companies such as Windmill, ZFC and Omnia Fertilizer.

### Producers

Zimbabwean producers are in most case outcompeted by imports of fruits (grapes, apples, nectarines and plum) and some vegetables (onions and potatoes) predominantly smuggled from South Africa. Amongst local producers, due to uncoordinated production horticultural market systems face unpredictable price fluctuations which impact the profitability at smallholder level. Smallholder competitiveness is further widened by weak vertical linkages with other chain actors such as input providers and service providers. Most urban based horticultural input suppliers reach rural farmers mainly through rural agro - dealers who seldom stock improved horticultural varieties, fertilizer and chemicals.

### Aggregators/Traders

Aggregators are found at informal trading places such as Mbare Musika and play an important role in absorbing excess horticulture produce and feed them to other markets where there is a demand.

### Processors

In Zimbabwe, processors range from informal business entities that sell local vegetable such as "mufushwa" in markets places such as Mbare to huge formal investments that include multi – million dollar food processing companies such as Cairns Foods.

### Wholesalers

Horticultural produce bulking is the main role played by wholesalers. The informal and wholesale outlets play an important role in bulk purchase of horticulture commodities from farmers. Manica Produce, Willgroove, FAVCO and Matanuska are part of the wholesale markets chain.

### Retailers

Retail outlets such as big supermarkets and even informal trading business constitute part of this category. Mbare, is considered to be a retail market in selling vegetable and horticulture produce bought from farmers at wholesale prices. Retailers are also found in urban centres where vegetables and fruits are sold at road side markets in residential places targeting people who stay in those towns.

## Consumers

For the entire marketing system to perform there has to be a demand for the product and the horticultural actors need to understand the market demand which is generated by customers/consumers. It is important to note that customers require the best quality at the lowest price so every producer should ask:

**How can I grow the best quality product at the lowest price possible?**

Consumers can be categorized into two broad categories:

- The high income group of customers who buy from the formal markets (supermarkets and fruit & vegetable shops).

- The low income group of customers are those who buy from informal/open markets such as Mbare Musika, Sakubva and vendors.

Generally, high income consumers highly value the product quality and presentation while the low income consumers mainly consider price, quantity and size. Understanding the target customers prior to growing will help farmers source the right variety, produce, deliver and present the right product. In trying to fulfill the customers' needs, a product should be presented with unique characteristics that give it a competitive edge in terms of taste, size, colour, firmness, packaging and shelf-life. This can get the product a better price and move the highest volumes.

## 1.2 Important Regulators in Horticultural Produce Marketing

Authorities such as Agriculture Marketing Authority (AMA) have an important role to play in importing and exporting of horticulture produce whilst on other hand municipality bodies and town authorities are also mandatory regulating bodies who work with traders, buyers and wholesalers of horticulture produce in Zimbabwe. Therefore it becomes mandatory, for the market players to observe and subscribe to the expected protocols of the regulators.

Also to note, the government of Zimbabwe through Ministry of Health and Child Care (MoHCC) is also one of the key regulators in food production and marketing to safeguard consumers against consuming toxic food products from poor agronomic and post-harvest handling techniques.

## 1.3 The Major Problem in Horticulture Marketing

Authorities such as Agriculture Marketing Authority (AMA) have an important role to play in importing and exporting of horticulture produce whilst on other hand municipality bodies and town authorities are also mandatory regulating bodies who work with traders, buyers and wholesalers of horticulture produce in Zimbabwe. Therefore it becomes mandatory, for the market players to observe and subscribe to the expected protocols of the regulators.

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## 1.4 Important Aspects to Consider in Horticulture Produce Marketing

**Seasonality –** most crops are difficult to produce throughout the year. E.g. potatoes, tomatoes

**Perishability –** horticulture fresh produce is highly perishable and requires meticulous post-harvest handling. It is important to keep in consideration the following:

- Ever present market- especially for key lines such as tomato, potato, onion, leafy vegetables
- Plenty of competing substitute's e.g. cabbage for rape or covo
- Usually intensive production techniques employed
- High price volatility
- Homogeneous produce

## 1.5 Important Regulators in Horticultural Produce Marketing

- Competitor prices
- Cost of production
- Post-harvest losses
- Payments terms (cash or credit)
- Quality
- Target market
- Demand and supply
- Location
- Quantities bought

## 1.6 How Best Can Smallholder Farmers Market Their Horticulture Produce?

### 1.6.1 Effective Utilization of Marketing Information Systems

Small-scale growers should be aware of the following information before deciding on the produce and market of fresh fruits and vegetables.

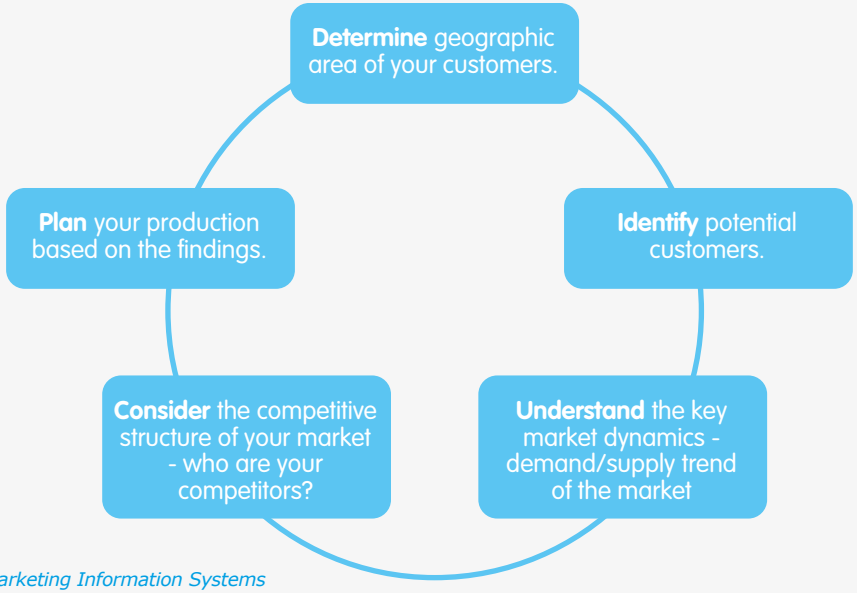



***Figure 2:*** *Key Marketing Information Systems*

## 1.6.2 Conducting Market Research or Market Study

Here are some important questions that every grower-marketer must find out about the market and the specific requirements of the targeted consumer: who the likely consumers of your produce are, where they live and what their specific needs and wants are.

- **Quality (Firmness, Visual Appearance, Taste)**
- **Size**
- **Variety**
- **Organic or inorganic**
- **Maximum Level Residue (MRLs) - acceptable level of chemicals**

- *How many people live within your marketing area?*
- *Are consumers currently buying a particular fruit or vegetable?*
- *How much of the product(s) do your potential customers currently use? Is this use seasonal?*
- *What prices are consumers paying for high-quality products?*
- *Are consumers adequately served at present?*

If consumers in the area are being adequately served, here are some additional questions:

- *Can you do the job better and draw part of the market away from competitors?*
- *Can the quantity that consumers purchase be increased by providing better quality than what is currently available?*
- *Will your anticipated production come at a time when little else is offered for sale?*
- *What level of quality must you produce to meet the need unfulfilled demands of consumers?*
- *How must you prepare and package the produce? What size containers is most popular? What marketing costs will be incurred?*

## 1.7 Sources of Market Information

Traditional sources of market information as well as use ICT are readily available for information generation and usage.

| Source | Examples | Merits | Demerits |
|---|---|---|---|
| **Buyers** | Traders, Retailers (supermarkets) and Wholesalers (Selby, FAVCO, Manica Produce) | First hand information / comparability | Vested interests may hinder accuracy |
| **Farmers Union Bulletins** | ZFU, ZCFU, CFU | Information collected with farmers in mind | Not always available in time and low dissemination |
| **Government Agencies** | Agritex | Technical information available, accessible at ground level | Limited capacity to generate latest and market-specific information |
| **Development Partners** | NGOs, CBOs and UN agencies (FAO, WFP, UNDP) | Capacity to generate current information | Consistent supply of information limited by project duration and funding |
| **Print Media** | Newspapers, magazines, flyers, posters, billboards | Can give detailed and credible information widely | Most times too general and only accessible to literate farmers |
| **Electronic Media** | TVs and radio | Wide coverage | Limited research and chance to clarify |
| **ICT** | Internet, text messages (e.g. EcoFarmers) | Ability to research specific issues and verify on different sources | Internet access limited and text messages limited by character / message |
| **Exhibitions** | Shows, Fairs, Field days | Can exhibit practical and current information | Low coverage and not done on a regular basis |

***Table 1:*** *Sources of Market Information*

## 1.8 Marketing Channels in Horticulture Value Chain

There are various ways in which smallholder horticultural producers in Zimbabwe are currently marketing their crops. The majority of the farmers prefer to sell directly to the consumers in order to maximize profits. However it is practically almost impossible for the farmer to market his/her product using this direct channel because of issues like:

- Distance to market (a farmer from Mutoko may find it prudent to sell to merchants who come and collect the product at the farm).
- Quantity of produce to be marketed
- Lack of adequate information

### 1.8.1 Two Major Channels Used in Horticulture

Two major channels are used in horticulture produce marketing and these are:

**a. Direct Channel** - No middleman.
**b. Indirect Channel** - Made up of various middleman performing different tasks. Through this channel farmers usually make a very small margin.

| Category | Names | |
|---|---|---|
| **Formal** | **Supermarkets** | TM, OK, Spar, Bon Marche, Fruit & Veg City, True Fresh, ValleyFresh, HoneyDew, Pick 'n' Pay, Food World |
| | **Wholesalers** | Selby, FAVCO, Matanuska, Sunspan, Willsgrove and Glen Forest Produce in Harare; Manica Produce Sales and Matanuska in Mutare; D.G. Patel, M.S. Patel, Madhubeko and Sons, Bulawayo Independent Market and Mandalay in Bulawayo |
| | **Processors** | Cairns, Honeywood, Mazowe, Olivine, National Foods, Interfoods |
| | **Exporters** | Selby, Barefoot, Vege Flora, Rollex |
| **Informal** | **Informal Market Centres** | Mbare and Lusaka (Highfield, Harare); eMalaleni and Bulawayo Upmarket Traders Association (Bulawayo); Sakubva and Chipangano (Mutare); Kudzanayi and Kombayi (Gweru); Garikayi and Mucheke (Masvingo); Kwekwe, Chinhoyi and Bindura |

**Table 2:** *Example of market channels in horticulture.*

## 1.9 Horticulture Fresh Produce Standards

Standards in horticulture are generally depend on the customers' needs. Different standards apply at different stage of the value chain. Thus within the standards there are two categories:

**Voluntary Standards -** Standards which are required by the market to comply e.g global GAP, Fairtrade, UTZ, Rainforest Alliance and International Fedaration of Organic (IFOAM)

**Mandatory Standards -** Farmers are obliged to comply to these standards e.g. phyto-sanitary requirements in Zimbabwe or any export destination where you have found a market

| Local Market Informal | Local Market Formal | Export Market | Specific Export Outlet e.g. Supermarket |
|---|---|---|---|
| **Intact** | **Intact** | SPS requirements for a given of destination | In-house requirements such as size, shape, colour, packaging and labelling |
| **Sound (for example, not rotten, severely bruised or severely damaged)** | **Sound (for example, not rotten, severely bruised or severely damaged)** | Maximum residue limit levels (MRLs) of chemicals | MRLs which can more stringent than those for the nation |
| **Clean** | **Clean** | Market voluntary standards e.g. GlobalGAP for primary production and HAACP for the packhouse | In-house standards fo the market outlet e.g. Tesco |
| **Practically free from pests** | **Practically free from pests** | Intact and clean | Intact and clean |
| **Practically free from damage caused by pests affecting the fresh produce** | **Practically free from damage caused by pests affecting the fresh produce** | (Not rotten, nor severely bruised or severely damaged) | (Not rotten, nor severely bruised or severely damaged) |
| **Free of abnormal external moisture** | **Free of abnormal external moisture** | Practically free from pests and foreign smell or test | Practically free from pests and foreign smell or test |
| **Free of foreign smell or taste** | **Free of foreign smell or taste** | Practically free from damage caused by pests affecting the flesh | Practically free from damage caused by pests |
| **Sufficiently developed / ripe, but not overdeveloped / overripe** | **Sufficiently developed / ripe, but not overdeveloped / overripe** | Sufficiently developed / ripe, but not overdeveloped / overripe | Sufficiently developed / ripe, but not overdeveloped / overripe |

***Table 3:*** *Different standards required by different markets*

## 1.9.1 The Specific Marketing Standard (SMS)

These mainly target local, regional or international formal markets. have various specifications for individual produce to European markets. For example for fine beans the length should be a minimum 8cm and maximum 10cm with a diameter of between 4mm and 6mm. The colour should be mid to dark green with a pest and disease tolerance of 0-5% rust and 0-5% anthracnose. For mangoes, the packing should be in the range of eight to 16 pieces with a maximum of 4kg per box. They should also be free from latex contamination, no physical insect pest and disease infestation, free from bruises and other mechanical damages. The fruits should be shiny and freshly looking with 5mm of stalk attached to control pathogen infestation through that point. The fruits are given sizes according to the number of the fruits per carton for example 8, 9 10, etc. Avocado should be packed in sizes of 10 to 18 pieces with a maximum of 4kg per box. Fruits should be uniform in size, at most 5mm stalk attached to the fruit, wax polish to prevent desiccation and dehydration.

### Contract Farming As A Solution To Penetrating Formal Markets

Contract farming is is an agreement between the farmer and a company or institution usually with the intent of purchasing all or part of the produce. At the moment the major contracts are between companies which export high value export vegetable (HVEV) and smallholder farmers.

**The two main types of contracts are:**

- Between companies and farmers where the firm provides input and technical support in return for being the buyer.
- Where three parties are involved and each play a distinct role, this usually involves MFIs, buyer and farmer.

### Benefits of a Contracted Farmer

- Access to inputs
- Opportunity to introduce high value crops e.g. mange peas, gem squash, fine beans
- Gateway to formal markets even after the contract ends. The experience and knowledge gained by the farmer with regards to specific formal market requirements regarding Size, MRLs, Packaging, Grading, etc are invaluable
- Transport (The challenge of swift transportation of fresh produce can result in post-harvest losses of up to 40% for farmers in areas Mutoko, Beatrice, Mhondoro, Rusitu Valley, Honde Valley etc who are far away from major markets)

## Contract Farming As A Solution To Penetrating Formal Markets

### Benefits of a Contracted Farmer (continued)

- Marketing facilities
- Generally income increases (not always the case though)
- Risk transfer, losses due to perishing and reduction is eliminated
- Technical support
- For the new farmers who receive demonstration on how to use the land is also important, as the threat of a land audit is always there. Hence it is better to seek partnerships with agro-industry players who often lack adequate land.
- Higher opportunities for skilled family members to be absorbed into jobs along the value chain as a result of the vertical linkages.

### Benefits to Contractor or Firm

- Securing produce.
- Quality control of produce
- Significant step towards securing the market for their product lines

### What Should the Farmer Consider Before Signing the Contract

- Identify the gaps with respect to production of a particular crop.
- Find out more about the various services which the firms offer. Check the track record of your business partner. For example if any horticultural farmers been deceived in the past, how effective are they in terms of early delivery of inputs, their flexibility etc.
- Understand the contractual obligations e.g selling to them only, delivery, quality, produce organically.
- Understand the agro-business firms or institution's contractual obligations.
- Farmers should always make it a habit to consult other farmers with relevant experience as well as local extension agents.

### What Does A Good Contract Agreement Look Like

Generally the contract should be written in clear, concise and unambiguous language. It should be easy to translate into languages that each party is conversant with. Thus horticulture farmers should be very pro-active and

## What Does A Good Contract Agreement Look Like (continued)

extensively participate at the crucial stage of drafting the agreement. **The farmer should be guided by the following key points which must be incorporated:**

**Commodity**
Quantity/Quality/Form/Variety

**Contract Duration**
How long will the agreement run? Is there a possibility of renewal/extension?

**Production Area and Projected Yields**
How many hectares? What levels of yields are projected (minimum and maximum)?

**Good Agriculture Practices (GAPs) to be Followed by the Farmer**
Is the company going to provide technical and business training? Is the company going to closely monitor farmers during the season?

**Loan Repayment Method**
Does the repayment schedule specify price, quantity and amount to be repaid? Is repayment based on cost price; principal + simple interest or repayment in product?

**Grading Requirements and Quality Standards**
Do the grades have clear reference points (e.g. color, size, shape, moisture content etc.)? Can farmers have a chance to see samples of the required grades? What amounts of contaminants are allowed (sand, dirt, stones, debris)?

**Product Delivery Logistics Including Transportation**
Will the company collect or the farmer will deliver the product? Who bear the cost? Actual points of delivery.

**Method and Time of Payment**
How long after delivery of products is payment made? Is payment by cash or through bank transfers to individuals or groups?

**Pricing Formula**
Is the price based on production costs + profit margin or on prevailing market prices or on import parity prices?

**Contract Signatory, Group or Individuals**
Does the contract agreement happen between the farmer as an individual or as part of a group? Who signs? Can a representative sign? Witnesses (how many).

**How will Areas of Disputes Be Addressed**
Arbitration or courts? What happens when one party wants out?

# Unit 2: Enterprise Analysis and Budgeting

## 2.0 How Can a Farmer Assess the Viability of a Horticulture Enterprise?

### Gross Margin Analysis

- Gross margin budgets are usually expressed on a per hectare basis to allow for comparisons of different crops. Gross income consists of not only the produce sold, but also the produce consumed, given away e.g. as gifts, bartered, and retained produce still in storage, and even by-products (e.g. green manuring), if they have value.

- The Gross Income from harvest is estimated from multiplying saleable harvest by area of crop planted and the unit price that the farmers are likely to obtain, (taking into the season, and the local market conditions).

- The unit prices for produce and inputs that are used in the budget estimates usually come from different sources including suppliers of agricultural inputs, prices observed in local produce markets, agencies that provide information such as AMA, ZFU, extension personnel, and private companies and contracting companies.

- Variable costs are production costs directly allocated to a particular horticultural enterprise and usually change according to seasons, and size and scale of production. Examples include seed, fertilizerilizers, agro-chemicals, casual or hired labour, packaging materials, land preparation and transport of inputs and produce.

Gross margin refers to the income generated from a horticulture enterprise and is equal to the difference between the total gross income and the total variable costs (i.e. all variable costs added together).

For horticultural crops, the marketable harvest takes into account losses that may occur since it is unlikely that the entire crop can be marketed. The losses can be due to poor harvesting methods, or they can occur during storage and problems in marketing such as lack of transport.. The exact rate of loss will depend on the type of crop and the distance to the market. Horticultural crop is usually perishable, and if grown in remote areas with unreliable transport facilities, then higher losses should be anticipated, unless storage and transport facilities are adequate.

For a farmer to measure profit for the whole farm, the farmer uses a whole farm budget where he/she adds together all the gross margins for the different enterprises, and subtracts the total fixed costs.

| **Example 1:** Gross Margin Budget for Gem Squash for a 0.1 ha plot | | | | |
|---|---|---|---|---|
| | **Unit** | **Quantity** | **Value** | **Blank** |
| **Area of crop planted by farmer (A)** | hectares | 0.1 | | |
| **Expected production/harvest (B)** | kgs | 800.0 | | |
| **Expected losses (C)** | kgs | 100.0 | | |
| **Marketable/Saleable harvest (D)** i.e. B minus C | kgs | 700.0 | | |
| **Average selling price (E)** | kgs | -- | 0.4 | |
| **Gross Income (F)** i.e. D multiplied by E | **$** | **--** | **280.0** | |
| **Variable Costs** | | | | |
| | **Units** | **Quantity Used** | **Cost Per Unit** | **Total Cost ($)** |
| **Seed** | kgs | 0.6 | 40.00 | 24.00 |
| **Fertilizers** | | | | 6.00 |
| 1. Basal dressing | kgs | 10.0 | 0.60 | 3.00 |
| 2. Top dressing | kgs | 5.00 | 0.60 | **9.00** |
| **Total Fertilizer Cost** | | | | |
| **Sprays for Pests & Diseases** | | | | |
| 1. Karate | kgs | 0.1 | 20.00 | 2.00 |
| 2. Sulphur | kgs | 0.8 | 6.00 | 4.80 |
| 3. Malathlon | kgs | 0.02 | 6.00 | 0.12 |
| **Total Spray Costs** | | | | **6.92** |

***Table 4:*** *Gross Margin budget for gem squash for a 0.1 ha plot*

| **Example 1:** Gross Margin Budget for Gem Squash for a 0.1 ha plot | | | | |
|---|---|---|---|---|
| **Variable Costs (continued)** | | | | |
| **Transport of fertilizer to farm** | per 50kg bag | 0.3 | 3.00 | 0.90 |
| **Hired Labour Costs** | | | | |
| Land preparation | ha | 0.1 | 40.00 | 4.00 |
| Weeding, spraying and harvesting | labour days | 10.0 | 3.00 | 30.00 |
| **Total Hired Labour Costs** | | | | **34.00** |
| **Total Production Input Costs (G)** | | | | **74.82** |
| | | | | |
| **Marketing Costs** | | | | |
| Transport of produce to market | per 50kg bag | 14.0 | 3.00 | 42.00 |
| Packaging materials | per 50kg bag | 14.0 | 0.50 | 7.00 |
| **Total Marketing Costs (H)** | | | | **49.00** |
| **Total Variable Costs (J)** i.e. Total Production (G) and Marketing Costs (H) | | | | **123.82** |
| **Gross Margin (K)** i.e. Gross Income (F) minus Total Variable Cosst (J) | | | | **156.18** |
| | | | | |
| **Other Measures of Viability for the Gem Squash Enterprise** | | | | |
| **Return per $ invested (L)** i.e. Gross Margin (K) divided by Total Variable Costs (J) | | | | **1.26** |
| **Break-even Price ($/kg) to cover variable costs** i.e. J divide by D | | | | **0.18** |
| **Break-even Price (kg/ha) to cover variable costs** i.e. J divide by E | | | | **310.00** |

***Table 4:*** *Gross Margin budget for gem squash for a 0.1 ha plot (continued)*

| Assumptions |
| --- |
| **01** **Total Cost** is equal to Quantity used multiplied by Cost per unit. |
| **02** **Total Production** costs include seed, fertilizer, agro-chemicals, transportation of fertilizer to the farm and hired labour. |
| **03** **The Budget** excludes family labour costs because it was not easily available during the production period of the crop. Hence, hired labour cost is included in this budget. |
| **04** **The Budget** assumes that the output (produce) is sold to local markets where transport costs are incurred, based on a calculated price of $3.00 per 50kg bag of produce. In cases where produce is sold at the farm gate, little or no transport costs are incurred by the farmer. |
| **05** **Packaging** materials are calculated based on the estimated marketable harvest of the gem squash. This is done by dividing the weight of the marketable harvest by the weight of the standard unit. In this case, the standard weight for the gem squash is a 50kg bag, and the marketed harvest is 7,000kg for 1 hectare. This therefore means that 14 bags (700 divided by 50) are required at an estimated cost of $0.50 per bag. |

***Table 5:*** *Assumptions on costs and budgets analysis*

## 2.1 How Can a Horticulture Farmer Interpret the Gross Margin Budget to Improve Business Viability?

### 1. Gross Income

- **Gross income can be increased by increasing the expected yield, the marketable yield, or the selling price.**
  - The expected yield can be increased by selection of appropriate and high yielding varieties of the crop, as well as proper selection and use of other inputs such as fertilizerilisers and chemicals.
  - Weeding, irrigating and pest and disease control, can result in increased yields which in turn can lead to increased income.
  - Increased yields can also be achieved by reducing field losses. For example, a crop such as tomato, which requires trellising, would suffer reduced losses if not properly trellised because of better coverage of crop protection chemicals, better ventilation, and reduced contact with the ground.
  - The marketable yield can be increased by correct harvesting and timing of harvest, correct post-harvest handling and transportation of produce, all contribute towards reducing post- harvest losses.
  - An increase in the pack-out percentage, for example, would increase the marketed yield. Pack out percentage refers to the proportion of the marketable produce after taking into account yield losses.
  - The selling price can be improved by synchronising production to coincide with periods when the market price is high, or, for products that you can store such as dried onions, to sell when the price is high. High prices are also usually obtainable when the quality of the produce is high, e.g. it may be better to grade product according to market requirements, and get premium prices for the high grades, rather than having a mixture of grades thereby getting an average price.

### 2. Total Variable Costs

- In assessing the viability of the particular horticultural enterprise, the farmer can increase the gross margin by carefully analysing total variable costs and eliminating those that are not necessary. For example, if the farmer is not applying the recommended quantity of inputs due to inadequate knowledge, he/she could seek extension advice to address that gap. By applying the correct quantity of inputs, and not over applying, the farmer could reduce the total variable costs.
- Careful planning and management of labour can also help in reducing total variable costs.

### 3. Gross Margin

- Gross margins can be improved either by increasing income, or by reducing costs, or both.

### 4. Return Per Dollar Invested

- In the above example, it was shown that the farmer invested $123.82 (i.e. the total variable costs) in the 0.1ha gem squash enterprise, and got a gross income of $156.18. Therefore, the return on the amount that he or she invested is $156.12 divided by $123.82, which is equal to $1.26. This is a positive return, which means the business is viable.

## 2.2 Break-even Analysis

Break-even analysis determines the level at which total revenue equals total cost. A farmer may also want to know the minimum price per kg that s/he should charge for tomatoes in order to cover production costs (break–even price) and the minimum yield/quantity she could expect per ha of tobacco in order to cover the costs (break–even yield/quantity).

### a. Break-even Yield

$$\text{Break-even yield to cover variable costs} = \frac{\text{Total variable costs (costs of production)}}{\text{Output price}}$$

**This is the yield necessary to just cover all costs at a given output price, e.g.**

**Total potato variable costs/ha** = **$9,000** (i.e. $0.30 per kg multiplied by expected yield of 30 000 kg per hectare)

**Price of potatoes per tonne** = **$600** (i.e. $0.60 per kilogramme)

**Break-even yield** = **$9,000/ha ÷ $600/tonne**
= **15 tonnes/ha**

This implies that at 15 tonnes per hectare the farmer will just cover his/her variable costs if the price remains at $600/tonne (i.e. $0.60 per kilogramme). His/her Gross margin will be zero at this point. The farmer has to aim for a yield of more than 15 tonnes per ha i.e. to operate above break-even point.

## b. Break-even Price

$$\text{Break-even price} = \frac{\text{Total variable costs}}{\text{Expected yield}}$$

**This is the price to cover variable costs at a given yield level. Below is a worked example.**

$$\text{Break-even price} = \frac{\text{Total variable costs}}{\text{Expected yield}}$$

$$= 800 \div 2$$

$$= 400$$

The farmer will just cover his or her variable costs if he or she sells the Michigan pea beans at $400 per tonne (i.e. $0.40 per kilogramme).

## 2.3 Why Use Gross Margin Budgets?

Gross Margin budgets are the basis for cash flow and capital budgets and show the short-term position of each crop enterprise, e.g. returns to investment. If Gross Margin is greater or equal to zero (≥0), then the horticulture enterprise is viable. They can be used to make decisions when resources are limited (e.g. when land, labour, capital or management is limiting) to select enterprises.

**NB: The following physical and economic indicators can be used by horticulture farmers to compare the productivity and efficiency of their crop enterprises using gross margin budgets:**

1. Break-even analysis
2. Returns to investment (such as land, labour and variable costs incurred)

In the *Table 6* shown below, the positive gross margins show that the value of the produce from the farmers is sufficient to cover their total variable costs of production for all the selected horticultural crops. Cabbages, carrots, green peppers and Tabasco chillies show the highest returns to investment whilst bananas generally have low returns to investment owing largely to their long production cycle requiring intensive labour usage. On average the farmers can realize at least $3.00 for every dollar invested in cabbage and Tabasco enterprises.

Summary of viability indicators from selected smallholder horticulture crop budgets

| Crops | Income | | | | | | Returns | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Prices | Gross Yield | Pack Out | Expected Net Yield | Gross Income | Total Variable Costs | Gross Margin | Break -even Price | Break -even Yield | Net Returns Per $ | Returns to Family Labour | |
| | $/kg | kg/ha | % | kg/ha | $/ha | $/ha | $/ha | $/kg | kg/ha | $1/$ | days/ha | $/day |
| | | | | | | | GI-TVC | TVC/ny | TVC/pp | GM/TVC | | GM/Lf |
| Fine beans | $1.00 | 7,200 | 70 | 5,040 | $5,040 | $2,668 | $2,372 | $0.53 | 2,668 | $0.89 | 168 | $14.12 |
| Butternuts | $0.20 | 20,000 | 75 | 15,000 | $3,000 | $1,572 | $1,428 | $0.10 | 7,860 | $0.91 | 114 | $12.53 |
| Gem Squash | $0.40 | 15,000 | 75 | 11,250 | $4,500 | $1,384 | $3,116 | $0.12 | 3,461 | $2.25 | 114 | $27.33 |
| Tabasco | $0.50 | 6,000 | 100 | 6,000 | $3,000 | $700 | $2,300 | $0.12 | 1,400 | $3.29 | 371 | $6.20 |
| Tomatoes | $0.75 | 24,000 | 70 | 16,800 | $12,600 | $4,869 | $7,731 | $0.29 | 6,492 | $1.59 | 224 | $34.51 |
| Cucumbers | $0.35 | 10,000 | 60 | 6,000 | $2,100 | $570 | $1,530 | $0.09 | 1,628 | $2.68 | 109 | $14.04 |
| Green Peppers | $1.50 | 7,500 | 80 | 6,000 | $9,000 | $2,430 | $6,570 | $0.40 | 1,620 | $2.70 | 228 | $28.82 |
| Rape | $0.30 | 10,000 | 80 | 8,000 | $2,400 | $1,242 | $1,158 | $0.16 | 4,139 | $0.93 | 50 | $23.17 |
| Onions | $0.50 | 20,000 | 90 | 18,000 | $9,000 | $2,398 | $6,602 | $0.13 | 4,796 | $2.75 | 120 | $55.02 |
| Carrots | $0.50 | 8,000 | 99 | 7,929 | $3,965 | $995 | $2,970 | $0.13 | 1,990 | $2.98 | 250 | $11.88 |
| Cabbages | $0.40 | 15,000 | 73 | 11,000 | $4,400 | $930 | $3,470 | $0.08 | 2,325 | $3.73 | 120 | $28.92 |
| Bananas | $0.22 | 40,000 | 100 | 40,000 | $8,800 | $5,952 | $2,848 | $0.15 | 27,055 | $0.48 | 411 | $6.93 |

***Table 6:*** *Summary of viability indicators from selected smallholder horticulture crop budgets*

**NB: The above comparisons of the gross margin parameters for the different horticulture crops should be used as a guide only since the specific calculations from differ from area to area.**

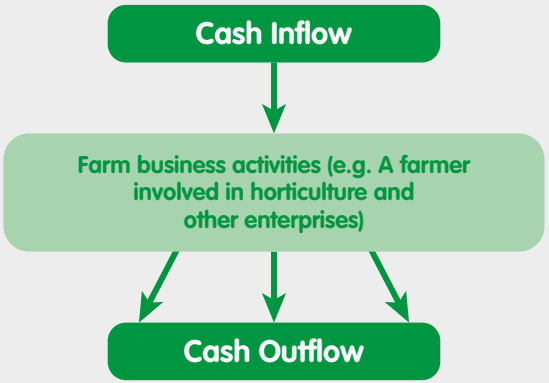
### How can farmers assess if they have sufficient cash throughout the crop production cycle?

Farmers can make use of cash flow budget in order to determine if they have sufficient cash throughout the production cycle of the crop(s).

## 2.4 What is a Cash Flow Budget?

Cash flow budget is a forecast of the movement of money into (cash inflows) and out of (cash outflows) the farming business over a given period of time. It is usually developed after the farmer has gone through all the steps of budgeting and has come up with a whole farm budget. It is most useful when prepared annually at the start of the farm business.

### What are the sources of cash (inflows) and cash expenses (outflows) for a farm business?




**NB: The farm must be able to balance its cash expenses with the cash income generated from its production.**

***Figure 3:***
*Cash Inflow/Outflow*

## What are the uses and applications of cash flow budgeting for horticultural farmers?

It seeks to answer the following questions:

- **Is the plan financially feasible?**
- **Will there be sufficient capital and if not would the plan sustain a loan?**
- **Is there need to borrow and if so, how much?**
- **When does the program get peak financial inflows and outflows?**

The above questions are addressed by the following applications of cash flow budgeting sample illustrated in *Table 7* on the next page (page 37).

## How can farmers finance deficits in their cash flows?

The smallholder farming sector in Zimbabwe has limited access to finance to develop their operations such as horticultural enterprises. **The following are possible various sources of finance available to farming businesses in Zimbabwe, as illustrated in *Table 8* on the following page 38.**

| ITEM / DESCRIPTION | 2013 | 2014 | | | Cumulative Total |
|---|---|---|---|---|---|
| | Oct-Dec | Jan-Mar | Apr-Jun | Jul-Sept | |
| **CASH INFLOW / INCOME** | | | | | |
| Balance brought forward | 1,000 | --- | --- | --- | 1,000 |
| Loan from Internal Savings and Lending group (ISAL) | 6,000 | --- | --- | --- | 6,000 |
| Crop sales (vegetables) | --- | --- | 193,000 | 45,000 | 238,000 |
| Livestock sales (poultry and goats) | 10,000 | --- | 40,000 | --- | 50,000 |
| Miscellaneous Income (sale of poultry, manure and remittances) | 100 | 1,000 | 500 | 500 | 2,100 |
| **TOTAL CASH INFLOW** | **17,100** | **1,000** | **233,500** | **45,500** | **297,100** |
| **CASH OUTFLOW / EXPENDITURE** | | | | | |
| Crop inputs | --- | 50,000 | --- | 170,000 | 220,000 |
| Livestock inputs | --- | --- | 40,000 | --- | --- |
| Living expenses | 1,500 | 1,500 | 1,500 | 1,500 | 6,000 |
| Fixed costs | 600 | 600 | 600 | 600 | 2,400 |
| Burial society contributions | --- | 20 | --- | --- | --- |
| Transport | 20 | 20 | 30 | 40 | 110 |
| Packaging material | 50 | --- | 40 | --- | 60 |
| Interest on loan (at 30% quarterly) | --- | 7,800 | --- | --- | 7,800 |
| Owner's withdrawal | 250 | --- | 250 | 1,000 | 1,500 |
| **TOTAL CASH OUTFLOW** | **2,420** | **59,940** | **49,420** | **173,140** | **284,920** |
| **QUARTERLY BALANCE** | **14,680** | **(58,940)** | **(525)** | **1,816** | **4,010** |

***Table 7:*** *Sample cashflow budget for a horticulture farmer*

| Finance Source | Description | Advantages | Disadvantages |
|---|---|---|---|
| **Individual financing (own savings)** | Use of personal money or income from other sources to finance farming activities | • If available is predictable and reliable, therefore, promotes timeliness of operations | • Usually not enough to promote commercial farming<br>• If the farming business fails it depletes family savings |
| **Community based cooperatives (e.g. Internal Savings and Lending groups)** | These are community groups or cooperatives which lend money usually to members at a reasonable interest | • Selection criteria is usually not very strict and, therefore, many farmers qualify<br>• Interests rates are usually lower than market rates | • Usually face viability problems due to poor administration and corruption<br>• Such groups are usually poorly funded and funds are often not enough |
| **Government support** | Include programmes such as input subsidies; farm mechanisation programme; crop input support and government programmes for the vulnerable | • Not very strict selection criteria therefore accessible to many farmers<br>• Interests rates usually low | • In Zimbabwe these programmes are not always on time<br>• Such programmes are normally underfunded therefore not available to everyone<br>• Corruption usually experienced as it can be altered to benefit the non-deserving group. |
| **NGOs and other relief organisations** | Include direct distribution of inputs, agro dealer voucher programmes, livestock restocking | • Selection criteria often very clear and transparent<br>• Inputs are often delivered on time to allow timely usage | • Assistance often available to few people<br>• Quantity of assistance often too low to promote commercial farming |
| **The private sector** | Include agro-dealers, contracting companies and input suppliers | • It is safe because farmers do not always get direct cash but farming inputs<br>• Farmers usually get technical support<br>• Usually minimum or no collateral required | • May assist farmers to purchase an input which may not be the best for farmers<br>• Normally give limited inputs e.g. for specific crop |
| **Financial institutions (for individual lending)** | Include commercial banks, building societies and other farm related financial organisations. They can give short, medium or long term loans | • Can give as much as one needs<br>• Farmers more likely to get timely loan<br>• Have specialised personnel to deal with farmer problems | • Often require collateral.<br>• May not offer backup technical support to the farmer<br>• High interests rates |
| **Financial institutions (for group lending)** | Include commercial lenders lending to farmers who are organised into groups | • Usually no need for collateral security<br>• Lower chances of defaulting | • Often difficult to find group members who are committed and faithful |

***Table 8:*** *Sources of finance available to farming businesses*

## 2.5 Partial Budget

A partial budget is a planning tool or technique for assessing the impact of relatively small changes in organisation production patterns, production methods, and management practices of costs, benefits and net benefit or gain.

### Steps in Developing Partial Budgets for Horticultural Enterprises

1. Describe and specify the proposed changes, starting with what is involved and other relevant information e.g. timing of the changes.
2. List those factors or items in the existing production or management practices that are likely to change. Please note direct and indirect effects of the change.
3. Determine gains i.e. determine what would contribute to increase in income. These are:
   a. Costs saved as a result of the change
   b. New income arising out of the change
4. Determine losses i.e Determine what would contribute to increase in costs or reduction in income
   a. New or extra costs incurred as a result of the proposed change
   b. Income foregone as a result of the change
5. Determine net change in income or gain
   **Net Gain = (a+b) – (c+d)**
6. Consider non-monetary factors that are not taken account of in steps 3, 4 and 5:

   a. Degree of risk and variability associated with the change. Major sources of risk in horticultural production include price fluctuations due to the combined effect of the following factors:

- **Perishability -** Horticultural crops are highly perishable and have to be marketed before quality deteriorates. Any loss in quality results in reduction in price.
- **Seasonal production patterns -** Production of horticultural crops is seasonal, therefore, marketing is seasonal. During the on-season prices are generally low due to increased supply.
- **Variability in areas grown and yields -** There are fairly numerous horticulture producers, therefore, the market is easily saturated. Variability in aggregated yield is fairly low due to irrigation based production. It is easy to vary area, therefore, output during a crop production period.
- **Demand is relatively fixed -** Quantities consumed are fairly standard across the year. Therefore, demand is inelastic. The fresh vegetable market fluctuates seasonally, monthly, weekly and geographically. Prices do not remain static for long periods.

b. Pre-requisites required before or for implementing the change
c. Implications of the change on resource utilization and management
d. Implications of other enterprises
e. Implications on production system management
f. Market prospects for the new or extra product
g. Amount of extra capital investment needed to bring about the change
h. Impact on net cash flow over time
i. Expected change in assets and debts over time

By comparing total reduction in profit with total increase in profit, the net change in profit can then be worked out:

| Additional Income (AI) | Reduced Income (RI) |
|---|---|
| Reduces Cost (RC) | Additional Cost (AC) |
| Total Gain (A) = AI + RC | Total Loss (B) = RI + AC |

**Net change in profit = A - B**
**Net Gain: (AI + RC) > (RI + AC)**

## Worked example of a partial budget

A farmer usually hires casual labour to weed his 5ha of bananas. A new herbicide has been introduced or the market and the farmer wants to introduce this herbicide. Is this an economic move? *Table 9* illustrates this example.

| REDUCED COSTS (USD) | | | ADDITIONAL COSTS (USD) | | |
|---|---|---|---|---|---|
| Weeding labour | = | 600 | Depreciation of sprayer | = | 300 |
| Depreciation of hoes | = | 200 | Purchase of chemical | = | 200 |
| | | | Protective clothing | = | 100 |
| **ADDITIONAL INCOME** | **=** | **Nil** | **ADDITIONAL INCOME** | **=** | **Nil** |
| **TOTAL** | **=** | **USD800** | **TOTAL** | **=** | **USD600** |

**Net Change = 800 - 600**
**= USD200**

***Table 9:*** *A partial budget example*

## 2.6 Record Keeping

### What is record keeping?

Record keeping is an art of collecting useful pieces of data or information on the events and activities of a particular undertaking with the view of processing it in future e.g. analyzing sales and costs and calculating returns.

### Which records can horticulture farmers keep?

There are no structured methods on how records are to be kept but any method used should record the major items necessary. Listed below are the common farming records kept by horticulture farmers:

**A. Physical Records**

1. Hectares to be grown to a crop
2. Input quantities (seed, fertilizerilizers, pesticides, herbicides, packaging materials, etc)
3. Input usage
4. Total yields
5. Stock record book
6. Quantities sold to output markets and locally
7. Quantities retained for home consumption or stock feeds
8. Labour journal/requirements for crops (e.g. in Labour Days)
9. Asset inventory (at the beginning and end of year)
10. Farm plans/layouts
11. Weather records

**B. Financial Records**

1. Income and expenditure record for all enterprises (using gross margin budgets)
2. Capital expenditure-on permanent developments e.g. roads, fences, buildings, equipment
3. Expenditure on overheads
4. Personal expenditure
5. Income from sale of the crops
6. Other farm income-from minor enterprises or other activities by the farmer
7. Personal income
8. Sales records
9. Credit records
10. Family living expenses
11. Financial statements
12. Bank statements
13. Invoices and receipts

## Examples of specific records

### a) Stock Record Book

This is a record of all the stock on a farm business at any given period of time. Items to be included on this record are e.g. fertilizerilizer, purchase date, buying price, item usage and the total value of used and remaining stock if any.

| Date | Item Purchased | Quantity Purchased | Total Cost ($) | Date Item was used | Quantity of product used | Value of product used ($) | Crop for which item was used | Notes |
|---|---|---|---|---|---|---|---|---|
| 01/09/14 | Basal fertilizer | 20kg | $16.00 | 05/11/14 | 20kg | $16.00 | Bananas (0.2 ha) | Inputs purchased from contacting company |
| 01/09/14 | Top dressing fertilizer | 90kg | $72.00 | 08/11/14 | 80kg | $64.00 | Bananas (0.2 ha) | |
| **01/09/14** | | | **$16.00** | | | **$16.00** | | |

***Table 10:*** *Example of stock record book for a farmer producing bananas in Chipinge district of Zimbabwe*

### b) Cash Book

It is important to know where all the farmer's money comes from and goes to. The cash book shows the following:

i. **Cash in hand:** This is the cash the farmer has, available to spend. It is the money at the beginning of the period.
ii. **Date:** The date/day when the transaction or business activity takes place.
iii. **Detail:** The details of the transaction are recorded in this column.
iv. **Money In:** You record all the money you receive in the business.
v. **Money out:** You record all the money you spend or give out of the business.
vi. **Description:** Indicate where the money is being debited and credited.

| Date | Detail | Revenue / Money In ($) | Expenses / Money Out ($) | Description |
|---|---|---|---|---|
| 01/04/2015 | **Cash in hand** | 1,000 | --- | --- |
| 02/04/2015 | Banana Sales | 500 | --- | Business |
| 02/04/2015 | Gave daughter bus fare | --- | 80 | Domestic |
| 03/04/2015 | Banana Sales | 500 | --- | Business |
| 03/04/2015 | Savings | --- | 300 | Business |
| 04/04/2015 | Bought groceries | --- | 100 | Domestic |
| 04/04/2015 | Transport | --- | 50 | Business |
| 05/04/2015 | **Sales** | 700 | --- | ---- |
| 06/04/2015 | Bought fertilizer | --- | 200 | Business |
| 06/04/2015 | Bought seed | --- | 100 | Business |
| 07/04/2015 | Church offering | --- | 100 | Domestic |

***Table 11*** *Example of basic cash book format for a smallholder irrigation farmer*

vii. **Farm sales record book (sales journal):** A farm sales record book should include quantities harvested, quantities sold, selling prices, dates for sales and harvesting, name of buyer(s) and payment methods as they occur.

| Harvest Date | Commodity | Quantity harvested (tonnes) | Sales Date | Quantity sold (tonnes) | Price per unit (USD) | Value of sale ($) | Name of buyer | Notes |
|---|---|---|---|---|---|---|---|---|
| 30/03/14 | Tomatoes | 10.0 | 04/04/14 | 10.0 | $350.00 | $3,500 | Favco | Cash payment made buyer but wants then graded by size |
| 10/04/14 | Tomatoes | 6.0 | 16/04/14 | 6.0 | $350.00 | $2,100 | Favco | Cash payment made buyer but wants then graded by size |
| 15/04/14 | Onion | 21 | 20/04/14 | 20 | $260.00 | $5,200 | Local schools | Payment made within 14 days of produce delivery |
| **TOTAL** | | **71** | | **71** | | **$72,600** | **$10,800** | |
| **Summarize monthly and forward sales data to cash flow** | | | | | | | | |

***Table 12:*** *Example: Tomatoes and Onions sale journal for the months of March and April 2014*

viii. **Credit journal:** This journal records what is borrowed, from whom, what was repaid in the form of cash, what the balance is.

| Date | Amount Borrowed | Source of Funds | Cash Repayment | Balance still to clear | Comments |
|---|---|---|---|---|---|
| 01/01/15 | $100.00 | Internal Savings and Lending group | ---- | $100.00 | Loan has a 10 percent interest rate per month and is for financing fertilizerilizers for producing fine beans |
| 30/11/15 | ---- | ---- | $110.00 | $0.00 | ---- |
| **Summarize monthly and forward sales data to cash flow** | | | | | |

***Table 13:*** *Example of a credit journal for January 2015 for a horticulture farmer*

## Why should horticulture farmers keep farming records?

Management of a farm business involves the coordination and control of farming operations and being able to assess performance of all the enterprises. Information (in the form of records) is required to perform this function. Listed below are some of the common uses of farm records:

a. To track individual enterprise performance
b. Records provide information for farm planning and budgeting
c. Evaluate farm profitability
d. Basis for price negotiation
e. To access loans from banks and other financial institutions
f. To get help from extension and developments agents
g. Records are a good management tool
h. Environmental regulations

## What are the requirements for a successful recording system for horticulture farmers?

1. Records must be accurate and up to date
2. Records must provide detailed and useful information
3. Records must not be complicated and time consuming
4. The time lag between data collection and analysis should not be too long as the data can easily become less useful.
5. Individual records and results must be confidential to the farmer and must not be used in a manner detrimental to his/her interests.

# Unit 3: Production/Agronomy

This manual identified the following 3 key anchors which if farmers address viz, production, productivity and profits will improve horticulture production significantly. Under this unit we will specifically focus on two key management issues affecting production and productivity which are:

- Soil analysis for effective fertility management
- Pest scouting for effective pest management

## 3.1 Soil Analysis For Effective Fertility Management In Horticulture

**Definition of Soil Testing:** Soil testing is a rapid chemical analysis to access available nutrient status of the soil and includes interpretation, evaluation and fertility recommendation based on the result of chemical analysis and other considerations. Soil sampling and testing provides an excellent inventory of plant available nutrients and soil PH for crop production. As soil nutrient levels vary from year to year, and frequently will vary within fields, this inventory serves as a basis for recommending additional nutrients to improve crop production on an individual field basis.

### Significance of Soil Sampling in Horticulture Production

Knowing the fertilizerility status of your soil is the key to effective crop production because soil which is too acidic and alkalinic affects crop vigour. In horticulture, optimum nutrients uptake by plants enhance growth, vigour and eventually yield hence necessary for farmer to continuously take soil for laboratory testing.

### Optimum pH for Crop Production

**Soil pH:** Soil pH is a measure of how acidic or basic things are. It is measured using a pH scale between 0 and 14. It should be noted that with continuous fertilizer use some soil can turn into acidity and times alkalinity, all this conditions interferes with plant growth as uptake of nutrients will be prohibited by the status.

### Methods of Collecting Soil Samples

Four basic methods are used in taking soil samples and these are:

**a) Benchmark Soil Sampling -** It involves selecting uniquely different areas within a field and sampling each area separately.

***Photographs 1 & 2:*** *A comparison of frail michigan pea beans as a result of soil acidity and health michigan pea crop in Chipendeke Irrigation Mutare, Manicaland Province.*

**b) Grid Soil Sampling –** This is a high cost method, where a field is sampled in an organized grid pattern. The smaller the soil sampling unit, the greater the accuracy of the sample. The advantage of this method is that a field map can be prepared for each nutrient and be used for variable rate fertilization and precision farming.

**c) Topographic Soil Sampling -** With this method, a producer selects a set of soil samples which is taken from each uniquely different topographic area within a field.

**d) Random Soil Sampling -** This involves taking 15 to 20 soil samples in a random pattern across a field (not more than 80 acres in size), generally avoiding unusual or problem soil areas within a field.

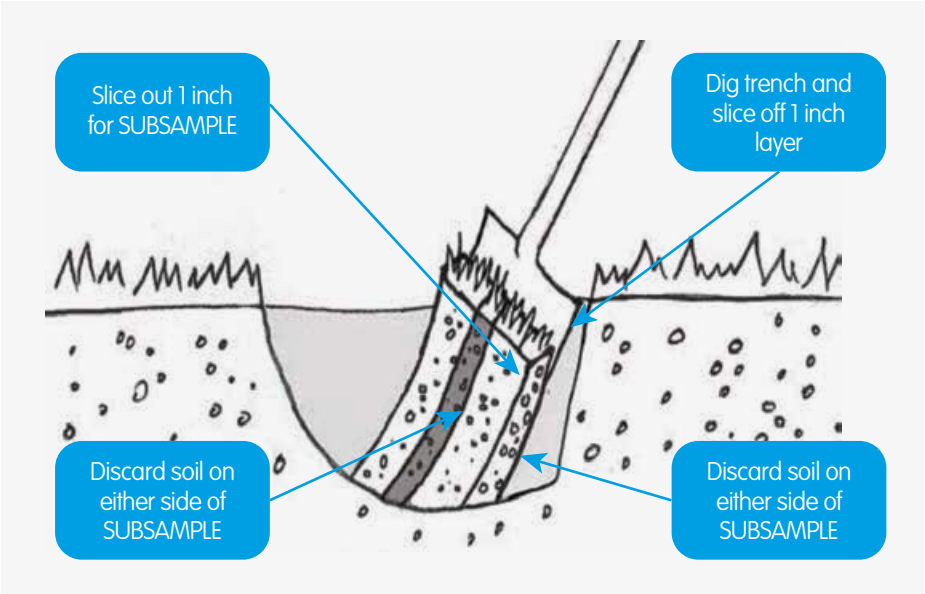



***Figure 4:***
*How to do soil sample using a spade*

## Soil Handling Techniques After Sampling

Soil from each depth should be placed in separate containers. Immediately after the samples have been taken:

- Mix the soil in each container thoroughly in order to obtain a homogeneous mixture.
- Spread soil on a piece of clean paper.
- Allow the soil to completely air dry at a temperature of not more than 30°C. Do not dry in an oven or at a high temperature since this can change the levels of some nutrients.
- Care should be taken to avoid contamination of the samples with fertilizer materials such as commercial fertilizers, manure, salt, water, and dust. Samples should not be dried on old fertilizer or feedbags or areas where fertilizers have been handled.
- Once the samples are thoroughly dry, fill the soil sample cartons. Label each carton with correct field number and sample depth.
- Complete an information sheet on cropping and fertilizer history and mail to a reputable soil testing laboratory. Consult your AGRITEX for details of soil testing laboratories that are available.

| Purpose | Product | Mineral Composition % | | | | | | | | | | | Use/Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | P | K | S | Bn | Zn | Cu | Ca | Mg | Mb | Fe | |
| Liming | Agric Lime | --- | --- | --- | --- | --- | --- | --- | --- | Agric Lime | Agric Lime | --- | • Liming has the following objectives: increases the pH of acidic soil (the lower the pH the more acidic the soil).<br>• Provides a source of calcium and magnesium for plants.<br>• Permits improved water penetration for acidic soils. Improves the uptake of major plant nutrients (nitrogen, phosphorus, and potassium) of plants growing on acid soils. |
| Seeding/ Nursery Stage | Seedbed Fertilizer | 7 | 21 | 8 | 7.5 | 0.66 | --- | --- | --- | --- | --- | --- | Provides adequate nutrient requirements for seedlings during nursery stage. |
| Early vegetative growth stage | Quick Start | 10 | 46 | 10 | 2.8 | 0.78 | 0.76 | 1.7 | --- | 1.7 | 0.6 | 3.35 | Enhance fertilizerility management during early vegetative growth. The fertilizeriliser provides plants with major nutrients like N, P, K during early plant growth. |
| | Tobacco Fertilizer / Comp C | 5 | 15 | 12 | 5 | --- | --- | --- | --- | --- | --- | --- | |
| | Double C | 6 | 28 | 23 | --- | --- | --- | --- | --- | --- | --- | --- | |
| Vegetative stage | Quick grow | 20 | 10 | 20 | --- | 0.875 | 0.6 | 1.7 | --- | 1.7 | 0.023 | 3.3 | Stimulate vegetative growth and vigour up to reproductive stage |
| Flowering and fruiting stage | Best Bloom | 15 | 5 | 35 | 4.42 | --- | --- | --- | --- | --- | --- | --- | • Enhances flower initiation and improves fruit quality.<br>• Also enhance shelf lives for highly perishable vegetable crop such as tomatoes. |
| | Foliar Fertilizer 15 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| | Calcium Nitrate | 15.5 | --- | --- | --- | --- | --- | --- | 19 | --- | --- | --- | |
| | Fruit fertilizer | 15 | 5 | 20 | 3.4 | --- | --- | --- | --- | --- | --- | --- | Enhances fruit quality, shelf life thereby increases marketability of horticultural crops especially for export markets. |

***Table 14:*** *Important fertilizers in Horticulture*

## 3.2 Pest Scouting for Effective Pest Management

### Importance of Scouting

Effective scouting gives an accurate estimate of the pest levels in the field. Scouting helps farmers determine:

- Pest abundance and diversity
- When to anticipate pest problems
- When to spray
- What chemical to use
- If spraying has been effective

**Without scouting the following may happen:**

1. Spray when spaying is not required
2. Delaying spaying when its required
3. Use the wrong pesticide for the pest present

### Timing of Scouting

- For vegetables, scout either 2 weeks after transplanting
- OR 8 weeks after direct seeding
- Scouting interval can be - 2 weekly OR fortnightly
- Scouting interval depends on:
  - labour availability
  - crop value
  - target market requirements

### Scouting Procedure

**Scouting types:** *Destructive sampling; Knockdown; and Leaf/Branch/Node Knockdown*

Use a chemical to spray the whole plant and collect all pests on a Selection procedure:

- Randomly select a plant to get a representative sample
- Sample size depend on the size of the field (Generally take 24 plants/ha)
- Follow a zigzag or diagonal pattern across your field
- Leave at least 5m between sampled plants
- Avoid sampling field edges and sampling plants of the same row
- Don't scout same plant every week
- Avoid sampling very large small or large plants

### Steps in Scouting

1. Scout for whiteflies
2. Scout for aphids, red spider mites
3. Scout for bollworm eggs and larvae
4. Scout for other pests
5. Scout for predators and parasitoids

## Scouting for Specific Pests

- Pest abundance and diversity
- When to anticipate pest problems
- When to spray
- What chemical to use

## Sample Scouting of

**a) Aphids**

- **Counts:** adults and nymphs only
- **Target:** 1st fully expanded leaves and 1 middle leaf
- **Count:** Numbers on positions with greatest infestations
- **Threshold:** spray when score is 48 on 24 plants
- **Score:** the findings as follows:

| Number of Aphids | Score |
|---|---|
| 0 | 0 |
| 1-10 | 1 |
| 11-30 | 11 |
| +30 | 111 |

***Photograph 3:*** *Mummified aphids on a lettuce leaf; Red spider mites; Whiteflies*

***Photograph 4:*** *H. armigera larva burrowing through tomato fruit*

## Sample Scouting of

**b) Other Pests**

### *i. Leaf-eaters*

### *ii. Natural enemies*

- Identify all predators in the field
- Note their numbers and type (predators & parasitoids)
- Correlate predator numbers and pest population to ascertain the predator suppressive threshold
- Only spray when natural enemies effectiveness is low

***Photograph 5:*** *Parasite*

## Natural enemies scouting helps farmers determine:

a) When to spray
b) By how long can we delay spraying
c) Which selective insecticide can we use

## Economic Thresholds

This is the total pest infestation level at or above which it has been established that above this level pest will cause economic damage to the crop.

Threshold level can vary depending on:

- Crop development
- Weather conditions

# Unit 4: Post-Harvest Handling & Value Addition

## 4.0 What is the Problem?

Fruits and vegetables are living tissue which are subject to continuous change after harvesting. These changes, be it ripening or deterioration, cannot be stopped but can only be slowed down within certain limits. With this view in mind, then for fresh produce, understanding post-harvest technology can help us to reduce losses in quantity and quality between harvest and consumption ultimately helping us to maintain eating quality for the longest time possible. To maintain the eating quality, one has to try and reduce the rate of produce deterioration by slowing down undesirable changes which can be done by putting the produce.

Horticultural produce currently suffer an estimated post-harvest loss of 30 to 50%, which occurs due to poor pre-production and post-harvest management as well as lack of appropriate processing and marketing facilities. *Table 15* below summarize losses which occur across the tomato and lettuce value chains in Benin and Ghana.

| Countries | PERCENTAGE LOSSES AT VARIOUS VALUE CHAIN NODES | | | |
|---|---|---|---|---|
| | Products | Collectors/ Aggregators | Wholesalers | Retailers |
| Benin | Tomato | 12% | 8% | 2% |
| | Lettuce | --- | 22% | 9% |
| Ghana | Tomato | 20% | 46% | 40% |
| | Lettuce | 32% | 32% | 32% |

***Table 15:*** *Quantitative Loss Assessment in Value Chain (%)*

**The objectives of implementing good post-harvest handling strategies are:**

1. To maintain the quality of the crop (appearance, texture, flavor and nutritive value)
2. To reduce losses (both physical and in market value) between harvest and consumption.
3. Ensure food safety

In most cases, failure to reduce the rate of deterioration in harvested products tend to result in high post-harvest losses.

| Aspects Which Affect Deterioration Rate | How |
|---|---|
| Control environmental factors (Temperature and humidity) | High temperatures and low relative humidity hasten undesirable changes in harvested horticultural produce. Through pre-cooling to remove field heat; refrigeration, icing and using drying fans, temperature and humidity can be regulated. |
| Manage high water content in harvested products | Horticultural produce contain high water content in cell and tissues with some products containing as high as 98% water. If the water content becomes too too high, cells burst making commodities prone to transpiration and insect and pest attacks. In some horticultural commodities, water loss of 10% can result in 100% commercial loss. |
| Manage pests and diseases | By damaging plant tissue, pests and diseases make the produce more prone to water loss, respiration and reduce shelf-life. Using chemicals to control pests and diseases and by avoiding mechanical damages during harvest and transporting, can exclude pathogens and pests. |
| Minimise respiration | Through this process, carbohydrates, proteins and fats are broken-down giving out carbon dioxide and energy. When respiration is high, post-harvest life is shortened and losses are highly likely hence farmers should aim to slow down respiration by reducing storage temperature to optimal levels favoured by specific commodities. |
| Reduce transpiration | This is water evaporation from plant organs such as the stomatal openings on leaves; lenticels on stems and roots or any injured areas on the plant. Farmers must minimise mechanical injury and in hot and dry conditions. |
| Manage ethylene | Ethylene, a natural product of plant metabolite which is release by fruits, can be desirable during ripening (in bananas) or undesirable when products are being exported to long distant markets since it accelerates ripening which leads to deterioration and senescence (process of deterioration with age). Excessive ethylene can result in Russet spotting in lettuce, formation of bitter principles in carrots and sprouting in cauliflower and cabbages. |

***Table 16:*** *Aspects which affect deterioration rate*

## 4.1 Understanding Post-Harvest Basics for Loss Management

The causes for post-harvest losses can be clustered into three broad categories which are:

- Physiological aspects of produce (wilting, shriveling, chilling injury),
- Pathological effects on produce (decay due to fungi and bacteria) and;
- Physical damage to produce (mechanical injury).

Using the Commodity System Analysis Methodology by La Gra et al.1990, losses can occur right at the pre-harvest and postharvest stages as summarized in the *Figure 5* below.

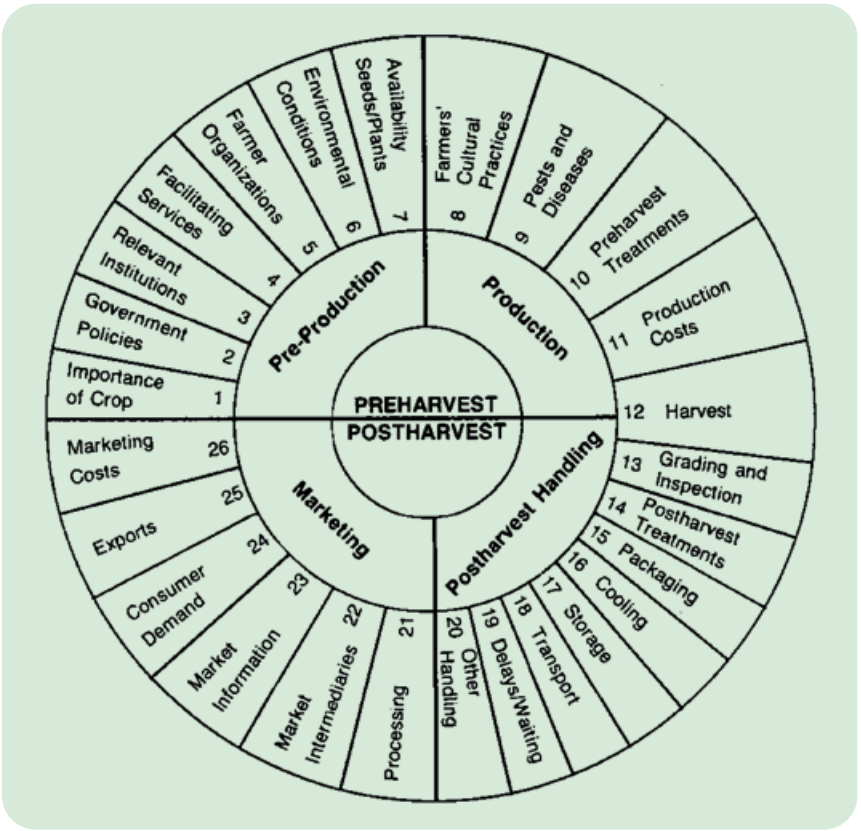



***Figure 5:***
*Commodity System Analysis Methodology, La Gra et al.1990*

## i. Production Practices

Unknown to many producers, production practises have a strong bearing on product shelf life and contributes significantly to the amount of post-harvest losses which eat farmers' profits. Too much or too little water, and over application of fertilizerilisers can be detrimental to plant growth and post-harvest condition of the produce, e.g. over application of nitrogen in onions prevent the onion bulbs from drying and storing well. Management practices such as mulching, trelling can affect the produce quality.

## ii. Harvesting

Harvesting indices should be strictly followed for horticultural crops in order to get the best price at the market. In summary under harvesting we need to pay attention of the following aspects:

- *Harvest at the proper stage of maturity*
- *Harvest when the crop and temperature are coolest and the plant has highest water content*
- *Train harvest labor to harvest properly and handle products gently*
- *Minimize bruising during harvesting*

## iii. Handling

Horticultural crops are generally highly perishable crops with a short shelf life. Therefore a general guide, for proper handling of vegetables are:

- *Handle produce with tender loving care to avoid unnecessary wounding, bruising, crushing, or damage.*
- *Encourage minimum handling (field pack if possible)*
- *Avoid over- or under-packing of containers*
- *Minimize mixing high quality product with damaged, decayed, or decay-prone products*
- *Move products as soon as possible into a cool and shaded situation and try to maintain this condition until the product gets to the customer*

## iv. Grading/Sorting

Grading is used to remove off-types, diseased and bruised products that would promote the rotting of the produce during storage. In summary under grading and sorting we need to pay attention of the following aspects:

- *Grade according to size, colour, texture, taste etc.*
- *Remove deformed, diseased & discoloured*
- *Minimize handling, field pack if possible.*
- *If possible, harvest, grade and pack in the field*

## v. Post-Harvest Treatment

This stage encompass key activities that one must do just after harvesting as the product transition from being attached to its mother plant to starting exist without additional water or nutrient support.

- *Removal of field heat*
- *Shading*
- *Cover with a shed cloth*
- *Wetting the product by sprinkling water on top (vegetables)*

## vi. Packaging

Packaging play an important role of protect, minimize abrasion, preserve from weather elements and enhance attractiveness of the product. The following guidelines for packaging are: Select appropriate packing materials (bags - butternut, crates - tomato, punnets - peas/ fine beans, sachets/packs - sugar beans, bunches - leafy vegetables):

- *Over-packing or under-packing may cause mechanical damage (cuts, compression bruises, impact damage & vibration rubbing)*
- *Empty containers gently to minimise drop height and fruit-to-fruit damage*

## vii. Cooling or Temperature Management

Exposing the produce to cool temperatures will reduce the enzymatic degradation of sugars in the produce and it will lower the rate of respiration of the produce. It will also reduce the rate of water loss thus reducing the rate of wilting. Key things to remembers on cooling or temperature management for all horticultural products:

- *All fresh produce are living, respiring tissues separated from their parent plant.*
- *Keep products at their lowest safe temperature will increase storage life by:*
  - *Lowering respiration rate*
  - *Decreasing sensitivity to ethylene gas, and*
  - *Reducing water loss*

## viii. Storage

Producer can either store produce for a short or long time prior to marketing in anticipation of favourable prices or whilst awaiting transport to the market in the following manner:

- *The produce to be stored should be free from pests and diseases and should not be damaged*
- *Produce that is stored together should be able to tolerate the same storage conditions*
- *Avoid storing produce that is ethylene sensitive (such as cucumbers, carrots, potatoes) with ethylene producing products such as ripe bananas, apples and tomatoes.*

## ix. Transportation

Losses can occur due to delay in collection; careless handling during loading and unloading and overheating during transportation. Generally during transportation, physical damages can occur as a result of the packaging sizes (large bags); overloading of transporting vehicle; inappropriate packing materials; poor road conditions and vehicle breakdown during transportation to the market. *See Photographs 6 and 7 on the following page.*

## 4.2 Processing Operations

Agro-processing activities comprise two major categories; primary and secondary operations. Primary processing operations involve activities such as crop drying, shelling/threshing, cleaning, grading, and packaging. These activities are mainly carried out at the farm and only transform the commodity into a slightly different form prior to storage, marketing or further processing. Secondary processing operations entail increasing nutritional or market value of the commodity and the physical form or appearance of the commodity is often totally changed from the original.

Some examples of secondary processing are milling grain into flour, grinding groundnuts into peanut butter, pressing oil out of vegetable seeds, pressing juice out of fruit, making cheese out of milk and manufacturing of mince meat.

Depending on type of commodity, equipment needed for primary processing is completely different from that used in secondary processing or major adjustments/modifications need to be done to suit either:

## Primary Processing of Horticultural Crops

- Primary processing activities that can be applied to horticultural crops include solar drying, cleaning, grading and packaging.
- Solar drying equipment can be obtained from the Development Technology Centre, at the University of Zimbabwe and from SIRDC in Harare.
- Packaging that can be done on farm includes punneting and cling wrapping of produce. The punnets and cling wrap can be easily purchased from most packaging shops nationwide.
- In Zimbabwe grading is done using visual assessment and does not require equipment.

## Secondary Processing of Horticultural Crops

- The secondary processing of horticultural crops involves the making of powders from dried fruits and spices, making of fruit juices and jams and extraction of vegetable oils e.g. Oil from mustard seed.
- *Table 17* on the following page showing manufacturers and distributors of secondary processing equipment.

| Company | Location | Retail Outlets | Product Range |
|---|---|---|---|
| Renox | Harare | Harare | Vegetable oil mills, |
| Intermediate Technology | Harare | Harare, Bulawayo, Mutare | Vegetable oil mills |
| Appropriate Technology Africa | Harare | Harare, Mutare | Vegetable oil mills, motorised juice extractor |
| Tanroy Engineering | Harare | Harare, Mutare, Bulawayo | Vegetable oil mills |
| Zimbabwe Oil Press Project (ZOPP) | Harare | Harare, Rusape, Mutare | Vegetable oil mills |
| Stainless Steel Products. | Harare | Harare, Bulawayo | Industrial pots, steam pots, pasteurizers, blenders, potato chippers and peelers, mixers |

***Table 17:*** *Some major manufacturers and distributors of secondary processing equipment in Zimbabwe.*

## 4.3 Value Addition

**a. Pickling:** Pickling is a method of preserving food by either anaerobic fermentation in brine or immersion in vinegar. The pickled food will be at a pH of 4.6 to prevent the growth of most bacteria and the food can be stored for several months.

**b. Jam-making:** Fruits can be used to make jams that can also be sold in addition to the marketing of the fruit. Care should be taken when making jam by sterilizing and using new lids in order to avoid contamination of the jam by moulds.

**c. Canning:** Canning is a food preservation method in which food is processed and sealed in an airtight container for up to 5 years without spoilage.

**d. Solar Drying and Powders:** Solar drying is a cost effective dryer which smallholder farmers can use solar drying to dry excess produce in order to reduce wastage. The dryers do not need other sources of fuel or energy to work and can be used in rural areas without electricity. Solar drying can be easily done under Zimbabwean conditions as the sun is readily available, the method is simple to use. Solar dried products like all leafy vegetables, tomatoes, mushroom, chillies and fruits. Tomatoes and chillies can be well packaged and labelled and sold to supermarkets or exported.

**e. Juicing:** Smallholder farmers can be out growers for companies such as Schweppes or Alpha and Omega Dairies and produce fruits such as pineapple, mango, apple and oranges for processing into juice.

# Unit 5: Area and Yield Estimation

## 5.0 Possible Area Estimation Techniques

### 1. 1 Hectare

The total area of a hectare is 100m length x 100m width. It is equivalent to 2.5 acres or the size of a 2.5 football pitches. In the field the area can be estimated by pacing.

### 2. 1 Acre

An acre is approximately the amount of land that can be tilled by one man and one ox in one day. It is approximately 40% of a hectare or 4,047m$^2$. It is the size of a football pitch.

### 3. Using Number of Plants

Using the spacing and number of plants used it is possible to calculate the total area planted.

## 5.1 Estimating Volumes Using Various Units of Measures that Farmers Use in Horticultural Markets

*Table 18*

| Horticultural Group | Crop | Farmers' Packaging Units | Weight Range in kgs |
|---|---|---|---|
| **Vegetables** | Tomato | Box | 10 |
| | Onion | Pockets | 10 |
| | Potato | Pockets | 15 |
| | Kale/Covo/Rape | Bundles | 1.5 to 2 |
| | Cabbage | Heads | 3 |
| | Butternut | 50kg Bags | 50 |
| | Gem squash | Pockets | 10 |
| | Pepper | Box | 10 |
| | Carrots | Pocket | 10 |
| | Cucumbers | Pocket | 10 |
| | Water melons | Each | 5 |
| **Fruits and Plantation Crops** | Bananas | Crate | 18 |
| | Pineapples | Basket | 10 |
| | Avocado pears | Box | 10 |
| **Niche Market and Potential Crops** | Fine beans | Box | 10 |
| | Baby marrows | Box | 10 |
| | Garden peas | Box | 10 |
| | Garlic | Pocket | 10 |
| | Okra | Box | 3 |
| | Mushroom | Punnet | 0.5 |
| | Macadamia nuts | Kg | 10 |
| | Mangoes | Box | 5 |

Module 2

# Horticultural Crop Production, Budgeting and Marketing

# Unit 1: Tomato Guide

## 1.0 Introduction

### Family, Family Members & Tomato Types

**FAMILY:**
Solanaceae

**FAMILY MEMBERS:**
Eggplant, potato, chillies, green pepper and tobacco

**TYPES:**
Fresh market table tomatoes, cherry tomatoes and canning/ processing tomatoes

Table Tomatoes

Cherry Tomatoes

Processing Tomatoes

## 1.1 Agronomy/Crop Production

### What needs to be done before production?

**Siting, land preparation and soil testing -** The ideal site for tomato production is one that is protected from stray animals, has a reliable source of water and free from frost attack.

**Variety selection -** The choice of a variety to grow is determined by marketing requirements. Market preferences are guided by the following: preferred fruit size, shape, colour (red, pink, orange) and use (slicing, canning, etc.).

| Growth Habits | Cultivar | Fruit Shape/Quality |
|---|---|---|
| **Determinate Types** | Alboran | Round, Smooth and pleasant taste |
| | Rodade | Good quality with high grading |
| | Roma | Long red and almost plum shaped |
| | Floradade | Firm fruit |
| | Red Khaki | Poor fruit firmness |
| | Rossol | Poor fruit firmness |
| | UC82B | Firm block fruit |
| | Heinz | Medium firmness |
| | Fortune Maker F1 | Square shaped, thick walled |
| **Indeterminate Types** | Money maker | Round red firm fruit |
| | Adelaide F1 | Round, firm deep red |
| | Thomas F1 | Medium to large size, deep red |
| | Raissa F1 | Glossy fruit with constant size |
| | Star 9030 F1 | Round smooth fruit |

***Table 19:*** *Cultivar description*

## 1. Land Preparation

Raised beds are usually used for water logging. On the other hand fertilizer trenches and or sunken beds are prepared where the soils are prone to high evaporation and the soil water moistures are slightly found in the lower soil horizons.

***What is key during production?***

The method of land preparation adopted is usually determined by:

i. **Time of planting:** In winter the crop is planted on raised beds or fertilizerility trenches may be used. But for a summer crop use raised beds to avoid water logging.
ii. **Methods of irrigation:** Basins may not be used where flood irrigation is used.

## 2. Crop Establishment

**a) Transplanting:**

- Transplant seedlings 4-6 weeks from emergence or when they are approximately 10-12cm tall. Select healthy seedlings only.
- Transplant during the morning or late in the afternoon when it is cool or on a cloudy day.

**b) Spacing:**

- The ideal spacing is determined by variety, implements to be used and disease control programme. Plant populations ranging between 16 000 to 37 000 plants per hectare are recommended at an in-row spacing of 30-50cm and inter-row 90-120cm.

## 3. Seedbed

**Preparation:**

- A seedbed should have a width of 1m to 1.2m. Furrows/planting rows should be marked or opened at 7-10cm apart with a depth of 1cm. Seeds may be hilled/planted (4-5 seeds) every 4cm in the row or may be thinly banded in the furrow.
- The seeds are then covered with a fine layer of sand soil to enhance emergence.
- Seed requirement per hectare is 120-160g of seed which is enough to plant on a bed of about 20m$^2$.
- Trays may be used in place of raised seed beds. When transplanting seedlings from trays, the plants should be lifted with the soil that it germinated from to reduce root damages which causes transplanting shock.

**Nursery management:**

- The bed may be covered with a layer of clean-disinfected grass to reduce the effect of heat from the sun and also regulate the soil temperature and conserve moisture.
- At 2 leaf stage in the seedbed the seedlings are thinned to maintain reasonable spacings of between 2.5-4cm in-row.
- Time taken from germination to transplanting is roughly 30 to 35 days. It is during this time that the field is prepared.
- Water the seedbed using a watering-can or a hose pipe fitted with a fine rose to avoid seed splashing. First watering should be done to field capacity.
- When the seed has germinated, one watering in the morning is sufficient. At no time should

the beds be over-watered. Older seedlings should be watered 2 or 3 times a week only.
• Watering should be done regularly until the seedling is between 5-7cm.
• Where trays are being used, care should be taken to allow free drainage of water out of the trays to prevent damping-off of seedlings.
• Under hot conditions, it is advisable to shed the bed with clean grass. The shed should be at least 30cm above the ground and should be gradually reduced or removed to harden-off the seedlings once they have germinated.
• Seedlings are ready for transplanting 4-6 weeks after germination.

## 4. Transplanting

• Transplant seedlings 4-6 weeks from emergence or when they are approximately 10-12cm tall. Select healthy seedlings only.
• Transplant during the morning or late in the afternoon when it is cool or on a cloudy day.

**Seedling Placement:**

• Seedlings should be placed carefully in planting stations opened either through the use a hoe or a dibber.
• The transplants should be placed in the hole so that the roots are not exposed to the sun and that the stem above the roots does not come into contact with wet soil to avoid fungal infection.
• Ensure that there is firm contact between the soil and the roots
• Plant tomatoes on top of the ridge where they will not get into contact with flowing water. This will protect them against water borne diseases.
• Apply wood ash after transplanting to protect transplants against ants and termites. The ash will also act as fertilizer supplying potash, which is important for fruit quality.

## 5. Fertilizer Management

**a) In Seedbed Fertilizer Management:**

• Use Seedbed fertilizer at a rate of 3kg per 25m²

**b) In-Field Fertilizer management:**

• Basal Application

**c) Use Compound S or C:**

• The crop requires Nitrgen, Phosphorous, Potash, Magnesium, Zinc and Molybdenum. These elements are applied through the use of Tobacco-fertilizers. (1500kg/ha)

**Poor fertilizerility management are characterised by the following:**

- **Nitrogen:** High application during the early stages will result in increased vegetative growth, delayed ripening and reduced yield. Low application will reduce growth, number and size of fruits as well as the quality of the fruits.
- **Phosphorus:** is highly required during the early stages. Half the total requirement is required during the early stages. Bend the fertilizeriliser on the side of the plant 5-10cm deep thus in the root zone. The rest may be worked in the bed during bed preparation. Phosphorous is important for plant vigour and fruit size.
- **Potash:** it should be applied the same way as phosphorus. It is important for fruit quality.
- **Magnesium:** it must be applied in areas where it is known to be deficient. Its application will reduce incidences of Yellow blotchy fruits. Dolomite at 300kg/ha during land preparation or Magnesium Sulphate at 1.5kg in 100 Litres of water applied as a folia spray will rectify the problem. Yellow blotches usually appear at the base.
- **Zinc:** its characterised by slow growth and leaves become thick with some developing a faint inter-venal chlorosis and they curl off. Use 1.5kg Zinc Sulphate in 500 Litres of water.

## 6. Insect Pest and Diseases

### a) Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Cut Worm** | Cut young plant stem at the base | Carbaryl, Dursban, Pyrinex, Karate 5EC/5CS | -- | Spray seedbeds or transplants when soil is moist in 150-300L of water. |
| **Aphids** | Suck plant sap and reduce plant growth | Chess 50WG-200g/ha<br><br>Actara 25WG – 200g/ha spray or 0,02g/plant drench or, 4g/100m of row 600ml/ha Polo 500Sc<br><br>Dimethoate, Metasystox 25 EC | 3 days<br><br>3 days<br><br>7 days | Spray in 300-500 L water/ha at 1st sign of infestation. Alternate with Actara.<br><br>Polo. Spray 3-4 times in 300-500 L water/ha at 1st sign of pest. Alternate with Chess, Polo. Mix 1.5-1.8 L water and incorporate. Spray in programme with Chess, Actara. Also controls red spider mites. |
| **African Bollworm** | Feed on leaves, flowers and fruit | Karate 5EC/5SC – 200ml/ha (12-20ml) per 15 L water<br><br>Match 050 EC – 400-600 ml/ha (6-12ml per 15L water<br><br>Thionex 35 EC, Dedevap, Tamaron 600 SL, Carbaryl, Dipterex 95 SP | 2 days<br><br><br><br>7 days | Spray preventatively at fruit set or when eggs or caterpillars are found. Check pyrethroid dates. Alternate chemicals. |
| **Red Spider Mite** | Leaves may become spotted, yellow, brown or silvery | Dynamec 18EC -280-560 ml/ha<br><br>Polo 500SC – 600ml/ha<br><br>Curacon – 130 – 400ml/ha<br><br>Malathion, Dimethoate 40 EC,<br><br>Mitac, Armitraz 20 EC, Kelthane 18 EC, Dicofol | 3 days<br><br><br><br>7 days<br><br><br><br>4 days | Spray 1st sign of infestation. Alternate chemicals. |
| **Leaf Miners** | Causes white spotting or stippling in leaves | Tamaron, Trigard 75 WP<br><br>Dynamec 18EC | 3 days<br><br>3 days | Spray at 1st sign of infestation |
| **Whitefly** | Suck plant sap and reduce plant growth | Confidor, Naturell, DDVP | -- | -- |

***Table 20:*** *Insect pests*

## b) Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Bacterial Canker** | Wilting of the foliage, stem splitting | Carbaryl, Dursban, Pyrinex, Karate 5EC/5CS | Use healthy seeds, plant on ridges and crop rotation | --- |
| **Bacterial Wilt** | Sudden wilting of the plant, browning of woody tissues | Use crop rotation and avoid use of areas prone to water logging | --- | --- |
| **Bacterial Spot** | Dark brown raised pustules on the fruit, later becoming slightly sunken and scabby | Use healthy seed, crop rotation | -- | --- |
| **Bacterial Speck** | Brown spots 2mm in diameter on leaf edges<br>On fruit black slightly raised superficial spots 3mm in diameter | Copper oxychloride and Mancozeb | --- | Use certified disease free seed. |
| **Early Blight** | A dark reddish brown leaf spot with concentric markings appearing first on the lowermost leaves, causing defoliation. Cracks on fruit and other skin injuries | Copper oxychloride 500g/100L water<br>Mancozeb 2kg/ha | 3 days<br>3 days | Repeat as necessary at 7 days interval, Full Cover Spray |
| **Late Blight** | Greyish green water soaked lesions on the leaves which rapidly turning black. Lesions on the stem are dark brown and large mottled brown areas develop on the fruit. | Copper oxychloride 500g/100Lwater<br>Mancozeb 2kg/ha<br>Captan 200ml/100Lwater | 3days<br>3days<br>7days | Full cover spray, repeat at 7 days interval.<br>Full Cover Spray repeat 7-10days intervals.<br>Spray twice in seedbeds. |
| **Tomato Mosaic Virus** | Light and dark green mottling. Distorted young leaves, and stunted or elongated growth | Use resistant cultivars<br>Control vectors<br>Practice good hygiene<br>Rogue out and destroy infected plants | --- | --- |

***Table 21:*** *Diseases*

### b) Diseases

| Physiological Disorder | Symptoms | Control |
|---|---|---|
| **Blossom end rot** | Appears as small 3 water soaked area at the blossom end of fruit. This enlarges, becomes sunken and turns black and leathery and sometimes turning the core of the fruit brown. | Grow resistant cultivars<br>Foliar applications of calcium chloride at transplanting time can be useful. |
| **Puffiness** | Fruits appear angular. Fruit feels lighter than it should be and when cut holes in the flesh are seen. | Apply sound nutrients |
| **Sunscald** | White or light tan discoloration of the fruit that has been over heated due to sun exposure. | Care should be taken when pruning fruits and harvesting not to overexpose fruits to the sun. |
| **Fruit cracking** | In concentric cracking, the fruit normally develops circular, concentric cracks around the stem end of the fruit. Radial cracking, the fruit cracks radiate from the blossom end. | Use cultivars tolerant to cracking such as Floradade and Rodade. |

***Table 22:*** *Key Marketing Information Systems*

## 7. Harvesting

Depends on proximity to market, package available and the variety of tomato being harvested.

## 8. Stages for Tomatoes Harvesting

**Stage 1**

**Green**

"Green" means that the surface of the tomato is completely green in colour. The shade of green may vary from light to dark.

**Stage 2**

**Breakers**

"Breakers" means there is a definite 'break' in colour from green to tannish-yellow, pink or red on not more than 10% of the surface.

**Stage 3**

**Turning**

"Turning" means that more than 10%, but not more than 30%, of the surface, in the aggregate, shows a definite change in colour from green to tannish-yellow, pink, red or a combination thereof.

**Stage 4**

**Pink**

"Pink" means that more than 30%, but not more than 60%, of the surface, in the aggregate, shows pink or red in colour.

**Stage 5**

**Light Red**

"Light Red" means that more than 60% of the surface, in the aggregate, shows pinkish-red or red.

**Stage 6**

**Red**

"Red" means that more than 90% of the surface, in the aggregate, is red.

## 9. Yields

- 20-60 t/ha is usually achievable.
- 100t/ha obtainable depending on cultural practices and cultivars.

## 10. Storage

- Ripe tomatoes may be stored for 7 to 10 days at 5oC to 10oC and humidity of 80 to 85%.
- Can be harvested at the mature green stage to increase shelf life

## 11. Marketing

- Can be sold to the local markets as fresh or dried or to processors, exporters.

## 1.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- The best harvesting time for tomatoes depends on the market that is being supplied.
- There are a number of stages that tomatoes can be harvested such as the mature green stage, pink and red stage. The eating/ organoleptic quality of the tomato improves as the tomato matures. This is shown in the Figure 6 below.

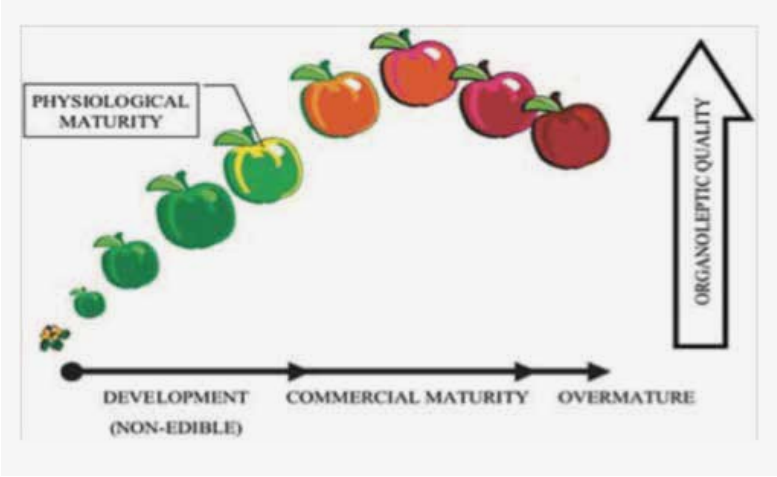



***Figure 6:***
*Change of organopletic quality of tomatoes with maturity (adapted from USDA recommendations at www.atinadiffley.com)*

- Harvesting should be done during the cool periods of the day, early morning or late afternoon. Harvesting is done by hand and care should be taken not to drop fruits as this causes internal bruising.
- Tomato quality is based on uniform size and freedom from growth or handling defects.
- The appearance is another quality factor, the tomato should have a waxy gloss, small blossom end and stem end scar, uniform colour, absence of growth cracks, catfacing, zippering, sunscald, mechanical injury or bruising.
- Tomatoes can be stored for 7 to 10 days at 5oC to 10oC at relative humidity of 80 to 85% when ripe.

## How to reduce loss

- Harvested fruit should be immediately kept under a cool shade to prevent overheating of the produce.
- Avoid dropping fruits into crate as this causes internal bruising. Some of the internal injury will only be evident after cutting of the fruit.
- Grading should be done to remove diseased and damaged fruits.

## How to add value

- Tomatoes can be processed into tomato paste, tomato juice or tomato puree.
- Sun dried tomatoes are becoming increasingly popular in up-market supermarkets. Tomatoes can also be dried in solar and mechanical driers.
- Tomatoes can also be canned or frozen. When producing for canning, the correct variety should be grown that is suitable for canning.

## Nutritional benefits

- Tomatoes are rich in vitamin A, C and folic acid.
- They also contain lycopene which is a powerful antioxidant that works with vitamin C to break down free radicals that cause cancer.
- The fiber, vitamin C and potassium help to improve the health of the heart and reduce blood pressure. Fiber reduces risk of constipation.

# Unit 2: Potato Guide

## 2.0 Introduction

### Family, Family Members & Potato Types

**FAMILY:**
Solanaceae
**SCIENTIFIC NAME:**
Solanum tuberosum

**FAMILY MEMBERS:**
Eggplant, tomato, chillies, green pepper and tobacco

**TYPES:**
Russet potatoes, red potatoes, white potatoes, yellow potatoes, purple blue potatoes, fingering and petite potatoes

Fingerling Potatoes

Waxy Potatoes

Red Potatoes

## 2.1 Agronomy/Crop Production

### 1. Soil Testing and Land Preparation

**a. Site Selection.** The ideal site for potato production is one that which:
- Is protected from stray animals
- Has a reliable source of water
- Free from frost attack

**b. Soil**
- Medium textured loamy soils with good organic matter content and a pH of between 5.0 and 5.5 (CaCl2).
- Deep plough to 600mm. Disc and harrow land to a fine tilth which is necessary for good tuber development.

## 2. Variety Selection

**Cultivars Selection**
The choice of a variety to grow is determined by marketing requirements. Market preferences are guided by the following:

- The preferred tuber size, shape, colour and use.
- Tuber quality, adaptability and reliability, susceptibility to diseases and pests, the specific market and the planting.

## 3. Input Sourcing

It is recommended to purchase potato seed from a reputable supplier. Seed sourced from unreliable suppliers may end up affecting production through the following:

- Varity not true to type
- Uneven tuber size
- Reduced yields levels and
- High persistence of pests and diseases

## 4. Land Preparation

Preparation of land is very important for the smallholder farmer. Potatoes may be grown on ridges to enhance lifting.

## 5. What is Key During Production?

The method of land preparation adopted is usually determined:

- **Resources available:**
  A well-resourced farmer may do conventional tillage techniques for his crop.
- **Methods of irrigation:**
  The method used will also affect the methods of land preparation.

## 6. Seed

Seed is supplied in 30kg pockets containing sizes from 25 to 56 mm and an average of 400 tubers per pocket.

| Seed Type | Varietal Purity | Health |
|---|---|---|
| **Grade 'AA'** | 99.5% | • Not more than 0.25% leaf roll or severe mosaic viruses.<br>• Not more than 2% visible mild mosaic<br>• No bacterial wilt at any growth stage |
| **Grade 'A'** | 99.5% | • Not more than 1% leaf roll or severe mosaic viruses<br>• Not more than 2% visible mild mosaic |
| **Grade 'XX'** | -- | • Grade AA is available for a limited period (June-July) in any one year, while Grade A is available throughout the year.<br>• Newly sprouted seed produce the most vigorous plants and highest yield. Newly sprouted seed is used when the sprouts are between 5 and 15 mm long.<br>• Tubers which are firm, disease free, reasonably free of damage and which have strong sprouts should be selected. Seed is sorted according to size and tubers smaller than 25 mm are discarded. |

***Table 23:*** *Seed types*

## 7. Sprouting

On a commercial scale, seed potatoes are usually un-sprouted when obtained. These should preferably be sprouted under daylight conditions.

## 8. Force Sprouting

- A constant temperature of 30-35°C will initiate sprouting. Merely covering with a tarpaulin in moderate sunshine will help.
- The tubers may be stacked in an air-tight room at 21-27°C containing 0.1% acetylene gas. 30g calcium carbide will generate sufficient gas for $2m^3$.
- Immerse in acetylene solution for 4-6 hours. For 45 litres of solution 230g calcium carbide is added slowly.

- Sprouting can be retarded by storing the seed at low temperatures, for one year at 3°C, or by the application of a sprout inhibitor.

## 9. Spacing

- Plant 70-100 mm deep under irrigation.
- Dryland planting may be up to 150 mm deep.
- Inter-row spacing 900 mm and the in-row spacing 300 mm.
- Seed producers will use a spacing of 600-1200 mm between rows and from 150-160 mm in the row.

## 10. Planting Time

**a. Summer Crop**

- Normally planted in November to mature towards the end of the rainy season.
- Earlier planting leads to high yields but lifting can be difficult.
- Use late blight resistant varieties

**b. First Winter Crop**

- Planted from February to April to mature before frost according to area.
- Grow varieties resistant to Late blight.
- Supplementary irrigation is essential.

**c. Second Winter Crop**

- Plant late July to early August.
- Use flood irrigation to reduce Late blight.
- Overhead irrigation increase risk of late blight.

## 11. Planting

- Uniform tilth is required and where flood irrigation is used ridging essential.
- Where overhead irrigation is used planting is done on flat land and ridging is done later.
- Hand planting is done behind a tractor-drawn ridger, which opens the furrows.
- Tubers are placed in the open furrow and are closed by the soil.

## 12. Fertilizer Requirements

| Fertilizer Nutrient | Nutrient Status of the Soil | | |
|---|---|---|---|
| | Good | Medium | Poor |
| | Kg per Hectare of Fertilizer Nutrient Required | | |
| -- | Up to 70 | 70 to 110 | 110 to 160 |
| Phosphate | Up to 325 | 350 to 400 | 400 to 450 |
| Potash | Up to 70 | 70 to 110 | 100 to 135 |

***Table 24:*** *Fertilizer Requirements*

- Compound S 1300-2100 kg/ha.
- 100-150 kg/ha ammonium nitrate, top dressing 1-3 weeks after emergence.
- The top dressing should be applied between rows or per plant before the final earthing up.

## 13. Water Requirements

- Irrigate to a depth of 600mm at planting.
- No further irrigation is done during emergence.
- Water regularly from flower buds appearance until maturity.
- Excessive watering leads to undue leaching of nutrients and reduces the keeping quality of potatoes.

| Soil Type | Hot Months | Cold Months | Irrigation Required |
|---|---|---|---|
| Light Soils | 3-4 days | 5-7 days | 25-30mm |
| Heavy Soils | 4-5 days | 8-9 days | 30-35mm |

***Table 25:*** *Water Requirements*

## 14. Weed Control

- Avoid excessive cultivation as potatoes are shallow rooted.
- Earthing up by ridging is necessary to protect the tubers from greening, tuber-moth and Late blight
- Re-ridging should be completed by the time the plant is 25cm in hight.
- Make low ridges for efficient flood irrigation.
- Herbicides that can be used are Topogard, Dual, Sencor, MCPA and 2-4D.

## 15. Harvesting

- Destroy haulms prematurely for production of seed potato.
- Harvest when 95% of the leaves have died off.
- When chemical haulm destruction has occurred lifting should be completed within 10 days to avoid attack by Black scurf (Rhizoctonia)
- Harvest when the potato skin has hardened sufficiently to reduce physical damage during lifting.
- In hot dry conditions move tubers to a sheltered place immediately after harvesting to avoid a reduction in quality.
- Wash very muddy potatoes only.

## 16. Storage

- Between 3°C and 5°C, potatoes will only start sprouting after 8-12 months.
- Dress clean pest free tubers with 1% malathion and store in a clean room treated with a suitable insecticide.
- Seed tubers are best stored in wooden trays called chitin trays.

## 17. Yields

- Yield of up to 40t/ha can be obtained
- Average summer yield is 17-20 t/ha
- Winter crop 24-27 t/ha.

## 18. Market

- Local markets as fresh produce.

## 2.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Potatoes are harvested 120 to 150 days from planting depending on variety, e.g. BP1 is ready to harvest in 120 days while Montclare is ready for harvest after 150 days. Signs of crop maturity are yellowing of foliage and senescence.
- When harvesting seed potato the haulms are slashed after 90 to 120 days from planting. The harvested seed should be dusted with 1% Malathion dust before storage.
- The potato haulms should be slashed off 2 weeks before harvesting to ensure curing and hardening of the skin of the tubers.
- Harvesting can be done using potato lifters or digging with a hoe. Care should be taken not to cut potatoes during harvesting.
- Harvested tubers should be sheltered immediately to avoid reduction in quality
- Tubers are packaged into 15kg potato pockets for marketing and are stored in a cool, dry place, preferably in the dark to prevent greening of the tubers.
- Optimum storage temperature is between 3°C and 5°C. Potatoes can be stored for up to 8 months under these conditions.

### How to add value

- Potatoes can be processed into chips, powder, flakes, granules, canned slices or frozen.

### Nutritional benefits

- Potatoes are rich in carbohydrates, dietary fibre, potassium, calcium and folate.
- They also contain Vitamin C, but this is lost when potatoes are boiled.

# Unit 3: Green Pepper Guide

## 3.0 Introduction

### Family, Family Members & Green Pepper Types

**FAMILY:**
Solanaceae
**SCIENTIFIC NAME:**
Capsicum annuum

**FAMILY MEMBERS:**
Eggplant, tomatoes, potato, chillies, green pepper and tobacco

**TYPES:**
Bell peppers, chilli peppers, sweet peppers, scotch bonnet peppers

Bell Peppers

Chilli Peppers

Scotch Bonnet Peppers

## 3.1 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Green pepper can be harvested 2 to 3 months from planting depending on variety, with regular pickings at intervals of 1 to 2 weeks for a period of 3 months.
- Harvesting is done by hand using secateurs. Mature peppers are firm, shiny in appearance and have a fresh green calyx and stem
- Pepper can be stored at 4.5°C to 7°C for 3 to 4 weeks.

## How to reduce losses

- Harvest during the cooler times of the day to avoid over heating the produce. Avoid exposing fruits to direct sun after harvest as fruits can suffer from sun scald.
- Harvesting containers should be washed and sanitized between harvests to prevent the spreading of diseases.
- Grading should be done to remove off types, diseased and damaged products.

## Nutritional benefits

- They contain fiber, vitamin E and C.
- They contain zeaxanthin which is good for eyes and prevents the development of eye disorders related with old age.
- It contains antioxidants that prevent cancer, heart disease and are anti-inflammatory.

# Unit 4: Onion Guide

## 4.0 Introduction

### Family, Family Members & Onion Types

**FAMILY:**
Amaryllidaceae
**SCIENTIFIC NAME:**
Allium cepa

**FAMILY MEMBERS:**
Include garlic and leeks

**TYPES:**
Yellow, red, shallots

Yellow Onion

Red Onion

Shallots

## 4.1 Agronomy/Crop Production

### What needs to be done before production?

1. Soil Testing and Land Preparation

**a. Site Selection.** The ideal site for onion production is one that which:
- Is protected from stray animals
- Has a reliable source of water
- Free from frost attack

**b. Soil**
- Onions thrive well on a wide range of soil types ranging from sands through to fine textured clays. However the best results are obtained from sandy loams.

## 2. Variety Selection

**Cultivars Selection**
The choice of a variety to grow is determined by marketing requirements. Market preferences are guided by the following:

- The preferred bulb size and quality.
- Bulb adaptability and or susceptibility to diseases and pests,
- The specific market.
- Climatic condition thus basing on the natural farming region from which the farmer is located, and
- The planting time

| Variety | Days to Maturity | Yield |
|---|---|---|
| Radium | 210 - 220 | 8 – 10 t/ha |
| Texas Grano | 210 - 220 | 60 t/ha |
| White Lisbon | 180 - 200 | 10 – 25 t/ha |
| Red Pinoy | 120 - 150 | 20 – 25 t/ha |

***Table 26:*** *Cultivar description (onions)*

## 3. Input Sourcing

It is recommended to purchase seed/seedling from a reputable supplier. Seedlings sourced from unreliable suppliers may end affecting production through the following:

- Varity not true to type
- Uneven bulb size
- Bulbs ripening at different time
- Reduced yields levels and
- High persistence of pests and diseases.

## 4. Land Preparation

Preparation of beds is very important for the smallholder farmer. Raised beds are usually used where the land has high chance of getting water logged.

## 5. What is Key During Production?

The method of land preparation adopted is usually determined by:

i) **Time of planting:** Where the crop is planted in winter, raised beds or fertilizer trenches may be used. But for a summer crop use raised beds to avoid water logging.

ii) **Methods of irrigation:** the method used will also affect the methods of land preparation.

## 6. Crop Establishment

**a. Transplanting:**

- Transplant seedlings at pencil thickness thus 6-8wks old.
- It is important to harden the seedlings should be hardened through holding water for two weeks and then giving a heavy downpour on the day.

**b. Spacing:**

- Infield spacing should be 300-450mm with an in-row of 50-100mm.
- Planting should be done in shallow furrows. This will encourage bulb development. Planting too deeply will retard growth.

## 7. Seedbed

**a. Two different methods may be used to propagate onions:**

i) By transplanting seedlings from seedbeds
ii) By sawing directly into the land

A bed of 1.2m wide by 15m long will need 2kg of seedbed fertilizer. If the soils are light, an AN top dressing of 0.5kg is recommended. Seedlings should be raised late January to July.

**b. Nursery management**

- The bed may be covered with a layer of clean-disinfected grass to reduce the effect of heat from the sun and also regulate the soil temperature and conserve moisture.
- Water the seedbed using a watering-can or a hose pipe fitted with a fine rose to avoid seed splashing.
- First watering should be done to field capacity. Where the seed has germinated, one watering in the morning is sufficient. At no time should the beds be over-watered. Older seedlings should be watered 2 or 3 times a week only.
- Watering should be done regularly until the seedlings are pencil size.
- Under hot conditions, direct heat from the sun may lead to poor germination. It is advisable to shed the bed with clean grass. The shed should be at least 30cm above the ground and should be gradually reduced or removed to harden-off the seedlings once they have germinated.
- Seedlings are ready for transplanting 4-6 weeks after germination.
- In order to reduce losses at transplanting, seedlings should be hardened before being lifted from the bed. Hardening is achieved by withholding water for a week and if planted in shade, this shed should be gradually reduced until the seedlings are in full sun. The seedlings should be watered thoroughly a day before transplanting.

## 8. Transplanting

- Transplant seedlings 4-6 weeks from emergence or when they are approximately pencil size thus 10-12cm tall. Select healthy seedlings only.
- Transplant during the morning or late in the afternoon when it is cool or on a cloudy day.

## 9. Seedling Placement

- Seedlings should be placed carefully in planting stations opened either through the use a hoe or a dibber.
- The transplants should be placed in the hole so that the roots are not exposed to the sun and that the stem above the roots does not come into contact with wet soil to avoid fungal infection.
- Ensure that some soil is kept on the roots during lifting from the seed bed or put them in a Hasan sack to keep them damp.
- Ensure that there is firm contact between the soil and the roots
- Do not plant onions in the irrigation furrow. Plant them on top of the ridge where they will not get into contact with flowing water. This will protect them against water borne diseases.

## 10. Fertilizer Management

**a. In Seedbed**

- Use Seed bed fertilizer at a rate of 2kg per 18m²
- Onion respond very well to organic manure applied at 40t/ha

**b. In-Field Fertilizer Management**

i) Basal Application

- Basal application Tobacco fertilizer, or Vergfertilizer at 1000-1300kg/ha

ii) Top dressing

- 100kg/ha Ammonium Nitrate 2-3 weeks after emergence.
- Too much Nitrogen causes delayed bulbing and causes bullnecks
- 1kg/ha Zinc oxide for zinc deficient soils is recommended

## 11. Pest & Disease Management

### Weed Management

| Weed | Chemical | LR/SR (Long /short residual effect) | Yield |
|---|---|---|---|
| Annual and perennial grasses | Fusilade super Ronstar | 3 months | Apply early post-emergence of grass and crop<br>Apply immediately after planting seedlings or sets |
| Broad leaves and grasses | Goal | --- | Apply to clean land at 10 to 18 days after transplanting |

***Table 27:*** *Weed Management*

## 12. Insect Pest and Diseases

### a) Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Thrips** | Silvery or blanched appearance on leaves, tender centre leaves become curled and deformed, outer leaves turn brown at tips | Actara 25 WG 600g/ha<br>Karate 5EC/CS120ml/ha | 7days<br>3days | Spray a 1st sign of infestation repeat after 2-3 weeks. |
| **Cutworm** | Cuts plants at the base | Karate 5EC/5SC | 2days | Spray over transplants 150-200ml/ha (Check pyrethroid dates) |

***Table 28:*** *Insect Pests*

### b) Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Purple Blotch (Alternaria)** | Small irregular white patches on the leaves | Dithane M45<br>Ridomil<br>Score 250 EC<br>Ortiva 250 EC | 3 days | Spray at 1st sign of infection. Repeat 10-14 days alternate the 2 chemicals. |
| **Downy Mildew White Tip** | Grey down covering the leaves | Dithane M45<br>Bravo 720 SC<br>MZ 68 WG<br>Ridomil Gold | 3days<br>14days<br>3days | Spray preventively 7 – 14 days. Maximum of 3 sprays. |
| **White Bulb Rot** | Black sooty like mould between the scales | Benlate<br>Quintozene | 14days | --- |
| **Neck Rot** | --- | Bravo720SC | -- | Spray preventively 7 – 14 days. |
| **Seedling disease /Soil borne fungi** | --- | Apron Star 42 WS | -- | Mix with 40ml water then seed, shake well. |

***Table 29:*** *Disease*

## 13. Yield

- Vary from 20-100 t/ha

## 4.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

Onions can be harvested when 50% of the tops have collapsed. Harvesting should be done when the weather is dry. Harvesting can be done mechanically using a lifter or by hand using garden forks. After harvesting the onions should be arranged into windrows and left in the field to cure for up to 10 days. If it rains onion bulbs should be removed from the field. Most markets locally (formal and informal) prefer bulbs with firm and tight neck, so after harvesting sort and grade to remove all thick-necked onions.

### Drying and storage

Onion for immediate use are not dried. Such onions should be marketed within a week of harvesting. For distant markets and most formal markets, onion bulbs should be adequately cured before storage and marketing. Well ventilated rooms and dryers may be used to dry the onions. Dryer are most preferred for drying since properly dried onion have a longer shelf-life and most dryers help bring out the uniform and shiny golden-brown skin which most markets prefer. Wire nets or polythene pockets can be used to store the bulbs.

Box barns are particularly well suited for drying onions. Wooden or metal boxes of the same dimensions as the tobacco boxes may be built for less than $100 each. Depending on the make and model of the barn, these boxes may have a capacity of up to 75 bushels each and can be trucked to the field for filling. *Photograph 8* illustrates onion drying in a tobacco-curing barn.

***Photograph 8:***
*Onions drying in a box type tobacco barn*

## How to reduce losses

- Avoid over application of water and nitrogen in the field as this result in thick-necked bulbs which have shorter shelf-life and causes high post-harvest losses.
- Store in a well-ventilated shed with low temperature and low humidity. Onion bulbs should be stored under dry conditions at a relative humidity of 65 to 70% and a temperature of 0oC. The storage period varies with variety with red onions storing longer than brown onions.
- In storage, bulbs should not be exposed to light as this will lead to greening
- A pre-harvest application of a sprout suppressant such as maleic hydrazide is used to prevent the premature sprouting of onions during storage
- Inspect your store-room weekly and remove all spoiled bulbs as these will accelerate deterioration of other good quality onions.

## How to add value

- Onions can be dried and ground into powder. The ground onions are used to make onion salt by mixing the onion powder and salt using a ratio of 1 part onion to 4 parts salt
- Onions can be canned or pickled
- Pink colours peels from red onion varieties can be used to make natural dye

## Nutritional benefits

- Onions contain antioxidants that breakdown free radicals in the body
- They are also rich in vitamin C, sulphur

# Unit 5: Garlic Guide

## 5.0 Introduction

### Family, Family Members & Garlic Types

**FAMILY:**
Amaryllidaceae
**SCIENTIFIC NAME:**
Allium sativum

**FAMILY MEMBERS:**
leek and onion

**TYPES:**
Culinary garlic, purple stripe garlic

Culinary Garlic

Purple Stripe Garlic

Garlic Seedlings

## 5.1 Agronomy/Crop Production

1. What needs to be done before production?

**Site Selection -** The ideal site for garlic production is the one which is protected from stray animals, has a reliable source of water and free from frost attack. Garlic is frost hardy and requires well drained soils with good tilth; soil pH should range 5.5-6.0 ($CaCl^2$). Optimum temperature is 12-16°C and the best planting is April to May.

**Variety Selection -** The choice of a variety to grow is determined by marketing requirements.

**Seed Rate -** The seed rate is 315–500 cloves /ha.

## 2. What is key during production?

The method of land preparation adopted is usually determined by:

**i. Time of planting:** Where the crop is planted in winter, raised beds may be used. But for a summer crop, use raised beds to avoid water logging.
**ii. Methods of irrigation:** The method used will also affect the methods of land preparation.

## 3. Crop Establishment

**a. Transplanting:**

- Highveld - August to April
- Lowveld - January to May.
- Use certified disease-free seed.
- Heat-treat at 500°C for 25 minutes to eliminate seed borne diseases.
- Dry and dust with 2g Thiram/kg seed.
- Sow seed in seedbeds at 300-450 g/ha.
- Seed takes 7-14 days to emergence
- Emergence to transplanting takes 4 to 8 weeks depending on variety.
- Harden seedlings and transplant at 10-15 cm tall.

**b) Spacing:**

- Rows spacing is 20 cm.
- Place the cloves at 8-10 cm apart in the row
- Separate cloves carefully to avoid double cloves which give twin plants and misshaped bulbs
- Plant with the tip of clove just above ground level

## 4. Seedbed

**Two different methods may be used to propagate onions:**

i. By transplanting seedlings from seedbeds
ii. By sawing directly into the land

A bed of 1.2m wide by 15m long will need 2kg of seedbedfertilizer. If the soils are light, an AN top dressing of 0.5kg is recommended. Seedlings should be raised late January to July.

## 5. Fertilizer Management

- Basal dressing, Compound C at 350-500 kg /ha is recommended
- Top dress with 200-300 kg /ha AN per month after planting.
- Garlic also responds well to Organic Manure.

## 6. Water Requirements

- Never allow garlic to run short of moisture. Water to field capacity.
- Water less frequently but increase the rate during bulb enlargement and cease watering one month before harvesting

## 7. Pest & Disease Management

### Weed Management

| Weed | Chemical/Rate | Stage of application | Chemical/Rate |
|---|---|---|---|
| **Annual and certain broad leaf weeds** | Trifluralin | Cross-disced into soil before transplanting | --- |
| **Annual and certain broad leaf weeds** | Lasso | After first transplanting irrigation but before weeds emerge | --- |
| **Annual and Perennial grasses** | Fusillade Super | Apply after weed emergence | --- |
| **Annual grasses and some broadleaf weeds** | Dual Magnum 960EC / 0.7-1.2L/ha | Pre-emergence for grass weeds: crop planted. Spray after transplanting irrigation | Rate depends on % clay |
| **Nut sedge purple; yellow** | Dual Magnum 960EC / 1.0 - 1.5 L/ha | Spray after transplanting irrigation | Suppression only |
| **Grass weeds** | Fusilade Forte 150 EC<br>0.3-2L/ha<br>1.25-6.7L/ha | Post-emergence | Annual grasses –depends on size and species<br>Perennial grasses-rate depends on size of grass |
| **All weeds** | Gramoxone 200SL/.5-2L/ha | Post-emergence before transplanting | Rate depends on size of weeds |

***Table 30:*** *Weed Management*

## 8. Insect Pest and Diseases

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Bagrada Bug** | Leaves wither and young plants may die in severe attack | Dichlorvos 5% EC at 200 ml/100 litres water, or Parathion 25 WP at 125g/100 litres water<br>Gamma BHC | 30 days | --- |
| **Cabbage Aphids** | Feed on the crop leaves and stems | Dimethoate 40% EC at 75ml/100 litres water<br>Chess 50WG-200g/ha | 14 days | Spray in 300-500 L water/ha at 1st sign of infestation |
| **Cutworms** | Slash young plants stems at the base | Bait made up of 100kg mealie meal plus 625g endosulfan, 50% WP is applied to the ground before planting or near plants in the late afternoon<br>Use Mavrik 2 E, Carbaryl 85 WP and<br>Dursban Karate 5EC | --- | --- |
| **Red Spider Mite** | Causes silvering and mottling of the leaves | Same as for aphids | --- | --- |
| **Diamond-back Moth** | Irregular holes, sometimes leaving the upper surface of the leaf in place (windowing) | Karate5EC/5SC 8ml/100Lwater/ha<br>Match 600ml/ha | 2 days<br>14 days | Apply every 14 days in 500L water/ha when pest is noticed<br>As for Karate 5EC Alternate with insecticides of different groups. Do not exceed 6 sprays |
| **Webworm** | Deformed growth and the formation of many growing points | Same as for Diamondback moth | --- | --- |
| **Leaf miner** | Burrowing into leaves causing them to fall or become unmarketable | Same as for cabbage aphids | --- | --- |

***Table 31:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Bacterial Black Rot** | Death of seedling leaves completely after they turn dark in colour. When the plants are larger, the disease causes yellow V-shaped areas at the edge of the leaves, particularly lower leaves near to the soil. | Use resistant varieties<br>Use certified disease free seed<br>Bion 50WG | 7 days | Spray 3-4 times after transplanting every 2-3 weeks<br>Use lower level when mixed with copper |
| **Bacterial Soft Rot** | Turns soft and rotten with a bad smell | Plant on ridges to prevent water logging around the plants<br>Prevention of other diseases will reduce the ability of soft rot to penetrate the crop.<br>Avoid growing cabbages in the same field for at least 3 seasons | --- | Avoid harvesting under warm moist conditions<br>Wash and disinfect hands and harvesting knives |
| **Downy mildew** | Fluffy fungal growth on the underside of the leaf | Dithane M45 at 200g/100 litres water every 7 to 10 days<br>Dip seedlings at transplanting<br>Ridomil Gold Mz 68WG-1.5kg/ha | --- | Spray after cooper and Bravo. Max 3 sprays |
| **Damping off** | Damping off and wire stem of seedlings in the seedbed<br>Bottom rot and head rot in growing cabbage crops or after harvest | Sow seed thinly and drench with Thiram at 10g/5 litres of water each week | --- | --- |

***Table 32:*** *Diseases*

NB: Alternate chemicals to reduce incidences of pests and disease resistance; crop rotation may be used to control pests, weeds and diseases.

## 9. Harvesting

- Crop matures 4-6 months after planting
- Harvest in August to October when conditions are dry
- Lift bulbs and leave to cure on the ground for a week

### 10. Yields

- 8-12 tonnes /ha

### 11. Post-Harvest

- At higher temperatures of (26 –3°C) garlic can be stored for 1 month
- Intermediate temperatures (4.4 –18°C) favours rapid sprouting and high relative humidity cause moulding
- At 0°C and 65% relative humidity, garlic stores for 28-36 weeks

### 12. Market

- Local or export market as fresh produce

## 5.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

Garlic is harvested when the tops have fallen and are completely dry. This is usually 100 to 140 days from planting. Harvesting can be done by hand pulling or using garden forks. After lifting the bulbs must be left in windrows to cure for 7 to 10 days in the field. High quality bulbs are clean, white (colour is dependent on the variety grown) and well cured. A well cured bulb is one with a dry neck and outer leaves. The bulb should be firm to touch. The minimum bulb diameter required on the fresh market is 4cm.
(Cantwell, 2006)

### How to reduce losses

- The leaves and roots of the bulb should be trimmed off in order to remove soil in order to prevent the movement of pathogens into storage

- Selection of good varieties.

- Judicious use of nitrogenous fertilizers and irrigation water
- Timely harvesting and proper curing bulbs
- Proper drying of leaves and shade curing
- Fumigation and use of ventilated store reduces the storage losses
- Avoid storing the bulbs in bags
- The storage room should be kept dry with a relative humidity of 70% or lower and the temperature should be 0-1°C. Under these conditions the garlic can be stored for 6 to 7 months. Garlic that is intended to be planted as seed should be stored at 10°C and a relative humidity of 60% to 70%.

## How to add value

- Garlic can be processed further by drying using hot air driers. The dried garlic can be ground into a powder to make garlic powder or mixed with salt to make garlic salt.
- It can also be used to make dried garlic chips or garlic flakes
- Garlic can also be pickled

## Nutritional benefits

- Garlic has a characteristic pungent, spicy flavor
- It is also claimed to help prevent heart disease including atherosclerosis, high cholesterol, high blood pressure, and cancer.
- Garlic is a relatively good source of calcium, phosphorus, and potassium. Its leaves are sources of protein and of Vitamins A and C.
- It is also used for pharmaceutical purposes due to its health promoting and disinfection properties when applied externally.

# Unit 6: Cabbage Guide

## 6.0 Introduction

### Family, Family Members & Cabbage Types

**FAMILY:**
Brassicaceae (also Cruciferae)

**SCIENTIFIC NAME:**
Brassica oleracea

**FAMILY MEMBERS:**
includes several classes of cabbage (ordinary cabbages, Chinese head, cauliflower, broccoli, Brussels sprouts, kale, rape and mustard)

**CABBAGE CULTIVARS (Brassica oleracea var. capitata:**
include several groups such as small pointed ones, small to medium round compact ones, dark green crinkly 'savoy' type and purple cabbages

Ordinary Cabbage

Purple Cabbage

Savoy Cabbage

## 6.1 Agronomy/Crop Production

### 1. Overview

Ordinary cabbages are direct substitutes of leafy vegetable hence have a high demand as they have a longer shelf-life than leafy vegetables such as rape and covo. Cabbage demand and prices are affected by availability of rape, covo and tsunga as they generally serve the same purpose.

Purple and savoy cabbages are generally demanded in smaller quantities by the upmarket buyers and are mainly used in making salads.

## 2. Pest & Disease Management

### Weed Management

| Weed | Chemical/Rate | Stage of application | Chemical/Rate |
|---|---|---|---|
| **Annual and certain broad leaf weeds** | Trifluralin | Cross-disced into soil before transplanting | --- |
| **Annual and certain broad leaf weeds** | Lasso | After first transplanting irrigation but before weeds emerge | --- |
| **Annual and Perennial grasses** | Fusillade Super | Apply after weed emergence | --- |
| **Annual grasses and some broadleaf weeds** | Dual Magnum 960EC / 0.7-1.2L/ha | Pre-emergence for grass weeds: crop planted. Spray after transplanting irrigation | Rate depends on % clay |
| **Nut sedge purple; yellow** | Dual Magnum 960EC / 1.0 - 1.5 L/ha | Spray after transplanting irrigation | Suppression only |
| **Grass weeds** | Fusilade Forte 150 EC<br>0.3-2L/ha<br>1.25-6.7L/ha | Post-emergence | Annual grasses –depends on size and species<br>Perennial grasses-rate depends on size of grass |
| **All weeds** | Gramoxone 200SL/.5-2L/ha | Post-emergence before transplanting | Rate depends on size of weeds |

***Table 33:*** *Cabbage diseases*

## 3. Insect Pest and Diseases

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Bagrada Bug** | Leaves wither and young plants may die in severe attack | Dichlorvos 5% EC at 200 ml/100 litres water, or Parathion 25 WP at 125g/100 litres water<br>Gamma BHC | 30 days | --- |
| **Aphids** | Feed on the crop leaves and stems | Dimethoate 40% EC at 75ml/100 litres water<br>Chess 50WG-200g/ha | 14 days | Spray in 300-500 L water/ha at 1st sign of infestation |
| **Cutworms** | Slash young plants stems at the base | Bait made up of 100kg mealie meal plus 625g endosulfan, 50% WP is applied to the ground before planting or near plants in the late afternoon<br>Use Mavrik 2 E, Carbaryl 85 WP and<br>Dursban Karate 5EC | --- | --- |
| **Red Spider Mite** | Causes silvering and mottling of the leaves | Same as for aphids | --- | --- |
| **Diamond-back Moth** | Irregular holes, sometimes leaving the upper surface of the leaf in place (windowing) | Karate5EC/5SC 8ml/100Lwater/ha<br>Match 600ml/ha | 2 days<br>14 days | Apply every 14 days in 500L water/ha when pest is noticed<br>As for Karate 5EC Alternate with insecticides of different groups. Do not exceed 6 sprays |
| **Webworm** | Deformed growth and the formation of many growing points | Same as for Diamondback moth | --- | --- |
| **Leaf miner** | Burrowing into leaves causing them to fall or become unmarketable | Same as for aphids | --- | --- |

***Table 34:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Bacterial Black Rot** | Death of seedling leaves completely after they turn dark in colour. When the plants are larger, the disease causes yellow V-shaped areas at the edge of the leaves, particularly lower leaves near to the soil. | Use resistant varieties<br>Use certified disease free seed<br>Bion 50WG | 7 days | Spray 3-4 times after transplanting every 2-3 weeks<br>Use lower level when mixed with copper |
| **Bacterial Soft Rot** | Turns soft and rotten with a bad smell | Plant on ridges to prevent water logging around the plants<br>Prevention of other diseases will reduce the ability of soft rot to penetrate the crop.<br>Avoid growing cabbages in the same field for at least 3 seasons | --- | Avoid harvesting under warm moist conditions<br>Wash and disinfect hands and harvesting knives |
| **Downy mildew** | Fluffy fungal growth on the underside of the leaf | Dithane M45 at 200g/100 litres water every 7 to 10 days<br>Dip seedlings at transplanting<br>Ridomil Gold Mz 68WG-1.5kg/ha | --- | Spray after cooper and Bravo. Max 3 sprays |
| **Damping off** | Damping off and wire stem of seedlings in the seedbed<br>Bottom rot and head rot in growing cabbage crops or after harvest | Sow seed thinly and drench with Thiram at 10g/5 litres of water each week | --- | --- |

***Table 35:*** *Diseases*

NB: Alternate chemicals to reduce incidences of pests and disease resistance; crop rotation may be used to control pests, weeds and diseases.

## 4. Harvesting

- Harvest at 60 to 90 days after transplanting depending on variety
- Harvesting may be for a period of 15 to 20 days

5. Yields

- Open pollinated varieties yield 30 - 35 tonnes/ha
- F1 hybrids yield 50 - 75 tonnes/ha

6. Market

- Local markets mainly as fresh or dried

## 6.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Mechanical harvesting of heads is possible but this is advance production systems
- In Zimbabwe cabbages are usually harvested by hand
- The head is harvested by bending it to one side and cutting it with a sharp knife. Harvesting knives should be sharpened frequently to reduce effort and lessen picker fatigue. The head should not be removed by snapping or twisting it since this practice damages the head and results in inconsistent stalk length and trim. Broken stalks are also more susceptible to decay.
- The stalk should be cut flat and as close to the head as possible, yet long enough to retain two to four wrapper leaves. Extra leaves act as cushions during handling and may be desired in certain markets.
- Harvesting time varies with variety as some varieties are early maturing while others are late maturing. Harvesting can be done up to 3 times as the heads do not mature at the same time
- Cabbage freshness can be determined by rubbing two heads together. Fresh cabbages will make a squeaking sound when rubbed against each other.
- If it is necessary to store cabbages they should be stored at 0°C and 98% relative humidity

## How to reduce loss

- The harvesters should avoid rough handling of the cabbage heads
- The harvesters should be trained on good sanitation techniques and how to select mature heads for harvesting
- Grading should be done where yellow, damaged or diseased leaves are removed from the cabbage heads. Heads with insect damage and defects should be discarded
- Heads should be placed in a cool place immediately after harvest to reduce field heat

## How to add value

- Cabbage can be dried and sold as dried vegetables mixed with other vegetables such as tomatoes and peppers.
- It can also be processed to make cabbage juice or it can be pickled. It can be shredded and sold as packaged shredded cabbage used for making coleslaw.

## Nutritional benefits

- Cabbages are a good source of vitamin B6, C, K, folate acid, manganese, potassium, calcium, iron, magnesium and phosphorous.
- Cabbage juice is known to treat digestive disorders such as peptic ulcers and it acts as a natural laxative.
- Red cabbage has a higher concentration of anthocyanins than white cabbage making it a better antioxidant and anti-inflammatory.
- Cabbages are also rich in glucosinolates and are good at preventing cancer.

# Unit 7: Rape/Covo Guide

## 7.0 Introduction

### Family, Family Members & Rape/Covo Types

**FAMILY:**
Brassicaceae (also Cruciferae)

**SCIENTIFIC NAME:**
Brassica napus

**FAMILY MEMBERS:**
includes several classes of cabbage (ordinary cabbages, Chinese head, cauliflower, broccoli, Brussels sprouts).

Covo/Chomolia

Covo/Chomolia

Covo/Chomolia

## 7.1 Agronomy/Crop Production

### 1. What needs to be done before production?

**Soil -** Leafy vegetables generally grow best in fertile, loamy, well-drained soils are ideal. They respond well to the addition of organic matter such as chicken, goat or cattle.

**Sowing Seed -** Beds should be made up to a good tilth and fertilized with Seedbed fertilizer (7-21-8) at 60 g/m². Farmers should sow seeds in rows 15cm apart and 1cm deep. Germination normally takes 4 - 7 days.

**Transplanting -** Seedlings should be transplanted when they are about 15cm (6 weeks after sowing). When transplanting, inter-row spacing of 400mm and in-row spacing of 150mm.

**Fertilizer Requirements -** Rape is a heavy feeder, so they require fairly heavy applications of fertilizer.

Rape or covo require 700-100kg of compound C or S and regular top dressing with 200-300kg Ammonium Nitrate.

## 2. Insect Pest and Diseases

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Cutworms** | These are greyish-brown caterpillars which attack the stem at ground level in either the seedbeds or shortly after planting out | Karate, Dursban 4 E (Chlorpyrifos)<br>Dipterex 95 SP | --- | Apply along the crop rows immediately after transplanting the seedlings or in seedbeds |
| **Aphids** | ---- | Disyston 5% G<br>Rogor (Dimethoate) Water<br>Apron Star 42 WS<br>Diazinon 30 EC | --- | Disyston 5% G applied at planting at a rate of 200g/100m of planting furrow<br>Rogor (Dimethoate) water as a full cover spray applying<br>Apron Star 42 WS applied as a seed dressing<br>Diazinon 30 EC as a full cover spray |
| **Diamond-back Moth** | --- | Malathion 25 WP, Orthene 75 SP, Tamaron 600 SL | --- | --- |

***Table 36:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Damping Off** | Seed and young seedlings are attacked and may rot before they emerge or topple over a few days afterwards | Apron Star 42 WS as a seed dressing | For up to 4 weeks after sowing | Control other diseases as well as protect seedlings from aphids for up to 4 weeks after sowing OR Thiram 80 WP as a seed dressing |

***Table 37:*** *Diseases*

## 3. Yields

Yields target of 25 – 50t/ha

## 7.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Rape leaves are ready to harvest 60 days from planting
- The leaves are harvested by hand and a sharp knife is used to cut the leaf away from the stem
- Leaves should be harvested when they are 25 to 30 cm long
- Harvesting can be done 6 to 8 times

### How to reduce losses

- Harvesting should be done early in the morning or late afternoon when the weather is cool
- Leaves should not be kept in the sun after harvesting. Leaves should be taken to a cool shed immediately after harvest
- Leaves are sold in bundles and bundles are made up of 35 leaves

### How to add value

- Value addition can be done by drying the rape and mixing it with other vegetables such as tomatoes, onions or chillies

### Nutritional benefits

- Rape is rich in minerals and vitamins A and C

# Unit 8: Butternut Guide

## 8.0 Introduction

### Family, Family Members & Butternut Types

**FAMILY:**
Curcubitaceae
**SCIENTIFIC NAME:**
Cucurbita moschata

**FAMILY MEMBERS:**
include cucumbers, gem squash, baby marrow, pumpkins and water melons

**TYPES:**
Butternut fruit, butternut squash

Butternut Fruit

Butternut Squash

Butternut Fruit

## 8.1 Agronomy/Crop Production

1. What needs to be done before production?

**Soils -** Well-drained soils and very sensitive to water-logging. Use of raised beds should be considered in areas prone to waterlogging. Grows well on an organic-rich medium hence soil amendments with well decomposed compost should be considered.

**Variety selection -** Farmers should practise buying certified seed that is true to type and has high yielding potential from reputable seed houses and refrain from using retained seed example Waltham is a common variety.

**Land Preparation -** Soil should be thoroughly prepared and deeply loosened before planting. Any residue from previous crops should be well-rotted. The use of raised beds should be considered if high rainfall that

could lead to waterlogging is expected.

## 2. What is key during production?

**Spacing -** A variety of spatial arrangements may be used, but a final population of 14 - 18,000 plants per hectare is normally targeted. An in-row spacing of 40 cm and between rows of 1.5m is most common.

**Nursery Management -** Most butternuts are direct-sown, Early in the season, some growers use seedlings in order to establish an early crop. If farmers go the nursery route, seedlings must be transplanted before they become root-bound in seed trays.

**Fertilizer Management -** Application of excessive top dressing results in vegetative growth at the expense of fruit bearing.

**Water Management -** Butternuts can be produced under dryland conditions but will produce much better results where irrigated. Water requirement will vary with soil type, season and growth stage. Avoid over irrigation and waterlogging.

## 3. Insect Pest and Diseases

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Red spider mite** | Leaves loose colour curling and drying of leaves | Spray Nuvacron 40, at 50ml/10L Water | --- | --- |
| **Root-knot nematode** | Swollen roots and stunted growth | Observe a four year rotation, avoiding the solanaceae family of potato,tomato, paprika etc | --- | --- |
| **Aphids** | Stunted growth, inside curled leaves with aphids at growth tips | Spray dimethoate 40EC at 7.5ml/10l of water | --- | --- |
| **Pumpkin Fly** | Rotting of fruits, worms observed inside the fruit | Lebaycid , Malathion | --- | --- |

***Table 38:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Fusarium wilt** | Soil-borne disease, takes about 2 weeks to by necrosis of older leaves | Dust seed with Thiram and use resistant cultivars | --- | --- |
| **Anthracnose** | Black spots on leaf stalk, stem and sunken lesions on the fruits. Spores visible on mycelium | Apply Dithane M 45 at 20g/10L water | --- | --- |
| **Downey mildew** | Circular brown spots on leaves with a yellowish halo. Looks like frost damage in advanced stages | Spray dimethoate 40EC at 7.5ml/10l of water | --- | --- |
| **Powdery mildew** | White powdery spots on the leaves | Bavistin at 5 g/10 litres of water, once a week | --- | --- |
| **Cucumber mosaic** | Chlorosis of leaves | Rogue out and destroy infected plants | --- | --- |

***Table 39:*** *Diseases*

## 8.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Butternuts are ready to harvest 110 to 120 days from planting depending on variety.
- Harvesting is done using a sharp knife and a short stem should be left attached to the fruit to prevent post-harvest entry of pathogens into the fruit.
- Butternut is ready to harvest when the skin has become hard and cannot be easily pierced with a fingernail. The skin should have coloured and not have green lines on it.
- The internal quality attributes include deep colour due to high carotenoid levels and high dry weight.

- Fruit that is harvested when it is wet and muddy should be washed and dried before packing and storage.
- Butternuts can be stored for up to 7 months at 15°C and 60% relative humidity.

## How to reduce loss

- Do not remove the stem from the fruit at harvest. This will prevent entry of pathogens into the fruit
- Avoid damaging fruits
- Avoid harvesting immature fruits. Immature fruits will have a poor eating quality as they have less stored carbohydrates.
- Immature fruits will lose weight faster than mature fruits during storage and they are more susceptible to decay.

## How to add value

- Butternuts can be processed into butternut puree and it can be frozen or pressure canned.

## Nutritional benefits

- Butternuts contain vitamins A and C, potassium, manganese and fibre.
- It contains antioxidants, has low calories, no saturated fats or cholesterol.
- The seeds are a good source of fibre and monounsaturated fatty acids that are good for the heart.

# Unit 9: Gem Squash Guide

## 9.0 Introduction

### Family, Family Members & Gem Squash Types

**FAMILY:**
Curcubitaceae
**SCIENTIFIC NAME:**
Cucurbita pepo var. pepo

**FAMILY MEMBERS:**
Include water melon, cucumber, baby marrow, pumpkin, butternut

**TYPES:**
Yellow squash, gem squash

Yellow Squash growing on vine

Flowering Squash Plant

Gem Squash Fruit

## 9.1 Agronomy/Crop Production

1. What needs to be done before production?

**Climatic Requirements -** Ideal soil temperature for ***germination*** is 20–25°C (minimum 16°C). Ideal temperature for ***growth*** is 18–24°C.

**Soil pH -** Soil ph 6.0 – 7.0 and well drained soils, low salt level and high organic matter.

**Product Types -** The form of gem squash does not vary greatly, most are round to slightly oval with a dark green colour. A certain amount of yellow speckling may be seen.

### 2. Cultivation Practices

**Soil Preparation -** Soil should be thoroughly prepared and deeply loosened before planting. Any residue from previous crops should be well-rotted. The use of raised beds should be considered if high rainfall that could lead to waterlogging is expected.

**Planting Periods -** Gem squash is sensitive to cold temperatures and frost will kill young plants and damage older ones. The crop can be planted anywhere there is no danger of frost during the growing period.

**Planting -** Most gem squash is direct-sown, that is the seed is planted directly into the soil. Early in the season, some growers use seedlings in order to establish an early crop. Seedlings must be transplanted before they become root-bound in seed trays.

**Spacing -** A variety of spatial arrangements may be used, but a final population of 12 - 15,000 plants per hectare is normally targeted. Some of the newer hybrids show a more restricted growth habit and these can be planted at populations of 18-20,000 plants per hectare.

## 9.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Gem squash is ready to harvest when the fruits are about the size of a tennis ball and the skin is tough enough that it cannot be pierced with a fingernail.
- The fruit can be harvested in 50 to 60 days if the market requires baby fruit. If the market requires mature fruit it can be harvested in 70 to 80 days.
- Harvesting is done using a sharp knife. A short piece of the stem (2cm) should be left attached to the fruit.
- The harvested fruit should be wiped clean.
- Gem squash can be stored for up to three months.

## How to prevent loss

- Care should be taken not to remove the stalk from the fruit at harvesting.
- Grading should be done to separate bruised and diseased fruits from healthy fruits.
- Gem squash is chilling sensitive and should not be stored below 10°C.
- Avoid harvesting immature fruits

## Nutritional benefits

- Gem squash contains vitamin A and C, calcium and iron.
- Gem squash contains carotene which prevents cancer and lung disease, high blood pressure, heart disease and type 2 diabetes.
- Vitamin C boosts the immune system, preventing colds and helps to fight allergies.
- Gem squash contains coumarins which interact with other nutrients in the body to work as anticoagulants and therefore act as blood thinners. This is beneficial to people with high blood pressure and poor blood circulation.

# Unit 10: Carrot Guide

## 10.0 Introduction

### Family, Family Members & Carrot Types

**FAMILY:**
Apiaceae/ Umbelliferae

**SCIENTIFIC NAME:**
Daucus carota

**FAMILY MEMBERS:**
Parsnip, celery, coriander and parsley

Carrots

Mini Carrots

Romeo 'turnip-type' Carrots

## 10.1 Agronomy/Crop Production

### 1. What needs to be done before production?

**Soils -** Best grow in deep well-drained soils. Heavy clay or compacted soil will not give the best shape and carrot sizes whilst or stony soils cause misshapen roots and produce poor quality carrots. Optimum pH range 6,5- 7,5 hence lime should be applied, at least 30 days before planting, if the pH is less than 6,5.

**Variety Selection -** This should be driven by market requirements since attributes vary, for instance colours may vary from yellow, orange, red to purple or black.

**Land Preparation -** Carrot seed is very small (800,000 to 1,100,000 seeds/kg) and the crop is direct sown therefore a fine tilth is a requirement for good germination. Make beds 1,5m wide and leave paths

50cm in-between beds. Before planting you need to water to filed capacity and make drills 30cm apart.

## 2. What is key during production?

**Spacing -** Seed rate is 5kg/ha. Sowing too thickly results in an uneven; extended germination period and time consuming since you need heavy thinning. Mixing seed with sand in a ratio of 1:5 helps achieve even distribution. Smallholder farmers can drill using a tin with a 5mm drilled hole at the bottom if the tin and use a 20:1 soil mixture ratio.

**Early Established Crop Management -** Thinning should be done 4-5 weeks after germination to maintain an in-row spacing of 5 inches. Weeding should be done early to avoid disturbing root development.

**Fertilizer Management -** In sandy soils or soils with a phosphorous content of less than 100ppm as depicted on the soil analysis results, application of between 100-200 kg/ha Double Super phosphate, or 200–400 kg/ha Single Super Phosphate in addition to the basal fertilizer (400kg compound C, J or S) is needed. Broadcast 150kg basal fertilizer during bed making and the balance in farrows at planting. Top dressing- apply 100kg AN/ha at 6 weeks if there are signs of deficiency.

**Water Management -** Low soil moisture gives rise to long tapering with good colour. High moisture content causes roots to be shorter, thicker and paler in colour. A uniform water supply is critical for good colour and root formation. Carrots are usually irrigated by sprinklers to establish a stand and then furrow-irrigated. Irrigation should be frequent after germination and during the early stages of growth. Carrots lifted from wet soils tend to crack and are more susceptible to damage. The soil should therefore be allowed to dry out to some extent before harvesting.

## 2. Pest & Disease Management

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Aphids, Carrot Root Fly** | Sucking pests<br>Leaves wilt and turn yellow | Polo 5000, Actara 25WG, Pegasus | 3 days | --- |
| **Nematodes** | Attack the root and cause slow growth<br>Tubers are deformed, forked or stringy | Crop rotation and use of resistant plants and soil disinfection | 7 days | --- |
| **Cutworm** | Slashing of young plants below or at ground level | Band spray over crop at emergence. Apply in 150-200l/ha | --- | --- |
| **Leaf miners** | Leaf discolouration due to chlorophyll loss | Dynamec 18EC @ 250-500ml/ha | --- | --- |

***Table 40:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| **Powdery Mildew** | Whitish growth on leaf and stem surface | Dithane M45 at 30g/15l water or Benomyl at 30 ml/15 l water; Thiovit 80WG@ 2-3kg/ha; Topas 100 EC | --- | Spray at 1st sign of infection every 10-14 days |
| **Alternaria Leaf Blight & Cercospora Leaf Blight** | Blackening of foliage which subsequently dies | Score 250EC@ 250-500ml/ha; Bravo 500SC@ 2l/ha; Alto 100SL@ 300ml/ha; Dithane M45 20g/ 10L; Copper Oxychloride 85% WP 200g/100L every 7 – 10 days | --- | --- |
| **Bacterial Soft Rot** | Reduce the carrots to a soft slimy mass | Grow in well drained soils; Rotation– do not follow carrots after lettuce or cabbage. The roots must be kept well ventilated after lifting | --- | --- |

***Table 41:*** *Diseases*

## 10.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Need to refer to buyer's specifications for maturity levels.
- Generally, harvesting should be done 3 to 4 months from planting, when the root diameter is 2cm, depending on variety.
- Harvesting is done using garden forks or hand pulling. Wash roots before taking them the market.
- Depending on the market carrots can be sold in bunches or in punnets. Bunched carrots have a shorter shelf because they have a higher respiration rate than carrots that have been topped and are in punnets. Packed carrots can be stored for up to 9 months at 0°C and a relative humidity of 98%.

### How to reduce losses

- Harvesting should be done when it is cool to extend shelf life. Low soil temperatures improve the storage potential of carrots by cooling the roots before they are harvested, and creating conditions that are not conducive for the growth of pathogens.
- Avoid exposing the roots to direct sun for long periods of time.
- Harvested carrots must be sorted to remove diseased, defective, cracked and undersized roots.

### How to add value

- Value addition of carrots can be done by preparing carrot juice or freezing to make frozen mixed vegetables.

## Nutritional benefits

Carrots contain vitamins A, K, C, B1 and B3 and dietary fibres. They contain beta carotene which a vitamin A precursor and a powerful antioxidant. Cooked carrots have more antioxidants than raw carrots because cooking releases these antioxidants. They also contain copper, calcium potassium, magnesium and phosphorous. Potassium helps control heart rate and blood pressure by countering the effects of sodium

# Unit 11: Cucumber Guide

## 11.0 Introduction

### Family, Family Members & Cucumber Types

**FAMILY:**
Cucurbitaceae
**SCIENTIFIC NAME:**
Cucumis sativus

**FAMILY MEMBERS:**
Butternut, gem squash, water melon. Pumpkin and baby marrow

**TYPES:**
Cucumber fruit


Flowering Cucumber Plant


Cucumber Fruit


Harvested Cucumber Fruit

## 11.1 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- They are mature from 8 to 11 weeks from sowing depending on the chosen variety. Harvesting takes place before they are physiologically mature that is 15cm in length.
- Once harvesting starts it should be done every 2 days.
- Overgrown fruits will be bitter with an unpleasant texture.
- For pickling, cucumbers are harvested when they are 6.5cm by 1.5cm.
- Harvesting should be done using harvesting shears

- Cucumbers should be sold fresh but if they need to be stored they can be refrigerated in loose or perforated bags.

## How to reduce loss

- Harvesting should be done early in the morning or late in the afternoon when it is cool
- Harvested fruits should be put under shade to prevent overheating of the fruit
- Care should be taken not to break the vines during harvesting
- Grading to remove diseased and damaged fruits should be done

## How to add value

- Cucumbers can be blended to make juice. Cucumber juice can be mixed with lime juice and used to make popsicles.

## Nutritional benefits

Cucumbers are rich in potassium and dietary fibre. They are moderately rich in Vitamin A, Vitamin C, calcium, folate (folic acid), phosphorus, and magnesium. If they are eaten in their natural state (without adding salt or fat), they are low in calories, fat, and sodium.

# Unit 12: Fine Beans Guide

## 12.0 Introduction

### Family, Family Members & Fine Beans Types

**FAMILY:**
Fabaceae
**SCIENTIFIC NAME:**
Phaseolus vulgaris

**FAMILY MEMBERS:**
Dry beans, navy beans, pinto beans, kidney beans

Fine Beans

Beans

Red Bean Plant

## 12.1 Agronomy/Crop Production

1. What needs to be done before production?

**a. Soil testing and land preparation**

**Site Selection -** The ideal site for Fine beans production is one that which:

- Is protected from stray animals
- Has a reliable source of water
- Free from frost attack

**Soil -**

- Well drained soils (Loam and sand loams)
- Slightly acidic to neutral soils with good water holding capacity (pH 5.5-6.8)
- Sensitive to frost and temperature about 300 for extended periods may cause flower drop.
- Plant between August and March.

**b. Variety Selection**

**Cultivars Selection -** The choice of a variety to grow is determined by marketing requirements. Market preferences are guided by the following:

- The preferred quality.
- Adaptability and or susceptibility to diseases and pests,
- Climatic condition thus basing on the natural farming

**c. Planting**

- Fine beans do well on ridges spaced at 1,5m apart centre to centre.
- Three rows may be planted on each ridge with an in-row-spacing of 65mm to give a plant population of 300 000plants/ha.
- Seed should be planted 10-25mm deep

**d. Irrigation**

- Frequent light irrigation is required during germination; thereafter approximately 25-35mm per week is required depending on crop stage and weather.

**e. Fertilizer Requirements**

- Correct Phosphorous and Potassium deficiencies before planting. Apply 500kg/ha basal dressing of Comp S (7. 21. 7) or similar fertilizer. Band into ridge before planting.

**f. Weed Control**

- Use Aflon pre-emergence herbicide at 1.5 to 2.5 kg/ha to control annual grasses and broad leaf weeds.
- Herbicide should not be used on soils with less than 20% clay and a plant depth of less than 25mm.
- Spray according to specification so as to have an effective control of the grasses.

## 2. Pests & Diseases

| Disease/Pest | Symptoms | Control | Comments |
|---|---|---|---|
| **Anthracnose** | Sunken brown lesions on the leaves and stems | Use disease free seeds. Preventive fungicide programme as per exporter's advice | --- |
| **Rust** | Raised red dish-brown spots on leaves and pods | Observe a four year rotation, avoiding the solanaceae family of potato,tomato, paprika etc | --- |
| **Heliothis Bollworm** | Damage developing pods | Insecticidal spray with advice from exporter | --- |
| **Nematodes** | Disfiguring of roots causing fluid blockade that kills the plants | Avoid conventional bromide preparations and consult exporter for advice on acceptable nematicides | --- |
| **Cutworms** | Damage emerging seedlings by cutting stems close to ground level | Poisoned bait or synthetic pyrethroid band spray over row | --- |

***Table 42:*** *Pest and diseases*

## 3. Harvesting

- Planting to first milling takes 8 weeks.
- Twenty pickers/ha should be sufficient during peak periods. Fine beans are highly perishable and should be moved to shade within half an hour of picking and be placed in a cold room same day.
- Harvesting can take 2 to 3 weeks.

## 4. Yield

- Gross yield of 15t/ha.

## 5. Market

- Export or local market as fresh produce.

## 12.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Harvesting is done by hand and it is done 14 days after flowering or 50 days after planting and lasts for 3 to 4 weeks.
- Harvesting should be done before the seeds have fully developed and the pods should be pencil thick.
- Harvesting is done by gently pulling the pods away from the vine or by snapping of the vine end if the beans are to be used immediately.
- Harvesters should have clean hands and have good sanitary behavior when handling crops like fine beans.
- Beans can be stored at 2 to 7°C and 95% relative humidity for 7 to 10 days without losing quality.

### How to reduce loss

- Frequent harvests reduce number of overgrown pods
- Harvesting crates should be regularly cleaned to prevent spreading of diseases
- Avoid over handling and rough handling of the produce
- Crates should not be packed too tightly
- Harvest only mature pods, leaving immature pods for the next harvest
- Harvesting should be done in the morning after all moisture has evaporated from the plants
- Produce should be quickly removed from the sun after harvesting
- Grading should be done to remove diseased, damaged and defective beans

## How to add value

- Green beans can be canned or pickled.

## Nutritional benefits

- Fine beans contain fiber, potassium and calcium.
- They are naturally low in calories, sodium and fat.
- Fine beans do not make significant dietary nutrient contributions and should be mixed with other vegetables that are high in vitamin A such as carrots.

# Unit 13: Garden Peas Guide

## 13.0 Introduction

### Family, Family Members & Garden Pea Types

**FAMILY:**
Fabaceae
**SCIENTIFIC NAME:**
Pisum sativum

**FAMILY MEMBERS:**
Pigeon pea and cowpeas

**TYPES:**
Garden peas


Flowering Pea Plant


Peas


Pea Plants

## 13.1 Agronomy/Crop Production

1. What needs to be done before production?

**a. Soil testing and land preparation:**

**Site Selection -** The ideal site for peas production is one that which:

- Is protected from stray animals
- Has a reliable source of water
- Free from frost attack

**Soil and temperature Requirements -**

- Well drained soils (Loam and sand loams)

- The crop does not grow well on acid soils. Soils with a pH range of 5.3-6.5 are ideal.
- Use of Dolomitic lime is recommended to correct the pH.
- Sensitive to frost. Temperature of about 300°C for extended periods may cause flower drop.
- Plant between August and March.
- The seeds can germinate at soil temperature of 5°C and can grow with temperatures between 7-24°C.

**b. Variety Selection**

**Cultivars Selection -** The choice of a variety to grow is determined by marketing requirements. Market preferences are guided by the following:

- Adaptability and or susceptibility to diseases and pests,
- Climatic condition thus basing on the natural farming region from which the farmer is located.

**c. Planting**

- Peas are best grown as from early March to mid-May although the production window can be stretched up to August.
- Delayed planting can have a negative effect on yield so it is recommended not to plant after mid-May.

**d. Seed Dressing**

- Suitable fungicides such as Thiram must be used to treat the seeds before planting. This is done to prevent soil borne diseases.

**e. Spacing**

- Tall varieties should have single rows spaced at 60cm and medium varieties must have two rows spaced at 35-45cm. In-row spacing should be 5cm with a sowing depth of 2.5cm depending on soil type.

**f. Irrigation**

- The soil must be at field moisture capacity prior to fertilizing and sowing. A light irrigation soon after sowing is recommended to increase germination.
- Over watering have a tendency promoting leaf spot.
- Reduce watering levels when the crop has reached full height to promote flowering.

### g. Fertilizer Requirements

- Maize-fertilizer (7, 14, 7) at 500kg/ha as a basal application and 100kg/ha of Ammonium Nitrate as a top dressing are recommended.

### h. Weed Control

- Pre-emergence herbicides such as Lasso may be used in consultation with extension experts.
- Fusilade Forte as a post emergence may be used to control grasses.

## 2. Pest & Disease Management

### a. Insect Pests

| Pest | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| Aphids | --- | Dimethoate 40Ec | --- | --- |
| Cutworms | --- | Karate | --- | --- |
| Eelworms | --- | Fumigate with recommended fumigants | --- | --- |
| Helionthis Bollworms and other leaf eaters | --- | Thionex 35EC | --- | --- |
| Red Spider Mite | --- | Dimethoate 40Ec and Kelthene | --- | --- |

***Table 43:*** *Insect pests*

### b. Diseases

| Disease | Symptoms | Control | Post-Harvest Interval | Comments |
|---|---|---|---|---|
| Seedling diseases | --- | Thiram and Apron | --- | --- |
| Powdery Mildew | --- | Sulphur 80%WP, Flower Powder, Karathane 20WP and Folicur | --- | --- |
| Black Spot | --- | Alternate Copper Oxychloride and Dithane M45 before flowering and Benomyl and Dithane after flowering<br>Bravo may also be used | --- | --- |

***Table 44:*** *Diseases*

3. Potential Yield

- A yield of up to 20 tonnes may be realised.

## 13.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Planting to first harvesting should take 4-5 weeks.
- Harvesting should be done early in the morning or late in the afternoon for the fresh peas and stored in cold rooms.
- Harvesting of peas is done by hand. Harvesting should be done in the morning after the dew has dried, that is when the peas will be crispy.
- When harvesting use both hand, one to secure the vine and the other to gently pull the pods away from the vine.
- Peas should be harvested regularly and harvesting can start 55 to 80 days from planting depending on variety.

### How to prevent loss

- Frequent harvests reduce number of overgrown pods
- Harvesting crates should be regularly cleaned to prevent spreading of diseases
- Avoid over handling and rough handling of the produce
- Crates should not be packed too tightly
- Harvest only mature pods, leaving immature pods for the next harvest

- Harvesting should be done in the morning after all moisture has evaporated from the plants
- Produce should be quickly removed from the sun after harvesting
- Grading should be done to remove diseased, damaged and defective beans

## How to add value

- Value addition of peas can be done by canning, or freezing to make mixed vegetable packs.

## Nutritional benefits

- Peas contain vitamin C and B6, folate, iron and are rich in antioxidants that prevent cancer.
- Peas also have anti-inflammatory properties.

# Unit 14: Okra Guide

## 14.0 Introduction

### Family, Family Members & Okra Types

**FAMILY:**
Malvaceae
**SCIENTIFIC NAME:**
Abelmoschus esculentus

**FAMILY MEMBERS:**
Cotton and coccoa

**TYPES:**
Okra


Okra Plant


Flowering Okra


Okra Fruits

## 14.1 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Harvesting of okra is done 5 to 10 days from flowering when the pods are 5 to 7.5cm long. Some varieties produce long pods that can get to 10cm while it is still tender.
- Harvesting is done by hand using a sharp knife or secateurs. Leave at least 1cm of the stem attached to the pod.
- Wear gloves and long sleeves when cutting the okra because most varieties are covered with tiny spines that will irritate the skin.
- Ripening of pods is sequential and harvesting can be done up to three times per week for more than two months. The more frequent the crop is harvested the more pods it will produce.

## How to reduce loss

- Okra should not be washed or cut after harvesting
- Store in plastic bags to reduce moisture loss
- Grading and sorting should be done to remove damaged and diseased pods

## How to add value

- Okra can be dried and stored as the dried product. It can also be pound into a powder.

## Nutritional benefits

- Okra is high in vitamin A, C, B and K, folate.
- It contains a superior fibre which helps with digestion, stabilises sugar and helps to control the rate at which sugar is absorbed. This helps to prevent diabetes. Fibres help to prevent colon cancer.
- Vitamin B helps to promote healthy pregnancy as it promotes growth of new cells.
- Maintains healthy skin

# Unit 15: Water Melon Guide

## 15.0 Introduction

### Family, Family Members & Water Melon Types

**FAMILY:**
Cucurbitaceae
**SCIENTIFIC NAME:**
Citrullus lanatus

**FAMILY MEMBERS:**
Include butternut, gem squash, pumpkin, cucumber and baby marrow

Water Melon Plant

Water Melon Fruit

Water Melons

## 15.1 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- To determine the maturity of watermelons can be difficult.
- Watermelons should be harvested with the stalk attached to the mother plant, when the green colour begins to turn yellow.
- A dull sound is produced when the mature watermelon is tapped whereas a metallic sound is produced on an immature watermelon.
- When the stalk that attaches the fruit starts to dry the fruit is ready to be picked.

## How to reduce loss

- Quality loss can be reduced by avoiding rough handling due to carelessness.
- It is advisable for loaders on the ground to hand pass melons to stackers.
- Avoiding stacking melons on their ends because the thin blossom is most susceptible to bruising.
- A drop of only 3.5cm to the ground can cause severe internal bruising. Care should be taken when handling watermelons.

## How to add value

- The seeds of water melon when salted and roasted can be consumed as a snack.
- Cheese can be prepared using the white portion of a watermelon rind.
- Juices can also be made from watermelons and can be added as flavourants to dairy products.

## Nutritional benefits

- Watermelons quenches thirst they are a great source of the much needed amount of sweetened water and have carotenoids activity and free radical scavenging activity that lowers incidence of prostate and oral cancers.
- The lycopenes that are found in these melons offer protection to skin from the ultra violet rays.
- The seeds are vital sources of proteins, oil, potassium and dietary fibre.

# Unit 16: Mushroom Guide

## 16.0 Introduction

### Family, Family Members & Mushroom Types

**FAMILY:**
Agaricaceae
**SCIENTIFIC NAME:**
Agaricus bisporus

**FAMILY MEMBERS:**
None

**TYPES:**
White button mushroom, oyster mushroom

White Button Mushroom

Oyster Mushroom

Mushrooms being grown

## 16.1 Agronomy/Crop Production

1. What needs to be done before production?

**a. Mushroom House -** Dimensions depend on the number of substrate bags the grower can handle at any one time. Use farm bricks or poles and dagga or a wooden frame for walls and thatch. Plastic or foam sheets may be used to line the walls. A roof thatched with grass or banana leaves. Air vents and windows on the upper side of walls are required for ventilation and lighting to initiate fruiting. Light sufficient to read a newspaper when in the house is adequate. Wooden shelves for holding the bags or wooden racks for hanging spawned substrate bags. The mushroom house should provide optimum conditions for fruiting. Maintained temperatures at 18–25°C and relative humidity at 80–90%.

**b. Incubation/Spawning Room -** Spawned substrate bags are kept in this room for the mushroom

mycelium to grow. Alternatively the spawned bags can be covered with a black plastic in the mushroom house. If using the mushroom house for incubation the air vents and the windows should be closed to provide dark conditions required for spawning. Light is not required in the incubation room. Temperatures should be about 24°C.

**c. Mushroom Spawn -** Spawn or mushroom seed is mushroom mycelium growing on sorghum, wheat or barley, used to seed substrate from Spawn laboratories. Substrate can be finely chopped wheat straw (about 6cm); Soya-beans stover; Shredded maize cobs; finely chopped maize stalks; banana leaves. Pleurotus ostreatus and Pleurotus sajor caju are the strains available locally for Oyster Mushroom production.

**d. Additives -** Wheat bran; Barley; Oats; Sunflowers. Any of these substrates may be supplemented with rice or wheat bran at 15–20% and Lime at 1-2%. Any substrate used must be pasteurised to eliminate contaminants or undesirable organisms.

**e. Steriliser -** The steriliser can be a huge pot, container or metal drum to hold large quantities of substrate for boiling in water at 100oC for a minimum of two hours. Firewood or other local materials for fire.

**f. Other requirements -** *Thermo-meter*: to check temperatures; *Hygrometer:* monitoring relative humidity; *Sprayer, watering can or bucket transparent plastic bags:* for containing the substrate during the cultivation process; *String:* required for tying the mouths of bags and hanging onto racks.

## 2. What is key during production?

**a. Substrate Preparation and Pasteurisation -** Process of killing pests and diseases through immersion in boiling water. Prepare the substrate by chopping and shredding into small pieces. Soak the substrate in water overnight. Drain off the water and add the supplements. Pack the substrate into a steriliser and fill with hot water. Heat and pasteurise by boiling for 1 hour. Transfer the substrate onto a sterilised sheet and cool to about 30°C. Pack the substrate into plastic bags not too tightly or too loosely. Add a handful of spawn after every 15cm of substrate.

**b. Spawning -** process of planting the mushroom- Use about 1 kg spawn to plant 8-10; 1.2m tubing plastic of substrate. Distribute the spawn evenly in alternating layers with the pasteurised substrate. Tie the mouth of the bag soon after spawning. Substrate spawning is the most delicate operation in mushroom

production. It must be done in a clean environment free of air movements. Avoid contaminating the spawn and the substrate.

**c. Incubation -** During incubation the mushroom mycelium grows to cover the whole substrate. Place spawned bags at 24°C in the dark incubation room or cover the bags with black plastic in the mushroom house. Bags are ready for mushroom formation when the substrate appears white. Full colonisation occurs in about 18-24 days. Transfer bags to the mushroom house or expose the bags by removing the black plastic.

**d. Fruiting -** Fruiting is the formation of the mushrooms in the mushroom bags after 21–24 days. Open the air vents or windows in the mushroom house to provide light and to initiate fruiting. After one day open the bags by making long and 6cm apart around the bag using clean sharp instruments. Pin heads will begin to form in 3 to 4 days and will be ready for harvesting in the next 2 to 3 days. A temperature of 20–28°C and relative humidity of 80–95% is required. To provide adequate moisture, water the substrate daily avoid over watering. If temperatures rise to 30°C apply a light water mist to cool and to quicken fruiting. The door and air vents or windows may be opened for an hour especially at night to allow cool air to enter. Maintain high relative humidity by applying water on the floors and walls several times a day.

## 3. Pest & Disease Management

### a. Insect Pests

| Pest | Identification | Symptoms |
|---|---|---|
| Scarid Fly | Small flies with yellow segmented abdomen. Maggots have distinct black, shiny head with creamy white body. | Dead pinheads, browning of stem, brown or black spots on pinheads of mushroom. Feed on mature mushroom. |
| Dung fly | Small flies with humped back with yellow to reddish brown colour on the back | --- |

***Table 45:*** *Insect pests*

### b. Diseases

***Moulds:*** most common are green, yellow and black. Damping off: (Fusarium) Fungal competitor inhibiting mushroom growth. Infected remain small with disproportionately small caps and stems.

4. Weed Control

- Competitor Weeds: Inky Cap (Coprinus) should be controlled.

5. Yield

- 10-15kg per 10kg substrate.

## 16.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Mushrooms are ready to harvest 4-5 days after pinheads appear when the mushroom cap is 5 to 10cm.

- Harvest gently by slowly and twisting the stalk and pulling out from the opened ends to remove it from the substrate. Continue harvesting as long as the substrate appears white. The bags can be removed from the house when the substrate becomes colourless and soft to touch. A total weight of 10 to 20 kg of mushrooms can be harvested from 10 kg of dry substrate. Mushrooms remain fresh for 3 to 6 days when kept in the refrigerator or in a cool area.

- Carefully trim the stalks that were attached to the substrate as these will be contaminated with substrate.

- The mushrooms should be placed in punnets making sure that they are facing the same direction. The punnets should be packed to a uniform weight of 400 or 500g/punnet. The punnet should then be cling wrapped.

## How to reduce losses

- Mushrooms should be sold immediately after harvest if refrigeration facilities are not available.
- Mushrooms can be refrigerated at 8°C for 4 to 5 days without losing quality.

## How to add value

***Drying***

Value addition of mushrooms can be done by drying using either solar driers of oven driers. Dried mushrooms are convenient for long term storage and transportation.

When using solar driers the rate of drying will depend on the prevailing weather conditions. However when using electric oven driers the rate of drying will be faster. To dry the mushrooms using sun drying spread the mushrooms on shelves in such a way that the gills face upward and are directly exposed to the sun. However sun drying produces mushrooms that are of a lower quality than those dried in solar driers or oven driers. Drying improves the taste of oyster mushrooms.

## Nutritional benefits

- Oyster mushrooms have antioxidant and antibacterial properties
- They are a rich sources source of iron and are beneficial to people with anemia
- Mushrooms are low in sodium and have a low starch ratio making them ideal for people suffering from diabetes, high blood pressure and obesity
- Lowers cholesterol levels and reduces inflammation for arthritis patients

# Unit 17: Banana Guide

## 17.0 Introduction

### Family, Origins and Common Names

**FAMILY:**
Musacease

**COMMON NAMES:**
Banana, Bananaier Nain, Canbur, Curro, Plantain

**ORIGIN:**
Edible bananas originated in the Indo-Malaysian region reaching to northern Australia

**SPECIES:**
Musa acuminata Colla, M. X paradisiaca L. (hybrid)

Banana Plant

Banana Fruit

Banana Field

## 17.1 Agronomy/Crop Production

1. What needs to be done before production?

**a. Root System -** is not extensively developed hence the plants needs to be anchored or supported so as to protect them from wind. Roots grow from the corm and occur in the top 30–50cm of the soil and are about pencil thickness and no tap root is developed.

**b. Soil Requirements -** Well drained soils with good water holding capacity; Deep soils 600-800mm, Poor aerated soils restrict root growth and plant development, pH 5.5-6.5 is optimum.

**c. Climatic Requirements -** The crop has high heat and water requirement; Temperature 20-30°C; Rainfall at least 125mm and severe frost damage causes leaf damages, poor yield and bunch quality

**d. Time of Planting -** Lowveld around October and elsewhere August to December.

**e. Fertilizer Application -**

1. Compound C 120g per planting station at planting
2. Lime 80-160kg at planting
3. Muriate of potash (MOP) 30g per planting station fortnightly from 2 weeks after planting up to 8 months.
4. Ammonium nitrate (AN) 30g per planting station fortnightly from 2 weeks after planting up to 8 months.
5. Compound J 65g per planting station fortnightly from 9 months for the life period of the plantation (to be applied in the direction of the follower sucker).

## 2. Siting the Plantation

Irrigation or water availability is a prerequisite requirement in siting a plantation. Other important considerations are:

- Site should be frost free as bananas are very susceptible to frost damage
- Soils should be deep and well drained. Heavy clays need to be avoided because of poor drainage in as much as sands should as they harbour nematodes.
- Site should have been free of banana growth for at least three months.
- If an old banana plot is to be used, in addition to a three months rest period, all banana corms and roots should be removed

## 3. Laying Out the Plantation

**Considerations should be given to:**

- **Slope -** The slope affects the direction of marching of the plantation which should always be up. This is done in order to prevent the plantation from growing out of the soil. The slope also affects the direction of throw of bunches.
- **Drainage -** Layout should allow for sufficient drainage
- **Mulching -** Correct orientation of mulching rows helps in reducing erosion especially on slopes. Mulching rows need to be across the face of the slope as opposed to along the slope.
- **Irrigation Systems -** The layout may be affected by the existing irrigation system especially the positions of hydrants (where water enter the field from the source) and laterals (pipes that take water from the hydrants into the field).

The direction of march and bunch throwing the following criteria should be used:

- Always march uphill on slopes – either directly or at an angle.
- Avoid marching in the North Western direction unless you are being limited by slope direction. The North Western direction is the direction in which most bunches will be thrown because of maximum sunlight exposure in this direction.
- If a North Western is chosen, then follower suckers may grow into bunches.
- On level ground a North Easterly to Easterly direction should be preferred

## 3. Marking Out the Plot

Once the layout has been established, marking out of the plantation can proceed. The following tools will be required:

- About 80 pegs, each about 40 cm long
- 50m long string or rope for establishing straight lines
- Measuring tape

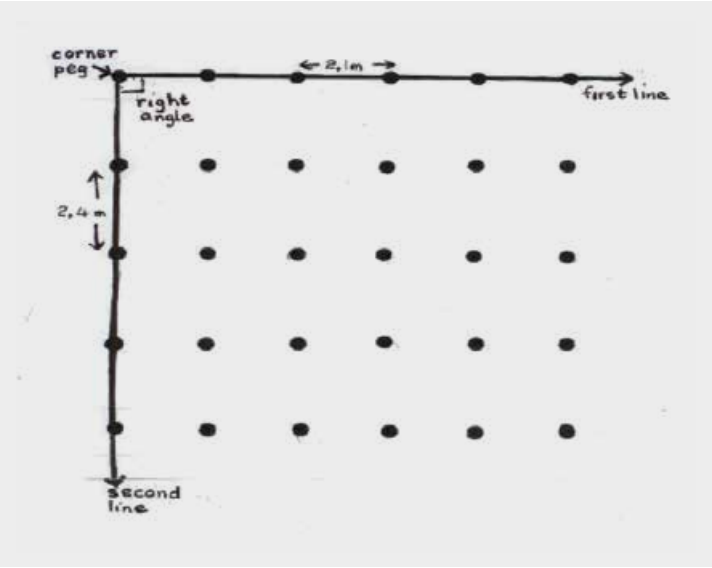



***Figure 7:*** *Lay out of plantation (NB: These peg positions are not planting positions)*

*Digging holes:*
The following tools will be required: Hoe, Shovel, Planting stick (2.1m long with a notch at the middle).

**Follow these steps:**

1. Place the planting stick between two peg positions and mark the middle position between the pegs as it corresponds to the notch on the planting stick. This is the position where the hole will be dug.
2. Dig the 45cm x 45cm x 45cm hole and separate topsoil and subsoil on either sides of the planting grows.
3. Fill up the holes with water a day before planting commences.

## 4. Planting

The ideal planting times are in January and August. Bananas planted in January tend to take longer to mature as they are retarded by the winter period early in their growth than the August plantings. It is necessary to plant at the ideal time in order to avoid frost damage. The month of November in particular should be avoided at all costs as it exposes the crop to frost at the critical stage of flowering initiation resulting in malformed bunches and fruits, a condition called November Dump. It is important to ensure that damage to seedlings is minimized especially by reducing direct exposure of roots to sunlight.If there are variations in the sizes of seedlings, plant same sized seedling in the same rows for uniformity.

**Follow these steps when planting:**

1. Put the first 30g of Compound C fertilizer on the topsoil side pile and mix.
2. Fill the hole with topsoil, enough to obtain the correct planting depth.
3. Gently remove the pot by cutting the bottom open and lifting the sleeve upwards.
4. Place the plant in the hole, positioning it in such a way that it is in line with the notch on the planting stick see *Figure 9*.

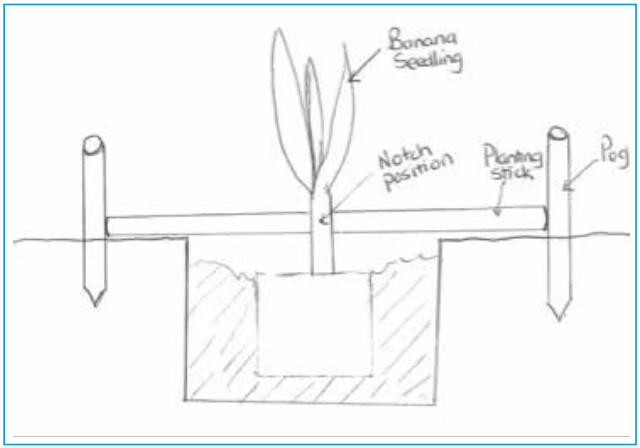



***Figure 8:*** *Positioning the plant in the hole*

5. Place the second 30g of Compound C fertilizer around the plant, inside the hole, but not in touch with the roots.
6. Cover with 10cm of soil and place the third 30g of Compound C in the hole.
7. Make about 90 cm diameter basin around the plant and make sure that the basin is able to hold water.
8. Place the fourth 30g of Compound C in the basin and make sure that the fertilizerilizer is well incorporated into the soil.
9. Press gently to reduce air pockets and fill the basin with water that is about 25 litres.
10. Two to three weeks after planting, apply 16g of a chemical called Temik per plant. Dig a shallow trench of about 4 to 5mm and spread the Temik evenly in the trench and cover up immediately. ***NB: Temik is extremely hazardous and should therefore be handled with extreme caution.***
11. Check and replace unsatisfactory plants 1 to 2 months after planting.

**NB: Planting depth is very important. Ensure that the top of the planting medium is 10-15cm below the basin surface. This will ensure that the corm does not grow out of the ground, which makes the plant susceptible to falling over. As a role it is better to plant too deep than too shallow.**

## 5. Maintenance

**a. Irrigation -** For the first fortnight after planting 'hose and basin' irrigation, where you pour water into the basin using a hosepipe, is recommended in order to consolidate soil around the roots. Beyond the fortnight as the roots begin to grow beyond the basin circumference, overhead irrigation become more important. Avoid over-irrigation, where water end up running off the field, in the early periods after establishment as this restricts root development.

**b. Weeding -** Ensure the plantation is kept weed free. Try to avoid use of hoes as they damage the shallow roots of the banana plant. Hand pulling in the basin is recommended. Around the basins weeds can be controlled by use of herbicides like Gramoxone and Round up. On sloped land it is recommended to just slash the weeds around the basins so that their root systems will continue to hold the soil together and reduce erosion.

**c. Sucker Selection for Succession and de-Suckering -** The right sucker should be selected to succeed the mother plant once the mother plant is about 1.5m tall. Cut off the first flush of suckers at ground level

so that they come out with renewed vigour. Select the best placed follower sucker relative to the desired direction of march. The follower sucker should be sword shaped. Discard water suckers which do not bear the same shape as these have a weak attachment to the mother plant. Remove any sucker not selected as follower sucker either by destroying or harvesting them for re-establishment of new plantation.

**d. Trimming -** All dead leaf material should be pruned off to ensure maximum light penetration. These may also harbour pests and diseases.

**e. Mulching -** Once plantation has been mulched, then it must not be left dry for too long as this encourages termites.

**f. Propping -** Ensure that the plants are supported by timber props particularly at bunch throwing to ensure that the bananas do not fall over under their own weight.

## 6. Pests and Diseases

Although there are not many diseases of bananas in the subtropics, it is important to continuously scout for any diseases in the plantation.

- Mole rats (nhuta) are particularly troublesome pests of bananas. Calcium phosphatetablets can be used to control the pests. Sufficient irrigation will also keep away mole rats.
- Nematodes can be controlled through proper siting and use of Temik as already discussed
- Bunches may also be covered with sacks to reduce bruising action by baboons, monkeys etc.

## 7. Harvesting

Proper handling at harvesting is vital as banana quality is severely affected by bruises and cuts and will not sell well. At least three people should be involved in harvesting. The bananas should be removed from the bunches as 'hands' which should be cleaned before packaging. Care should be taken to ensure that the juice from the cut 'hands' do not spill on to the banana as this compromises quality. If bananas are to be transported over some distance to the market, then this must be done in crates, preferably in the evening to reduce sunburn

## 8. Production Calender

| Field operation | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nursery Practice | x | x | x | | | x | x | x | x | x | | |
| Site Selection | x | x | | | | | | x | x | | | |
| Land Preparation | | x | x | | | | | | x | x | | |
| Marking Out | | x | x | | | | | | x | x | | |
| Planting | | | | x | x | | | | | | x | x |
| Fertilizer Application | x | x | x | x | x | x | x | x | | | x | x |
| Weed Control | x | x | x | x | x | x | x | x | x | x | x | x |
| Pest and Disease Control | x | x | x | x | x | x | x | x | x | x | x | x |
| Sucker Selection | | | | | | | x | x | | | | |
| Desuckering | x | x | x | | | x | x | x | x | x | x | x |
| Bunch Throwing | x | x | x | | | | | | | x | x | x |
| Leaf Cutting | x | x | x | x | x | x | x | | | | | |
| Propping | x | x | x | | | | | x | x | x | | |
| Bunch Care | x | x | x | | | | | x | x | x | | |

***Figure 9:*** *Production Calendar*

**a. Harvesting -** Fruits are harvested at 16-18 weeks in summer and 22 weeks in winter. Bunches are usually thrown at the 7-8 months stage.

**b. Grading -** There are 5 grades which are:

1. *Extra large -* mainly export quality that is with no blemishes: bruises and spots
2. *Large -* also export quality that is with no blemishes: bruises and spots
3. *Medium -* for local market mainly bid supermarkets ie SPAR TM, OK
4. *Small -* for local market
5. *Farm Sales -* to be sold on the farm especially for local farm workers

## 17.2 Harvesting, Post-Harvest Handing and Value Addition

### When and how to harvest

- Dwarf bananas can be harvested 11 to 14 months from planting while tall varieties take 14 to 16 months to harvest.
- The fruits mature 120 to 140 days from flowering.
- The fruit bunch can be harvested when the ridges on the fruit their change from angular to round and the fruits change colour from dark green to pale green.
- The flowers at the top of the fruit dries up and the fruit drops off easily.
- Fruits destined for distant markets should be harvested when they are mature green. They can be treated with ethylene to hasten the ripening process before marketing.
- Harvesting is done by cutting down the whole stalk. About 30 cm of the stem should be left attached to the bunch. The mother plant should be cut off after harvest as it will not produce more bananas.
- Harvested bunches should be placed in padded baskets or trucks padded with a layer of foam rubber to avoid bruising the fruits.
- The bunches should be kept away from the light in a cool, shady place. The hands are removed from the bunch stalk at the pack she and dipped in fungicide before packing.

### How to prevent loss

- Bananas should not be left to ripen on the plant as it will affect the quality. Harvesting too early will also negatively affect the quality by affecting size and taste.
- Rough handling should be avoided as bananas bruise easily
- Bananas should not be stored below 13°C as it stops the ripening process

## How to add value

- Bananas can be processed to make purees that are used in the beverage industry and to make baby food, jams and sauces.
- Banana powder can be used in cake pre-mixes.
- Banana can be processed to make banana vinegar.
- Bananas can be sun dried to make dried fruit chips.

## Nutritional benefits

- Ripe bananas contain many nourishing ingredients.
- Bananas are a good source of vitamins, minerals and fiber.
- Bananas are a good source of natural energy with energy values around 371kJ (89 Pascal)
- Bananas contain potassium which is essential in maintaining normal blood pressure and heart function. Potassium helps to maintain a proper balance of water in the body.
- The fibre helps to regulate the conversion of carbohydrates to sugar and it makes bowel movements more regular.

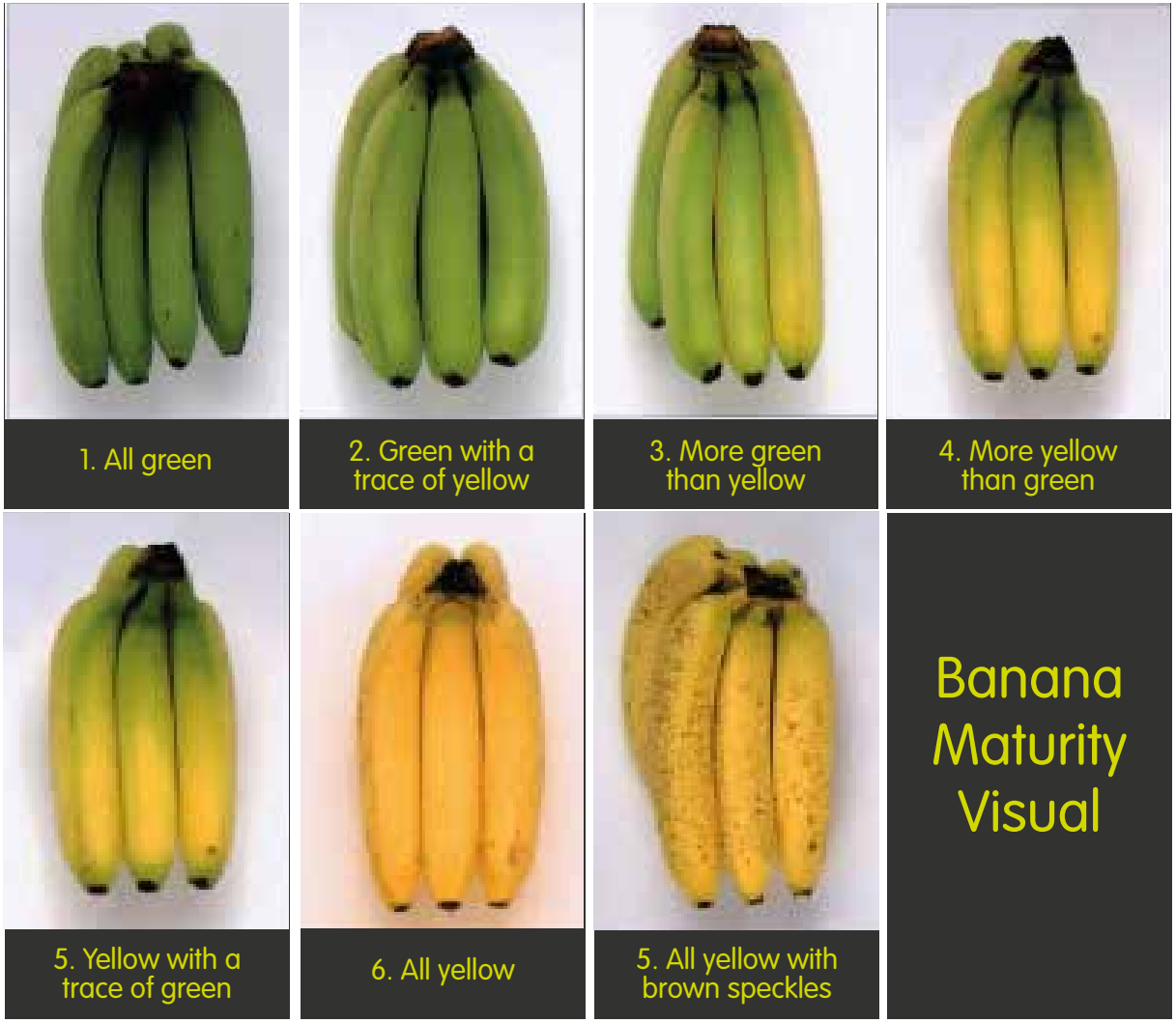



***Figure 10:*** *Banana maturity indices*

Module 3

# Pest and Disease Identification

**Unit 1: Pests**

1.1 Diamond-back Moths
1.2 Aphids
1.3 Cutworms
1.4 Leafminers
1.5 Whiteflies
1.6 Thrips
1.7 Spider Mites
1.8 Heliothis Bollworm
1.9 Sciarid Fly
1.10 Fruit Fly
1.11 Cucumber Beetle
1.12 Carrots Weevil
1.13 Root-Knot Nematodes

**Unit 2: Diseases**

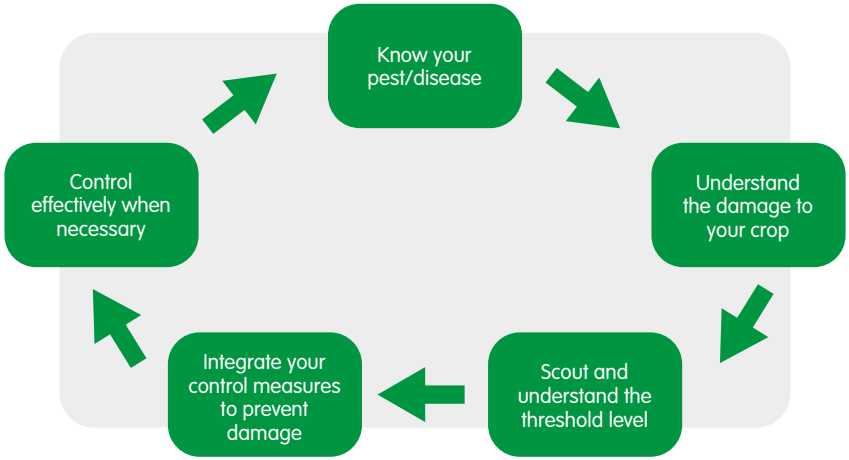
2.1 Powdery Mildew
2.2 Damping Off
2.3 Late Blight
2.4 Early Blight/Alternaria Leaf Spot
2.5 Black Rot
2.6 Bacteria Soft Rot
2.7 Downy Mildew
2.8 Anthracnose
2.9 Blossom-End Rot
2.10 Green Mould
2.11 Stem Rot
2.12 Cottony Soft Rot

## Introduction

There is a vast array of insects, spiders, mites and ticks found in agricultural farming environment and interestingly most insects are actually beneficial and not pests. According the NCSU Extension, out of the 800,000 - 1,000,000 species of insects that are found, not more than 1,000 (about 1/10 or 1%) can be regarded as serious pests. But poor pest and diseases identification by most smallholder farmers is still one of the major challenges that damages the crops. This has often seen their produce being rejected and losing out in market competitiveness. Because of huge economic losses, most smallholder farmers in Zimbabwe have embraced a routine spraying culture with hazardous chemicals that have a long lasting harmful impact on the produce.

With certification of horticultural commodities now being mandatory in local as well as international markets, farmers should effectively manage pests and diseases through scouting, sampling and make informed decisions regarding agrochemical use. Thus more capacitation through training, mentoring and advisory becomes key action points that can enhance their ability to have an effective pest management system embedded in their production, post – harvest handling, till they market their produce.

This module provides visual illustration of various pests and diseases through pictures, to assist farmers to distinguish various feeding habits of pests, their damaging stages and also conditions necessary for their infestations. It also provide the much needed information on the alternative, biological, cost-effective control measures and other good crop husbandry skills that can add value to production, produce marketing and finally income earning.



# Unit 1: Pests

## 1.1 Diamond-back Moth (DBM)

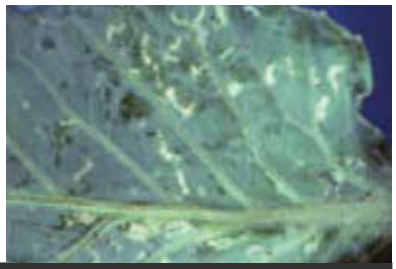
**Key Pest:** Diamond-back Moth

**SCIENTIFIC NAME:** Plutella xylostella

**Target Crops:** Cabbages, rape, tsunga, broccoli, cauliflower and other crucifers. DBM is the most serious pest of cabbage.

Caterpillar - Destructive

Adult Moth



Damage

### a. Geographic Distribution:

Worldwide. DBM is a serious pest in the dry season, but heavy rain washes out the larvae. It colonizes the crucifer growing regions at the end of the growing season, or by seedlings that come from subtropical areas.

### b. Description:

Size from 8 to 12mm, colour varies from light brown at hatching to dark green when fully grown. Wriggle away quickly and drop from the leaf on a silk thread if disturbed. They climb back on the leaf on this thread once the danger has passed.

### c. Location:

Underside of leaves, between veins. They can burrow into the leaves when they are small, making small white tunnels. Later, the caterpillars feed on the underside of the leaves. They do not eat the veins and often leave the upper skin of the leaf intact, which leaves a window-like appearance. They also feed on the growing tips of the young plants, preventing them from developing further.

### d. Damage and Importance:

The caterpillars feed on the leaves of cabbage, rape, and tsunga. They prefer the undersides of leaves and do not eat the veins. The damaged skin tears as the leaf grow, creating holes and tears in the leaf. DBM also feed on the growing tips of young plants, preventing further development. In broccoli and cauliflower, the damage is indirect because DBM feed on the leaves and not on the commercial flower head. Sometimes large caterpillars or cocoons are hidden in the heads, and these may be rejected for export.

### e. Control

- **Sampling and economic thresholds:** DBM caterpillars are detected by visual observations of the whole plant especially under the leaves in the basal part of the plant. Sample at least 60 plants on a 0.25ha plot and take action if you find 1 caterpillar per plant.

- **Promote biological methods:** Use Bacillus thuringiensis (Bt) as a biological control, DBM caterpillars are killed when they eat very small amounts of leaves or other plant parts that have been coated (sprayed) with Bt. Promote or introduce bacterial parasitoid wasp Diadegma insularis (Hymenoptera: Chalcididae) which control up to 40% of the caterpillars when there is a limited use of synthetic pesticides.

- **IPM practices:** Plant cabbage in the rainy season when the population of DBM is deterred by the rain; Sprinkle irrigation may reduce the number of caterpillars in the field; rogue all infested plants; use trap crops such as crucifer weeds to lure pest away from commercial crop and light trap near the beds with a bucket of water underneath will catch large numbers of adult moths.

- **Chemical Control:** Because of severe pesticide resistance problems with DBM globally, rotate two chemicals from different pesticide families and also use spreaders which allow chemicals to stick in the waxy leaf surface. Since majority of DBM caterpillars live under the leaf surface, during spraying, target under-leaf and hydraulic nozzles are the best to use with backpack or tractor sprayers.

## 1.2 Aphids

**Key Pest:** Aphids

**SCIENTIFIC NAME:** Aphis spp, Brevicoryne spp, Myzus spp, Macrosiphum spp.

**Target Crops:** Potato, spinach, lettuce, tomato, peppers, spinach, tomato, cucurbits, carrot, lettuce, legumes, corn, flowers, flowering plum, stone fruit and cole crops and other mustard family plants. Aphids are major pest in crucifers.

Aphids
(Brevicoryne brassicae)

Aphids
Linnaeus, colony or cluster on cabbage leaf

Aphids
Colony or cluster under leaf

### a. Geographic Distribution:

Worldwide. Aphids are more troublesome during cool, dry weather hence a major pest in the tropics. The reproduction rate for each adult aphid can produce up to 80 offspring in a matter of a week.

### b. Description:

Aphids are small, soft-bodied insects with long slender mouthparts that they use to pierce stems, leaves, and other tender plant parts and suck out fluids. Almost every plant has one or more aphid species that occasionally feed on it. Many aphid species are difficult to distinguish from one another though management of most aphid species is similar.

### c. Location:

Aphids are usually found on the underside of leaves and on the stems of plants.

### d. Damage and Importance:

Aphids are sap-sucking pests that often feed in dense groups on leaves or stems of plants. Aphids transmit

viruses from plant to plant on certain vegetable and ornamental plants. A few aphid species attack parts of plants other than leaves and shoots. The lettuce root aphid is a soil dweller that attacks lettuce roots in spring and summer, causing lettuce plants to wilt and occasionally die.

### e. Control

- **Sampling and economic thresholds:** Aphids are sap sucking pests that can be seen on leaves and or stems. The economic threshold differs among crop. In cabbage is 10-20% of the stem have aphids. On potatoes, 2-3 aphids/main stem at full bloom, and on peas the threshold is 2-3 aphids on top 20cm of plant tip.

- **Promote biological methods:** Natural enemies can be very important for controlling aphids, especially in gardens not sprayed with broad-spectrum pesticides (e.g., organophosphates, carbamates, and pyrethroids) that kill natural enemy species as well as pests. Parasitic wasps that lay their eggs inside aphids. Many predators also feed on aphids and the most well-known are lady beetle adults and larvae, lacewing larvae, soldier beetles, and syrphid fly larvae. Naturally occurring predators work best, especially in garden and landscape situations.

- **IPM practices:** The use of certified varieties and field hygiene are a prerequisite in aphid control for all crops. Often a forceful spray of water or water-soap solution, even on large street trees, when applied with appropriate equipment, will provide sufficient control.

- **Chemical Control:** Use recommended aphicides such as Malathion, permethrin. To protect pollinators, don't apply Imidacloprid or other systemic insecticides to plants in bloom or prior to bloom.

## 1.3 Cutworm

**Key Pest:** Cutworm

**SCIENTIFIC NAME:** Agrotis spp, Crymodes spp, Feltia spp, Peridroma spp.

**Target Crops:** Asparagus, bean, cabbage and other crucifers, carrot, celery, corn, lettuce, pea, pepper, potato, and tomato

Variegated Cutworm (larvae)

Destructive Stage of Black Cutworm (Aphis fabae)

Damage on Tomato Fruit

### a. Geographic Distribution:

Worldwide.

### b. Description:

Cutworms are the larvae (caterpillars) of several species of night-flying moths in the family Noctuidae. The larvae are called cutworms because they cut down young plants as they feed on stems at or below the soil surface. Other species are climbing cutworms that move up plants and feed upon foliage, buds and shoots. The adults are night-flying moths and do not cause damage. As general feeders, most cutworms attack a wide range of plants. Cutworms can be quite distinct from one another, and their colouring can vary from brown or tan to pink, green or grey and black. Some cutworms are a uniform colour while others are spotted or striped. Some larvae are dull and others appear glossy or shiny. Cutworms curl up into a tight "C" when disturbed.

### c. Location:

Soil surface, crown and stem of seedling crops of host plants.

### d. Damage and Importance:

First stage larvae of black cutworms feed briefly on foliage of host plants before moving into the soil to fee on roots and crowns of crops. The older larvae feed on underground plant parts during the day. Second and third stage larvae feed at the soil surface. Variegated cutworm larvae feed on foliage of vegetables crops such as beans. Heavy infestations of cutworms cause complete defoliation of plants and subsequent reduction in plant population which translate to decreased yields and income to a farmer.

### e. Control

- **Sampling and economic thresholds:** When scouting for black cutworms, plan to scout all fields at least once a week for a 3 to 4 week period following emergence. Pay particular attention to fields that were planted late or had an early season weed infestation. Check fields for leaf-feeding, cutting, wilting, and missing plants. Check these fields again in 24 to 48 hours. Record the number and size of larvae found per 100 plants, the percentage of injured plants, and the plant stage (the average number of leaves with collars visible per plant). A threshold of 2-3 larvae /m² in the top 7 cm (3 in.) of soil is recommended.

- **Promote biological methods:** Cutworms are attacked by a number of predators, parasites, and diseases. Many of these natural control agents are not effective on black cutworms because of their subterranean nature. Several strains and products of (Bacillus thuringiensis) (Bt) are available.

- **IPM practices:** Cutworms are most injurious in weedy fields with high plant residue and weedy field boundaries. Field hygiene through weed control and clean tillage can reduce risk of black cutworm damage by removing overwintering sites.

- **Chemical Control:** Larvae of the black cutworm can be difficult to control with insecticides because of their subterranean nature. It is important to detect and treat larvae as early as possible. Foliar applications of insecticides will reduce the population of young larvae because even early stage larvae that feed near the soil surface will feed on treated foliage at night. Chemical likes Carbaryl, Acephate, Lambda Cyhalothrin and 58,5% Methamidophos can control cutworms.

## 1.4 Leafminers

**Key Pest:** Leafminers

**SCIENTIFIC NAME:** Liriomyza spp

**Target Crops:** Different vegetable beans, blackberries, cabbage, lettuce, peppers, and a variety of ornamental flowers, trees and shrubs, cole crops, cucurbits, tomatoes, peas, spinach and beans. Leafminers are a major challenges to leafy vegetables especially spinach.

Leafminer Adult

Destructive stage -
Adult serpentine leafminer

Typical leafminer trail on pea leaf

### a. Geographic Distribution:

Worldwide.

### b. Description:

Leafminers are insects that feed on the tissue between the upper and lower epidermal layers of leaves. Leafminers can be serious problem on vegetables that are harvested for their foliage for instance spinach. Leafminers can be the larval stages of flies, moths, sawflies or beetles, but those that feed on vegetables are all fly larvae and belong to the Order Diptera. Common leafminer species include the serpentine leafminer (Liriomyza brassicae), vegetable leafminer (Liriomyza sativae) and the spinach leafminer (Pergomya hyoscyami).

### c. Location:

Favours gardens and greenhouses. They feed between the upper and lower surfaces of leaves. On heavily infested plants, it is not unusual to find 6 or more maggots per leaf.

### d. Damage and Importance:

Damage can be limited in initial stages of infestations but increase as leafminer numbers multiply, and even minor infestations, while not killing a plant, will cripple its hardiness. Leafminers are a major cause of poor harvest numbers in home gardens as they weaken individual vegetable plants. They're especially fond of spinach leaves and their tunnelling severely decreases the attractiveness and value of the crop which is loss of yield and money to the farmer.

### e. Control

- **Sampling and economic thresholds:** Leaf miners are detected by visual observation and early detection of leafminer damage is important in preventing a reduction in the marketability of affected crops. Though there is no supporting information pertaining threshold, 5% threshold level is often used.

- **Promote biological methods:** Parasitic wasps can also provide a limited degree of natural control of leafminers.

- **IPM practices:** Deep ploughing in early spring to destroy infested weeds and plant material from the previous season can reduce the severity of leafminer outbreaks. Covering susceptible crops with floating row covers to exclude the leafminer flies from laying eggs may also be beneficial. Weed hosts such as pigweed, lambsquarter, plantain, chickweed, and nightshade should also be destroyed.

- **Chemical Control:** Because of the protected habit of leafminers within the plant, control using insecticides is often difficult. In addition, some leafminer populations have exhibited resistance to organophosphates insecticides. If insecticides are used, they must be applied early in the insect's life cycle to be effective.

## 1.5 Whiteflies

**Key Pest:** Whiteflies

**SCIENTIFIC NAME:** Trialeurodes spp, Aleurodicus spp, Bemisia spp.

**Target Crops:** Citrus, squash, potato, cucumber, grape and tomato.

Greenhouse Whitefly
(Trialeurodes vaporariorum)

Whitefly on squash leaf

Squash plant after damage

### a. Geographic Distribution:

Worldwide. Whiteflies develop rapidly in warm weather, and populations can build up quickly in situations where natural enemies are ineffective and when weather and host plants favour outbreaks.

### b. Description:

Common on indoor plants and in greenhouses, the whitefly (Trialeurodes vaporariorum) is a sap-sucking insect that is often found in thick crowds on the undersides of leaves.

### c. Location:

Found on undersides of host plant leaves.

### d. Damage and Importance:

Whiteflies use their piercing, needlelike mouthparts to suck sap from phloem, the food-conducting tissues in plant stems and leaves. Large populations can cause leaves to turn yellow, appear dry, or fall off plants. Like aphids, whiteflies excrete sugary liquid called honeydew, so leaves may be sticky or covered with

black sooty mould that grows on honeydew. Like aphids, whiteflies are also responsible for transmitting several plant viruses and also secrete honeydew, so leaves maybe sticky or covered with a black sooty mould.

### e. Control

- **Sampling and economic thresholds:** Small lady beetles including Clitostethus arcuatus (on ash whitefly) and scale predators, such as Scymnus or Chilocorus species, and the Asian multi-coloured lady beetle, Harmonia axyridis, feed on whiteflies. You can evaluate the degree of natural parasitization in your plants by checking empty whitefly pupal cases.

- **IPM practices:** In many situations, natural enemies will provide adequate control of whiteflies; outbreaks often occur when natural enemies are disrupted by insecticide applications, dusty conditions, or interference by ants. Avoid or remove plants that repeatedly host high populations of whiteflies. In early stages, population development can be held down by a vigilant program of removing infested leaves or hosing down with water sprays. Reflective mulches can repel whiteflies from vegetable gardens, and yellow sticky traps can be used to monitor or, at high levels, reduce whitefly numbers.

- **Chemical Control:** If you choose to use insecticides, insecticidal soaps or oils such as neem oil may reduce but not eliminate populations. Systemic insecticides may be more effective but are not registered for use on many food crops in gardens and can have negative impacts on beneficial insects and pollinators. The soil-applied systemic insecticide Imidacloprid can control whiteflies.

## 1.6 Thrips

**Key Pest:** Thrips

**SCIENTIFIC NAME:** Frankliniella spp, Thrips spp, Caliothrips spp.

**Target Crops:** vegetables including garlic, onion, carrots, squash and pepper. Citrus, avocado. Thrips are major pest in onion.

Onion thrips leaf stippling

Bean thrips adults

Onion bulb thrips after thrips damage

### a. Geographic Distribution:

Worldwide.

### b. Description:

Thrips are sap sucking pest which suck juices and causes scraping at fruits, flowers, and leaves. Adults are very small (less than 1/25 inch) straw-coloured or black slender insects with two pairs of feathery wings. Without the use of a hand lens, they resemble tiny dark threads.

### c. Location:

Found on leaves and flowers.

### d. Damage and Importance:

Thrips feeding on plants can damage fruit, leaves, and shoots and very noticeably affect plants' cosmetic appearance. Immediate symptoms are stunted, growth damaged leaves to become papery and distorted, develop tiny pale spots (stippling), and drop prematurely. Diseased terminals may discolour and become

rolled. On severe cases, plant leaves may turn pale, splotchy, and silvery, then die.

### e. Control

- **Sampling and economic thresholds:** Though tiny, thrips can be observed by visual detection.

- **Promote biological methods:** Specific natural enemies are important in thrips control. Predatory thrips such as green lacewings, minute pirate bugs, mites, and certain parasitic wasps help to control plant-feeding thrips. Therefore avoid creating dust and consider occasionally rinsing dust off of small plants, avoid persistent pesticides, and grow a diversity of plant species so as to conserve and encourage naturally occurring populations of these beneficials.

- **IPM practices:** Distinguishing thrips species is a prerequisite when using IPM. Avoid planting susceptible plants next to these areas, and effective weed control is crucial. Provide appropriate cultural care to keep plants vigorous and increase their tolerance to thrips damage. Keep plants well irrigated, and avoid excessive applications of nitrogen fertilizer, which may promote higher populations of thrips. Use of resistant varieties is also recommendable.

- **Chemical Control:** Insecticides control is not effective for thrips partly because of their mobility, feeding behaviour, and protected egg and pupal stages. However use Actara 25WG or Karate 5EC/5CS.

## 1.7 Spider Mites

**Key Pest:** Spider Mites

**SCIENTIFIC NAME:** Tetranychus urticae

**Target Crops:** Watermelons squash, melons, tomatoes, potatoes, peas and beans. Spider mite is a major pest in Solanaeceous family

Spider mite building web on a crop

Spider mites

Mite colony on underside of leaf

### a. Geographic Distribution:

Worldwide. Spider mites reproduce rapidly in hot weather and if the temperature and food supplies are favourable, a generation can be completed in less than a week.

### b. Description:

Spider mites look like tiny, moving dots which cannot easily detected by naked eye. The names "spider mite" and "web spinning mite" come from the silk webbing most species produce on infested leaves. Adult mites have eight legs and an oval body with two red eyespots near the head end. Females usually have a large, dark blotch on each side of the body and numerous bristles covering the legs and body.

### c. Location:

Spider mites live in colonies, mostly on the under surfaces of leaves of host plants and a single colony may contain hundreds of individuals.

### d. Damage and Importance:

Damage is by sucking cell contents from leaves. The damage shows up as a stippling of light dots on the leaves; sometimes the leaves take on a bronze colour. As feeding remains, the leaves turn yellowish or reddish and drop off. Large amounts of webbing cover leaves, twigs, and fruit and at most the damage is aggravated by water stress. As foliage quality declines on heavily infested plants, plants will eventually wilt and die. Quality, yield and income are lost as a result of spider mites.

### e. Control

- **Sampling and economic thresholds:** Counts the number adults only. Target the first fully expanded leaves and 1 middle leaf. Count the adult numbers on positions with greatest infestations. Commence spraying as soon as they are seen in the field.

- **Promote biological methods:** Spider mites have many natural enemies, which limit their numbers in horticulture. Some of the predators are western predatory mites.

- **IPM practices:** Adequate irrigation is important, because water-stressed plants are most likely to be damaged. Broad-spectrum insecticide treatments for other pests frequently cause mite outbreaks, so avoid these pesticides when possible. Sprays of water, insecticidal oils, or soaps can be used for management. Always monitor mite levels before treatment.

- **Chemical Control:** Spider mites frequently become a problem after applying insecticides. Such outbreaks are commonly a result of the insecticide killing off the mites' natural enemies but also occur when certain insecticides stimulate mite reproduction. Chemicals like 40% Dimethoate EC, 1.8% Abamectin, 18.5% Dicofol, 20% Amitraz are recommended in Solanaeceous crops.

## 1.8 Heliothis Bollworm

**Key Pest:** Heliothis Bollworm

**SCIENTIFIC NAME:** Helicoverpa armigera

**Target Crops:** Beans, Cotton, Cowpea, Green gram, Maize, Okra, Peas, Peppers, Sorghum and Tomato.

African bollworm eggs are tiny

The African bollworm pupa

Heliothis bollworm on an unripe tomato fruit

### a. Geographic Distribution:

Heliothis Bollworm is also known as the African bollworm and is reported to be present in all African countries (CABI Compendium 2006).

### b. Description:

The eggs are tiny (about 0.5 mm in diameter), round and yellowish-white in colour. They darken before hatching and are deposited singly on tender parts of the plant. Young caterpillars (larvae) are generally yellowish-white to reddish brown. They have a dark brown to black head and several rows of black bumps with short hairs along their backs, which give them a spotted appearance. Fully-grown caterpillars are 35 - 40 mm long. Older caterpillars vary in colour from almost black, brown or green to pale yellow with dark grey yellow stripes along the sides of the body. All caterpillars have a typical light stripe along each side of the body. The head is brown or green and mottled. The fully-grown caterpillars drop from the plant and burrow into the soil to pupate. The pupa is shiny brown, about 16 mm long, with smooth surface, with two short parallel spines at the posterior tip of the body. Pupation takes place in the soil. The adult moth is fleshy, yellowish-brown with a dark speck, greyish irregular lines and a black kidney-shaped mark on the

forewings. The hind wings are whitish with a black patch along the outer margin. The moth is about 14 to 18 mm long with a wingspan of 35 to 40 mm. They are relatively strong fliers, dispersing widely within areas where the host plants are found. They can also be carried by strong winds. Moths are strongly attracted to plants that provide honeydew or nectar.

### c. Location:

Caterpillars feeds on leaves, growing points, inflorescence and fruits/pods.

### d. Damage and Importance:

The damage is on flower and fruits. Flower feeding can prevent fruit formation. Caterpillars usually bore clean, circular holes through fruits/pods. Apart from disturbing fruit formation and development, the serve as entry points for secondary infection by diseases causing fruit decay. One caterpillar can damage several fruits/pods. Once they burrow into the fruits/pods they are difficult to reach and to control with insecticides. Often caterpillars feed with the head and forepart of the body inside the fruit/pod and the rest of the body outside. The damage affects both quality and yield of harvested tomatoes fruits. Since the bollworm prefers to cut-flowers, it is responsible for huge economic losses and socio-economic costs hence regarded as is a quarantine pest.

### e. Control

- **Sampling and economic thresholds:** Prior to spray, randomly select 30 tomato plants and examine the leaves immediately below the topmost open flowers to look for eggs of African bollworm (AVRDC, 2000). The decision to make an intervention to manage this pest should be based on an analysis of the situation (stage of the crop, presence of natural enemies and economic return (based on market value of the crop and the value of the intervention) at an average of one egg per two plants in twice-weekly counts.

- **Promote biological methods:** Natural enemies like egg parasitoids (e.g. Trichogramma spp.) and larval parasitoids (wasps and flies that parasitise caterpillars) can offer biological control. Also chicken, birds, ants, assassin bugs, minute pirate (anthocorid) bugs, lacewings and ladybird beetles can also control.

- **IPM practices:** Destroy plant residue after harvesting. Plough the soil after harvesting. This exposes pupae, which may then be killed by natural enemies or through desiccation by the sun. Handpick and destroy eggs and small caterpillars. Practice crop rotation, intercropping and use trap crops.

- **Chemical Control:** Spraying practices can harm natural enemies. However use Carbaryl 85WP.

## 1.9 Sciarid Fly

**Key Pest:** Sciarid Fly

**SCIENTIFIC NAME:** Lycoriella spp.

**Target Crops:** Mushrooms.

A Sciaridae ovipositing into a leaf of Urtica

Damaging larval stage

Mushroom after the damage

### a. Geographic Distribution:

The Sciaridae occur worldwide, even in extreme habitats such as sub Antarctic islands and mountainous regions above 4,000 m. Others (such as Parapnyxia) are found in deserts, where they dig into the sand at extreme temperatures. Several species live exclusively in caves. However, most species live in forests, swamps, and moist meadows, where they live in the foliage.

### b. Description:

These gnats are small, from one to at the very most seven millimetres long. They have slender, darkly coloured bodies and dark wings. However, the females of several species are wingless. Their long legs and antennae with eight to 16 segments are typical of many gnats.

### c. Location:

Large colonies often develop on the undersides of leaves.

### d. Damage and Importance:

Sciarid larvae feed on mycelium; destroy pins of developing mushrooms, and burrow or tunnel into the stems and caps of maturing mushrooms. In addition to destroying mushroom tissue and depositing frass, sciarid larvae may introduce decay-causing organisms which make it necessary to trim and discard sections or whole mushrooms.

### e. Control

- **Promote biological methods:** The damaging larval stage can be controlled using the beneficial nematode Steinernema feltiae, which enters the larva and releases a bacterium that kills the insect. The nematode then reproduces within the larva and its young are released into the growing medium, where they actively search out new host larvae.

- **IPM practices:** Practice field hygiene. Maintenance of desirable moisture in mushroom production.

- **Cultural Control:** Large numbers of flies can be caught on sticky yellow traps (including roller traps) that are sticky on both sides. Avoid over-watering. Sub-irrigation in nurseries and interior landscapes helps to keep the compost surface dry, preventing sciarid flies from breeding.

- **Chemical Control:** use chemicals with Chlorpyrifos as the active ingredient.

## 1.10 Fruit Fly

**Key Pest:** Fruit Fly

**SCIENTIFIC NAME:** Ceratitis spp., Dacus spp., Bactrocera spp.

**Target Crops:** Butternut and other Cucurbits crops.

Adult fruit fly

Pumpkin fruit after fruit fly damage

Butternut fruit after fruit fly damage

### a. Geographic Distribution:

Fruit flies (diverse species) have been recorded in all African countries. The Mediterranean fruit fly is the most widely distributed.

### b. Description:

Fruit flies (Drosophila melanogaster) are also sometimes called vinegar flies. They are common in homes, restaurants, supermarkets and wherever else food is allowed to rot and ferment. Adults are about 1/8 inch long and usually have red eyes. The front portion of the body is tan and the rear portion is black.

### c. Location:

Butternut fruits.

### d. Damage and Importance:

Adult female fruit flies lay eggs in the flesh of ripening and ripe fruits and vegetables. Fruit fly larvae (maggots) can cause your fruit and vegetables to turn into a soft, mushy mess. Once the

eggs hatch, the larvae begin to feed within the fruit, causing it to ripen prematurely, rot and drop to the ground. Look for wiggling white larvae the next time you pick a very ripe guava or other fruit. This damage can make your fruit inedible.

### e. Control

- **Promote biological methods:** Fruit fly has no specific predator, generalist predators include: braconid wasps which are egg parasites; ants and ground beetles feed on maggots; spiders catch adults in webs; predatory flying insects such as dragonflies and robber flies; birds such as swallows, restless flycatchers and willy wagtails. Poultry are an enormous help in fruit fly control.

- **IPM practices:** Farmers can use baits and traps. Practice sanitation through removing any fruit from the tree with dimples or weeping clear sap as this is a sign that eggs have already been laid in the fruit.

- **Chemical Control:** Systemic products such as Fenthion can even kill the flies that sting the fruit soon after application, as well as eggs and maggots for a few days after application. The fruit needs to be wetted as well. Pyrethroids can also be used to kill the flies landing on the leaves. Use 25% Malathion and 95% Trichlorfon for control.

## 1.11 Cucumber Beetle

**Key Pest:** Cucumber Beetle

**SCIENTIFIC NAME:** Diabrotica spp.

**Target Crops:** Major pest of cucurbits particularly cucumbers.

Eggs of cucumber beetle

Beetle piercing the leaf of cucumber leaves

Damage caused by the beetles to cucumber leaves.

### a. Geographic Distribution:

Worldwide.

### b. Description:

Cucumber beetles are about 0.36 inch (9 mm) long and either have a greenish yellow background with black spots or alternating black and yellow stripes. They fly readily and migrate into cultivated areas from alfalfa and other crops, and from uncultivated lands. Cucumber beetles like moisture and dislike heat; consequently, melon fields are especially attractive in hot weather during and after irrigation.

### c. Location:

Cucumber beetles (adults) and eggs are found leaves of host plants.

### d. Damage and Importance:

Cucumber beetles are serious pests of smooth-skinned cucurbits, especially melon varieties such as honeydew, crenshaw, and casaba. While the adults prefer tender, succulent portions of plants, including

the flowers and leaves, which they may destroy with their feeding, it is the damage to the surface of the melon that reduces marketable yield. When temperatures are high, adults especially feed on the undersides of young melons, scarring them. After the skin hardens, melons are much less subject to attack. Scarring in the crown of the plant is also typical of adult damage. Feeding on stems of young plants, followed by sustained winds, may result in severe stand reductions making replanting necessary. In some situations, larvae may cause serious injury by feeding on roots, and young plants can be killed. Cucumber beetles also spread squash mosaic virus.

### e. Control

- **Sampling and economic thresholds:** Thresholds for use of botanical or chemical control measures vary depending on species susceptibility to bacterial wilt. Pesticide applications for adults may be necessary if there is an average of one beetle per plant during the seedling-to-4-inch-tall stage. Infestations that develop late in the season are usually not as damaging as those that begin earlier because numbers tend to be lower. Apply insecticides before beehives are introduced into the field; typically, an application is often made the day before bees are put in the field.

- **Promote biological methods:** Cucumber beetles are attacked by a variety of natural enemies, the most important being a parasitic tachinid fly, Celatoria diabroticae. Natural enemies are rarely effective enough, however, to reduce populations below economically damaging levels. Use repellent plants such as Broccoli, calendula, catnip, goldenrod, nasturtiums, radish, rue and tansy. If you want to try marigolds to repel them use the more pungent varieties like African, French or Mexican marigolds.

- **IPM practices:** Start monitoring for cucumber beetles after transplanting or when seedlings emerge, through the fruiting stage. Plant any type of beans with cucumber. Cultivate in the fall to expose the eggs to freezing weather and for birds to eat. Because spotted cucumber beetle larvae also feed on corn, avoiding planting cucurbits next to corn may help.

- **Chemical Control:** Use 50% Malathion at recommended rate.

## 1.12 Carrots Weevil

**Key Pest:** Carrots Weevil

**SCIENTIFIC NAME:** Meloidogyne spp.

**Target Crops:** Carrots, sweet potatoes and roots crops.

Carrot damaged by carrot weevil

Destructive stage - weevil larvae feeding on carrots

Field showing carrots affected by carrots weevil

### a. Geographic Distribution:

Worldwide.

### b. Description:

Adult weevils overwinter in crop debris remaining in the ground; larvae feed for approximately 2 weeks before pupating in the soil; insect undergoes several generations each year.

### c. Location:

Roots of crop.

### d. Damage and Importance:

Irregular dark grooves in zig-zag pattern on roots; leaves of plant may yellow; adult insect is a dark colored beetle; larvae are white to pinkish white C-shaped grubs with a yellow-brown head.

### e. Control

- **Promote biological methods:** Introduction of predators and pathogens (e.g beneficial viruses, bacteria and fungi).

- **IPM practices:** Remove all debris from Umbelliferous crops (e.g. parsley, dill, celerey etc.) to reduce sites where weevil can survive and persist; try to rotate Umbelliferous crops to different areas of the home garden each year to reduce survival of larvae in soil.

- **Chemical Control:** You can use chemical fumigants (40% Fenamiphos or 99.5% Ethylene Dibromide).

## 1.13 Root-Knot Nematodes

**Key Pest:** Root-Knot Nematodes

**SCIENTIFIC NAME:** Meloidogyne spp, Paratrichodorus spp, Longidorus africanus.

**Target Crops:** Bananas, beans, carrot, citrus plants, coffee, cotton, cowpea, cucumber, eggplant, groundnut, okra, papaya, passion fruit, peas, peppers, pigeon pea, pineapple, potato , rice, soybean, sweet potato, tea, tomato, watermelon. Nematodes are major pest in Solanaceous crops.

Root-knot nematodes
Severely attacked (left); healthy plant (right)

Root knot nematodes symptoms in carrots

Reduced crop stand due to nematode damage

### a. Geographic Distribution:

Worldwide. Is the most serious plant parasitic nematode pest of tropical and subtropical regions throughout the world.

### b. Description:

Root-knot nematodes measure about 0.5 mm to 1.5 mm in length. Juveniles (young nematodes) penetrate the root tips and occasionally invade roots in the zone of root elongation. Invaded nematodes initiate the development of giant cells in the root tissues and galling of roots occurs. Root knot nematodes are soil inhabitants. They are spread by transplanting infested seedlings, or from soil washed down slopes or sticking to farm implements and farm workers. They may also be spread by irrigation water.

### c. Location:

Affects leaves, roots and whole plant.

### d. Damage and Importance:

Affected plants are stunted and yellow and have a tendency to wilt in hot weather. Very heavily infested plants are killed. Affected plants appear in patches. If infested plants are pulled from the soil, the roots are severely distorted, swollen and have lumps known as galls or root knots. The galls range in size from smaller than a pinhead to 25 mm or more in diameter. It affects plants at lowering stage, fruiting stage, seedling stage and vegetative growing stage. Affected plants are normally stunted and eventually wilt and die. The most characteristic symptom is formation of root galls (knots) and these can be seen with the naked eye. Affected roots rot.

### e. Control

- **Promote biological methods:** Introduction of predators and pathogens (e.g beneficial viruses, bacteria and fungi).

- **IPM practices:** Crop rotation, enhancement of soil quality, use of resistant varieties, water management, monitoring/screening, chemical barrier, field sanitation and post-harvest treatment.

- **Chemical Control:** You can use chemical fumigants (40% Fenamiphos or 99.5% Ethylene Dibromide).

# Unit 2: Diseases

## 2.1 Powdery Mildew

**Key Disease:** Powdery Mildew

**CAUSAL AGENT:** Various

**Target Crops:** beans, beets, carrot, cucumber, eggplant, cole crops, melons, parsnips, butternut, peas, peppers, tomatoes, radishes, squash, turnips, okra and pumpkins. A major disease in Cucurbits crops especially butter nut.

Powdery mildew on cucumber leaves

Causes irregular yellow blotches on tomato leaves

Brownish spots on pea pod from powdery mildew infection

### a. Geographic Distribution:

Worldwide. Infection can occur when temperatures are between 50 and 90 °F, during dry weather with high relative humidity. In cucurbits, the disease can be a particular problem on late-planted squash. It is also more prevalent than many other leaf-infecting diseases under dry summer conditions.

### b. Description:

It is a fungal disease which may cause the leaves to twist, buckle, or otherwise distort. Powdery mildew first appears as white, powdery spots that may form on both surfaces of leaves, on shoots, and sometimes on flowers and fruit. These spots gradually spread over a large area of the leaves and stems and it produces yellow patches on leaves but little powdery growth.

### c. Location:

Surface of leaves, on shoots, and sometimes on flowers and fruit.

### d. Damage and Importance:

Leaves infected with powdery mildew may gradually turn completely yellow, die, and fall off, which may expose fruit to sunburn. Severely infected plants may have reduced yields which translate decreased income to farmer, shortened production times, and fruit that has little flavour.

### e. Control

- **Promote biological methods:** Where thrips are a problem, learn whether that pest has specific natural enemies important in its control. Predatory thrips such as green lacewings, minute pirate bugs, mites, and certain parasitic wasps help to control plant-feeding thrips. To conserve and encourage naturally occurring populations of these beneficials, avoid creating dust and consider periodically rinsing dust off of small plants, avoid persistent pesticides, and grow a diversity of plant species.

- **IPM practices:** Plant in sunny areas as much as possible, provide good air circulation, and avoid applying excess fertilizer. A good alternative is to use a slow-release fertilizer. Overhead sprinkling may help reduce powdery mildew because spores are washed off the plant. However, overhead sprinklers are not usually recommended as a control method in vegetables because their use may contribute to other pest problems. Use of resistant crop c cultivars is recommended.

- **Chemical Control:** In some situations, especially in the production of susceptible cucurbits, fungicides may be needed. Fungicides function as protectants, eradicants, or both. A protectant fungicide prevents new infections from occurring whereas an eradicant can kill an existing infection. Apply protectant fungicides to highly susceptible plants before the disease appears. Use eradicants at the earliest signs of the disease. Once mildew growth is extensive, control with any fungicide becomes more difficult. Farmers can use Thiovit 80WG, Topas 100EC and Alto 100SL.

## 2.2 Damping Off

**Key Disease:** Damping Off

**CAUSAL AGENT:** Various

**Target Crops:** All vegetables seedlings, garlic, onion, carrots, squash and pepper. Citrus and avocado.

Tomatoes seedling affected by damping off

Tomatoes seedling affected by damping off

Tomatoes seedling affected by damping off

### a. Geographic Distribution:

Worldwide. Damping off is a problem during wet season when light levels and temperatures are high and seedlings grow slowly, but may occur at any time of year.

### b. Description:

Damping off is a fungal disease of seedlings which cause emerging seedlings to collapse, often submerged in a mass of white fungal growth. It is particularly a problem when sowing seed indoors or under glass.

### c. Location:

At most it affects roots, stem at ground level or the whole stem and leaves of the seedlings.

### d. Damage and Importance:

Damping off can affect most seedlings, particularly under levels of high humidity, poor air circulation and if seed is sown to thick. It is mainly a problem when sowing early indoors or under glass, but can affect seedlings sown outdoors. Failure of seedlings to emerge is known as pre-emergence damping off.

Seedlings collapse, often submerged in a mass of whitish fungal growth is the immediate symptoms of Damping off.

### e. Control

- **IPM practices:** Raise seedlings in commercial growing compost, which is usually free of these fungi. If home-produced compost must be used, consider steam sterilisation to destroy pathogens. Ideally, use new pots and trays whenever raising seedlings. If they must be re-used, wash them thoroughly and preferably also treat them with a disinfectant such as Jeyes Fluid. Never reuse pots and trays in which damping off has been a problem. Sow seedlings thinly to avoid crowding. Use mains water if possible when irrigating seedlings grown in pots and trays. If using rainwater, ensure that the water butt is covered to prevent the entry of leaves and other organic debris that could harbour some of the damping off fungi. Do not overwater. Keep seedlings well ventilated to reduce humidity.

- **Chemical Control:** Use recommended fungicide such as Copper Oxychloride and (Mancozeb) Dithane M45.

## 2.3 Late Blight

**Key Disease:** Late Blight

**CAUSAL AGENT:** Phytophthora infestans

**Target Crops:** Solanaceous crop such as potatoes, eggplant, tomatoes.

Late blight in a Tomato crop

Symptom of Late blight tomatoes fruit affected

Symptom of Late blight on potatoes tuber affected

### a. Geographic Distribution:

Worldwide. Wet or humid weather conditions causes severe damage and its major disease in the tropics where the temperature are relatively higher.

### b. Description:

It is a fungal disease that cause greyish green water soaked lesions on the leaves, rapidly turning black. Under moist conditions white downy fungal growth develops on the margins of the lesions. Stem lesions are dark brown; large mottled areas develop on the fruit.

### c. Location:

Late blight may infect either young (upper) or old (lower) leaves of host plant. It first appears as water-soaked areas that enlarge rapidly, forming irregular, greenish black blotches, giving the plant a frost-damaged appearance.

### d. Damage and Importance:

First appears as water-soaked areas that enlarge rapidly forming irregular, greenish black blotches giving the plant a frost-damaged appearance. The undersides of the leaves often show a downy white growth in moist weather. Infection of green or ripe fruit produces large, irregularly shaped brown blotches. Infection of green or ripe fruit produces large, irregularly shaped brown blotches. Infected fruits rapidly deteriorate into foul-smelling masses. The disease negatively impact crop marketability and shelf life hence loss of both yield and income to a farmer.

### e. Control

- **IPM practices:** Avoid overhead watering - Water at the base of the plants, and in the morning rather than the evening, to minimize the amount of time that the leaves are wet. Use of resistant varieties can also control the disease.

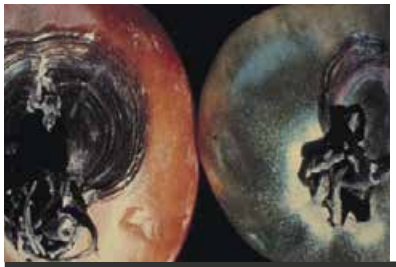
- **Chemical Control:** The fungi causing Late blight can be resistant to fungicide hence it is very important to rotate chemicals. Use Captan 50WP, Copper Oxychloride, Mancozeb and Bravo.

## 2.4 Early Blight or Alternaria Leaf Spot

**Key Disease:** Early Blight or Alternaria Leaf Spot

**CAUSAL AGENT:** Alternaria solani

**Target Crops:** Solanaceous crop – potatoes, eggplant, tomatoes. Early blight is one of major diseases in tomatoes.



Blotched tomatoes crop affected by Early blight

Foliage damage due to early blight

Defoliation caused by Early blight

### a. Geographic Distribution:

Worldwide.

### b. Description:

Early blight, caused by the fungus Alternaria solani, is also known as Alternaria leaf spot or target spot. Dark reddish-brown leaf spots with concentric marking appear first on the lower most leaves; cause defoliation. Infection of the fruit is usually around the calyx but may be associated with cracks and other skin injuries.

### c. Location:

Fruits and leaves of host crop.

### d. Damage and Importance:

Premature loss of lower leaves is the most obvious symptom of the disease. Like Septoria leaf spot, early blight can infect plants at any stage during the growing season but usually progresses most rapidly after

plants have set fruit. Yield reduction and poor fruit quality are the immediate effects of the disease in tomatoes.

### e. Control

- **Sampling and economic thresholds:** The best way to manage the disease is on a preventive basis. Once early blight is established in the crop, it is very difficult to control. Inspect the crop twice a week for plants with disease symptoms before initiating the fungicide application.

- **IPM practices:** *Planting season:* It is preferable to plant tomatoes in the dry season when the incidence of early blight is lower. *Plot location:* It is better not to have multiple plantings in the same area because old crops will serve as inoculum of early blight for the new plantings. Select plots surrounded by grasslands because they are not a host of this disease. *Windbreaks:* Plant windbreaks of fodder grasses such as Napier (elephant grass), or more permanent fruits trees such as mango, fig, banana or mulberry. *Irrigation:* Avoid the use of overhead irrigation. If overhead irrigation is used, then apply it early in the day to allow time for the crop to dry. *Seed quality:* Use disease-free certified seed. This can be bought from reputable seed merchants. Ensure the seed is in the original seed packet. *Seedling:* Seed-beds should be distant from old plantings. It is important to use new deep soil that has good drainage properties for the seed-beds. Sterilize the soil with hot water or ashes to eliminate the fungi from the soil. Inspect seedlings for any sign of disease and discard and destroy any that are suspected of being infected. *Fertilization:* Increase the organic matter in the soil as much as possible, especially by using old manure and maize stalk. This will increase fertility and decrease nematodes. The use of nitrogen fixing legumes in the crop rotation scheme can also increase the fertility of the land and eliminate some of the inoculum. *Remove un-harvested plant parts:* Destroy tomato plant and crop debris as soon as the crop is finished. Make a compost heap and cover it with a layer of soil. Do not use this compost on tomato or any susceptible crops. *Rotation:* Rotate crops by not planting tomatoes, potatoes, peppers, or eggplant in the same land for at least two, and preferably three, years.

- **Chemical Control:** *Pesticide recommendations* - Use only fungicides that are legal to use for this pest and crop in Zimbabwe. When early symptoms of the early blight are detected in the field, apply protectant fungicides (carbamates, clorotalonil, cuprics); use seven day intervals when the weather is cool and damp, and up to ten day intervals if the weather is dry. Overhead irrigation and rainfall will wash the fungicide off. They should be applied after an irrigation cycle and may have to be reapplied after a heavy rainstorm.

- **Spray techniques:** Sprays should be applied using a knapsack sprayer which is in good condition. It should be fitted with a hollow cone nozzle. The applicator should walk slowly down the rows covering the whole plant. Enough spray must be applied to coat the plant thoroughly, but the spray must not run off the plant.

## 2.5 Black Rot

**Key Disease:** Black Rot

**CAUSAL AGENT:** : Xanthomonas campestris

**Target Crops:** Brassica crops such as rape, covo, cabbage, brocolli

Initial stage of black rot on cabbage head

The advanced stage of the disease on cabbage head

Darkened cabbage head after Black rot

### a. Geographic Distribution:

Worldwide.

### b. Description:

Black rot is a bacterial diseases caused by Xanthomonas campestris pv. campestris.

### c. Location:

Leaves and stems.

### d. Damage and Importance:

The affected crop is evidenced with light-brown to yellow V-shaped lesions on the leaf, which become brittle and dry with age. Vein blackening with the necrotic area.

### e. Control

- **IPM practices:** maintaining field hygiene and sanitation through washing hands thoroughly with soap and water. Disease plants should be removed and destroyed (roguing). Avoid the purchase of any affected plant and control of weeds and chewing insects. Decontaminate any tools used in the process before contacting healthy plants.

- **Chemical Control:** Use copper compounds.

## 2.6 Bacteria Soft Rot

**Key Disease:** Bacteria Soft Rot

**CAUSAL AGENT:** Pseudomonas spp.

**Target Crops:** Wide range of vegetable crop such as broccoli, cabbages, lettuce, cucurbits, tomato, capsicum, potato, sweet potato, carrots, herbs and onion. Bacteria soft rot is a major disease in potatoes and brassicas.

Broccoli damaged by Bacteria soft rot

Bacteria soft rot on Potato tuber

Onion bulb affected by soft rot

### a. Geographic Distribution:

Worldwide.

### b. Description:

Symptoms first appear on leaves as small, water-soaked lesions that quickly enlarge. Affected tissue turns brown and becomes soft and mushy with an accompanying foul odour. Eventually, leaves, stems and roots may decay entirely. This disease may be found in the field on cabbage, Chinese cabbage, rutabaga and turnips, but post-harvest soft rot during shipping or storage accounts for the majority of losses from this pathogen.

### c. Location:

Bacteria soft rot occurs on leaves, roots, stems and heads of host plant.

### d. Damage and Importance:

Wet, slimy, soft rot that affects any part of vegetable crops including heads, curds, edible roots, stems and

leaves. May have a disagreeable odour. This accelerates crop perishability and also affects crop quality for local and export market.

### e. Control

- **IPM practices:** For all crops maintain field sanitation and crop rotation are a prerequisite in controlling the disease. In onions, proper curing and cold storage is vital. For potatoes, sanitation, avoid injury, crop rotation. Avoid soils which are too wet or dry, don't over irrigate, harvest when tubers are fully mature, provide adequate air circulation. In cabbages, avoid mechanical injury.

- **Chemical Control:** - Use Bion 50WG and copper compounds.

## 2.7 Downy Mildew

**Key Disease:** Downy Mildew

**CAUSAL AGENT:** Hyaloperonospora spp.

**Target Crops:** Cucurbits crops (melon, cucumber and squash) and Crucifers crops such as cauliflower, broccoli, cabbage and leafy vegetables.

Cauliflower crop affected with Downey Mildew

Discoloration on a Brocolli crop

Downy Mildew on underside of leaf

### a. Geographic Distribution:

Worldwide.

### b. Description:

Downy mildew is one of the most important leaf diseases of cucurbits.

### c. Location:

Typically, symptoms begin as small yellow areas on the upper leaf surface. As lesions expand, they may become brown with irregular margins.

### d. Damage and Importance:

Leaves infected with downy mildew curl inward as the leaf dies. As on other crops, spores usually are found on the bottom of the leaf, although spores may be formed on top of the leaf in severe infections or foggy weather.

### e. Control

- **IPM practices:** Use varieties that are resistant to this disease.

- **Chemical Control:** No fungicides are available to amateur gardeners for treating downy mildews.

## 2.8 Anthracnose

**Key Disease:** Anthracnose

**CAUSAL AGENT:** Colletotrichum orbiculare

**Target Crops:** Cucurbits – melons, tomatoes, fine beans and Solanaeceous crops.

Anthracnose lesions on watermelon fruit

Anthracnose damgge on ripe tomatoes fruit

Anthracnose damaged tomatoes leaves

### a. Geographic Distribution:

Worldwide. Spores are spread by rain splash, and the fungus is most common in warm, wet weather. The fungus survives the winter on diseased tomato vines, in the soil, and in seeds.

### b. Description:

Anthracnose, caused by the fungus Colletotrichum coccodes, is probably the most common fruit-attacking disease of tomato. Small, circular, indented area on tomato fruits As these spots expand; they develop dark centres or concentric rings of dark specks, which are the spore-producing bodies of the fungus. The flesh of the fruits may rot completely through, especially on overripe tomatoes, so keep fruits picked as they ripen.

### c. Location:

Depending on the type of crop, Anthracnose affects fruits, leaves (foliage) of crops. In tomatoes it can affect the fruit itself and in cucurbits can affects both fruits and foliage.

### d. Damage and Importance:

Anthracnose appears most commonly on overripe fruits. Affected plants die early and produce few, if any, fruit. Splitting open an infected stem reveals brownish streaks extending up and down the stem.

### e. Control

- **IPM practices:** Any diseased plants should be removed and destroyed to prevent further spread; crop debris should be removed after harvest or ploughed deeply into the soil to reduce inoculum. Plant disease-free transplants far enough apart that the plants will not be crowded after they are full grown, in order to help the foliage dry rapidly. Practice rotation and avoid working with plants when foliage is wet to avoid spreading disease-causing microorganisms. Avoid working with plants when foliage is wet to avoid spreading disease-causing microorganisms.

## 2.9 Blossom-End Rot

**Key Disease:** Blossom-End Rot

**CAUSAL AGENT:** Xanthomonas campestris

**Target Crops:** Peppers, melons, and eggplant and mostly tomatoes.

Blossom end rot on ripe tomatoes fruits

Water melon affected by Blossom end rot

Blossom end rot unripe tomatoes fruits

### a. Geographic Distribution:

In all areas where tomatoes are grown.

### b. Description:

Blossom end rot is a troublesome disease, familiar to most gardeners who have grown tomatoes. The disease is often prevalent in commercial as well as home garden tomatoes, and severe losses may occur if preventive control measures are not undertaken. Symptoms may occur at any stage in the development of the fruit, but, most commonly, are first seen when the fruit is one-third to one-half full size. As the name of the disease implies, symptoms appear only at the blossom end of the fruit.

### c. Location:

Tomato fruits and melons.

### d. Damage and Importance:

Initially a small, water-soaked spot appears, which enlarges and darkens rapidly as the fruits develop. The

spot may enlarge until it covers as much as one third to one-half of the entire fruit surface, or the spot may remain small and superficial. Large lesions soon dry out and become flattened, black, and leathery in appearance and texture.

This disease does not spread from plant to plant in the field, nor from fruit to fruit in transit. Since it is of a physiological nature, fungicides and insecticides are useless as control measures. The occurrence of the disease is dependent upon a number of environmental conditions, especially those that affect the supply of water and calcium in the developing fruits. Factors that influence the uptake of water and calcium by the plant have an effect on the incidence and severity of blossom end rot. The disease is especially prevalent when rapidly growing, succulent plants are exposed suddenly to a period of drought. When the roots fail to obtain sufficient water and calcium to be transported up to the rapidly developing fruits, the latter become rotted on their basal ends.

Another common predisposing factor is cultivation too close to the plant; this practice destroys valuable roots, which take up water and minerals. Tomatoes planted in cold, heavy soils often have poorly developed root systems. Since they are unable to supply adequate amounts of water and nutrients to plants during times of stress, blossom end rot may result. Soils that contain excessive amounts of soluble salts may predispose tomatoes to the disease, for the availability of calcium to the plants decreases rapidly as total salts in the soil increase.

### e. Control

- **IPM practices:** Control of blossom end rot is dependent upon maintaining adequate supplies of moisture and calcium to the developing fruits. Tomatoes should not be excessively hardened or too succulent when set in the field. They should be planted in well drained, adequately aerated soils. Tomatoes planted early in cold soil are likely to develop blossom end rot on the first fruits, with the severity of the disease often subsiding on fruits set later. Thus, planting tomatoes in warmer soils helps to alleviate the problem. Irrigation must be sufficient to maintain a steady even growth rate of the plants. Mulching of the soil is often helpful in maintaining adequate supplies of soil water in times of moisture stress.

When cultivation is necessary, it should not be too near the plants nor too deep, so that valuable feeder roots remain uninjured and viable. In home gardens, shading the plants is often helpful when hot, dry winds are blowing, and soil moisture is low. Use of fertilizer low in nitrogen, but high in superphosphate, such as 4-12-4 or 5-20-5, will do much to alleviate the problem of blossom end rot. In emergency situations, foliage can be sprayed with calcium chloride solutions. However, extreme caution must be exercised since calcium chloride can be phytotoxic if applied too frequently or in excessive amounts. Foliar

treatment is not a substitute for proper treatment of the soil to maintain adequate supplies of water and calcium.

Although differences exist among varieties with respect to susceptibility to blossom end rot, no varieties as yet have commercially useful resistance. When tomatoes, peppers, melons, and eggplant develop a sunken, rotten spot on the end of the fruit, the cause came long before you found the problem.

- **Chemical Control:** As a stop-gap measure, spray tomato plants with a calcium solution made for blossom-end rot. Follow label directions. Apply two to three times a week, beginning when the first blooms appear. This is not a long-term fix, but it may salvage your crop until you can take the steps mentioned above. The spray seems to work better on tomatoes than other vegetables.

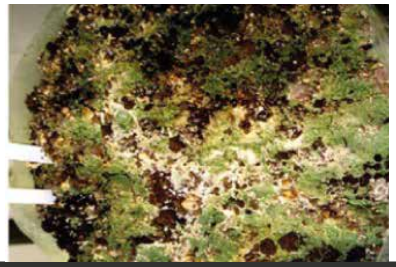
## 2.10 Green Mould

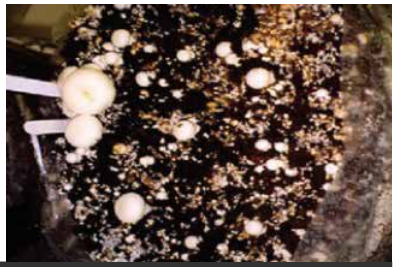
**Key Disease:** Green Mould

**CAUSAL AGENT:** Trichoderma harzianu

**Target Crops:** Mushrooms

Small pins turn brown and appear to lytically degrade





The bag on the left shows casing with healthy spawn growth, while the bag on the right shows the effects of green mold caused by Trichoderma harzianum biotype 4 (Th4)

a. Geographic Distribution: Worldwide.

b. Description:
Green mould is characterized by dense white mycelial growth followed by extensive green sporulation of the fungus. Apparently normal spawn runs can give way to large patches of green Trichoderma sporulation (Seaby 1996).

c. Location: Fungus found in soil as spores and on the outer surface of other plants.

d. Damage and Importance:
When mushroom beds spawned with the cultivated mushroom, Agaricus bisporus, are infested with Trichoderma green mould, non-productive areas occur on the casing surface resulting in serious yield losses. Trichoderma spp. have traditionally been found as weed moulds in compost, causing only limited green patches on casing/compost or cap spotting on mushrooms.

e. Control: **Chemical Control:** Chemical control is not effective in mushroom production.

## 2.11 Fusarium Wilt

**Key Disease:** Fusarium Wilt

**CAUSAL AGENT:** Fusarium oxysporum

**Target Crops:** Tomatoes, tobacco, legumes, cucurbits, sweet potatoes and bananas it is a major disease of bananas. In bananas it is as Banana wilt or Panama disease.

Split pseudostem as a result of Panama disease

Yellowing and wilting of the oldest leaves

Pumpkins affected with fusarium wilt

### a. Geographic Distribution:

The disease is common in tropical banana growing areas. Race 1: pan-tropical. TR4: southeast Asia, northern Australia, Middle East and Mozambique. It becomes a threat to banana farmers in Zimbabwe.

### b. Description:

Panama disease or banana wilt is the fungal disease which affects bananas. Panama disease, a form of Fusarium wilt, is widespread throughout the tropics and can be found wherever susceptible banana cultivars are grown.

### c. Location:

Panama disease is located at young roots, roots bases, rhizomes and leaf bases.

### d. Damage and Importance:

The Fusarium fungus invades young roots or root bases, often through wounds. Some infections progress into the rhizome (rootlike stem), followed by rapid invasion of the rootstock and leaf bases. Spread occurs

through vascular bundles, which become discoloured brown or dark red, and finally purplish or black. The outer edges of older leaves turn yellow. Within a month or two all but the youngest leaves turn yellow, wilt, collapse, and hang downward, covering the trunk (pseudostem) with dead brown leaves. All above ground parts are eventually killed, although fresh shoots may form at the base. These later wilt and the entire plant dies, usually within several years. The Fusarium fungus then continues to thrive in surrounding soil, preventing the success of future plantings. Fusarium wilt is responsible for the demise of the export quality bananas.

### e. Control

- **IPM practices:** In disease-free areas, using tissue-culture plantlets will prevent the spread of the disease through planting material. Drainage, environmental conditions and soil type influence host-pathogen interactions. Use of resistance cultivars is also recommended.

- **Chemical Control:** The fungus cannot be controlled using fungicides and cannot be eradicated from soil using fumigants.

## 2.12 Stem Rot

**Key Disease:** Stem Rot

**CAUSAL AGENT:** Sclerotinia spp

**Target Crops:** Vegetables, bean, cabbage and other crucifers, carrot, cucumber, eggplant, Irish potato, lettuce, pepper and squash. Many other crops such as clover, soybean and peanuts are susceptible

Stem rot on banana stem plant

Soyabean plant affected with stem rot

Stem rot on tomato plant

### a. Geographic Distribution:

Worldwide.

### b. Description:

The disease can be recognized by a soft, watery rot with white, moldy growth on stems, petioles, and leaves of tomato plants. Sclerotinia range from 2 to 10 mm inch in length and tend to be about 2 to 3 times longer than thick. They are white to pinkish inside. After the infection has apparently dried up, the line of demarcation between healthy and diseased tissue is very sharp. Often the diseased tissue is a light, straw color.

### c. Location:

Stem of the host plant.

### d. Damage and Importance:

Often initial infection occurs in the axes of branches or where a supporting string may be tied to the base

of the plant. These points accumulate nutrients, plant refuse, and moisture on which the fungus becomes established. Infection may start on leaves in contact with the soil and gradually grow through the petiole to the stem and eventually girdle it. If conditions remain moist, a large amount of cottony, moldy growth can be seen on the dead tissue. As this growth progresses, hard black, irregularly shaped bodies called sclerotia form on the surface or in the pith of the stem; they are diagnostic for the disease. Sclerotinia stem rot (timber rot) in greenhouse tomatoes occurs erratically during moist, cool periods in the spring. Distribution of diseased plants in a greenhouse is random. Plants of all ages are susceptible. The disease is important because 5 to 10% of the bearing plants may be killed and the fungus can survive several years in the soil.

### e. Control

- **IPM practices:** The control of this disease, as with many soil-borne diseases, requires a continuous good management program all year:

*Sanitation:* All infected plant parts should be removed from the greenhouse as they appear on plants. At the end of the season, plants should be removed promptly and the greenhouse thoroughly cleaned. During the summer, the soil should be cultivated and kept moist and free from weeds as these might harbor the fungus and make soil fumigation more difficult. Livestock manure and plant mulches should not be used unless disinfected by heat or gas. Fields surrounding the houses should not be cultivated with susceptible crops.

*Soil disinfestation:* Greenhouse soils should be fumigated or heated to make sure that all disease-causing germs have been killed. This is a good practice even if the stem rot is not a problem since other diseases and pests are also controlled. Use a broad spectrum soil fumigant. Heat the soil with stem to 180 degrees F for 30 minutes.

*Moisture control:* During the growing season, the greenhouse soil should be maintained as dry on the surface as possible. This can be done by irrigating heavily, but infrequently in holes next to tomato plants. Frequent, irrigations that wet plants must be avoided. The greenhouse atmosphere must be maintained as dry as possible by continuous, forced air circulation through a "poly tube" and by introducing cold air while heating. Removing lower leaves from the plants will enhance air movement and help prevent infection through the leaf tips

*Solarisation:* After sanitizing the greenhouse in late spring, close up the greenhouse during a hot and sunny week in the summer.

- **Chemical Control:** Use fungicides.

## 2.13 Cottony Soft Rot

**Key Disease:** Cottony Soft Rot

**CAUSAL AGENT:** Sclerotinia sclerotiorum

**Target Crops:** Major disease in carrots

Initial stage of cotton rot on carrots

Carrot covered in white mold caused by Sclerotinia infection

Cottony rot in carrots

### a. Geographic Distribution:

Worldwide.

### b. Description:

Sclerotinia infection may occur at any stage of growth, and extensive root decay may occur before symptoms of wilt and collapse appear on the upper part of the plant. Infection is always accompanied by a characteristic cottony, white mycelium that appears on the surface of the infected tissues. On or inside the white mycelium appear black, round-to-irregular-shaped structures (sclerotia), which are about 0.1 to 0.4 inch wide. Sclerotia are survival structures of the fungus. The fungi Pythium or Rhizoctonia may also produce cottony growth, but will not produce sclerotial bodies in the mycelium.

### c. Location:

Carrot roots.

### d. Control

- **Promote biological methods:** The use of the biological fungus, Coniothyrium minitans, are acceptable for use on organically grown produce.

- **IPM practices:** Cultural practices play an important role in the control of cottony rot as there are no resistant carrot varieties: in carrot fields, the use of drip irrigation 5-8 cm below the soil surface can provide good control; deep ploughing of soil and trimming back carrot foliage to promote air circulation can also be useful; fungicides may be warranted in periods of extended cool, damp weather.

- **Chemical Control:** Spray with fungicides.

# Appendix

# **Appendix 1:** Horticultural Market Availability Chart, 2008-2013

**Key** Full Supply | Erratic Supply | No Supply

| Product | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baby corn | 0.70 | .0.70 | 0.70 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.80 | 0.80 | 0.70 |
| Beans | 0.60 | 0.60 | 0.60 | 0.60 | 0.80 | 1.00 | 1.0 | 1.00 | 0.80 | 0..70 | 0.60 | 0.60 |
| Beetroot | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Broccoli | 1.00 | 1.00 | 0.80 | 0.80 | 0.70 | 0.70 | 0.4 | 0.40 | 0.40 | 0.70 | 0.80 | 0.80 |
| Butternut | 0.15 | 0.15 | 0.40 | 0.40 | 0.40 | 0.60 | 0.8 | 1.00 | 1.30 | 0.30 | 0.60 | 0.50 |
| Cabbage | 0.30 | 0.40 | 0.50 | 0.40 | 0.40 | 0.35 | 0.35 | 0.35 | 0.30 | 0.20 | 0.20 | 0.20 |
| Carrots | 0.60 | 0.60 | 0.60 | 0.60 | 0.40 | 0.40 | 0.40 | 0.35 | 0.30 | 0.30 | 0.30 | 0.40 |
| Cauliflower | 1.00 | 1.00 | 0.80 | 0.80 | 0.70 | 0.70 | 0.4 | 0.40 | 0.40 | 0.70 | 0.80 | 0.88 |
| Cucumber | 0.35 | 0.35 | 0.50 | 0.50 | 0.40 | 0.40 | 0.40 | 0.40 | 0.50 | 0.50 | 0.35 | 0.35 |
| Garlic | 1.50 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.5 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Lettuce | 0.50 | 0.50 | 0.40 | 0.40 | 0.35 | 0.35 | 0.30 | 0.30 | 0.35 | 0.50 | 0.50 | 0..50 |
| Muboora | 0.25 | 0.25 | 0.30 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.30 | 0.25 | 0.25 | 0.25 |
| Okra | 0.50 | 0.50 | 0.50 | 0.50 | 0.60 | 0.70 | 0.70 | 0.70 | 0.70 | 0.60 | 0.60 | 0.50 |
| Onions Zim | 0.75 | 0.75 | 0.75 | 0.75 | 0.60 | 0.50 | 0.50 | 0.50 | 0.60 | 0.50 | 0.50 | 0.45 |
| Onions SA | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| Onions green | | | | | | 0.40 | 0.4 | 0.35 | 0.35 | 0.40 | | |
| Peppers green | 0.75 | 075 | 0.75 | 0.70 | 0.70 | 0.80 | 0.80 | 0.80 | 0.80 | 0.60 | 0.60 | 0.60 |
| Potatoes | 0.70 | 0.70 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.70 | 0.80 | 0.80 | 0.60 | 0.60 |
| Pumpkins | 0.30 | 0.30 | 0.40 | 0.40 | 0.40 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Rape | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.25 | 0.25 | 0.25 | 0.25 |
| Tsunga | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.25 | 0.25 | | |
| Spinach | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Spring onions | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Tomatoes | 0.8 | 0.80 | 0.70 | 0.70 | 0.70 | 0.70 | 0.6 | 0.60 | 0.60 | 0.60 | 0.35 | 0.35 |
| Watermelons | 0.40 | 0.40 | 0.40 | 0.40 | 0.50 | 0.50 | 0.5 | 0.50 | 0.50 | 0.50 | 0.50 | 0.40 |

***NB:*** *This price and availability chart is based on optimum growing conditions. Due to the seasons and the weather, the theoretical availability may slightly differ from the actual changes in availability.*

# **Appendix 2:** Horticultural Pest and Disease Chart

## **Appendix 2:** FIne beans, Brassicas and Carrots

| Crop | Fungicide | Insecticide | Targeted Problem | Rate |
|---|---|---|---|---|
| **Fine Beans** | --- | Apron star 42WS | Aphids, bean stem maggot | 10g/4kg seed |
| | --- | Karate 5EC | Beetles, cutworm, caterpillars | 200ml/ha |
| | --- | Dynamec 18EC | Leafminer, red spider mite | 560ml/ha |
| | Bravo 720SC | --- | Anthracnose, rust | 1.8 - 2.3l/ha |
| | Copper compounds | --- | Bacterial blight | read label |
| | Score 250EC | --- | Rust | 300ml/ha |
| **Brassicas (cabbage, rape)** | --- | Chess 50WG | Aphids | 200g/ha |
| | --- | Actara 25WG | Aphids | 200g/ha |
| | --- | Polo 500SC | Aphids | 200-600ml/ha |
| | --- | Karate 5EC | Cutworm | 100ml/ha |
| | --- | Karate 5EC | Diamond back moth (DBM) | 8ml/100l water |
| | --- | Match 5EC | Diamond back moth, caterpillars | 600ml/ha |
| | Bravo 720SC | --- | Alternaria | 1.7 - 2l/ha |
| | Bion 50WG | --- | Bacterial/black spot | 25-50g/ha |
| | Apron star 42WS | --- | Black leg, seedling diseases & soil borne fungi | 10g/4kg seed |
| | Ridomil Gold Mz 68WG | --- | Downey mildew | 1.5kg/ha |
| **Carrots** | --- | Actara 25WG | Aphids | 200g/ha |
| | --- | Polo 500SC | Aphids | 200-600ml/ha |
| | --- | Karate 5EC | Cutworm | 100ml/ha |
| | --- | Dynamec | Leaf miners | 250-500ml/ha |
| | --- | Trigard | Leaf miners | 150g/ha |
| | Bravo 720SC | --- | Alternaria and cercospora | 1.5 - 2.5l/ha |
| | Alto 100SL | --- | Alternaria and cercospora | 300ml/ha |
| | Score 250EC | --- | Alternaria and cercospora | 250-500ml/ha |
| | Thiovit 80WG | --- | Powdery mildew | 2.5kg/ha |
| | Topas 100EC | --- | Powdery mildew | 125-360ml/ha |

# **Appendix 2:** Horticultural Pest and Disease Chart

## **Appendix 2:** Cucurbits (butternut, cucumber, melons and squashes), Onions & Garlic

| Crop | Fungicide | Insecticide | Targeted Problem | Rate |
|---|---|---|---|---|
| **Cucurbits (butternut, cucumber, melons and squashes)** | --- | Chess 50WG | Aphids | 200g/ha |
| | --- | Actara 25WG | Aphids | 200g/ha |
| | --- | Polo 500SC | Aphids, white fly | 200-600ml/ha |
| | --- | Karate 5EC/5SC | Caterpillars | 200ml/ha |
| | --- | Match 050Ec | Caterpillars | 400-600ml/ha |
| | --- | Karate 5EC/5SC | Cutworm | 100ml/ha |
| | --- | Dynamec 18EC | Leaf miners, red spider mite | 250-500ml/ha |
| | --- | Trigard 75WP | Leaf miners | 150g/ha |
| | --- | Dimethoate 40EC | Pumpkin fly | read label |
| | --- | Fenthion 50Ec | Pumpkin fly | read label |
| | --- | Karate 5EC/5SC | Thrips | 200ml/ha |
| | --- | Chess 50WG | White fly | 60g/100l water |
| | --- | Actara 25WG | White fly | 400g/ha |
| | Bravo 720SC | --- | Anthracnose, Downey mildew | 1.4-2l/ha |
| | Tecto 500SC | --- | Post-harvest rot in melons | 90ml/25l water |
| | Alto 100SL | --- | Powdery mildew | 300ml.ha |
| | Topas 100EC | --- | Powdery mildew | 225ml/ha |
| **Onions and Garlic** | --- | Karate 5EC/5CS | Cutworm | 100ml/ha |
| | --- | Actara 25WG | Thrips | 600g/ha |
| | Score 250EC | --- | Purple blotch , rust | 250-500ml/ha |
| | Ortiva 250SC | --- | Purple blotch , rust | 600ml/ha |
| | Bravo 720EC | --- | Downey mildew, white tip, neck rot | 280ml/100l water |
| | Ridomil Gold Mz 68WG | --- | Downey mildew, white tip | --- |

# **Appendix 2:** Horticultural Pest and Disease Chart

## **Appendix 2:** Peas and potatoes

| Crop | Fungicide | Insecticide | Targeted Problem | Rate |
|---|---|---|---|---|
| **Peas** | --- | Dimethoate | Aphids | Read label |
| | --- | Karate 5EC/5CS | Heliothis bollworm | 150-200ml/ha |
| | --- | Karate 5EC/5CS | Cutworm | 100ml/ha |
| | Alto 100SL | --- | Black spot | 300ml/ha |
| | Bravo 720SC | --- | --- | 1.4l/ha |
| | Ortiva 250SC | --- | --- | 600ml/ha |
| | Apron star 42WS | --- | Damping off, downey mildew | 10g/4kg seed |
| | Thiovit 80WG | --- | Powdery mildew | --- |
| | Topas 100EC | --- | Powdery mildew | 200ml/ha |
| | Alto 100SL | --- | Powdery mildew | 150-175ml/ha |
| **Potatoes** | --- | Karate 5EC/5CS | Cutworm | 100ml/ha |
| | --- | Trigard 75WP | Leafminer | 150g/ha |
| | --- | Dynamec 18Ec | Leafminer, red spider mite | 560ml/ha |
| | --- | Fenamiphos | Nematodes | Read label |
| | --- | Karate 5EC/5CS | Tuber moth | 150-200ml/ha |
| | --- | Match 50EC | Tuber moth | 400-600ml/ha |
| | --- | Chlopyrifos | White grub | Read label |
| | Tecto 500Sc | --- | Black scurf, stem canker, silver scurf | 400-800ml/100l water |
| | Bravo 720EC | --- | Early blight, late blight | 0.7-1.95l/ha |
| | Score 250EC | --- | Early blight | 35ml/100l water |
| | Ortiva 250SC | --- | Early blight | 300ml/ha |
| | Ridomil gold Mz 68WG | --- | Late blight | 2.5kg/ha |

# **Appendix 2:** Horticultural Pest and Disease Chart

## **Appendix 2:** Tomatoes

| Crop | Fungicide | Insecticide | Targeted Problem | Rate |
|---|---|---|---|---|
| **Tomatoes** | --- | Chess 50WG | Aphids | 200g/ha |
| | --- | Actara 25WG | Aphids | 200g/ha |
| | --- | Polo 500SC | Aphids, white fly | 600ml/ha |
| | --- | Karate 5EC/5CS | Cutworm | 100ml/ha |
| | --- | Karate 5EC/5CS | Bollworm | 200ml/ha |
| | --- | Match 050EC | Bollworm | 400-600ml/ha |
| | --- | Fenamiphos | Nematodes | Read label |
| | --- | Dynamec 18EC | Red spider mites | 560ml/ha |
| | --- | Chess 50WG | White fly | 60g/100l water |
| | --- | Actara 25WG | White fly | 400g/ha |
| | --- | Chlopyrifos | White grub | Read label |
| | Bion 50WG | --- | Bacterial diseases | Read label |
| | Coppers | --- | Bacterial diseases | Read label |
| | Calcium | --- | Blossom end rot | Read label |
| | Bravo 720SC | --- | Botrytis | 208-380ml/100l water |
| | Bravo 720SC | --- | Early blight, late blight | 0.7-1.95l/ha |
| | Ortiva 250SC | --- | Early blight | 300ml/ha |
| | Ridomil Gold Mz 68WG | --- | Late blight | 350g/150l water |

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