EVERYTHING YOU EVER WANTED TO KNOW ABOUT SWEETPOTATO

TOPIC 7

Sweetpotato Pest and Disease Management

Reaching Agents of Change Training of Trainers (ToT) manual

October 2018

Building Nutritious Food Baskets

RAC Support Vitamin A Sweetpotato

CIP INTERNATIONAL POTATO CENTER A CGIAR RESEARCH CENTER

UNIVERSITY of GREENWICH

NRI | Natural Resources Institute

Helen Keller INTERNATIONAL

Orange-Fleshed SWEETPOTATO Rich in Energy & Natural Vitamin A

Everything You Ever Wanted to Know about Sweetpotato. Topic 7 - Sweetpotato Pest and Disease Management
Reaching Agents of Change ToT Training Manual

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Contents

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This team has brought together and shared their many years of experience of working with sweetpotato systems and farmer learning processes across Sub-Saharan Africa to compile this *Everything You Ever Wanted to Know about Sweetpotato* resource. None of this experience would have been gained without the partnership of many sweetpotato farmers and other stakeholders (extensionists, national researchers, traders, transporters, NGO staff, nutritionists, media and donors) across the region. We thank you, and hope that this resource can in return offer you support in your sweetpotato activities.

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This manual was originally produced as part of the Reaching Agents of Change project in 2013 and updated by the Building Nutritious Food Baskets project in 2017/2018 – both projects funded by the Bill & Melinda Gates Foundation.

Acronyms and Abbreviations

AIs	Adequate Intakes
AVRDC	The World Vegetable Centre
BNFB	Building Nutritious Food Baskets
CBO	Community Based Organisation
CIP	International Potato
DAP	Days After Planting
DFE	Dietary Folate Equivalents
DONATA	Dissemination of New Agricultural Technologies in Africa
DVM	Decentralised Vine Multipliers
dwb	Dry Weight Basis
FAO	Food and Agriculture Organisation of the United Nations
FW	Fresh Weight
HH	Household
HKI	Helen Keller International
IBPGR	Bioversity International
IPM	Integrated Pest Management
IPPM	Integrated Pest & Production Management
K	Potassium
LGA	Local Government Areas
M&E	Monitoring and Evaluation
MAP	Months After Planting
m.a.s.l.	Metres Above Sea Level
Mm	Mass Multiplication
MSC	Most Significant Change
N	Nitrogen
NARO	National Agricultural Research Organisation
NGO	Non-Government Organisations
NHV	Negative Horizontal Ventilation
NRI	Natural Resources Institute
OFSP	Orange-fleshed Sweetpotato
P	Phosphorous
PMCA	Participatory Market Chain Approach
PMS	Primary Multiplication Site
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
QDPM	Quality Declared Planting Material

QDS	Quality Declared Seed
RAC	Reaching Agents of Change
RAE	Retinol Activity Equivalents
RCT	Randomised Control Trial
RDA	Recommended Daily Allowances
RE	Retinol Equivalents
REU	Reaching End Users
RH	Relative Humidity
SASHA	Sweetpotato Action for Security and Health in Africa
SMS	Secondary Multiplication Site
SP	Sweetpotato
SPCSV	Sweetpotato Chlorotic Stunt Virus
SPFMV	Sweetpotato Feathery Mottle Virus
SPKP	Sweetpotato Knowledge Portal
SPVD	Sweetpotato Virus Disease
SSA	Sub-Saharan Africa
ToT	Training of Trainers
TMS	Tertiary Multiplication Site
Tshs.	Tanzanian Shillings
TSNI	Towards Sustainable Nutrition Improvement
UNICEF	United Nations Children's Fund
USD	United States Dollar
Ushs.	Ugandan Shillings
VAD	Vitamin A Deficiency
WAP	Weeks After Planting
WHO	World Health Organisation
WTP	Willingness to Pay

Foreword

During the past decade, interest in sweetpotato in Sub-Saharan Africa (SSA) has expanded, the number of projects utilizing sweetpotato has increased, and the demand for quality training resources, training development practitioners and farmers has subsequently risen. Sweetpotato scientists at the International Potato Center and national research centres often received these requests and frequently held 1-3 day training sessions, drawing on whatever training materials they had or could quickly pull together.

The Reaching Agents of Change (RAC) project in 2011 changed that situation. Jointly implemented by the International Potato Center (CIP) and Helen Keller International (HKI), RAC sought to empower advocates for orange-fleshed sweetpotato (OFSP) to successfully raise awareness about OFSP and mobilize resources for OFSP projects. RAC also sought to build the capacity of public sector extension and non-governmental organizational personnel to effectively implement those projects to promote the dissemination and appropriate use of vitamin A rich, orange-fleshed sweetpotato. The Building Nutritious Food Basket (BNFB) is a three-year project (November 2015 to October 2018) that followed on from the RAC project. The project is implemented in Nigeria and Tanzania and funded by the Bill & Melinda Gates Foundation. The goal of the project is to accelerate and support scaling up of biofortified crops for food and nutrition security and to help reduce hidden hunger by catalyzing sustainable investment for the utilization of biofortified crops (OFSP, PVA maize, high iron beans and vitamin A cassava) at scale. BNFB develops institutional, community and individual capacities to produce and consume biofortified crops. The objectives of the project are to strengthen the enabling environment for increased investments in biofortified crops and to develop institutional and individual capacities to produce and consume biofortified crops.

RAC/BNFB goal of developing and revising the Training of Trainers (ToT) manual on *Everything You Ever Wanted to Know about Sweetpotato* was to see *sustained* capacity for training senior extension personnel about the latest developments in sweetpotato production and utilization in each of the major sub-regions of SSA: Eastern and Central Africa, Southern Africa, and West Africa. Hence, CIP identified local institutions to work with in Mozambique, Tanzania, and Nigeria to host an annual course entitled: *Everything You Ever Wanted to Know about Sweetpotato.* The course has progressed from initially having CIP scientists working closely with national scientists to implement it, to national scientists and partners independently organising and conducting the course. In subsequent years, institutions in Burkina Faso, Ethiopia, Ghana, Malawi and others have been capacitated in conducting the course.

In developing the course content, a long-time collaborator of CIP, Tanya Stathers of the Natural Resources Institute (NRI), University of Greenwich, worked with CIP Scientists to review the existing training material, added in new knowledge from sweetpotato scientists and practitioners, and designed the course with a heavy emphasis on learning-by-doing. The CIP personnel who contributed to the development of the initial manual include, (Robert Mwanga, Ted Carey, Jan Low, Maria Andrade, Margaret McEwan, Jude Njoku, Sam Namanda, Sammy Agili, Jonathan Mkumbira, Joyce Malinga, Godfrey Mulongo), Adiel Mbabu and HKI nutritionists (Margaret Benjamin, Heather Katcher, Jessica Blankenship) and an HKI gender specialist (Sonii David) as well as NRI colleagues (Richard Gibson, Aurelie Bechoff, Keith Tomlins). Some of the materials were adapted from the DONATA project training materials, the Reaching End Users project and many others. After practitioners had used the course and the manual, a review was held in 2012 and the manual and course were subsequently updated, and a standard set of accompanying Power Point presentations created. In 2017-2018, the Building Nutritious Food Baskets project led a further review of the manual working closely with Tanya Stathers, the above mentioned CIP teams again plus Robert Ackatia-Armah, Kwame Ogera, Srini Rajendra, Julius Okello, Fred Grant, Joyce Maru, Hilda Munyua and Netsayi Mudege to update the content of topics 3, 4, 5, 12 and 13 which cover: sweetpotato varietal selection; nutrition; seed systems; monitoring, learning and evaluation; and using the 10 and 5 day ToT course.

This manual is designed to potentially serve a wide variety of audiences (nutritionists and agronomists, policymakers, extension workers, community development workers, leaders of farmer organizations, farmers etc.). Not all the materials will be relevant to all audiences, but facilitators can adapt the content to their audience and facilitation best practices. To ensure sustainability and wide reach; a cascading approach in the delivery of training is recommended; where key experts (agriculturalists, nutritionists, health workers, marketing and gender experts) will attend more detailed ToT workshops. The experts trained will then become primary facilitators and drive the agenda for OFSP. This group will in turn deliver shorter version courses and step-down the training to various levels of audiences (secondary and tertiary) – based on needs identified. This trend will continue until the training cascades down to "farmer trainers" who finally train the end users in their communities.

The original version of the manual has also been translated into Swahili, French, Portuguese, and Amharic are available online at https://www.sweetpotatoknowledge.org/learn-everything-you-ever-wanted-to-know-about-sweetpotato/ with the intension of translating the revised chapters as soon as resources permit. We envision the course to continue to be improved as new knowledge comes in. In this way, we expect the vibrant and knowledgeable sweetpotato community of practice to continue to grow in the coming years. The *Everything You Ever Wanted to Know about Sweetpotato* course will help us to achieve the major objectives of the Sweetpotato Profit and Health Initiative (SPHI). Launched in October 2009, the SPHI seeks to improve the lives of 10 million sub-Saharan African families in 16 countries by 2020 through the diversified use of improved sweetpotato varieties.

Jan W. Low, Leader of the Sweetpotato for Profit and Health Initiative, International Potato Center
October 2018, 2nd edition.

How to Use This Guide

This guide was designed to be used in two ways:

- As self-study material, or
- As a facilitator's guide for classroom training sessions

For each topic we have provided:

- A handbook (this volume)
- A PowerPoint presentation, and
- A handout for classroom training participants

If you plan to deliver this as classroom training, then we would encourage you to read the **Facilitator's Guide** (separate volume) prior to planning your lessons.

Introduction: Sweetpotato Pest and Disease Management

Objectives

Upon completing this module, participants should be able to:

- Explain the origin and transmission of common sweetpotato pests and diseases.
- Describe the lifecycles of insects and diseases.
- Define Integrated Pest Management.
- Tell how to recognise and control sweetpotato pests, including mole rats and eriophyid mites.
- Tell how to recognise and control sweetpotato diseases, including fungal diseases and viruses.
- Discuss gender and diversity in sweetpotato pest control management.
- Create and lead learning-by-doing activities around pest and disease control management.

Synopsis

Topic 7 explains how recognising the lifecycles of the damaging insect pests and diseases such as the sweetpotato weevil (*Cylas* spp.) and viruses can help farmers learn how to manage them more successfully. The signs and management strategies for mole rats and erinose are also discussed.

Unit 1 – Where Do Sweetpotato Pests and Diseases Come from, and How Do They Spread?

Objectives

By the end of this unit, you should be able to:

- Cite the main origins of disease and pest problems in sweetpotato crops.
- Tell why it is important to understand pest and disease lifecycles.
- Explain why phytosanitary officers are essential to disease control.
- Compare the two types of insect lifecycle.
- Describe the lifecycle of a typical virus and fungus.
- Name common sources of virus and fungus contamination.
- Describe how sweetpotato viruses are spread.
- Define and describe Integrated Pest Management.

Key Points

- **Adult forms of insects are the form we most readily recognise. Recognising all forms of all pests is essential to control.**
- **Pests such as the sweetpotato weevil undergo a complete metamorphosis that includes larval and pupal forms which do not resemble the adult.**
- **Pests such as the sweetpotato hawkmoth have an incomplete metamorphosis, where a juvenile form called the nymph grows to adult size.**
- **Most insect populations can grow very quickly. Warm temperatures speed up the growth cycle, but extreme heat can stop it.**
- **Movement of planting and agricultural materials from place to place can spread disease. Phytosanitary officers are essential to checking shoes, tools, people, livestock, etc. for the possible movement of pests.**
- **The vegetative planting techniques used with sweetpotato make it vulnerable to spreading dormant fungal disease stages.**
- **Viruses need another agent such as a feeding insect to inject them into the sweetpotato plant. This is another reason to promote insect control.**
- **Integrated Pest Management (IPM) combines an understanding of the ecology and lifecycles of pests with multiple techniques for pest control.**
- **IPM pest control methods include crop sanitation, cultural control, mechanical control, and biological control (including the use of natural enemies and beneficials to control pests and diseases.**
- **IPM encourages consideration of human health concerns in the use of chemical pesticides.**

How Do They Spread?

In order to manage pests and diseases, it is important to know where they come from, how they spread, when they typically arrive and of course how to recognise and manage them.

It is important to understand the typical lifecycles, behaviours and modes of movement of pests and diseases in order to be able to: recognise them during different stages of their lifecycles, be aware of their populations building up to damaging levels, and in order to break their lifecycles and transmission patterns.

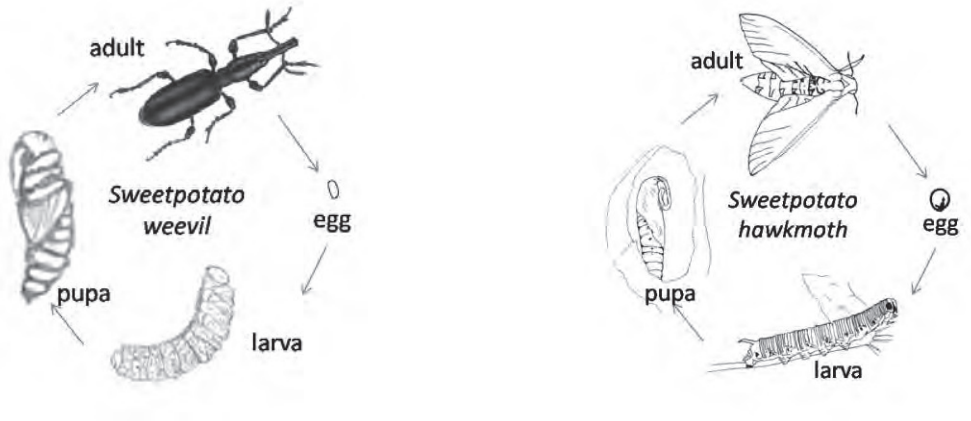
Insect Lifecycles

During the course of their lives, insects pass through a number of stages. Often, we are only familiar with one of the stages and cannot recognise the other stages. The adult stage is responsible for reproduction and may or may not feed. After mating, the female adult insect deposits her eggs in selected places (e.g. under leaves, on the soil surface etc.). The eggs hatch and the immature insects feed and grow and eventually become adults. However, for many insects the form of the immature insect looks completely different to the adult insect, and it can be difficult to imagine they are even related. The transformation process that an insect goes through as it changes from one form to the next during its lifecycle is called metamorphosis. Some insect species go through a complete metamorphosis whereby there are larval and pupal forms which do not resemble the adult insect. Other insect species go through an incomplete metamorphosis whereby a juvenile form called a nymph hatches from the egg, and then gradually gets bigger until it reaches adult size. These two types of metamorphosis are described below.

Complete metamorphosis (adult ⇨ egg ⇨ larva ⇨ pupa ⇨ adult)

Some insects go through complete metamorphosis whereby a larva (e.g., a caterpillar or maggot) hatches from the egg, and usually feeds on the plant material surrounding it for a period of time, shedding its skin as it becomes larger; it then stops moving, and changes into a pupa. Although the pupa does not move around, internally there is a huge amount of change going on as its tissues are reorganised so that, when it emerges as an adult, it looks completely different, e.g., as a beetle, a moth or a butterfly and also behaves quite differently. This complete change of appearance and behaviour often makes it very difficult for farmers to associate the few small black beetles they see crawling on their sweetpotato plants with the mass of feeding tunnels and many small soft white larvae they find inside their sweetpotato roots a week or so later.

Lifecycles of The Sweetpotato Weevil and the Sweetpotato Hawkmoth, Showing Their Complete Metamorphosis from Egg to Larva to Pupa to Adult



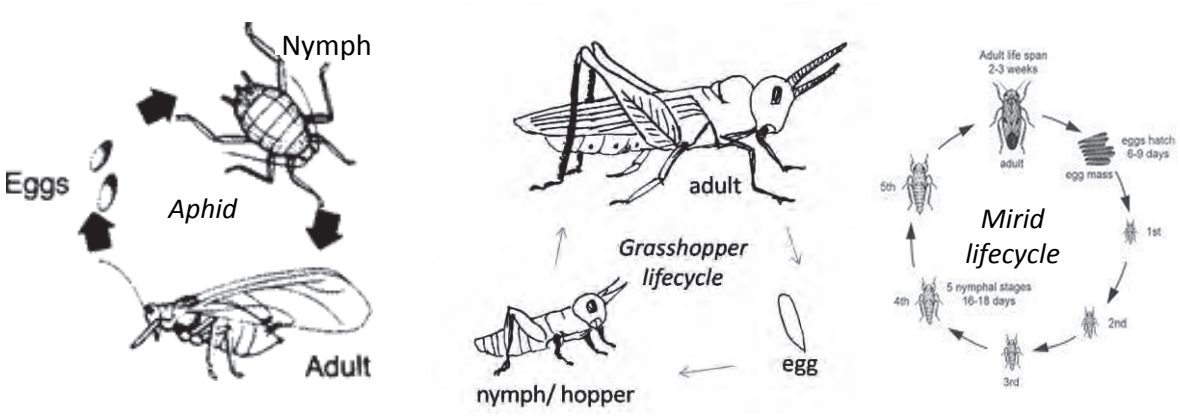
Helping farmers make this link between the adult and the egg, larval and pupal forms of an insect is the first step in helping them to recognise pest presence and damage before it reaches more serious levels. It is much better to try and prevent the adult insects from arriving or laying eggs than it is to have to try and deal with a large-scale infestation of larvae chewing their way through your roots!

The sweetpotato weevil *Cylas* spp., the rough weevil *Blosyrus* sp., the clear wing moth, the sweetpotato butterfly, the sweetpotato hornworm and armyworms are examples of sweetpotato insect pests which go through complete metamorphosis, where the adult and immature forms look completely different from each other.

Incomplete metamorphosis (adult ⇨ egg ⇨ nymph ⇨ adult)

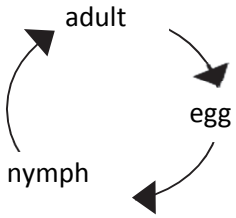
Some types of insects develop through a process of incomplete metamorphosis, whereby a nymph (as opposed to a larva) hatches from their egg. The nymph looks very similar to the adult insect, just smaller and lacking the wings and sexual organs, and feeds in the same way. Nymphs feed and grow through a series of moults, eventually becoming adults. Aphids, whitefly, grasshoppers and sucking bugs such as mirids are examples of sweetpotato insect pests which go through incomplete metamorphosis. Aphids and whiteflies can spread sweetpotato virus diseases. Grasshoppers can consume the leaves of sweetpotato plants but are usually only considered a minor pest of sweetpotato. Sucking bugs such as mirids, typically feed on the young shoots and leaves causing black lesions and leaf puckering, severe damage can arrest plant growth if all tips are killed.

Lifecycles of The Aphid, Grasshopper, and Mirid Bug Showing Their Incomplete Metamorphosis (Egg to Nymph to Adult)



Insect Development Times and Pest Population Build Ups

The period of time it takes for an insect to develop from an egg to an adult is influenced by the environment. Warmer temperatures typically lead to faster development in insects, until the temperature become so hot that it actually prevents insects from developing and surviving. The type of food that the immature insect feeds on will also affect its rate of development. Some insects can feed on a number of different plants and plant parts during their lifecycle, and we refer to these plants as alternative host plants. For example: the sweetpotato weevil can also feed on the water spinach plant, *Ipomoea aquatic*, and can shelter on this plant between sweetpotato crops, and then infest the newly planted sweetpotato crop.

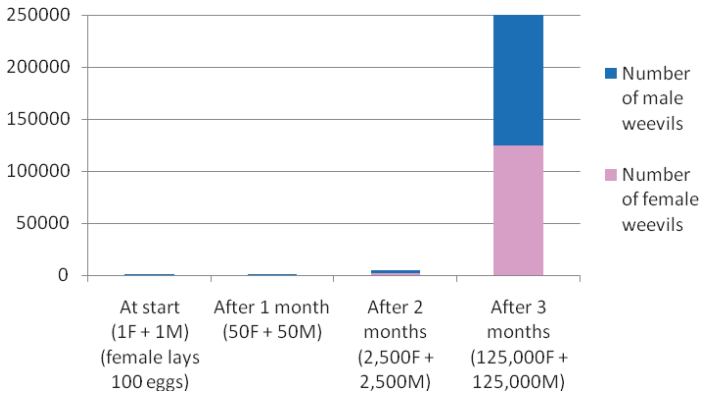


Rapid Population Growth of Insects

Due to their short development times, whereby insects can often go from an egg to an adult that is laying yet more eggs within a month, high populations can build up over very short periods of time.

If one sweetpotato weevil lays 100 eggs that all hatch and develop into adults within a month, this would mean there would then be 50 female sweetpotato weevils who could mate and each lay 100 eggs, and one month later there would be 2,500 female sweetpotato weevils to feed and lay eggs on your crop plus 2,500 male ones. If these females all laid 100 eggs each, within a month there would be 125,000 females ready to mate and lay their eggs on your sweetpotato crop!

Whilst spectacular pest outbreaks like this do happen from time to time, many are avoided by the insect pests being killed off by pathogens/ diseases, predators or parasites or simply running out of food.



Rapid population growth of sweetpotato weevils

Pathogens

Micro-organisms such as bacteria, fungi or viruses that cause disease. They enter the body of the insect and live and multiply within it, weakening and finally killing the insect. Insects attacked by pathogens are usually swollen, a different colour, move more slowly than usual and stop eating. These pathogens are sometimes grown for use in insect biological control programs. The bacteria *Bacillus thuringiensis*, better known as 'Bt' is an example of a pathogen that is produced as a biological pesticide.

Predators

Animals or insects that hunt, kill and eat other creatures. Spiders, ants, ground beetles, earwigs, ladybird beetles, lacewings, and flower beetles are insects that are commonly found in sweetpotato fields and are helpful to farmers as they kill and eat sweetpotato insect pests. Therefore, we don't want to kill them off with insecticides!

Parasites

Organisms that enter the body of their victims and feed on them before eventually killing them. The parasites that attack insects are usually species of tiny wasps or flies. They lay their eggs on their victim and, when the eggs hatch, the larvae start to bury into and feed on their host.

Spread of Insects

We have all seen insects crawling and flying and it is obvious that pest problems can spread when an insect flies or crawls onto a new plant. However, what is often less well understood is that insect pests can also be transported long distances by being blown in the wind or through the accidental movement of infested soil, plant materials (including human food), tools and shoes, and by getting a secret lift on livestock or vehicles. This is why phytosanitary officers inspect samples of food and other plant materials that are transported within and between countries to try and reduce the chances of pest problems spreading to new areas.

Lifecycles of Plant Diseases

Plant diseases have varied and often complex lifecycles. But, as with the insect pests whose lifecycles and population build up start with an egg laying adult, so a plant disease's life cycle and population build-up have to start with a previous infection of the same disease. Hence the importance of not using disease-infected planting materials or transporting disease-affected plants.

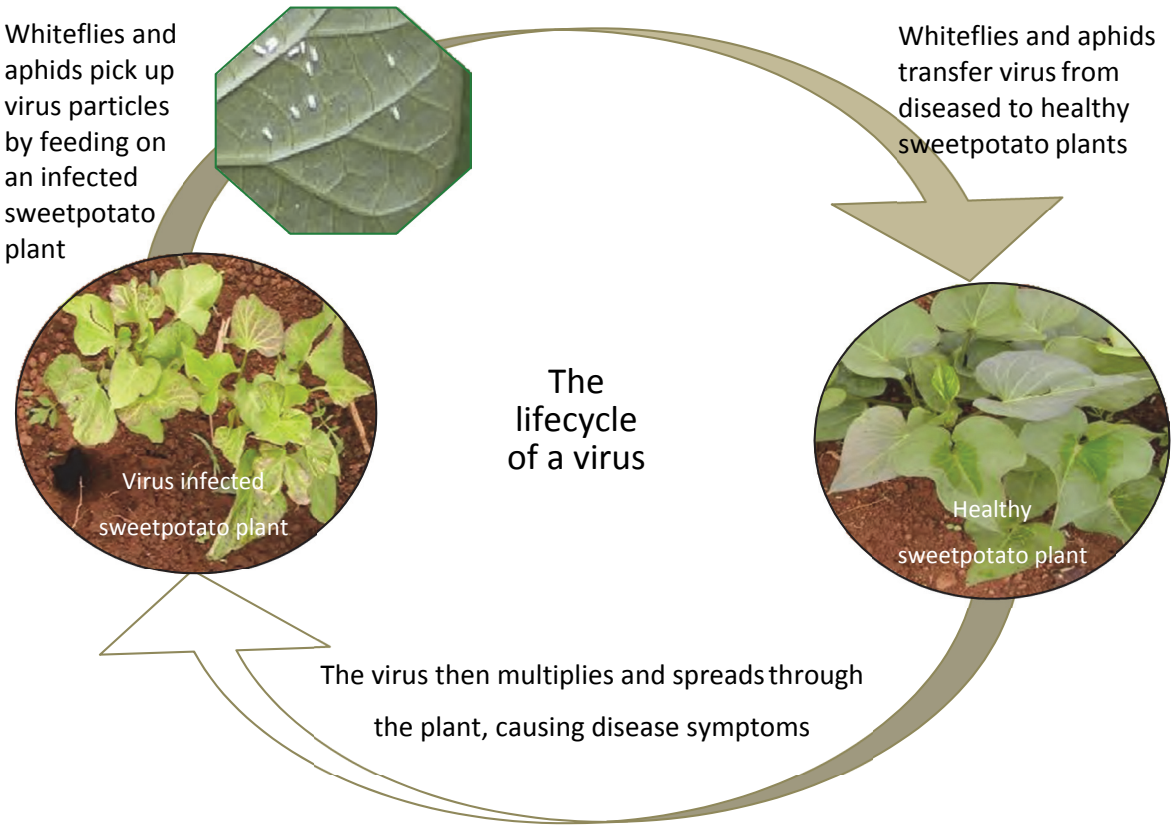
Fungal and bacterial diseases usually have special resting stages in which the disease organism can survive for long periods of time, often in dead leaves, and may be blown in the wind onto young, previously unaffected crops. These resting stages, when they arrive on a new host plant, can germinate and penetrate into the new host plant. With fungal diseases, you can often see their resting stages or spores as a fine dot at the tips of fine hairs often sticking out as a mat from the surface of a diseased leaf. Occasionally, as with smuts, these fruiting bodies can be quite massive,

and the spores form a very obvious fine dust. Common ways by which plants get infected by fungal and bacterial diseases are:

- By spores blown about in the wind from older diseased crops;
- By spores splashed up by heavy rain from leaf litter;
- From diseased planting material, especially if the crop is propagated vegetatively as sweetpotato is.

Virus diseases are unusual in that they do not have a form that by itself can penetrate the skin of a new host so as to infect it. Instead, they rely on another organism, often a plant-sucking insect that feeds on the crop such as a whitefly, leafhopper or aphid, to carry the virus from one plant and to insert it into another plant. We call the organism that plays this role, a vector. Just as the mosquito has first to feed on a human with malaria in order to transmit the disease to another healthy human, so the aphid or whitefly has first to feed on a diseased plant in order to transmit the disease to a healthy plant. In this way, the insect acts in much the same way as mosquitoes act in transmitting malaria in humans. So, if we can stop such insects feeding and moving from an old diseased crop to a new crop, this can prevent plants in the new crop becoming diseased. Also, just as only the Anopheline mosquito species can transmit malaria, so only one type of insect can transmit a particular virus. Thus, only whiteflies can transmit cassava mosaic disease or Sweet potato chlorotic stunt virus and only aphids can transmit Sweet potato feathery mottle virus. Once the plant is infected by the virus, the virus then multiplies and spreads through the plant, so every part is infected with millions of virus particles (which are so tiny you need a special electron microscope to see them). In this way, the whole plant becomes diseased, an aphid or whitefly can pick up virus from any part of the plant and cuttings taken from even a healthy-looking part of a newly-diseased plant is probably infected.

Lifecycle of Sweetpotato Viruses



Integrated Pest Management

Integrated Pest Management (IPM) integrates an understanding of the ecology of the pest organism with a variety of tactics that prevent, avoid or reduce the crop losses caused by the pest. It combines monitoring, crop sanitation, and cultural, mechanical and biological control methods to discourage the development of pest populations and limits the need for pesticides in order to minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

The IPM practices are likely to differ by farm in their specifics as a result of the crops grown, the climate, the soil and surrounding landscape. However, in general, biodiversity will be enhanced (temporal and spatial inclusion of different plant species and beneficial organisms) so that the farm is less susceptible to pest outbreaks, and a variety of pest management approaches will have been combined. If pesticides are being used they will be used only when pest densities have reached a particular level, the types of pesticides being used will be those which are less harmful to human and environmental health, and they will be being used in a way that reduces the risk to the applicator, other humans and animals including beneficials and minimises pollution of local water courses.

Monitoring includes regular scouting of the crop for signs of pest or disease damage, combines these findings with an understanding of how the different pests and diseases and beneficials develop and behave under various environmental conditions, and examines the effectiveness of control measures.

Crop sanitation aims to prevent or eradicate sources and vectors of pests and diseases. Planting materials should be healthy and pest and disease-free. Old plant materials, weeds or volunteer plants which could act as a source of infestation for the new crop should be removed and burnt, buried or used as fodder. Care should be taken not to damage healthy plants as this may facilitate the entry of pests or diseases. Care should be taken to work from the clean towards the more infested part of the crop to lessen the spread of pests and diseases to clean areas of the crop, and field workers should be made aware of the possibility of spreading harmful organisms on shoes, tools, clothes, livestock and through irrigation water. Crop rotation can help prevent the build-up of crop specific pests and diseases in one area of the field.

Cultural control includes using pest and disease-free planting materials; growing the crop in ways that increases its resistance against pests and diseases by making sure it is not suffering from soil nutrient deficiencies, or water stress, and growing it in a climate that it is well suited to. If any of the growing factors are sub-optimal the crop will become stressed, and when plants are stressed they have less resistance to pests and diseases. A healthy plant may be more resistant to attack by pests or diseases. Also, when you know there is a high likelihood of attack by a particular pest or disease, it may be possible to grow varieties that are resistant. The planting time of the crop can be adjusted so that it does not coincide with the main pest or disease infestation times. High plant densities should be avoided as they can result in weak plants that are more susceptible to pests and diseases. The diversity of plant species being grown in the surrounding area can be increased; intercropping can also help achieve this. Crop rotation can be practiced to reduce the build-up of crop specific pests and diseases.

Mechanical control involves the use of physical measures. Flying insects can be kept away from planting materials and nurseries with the help of net tunnels (see Appendix 5.2). Coverage of the soil with polythene can reduce larval attack of roots. Sticky traps, pheromone traps and insect-o-cutors can be used to trap flying insects. The seeds, bulbs, tubers or cuttings of some plants can be immersed in hot water or treated with hot air to kill some pests, soil can be solarised by covering with transparent polythene for several weeks enabling high soil temperatures to kill pest organisms. Flooding an area for a sufficient period of time can kill off some harmful organisms. Removal and destruction of infested planting materials can reduce spread of pests and diseases.

Biological control methods use natural enemies/ beneficials to control pests and diseases. Natural enemies include: predators; parasites and micro-organisms. Predators are animals that hunt and eat other animals; they generally have strong mouthparts, sharp vision and strong legs. Parasites also consume other organisms but do so by entering the body of their victims and obtaining nourishment from their fluids and tissues, which then weakens or even kills their victim (the host). The parasites that attack insects are usually species of wasps or flies, the adult usually searches for the host and then lays its eggs in or on the host's body (some parasite lay their eggs on the host's eggs, others on the host's larval stage, others on the host's pupal stage and others in the nymphal or adult stage of their host). These parasites' eggs then develop into larvae which feed inside the host, slowly weakening the host and preventing it from developing, while they themselves feed and develop and then pupate either inside or near to the host, the adult parasites then emerge and usually feed on nectar or pollen. Pathogens are micro-organisms (such as bacteria, fungi and viruses) that cause disease. They enter the body of their host, living and multiplying within it and eventually killing it.

Insects attacked by pathogens are usually swollen, exhibit colour changes, move slowly, often stop eating and may be covered with a powdery substance. The bacteria, *Bacillus thuringiensis* (or Bt for short) is a well-known insect pathogen that is now commercially produced for use as a biological pesticide. When using natural enemies, it is important that they are introduced as early as possible, optimal conditions can be created in the crop to help attract them e.g. attractant plants, or increased humidity. It is helpful to understand the biology of the natural enemies, and if possible to take care when harvesting so as not to eliminate the beneficial populations. To maintain their lifecycles, natural enemies must have some food source. This means that we have to accept the existence of at least a small number of pests in agricultural fields, otherwise natural enemies, especially those that eat only one type of food, cannot survive. If they starve, their disappearance can lead to a rapid increase in pest numbers.

Chemical control within an IPM approach, means selective pesticides are used which are less damaging to beneficial, selective application techniques are practiced such as restricting application to young plants or using seeds treated with a seed coating. Short persistence chemicals can be used. Chemicals must be applied in ways that reduce the risk to the applicator, the neighbouring human and animal populations and the environment – this involves wearing protective equipment, ensuring that pregnant or lactating women, or children, or those who prepare food do not spray pesticides, spraying is not done during windy conditions when the pesticide may drift into nearby areas, spraying equipment should be washed carefully and not rinsed in or near water courses, chemicals need to be well labelled and kept well away from food stuffs. Pesticide containers should be punctured after use to prevent misuse. It should be remembered that pesticides are poisons, not medicines. Pesticide application should be based on pest or disease monitoring observations as opposed to a regular calendar spraying schedule, and pesticide spraying should only occur when the economic threshold is reached (e.g. when the cost of spraying is lower than the cost of expected crop damage if no action were taken).

Most farmers are likely to want to combine a variety of different pest management practices. Each farmer will need to experiment with these different practices to find out which best fit their unique circumstances.

Review Questions

1. What is the difference between the complete and incomplete metamorphosis of insects?
2. What are some common ways that plants get infected by fungal and bacterial diseases?
3. What is Integrated Pest Management (IPM) a combination of?

Unit 2 – How to Recognise and Manage Sweetpotato Weevils

Objectives

By the end of this unit, you should be able to:

- Identify the sweetpotato weevil and its male and female adult forms.
- Describe the weevil's life cycle and life stages (eggs, larvae).
- Name the symptoms of a sweetpotato weevil infestation.
- Explain sweetpotato weevil control techniques and tell why root protection is important.
- Compare the sweetpotato weevil to the rough sweetpotato weevil.

Key Points

- **The adult weevil is a black or metallic blue beetle with an elongated shape and straight (male) or clubbed (female) antennae.**
- **The life cycle takes roughly 32 days. The eggs are laid singly in vines, leaves, and exposed storage roots; larvae are legless and whitish with a dark brown head.**
- **A large number of adults in the foliage indicates heavily infested roots.**
- **The roots are key in weevil control. "Hilling up" soil around the roots can protect them from infestation.**
- **Crop rotation, field sanitation (destroying volunteer plants and old plant material), use of natural enemies, clean planting materials, and timely harvesting are other key weevil control practices.**
- **Flooding the field can drown the various life stages of the weevil; mulching, pesticides, plot separation, pheromone traps, and weevil resistant varieties all help fight the sweetpotato weevil.**
- **Most of these practices are also effective against the rough sweetpotato weevil.**

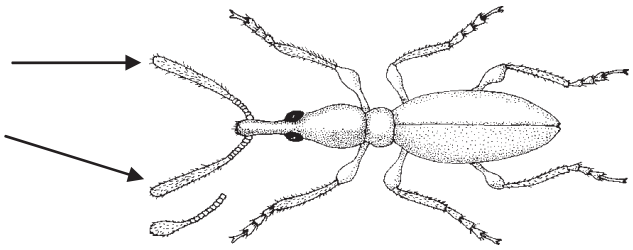
Recognising and Understanding the Lifecycle and Behaviour of Sweetpotato Weevils (Cylas Spp.)

The sweetpotato weevil (*Cylas* spp.) is the main pest of sweetpotato; it is found in all sweetpotato-growing regions of the world.

In its adult stage, it is an elongated, small black or metallic blue coloured beetle (5-6 mm long), that looks rather like a large ant. The male and female adults can be told apart by the shape of their antennae: the males' antennae are straight while the females' have a club-shaped end.

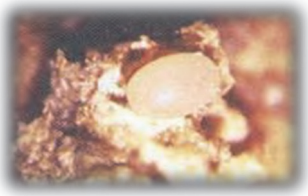
Male weevil's antenna is straight

Female weevil's antenna is club-shaped



After mating, the female sweetpotato weevil lays eggs singly in holes that she has chewed into either the vines or exposed and easily accessible storage roots. While the female weevil can survive for up to 4 months, she typically lays all her eggs (50-250) within the first two months. If she arrives on the plant prior to its formation of storage roots, she will lay her eggs in the vines and leaves. If the storage roots have already formed, she will search for exposed ones.

Weevils cannot dig, so they access the sweetpotato roots through cracks in the soil when it dries out or by following the vine down into the soil and moving along the root system until they come across a storage root. The female weevils make feeding punctures and egg-laying punctures in the vines and roots. The punctures containing eggs can be distinguished by their dark colour, as the eggs are covered with a plug of weevil excrement. Whilst the developmental period will be affected by the temperature at that time, the egg typically hatches 3-7 days after it was laid.



Sweetpotato weevil egg

The larva that emerges is legless, curved and whitish with a dark brown head. It will start feeding and, as it does so, it tunnels through the vine or root into which it was placed as an egg. It is this tunnelling that is so destructive to the sweetpotato crop, causing the holes and black tunnels so frequently seen in the roots. The feeding punctures and tunnelling reduce the market value of the roots and can act as a source of infestation if the infested root is placed next to undamaged roots. Even low levels of infestation can reduce root quality and marketable yield as the root produces a bitter tasting toxin, a terpenoid, in response to the sweetpotato weevil's feeding. This damage can continue even after the roots have been harvested. The larvae live for 11-33 days before they pupate.

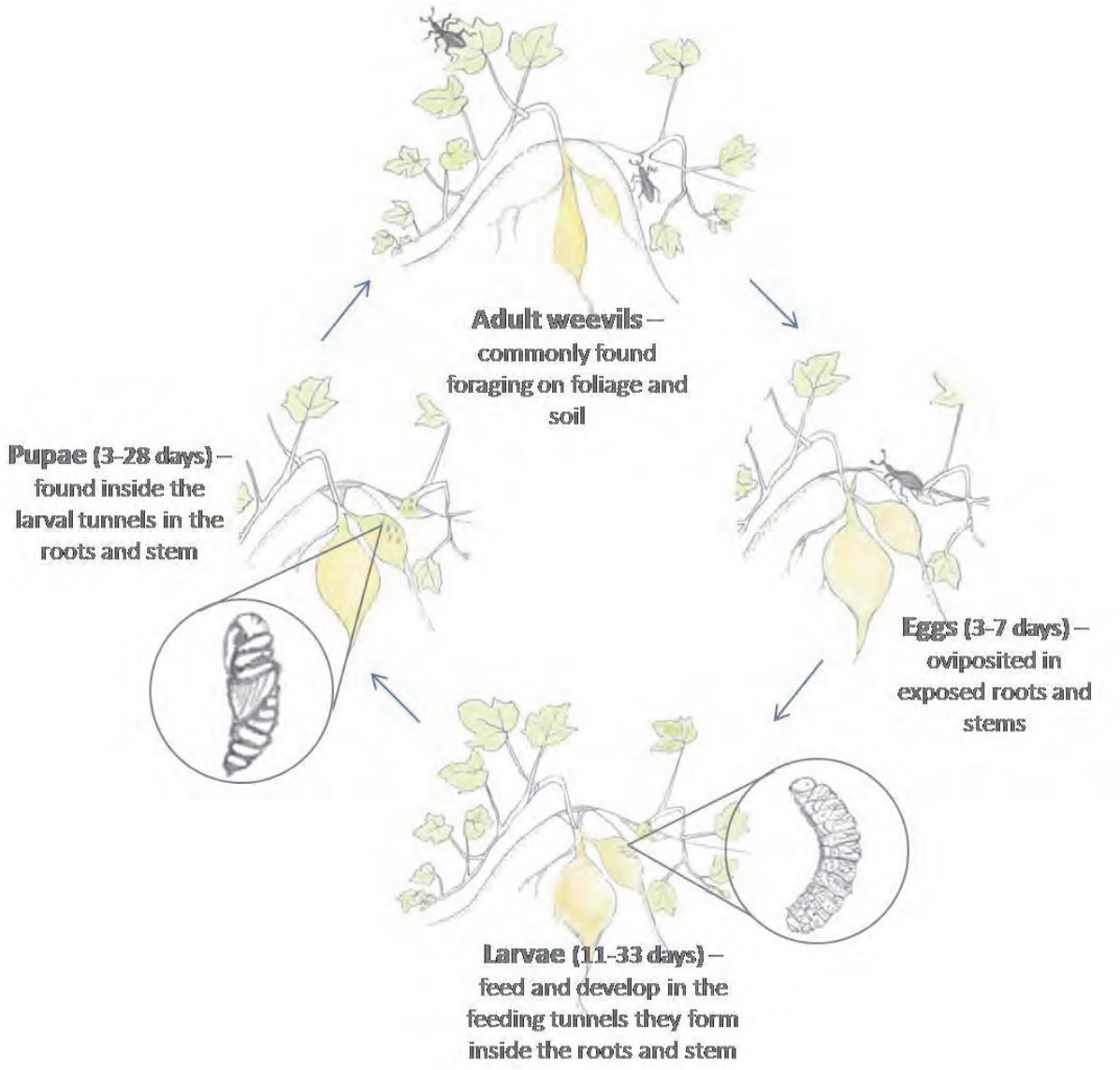
Sweetpotato weevil larva

Pupation occurs within the larval tunnels and lasts for 3-28 days after which the adult beetle emerges.

Sweetpotato weevil pupa

The adult is initially a light brown colour but, after about a week, its skin hardens and becomes dark brown in colour. The adult then leaves the root zone and starts to search for a mate. The female weevil produces a pheromone (a chemical signal) to attract the male. Male weevils typically move around on the foliage at night searching for the females, hiding under the leaves or in soil cracks during the day. They mate at night after which the female feeds and lays eggs during the day. The whole lifecycle from egg to adult typically takes 32 days. If many weevils are found on the foliage, this is an indication that the roots are heavily infested.

Adult sweetpotato weevil



Life Cycle of The Sweetpotato Weevil, Cylas Spp.

Sweetpotato weevil damaged roots

Sweetpotato weevil damaged vines

Sweetpotato Weevil Pest Management Practices

Farmers can integrate as many as possible of the following pest management practices to help reduce crop losses from sweetpotato weevils.

Hilling Up

When conditions are dry and the soil cracks, sweetpotato weevil damage can become a serious problem as the insects can more easily reach the roots. The soil pulls away from the plant's stem, allowing easy access to the roots, and the soil of the ridges and mounds often cracks exposing the roots. For this reason, sweetpotato roots, unlike cassava, cannot be stored in-ground in the field for any significant length of time without investing in hilling up. Hilling up soil around the base of the plant and on the sides of the ridges to prevent or fill soil cracks can be used by farmers to give some protection to their crop. Hilling up is typically done during piecemeal harvesting: as the women move from plant to plant checking for large roots which they might take home to cook or sell, they also move the soil back up the ridges or mounds to fill any cracks. This practice can help increase root yields as well as reducing weevil damage.

Field Sanitation

Carefully removing and destroying (through burning or feeding to livestock) all old vines or root residues left in the field can help break the sweetpotato weevil's and other pests' lifecycle by preventing them from surviving and moving to a newly-planted field. This is less easy to do in areas where there are two or more sweetpotato crops per year, and weevils can easily survive and find a fresh sweetpotato crop to infest. Highlighting the importance of not planting sweetpotato continuously in the same place (crop rotation), and ensuring the new crop is planted as far away from the earlier crop as possible (plot separation). If vines are typically left in the field to improve soil fertility, then they should be left in the hot sun until they are dead and not able to sprout before they are incorporated into the soil. During piecemeal harvesting, any infested roots which are found should be removed and used as food or feed or destroyed.

Any volunteer plants (sweetpotato plants that have developed from vines or roots accidentally left in the field), and alternative host plants should be removed to try and decrease the weevil population and reduce the chances of carryover of weevils from one season to another.

Using Clean Planting Materials

It is essential to use clean (uninfected) planting materials. Weevils tend to lay their eggs in the older woodier parts of the vine. The feeding and egg-laying puncture holes of weevils are also not easy to see on vines, so it is sensible to take cuttings from the apical end of vines and to strictly avoid using the basal 10cm part of the vine. Planting materials should only be taken from healthy looking plants, as viral disease can be transferred to new areas if viral infected planting materials are used.

Timely Harvesting to Avoid Soil Cracking During the Dry Season

By planting the sweetpotato crop early in the rainy season, you increase the chances of it having been harvested before the dry season causes the soil to crack and exposes the roots to weevil infestation. In Vietnam, harvesting 2 weeks early reduced the loss due to weevils from >30% to <5%.

Crop Rotation

It is essential to rotate sweetpotato with other crops, so that one part of your field does not have a continuous sweetpotato crop in it, which would lead to more chances of carry-over of weevils from one season to the next through infested pieces of roots or vines left behind in the field.

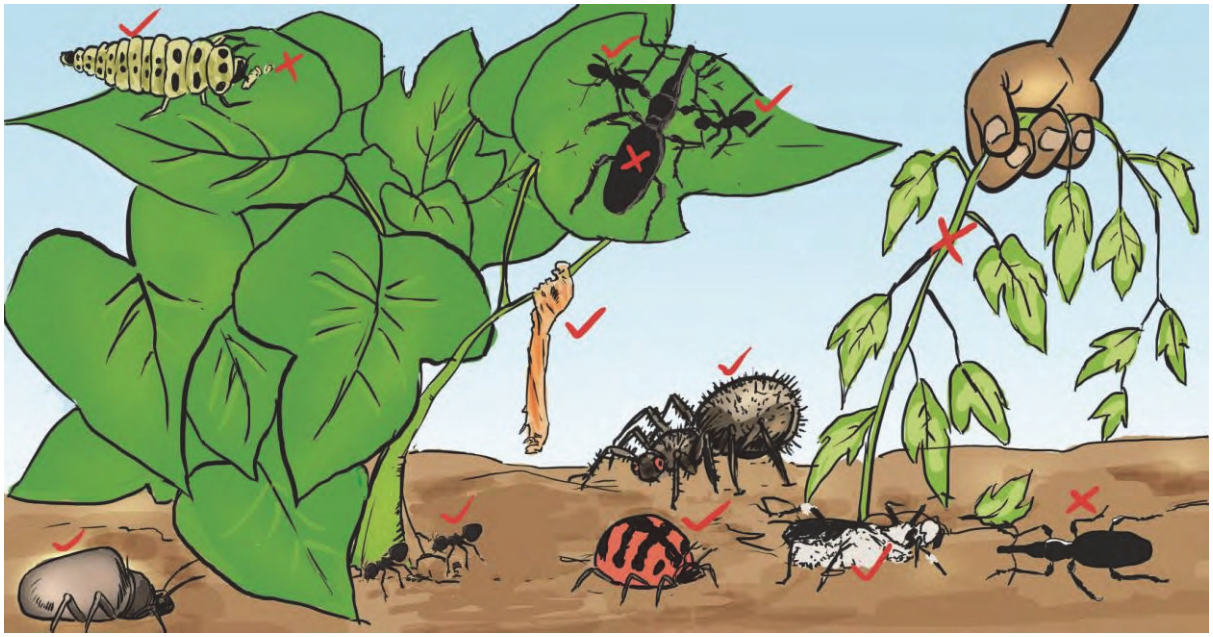
Season/Year 1		Season/Year 2		Season/Year 3	
Sweetpotato			Sweetpotato		
				Sweetpotato	

Plot Separation

As sweetpotato weevils do not fly very often and generally only for short distances of 500m-1000m in order to find sweetpotato plants, planting your new field of sweetpotato some distance from existing and recently-harvested fields of sweetpotato can help reduce the likelihood of many weevils finding your newly planted field.

Natural Enemies

Allowing predatory natural enemies such as ants, earwigs, ground beetles and spiders to move through the sweetpotato fields can help keep weevil populations under control. Ant nests can be



moved to the sweetpotato field to enhance predation. In some places a solution of a pathogenic fungus, *Beauveria bassiana*, is used for treating planting materials and the soil in order to reduce weevil populations. Not spraying chemical pesticides in your field will help maintain natural enemy populations.

Barrier Crops

Using a barrier crop such as cassava, maize, bananas or sorghum in strips of at least 3- 5m wide between existing sweetpotato fields and your newly planted sweetpotato field, can reduce the number of weevils' migrating to your newly planted crop. However, in order for this to be the case, the barrier crop needs to have been planted sufficiently early enough to ensure that it is high enough to act as a flight barrier and one that may stop the weevils sensing attractive volatiles from sweetpotato plants.

Mulching

Adding mulch to the soil surface shortly after planting and maintaining the cover, helps to retain soil moisture and reduce the likelihood of soil cracking and weevil infestation.

Flooding

Flooding the sweetpotato field for at least 48 hours after completing the harvest will drown all the weevils in the soil.

Chemical Control

Sweetpotato weevils are difficult to control using chemical pesticides as the egg, larval and pupal stages of their lifecycle are protected within the stems and roots, and not easily reached by insecticides. In some countries, planting materials are dipped into an insecticide prior to planting, which can delay pest infestation for several months.

Weevil Resistant Varieties

Breeders have not yet developed any sweetpotato varieties that are resistant to weevils. However, deep rooting varieties seem to be less attacked than shallow rooting varieties as the weevils cannot reach the storage roots so easily. Early maturing varieties can also escape weevil damage because they are harvested before the soils start to dry out, crack and provide easy access to the roots.

Pheromone Traps

The sex pheromone of the sweetpotato weevil is commercially produced in some countries and lures containing it can be hung in the field above a container of soapy water. When the male adults arrive, attracted by the pheromone, they fall into the soapy water and die. However, in trials in Uganda, use of pheromone traps did not lead to a reduction in weevil damage of roots.

The Rough Sweetpotato Weevil (Blosyrus spp.)

The rough sweetpotato weevil is not as serious a pest as the sweetpotato weevil; however, it does cause significant damage to sweetpotato roots in some parts of Africa.

The adult rough sweetpotato weevil is 8-9mm long and appears much larger than the sweetpotato weevil (*Cylas* spp.), its rough body and mottled markings enabling it to be well camouflaged against the soil. It lays its yellow eggs in groups around the edges of sweetpotato leaves and often folds the leaf edge over the eggs. It may also lay its eggs on the ground under fallen leaves. After hatching, the C-shaped larvae roll off the leaves onto the ground and drill themselves into the soil searching for food. When they encounter sweetpotato storage roots, they feed on the surface of them, making deep grooves on the skin. The damage looks similar to that of millipedes and white grubs and can seriously reduce the market value of the roots, as deep peeling is needed to remove the damage and so yield losses result. However, unlike sweetpotato weevil damage, the rough weevil's feeding does not appear to trigger the production of bitter terpenoids in the root. After about 30 days of feeding the larva pupates in the soil for a period of about 20 days, before the adult emerges. The adults tend to hide under foliage on the ground during the day. Their purple to black excrement (~7mm in diameter), is often the main above-ground indication of rough sweetpotato weevils.

Most of the pest management methods described in section 7.2.2 for managing sweetpotato weevils are also applicable for rough weevil pest management.

Further information about and photos of sweetpotato pests and diseases can be obtained from the 'Manual for Sweetpotato IPPM Farmer Field Schools in sub-Saharan Africa' and the 'Sweetpotato DiagNotes' website https://keys.lucidcentral.org/keys/sweetpotato/

Review Questions

1. How can the male and female sweetpotato weevil be told apart?
2. What is a clear indication that roots are heavily infested with sweetpotato weevil?
3. How does hilling up help protect crops from sweetpotato weevil?
4. Where do weevils tend to lay their eggs?
5. Why will planting your new field of sweetpotato some distance from existing and recently-harvested fields of sweetpotato help reduce the likelihood of weevils invading your crops?

Unit 3 – How to Recognise and Manage Sweetpotato Viruses

Objectives

By the end of this unit, you should be able to:

- Explain the biology and lifecycle of a typical plant virus.
- Describe the symptoms of common sweetpotato viruses.
- Identify the two most common sweetpotato viruses in SSA.
- List and describe prevention techniques.

Key Points

- **Viruses are too small to see with the human eye, but they are one of the most damaging sources of sweetpotato disease in Africa.**
- **Virus symptoms include stunting; pale or misshapen leaves; purple or yellow leaves, spots, or rings; and reduced storage root production.**
- **Sweet potato feathery mottle virus (SPFMV), which is transmitted by aphids, and Sweet potato chlorotic stunt virus (SPCSV,) transmitted by whiteflies, are the most prevalent sweetpotato viral infections.**
- **These diseases are fairly mild on their own, but an infection by both viruses produces the serious condition called sweetpotato virus disease (SPVD).**
- **To prevent SPVD, farmers should use clean planting materials, destroy any plants showing signs of infection, use resistant strains, rotate crops by season, plant new crops at a distance from old crops, and take cuttings from young plants, as infection is harder to spot in older plants.**

How to Recognize and Manage Sweetpotato Viruses

Sweetpotato virus disease (SPVD) affected plant

Viruses are so small you cannot see them. However, you can see their effects as, despite their small size, they are the most damaging group of disease organisms affecting sweetpotato in Africa.

Viruses only survive inside their living hosts and it is inside their hosts that they multiply and cause damage. All plant viruses need somehow to be spread from plant to plant and it is usually by an

insect that feeds on the plant's sap. As the insect, such as an aphid or whitefly, feeds on a plant it simultaneously transfers the virus to that plant. Once the virus enters a cell in the new host, it starts to take over the management and control of that cell's processes and forces the cell to produce more viruses identical to itself – instead of the crop yield. These new virus particles then spread through the plant to infect more cells.

Common symptoms of virus infection in plants, including sweetpotato, are:

- Diminished growth/ stunting, causing the plant and leaves to remain small;
- Chlorosis (paleness) of the leaf tissue so that the diseased plants stand out from the rest of the crop (this can be general or in a pattern, often either between the lead veins in a mosaic or less well-defined mottle, or along the veins to form a chlorotic network);
- Misshapen leaves with an uneven or curled appearance;
- Pigmented leaves, often purple or yellow generally or in spots or rings;
- Reduced production of sweetpotato storage roots.

There are two main sweetpotato viruses that affect sweetpotato in Africa (Sweet potato feathery mottle virus (SPFMV), transmitted by aphids, and Sweet potato chlorotic stunt virus (SPCSV), transmitted by whiteflies. Each virus by itself may cause only very mild symptoms, but when a sweetpotato plant gets infected by both the viruses, a very severe disease results, which is known as sweetpotato virus disease (SPVD).

The insects do not spread SPVD over very long distances. But if virus infected planting materials (vines or roots) are transported long distances, then the disease can be spread very widely.

In Order to Reduce the Chances of Your Crop Getting Infected with Virus Disease:

Always use planting materials cut from healthy-looking plants. In addition:

- Try and make sure the whole field that you take your planting materials from is healthy, as this will reduce the likelihood of taking cuttings from plants that have just been infected but are not yet showing symptoms.
- Try to collect cuttings from young or mature crops (3-4 months old), as sweetpotato virus disease symptoms are harder to see in older plants.
- **Remove and burn or feed to livestock any diseased plants as soon as they appear in young crops**. This practice of removing diseased plants is known as roguing and is very important to reduce the spread of the virus within your sweetpotato field. Remember, if a plant becomes infected it won't yield very much anyway, so you are improving your chances of harvesting a good yield if you removed infected plants as early as possible. Otherwise, the insects can use them to spread the disease widely in your field and seriously reduce your yields. The neighbours of plants which have been rogued will soon fill up the gap and produce larger roots as a result, or you can gap fill with a new cutting.
- Plant sweetpotato varieties that are resistant to the disease. Some varieties are rarely affected by virus disease. You can set up a replicated trial to test which varieties seem to be resistant to virus diseases.
- Avoid planting new sweetpotato crops where you grew sweetpotato last season. If there are roots or vines from old diseased plants surviving in the soil, they may sprout and produce diseased plants from which infection will easily spread to your new crop. This is also an important aspect of weevil control.
- Plant your new sweetpotato crop away from old sweetpotato crops. This will make it harder for the aphids and whiteflies to reach your new crop and bring the virus disease from the old crop. This is also an important aspect of weevil control.

Review Questions

1. Once a virus enters a cell in a new host, how does it affect the cell?
2. What are some common symptoms of virus infection in plants?
3. When choosing new planting materials, why is it important to collect cuttings from young sweetpotato crops?

Unit 4 – How to Recognise and Control Fungal Diseases

Objectives

By the end of this unit, you should be able to:

- List symptoms and mode of spread of the three major sweetpotato fungal diseases.
- Describe recommended fungal management techniques.

Key Points

- **Fungal and bacterial diseases typically cause brown or blackened lesions on sweetpotato leaves and stems.**
- ***Alternaria*, *Phomopsis* and black rots are the three major sweetpotato fungi.**
- **Powdery areas are composed of fungal spores. These spores will spread disease to other plants.**

How to Recognize and Control Fungal Diseases

In addition to virus disease, sweetpotato plants can also be attacked by fungal or bacterial diseases. Fungal diseases on the leaves and stems of sweetpotato, typically cause circular brown or blackened areas called lesions. Other symptoms include powdery areas, or masses of filaments. Powdery areas are composed of fungal spores which can then spread the disease to other plants, and the filaments are the means by which the fungus spreads to invade new parts of the plant. *Alternaria*, *Phomopsis* and black rots are serious fungal diseases of sweetpotato (see table overleaf).

Symptoms, Mode of Spread, and Recommended Management of Three Fungal Diseases

Alternaria diseases	*Phomopsis* disease	Black rot disease (*Ceratocystis* sp.)
Symptoms: Brown necrotic lesions on leaves, stems or petioles with typical bull's eye appearance of concentric rings and well-defined margins. Spots are usually surrounded by a chlorotic halo. Several lesion fuse, covering the leaf surface, followed by leaf drop. The ground under affected vines is often carpeted with blackened leaf debris. *Spread*: The fungus remains in plant debris on the soil as mycelium and conidia and can be spread by rain splash, irrigation water, wind and insects. High relative humidity is necessary for infection and sporulation.	*Symptoms*: Older leaves have irregularly shaped (~5-10mm wide) whitish to tan brown lesions surrounded by dark purple to brown margin, with black pinhead like structures in the centre. *Spread*: The fungus remains in plant debris on the soil, and its spores are released when the field receives moisture.	*Symptoms*: On storage roots, brown sunken spots (~0.5cm diam.) appear and then become firm, dry and black. They may coalesce to cover the whole root. The root area surrounding the spots has a bitter fruity taste. The plants appear stunted and chlorotic due to the cankers on the roots. Black rot can affect roots, plants and planting materials in field and storage. *Spread*: The fungus survives in soil and plant debris. Wounding increases the possibility of infection, although the fungus also penetrates through lenticels. Infected roots result in infected sprouts.
 *Symptoms of* Alternaria *leaf spot*	 *Old leaf symptoms of* Phomopsis	 *Black rot inside and outside of root*
 *Black lesions on petioles and stems*	 *New leaf symptoms of* Phomopsis	 *Black rot symptoms on roots*
Management: Rotate fields. Destroy and burn crop residues after harvest. Use clean planting materials. Avoid overhead irrigation. Fungicides such as mancozeb, chlorotalonil and dyrene may be effective but need testing. Plant resistant varieties.	*Management*: Rotate fields. Field sanitation should be effective as the fungus survives in affected crop debris left in the field.	*Management*: Rotate fields. Use clean planting materials. Use less susceptible cultivars. Carefully select roots to be stored. Control insects and rodents in stores. Planting materials may be dipped in Benomyl or Thibendazole fungicides, or roots sprayed before storage.

Review Questions

1. How might you spot fungal diseases on sweetpotato plants?
2. What are three serious fungal diseases of sweetpotato?

Unit 5 – How to Recognise and Manage Mole Rats

Objectives

By the end of this unit, you should be able to:

- Describe the mole rat and its typical habits.
- Identify signs of mole rat infestation.
- List and explain effective mole rat control techniques.

Key Points

- **Domestic animals and wild animals can both damage sweetpotato crops.**
- **Mole rats burrow through sweetpotato beds to feed on roots; they spoil more sweetpotato root than they consume.**
- **Mole rats can be recognized through evidence such as mounds of freshly dug soil, vines being pulled down into the earth, and holes in the sides of ridges and mounds.**
- **Neighbouring farmers should cooperate for more effective large-scale rodent control.**
- **Repellent materials such as human dung and certain plant leaves can be placed in burrows; burning dung and pepper can smoke out the mole rats, or boiling water can be poured into burrows.**
- **Deep rooted poisonous plants or sesame plantings can also deter the animal, along with traps, ditches, and field sanitation.**
- **Poisons should be used with care, as they can also affect humans and domestic animals.**

How to Recognise and Manage Mole Rats

In addition to the insects and plant diseases, there are some important vertebrate pests of sweetpotato such as mole rats, rats, porcupines, goats, cattle, guinea fowl, monkeys, baboons, elephants. Hedges or thorn fences can help protect sweetpotato against pests such as goats, cattle, wild pigs, and porcupines. Domestic animals should be tethered during the dry season to prevent them grazing on planting materials, conservation and multiplication plots.

Mole rats burrow through ridges and mounds feeding on the sweetpotato roots. They often spoil more roots than they actually eat. Signs of their damage and presence include: small mounds of freshly dug soil, sweetpotato vines being pulled back down into the soil, holes in the sides of ridges or mounds.

Rodent control works better if done on a large scale, so farmers should work with their neighbours to combine forces.

Farmers use the following practices to reduce rodent damage in their sweetpotato crop:

- Destroying rodent burrows.
- Keeping the field and surrounding areas clean of vegetation and rubbish to help reduce rodent populations.
- Digging a deep ditch around the perimeter of their field to prevent rodents from digging tunnels straight into the fields.
- Use of repellent materials inside the rodent's unblocked burrows. The leaves of some plants are repellent, or a mixture of burning cow dung and pepper to smoke the rodent out, or

human faeces.

- The planting of deep-rooted poisonous shrubs such as *Tephrosia vogelli* in the field as a repellent.
- The planting of sesame all around the perimeter of the field, as the roots are thought to be poisonous to mole rats and so they won't burrow through them.
- Scalding and drowning the rodent by pouring water or a hot water and pounded chilli pepper mixture into the burrow.
- Setting of traps in locations where children will not get hurt by them.
- Poisoning. Poisons are sometimes placed inside rodent burrows and sometimes sweetpotato roots are poisoned as bait. However, it should be remembered that as rodents are mammals, any poison that is toxic to them will also be toxic to humans and livestock, so poisoning is not recommended unless it can be very carefully supervised to prevent the baits being eaten by children or livestock.

Review Questions

1. What are the signs of rat mole infestation?
2. What are some of the methods for rodent control?

Unit 6 – How to Recognise and Manage Erinose/ Hairiness/ Eriophyid Mites

Objectives

By the end of this unit, you should be able to:

- List symptoms and mode of spread of erinose.
- Differentiate the condition called erinose from the *Eriophyhid* mite.
- Describe recommended management techniques.

Key Points

- **Erinose, which covers sweetpotato plants in a layer of white hairs, is caused by the *Eriophyid* mite.**
- **Erinose causes sweetpotato plant stunting and poor yield. It usually affects one plant or a patch of plants.**
- **The mites are so small they look like a speck of dust in their adult form.**
- **Control measures include scouting for the appearance of hairy shoot tips and quickly removing them to allow re-growth of healthy shoots.**
- **Pruning and a mitocide spray are the second line of defence.**
- **Some farmers find that burying the affected vines or cutting them and leaving them in the shade till the leaves drop off result in a newly healthy vine that can be re-planted**

How to Recognize and Manage Erinose/ Hairiness/ Eriophyid Mites

Erinose, a condition where sweetpotato leaves and vines become covered with a dense almost felt-like layer of white hairs, is caused by infestation by *Eriophyid* mites and can occasionally be a problem. The leaves and plants are also generally slightly stunted, the leaves and vines thickened, and the plants yield poorly.

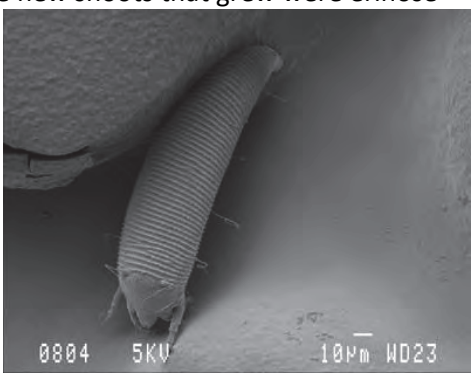
The shoot on the right shows typical erinose symptoms (white hairs and stem thickening). The shoot on the left if unaffected and of the same variety

Occasionally, whole crops are affected but often the symptoms affect just one or a patch of plants, and often particular varieties. The mites feed in the bud and on young foliage of the sweetpotato plant, injecting growth substances into it at the same time so as to make the plant produce the dense mat of hairs (which provide protection for the mites). The adult mites are tiny and look like a speck of dust. The mites invade crops by being blown like dust particles in the wind. Little is known about them or how to control them.

The following control measures were developed and are used successfully by Patrick Makokha of the Siwongo Processing Company - OFSP Systems in Western Kenya:

- Scout fields regularly, looking for hairy shoot tips, the first sign that a mite infestation is underway. Simply removing and destroying the hairy vine tips allows for rapid re-growth of uninfested shoots.

- If the infestation showed signs of recurring, pruning was combined with a selective foliar fertiliser and miticide (mitigan/dicofol) spray and the new shoots that grew were erinose-free.
- Erinose on the infested shoot tips has also been controlled by completely burying affected vines at a depth of ~30 cm for 4 to 5 days, during which time the mites die. The vines were then planted and grew healthily.
- Other farmers in Western Kenya report having cut the infested vines and then kept them in the shade for some time until the leaves drop off and then planting these vines.



Scanning electron micrograph showing a highly magnified picture of the eriophyid mite which causes hairiness

Review Questions

1. What are some of the symptoms of erinose mites?
2. How can erinose mites be prevented?

Unit 7 – How to Recognise and Manage Sweetpotato Storage Pests

Objectives

By the end of this unit, you should be able to:

- Explain the risk factors that attract and nurture sweetpotato storage pests and diseases.
- Tell how to best prevent storage pest infestation and attack.

Key Points

- **Fresh or dry sweetpotatoes in storage are vulnerable to pests and diseases.**
- **Losses can be reduced by steps such as using secure containers, raising containers 1m off the floor to deter rodents, using rat guards, and practicing good storage hygiene.**
- **Regular and continual monitoring is also key. Grain borers can do a great deal of damage very quickly.**
- **Dried sweetpotato can be made insect resistant through practices such as sun-drying, salting, rolling & shaking, parboiling, and adding traditional ash and plant materials.**

How to Recognise and Manage Sweetpotato Storage Pests

Pests and diseases can also damage sweetpotato after harvest. Actions can be taken to help prevent losses during storage of fresh or dried sweetpotato. These include making sure that:

- The product to be stored is in good condition (e.g. for dried products – sufficiently dried; and for fresh or dried products undamaged and uninfested by pests or diseases);
- The storage container in good condition (the storage container should enable the product to be kept: relatively cool; free from rodents [to prevent rodent entry it should be raised 1m from the ground, have rat guards fitted on its legs, and have no overhanging branches], birds, livestock and thieves; free from water damage [under a roof that keeps water out, and not sited in an area prone to flooding];
- Good storage hygiene is practiced (the area around the store should be kept clean of rubbish or pests may breed in it; all residues of the previous seasons crop must be removed and the storage container cleaned thoroughly to prevent any carryover of pests to the new crop to be stored [sacks can be turned inside out and brushed and then dipped into boiling water and then hung to dry, stores with mud walls should be re-plastered each year to destroy any insects or spores hiding in the crevices, if storage pests such as the larger grain borer *Prostephanus truncatus* have bored into the wooden parts of the store this wood will need to be destroyed by burning to prevent cross infestation]);
- Regular and careful monitoring of the stored produce and store for any signs of damage (such as small feeding holes in the product, large amounts of dust, presence of insects, strange smells) is done.

The main storage insect pests attacking dried sweetpotato are similar to those that attack dried cassava pieces. Adult stages of many of these stored product pests are shown overleaf.

Stored Products Insects Which Attack Dried Sweetpotato

(from top left: Prostephanus truncatus [larger grain borer (LGB)], Rhizopertha dominica [lesser grain borer], Tribolium castaneum [red flour beetle], Sitophilus zeamais [maize weevil], Lassioderma serricorne [cigarette or tobacco beetle], Dinoderus minutus, Araecerus fasciculatus [coffee bean weevil])

Stored product pests are generally small, less than 1 cm in length. The adults usually bore holes in the product and lay their eggs, the developing larvae then feed in the product producing feeding tunnels and dust – which causes both quantitative and qualitative losses of the stored product.

Pupation usually occurs within the product and the adult insects then emerge, mate and lay the next generation of eggs within the product.

Pest management practices which can be combined to help protect and reduce damage to dried sweetpotato during storage include:

Sun-drying

The product must be well dried before storage to help prevent fungal decay. If the dried product becomes infested by insects during storage, it can be placed in the sun in a thin layer on a mat or sheet of plastic for a few hours to allow the heat of the sun to destroy the developing eggs, larvae and pupae within it. Regular re-drying also helps to reduce the moisture content of the product and enables the farmer to check thoroughly for any signs of infestation.

Parboiling

Freshly sliced sweetpotato chips can be parboiled for 5 minutes or more and then sun- dried, this helps to reduce likelihood of infestation and development of insects in the dried chips. Alternatively, fresh sweetpotato roots can be boiled for 30-60 minutes prior to peeling, slicing and sun-drying. The hardness of the parboiled slices helps protect them from insect damage.

Salting

Salt applied at an application rate of 20-30g of salt per kg of freshly sliced sweetpotato chips prior to sun-drying has been found to negatively affect storage pest infestation and development of dried chips.

Rolling and Shaking

The periodic rolling or shaking of sacks or containers of sweetpotato chips may kill developing larvae and thus reduce adult emergence and damage. However, it will also break some of the chips into smaller pieces.

Traditional Protectants

Ash and plant materials can be added to the dried sweetpotato to repel, reduce the feeding damage or kill storage insect pests. However large quantities of these materials typically have to be added to the stored product to protect it and then later removed from the product before consumption, which can be quite laborious. Some plant materials might be toxic to human and care should be taken in selecting which ones to use.

Insect-Proof Containers

The use of insect-proof containers such as clay pots with sealed tops can be very effective in preventing insect damage during storage as long as the product is not infested prior to being placed in the container.

Storage Duration

The duration that the dried sweetpotato is to be stored for will affect the control methods used; most storage insect pests take about a month to complete their lifecycle from egg to adult. If the product is only being stored for a few months, pest damage is unlikely to be high unless there was a very high level of infestation at the start of the storage season. However, the larger grain borer *Prostephanus truncatus* causes high levels of damage very rapidly and control measures need to be taken immediately if this pest is found.

Varietal Differences

There appear to be differences in susceptibility to storage insect damage between varieties. If farmers are aware that some varieties are more susceptible to insect damage during storage than others the susceptible varieties should be consumed first.

Hygiene

Larvae of some of the insect pests can also survive in sweetpotato flour. If sweetpotato flour is left near the storage environment it may act as an important source of carryover of pests between seasons. The storage container needs to be carefully cleaned, and all the previous seasons' residual stored products removed before the new product is stored, otherwise the insects will move directly to the new product and start damaging it.

Fresh sweetpotato can be stored in pit or clamp stores for several months. Only roots with no damage from wounding during harvest, transport or insect pests should be placed in the store. The stores need to be regularly inspected every 3 or 4 weeks to check the roots for root rotting, rodent or insect damage. If any signs of these problems are found the whole store should be emptied and the affected roots discarded, and the other roots used or sold quickly to avoid further losses. If there are no signs of any problems during the inspection the store should be resealed carefully, and the shade roof replaced. Care should be taken during inspection as snakes are occasionally found in the stores. More information on fresh root storage is given in Harvesting and Postharvest Management.

Review Questions

1. What are the recommendations for good storage hygiene?
2. What are some of the ways to make dried sweetpotato insect resistant?

Unit 8 – Gender and Diversity Aspects of Sweetpotato Pest and Disease Management

Objectives

By the end of this unit, you should be able to:

- Identify gender and diversity issues in sweetpotato pest and disease management.

Key Points

- **Different people have different experiences and understanding when it comes to sweetpotato pests and disease.**
- **Women who do most of the labour in weeding, etc., may have had much opportunity to observe pest and disease symptoms.**
- **Some farmers are unaware of different pest life cycles. Sharing this information can help them begin the process of experimenting with control techniques.**
- **Pregnant and nursing mothers as well as children should avoid contact with pesticides. Child and uterus exposure to these chemicals can result in severe medical complications.**

Gender and Diversity Aspects of Sweetpotato Pest and Disease Management

A thorough discussion of gender and diversity aspects in relation to sweetpotato is presented in the topic, Gender and Diversity Aspects. However, key gender and diversity issues relevant to sweetpotato pest and disease management include:

Different people will have different understanding, knowledge and experiences of pest and disease management, their information pathways will differ and may include grandparents, parents, neighbours, extension agents and materials, traders, and school. It is important for development workers to understand who is involved in the different sweetpotato production, storage and processing activities as this will influence their experiences and knowledge and help in deciding who should be targeted for training.

If women are typically involved in monitoring, weeding and harvesting the sweetpotato crop they may have a great deal of experience in having observed pest behaviours in the field or the patterns of disease spread, and may have evaluated different pest management practices. If men have attended extension trainings on pest and disease management, they may have knowledge about appropriate pest management strategies.

It is important to find out who does which activities, what the typical information pathways are, and what understanding of pests and diseases and their management already exists in the focal community. This information can then be used to develop a training programme, targeting those who undertake the crop activities during the periods when pest and disease management strategies can occur and those who make the decisions regards what needs to be done in the field or store.

Many farmers are unaware of the different stages of insect lifecycles or how plant diseases spread. By sharing this knowledge and helping farmers to make relevant observations, one is empowering them to start experimenting with different practices. In some situations, women may have limited access to irrigated areas in which to preserve and produce clean sweetpotato planting materials resulting in delayed planting, use of diseased planting materials, low yields, late harvesting and high weevil infestation. By helping these women and their husbands experiment with use of cleaning

planting materials it may help influence decision-making around planting material conservation and quality and lead to higher productivity and reduced losses for the household.

It is generally advised that pregnant or breastfeeding women, those who prepare food and children should not be involved in spraying pesticides. Pesticides are poisons and children should be kept away from them. Children may be especially sensitive to health risks posed by pesticides because: their internal organs are still developing and maturing; in relation to their body weight, they eat, drink and breathe more than adults, possibly increasing their exposure to pesticides in food, water and the air; certain behaviours – such as playing on the ground or putting objects in their mouths can increase a child's exposure. Children exposed to pesticides, either *in utero* or during other critical periods face significant health risks including higher incidence of: birth defects, neurodevelopment delays and cognitive impairment, childhood brain cancers, autism spectrum disorders, attention deficit/ hyperactivity disorder, and endocrine disruption. Care must be taken in storing pesticides and ensuring they are not stored in food or drink containers which children or adults may accidentally consume.

Activities

These learning-by-doing activities will provide hands-on discovery opportunities for participants.

Activity 7.1 Field Hunting for Sweetpotato Pests and Diseases and Learning How to Manage Them

Objectives

Participants will be able to find field examples of the key pests and diseases of sweetpotato and explain and show the damage each can cause

Time

85 mins plus transport time

Materials

- A nearby young crop with SPVD in it;
- A field which previously had sweetpotato in it;
- A mature or old sweetpotato crop which participants can explore and find diseases and pest damaged sweetpotato plants in;
- 20 digging sticks;
- 8 buckets for carrying infested roots;
- 8 sacks;
- 20 transparent collecting pots or jars with lids with a few small holes in them;
- 20 magnifying lenses;
- participants should carry their notebooks and pencils;
- Flip chart and stand;
- Marker pens;
- Tape.

Advanced Preparations

Identify one nearby field with a young crop with SPVD in it, a field which previously had sweetpotato in it, and a mature or old sweetpotato crop, which participants can explore and find diseases and pest damaged sweetpotato plants in.

Suggested Steps

1. Split the participants up into small groups of ~6 people, explain that you will be visiting nearby sweetpotato fields in order to identify sweetpotato pest and disease problems. These problems could damage the roots, the vines and leaves, or the whole plant. They should also be trying to find the insects or other types of pests which have caused the damage and collect them in the collection jars to then show to the other groups. [5 mins]
2. Journey to sweetpotato field.
3. Pest and disease hunting. Give each small group a couple of digging sticks and collection jars, and a bucket or sack. Ask each of the groups to cover different areas of the fields. Give them 20 minutes to hunt for insect pests, and signs of pest and disease damage on sweetpotato - which they should collect samples of for the field discussion session. Remind them that they should try and observe the pests in action to gain a better understanding of what the pests do and how they damage sweetpotato. While the groups are hunting, the facilitator must move around between the groups ensuring that each group sees some virus disease, some aphids and whiteflies, and some weevil damaged roots.
4. Call them for the discussion under a shady tree near the fields. Ask each group to display

their infested roots, leaves etc. and collection jars on their sack. As a whole group move around from sack to sack hearing about what each of the small groups observed and collected. If they have all collected similar things, speed up the exercise by asking subsequent groups to describe and show anything different they saw or collected.

5. Using open probing questions, the facilitator should ask the participants to share their observations and thoughts on:
    a) What the pest was doing when they saw it,
    b) How it causes damage,
    c) Where it might have come from,
    d) How it survives during the season when there is no sweetpotato crop in the field, and
    e) How diseases spread.
6. Ask one of the participants to act as a rapporteur and record the suggestions and questions on a flip chart. Pack the plant parts and collection jars containing the insects back into the sacks ready to take to the training room.
7. The facilitator should take the group back into the field and ask them what they might do to help prevent pest or disease infestations in their sweetpotato field, and what they can do if such infestations do occur to prevent them from spreading and causing further damage. The importance of clean planting materials, resistant varieties, field sanitation, regular monitoring, natural enemies, hilling-up, regular roguing and timely harvesting should be discussed. Each participant should practice some hilling-up of exposed roots and some roguing of virus infested plants.

Activity 7.2 Hidden Damage: The Importance of Understanding Lifecycles

Objective

Participants will understand the different life cycle stages of the sweetpotato weevil, and which stages cause serious damage

Time

1 hour

Materials

- About 50 weevil-infested sweetpotato roots;
- 20 wooden boards;
- 20 sharp knives;
- 20 magnifying lenses;
- 40 dishes or plastic bags;
- 1 set of scales for weighing the damaged and undamaged portions of the sweetpotato roots;
- Participants' notebooks and pencils.

Advance Preparations

Collect some weevil infested sweetpotato roots a couple of weeks before the training course. The participants may find some during their field hunt but, in case they do not, the facilitator should be sure they have some for the participants to dissect to see the eggs, larvae, pupae and feeding tunnels. This may require artificially investing roots in the laboratory if field invested examples are not easily available at the time of the course.

Suggested Steps

1. Remind the participants that they saw and collected damaged sweetpotato roots and vines in the field. Working in pairs, you now want them to cut open these roots (and vines) and look for different life cycle stages of the insect pests inside the roots [*Note: they will have just had a lecture on the lifecycles of key sweetpotato insect pests and diseases*]. Each pair should work with at least 5 damaged roots. They need to weigh their roots at the beginning before they start cutting them and record this total weight in their notebooks. They should then carefully begin to cut open the roots and search for the different lifecycle stages in the root and investigate them using their magnifying lenses: they can draw a sketch of each of the different life cycle stages they find. As they cut up the roots, they need to keep the undamaged portions on one side and the damaged portions on the other side. The facilitator should move around the pairs helping them to: identify the eggs, larvae, pupae and adult stages of the sweetpotato weevils; ensuring they see the feeding tunnels; helping them to separate the damaged (inedible) parts of the roots from the undamaged parts.
2. When they have finished dissecting their roots they can put all the damaged portions into one bag and weigh them and record the weight. They can then do the same for the undamaged portions of the roots. They should then calculate what % of the total roots was inedible as a result of this insect damage.
3. The facilitator should then ask the groups what they have learnt from the exercise. Areas to probe include:
    a) How important it is to understand what the different lifecycle stages of an insect look like so that farmers can link the presence of the seemingly harmless adult stage with the damage that occurs later caused by the larval stage?
    b) How might they reduce the spread of these pests and limit the damage they cause?

c) What proportion of the edible roots can be lost due to sweetpotato weevil infestation?
d) What effect does this damage have on the marketing of sweetpotato weevils?
e) If you stored weevil infested roots next to clean uninfested roots, what might happen?

4. Clearing up.

Activity 7.3 Training Others on Key Sweetpotato Pests and Diseases

Objectives

Participants will have experience in using their field observations to develop training approaches and materials for training others (extensionists or farmers) on sweetpotato pests and diseases

Time

1hour and 45 mins

Materials

- The root and vine and insect materials they collected during the field hunt that morning;
- Flip charts;
- 40 marker pens;
- Masking tape;
- Magnifying lenses;
- 3 packs of stickers/ Post-its;
- Participants' notebooks and pens.

Suggested Steps

1. Divide the participants into small groups (~3 people per group) and allocate each group a sweetpotato pest or disease (e.g. sweetpotato weevil, sweetpotato virus, mole rats, rough sweetpotato weevil, armyworm). Explain that each group has 20 mins to prepare a 5-minute presentation, folk drama or role play about their pest or disease and the damage it causes farmers. Remind them that these presentations they are developing may be useful for them when they come to train others.
2. Ask each group to share their presentation, remind them they have a maximum of 5 minutes only, and ask someone to act as the timekeeper. Ask the other participants to use stickers to make quick notes after each presentation on the things they liked about it, the information that was missing or incorrect in the presentation and a suggestion for how the presentation could be improved (one sticker per presentation). Make a flipchart page for each presentation onto which those watching can stick their review comments (this means at the end each small group will be able to look at all the comments about their presentation and get ideas for how they could have done it differently).
3. The facilitator can use the presentations as a way of assessing understanding of the topic by participants, and to help them start to think about how they will share the knowledge they are developing with others. The facilitator should invite each small group to visit the flip chart page which has comments about their presentation on it and give them 5 minutes to review and discuss those comments, before opening a 10-minute group discussion on the presentation process. The facilitator must remind participants that we learn continuously, and that listening to and responding to feedback from others is a very important part of improving our performance.

Answers to Review Questions

Unit 1

1. What is the difference between the complete and incomplete metamorphosis of insects?
    - *A complete metamorphosis means the insect has larval and pupal forms which do not resemble the adult insect; an incomplete metamorphosis means a nymph hatches from the egg and then gradually gets bigger until it reaches adult size.*
2. What are some common ways that plants get infected by fungal and bacterial diseases?
    - *By spores blown in the wind from older diseased crops; from spores splashed up by heavy rain from leaf litter; and from diseased planting material.*
3. What is Integrated Pest Management (IPM) a combination of?
    - *It combines monitoring, crop sanitation, and cultural, mechanical and biological control methods to discourage the development of pest populations, thus limiting the need for pesticides.*

Unit 2

1. How can the male and female sweetpotato weevil be told apart?
    - *By the shape of their antennae: The males' antennae are straight while the females' have a club-shaped end.*
2. What is a clear indication that roots are heavily infested with sweetpotato weevil?
    - *If many weevils are found on the foliage.*
3. How does hilling up help protect crops from sweetpotato weevil?
    - *Hilling up soil around the base of the plant and on the sides of the ridges prevents or fills soil cracks, and thus provides some protection.*
4. Where do weevils tend to lay their eggs?
    - *In the older, woodier parts of the vine, making it essential to use clean (uninfested) planting materials.*
5. Why will planting your new field of sweetpotato some distance from existing and recently-harvested fields of sweetpotato help reduce the likelihood of weevils invading your crops?
    - *Because sweetpotato weevils do not fly very often and generally only for short distances of 500 to 1000m in order to find new sweetpotato plants.*

Unit 3

1. Once a virus enters a cell in a new host, how does it affect the cell?
    - *It takes over the management and control of that cell's processes and forces the cell to produce more viruses identical to itself – instead of the crop yield.*
2. What are some common symptoms of virus infection in plants?
    - *Diminished growth; chlorosis (paleness) of the leaf tissue; misshapen leaves with an uneven or curled appearance; pigmented leaves, often purple or yellow; and reduced production of sweetpotato storage roots.*
3. When choosing new planting materials, why is it important to collect cuttings from young sweetpotato crops?
    - *Because sweetpotato virus disease symptoms are harder to see in older plants.*

Unit 4

1. How might you spot fungal diseases on sweetpotato plants?
    - *Circular brown or blackened areas called lesions will show up on the leaves and stems.*
2. What are three serious fungal diseases of sweetpotato?
    - *Alternaria, Phomopsis and Black rot.*

Unit 5

1. What are the signs of rat mole infestation?
    - *Small mounds of freshly dug soil; OFSP vines being pulled back down into the soil; Holes in the sides of ridges or mounds.*
2. What are some of the methods for rodent control?
    - *Destroying rodent burrows; Keeping field and surrounding areas clean of vegetation and rubbish; Digging deep ditch around perimeter of field; Using repellent materials inside the rodent's unblocked burrows; Planting deep rooted poisonous shrubs; Planting of sesame all around the perimeter of the field; Scalding and drowning by pouring water or hot water and pounded chili pepper mixture into the burrow; Setting of traps; Poisoning is not recommended.*

Unit 6

1. What are some of the symptoms of erinose mites?
    - *Leaves and plants slightly stunted; Vines and leaves thicken; Poor plant yield; Can affect one or multiple plants.*
2. How can erinose mites be prevented?
    - *Scout fields regularly, remove and destroy hairy shoot tips; Use Pruning, Foliar fertilizer, Miticide; Bury vine; Cut infested vines and leave in shade until leaves drop off, before planting.*

Unit 7

1. What are the recommendations for good storage hygiene?
    - *Regular inspections; keeping the area clean of rubbish; removing residue of previous crop; thoroughly cleaning containers and sacks.*
2. What are some of the ways to make dried sweetpotato insect resistant?
    - *Sun-drying; Parboiling; Salting; Rolling and shaking sacks or containers periodically; Adding traditional protectants, such as ash.*

References

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