Learning to control potato late blight- A facilitator's guide

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1. Late Blight. **2.** *Phytophthora infestans*. **3.** Potato. **4.** Training. **I.** Paola A. Cáceres, Manuel Pumisacho, Gregory A. Forbes, Jorge L. Andrade-Piedra. **II.** Learning to Control Potato Late Blight – A Facilitator's Guide. **III.** International Potato Center, Instituto Nacional Autónomo de Investigaciones Agropecuarias del Ecuador, Secretaria Nacional de Ciencia y Tecnología del Ecuador.

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Presentation

Late blight, caused by *Phytophthora infestans* (Mont.) de Bary is the most important disease of potato worldwide. This guide began with an experience in Ecuador where late blight is particularly severe in highland potato production. In an effort to find solutions to this problem, several actors participated in the elaboration of the first Ecuadorian version of the guide, including the International Potato Center (CIP) through the Integrated Crop Management Division and the Papa Andina project and the "Instituto Nacional Autónomo de Investigaciones Agropecuarias" del Ecuador (INIAP), through the "Programa de Raíces y Tubérculos – rubro Papa"; and the "Secretaría Nacional de Ciencia y Tecnología del Ecuador" (SENACYT). The title of the initial version was "Guía para facilitar el aprendizaje sobre control de tizón tardío de la papa".

The users of the guide (those who use it directly) are trainers of farmers, referred to herein as facilitators. In many cases facilitators are farmers that have gone through a capacity building process themselves. However, this guide can also be used by extension agents and even teachers in colleges or other institutions of higher education. The beneficiaries of the guide (those who will learn as a result of it) are small-scale potato farmers. Nonetheless, some parts can be used by students in elementary courses in agronomy.

This guide was designed using an analysis of activities related to late blight management. It began with an analysis of competencies that farmers should have to control the disease[1]. Learning components were developed for knowledge, mental abilities, physical skills and attitudes related to the competencies. These components were then used to develop learning objectives that oriented the development of the guide's content, exercises and evaluation tools. This farmer- centered approach helps the facilitators focus the management of farmer knowledge on elements that are important for the control of potato late blight.

It is hoped that the guide will be adapted to many different contexts and will be of use to facilitators globally.

1. Zapata, V. 2006. Manual para la Formación de Gestores de Conocimientos. Centro Internacional de Agricultura Tropical, Programa FIT Bolivia. Cali, Colombia. 164 p.

Introduction

This guide is designed to provide instructions to facilitators involved in building capacity of small-scale farmers to control late blight. It is divided into five learning modules. Each module deals with one competency that farmers need to control late blight effectively. The competencies are as follows:

- Capable of recognizing the symptoms of disease and know which organism causes the disease (Module1)
- Know how this organism lives (Module 2)
- Identify the characteristics and benefits of potato varieties that are resistant to late blight (Module 3)
- Use fungicides effectively in the control of late blight
- By periodically visiting the potato field, be able to select practices that control late blight efficiently

These competencies were identified by farmers, facilitators, extension agents, and plant pathologist in a workshop that was held in Ecuador at the beginning of 2006. Subsequently, the modules were developed borrowing from other material that had been published earlier in Bolivia[2], Ecuador[3,4], Peru[5], and El Salvador[6]. Later, the modules were tested in courses for facilitators and in Farmer Field Schools (FFS) that were held in the highlands of Ecuador and 2006. The modules were also evaluated by facilitators in a workshop that was held in Cajamarca, Peru in 2007. Finally some advanced versions of the modules were translated into English and were evaluated by scientists in a workshop that was held in Pyongyang, Democratic Peoples Republic of Korea.

There are several characteristics of this guide that should be taken into consideration before using it:

2. Gandarillas, E., Meneces, P., Thiele, G., y Vallejos, J. (eds.). 2001. Pautas para facilitadores de escuelas de campo de agricultores. Programa de Investigación en Productos Andinos (PROINPA). Cochabamba, Bolivia. 143 p.

3. Pumisacho, M. y Sherwood, S. (eds.). 2000. Herramientas de aprendizaje para facilitadores - Manejo integrado del cultivo de papa. Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Centro Internacional de la Papa (CIP), Organización de la Naciones Unidas para la Agricultura y la Alimentación (FAO), Instituto Internacional de Reconstrucción Rural (IIRR). Quito, Ecuador. 181 p.

4. Pumisacho, M. y Sherwood, S. (eds). 2005. Guía metodológica sobre ECAs - Escuelas de campo de agricultores. Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Centro Internacional de la Papa (CIP), World Neighbors. Quito, Ecuador.185 pp.

5. Nelson, R., Palacios, M., Orrego, R., y Ortiz, O. (eds.). 2002. Guía para facilitar el desarrollo de escuelas de campo de agricultores - Manejo integrado de las principales enfermedades e insectos de la papa - Caso San Miguel, Cajamarca, Perú. Centro Internacional de la Papa (CIP), CARE. Lima, Perú. 264 p.

6. COSUDE/Zamorano/PROMIPAC. 2001. Escuelas de Campo - Guía del Facilitador. Resultado de las experiencias del curso taller "Capacitación de Capacitadores en Manejo integrado de Cultivos: la Metodología Escuelas de Campo" realizado en Morazán, El Salvador en octubre y noviembre del 2000. San Salvador, El Salvador. 100 p.

- **Learning approach.** This guide can be used in different participatory learning approaches, particularly in FFS and short courses. It utilizes several different techniques to facilitate learning, for example, observation, analogies, skits, discussions, experimentation and simulation. It also emphasizes the importance of building on the existing farmer knowledge and subsequently developing with farmers improved knowledge by strengthening the competencies they need to control late blight. For this reason, the facilitator should act as an intermediary of knowledge and not as a traditional professor.
- **Depth.** This guide is not intended to be highly technical in the different aspects of control of late blight. Other sources such as books, scientific articles and technical sheets[7] can be used if greater knowledge is needed. The objective of this guide is to present the information that is essential for the participants to be able to adequately control late blight.
- **Language.** Because of the type of users and beneficiaries of this guide, it is essential to use simple language. For example, while the pathogen that causes late blight, *Phytophthora infestans*, actually belongs to the group of microorganisms known as oomycetes, in the guide it is referred to as a fungus, which is much more familiar to most people. Other simplifications have also been made in language.
- **Minimum requirements of users and beneficiaries.** The users of this guide should be able to read and write. Also it is highly recommended that they have some experience in potato cultivation and in processes of participatory capacity building. The beneficiaries do not necessarily have to know how to read and write.
- **Building capacity of the user.** It's highly recommended that users of this guide participate in a course on how it should be correctly used. This course might last 2 or 3 days and could be given by people with experience in late blight control and in the use of this guide.
- **Adaptation.** This guide should be tried and adapted to the local social and agro-ecological conditions. Furthermore, some contents are specific to each location, as for example lists of cultivars or lists of fungicides.
- **Structure.** Each module has the following structure:

  1. Instructions for the facilitator before the session
     - » Prerequisite
     - » Time needed
     - » Introduction

7. Pérez, W. y Forbes, G. 2007. Manejo integrado del tizón tardío. Hojas Divulgativas 1 a 6: 1. ¿Qué es el tizón tardío?; 2. ¿Qué es el manejo integrado del tizón tardío?; 3. ¿Qué es la resistencia genética?; 4. ¿Qué son los plaguicidas?; 5. ¿Qué es un fungicida?; 6. ¿Para qué se calibra la bomba de mochila? Centro Internacional de la Papa (CIP). Lima, Perú.

» Objectives
» Structure the module
» Preparation for the facilitator

2. Activities to be developed with the participants during the session
» Revision of the preceding module
» Evaluation of the existing knowledge
» Expectations of the participants
» Practical (in the case of Module 1 the Practical's are grouped in sessions)
  › Objective
  › Materials
  › Procedure
  › Technical notes
  › Materials to give participants

» Final activities
  › Synthesis of the module
  › Evaluation of knowledge
  › Feedback
  › Questionnaire

▶ **Use**
» This guide should only be used for building capacity in the control of late blight of potato. Many aspects of it could be used for the control of late blight in other plants, as for example in tomato. However, in that case certain adaptations would be needed.
» Modules 1 to 5 are given in the order that they should be used.
» Within the context of a FFS, the modules should be given as soon as the plants in the learning plot have emerged. Under conditions of severe late blight, it may be necessary to spray the plot with fungicides prior to the session on fungicides. In that case, participants should be informed that fungicides will be dealt with in a subsequent Module. Module 3 on resistant varieties could be repeated before selecting a variety in the subsequent season.

Module 1

Knowing *Phytophthora infestans* and Symptoms of Potato Late Blight

Directions for the facilitator before the session

Prerequisite None.

Timing This module contains two sessions. The first session lasts approximately three hours. The second session takes place seven days later and lasts approximately 30 minutes.

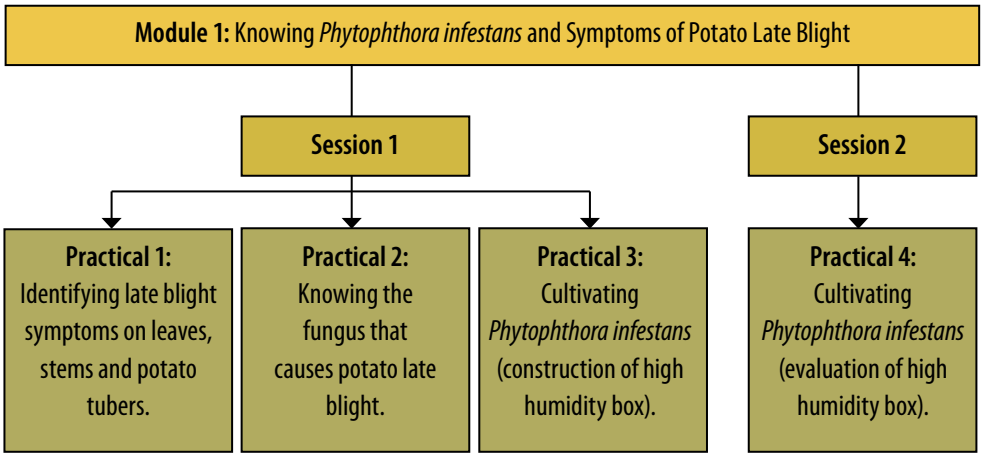
Introduction Late blight is often confused with other problems of the potato. Therefore, it is necessary to clarify its symptoms. It is also important to know that it is caused by a fungus called *Phytophthora infestans* (see Note 1 below). The fungus presents itself on the plant as a white fuzz, that is made up of thousands of spores .

Objectives After finishing this module, the participants will be able to:

1. Explain the concept of symptom and give an example related to animal diseases.
2. Describe late blight symptoms on leaves, stems and potato tubers under field conditions and how to distinguish them from those of other diseases.
3. Draw the agent causing late blight and describe how to recognize it on plants.
4. Explain what f *Phytophthora infestans* spores are and how they function.

Note 1 *Phytophthora infestans* is not a true fungus. However it looks very much like a fungus so for sake of simplicity has been described as such above.

Module Structure



Preparing the facilitator

1. Review this guide carefully.
2. Obtain the materials needed for Practicals 1, 2 and 3.
3. Obtain color copies of the handouts on pages 20, 21 and 27 (one set of copies for each participant).
4. Obtain black and white copies of pages 33, 34 and 36 (one set of copies for each participant).
5. **Optional.** If desired, the participants' knowledge can be objectively evaluated using the instructions described in Annex 1 and the questionnaire on page 39.
6. Find an enclosed area to perform certain steps of the praticals (for example, drawing symptoms, microscope observation and preparation of high humidity boxes).
7. If possible, locate a potato crop with late blight symptoms.

Activities to do with the participants during the session

Session 1

Session 1 starts with the facilitator's introduction and presentation of the subject. This if followed by the activities described below.

Initial Evaluation of Knowledge

Mandatory evaluation. The following questions should be proposed to motivate the participants to get involved in the subject, refresh their knowledge of the subject, and at the same time provide a general idea of their level of understanding:

- Has any of you had the flu?
- What is a disease? What is a symptom?
- How many of you have encountered late blight in your potato crops? Did you make a mistake and think it was another disease?
- What are the symptoms of late blight on leaves? On stems? On tubers?
- What do you believe is the cause of late blight on potatoes?
- What is a spore and what is its function?

The answers to the questions that have been underlined should be written on a large piece of paper. In the module's synthesis (page 37), the answers should be reviewed to emphasize that various issues are indeed known by the participants while others are new to them.

Optional evaluation. The participants' level of knowledge may be objectively evaluated using the questionnaire found on page 39, which should also be applied once more at the end of the module. Methodology for this evaluation may be found in Annex 1.

Participants' Expectations

To learn what the participants expect from the module, questions such as "why have we met today" may be used.

Afterwards, the objectives of the module (page 13) will be shared with the participants, and these may be summarized by writing them on a large piece of paper or on cards.

It is imperative to set a time schedule for Sessions 1 and 2, and to clarify that certain issues will not be discussed, such as:

- Other potato diseases.
- Late blight control.

Practical 1. Identifying late blight symptoms on leaves, stems and potato tubers

Objectives

At the end of this practical, participants will be able to:

1. Explain the concept of symptom and give an example related to animal diseases.
2. Describe late blight symptoms on leaves, stems and potato tubers under field conditions and how to distinguish them from those of other diseases.

Materials

- Samples with fresh late blight symptoms and other potato diseases (see Note 2).
- Magnifying glasses, one per participant, if possible.
- Drawing materials: paper and colored pencils.
- An award for a drawing contest among the participants

Procedure

1. Share the objectives of the practical with the participants.
2. Form groups of four or five people. Each group will work as a team on activities 4 and 5 below.
3. Give samples, magnifying glasses and drawing materials to participants.
4. Ask participants to separate the specimens according to symptoms, identify those that have late blight. Then ask them to describe the different types of symptoms. If necessary, add complementary information to the descriptions.
5. Verify that each participant observe the late blight symptoms and the white fuzz with a magnifying glass.
6. During the plenary, discuss with the participants the topics that were covered. Jointly define with them the concept of symptom, and the characteristics of late blight symptoms on leaves, stems and tubers.
7. Ask the participants to draw late blight symptoms. Mention that there will be an award for the best drawing at the end of Practical 2.

8. Give copies of pages 20 and 21 to each participant to clarify terms and reinforce concepts.

Note 2 **Should a potato plot be available, visit and gather samples with the participants. Should a potato plot not be available, the facilitator should collect and bring samples to the practical. They should be gathered in the morning. It is important that these specimens be fresh. To preserve them, they may be kept in plastic bags in the refrigerator.**

Technical notes

For the facilitator

Late blight is a potato disease caused by a microbe that attacks leaves, stems and tubers.

Microbe A microbe is a living organism that cannot be seen with the naked eye or at least is very difficult to see (see Note 3).

- There are microbes that are beneficial. For example, soil microbes contribute to the decay of organic matter.
- There are also microbes that cause disease. For example, microbes that cause late blight, microbes that cause human influenza, or microbes that cause mastitis in cows.

Disease Disease is a health problem in any living organism. Diseases are produced by microbes or by other causes.

- Diseases caused by microbes are, for example, potato late blight, human influenza, cow mastitis.
- Diseases produced by other causes are, for example, potato yellowing due to lack of nitrogen, human diarrhea from eating poisoned food, loss of hair in animals due to lack of minerals.

Symptom Symptoms are the way that a living organism reacts to a disease. For example, the potato plant produces blotches when suffering from late blight, people get headaches when they have the influenza and cows produce curdled milk when they have mastitis.

Note 3 **This concept can be useful to reinforce the concept of disease. Nevertheless, its use is not mandatory.**

Potato late blight symptoms

Handout

What is a symptom?

It is the way a living organism reacts to a disease. For example, potato plants produce blotches when suffering from late blight.

Symptoms on leaves

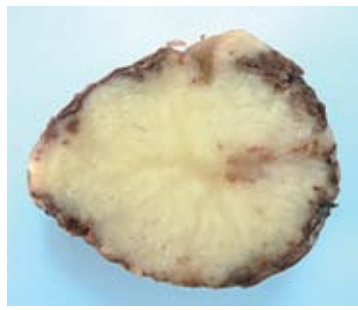
Round, dark brown watery looking blotches. Sometimes these blotches can be surrounded by a yellowish green ring.

Stem symptoms

Dry, dark brown blotches. Stems may break at the location of the blotch.

Tuber symptoms

Light brown blotches that are slightly sunken may appear on the surface. Dry, light brown blotches may be seen when cutting the tubers. Tubers with late blight symptons do not have a bad odor.



A potato crop infected with late blight has a smell similar to rotten leaves.

Do not confuse late blight symptoms with those of other diseases

Handout

Frost
produces blotches of dry and torn appearance, generally on the upper leaves.

Early blight
produces blotches with brown-colored rings. The leaf may turn yellow.

Phoma leaf spot
produces blotches that can join and cover most of the leaf.

Septoria leaf spot
produces blotches with tiny black spots. These blotches may be surrounded by a yellow ring.

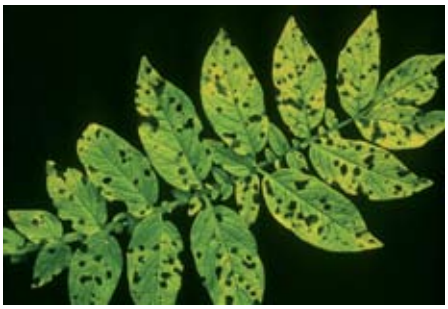


Photo: CIP

Practical 2. Knowing the fungus that causes potato late blight

Objectives

When participants finish this practical they will be able to:

1. Draw the agent causing late blight and describe how to recognize it on a plant.
2. Explain what *Phytophthora infestans* spores are and how they function.

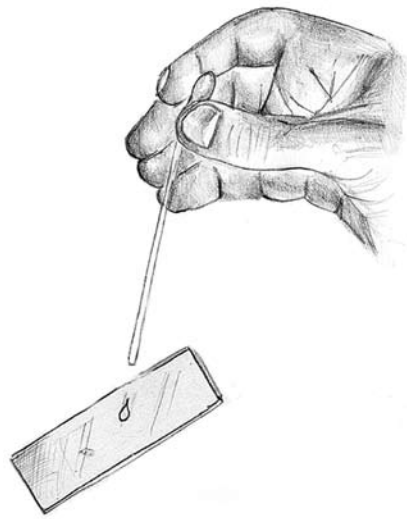
Materials

- At least one microscope (see Note 4).
- Microscope glass slides (one per microscope).
- Transparent adhesive tape.
- Water.
- Cotton, glue and flour to represent fuzz and *Phytophthora infestans* spores.

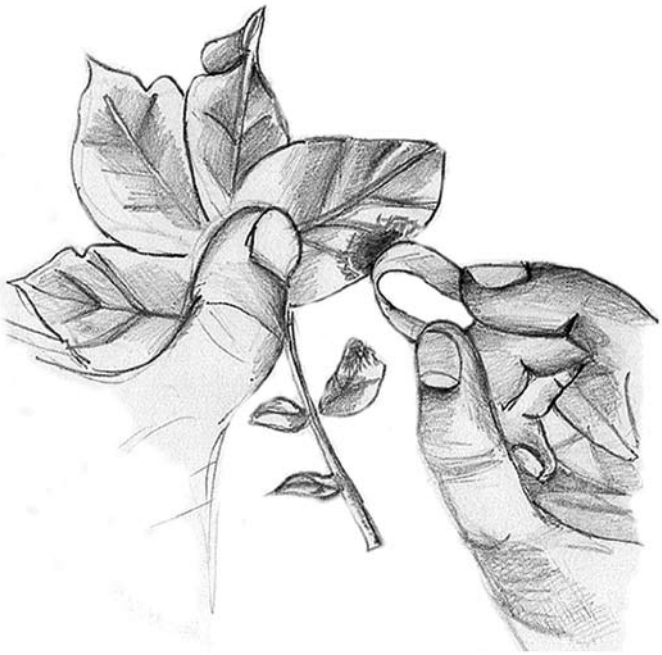
Procedure

1. Share the objectives of this practical with the participants.
2. Keep the same groups of participants previously formed and hand out materials.
3. Perform the following demonstration for the observation of spores:

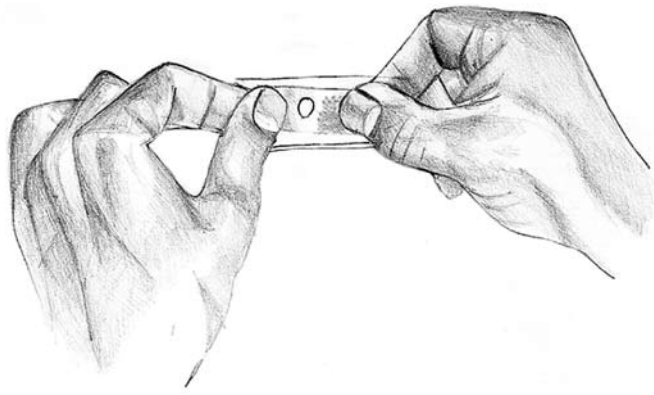
- Place a drop of water on a glass slide.



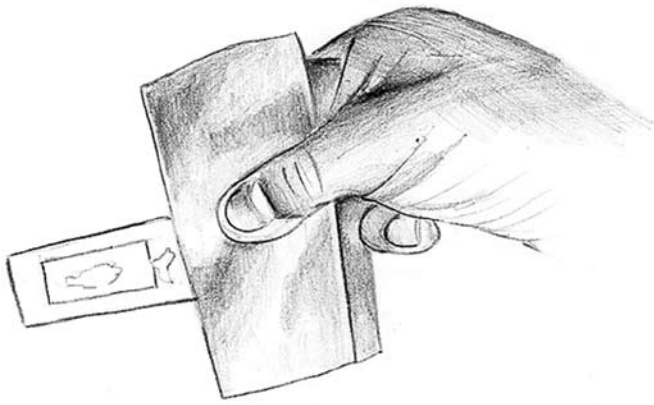
- Cut a piece of transparent adhesive tape and carefully touch it to the fuzz found on the leaf, using the sticky part of the tape.



- Place the tape over the drop of water trying not to form wrinkles. Don't put pressure on the tape.



- Dry the excess water with toilet paper.



- Observe through the microscope.

4. Make sure that participants observe spores and the stalks that support them.
5. Ask the participants to draw spores and stalks that support them. Do this on the drawings of symptoms from Practical 1.
6. Encourage participants to represent the late blight fuzz on their drawings of symptoms using glue and cotton. Flour may be used to represent the spores.
7. Ask the participants to choose the best drawing, which will receive the award.
8. During a plenary, discuss with the participants the topics covered and define with them the agent causing late blight, the way to recognize it on a plant, and the concept and function of *Phytophthora* spores.
9. Give each participant a copy of page 27 to clarify terminology and reinforce concepts.

Note 4 **A conventional or field microscope may be used. In either case, it needs to be able to magnify 100 times to be able to see the spores well. Field microscopes may be acquired at the following link (approximate cost US$40): http://www.gemplers.com/pestmgmt/magnification/lightedmagnifiers/78015.html .**

Technical notes

For the facilitator

Fungus A fungus is a living organism that generally has spores and a body formed by small threads.

- There are fungi that can be seen with the naked eye. For example, umbrella-like fungi that can be found in humid, dark places.
- Some fungi can't be seen with the naked eye, and therefore are called microbes. For example, the fungus that causes late blight. To see this fungi, a microscope is required (an instrument used to see microbes and other very small bodies).
- Some fungi are useful. For example, many medicines for humans and animals are produced by fungi.
- Other fungi cause diseases. For example, the fungus that causes late blight and the fungus that causes ringworm in humans and animals

Spores They are very small bodies and their function is to permit fungal reproduction. It is possible to see their shape with the help of a microscope.

Phytophthora infestans The fungus that causes potato late blight. In other words, *Phytophthora infestans* is the causal agent of potato late blight.

Sign This word is used to refer to the body of the microbes that cause plant diseases. It is not possible to see the body of these microbes with the naked eye except when thousands of these bodies are present. See Note 5.

Sign of *Phytophthora infestans* The white-colored fuzz that appears surrounding the blotches on leaves and sometimes on stems, after a cool and humid night. This fuzz is formed by thousands of spores that are held by small threads, or stalks. This fuzz is the best way to differentiate late blight from other diseases of potato.

- *Phytophthora infestans* spores are lemon shaped.

Note 5 **The word "sign" can be confusing for some participants. It can be replaced by using the words "fuzz", "cotton-like", "wool-like".**

Potato late blight is caused by the *Phytophthora* fungus

Handout

- When the environment is humid, white fuzz can be observed on the back of the leaves.
- This fuzz is formed by the *Phytophthora infestans* spores and by very small threads that hold them.
- The best way to recognize late blight is by the presence of the fuzz.

- When seeing fuzz through a microscope, *Phytophthora infestans* spores and very small threads that hold them may be observed.
- The function of spores is to allow *Phytophthora* to reproduce.
- *Phytophthora* spores are lemon shaped.

Practical 3. Cultivating *Phytophthora infestans* (construction of a high humidity box)

Objective

After finishing this practical, participants will be able to cultivate *Phytophthora infestans* in a high humidity box, with the purpose of reinforcing their knowledge from Practical 2 (Knowing the fungus that causes potato late blight).

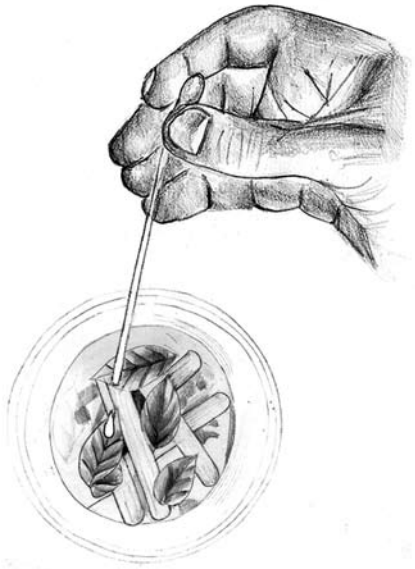
Materials

- Potato leaves with fresh late blight symptoms and abundant fuzz.
- Healthy potato leaves without fungicide.
- Materials for high humidity boxes:
  - Each participant should have:
    - Two disposable transparent plastic containers with lids.
    - Two disposable plastic glasses.
    - Toothpicks.
    - One plastic spoon.
    - One pair of scissors.
    - Clean small sticks.
  - The group should have:
    - Bleach (Chlorine).
    - Cold boiled water.
    - Toilet or tissue papel.

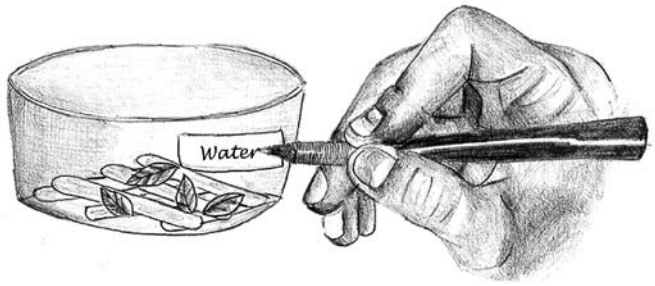
Procedure

1. Share with participants the objective of the practical.
2. Describe the high humidity box and its purpose.
3. This practical is carried out individually. Hand out materials to each participant.
4. Give each participant a copy of page 33. Demonstrate how to construct the high humidity box.

5. Ask each participant to build two high humidity boxes and place in each box two or three leaves of a healthy plant with the back side facing up.



6. In the first high humidity box use a toothpick to place several drops of water on the back side of each leaf. Cover the box and label it "Water".



7. Carry out a demonstration of how to wash the fuzz and obtain the spores in the following way:

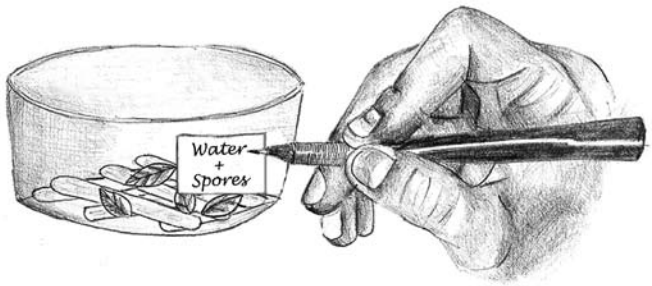
- Take at least ten or fifteen leaves that display symptoms and remove the area with fuzz.

- Put these pieces in a plastic cup with very little water (just enough to cover the leaves). Stir the leaves with the help of a toothpick and then take them out of the glass.

8. Inoculate the *Phytophthora* spores into the second high humidity box:

- Place several drops of the spores on the back side of the leaves using a toothpick (see Note 6).

- Close the box and label it "Water plus spores".



- Ask participants to carefully discard the cup with the spores in the garbage (see Note 7).

9. Ask participants to put their high humidity boxes in a moderately warm place (for example, inside the house near a window) and to place a small quantity of water in each box every two or three days to maintain humidity
10. Guide participants in filling out their worksheets (page 34).
11. Continue with the module's Synthesis (page 37) and mention that four to seven days must pass before late blight symptoms will appear on the leaves in the high humidity boxes.

Note 6 **Inoculation should be performed on the back side of leaves because *Phytophthora infestans* penetrates easily on that side.**

Note 7 **Spores may pass the disease to healthy potato plants. To avoid this, a small quantity of bleach may be put inside each glass before its disposal.**

Cultivating *Phytophthora infestans*

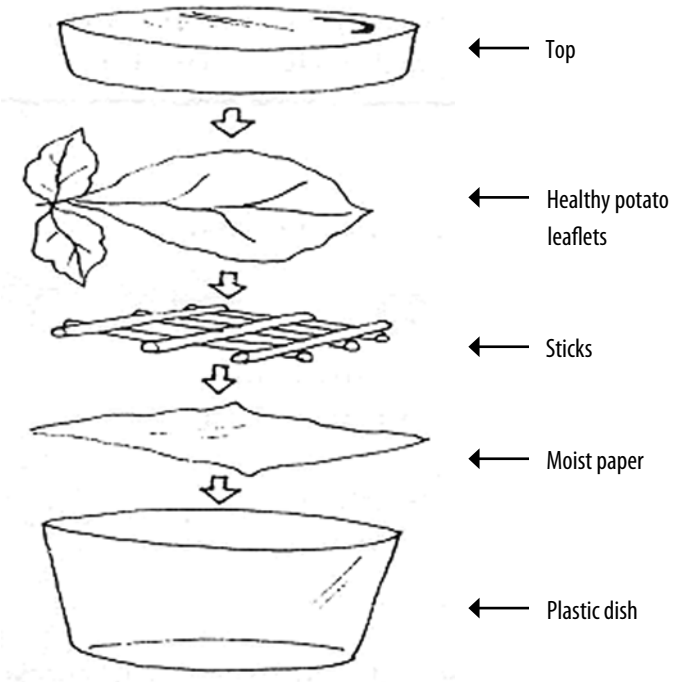
Handout

What is a high humidity box?

A chamber that allows the cultivation of *Phytophthora infestans* on potato leaves. It helps us understand how this fungus causes late blight.

How to build a high humidity box

- Put two tablespoons of bleach (chlorine) in a cup of water.
- Place several small wooden sticks inside the cup for one minute.
- Remove the sticks and rinse them with clean water.
- Discard the cup with bleach in the garbage.
- Build the high humidity box as indicated in the following drawing



What do we observe in our high humidity boxes?

Handout

Name of participant: _____

Name of the box: _____

Day	Date	What do we observe?
1		
2		
3		
4		
5		
6		
7		

Session 2 (4-7 days later)

Practical 4. Cultivating *Phytophthora infestans* (high humidity box evaluation)

Objective

After finishing this practical, participants will be able to evaluate the high humidity boxes.

Materials

- Magnifying glasses, one per participant, if possible.
- At least one microscope.
- Glass slides for the microscope (one per microscope).
- Transparent adhesive tape.
- Water

Procedure

1. Share the objective of the practical with the participants.
2. Ask for volunteers to briefly explain their results. It is expected that the leaves in the box labeled "Water plus spores" will be infected with late blight, whereas the leaves in the box labeled "Water" will be healthy. To promote discussion, the following questions may be asked:

- Why do some boxes have late blight and others do not?
- What is the function of *Phytophthora infestans* spores?
- What function does humidity have? (see Note 8)

3. Ask participants to observe with a magnifying glass the symptoms and the *Phytophthora infestans* fuzz in their high humidity boxes.
4. Observe spores with the help of a microscope (see Practical 2).
5. During the plenary discuss the topics that were covered: description of the causal agent of late blight and the symptoms it causes in potato, how the fungus is recognized on the plant, and the characteristics and function of spores of *Phytophthora infestans*.
6. Hand out copies of page 36 to each participant to clarify terminology and reinforce concepts.

Note 8 **This subject will be dealt with in Module 2. Nevertheless, the need for high humidity for the *Phytophthora infestans* to grow and cause late blight may be mentioned.**

What do we learn by using high humidity boxes?

Handout

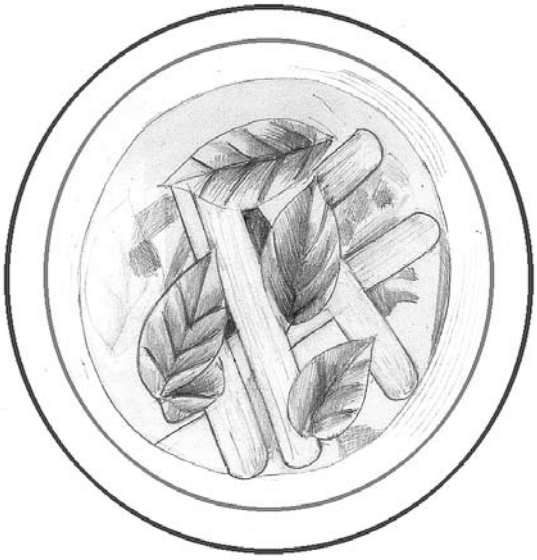
By using the high humidity boxes, we learn that potato late blight is caused by a fungus named *Phytophthora infestans* . This fungus has spores that permit its reproduction by passing from a sick plant to a healthy one, causing more blight.

Leaves in this high humidity box have late blight. What we did was the following:

1. Washed the fuzz from infected leaves and, in this way, obtained spores of *Phytophthora infestans*.
2 Placed these spores on healthy leaves.
3 The spores penetrated the leaves and infected them with blight.

There is no late blight on the leaves in this high humidity box. What we did was the following:

1. Placed several drops of clean water on healthy leaves.
2. Since there are no spores of *Phytophthora infestans*, there is no late blight.



Final Activities

Module Synthesis

To reinforce the learning objectives, a synthesis of the following issues should be made at the end of Session 1:

- The concept of symptom.
- Late blight symptoms.
- Causal agent of late blight and the way to recognize it on a plant.
- Characteristics and function of *Phytophthora infestans* spores.

The photocopies that have been handed out to the participants may be used for this synthesis. At this point, the participants' answers made at the beginning of the module should be reviewed, so as to relate them to recently acquired knowledge. The notes taken by the facilitator during discussions may also be reviewed.

At the end of Session 2, a quick summary of the work done with the high humidity boxes may be made. It must be clear to the participants that late blight is caused by spores of *Phytophthora infestans*.

Final Knowledge Evaluation

Mandatory evaluation. To evaluate if the learning objectives were achieved, several randomly chosen participants should to be requested to do the following activities:

1. Explain the concept of symptoms and give an example related to an animal disease.
2. Describe late blight symptoms on leaves, stems and potato tubers under field conditions and distinguish them from other diseases.
3. Draw the causal agent of late blight and demonstrate with the drawing how to recognize it on a plant.
4. Explain the characteristics and function of *Phytophthora infestans* spores.

Optional Evaluation. The participants level of knowledge acquired in this module can be evaluated using the questionnaire on the following page. Immediately after the test, it is recommended that you indicate the correct answers and discuss them with the participants.

Feedback The following questions may be used to determine the reaction of the participants to the module:

- Was it necessary to draw the late blight symptoms?
- Were the magnifying glasses and microscopes necessary?
- Did the high humidity boxes help you to understand that *Phytophthora infestans* spores cause late blight?
- What problems were encountered?
- Was sufficient the time assigned to the exercises?

Questionaire for knowledge assessment

1. What is a symptom?
   (a) It is the reaction of a living organism to a disease.
   (b) It is what causes a disease.
   (c) I don't know.

2. What are influenza symptoms?
   (a) Cold weather and virus.
   (b) Headache and fever.
   (c) I don't know.

3. What are the symptoms of late blight on potato leaves and stems?
   (a) Dark brown blotches on leaves and stems.
   (b) Dry leaves and stems.
   (c) I don't know.

4. What is the late blight symptom in potato tubers like?
   (a) Dry, light brown blotches.
   (b) Watery blotches with a bad smell.
   (c) I don't know.

5. How do you recognize late blight on potato leaves and stems?
   (a) Because there are blotches surrounded by fuzz.
   (b) Because the leaves and stems dry out.
   (c) I don't know.

6. What is the white-colored fuzz that appears on leaves and stems with blight?
   (a) A plant's defense mechanism.
   (b) Thousands of fungus spores that cause blight.
   (c) I don't know.

7. What is a spore and what is it for?
   ((a) It is the part of the fungus used for reproduction.
   (b) It is part of the plant and it is useful for protection against diseases.
   (c) I don't know.

8. What causes potato late blight?
   (a) Rain.
   (b) *Phytophthora infestans* fungus.
   (c) I don't know.

Correct Answers: 1 a; 2 b; 3 a; 4 a; 5 a; 6 b; 7 a; 8 b

Module 2

Learning more about *Phytophthora infestans* – the Cause of Potato Late Blight

Directions for the facilitator before the session

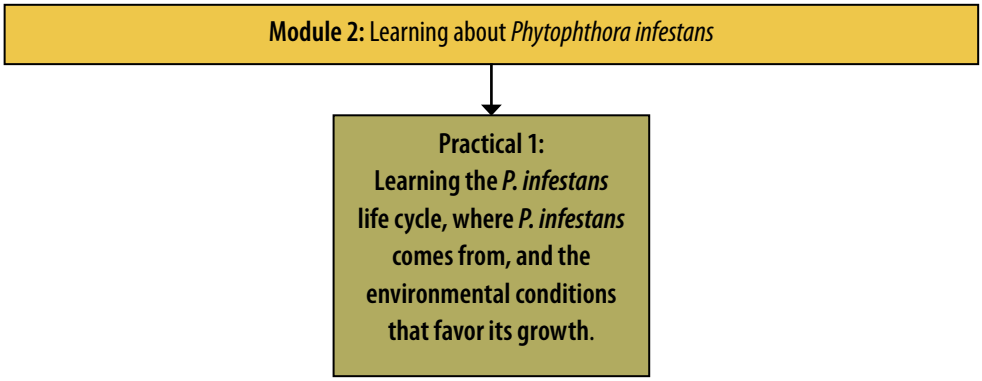
Prerequisite Knowledge acquired with Module 1.

Timing One, two-hour session. This module should be carried out as soon as possible after finishing Module 1, Session 2.

Introduction To efficiently control potato late blight, it is imperative to know the life cycle of the late blight pathogen, *Phytophthora infestans*, identify sources of infections and know the environmental conditions that favor its growth. These are the issues that will be covered in this module.

Objective At the end of this module, it is expected that participants will be able to draw and explain the *P. infestans* life cycle by using a drawing, including sources of *P. infestans* and the environmental conditions that favor the various phases of the pathogen's growth.

Module's Structure



Preparation for the Facilitator

1. Review this guide carefully.
2. Obtain materials needed for Practical 1.
3. Obtain copies of page 53 (one copy per participant).
4. Optional. When desired, participants' knowledge can be evaluated objectively. Materials should be prepared for an initial and final evaluation (Annex 1 and page 55).
5. Review the methodology of Practical 1. The *P. infestans* life cycle should be clearly understood, as well as the origin of the infections and the environmental conditions that favor disease.
6. Find an enclosed location to perform certain steps of the Practical (for example, drawing the life cycle) and, if possible, a potato plot with late blight symptoms.

Activities to do with participants during the session

Revision of Previous Module

The session begins with the facilitator's introduction and the presentation of the subject. This should be followed by a review of the following topics:

- Concept of symptom.
- Potato late blight symptoms on leaves, stems and potato tubers.
- The agent causing late blight.
- Characteristics and function of spores of *Phytophthora infestans*.

Copies handed out to participants during Module 1 may be used for this purpose.

Initial Knowledge Evaluation

Mandatory evaluation. The following questions should be asked to encourage the participants to become involved in the subject, refresh their knowledge, and at the same time, obtain a general idea of their level of understanding:

- Where does *Phytophthora infestans* come from?
- How does it reproduce? What is the life cycle of the late blight pathogen? (see Note 1).
- What are the environmental conditions favorable for *Phytophthora infestans*?
- What role do rain and temperature play in late blight development?

Answers to these questions should be written on a large piece of paper. In this module's Synthesis (page 54), these answers should be reviewed to emphasize that some issues were already familiar to the participants, whereas others are new to them.

Optional Evaluation. The participants' level of knowledge may be objectively evaluated by using the questionnaire found on page 55, which should be applied again at the end of the module. Instructions for the evaluation can be found on Annex 1 (page 129).

Participants' Expectations

To understand what the participants expect from this module, a question such as "why have we met today?" may be asked.

After the discussion on participants' expectations, the objectives of the module will be shared among the participants, which may be summarized by writing them on a large piece of paper or on cards.

It is important to define the time that will be used in this module and also to specify that some issues that will not be discussed, such as:

- Other pathogen cycles.
- Late blight control.

Note 1 **To introduce the life cycle concept, the following example may be used: "Juan's life cycle is like this: his parents came from the coast, they were married when they were 25 years old and then Juan was born. He was born and raised in the city of Guaranda, got married at the age of 30 and now has two children". Note that here we say life cycle of *Phytophthora infestans* or of the pathogen and this is correct. However, for the sake of simplicity one might also talk to farmers about the cycle of late blight. Late blight refers to the disease, but here the pathogen is implied.**

Practical 1. Learning the *P. infestans* life cycle, where *P. infestans* comes from, and the environmental conditions that favor its growth

Objective

When participants finish this exercise they will be able to draw and explain the *P. infestans* life cycle, including sources of *P. infestans* and the environmental conditions that favor the following phases of its growth:

- Spore penetration into the plant (infection).
- Blotch growth (see Note 2).
- Fuzz formation (sporulation).
- Spore travel from one plant to another and to tubers

Materials

- Large pieces of paper, markers and colored pencils.
- Cotton and glue to represent fuzz of *Phytophthora infestans*.
- Small paper or synthetic foam balls to represent spores of *Phytophthora infestans*. Glue a group of balls on to a small piece of black cardboard.
- Four large poster boards (70 x 50 cm.) of different colors (three green and one blue). Draw the following on the poster boards (use the graphic on page 9 as a reference)
  - » One healthy potato plant on a green poster board.
  - » One potato plant with small late blight blotches on a green poster board (this represents a sick plant obtained by planting sick tuber seeds infected with blight).
  - » A sick tuber with blight on a green poster board.
  - » Rain on a blue poster board.

Note 2 **"Lesion" is the correct term for the spot caused by *Phytophthora* but it may not be familiar to many people.**

Procedures

1. Share the objective of the practical with the participants. If a potato plot with late blight symptoms is available, this practical can be done in the field. This way, each one of the phases of the life cycle can be related to what is observed in field plants.

2. Select five volunteers to demonstrate the life cycle. Each person will be handed a poster board and will be assigned a task. According to the drawing on the poster boards, the participants will represent:

- Potato crop without late blight.
- Spores of *Phytophthora infestans*.
- Rain.
- Potato tuber with blight.

3. While the facilitator narrates the life cycle and indicates the presence of a certain element, the person who represents it should come forward. The cycle steps should be narrated by the facilitator and carried out by the participants (numbering corresponds to the notes for the facilitator, pages 51 and 52). The steps are as follows:

   a. **Spores travel from sources of *Phytophthora infestans***. The life cycle starts with spores coming from potato crops, wild plants and voluntary plants infected with late blight. Represent the travelling spores with white paper or synthetic foam balls glued to a piece of black cardboard.

   b. **Spores penetrate leaves and healthy stems**. In the presence of rain, spores reach a healthy plant and penetrate it, causing small brown blotches. Glue on top of the healthy plant's drawing several white paper or synthetic foam balls to represent spores of *Phytophthora infestans* and afterwards draw blotches with a brown marker.

c. **Blotches grow**. If the weather is cold, blotches grow slowly. If the weather is warm, blotches grow rapidly. Show the growth of the blotches with the brown marker.

d. **Fuzz is formed**. In the presence of rain, white-colored fuzz appears around the blotches. Represent the fuzz with cotton, gluing it around the blotches. Place small white paper or synthetic foam balls on top of the fuzz to represent the spores of *Phytophthora infestans*.

e. **Spores travel to other plants and tubers**:
   - **Spores travel**. In absence of rain, spores are liberated from sick plants into the air. Afterwards, they reach healthy plants and the cycle starts again.
   - **Spore spatter**. In the presence of rain, spores are spread from a sick plant to a healthy one by rain spatter, again starting the cycle.
   - **Spores are washed down to the tubers** In the presence of rain, spores are washed down from the leaves towards the tubers. If the soil is wet, spores penetrate tubers causing blotches, which should be drawn with a brown marker. If these tubers are planted, plants with late blight grow up and the cycle starts again.

4. This demonstration should be repeated at least twice with different participants.
5. Divide the participants into groups of three to five people.
6. To each group, hand out the drawing materials, cotton, glue and small paper or synthetic foam balls. Ask each group to draw the life cycle of *Phytophthora infestans* using the materials that were handed out.
7. Ask each group to explain its drawings.

8. During the plenary, discuss the topics that were covered, specifying the life cycle of *Phytophthora infestans*, sources of Phytophthora infestans and the environmental conditions that favor the various growth phases.
9. Give each participant a copy of page 53 and reinforce the above mentioned concepts.

Technical Notes

For the facilitator

Where does *Phytophthora infestans* come from?

- The origin of the *Phytophthora infestans* may be Mexico or the Andes.
- The first blight blotches on a potato crop are caused by *Phytophthora infestans* spores that travel from:
  - » Potato crops
  - » Wild plants
  - » Voluntary plants

  } Infected with late blight
- The first blight blotches may also appear on plants coming from tuber seeds infected with *Phytophthora infestans* (see Note 3) .

The ***Phytophthora infestans* life cycle** steps are described below. This cycle may last between three and fifteen days, depending on weather and the level of plant resistance.

a. Spores travel from *sources of Phytophthora infestans*

The cycle starts when the *Phytophthora infestans* spores (coming from potato crops, wild plants and voluntary sick plants infected with blight) reach a healthy plant.

b. Spores penetrate leaves and healthy stems

- Once the spores have fallen on leaves and healthy stems, they produce brown blotches.
- In order for spores to enter the plant, water must be available on the leaf surface (from rain, dew or fog).
- The first blotches generally appear on the lower part of the plants' leaves.
- The penetration of spores into the plant is also called *infection*.

c. Blotches grow

The most important element for blotches to grow is temperature. The higher the temperature (up to 25º C) the faster the blotches grow.

d. Fuzz formation

- For fuzz to appear, there must be high humidity.
- Most of the time fuzz appears at night because of the high humidity caused by dew. If there is rain or fog, fuzz can appear at any time.
- Fuzz is formed by spores of *Phytophthora infestans* borne on stalks growing out of the plant.
- Fuzz formation is also called *sporulation*.

e. Spores go to other plants and tubers

- **Spores travel**. In the absence of rain, spores fly from sick plants into the air, reaching healthy plants and starting the cycle again.
- **Spores spatter**. In the presence of rain, spores are spread from a sick plant to a healthy one by rain spatter, again starting the cycle.
- **Spores are washed down to the tubers**. In the presence of rain, spores are washed down from the leaves towards the tubers causing blotches. If these tubers are planted, plants with late blight grow up and the cycle starts once again.

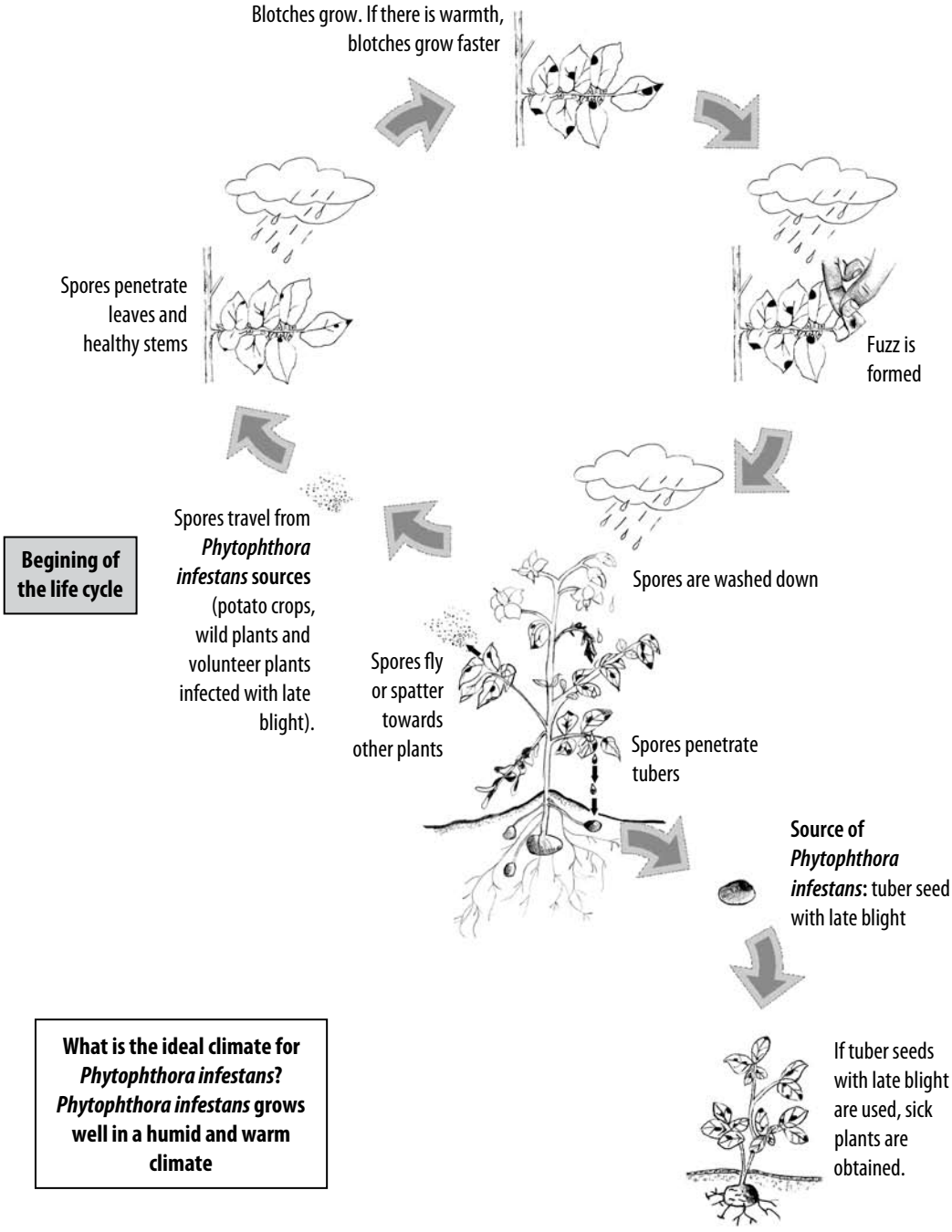
What are the best environmental conditions for *Phytophthora infestans*?

Humidity is the most important element. *Phytophthora infestans* grows very well in humid locations and seasons. Another important aspect is temperature: if days are warm, blotches grow rapidly. In locations or seasons that are dry or cold, late blight generally is not a serious problem.

Note 3 **In some parts of the world cull piles of discarded potatoes are also sources of *Phytophthora infestans*.**

Phytophthora infestans life cycle

Handout



What is the ideal climate for *Phytophthora infestans*? *Phytophthora infestans* grows well in a humid and warm climate

Final activities

Module synthesis

To reinforce the learning objective, a synthesis will be made of the following subjects:

- *Phytophthora infestans* life cycle.
- The sources of *Phytophthora infestans*.
- Environmental conditions that favor the growing phases of *Phytophthora infestans*.

For this purpose, the photocopies handed out to the participants may be used. At this time, the participants' answers written at the beginning of the module may be reviewed to relate them to the recently acquired knowledge. The facilitator's notes may also be reviewed during the discussions.

Final evaluation of knowledge

Mandatory evaluation. To evaluate if the learning objectives have been accomplished, several randomly selected participants should be asked to draw and explain the life cycle, the source of *Phytophthora infestans* and the environmental conditions that favor the following phases of its growth:

1. Penetration of spores into the plant (infection).
2. Blotch growth.
3. Fuzz formation (sporulation).
4. Movement of spores from one plant to another and to tubers.

Optional Evaluation. Should the facilitator want to objectively evaluate the knowledge acquired by the participants, the questionnaire on page 55 may be used. Immediately after finishing this evaluation, the facilitator should give the correct answers and discuss them with the participants.

Feedback

Ask the participants to give their opinion of the module. The following questions are suggested:

- Why is it necessary to learn about the *Phytophthora infestans* cycle?
- What problems did you encounter?
- Was sufficient time assigned

Questionaire for knowledge assessment

1. Where does *Phytophthora infestans* come from?
   (a) Lightning and thunder.
   (b) Potato plants or sick wild plants with late blight.
   (c) I don't know.

2. What are the ideal conditions for the *Phytophthora infestans* spores to penetrate the leaves of a healthy plant?
   (a) Lack of fertilizer.
   (b) Rain or dew.
   (c) I don't know.

3. What is the first thing that happens when a spore falls on the leaf of a healthy plant?
   (a) A brown blotch is formed.
   (b) Fuzz is formed.
   (c) I don't know.

4. What is the ideal climate for late blight blotches to grow rapidly?
   (a) Cold .
   (b) Warmth .
   (c) I don't know.

5. What is the ideal climate for *Phytophthora infestans* to produce fuzz?
   (a) High humidity.
   (b) Low humidity.
   (c) I don't know.

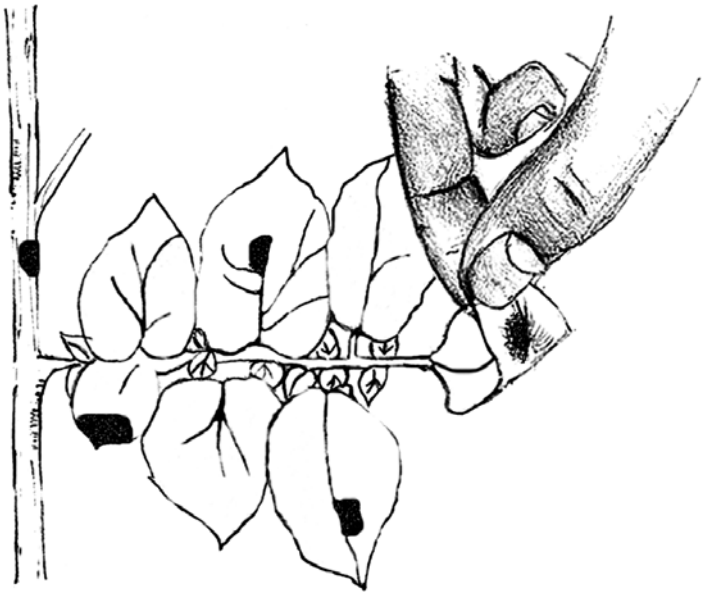
6. How do spores travel from a sick plant to a healthy one?
   (a) By wind or by rain spatter.
   (b) By night dew.
   (c) I don't know.

7. How do *Phytophthora infestans* spores reach tubers?
   (a) They are washed down by rain.
   (b) They reach the tubers through the stems.
   (c) I don't know.

Correct Answers: 1 b; 2 b; 3 a; 4 b; 5 a; 6 a; 7 a.

Module 3

Controlling Late Blight by Using Resistant Potato Varieties



Directions for the Facilitator before the Session

Prerequisite Knowledge gained in Modules 1 and 2.

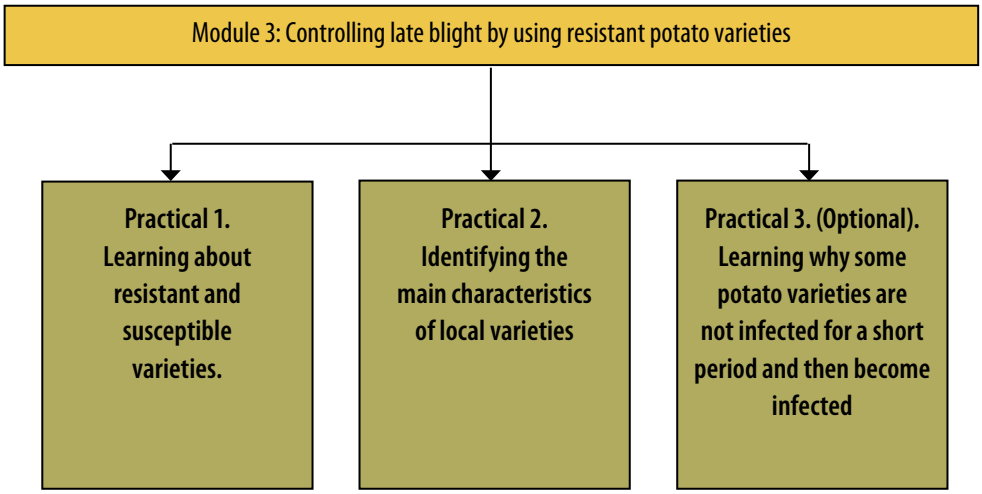
Timing One, two-hour session.

Introduction The best way to control late blight is by planting resistant potato varieties. This and other concepts to be learned further on are important when deciding what variety to plant. This module includes an optional practical to be done if participants are interested in learning concepts related to the nature of resistance in certain potato varieties.

Objectives After completing this module, participants will be able to:

1. Explain through a diagram the concepts of resistant and susceptible varieties, depicting the three main characteristics that differentiate them and the benefits of using resistant varieties to control late blight.
2. Identify the main characteristics of local potato varieties in relation to late blight using a table.
3. Optional. Following the steps indicated in the practical, explain to the group the concept of immune varieties and the reason why immunity is lost.

Module's Structure



Preparation for the Facilitator

1. Carefully review this guide.
2. Get the materials needed for Practicals 1, 2 and 3.
3. Obtain copies of pages 66, 68, 69, 70 and optionally 76 (one set per participant).
4. Optional. Should you want to objectively evaluate the participants' knowledge, materials should be prepared for an initial and final knowledge evaluation (Annex 1 and page 79).
5. Find an enclosed location to perform certain steps of the practical (for example, filling out a table with the characteristics and benefits of local varieties) and, if possible, a potato crop with late blight symptoms.

Activities to be done by participants during the session

Review of Previous Module

The session starts with the introduction of the facilitator and the presentation of the subject. Then, the following topics should be reviewed:

- Late blight symptoms on leaves and tubers.
- The causal agent of late blight
- Concept and function of *Phytophthora infestans* spores.
- The life cycle of *Phytophthora infestans*.
- Sources of *Phytophthora infestans*.
- Environmental conditions that favor growth of *Phytophthora infestans*.

For this purpose, copies handed out to participants in Modules 1 and 2 may be used.

Initial Knowledge Evaluation

Mandatory Evaluation. The following questions should be asked to encourage the participants to become involved in the subject, refresh their knowledge, and at the same time, obtain a general idea of their level of understanding:

- What is a late blight resistant variety? What is a susceptible variety?
- What are the main characteristics that differentiate a resistant variety from a susceptible variety?
- What are the benefits of using resistant varieties for late blight control?
- **Optional.** When certain varieties are introduced (see Note 1) they do not become infected with late blight, but later they easily become infected. Why does this happen?

The answers to these questions should be written on a large piece of paper. In the module's Synthesis (page 77), responses should be revisited to emphasize that various topics were familiar to the participants while others were new to them.

Optional Evaluation. The participants' level of knowledge may be objectively evaluated by using the questionnaire found on page 79, which should be applied once more at the end of the module. Methodology for the evaluation can be found in Annex 1.

Participants' Expectations

To understand what participants expect from this module, a question such as: "why have we met today?" may be asked. Later, the objectives of the module will be shared with the participants. The objectives may be summarized by writing them on a large piece of paper or cards.

It is important to specify the topics that will not be covered in this module, such as:

- Chemical control of late blight.

Note 1 **A variety has been "introduced" when a research center or another entity makes it available to farmers.**

Practical 1. Learning about resistant and susceptible varieties

Objective

After completing this practical, participants will be capable of using a diagram to explain the concept of resistant and susceptible varieties, pointing out the three main characteristics that differentiate them and the benefits of using resistant varieties when controlling late blight.

Materials

- Cotton and glue to represent *Phytophthora infestans* fuzz.
- Small white paper or synthetic foam balls to represent spores of *Phytophthora infestans*.
- Brown markers.
- 3 large poster boards (70 x 50 cm) of different colors (2 green and 1 blue). Draw the following:
  - Two potato plants, each one on a green poster board.
  - Rain on a blue poster board.

Procedure

This practical can be done in a potato plot with late blight symptoms and it is based on the life cycle of *Phytophthora infestans* (Module 2).

1. Share the objective of the practical with participants.
2. Select four volunteers to represent the following: i) *Phytophthora infestans*, ii) resistant potato variety, iii) susceptible variety, and iv) rain.

- Give the small white balls or synthetic foam (that represent spores) and cotton (that represents fuzz) to the person who will represent *Phytophthora infestans*.
- Give poster boards with the corresponding drawings to the people who will represent potato plants and rain.

3. Explain to each participant the role he/she will play:

- The people representing *Phytophthora infestans* should go up to the two varieties and glue the spores on them. The person who represents the rain should be present so that the spores can penetrate the plants.
- The person representing the resistant variety should let some spores fall. On the other hand, the person representing the susceptible variety should accept all the spores. In the place where each spore has stuck, small spots should be drawn with the help of a brown marker.
- Enlarge the spots. Spots of the susceptible variety should grow faster than on the resistant variety.
- When the person who represents the rain gets close, cotton should be glued (representing fuzz) around the spots, and on top of the cotton, balls should be glued (representing the spores). On the susceptible variety, the amount of fuzz and spores should be larger than on the resistant variety. This life cycle can be repeated several times, emphasizing the difference between the resistant and susceptible varieties.
- Motivate participants to think about the amount of fungicide that resistant and susceptible varieties will need, and about the risk of losing crop yield during a rainy year. If necessary, give a short explanation of what a fungicide is (see Module 4).
- On each variety poster, draw some tubers. For the resistant variety, tubers should be large to indicate that these grow better because there is less late blight. For the susceptible variety, draw small tubers to show that these are not as large because there is more late blight.
- At the end, ask participants to write on each plant the name of a local variety they could represent as either resistant or susceptible.

4. During a plenary, discuss the topics covered and define with the participants the concepts of resistant and susceptible varieties, the three main characteristics that differentiate them and the benefits of using the resistant varieties in late blight control (see handout).
5. Give a copy of page 66 to each participant to clarify terminology and reinforce concepts.

Learning about resistant and susceptible varieties

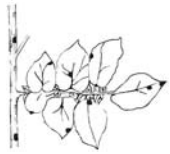
Handout

Resistant Variety	Susceptible Variety
It is a variety that does easily become infected with late blight. It does not die during rainy weather (or dies later) and production is therefore better.	It is a variety that gets a lot of late blight. In rainy weather it may die and production is low.

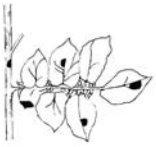
Their main characteristics

Few spores penetrate the plant

Many spores penetrate the plant

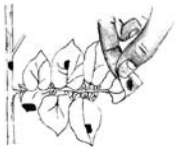


Blotches grow slowly



Blotches grow fast

Little fuzz is formed



Much fuzz is formed

Their advantages or disadvantages

Less fungicide application is required

- Less money and time are spent
- Less environmental contamination.
- Lower health risk.
- Lower risk to lose crop yield during a rainy year.

More fungicide applications are required

- More money and time are spent.
- Greater environment contamination.
- Greater health risk.
- Greater risk of crop loss in rainy weather.

Practical 2. Identifying the main characteristics of local varieties

Objective

Having completed this practical, participants will be able to demonstrate using a table the main characteristics of local potato varieties in relation to late blight.

Materials

- Markers.
- A large piece of paper. Draw the table found on page 68 on it.
- Pencils and erasers.

Procedure

1. Share the objective of the practical with participants.
2. Form groups of three to five participants. Form each group in such a way that it has at least one person who knows how to read and write.
3. Give each group a pencil, eraser and one or several copies of page 68.
4. Have each group fill out a table on the copy of page 68 (see Note 2):
   - » List 3 to 6 local varieties.
   - » Add characteristics of the varieties identified in each column; each person may fill out a table or they may make one per group.
5. Come back together in a plenary. Through discussion, arrive at a consensus on 3 to 6 cultivars putting the characteristics on the large table.
6. Give a copy of pages 69 and 70 to each participant as reference.

Note 2 **From the point of view of controlling late blight, the selection of resistant varieties is preferred because they need fewer fungicide applications and the risk of losing crop yield is lower. Nevertheless, there are other criteria, such as productivity and market value, that should be taken into consideration**

Characteristics and Benefits of our Potato Varieties in Relation to Late Blight

Handout

Variety	Resistant or Susceptible	Number of fungicide applications	Environmental contamination	Risk of losing the crop	Crop yield	Market price	Conclusion

*One can discuss the number of sprays needed in both rainy and dry conditions

Several Ecuadorian potato varieties and their reaction to late blight

Handout

Name	Tuber	Foliage	Reaction to late blight
Bolona			Susceptible
Cecilia			Susceptible
Chola			Susceptible
INIAP-Esperanza			Susceptible
INIAP-Fripapa			Moderately resistant
INIAP-Gabriela			Susceptible
INIAP-Margarita			Resistant
INIAP-María			Susceptible

Name	Tuber	Foliage	Reaction to late blight
INIAP-Rosita			Resistant
INIAP-Santa Catalina			Moderately resistant
INIAP-Santa Isabela			Susceptible
INIAP-Soledad			Resistant
Superchola			Susceptible
Uvilla			Susceptible
Yema de huevo			Susceptible

Source: Hardy, B. y Andrade, H. (eds.). 1998. Variedades de papa cultivadas en el Ecuador. Instituto Nacional Autónomo de Investigaciones Agropecuarias, Programa Nacional de Raíces y Tubérculos, Proyecto FORTIPAPA. Quito.

Optional

Practical 3. Learning why some potato varieties are not infected for a short period and then become infected

Objective

After completing this practical, participants will be able to explain the concept of variety immunity and what causes the loss of immunity.

Materials

- One synthetic foam sheet.
- Five white darts and five red darts.
- One lock with its corresponding key and an additional key that does not open the lock.
- Twenty small green poster boards (2 x 2 cm). Draw a potato plant on each card.

Procedure

1. Share the objective of the practical with the participants.
2. Place three or four of the potato plants drawn on poster board cards on the synthetic foam sheet. Specify that these plants represent a recently introduced variety and that there are few of them because there is not enough seed.
3. Hand out to participants the white colored darts and mention that each dart represents a *Phytophthora infestans* spore produced by wild plants, voluntary plants, etc., but that these cannot penetrate the new variety.
4. Ask participants to throw darts, trying to hit the plants.
5. When a dart does not hit a plant, indicate that this spore fell on the floor and died.
6. When a dart hits a plant, specify that such plant does not become infected with late blight because it belongs to an immune variety.

7. To explain the reason why the immune variety does not become infected, ask a person to represent such a variety and give them a closed lock. Give the incorrect key to the person who accurately hit the plant with the dart and ask him/her to open the lock. Since the variety is immune, the lock (representing the plant's defenses) cannot be open using an incorrect key (that represents a *Phytophthora infestans* spore not capable of overcoming these immunities).
8. Note that *Phytophthora infestans* has to change to be capable of surviving on this new variety. To represent this, substitute one red dart for a white. The red dart represents a *Phytophthora infestans* spore that is capable of overcoming our immune variety plants and infecting them.
9. Glue five or six new plants on the synthetic foam and specify that the number of plants has increased because the farmers liked the variety and, therefore, planted them in a larger area.
10. Once again, ask for volunteers to throw the darts. When the person who has the red dart succeeds in hitting a plant, specify that such a plant is infected with late blight. Point out that it is difficult to hit them with the red dart since there are few plants and that it would be easier if more plants existed.
11. To explain the reason why this plant becomes infected, give a closed lock to a person representing the plant.
12. Give the correct key to the person who successfully hit the plant with the red dart and ask her/him to open the lock. Since the variety is sick, the key can open the lock.
13. Specify that the new *Phytophthora infestans* spores are going to be the red dart type since they are the only ones that will survive. Replace all the white darts by red ones.

14. Glue five or six new plants on the synthetic foam and specify that the number of plants has increased again because farmers prefer this variety.
15. Ask again for volunteers to throw the darts. Mention that with a greater number of plants (and now with more red darts) it is easier to successfully hit the plants. Point out that immunity in our variety has been lost.
16. During a plenary, discuss with participants the topics covered and define with them the concept of immune variety and what causes the loss of immunity.
17. Give a copy of page 76 to each participant and use it to clarify terminology and reinforce concepts.

Technical notes for the Facilitator

Optional

What is an immune variety?

- It is a variety that does not become infected.
- In the case of late blight, the *Phytophthora infestans* spores can penetrate the plant, but they do not form blotches or fuzz.
- Such varieties do not need fungicide, although fungicide maybe used to delay the loss of immunity.

How does the immunity work?

To understand the concept of immunity, one can think that the variety has a lock and the *Phytophthora infestans* spores do not have a key to open the lock. Therefore, spores cannot form blotches or fuzz on the plant and kill it.

Is it possible to avoid loss of immunity?

- It is almost impossible to avoid loss of immunity.
- *Phytophthora infestans* produces thousands of millions of spores and, sooner or later, the spores that are capable of infecting the new variety will do so.
- Immunity loss may be delayed with fungicide applications.
- Immunity loss may take several years, depending primarily on the amount of the immune variety that is planted

There are some varieties that are immune when introduced, but later become infected. Why?

Let's see what happens::

1. The variety is introduced in a region and it is immune

- Some potato varieties are immune to late blight when introduced.
- *Phytophthora infestans* spores cannot enter plants (remember the concept of the lock and key) and the majority of them die (these spores are represented in Practical 3 with white darts). Nevertheless, there are few spores that can enter into the plant and cause disease (these spores are represented with red darts).

- Since the introduction of this variety is recent, not enough seed is available and there is little of it in the field. Therefore, all the spores capable of causing disease miss these plants and fall and die

2. The variety spreads among the farms and the first plants with disease appear.

- If the variety has been accepted by the farmers, the amount planted increases.
- The few spores that can infect these plants now have a greater opportunity to fall on a plant and cause disease. Some diseased plants begin to appear in the field.
- Blotches on these plants now produce only spores capable of causing disease.

3. The variety is grown more and more and its immunity is lost

- The variety is now planted widely, but now all *Phytophthora infestans* spores are capable of infecting this variety. Therefore, the variety's immunity has been lost.

Important to remember

Immunity is lost because the *Phytophthora infestans* spores have changed. Potato plants do not change, they have only increased in number.

When a variety loses its immunity, it may still have some level of resistance and may be considered as either resistant or susceptible (refer to Practical 1).

Learning why some potato varieties when introduced do not become infected with late blight, but later they easily become infected with this disease

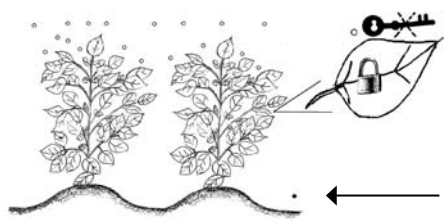
Optional handout

The potato varieties that do not become infected are called ***immune***

Why doesn't an immune variety become infected?
The immunity of a plant is like a lock and the *Phytophthora infestans* spores are like the keys. When the spore does not have the correct key, it cannot open the lock and, therefore, the variety does not become infected.

Why does an immune variety become infected after a while?
To understand this, let us take a look at the following steps:

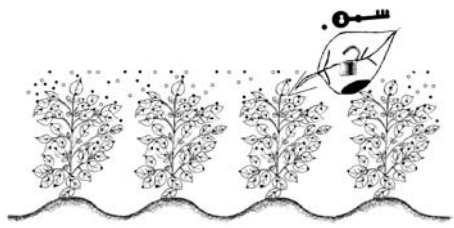
1. The variety is introduced in a region and it is immune. The majority of spores cannot get this variety infected because they do not have the correct key to open the lock.



Spores cannot form blotches or fuzz.

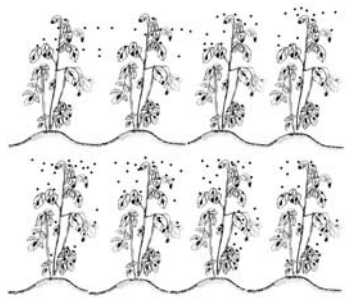
There exists a spore that indeed has the correct key to open the lock, but since there are few susceptible plants, this spore falls to the ground and dies.

2. The variety is grown more and more among the farmers and the first sick plants appear. Spores capable of becoming infected have a greater chance of falling on a plant, forming blotches and fuzz. When a blotch is formed, all the new spores are capable of infecting the immune variety.



Spores can form blotches and fuzz.

3. The variety is grown more widely and its immunity is lost. The majority of spores are capable of infecting the immune variety.



Immunity is lost because *Phytophthora infestans* spores have changed. Potato plants have not changed, they have only increased in number.

Final activities

Module Synthesis

To reinforce the learning objectives, a synthesis of the following topics will be made:

- Concepts of resistant and susceptible varieties.
- Main characteristics that differentiate a resistant variety from a susceptible variety.
- Main benefits of using a resistant variety.
- (Optional) The concept of an immune variety and what causes loss of immunity.

For this purpose, photocopies handed out to participants may be used. At this time, the participants' responses written down at the beginning of the module should be reviewed to relate them to the knowledge recently acquired. Also, notes taken by the facilitator during the discussions may be reviewed.

Final Evaluation of Knowledge

Mandatory Evaluation. To determine whether the learning objectives were accomplished, several randomly selected participants should be requested to do the following:

1. Using a diagram, explain the concepts of resistant and susceptible varieties, pointing out the three main characteristics that differentiate them, and the benefits of using resistant varieties in late blight control.
2. Using the table from Practical 2, identify the main characteristics and benefits of the local varieties in relation to late blight.
3. **Optional.** Explain the concept of an immune variety and what causes the loss of immunity

Optional Evaluation. If necessary to objectively evaluate knowledge acquired by participants, the questionnaire on page 79 may be used. Immediately after completing this evaluation, it is recommended that the correct responses be given to participants and discussed.

Feedback Ask about the module. The following questions are suggested:

- Is it important to know the differences between a resistant and a susceptible variety? Why?
- What problems were encountered in the activities of this module?
- Was the assigned time sufficient?

Questionaire for knowledge assessment

1. What is a susceptible cultivar?
   (a) It is a cultivar that easily gets late blight
   (b) It is a cultivar with a long growing period
   (c) I don't know

2. What is a resistant cultivar?
   (a) It is a cultivar with a short growing period
   (b) It is a cultivar that does not easily get late blight
   (c) I don't know

3. What are the three main characteristics that make a potato cultivar resistant to *Phytophthora infestans*?
   (a) That it is a plant that does not allow penetration of many spores, or that blotches grow rapidly, or much fuzz is formed
   (b) That it be a big, robust plant with a good number of stems
   (c) I don't know

4. What are the main advantages of using a resistant cultivar in late blight control?
   (a) Greater production and better market price
   (b) Fewer applications of fungicides and lower risk of production loss
   (c) I don't know

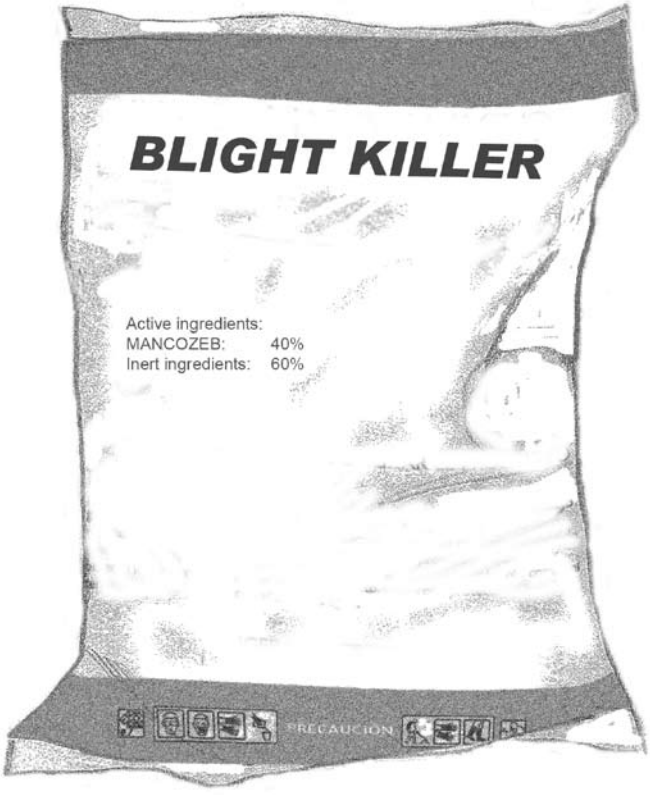
5. What is an inmnuve cultivar? (optional)
   (a) It is a cultivar that does not need much fertilizer
   (b) It is a cultivar that does not get at all late blight
   (c) I don't know

6. What is the cause of potato cultivars losing immunity? (optional)
   (a) There is a change in the *Phytophthora infestans* fungus
   (b) There is a change in the potato cultivar
   (c) I don't know

Correct Answers: 1 a; 2 b; 3 a; 4 b; 5 b; 6 a

Module 4

Controlling Potato Late Blight with Fungicides



Directions for the facilitator before the session

Prerequisite Knowledge gained in Modules 1, 2 and 3

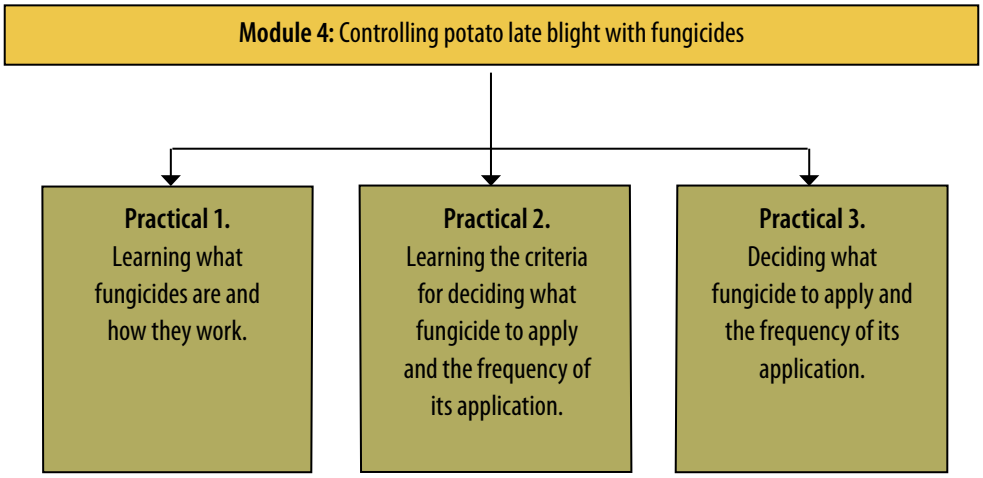
Timing One, four-hour session.

Introduction To control potato late blight with fungicides, it is important to understand several concepts related to active ingredient, commercial name, working principle, and formulation. It is also important to know which fungicides are available in the market. Finally, it is important to consider basic criteria for knowing what and when to apply: prevention, fungicide effectiveness, amount of blight in and around the field, environmental conditions, level of resistance of the potato variety, growth stage of the crop, and period since the last application. These factors will be covered in this module in an effort to demonstrate how they are important in deciding what fungicide to apply and the frequency of its application.

Objectives After completing this module, participants will be able to:

1. Explain what a fungicide is and provide an example.
2. Identify the active ingredient, commercial name, working principle (contact or systemic), and formulation of at least two fungicides.
3. Identify in the Guide of Fungicides provided in this module the active ingredients, commercial names, working principle and doses of fungicides used to control late blight.
4. Explain the criteria used in deciding which fungicide to apply and the frequency of its application (prevention, fungicide effectiveness, amount of late blight in and around the crop, environmental conditions, potato variety, crop growth stage and period since the last application).
5. Decide which fungicide to apply and the application frequency in a specific situation, considering the criteria explained in this module.

Module Structure



Preparation for the Facilitator

1. Carefully review this guide.
2. Get the materials needed for Practicals 1, 2 and 3.
3. Make copies of pages 90, 93, 95, 98, 105, and 106 (one set per participant).
4. Optional. If it is necessary to objectively evaluate the degree of the participants' knowledge, materials should be prepared for an initial and final knowledge evaluation. (Annex 1 and pages 112 and 113).
5. Find a location with proper ventilation to do Practical 1 (for example, a potato plot) and, if possible, a shelter to do Practicals 2 and 3.

Activities to be done with participants during the session

Knowledge Review

The session starts with the introduction of the facilitator and the presentation of the subject. Then, the following topics should be reviewed:

- The concept of symptom.
- Blight symptoms on leaves, stems and tubers.
- Late blight's causal agent.
- Concept and function of *Phytophthora infestans* spores.
- The life cycle of *Phytophthora infestans*.
- Sources of *Phytophthora infestans*.
- Environmental conditions which favor growth of *Phytophthora infestans*.
- Characteristics of resistant and susceptible varieties.
- Benefits of resistant varieties.

For this purpose, copies handed out to participants in previous modules can be utilized.

Initial Knowledge Evaluation

Mandatory Evaluation. To motivate participants to become involved in the subject, reinforce existing knowledge and, at the same time, obtain a general idea of their level of understanding, the following questions should be asked:

- What are fungicides used for?
- How do they work? What is a contact fungicide? What is a systemic fungicide?
- What is the commercial name? The active ingredient?
- What is the formulation of a fungicide?
- What are the main criteria used to decide which fungicide to apply and the frequency of its application?

The answers to these questions should be written on a large piece of paper. In the Module Synthesis (page 110) responses should be reviewed to emphasize the fact that various topics are recognized by the participants, but others are new to them.

Optional Evaluation. The participants' level of knowledge may be objectively evaluated by using the questionnaire found on pages 112 and 113, which should be applied again at the end of the module. Instructions for the evaluation can be found on Page 129, Annex 1.

Participants' Expectations

To learn what participants expect from this module, questions such as "Why have we met today?" may be asked.

Later, the objectives of the module will be shared with participants, which may be summarized by writing them on a large piece of paper or on cards.

It is important to clarify the topics which will not be covered, for example:

- Fungicide dosage .
- Calibration of application equipment.
- Use of protective equipment.
- Contamination pathways.
- Intoxication symptoms.

Practical 1. Learning what fungicides are and how they work

Objectives

After completing this practical, the participants will be capable of:

1. Explaining what a fungicide is and providing an example.
2. Identifying the active ingredient, commercial name, working principle (contact or systemic), and formulation in at least two fungicides.

Materials

- Four posterboards. On individual boards draw a fungicide container, an insect, weeds and spores of *Phytophthora infestans*.
- Ointment and a pill for a skit.
- Cotton and glue to represent *Phytophthora infestans* fuzz.
- Small white paper or synthetic foam balls to represent *Phytophthora infestans* spores.
- Red cellophane paper to represent a contact fungicide.
- Strips of blue cellophane paper to represent a systemic fungicide.
- Drawing materials: sheets of paper and color pencils.
- An award for a drawing contest among the participants.
- Posterboard or sythetic foam, glue and scissors. Build a potato leaf of approximately 30 cm long, sandwich-like, leaving a space between each layer of approximately 5 cm. See the following figure as reference.

For each group of three to five participants:

- At least three contact and three systemic fungicides. Make sure to have the following:
  - At least two fungicides with different commercial names but with the same active ingredient.
  - At least two fungicides with different active ingredients.
  - At least one powder and one liquid fungicide

Procedure

1. Do this practical in a well ventilated location and far away from houses. Do not use tables; do the practical on the ground.
2. Share the objectives of the practical with participants.
3. Form groups of three to five participants and hand out the fungicides to each group (see Note 1). Form each group in such a way that it has at least one person who knows how to read and write.
4. Hand out a copy of page 90 to each group.

Note 1 **Take the following precautions:**

- Do not use empty fungicide containers because they can cause poisonings. Despite repeatedly washing a container, fungicide residues will always remain. In addition, it could give the wrong idea that these containers can be stored and reused.
- Ensure that the containers are sealed. They can also be placed inside plastic bags.
- Use gloves.
- Do not handle food.
- Do not allow children and domestic animals to be present.
- Wash your hands after the exercise.

Controlling potato late blight using fungicides

Handout

Comercial Name	Active Ingredient	Formulation	Working Principle*	Price

*Systemic or contact

Part 1

Learning what a fungicide is

1. Request four volunteers for a skit.
2. Give volunteers the drawings of the fungicide container, the *Phytophthora infestans* spore, the weeds and the insect.
3. Explain what the skit is about: In a potato crop, a *Phytophthora infestans* spore, an insect, and a weed are having a conversation. All of a sudden, a fungicide appears and kills the *Phytophthora infestans* spore but does not harm the weed or the insect.
4. During the plenary, discuss and elaborate on the concept of fungicide with participants. Write down the concept on a large piece of paper.

Part 2

Learning about active ingredients and commercial names

1. Ask the participants the following questions:
   - » Have you ever used cement?
   - » How many cement brands do you know? Write down the answers on a large piece of paper.
   - » What is the difference between one brand and the other if, in the end, they are all cements?
2. Repeat the same questions but using other examples, like car oil.
3. Ask participants for other similar examples (see Note 2).
4. During the plenary, discuss and elaborate on the concepts of active ingredients and commercial name. Write the concepts on a large piece of paper.
5. Ask participants to identify the commercial name and the active ingredient(s) on fungicide labels..
6. With this information, ask participants to fill out their copies (page 90).
7. Emphasize the following:
   - » There are fungicides with different commercial names, but with the same active ingredient.
   - » There are fungicides which have one active ingredient. Others have two or more active ingredients.
8. Give a copy of page 93 to each participant to clarify terminology and reinforce concepts.

Note 2 **If participants mention examples of food or medicines, emphasize that fungicides are poisonous and that to avoid confusion it is preferable not to use such examples.**

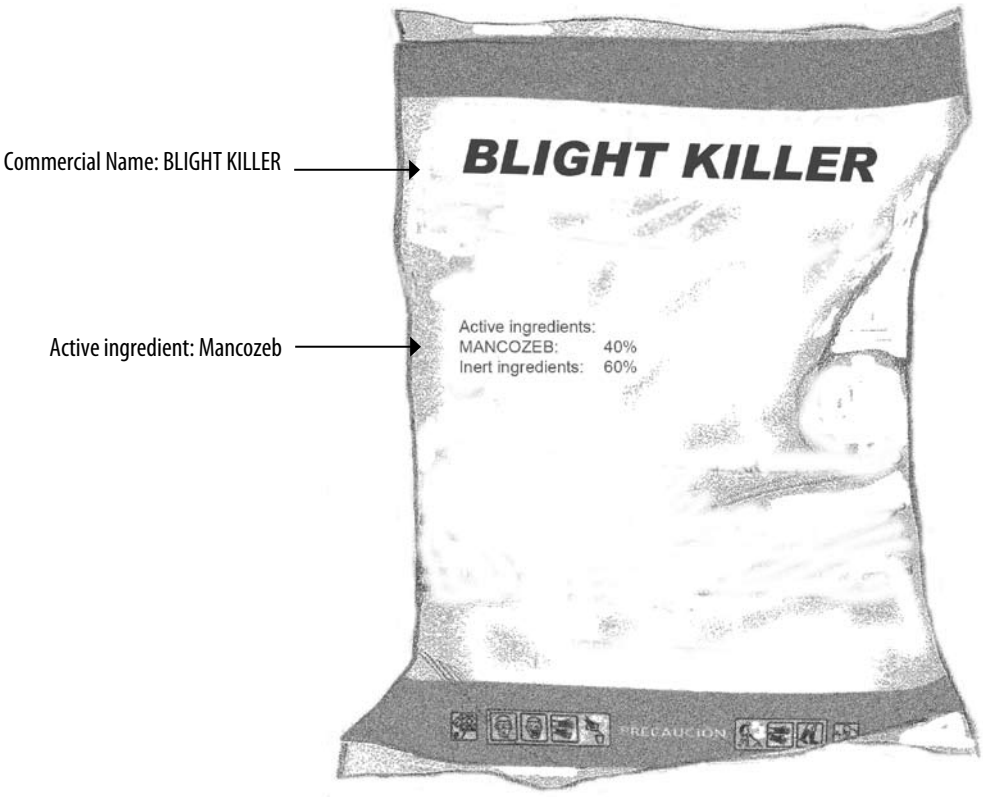
Learning what fungicides are and how they work

Handout

Fungicides Are poisons that control plant diseases caused by fungi, like *Phytophthora infestans.*

Comercial Name Is the name under which a fungicide is sold.

Active Ingredient Is the name of the chemical that kills the fungus



Remember:

- There are fungicides with different commercial names, but with the same active ingredient.
- There are fungicides that have only one active ingredient. Others have two or more active ingredients.

Part 3

Learning what formulation means

1. Give an example of two physical states of water: solid (hail or snow) and liquid.
2. Ask participants about the difference between hail (or snow) and liquid water.
3. Compare the example of states of water with fungicide formulations: solids (powder and granules) and liquids.
4. Ask participants about other similar examples (see Note 2)
5. During the plenary, discuss and elaborate on the concept of formulation. Write down the concept on a large piece of paper.
6. Discuss with participants the advantages and disadvantages of the two types of formulations (solid and liquid). Write down the answers.
7. Ask participants to identify the type of fungicide formulation handed out and to complete this information in their corresponding copies (page 90).
8. Give each participant a copy of page 95 to clarify terminology and reinforce concepts.

Learning what formulation means

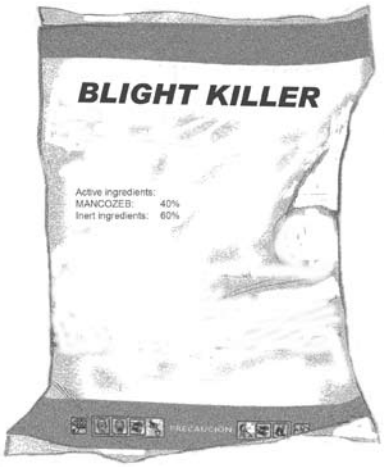
Handout

Formulation Is the form in which fungicides are available. The most common ones are: solid (powder and granules) and liquid.

Powdered fungicides are dangerous because they may be inhaled when mixing. They also need to be agitated continuously so that they do not settle at the bottom of the tank. Nevertheless, they can be less expensive than the liquid fungicides.

Examples

Solid Fungicide



Often sold in bags

Liquid Fungicide

Generally sold in bottles

Part 4

Learning about the working principle (contact and systemic fungicides)

1. Ask for three volunteers for the following skit: Esperanza has two children, Luis and Jose. Luis has been hurt on the leg and José has the flu. Esperanza decides she is going to cure Luis using an ointment. Luis asks her to let him taste it but his mother answers that this medicine acts only outside the body. Then, she gives José a pill and tells him that this medicine does act inside the body.
2. During the plenary, discuss and elaborate the concept of working principle (systemic and contact). Write down the concept on a large piece of paper.
3. Represent the concepts of "contact" and "systemic" by using the leaf made with poster board or synthetic foam. Follow this procedure.
   - » Cover the leaf with red cellophane paper specifying that it represents a contact fungicide. Use paper or foam balls representing spores of *Phytophthora infestans*. Indicate what happens with the spores when applying a contact fungicide.
   - » Put the cotton inside the leaf and indicate that it represents the fuzz of *Phytophthora infestans* that has penetrated the plant. Then, cover it with red cellophane paper and indicate that the contact fungicide does not have any effect on the fuzz which is inside the plant. Emphasize that contact fungicides are utilized:
     - › When the season is not very rainy.
     - › When the variety is resistant.
     - › Before the blotches appear on the plant.
   - » Introduce strips of blue cellophane paper inside the leaf and indicate that they represent a systemic fungicide, which indeed can kill the fuzz of *Phytophthora infestans* (see Note 3). Emphasize that systemic fungicides are used when:

- The weather is very rainy.
- The variety is susceptible
- After blotches appear on the plant.

4. During the plenary, elaborate on the contact and systemic fungicide concepts, and fill the following table.

	Contact	Systemic
What other names do these have?		
How do they act on the plant?		
Do they kill fungi that are inside the plant?		
When are they applied?		
Are they washed away by rain?		
Can they lose their effectiveness?		
Price		

5. Ask participants to identify the working principle of the fungicides handed out and to fill out this information in their respective worksheets (page 90).
6. Emphasize that the majority of systemic fungicides come mixed with a contact fungicide.
7. Hand out the drawing materials and organize a contest to see who best represents the contact and systemic fungicides. Give an award to the best drawing.
8. Give a copy of page 98 to each participant to clarify terminology and reinforce concepts.

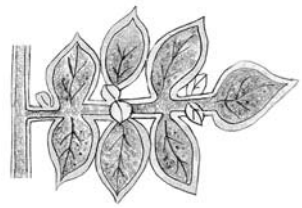
Note 3 **In reality most systemic fungicides only slow down the growth of the blotches. Fungicides like metalaxyl may actually kill the blotch, but many pathogen populations are not sensitive to this kind of fungicide**

Working principle of the fungicides

Handout

Working principle. It is the way in which a fungicide acts on the plant. According to the working principle, they are contact or systemic fungicides.

Characteristics of Contact and Systemic Fungicides

	Contact	Systemic
What other names does it have?	Preventive or protectant	Curative
How do they act on the plant?	They remain on top of the leaves and do not penetrate the plant 	Penetrate the plant and move inside 
Do they kill the fungus existing in the plant?	No, they only prevents spores from penetrating the plant.	Yes, they can kill a fungus existing inside the plant and stop or slow down blotch growth
When are they applied?	• When the weather is not very rainy • When the variety is resistant • Before blotches appear on the plant	• When the weather is rainy • When the variety is susceptible • After blotches appear on the plant
Are they washed away by rain?	Yes	No*
Can they lose their effectiveness	No	Yes, in some fungicides
Price	Low	High

*** Even systemic fungicides may be washed away if they do not have time to penetrate the plant!**

Systemic fungicides are more effective than contact fungicides, but their price is higher and some of them may lose their effectiveness.

Part 5

Learning how to use a fungicide guide to control late blight

1. Give a copy of the Guide of fungicides (Annex 2). Mention that it should be used when buying fungicides (see Note 4).
2. Explain the information available in the Guide. Ask the participants to identify the active ingredients, commercial names and doses of fungicides.

Note 4 **In case of illiterate participants, suggest that they ask for help to read the labels when buying fungicides.**

Practical 2. Learning the criteria for deciding which fungicide to apply and the frequency of its application

Objective After completing this practical, the participants will be able to explain the criteria used for deciding which fungicide to apply and the frequency of its application.

Materials
- Large pieces of paper and markers.

Procedure
1. Share the objectives of the practical with the participants.
2. While the discussion with the participants progresses, have on hand a large piece of paper to write down the criteria used in deciding which fungicide to apply and the frequency of its application. At the end of the discussions, one should get a chart similar to the one found on pages 105 and 106.
3. Together with participants, draw the *Phytophthora infestans* life cycle (see page 53, Module 2). This graphic will be utilized in various discussions that follow.

Part 1

Effectiveness of Fungicides

1. Remind participants about Practical 1, Part 4. Using a drawing, briefly discuss how contact and systemic fungicides work.
2. During the plenary, decide which of them is more efficient.

Part 2

Prevention

1. Use the example of rust that forms on the metal and the way paint can be used to protect metal.

2. Discuss with participants about the importance of painting the metal to prevent rusting. Also, you may use the example of vaccines for children that are used to prevent disease infections.
3. Ask participants for similar examples.
4. Using the life cycle of *Phytophthora infestans*, emphasize that contact fungicides prevent the fungus from penetrating potato plants.
5. During the plenary, discuss and define the importance of prevention in late blight control.

Part 3

Field data to decide which fungicide to use and its application frequency

Field data to be discussed with the participants are the following:

a) Amount of late blight around and inside the field.
b) Environmental conditions (rain and temperature).
c) Potato variety.
d) Crop growth stage.
e) Period since the last application.

a) Amount of late blight around and inside the field

- Divide a large piece of paper into two halves and draw two different locations. Ask participants to assign names to these locations.
  - In each location, draw several potato plots represented by squares. Indicate that a farmer (Juan) has a potato plot in each of these locations. Mark Juan's plot in each location.
  - In the neighbors' plots and in Juan's, draw spots representing late blight blotches. Draw a few spots in the first location and many spots in the second location.
- Discuss with participants in what location should Juan apply more fungicide and why. Write down the answers.
- Using the *Phytophthora infestans* life cycle, emphasize that more fungicide should be used

when there is a larger amount of spores in the environment, whether originated from neighboring crops, from voluntary plants or from wild or infected plants from the same plot.

b) Environmental conditions (rain and temperature)

- Using the late blight life cycle, remind participants about the effect of rain and temperature.
- Rain has several effects:
  - Helps spores to enter into the plant.
  - Promotes production of fuzz around blotches.
  - Transports spores from leaves to tubers.
  - Transports spores from an infected plant to a healthy one by spattering.
  - Washes off the fungicide which is on the surface of the leaves.
- Temperature allows blotches to grow. The warmer the temperature, the faster the blotches grow (up to 25º C).
- Discuss with participants that during rainy and warm seasons a larger amount of fungicide may be needed than when the weather is dry and cold.

c) Potato variety

- On a large piece of paper draw two potato leaves, one representing the resistant variety and the other the susceptible variety.
- Along with participants, repeat the three main differences between a resistant variety and a susceptible one (see page 66, Module 3).
- During plenary, discuss that a susceptible variety needs more fungicide that a resistant one.
- Remind participants that less fungicide means lower production cost and less contamination

d) Crop Growth Stage

- On a large piece of paper draw the potato growth stages (see page 106).

- Ask participants to point out the key moments for late blight control. Write down the answers.
- Emphasize that when plants are growing, more fungicide applications are needed. To illustrate this concept, a visual method may be used:
  - Draw a small plant.
  - Specify that a contact fungicide was applied. To represent the fungicide, the plant can be painted yellow.
  - Specify that since the plant is growing, new stems and leaves and produced. Draw them but emphasize that these are no longer protected by the fungicide.
  - Discuss with the participants the reason why growing plants need more frequent fungicide application.
- If in previous crops, the presence of blight on tubers has been observed, fungicide applications should be recommended during the last stages of cultivation. This is done to protect the tubers from spores of the *Phytophthora infestans*.
- The importance of making high hills around plants and cutting the foliage when the tubers reach commercial size to protect them from the spores can also be discussed. Use the *Phytophthora infestans* life cycle to discuss these concepts.

e) Period since the last application

- Ask the participants the following questions:
  - If we apply the fungicide today, how long will it remain on the leaf?
  - What factors cause the fungicide to be removed from the leaf's surface?
- Discuss the effect of rain on fungicides (rain washes fungicide of leaf surfaces).

- Discuss the importance in taking into account the period that has passed since the last application and the environmental conditions during that period. For example:
  - If an application was performed seven days earlier and during that time there were light rains, it is possible that there still be fungicide on the leaf's surface. Therefore, it is not necessary to apply fungicide.
  - On the contrary, if during that time there were heavy rains, it is possible that the fungicide has been washed out. Therefore, fungicide needs to be applied.

5. Give a copy of page 106 and 107 to each participant. Discuss with them the conditions for late blight:
   - Favorable conditions:
     - Blight present in the area and/or in the field
     - Rainy and warm weather conditions
     - Susceptible variety
     - Crop between emergence and blooming
     - Many days passed since the last fungicide application.
   - Unfavorable conditions:
     - No blight present in the area and/or in the field
     - Dry and cold weather conditions
     - Resistant variety
     - Crop after blooming
     - Few days passed since the last fungicide application.
6. Discuss with the participants that it is not possible to use specific pre-established recommendations to efficiently control late blight.

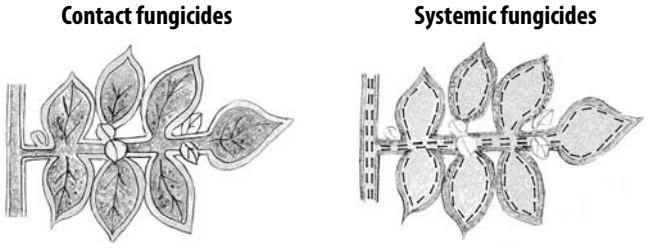
Controlling potato late blight using fungicides

Handout

To control late blight using fungicides it is necessary to consider the following:

1. Effectiveness of fungicides
2. Prevention
3. Field data

1. Effectiveness of fungicides



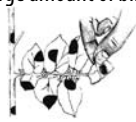
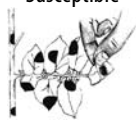
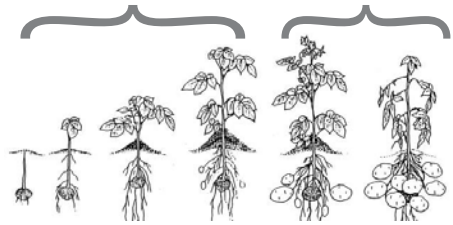
Remember: Systemic fungicides are more effective than contact fungicides, but their price is higher and some of them may lose their effectiveness.

2. Prevention

- Remember that potato late blight is a very rapid disease: in one or two weeks an entire field could be destroyed.
- If conditions are favorable for blight, it is necessary to apply fungicides before blotches appear on the plants.

3. Field data used to decide which fungicide use and its application frequency

Handout

A. Amount of blight around and in the field	Large amount of blight  More fungicide	Small amount of blight  Less fungicide
B. Environmental conditions: rain and temperature	Rainy and warm  More fungicide	Dry and cold  Less fungicide
C. Potato variety	Susceptible  More fungicide	Resistant  Less fungicide
D. Crop growth stage	More fungicides and systemic Less fungicides and contact 	
E. Period since the last application	It is necessary to know when a fungicide was applied last and what the environmental conditions were during this period (rain washes off the fungicide from the leaf surface). For example: • If an application was done seven days ago and during that time there were light rains, it is possible that fungicide still exists on the leaf. Therefore, it is not necessary to apply fungicide. • On the other hand, if during that time there were strong rains, it is possible that there is not much fungicide on the leaf surface and it is necessary to apply fungicide.	

Remember:

- If conditions are favorable for late blight, applications can be done every 5 to 7 days.
- If conditions are unfavorable for late blight, applications can be done every 4 weeks or more.

Practical 3. Deciding which fungicide to apply and the frequency of its application

Objective

After completing this practical, participants will be better prepared to decide which fungicide to apply and the frequency of its application in a certain situation, taking into account the criteria described in this module (effectiveness of fungicides, prevention, amount of blight around and in the field, environmental conditions, potato variety, growth stage of the crop and period since the last application).

Materials

- Two large pieces of paper and markers. Draw the potato life cycle on each piece of paper.
- Five yellow posterboards and five blue ones (20 x 15 cm). Draw a sun on each yellow poster board and rain on each blue poster board.
- Four posterboard signs (40 x 30 cm).
- Ten letters "S" and 10 "C" (10 x 5 cm) made out of black posterboard. The letter S means systemic and C means contact.
- Small white paper or synthetic foam balls to represent spores of *Phytophthora infestans*.

Procedure

1. Share the objective of the practical with participants.
2. Explain to participants that they will create different situations in which they will decide which fungicide to apply and how frequently to apply it (see Note 4).

Situation 1

» Put two potato life cycles on the ground or fix them against a wall. One life cycle will represent a resistant variety and in the other a susceptible variety. Assign names of local varieties suggested by the participants and write them on the signs.

- » In each life cycles, place a similar quantity of spores in the same growth stage of the plant and allocate the same environmental conditions using the poster board representing the sun and the rain. Indicate that both varieties are at the same altitude, for example, 2800 meters above sea level. Give the location a name suggested by the participants.
- » Ask for two volunteers. Give five letters "C" and five "S" to each one. Explain that each letter represents one contact fungicide application (C) or systemic (S). Ask volunteers to place the letters in a potato crop life cycle, taking into consideration the criteria described in Practical 2.
- » Using the information from the list of fungicides developed earlier, specific active ingredients may be assigned to each of these applications. Specify that in the systemic fungicide case, it is important not to use an active ingredients many times in a row (see Note 5).
- » Specify that the minimum interval between applications is from five to seven days. This interval is utilized only in extremely favorable conditions for late blight. Under less favorable conditions, the interval between applications may go up to four weeks or more (see Note 6).
- » At the end, each volunteer should explain the reasons for having chosen this or that fungicide and the frequency of its application.
- » Count the number of applications of each of the fungicides and obtain the approximate cost.
- » Discuss the effect of the potato varieties' level of resistance for late blight control.

Note 4 **There is probably no "exact" set of fungicides and intervals for any situation. The objective here is to get participants to think of the different factors that may affect disease and therefore the need for fungicides.**

Note 5 **This is particularly true with the phenylamide group of fungicides (benalaxyl, furalaxyl, metalaxyl, ofurace, and oxadixyl). There is little evidence for resistance to other systemic compounds.**

3. Create other situations and ask new volunteers. For example, a situation may be created in which you have two varieties with the same level of resistance but located in different locations, one cold and dry,, and the other warm and rainy. The amount of spores and the season in which they enter the cultivation field may also be modified.
   » These situations also may be created by the participants. Contests may be made to define situations in which more or less fungicide is used.
4. During the plenary, emphasize the criteria that should be taken into consideration for deciding which fungicide to apply and the frequency of its application. For this purpose, copies of pages 105 and 106 can be used. Emphasize that to control late blight, specific pre-established recommendations may not be useful because so many factors affect disease severity.

Note 6 **This minimum interval is for the Andean region; in some parts of the world susceptible cultivars are sprayed with contact fungicides every 2 to 3 days.**

Final activities

Synthesis of Module

To reinforce the learning objectives, a synthesis of the following topics will be made:

- Fungicide, working principle, contact and systemic fungicides.
- Commercial name and active ingredient.
- Formulation.
- Main criteria for deciding which fungicide to apply and the frequency of its application.

Copies handed out to participants can be used for this purpose. At this moment, the participants' responses written on a piece of paper at the beginning of the module should be reviewed to relate them to their recently acquired knowledge.

Final Evaluation of Knowledge

Mandatory evaluation. To evaluate if the learning objectives were achieved, several randomly chosen participants should be asked to do the following:

1. Explain what a fungicide is and give an example.
2. Identify the active ingredient, commercial name, working principle and formulation of at least two fungicides.
3. Identify in the fungicide list provided here, the active ingredients, commercial names, working principle of some of the fungicides used in controlling late blight in this area.
4. Explain the criteria for deciding which fungicide to apply and the frequency of its application.
5. Decide which fungicide to apply and the frequency of application during a specific situation, taking into consideration the criteria of prevention, fungicide effectiveness, and certain field data (quantity of late blight around and in the field, environmental conditions, potato variety, crop growth stage, and period since the last application of fungicide).

Optional Evaluation. If desired, to objectively evaluate the knowledge acquired by the participants, the questionnaire on pages 112 and 113 may be used. Immediately after completing the evaluation, discuss the correct answers with the participants.

Feedback This step consists of inquiring about the participants' impression of the module. Some questions that may be used:

- Why is it necessary to learn the criteria described in Practical 2?
- What problems were encountered in doing the module?
- Was the appropriate amout of time assigned?

Questionaire for knowledge assessment

1. What is a fungicide used for?
   (a) To kill fungi that damage our crops.
   (b) To feed the plants.
   (c) I don't know

2. What is a contact fungicide?
   (a) It is a fungicide that is used on the ground.
   (b) It is a fungicide that remains on the leaves and does not penetrate the plant.
   (c) I don't know

3. What is a systemic fungicide?
   (a) It is a fungicide that penetrates the plant.
   (b) It is a fungicide that is used in young plants.
   (c) I don't know.

4. What is the active ingredient of a fungicide?
   (a) It is the name under which a fungicide is sold
   (b) It is the name of the chemical that kill the fungus
   (c) I don't know

5. Why is it useful to know a fungicide's active ingredient?
   (a) Because two fungicides with different commercial names may have the same active ingredient.
   (b) To know when to apply the fungicide.
   (c) I don't know.

6. What has been pointed out in this label?
   (a) Active ingredient
   (b) Commercial name
   (c) I don't know.

7. What are the most common formulations for fungicides:
   (a) Packs of 500 and 1000 g
   (b) Solid and liquid
   (c) I don't know.

8. How can late blight be prevented in a suceptible potato variety?
   (a) Applying fertilizer at planting
   (b) Applying fungicides before the disease appears
   (c) I don't know.

9. What are the field data to be considered before using a fungicide?
   (a) Amount of late blight around and inside the field
   Environmental conditions (rain and temperature)
   Potato variety
   Crop growth stage
   Period since the last fungicide application

   (b) Amount of fertilizer
   Humidity in soil
   Presence of weeds
   Plot size
   Period since hilling

   (c) I don't know.

Correct Answers: 1 a; 2 b; 3 a; 4 b; 5 a; 6 b; 7 b; 8 b; 9 a.

Module 5

Visiting our Potato Plot to Control Late Blight

Directions for the facilitator before the session

Prerequisite Knowledge gained in Modules 1, 2, 3, and 4.

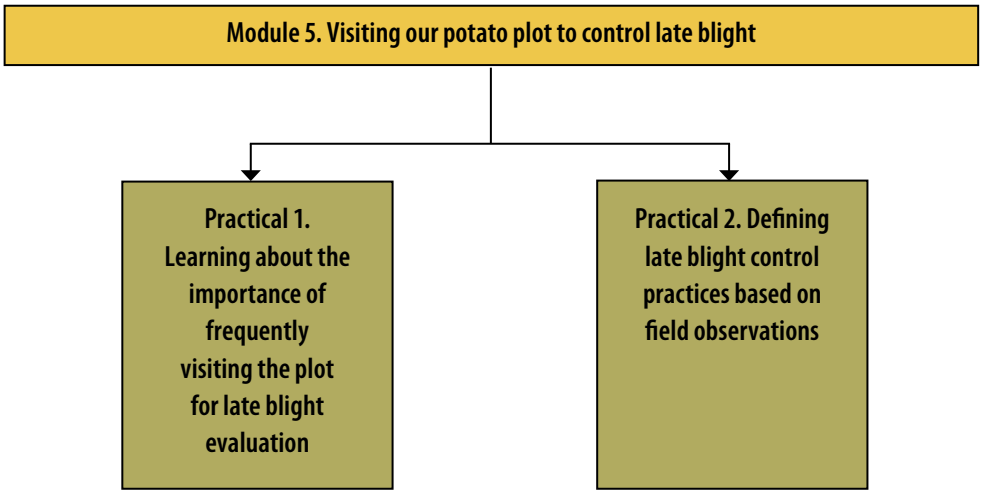
Timing A one-hour session.

Introduction This module is shorter and simpler than the previous ones and it should be conducted every time the potato plot is visited. Late blight is a disease that progresses rapidly, and for this reason the plot should be visited at least once a week. Visits allow evaluation of the amount of late blight and also the implementation of timely control measures. This module can be combined with the agro-ecosystem analysis done in Farmer Field Schools (FFS).

Objectives After completing this module, the participants will be capable of:

1. Explaining the importance of frequently visiting the potato plot for late blight evaluation.
2. Identifying practices for controlling late blight based on field observations using the following criteria: prevention, fungicide working principle, amount of late blight in and around the crop field, environmental conditions, level of resistance of the potato variety, growth stage of the crop and days since the last fungicide application.

Module structure



Preparation for the Facilitator

1. Carefully review these guidelines.
2. Obtain the materials needed for Practicals 1 and 2.
3. Obtain copies of pages 123 to 127 (one set per participant).

Activities to be covered with participants during the session

Practical 1. Learning about the importance of frequently visiting the plot for late blight evaluation

Objective After completing this practice, participants will be capable of explaining the importance of frequently visiting the plot for late blight evaluation.

Materials

- Large pieces of paper and markers.

Procedure

1. Share the objective of the practice with the participants.
2. Ask the participants the following questions and write down the answers:
   - Why is it important to take children to the doctor?
   - How often should children get medical check-ups?
   - What happens if these medical check-ups are not done?
3. Based on this example, and on others proposed by the participants, discuss the importance of frequently visiting the plot for late blight evaluation.
4. Discuss the role of the person who enters the field for late blight evaluation (he/she can carry *Phytophthora infestans* spores in their clothes from a diseased plant to a healthy one).

Practical 2. Defining late blight control practices based on field observations

Objective

After completing this module, the participants will be able to identify practices for late blight control based on field observations using the following criteria: prevention, fungicide working principle, amount of late blight around and in the crop field, environmental conditions, potato variety, growth stage of the crop and days since the last fungicide application.

Materials

- A large piece of paper for each group of 3 to 5 people.
- Different colored markers.

Procedure

1. Describe the objective of the practical to the participants.
2. Visit a potato plot.
3. Remind the participants of late blight symptoms (Practice 1, Module 1), and the criteria for deciding which fungicide to apply and the frequency of application (prevention, fungicide working principle, amount of late blight around and in the crop, environmental conditions, potato variety, growth stage of the crop and days since the last application (Practice 2, Module 4) (see Note 1).
4. Depending on the type of participants, one of the two methodologies described here can be used.

Methodology 1 (for participants who know how to read and write).

- Give each participant working sheets (pages 123, 124 and 127) and give them one example of their use (page 125 and 126).
- Ask participants to make observations on the plot, taking into account the criteria previously discussed, and to record the observations on their working sheets. This work can be done in groups of 3 to 5 participants.

» Using the "Criteria and Scores" chart (page 123), participants will assign a value to each one of the criteria. For example, if it is a very susceptible variety, No. 3 will be written down inside the corresponding box of the table "Field Observations" (page 124).
» After completing these criteria on the "Field Observations" chart, numbers will be added. The value obtained will be compared with the value from the table "Recommendation Guidelines" and a recommendation will be obtained.

Important: This recommendation should be considered as a guideline for supporting the final decision of the participants, and not as a rule. The objective of using this system is to make it clear that the farmers should think about various factors (environmental conditions, amount of late blight, etc.) when deciding which fungicide to apply and the frequency of application.

» In order to facilitate the explanation of this process, examples described on pages 125 and 126 can be used

Methodology 2 (for participants who do not know how to read or write).

- Ask participants to make observations inside the plot taking into account the criteria previously discussed (prevention, fungicide working principle, amount of late blight around and in the crop, environmental conditions, potato variety, crop's growth stage and days since the last application.
- Ask each group to do the following:
  » Draw their observations on a large piece of paper.
  » Recommend a method of controlling late blight

5. During the plenary, decide on a practice for controlling late blight and record it on page 127. Note that control practices may be fungicide

applications, making high hills around the plant, and foliage cutting.

6. Define with participants the date for the next visit to the plot. Ideally it should be done at least once a week. Highlight the importance of visiting the plot frequently.
7. When the method of controlling late blight is a fungicide application, use the guidelines handed out in Module 4 for deciding which active ingredients to use. It is recommended to visit a farm supply store with the participants, to select and buy one fungicide (see Note 2).

Note 1 **If there are reports of tuber blight in the area, emphasis should be put on the need to apply fungicide until the end of the crop cycle, to make high hills around the plant and to cut the foliage when the tubers have reached commercial size. The purpose of these practices is to protect the tubers from spores of *Phytophthora infestans*. In order to illustrate these concepts, the drawing of the *Phytophthora infestans* life cycle may be used (Page 53, Module 2).**

Note 2 **If the applications are made with backpack sprayers, it is recommended to choose fungicides for which doses are mentioned in amount of fungicide per volume of water (e.g. 500 grams in 200 liters of water). Doses of fungicides mentioned in amount per crop area (for example, 1 kg per ha) are more difficult to measure.**

Simple decision support system for late blight control practices

Handout

Criteria and scores

Criteria	Scores
Variety resistance	
Very susceptible	3
Susceptible	2
Resistant	1
Environmental conditions	
Very rainy	3
Rainy	2
Dry	1
Crop growth stage	
Growth and flowering	2
Maturity	1
Amount of late blight in and around the field	
Large amount of blight	3
Small amount of blight	2
No blight	1
Days since the last fungicide application	
More than 14 days	3
8 to 13 days	2
7 days or less	1

Recommendation guidelines

Total scores	Recommendation
5	Do not apply
6 to 9	Contact
10 to 14	Systemic

Field observations

Handout

Location:
Altitude:
Sowing Date:
Name of Variety:

Date	Variety resistance	Environmental conditions	Crop growth stage	Amount of blight around and inside the field	Days since the last fungicide application	Total	Recommendation

*It can be assumed that the variety resistance does not change during the crop cycle.

Examples of field observations

Handout

- A farmer has his or her potato crop in the town of Loma Grande, located at 2900 m above sea level
- The planting date was January 2, 2007.
- The potato variety planted was INIAP-Gabriela, very susceptible to late blight. According to the criteria and chart score, No. 3 corresponds to the box "Variety Resistance". This value remains the same during all the crop cycle.

- The farmer evaluated the potato crop on February 5.
- The environmental conditions were rainy. According to the criteria and chart score, No. 2 corresponds to the box "Environmental Conditions".
- The crop was in full growth stage. Therefore, No. 2 corresponds to the respective box.
- There was much blight around and in the field. Therefore, 3 is the corresponding number.
- No fungicide applications were made until February 5. Therefore, 3 was put in the box "Days since the Last Fungicide Application".
- The farmer added up the numbers and got 13.
- According to the chart "Recommendation Guidelines", the suggestion was to apply a systemic fungicide. At the same time the farmer remembered the importance of prevention of late blight. With these data, the farmer decided to apply a systemic fungicide.

- Seven days later (February 12), the farmer evaluated the potato crop once more.
- The environmental conditions were dry. According to the criteria and chart score, No.1 is the corresponding number
- The crop continued in full growth stage. Therefore, No. 2 is the corresponding number.
- There was small amount of blight around and in the field. Therefore, No. 2 is the corresponding number.
- The number of days since the last fungicide application is 7. Therefore, the corresponding value is 1.
- The farmer added the previous values and obtained 9. According to the chart "Recommendation Guidelines", the recommendation was to apply a contact fungicide. However, the farmer heard on the radio that heavy rains were expected in the area and decided not to take risks and applied a systemic fungicide.

Location: Loma Grande
Altitude: 2900 m above sea level
Sowing date: January 2, 2007
Name of Variety: INIAP-Gabriela

Date	Variety resistance	Environmental conditions	Crop Stage	Amount of blight around and inside the field	Days since the last fungicide application	Total	Recommendation
feb 5	3	2	2	3	3	13	Systemic
feb 12	3	1	2	2	1	9	Contact

* It can be assumed that the variety resistance does not change during the crop cycle.

Record of late blight control practices

Handout

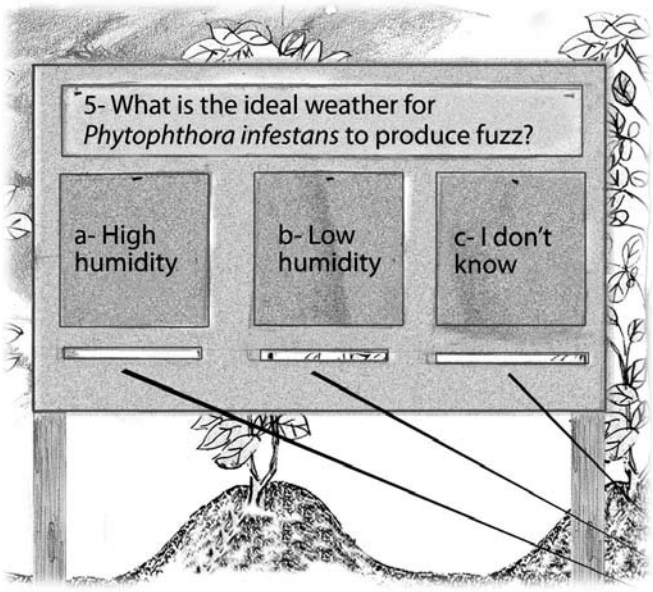
Location:
Altitude:
Name of Variety:
Date of Sowing:
Area:

Date	Control practice*	Name of product	Active ingredient	Doses	Price	Amount of water	Day-wages

* Fungicide application, making high hills around the plant or cutting foliage when the tubers have reached commercial size.

Annex 1

Knowledge test



Instructions for the facilitator before the session

Introduction

This test is known as the box test, field test or farm test. It is frequently used in farmer field schools (FFS). At the beginning of an FFS, this test helps the facilitator evaluate the level of knowledge of the participants, and thereby make adjustments in the themes that will be covered. It can also be used after the FFS to see what has been learned. In this guide, it is recommended that the test be used before and after *every module* to objectively evalute what was learned by the participants.

Preparation

One or two days before:

Materials

- Pieces of cardboard approximately 50 x 50 cm (one piece for each question).
- Several colors of posterboard, scissors and glue.
- Felt tip pens.
- Wooden posts and nails to hold up the cardboard pieces (two posts per cardboard piece).
- Small boxes made of posterboard.
- A potato field, preferably with late blight.

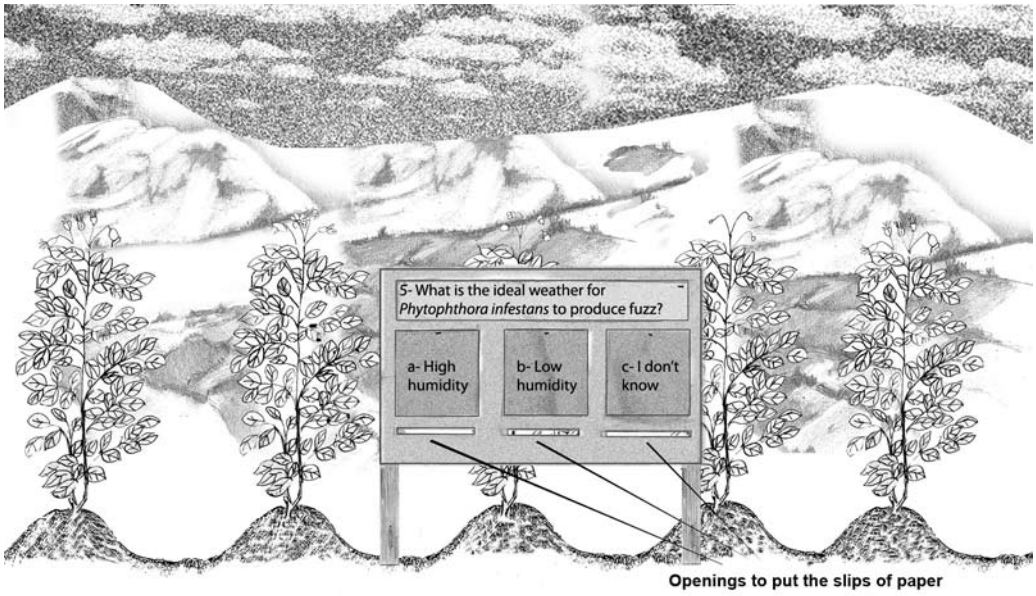
Procedure

a) Preparing the evaluations stations

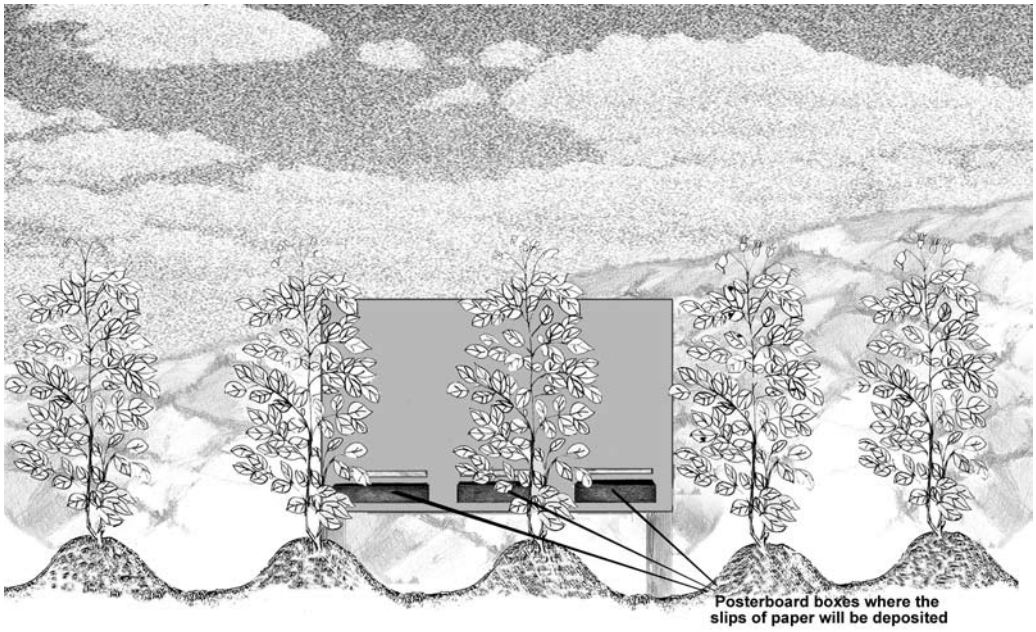
- Make three openings of 4 X 2 cm in each piece of cardboard as in the Figure on page 132. These openings are used to put the slips of paper with answers.
- Put a small posterboard box behind and below each opening. This is where the slips of paper will be deposited.
- Cut cards from posterboard and write the questions found at the end of each module. Each question should be identified with a number (1, 2, 3, etc.) and each answer option with a letter (a, b, c).

Image of an evaluation station

Seen from the front

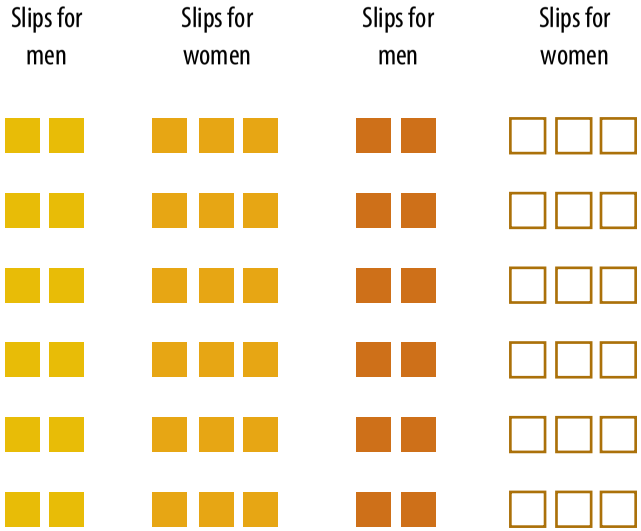


Seen from the back



Case 1: Group test

1. Make answer slips for each participant: one slip per question, using different colors for men, women and each test of knowledge (initial and final).

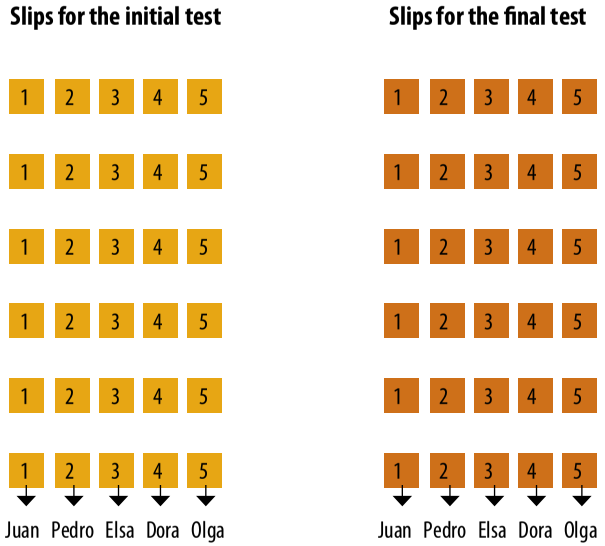


Case 2: Individual test

1. Make a numbered list for the participants, for example:

1. Juan
2. Pedro
3. Dora
4. Olga
5. Elsa

2. Make numbered slips for each participant: one slip per question, with differernt colors for the initial and final tests.



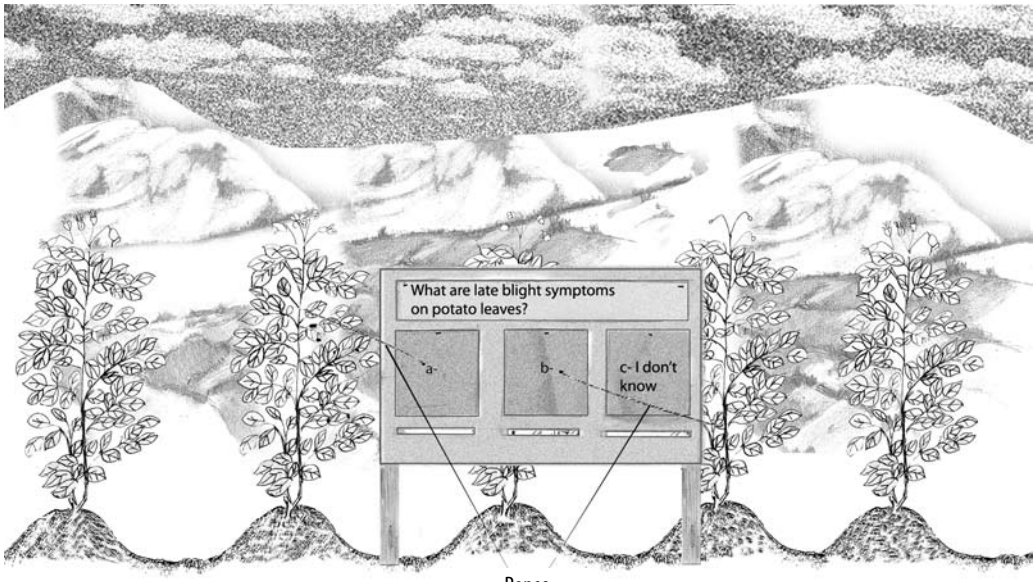
- Paste a question in the upper part of each cardboard sheet.
- Paste the possible answers above the different openings in the cardboard.
- Attach the posts to the edges of the cardboard.
- Each cardboard sheet with questions and answers is called an *evaluation station*.
- Cut pieces of different colored posterboard about 3 X 3 cm. These may be used either for group tests, which are anonymous, or for individual tests where the results are identified by the names of the participants.

  Example. A test of 6 questions is done for 5 people (2 men and 3 women) at the beginning and at the end of a training exercise.

b) Initial knowledge test

This test is done before each module; the steps are as follows:

- Locate the evaluation stations where the knowledge test will be done. This test is generally done near an FFS learning plot. Stations should be between 3 and 5 m apart to avoid interference among participants.
- In some cases, objects (samples) can be used as answer options, as in the following figure.



- Give the participants the answer slips. Each participant should get one slip per question; the number of slips per participant should equal then number of questions in the test.
- Put one participant at each evaluation station (see Note 2). The number of stations should be equal to the number of people being evaluated; it is not

important if there are stations without questions - these are referred to as *rest stations*.

- Give the following instructions to the participants:
  - » Carefully read the question and the answer options.
  - » Answer the question by putting a slip in the opening of the option that you think is correct.

- Determine how much time will be spent on each question.
- Ask the participants to start the test. When all have finished answering, ask them to move to the next station (they can rotate clockwise). Continue doing this until all questions are answered by all participants.

Note 2 **If some participants can't read, someone who can read should be put at each station.**

c) Final knowledge test

This test is done at the end of each module.

- Give a set of slips to each participante. These should be a different color than those used in the initial test.
- Repeat the process described previously.
- Finally, count the correct answers. The difference in results between the initial and final tests indicates the knowledge acquired in the module.

Annex 2

Fungicide guide

Guide of fungicides used to control potato late blight in Ecuador (*)

Handouts

Active ingredients for controlling late blight

Contact	Copper based (1)
	Clorotalonil
	Fentín (1)
	Folpet
	Mancozeb
	Maneb
	Metiran
	Propineb
	Zineb
Systemic	Benalaxyl (2)
	Cymoxanil
	Dimethomorph
	Fosetyl aluminum
	Furalaxyl (2)
	Metalaxyl (2)
	Propamocarb
	Ofurace (2)
	Oxadixyl (2)
	Systemic copper (1)

(1) Use before flowering
(2) Use in rotation with other active ingredients

CIP does not endorse or recommend the use of specific products found in this guide. The proper use of fungicides is the sole responsibility of the user and anyone using this guide.

(*) Sources:

- Gallegos, P., Orellana, H., y Velasteguí, J. 2004. Vademécum Agrícola 8th. ed. Edifarm, Quito. 920 p.
- Falconí, C., Orellana, H., Velasteguí, J., y Gallegos, P. 2006. Vademécum Agrícola. 9th. ed. Edifarm, Quito. 1256 p.
- Schwinn, F. J. y Margot, P. 1991. Control with chemicals. In Advances in Plant Pathology. Vol. 7. *Phytophthora infestans*, the cause of late blight of potato. D. S. Ingram and P.H. Williams, (eds.). Academic Press. London. pp. 225-265.

1. Contact fungicides

Active ingredient	Commercial name	Dose
Clorotalonil	Balear 720	38 ml per 20 liters
	Bravo 720	1 to 2 liters per ha
	Dacapo	26 ml per 20 liters
	Daconil ultrex	1.5 to 1.8 liters per ha
	Daconil 720	0.7 to 1.5 liters per ha
	Echo 720	1 to 2 liters per ha
	Fungil 500	50 to 100 ml per 20 liters
	Fungil 720	50 to 75 ml per 20 liters
	Thalonex 500 y 720	1.2 to 2.4 liters per ha
Copper based	Caldo bordelés 80%PM	2 to 3.5 kg per ha
	Champion PM	3.4 to 4.5 kg per ha
	Kocide 2000	40 g per 20 liters
	Kocide 101	1.5 to 3 kg per ha
	Oxicel	50 to 100 liters per 20 liters
	Copper oxychloride 85 PM	80 g per 20 liters
Fentin	Brestan 60% PM	10 g per 20 liters
	Brestanid	12 ml per 20 liters
	Supertin 48sc	10 ml per 20 liters
Folpet	Folpan 50 PM	50 to 100 g per 20 liters
Mancozeb	Alarm 80WP	Not available
	Dithane FMB	125 ml per 20 liters
	Dithane M-45 NT	45 g per 20 liters
	Flonex MZ 400	3 to 3.5 liters per ha
	Fungis-Khan PM	50 g per 20 liters
	Mancothane	2.5 to 3.5 kg per ha
	Mancozeb 80 PM	140 g per 20 liters
	Mancozin 43 F Manzin 800 PM	150 to 270 ml per 20 liters
	Titan 80 WP	100 g per 20 liters
	Triziman D	2 to 4 kg per ha
	Vondozeb 62% SC	100 ml per 20 liters
Maneb	Trimangol 80% PM	2 to 4 kg per ha
	Maneb 80% PM	
Propineb	Angular	50 g per 20 liters
	Antracol 70 PM	50 g per 20 liters
	Rifle 70 PM	50 g per 20 liters
	Siti	1.5 to 2.5 kg per ha

Abbreviations : ml = Mililiter, g = Gram, kg = Kilogram, ha = Hectare
Equivalents: 1 liter = 1,000 ml, 1 kg = 1,000 g, 1 ha = 10,000 m^2

2. Mixes of contact fungicides

Active ingredient	Commercial name	Dose
Folpet + copper	Folpex Forte	50 to 100 g per 20 liters
Mancozeb + Bordeaux mixture	Cuprofix 30	50 g per 20 liters
	Sulcopac	50 g per 20 liters
Mancozeb + copper	Cobrethane	50 to 100 g per 20 liters
	Oxithane	100 g per 20 liters
Maneb + Zineb + copper oxychloride	Cupropac	1.5 to 2 kg per ha
Propineb + copper	Punto 50.3 PM	3 to 3.5 kg per ha
Zineb + maneb + ferbam	Tricarbamix Especial 70%	2 to 3 kg per ha

3. Systemic fungicides

Active ingredient	Commercial name	Dose
Copper (systemic)	Cupron 40	20 to 25 cc per 20 liters
	Phyton	0.75 to 1.5 liters per ha
	Skul 27	0.75 to 1.5 liters per ha
	Sulcopen 24%	20 cc per 20 liters
Fosetyl	Aliette	60 g per 20 liters
	Fosetal	40 g per 20 liters
	Fostar	40 g per 20 liters
	Fostonic	2.5 g per ha
	Fozzy	40 g per 20 liters
Propamocarb	Dovex	50 cc per 20 liters
	Kemikar	50 cc per 20 liters
	Previcur N	50 to 100 cc per 20 liters
	Procure	50 to 100 cc per 20 liters
	Proplant	1.5 to 2 liters per ha
	Proton	50 cc per 20 liters
	Sargent	50 cc per 20 liters

Abbreviations : ml = Mililiter, g = Gram, kg = Kilogram, ha = Hectare
Equivalents: 1 liter = 1,000 ml, 1 kg = 1,000 g, 1 ha = 10,000 m^2

4. Mixtures of systemic and contact fungicides

Active ingredient	Commercial name	Dose
Benalaxyl + mancozeb	Galben M-8-65	50 g per 20 liters
Cymoxanil + copper	Volcán	50 g per 20 liters
Cymoxanil + folpet	Foxanil	50 to 100 g per 20 liters
Cymoxanil + mancozeb	Curalancha	50 g per 20 liters
	Curathane	50 g per 20 liters
	Campuz M-8	50 g per 20 liters
	Curzate M-8	50 g per 20 liters
	CY_MAN 720	50 g per 20 liters
	Fungidor MC-8	2 to 3 k g per ha
	Fungimont MC-8	50 g per 20 liters
	Kuralan	50 g per 20 liters
	Lanchafin	50 g per 20 liters
	Moxan	50 g per 20 liters
	Persist	50 g per 20 liters
	Recio	50 to 100 g per 20 liters
	Tromba	50 g per 20 liters
	Procymox	50 g per 20 liters
Cymoxanil + metiram	Aviso DF	50 g per 20 liters
Cymoxanil + propineb	Fitoraz 76 PM	1.5 to 2 kg per ha
	Fitoroc 76 PM	50 g per 20 liters
Dimetomorph + mancozeb	Acrobat	75 g per 20 liters
	Corbat	75 g per 20 liters
	Patron	75 g per 20 liters
Fosetyl + mancozeb	Rhodax PM	50 g per 20 liters
	Rhodax 70 WP	50 to 100 g per 20 liters
Metalaxyl + copper	Lanchero	200 to 250 g per 20 liters
Metalaxyl + mancozeb	Kóctel 720	2 to 2.5 kg per ha
	Metasan	2 to 2.5 kg per ha
	Metaranch	50 g per 20 liters
	Metron	50 g per 20 liters
	Milor	25 g per 20 liters
	Otria Plus	200 to 300 g per ha
	Prior MZ	50 g per 20 liters
	Ridomil Gold	2.5 to 3 kg per ha
	Rolaxil	2 kg per ha
	Talon	2 to 3 kg per ha
Metalaxyl + propamocarb	Predomil	40 g per 20 liters
Ofurace + Mancozeb	Patafol Plus	2 to 3 kg per ha
	Grolan	50 to 100 g per 20 liters
Oxadixyl + Mancoceb	Sandofan	2.4 to 3 kg per ha
Propamocarb + mancozeb	Tatoo	4 liters per ha

CENTRO INTERNACIONAL DE LA PAPA
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