FARMER FIELD SCHOOL
FOR POTATO
INTEGRATED PEST MANAGEMENT

A Facilitator's Field Guide

2006

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Farmer Field School for Potato Integrated Pest Management

A Facilitator's Field Guide

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For additional technical information on potato production and protection, please consult the following website: www.cipotato.org. For additional information on vegetable production and protection, including technical and training materials, please consult the following website: www.vegetableipmasia.org.

FOREWORD

Potatoes are an important commodity in the upland regions of Indonesia and other Asian countries owing to their many relative advantages on the one hand, and the complexity of production constraints involved on the other hand. The main problems potato farmers are faced with are the scarcity of healthy seed potatoes, pests and diseases damaging their crops, their reliance on chemical pesticides and fertilizers, and deteriorating soil fertility levels. To help farmers find answers to these problems, several institutions have contributed to the development of a farmer field school model for potato integrated pest management, or Potato IPM FFS.

This guide is meant as a reference for IPM FFS facilitators. It describes exercises for the farmer field school learning process relating to sustainable potato cultivation. This learning process begins with preparing fields for planting and goes on right up to marketing harvest produce. These experiential learning exercises are intended to empower farmers to become agroecosystem managers through enhancing both their understanding of technical aspects of potato IPM and their decision making and experimental skills. This field guide with learning exercises is closely linked to the potato ecological production guide "*All about Potatoes: A Handbook to the Ecology and Integrated Management of Potato*". Elaborations on the technical content of the learning exercises in this guide can be found in the respective chapters of the ecological production guide. Potato IPM FFS facilitators should master the contents of both guides.

It should be realized that this guide was developed in Indonesia, and hence often refers to typical Indonesian characteristics of ecological, socio-economic and institutional conditions. It is recommended to flexibly adapt exercises for use in other countries to make them suitable to prevailing conditions.

This manual is the result of a collaborative effort by a variety of institutions and individuals, with the financial support of the United Nations' Food and Agriculture Organization (FAO). The authors of this book come from diverse backgrounds. We anticipate that the amalgamation of this diversity has contributed to a comprehensive approach to potato IPM FFS. Hopefully, this guide can be used by individuals and institutions, researchers, facilitators and farmers in a variety of places interested in the development of potato IPM.

Finally, the writing team wishes to express gratitude and appreciation to all the individuals and institutions that have helped in compiling and improving this guide.

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We welcome your comments and suggestions. Please contact:

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For more information on vegetable IPM, including other training materials and ecological production guides, please consult www.vegetableipmasia.org.

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PREPARATIONS FOR POTATO INTEGRATED PEST MANAGEMENT FARMER FIELD SCHOOLS

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1 SITE FEASIBILITY SURVEYS

Feasibility surveys are done in order to select appropriate villages or areas in which to initiate Integrated Pest Management Farmer Field Schools (IPM FFS). Choice of location is extremely important to ensure that program content is applicable to the problems farmers are faced with.

STEPS

1. Determine beforehand what conditions you are looking for in an ideal location for potato IPM FFS. These may include:
   - Whether it is a centre for potato production or another commodity, and whether potatoes or other vegetables are the primary source of income for farmers in the area.
   - Whether farmers depend on potato or other crops for their livelihoods.
   - Whether there are problems with pests and diseases affecting potato plants.
   - Whether pesticides and chemical fertilizers are being used.
   - Whether farmers are interested in learning.

   Other considerations might be economic, social and cultural conditions.
2. Visit chosen locations, going to fields, villages, and individual farmers' homes. Hold informal discussions with the farmers and keep a record of all information you obtain.

2 COORDINATION WITH SUB-DISTRICT AND VILLAGE OFFICIALS

Support from sub-district[1] and village officials is essential in expediting Potato IPM FFS preparations. They can also help determine potential participants or suggest suitable contact persons.

A. SUB-DISTRICT LEVEL COORDINATION

STEPS

1. Talk to the sub-district administrator, pest and disease observers and agricultural extension officers explaining the aims of the potato IPM FFS and the preparatory meetings with potato farmers that will be held in their sub-district.
2. Also discuss the following with them:
   - Strategic locations for potato IPM FFS
   - Criteria for participants
   - Activities to be carried out
3. Request the officials' support for potato IPM FFS activities in their sub-district.

B. VILLAGE LEVEL COORDINATION

STEPS

1. Explain about plans to initiate IPM activities in the village to the Village Head, Village Secretary, extension officer and other village officials and tell them about the objectives of the potato IPM FFS and preparatory meetings with potato farmers.
2. Also discuss the following with them:
   - Strategic locations for Potato IPM FFS
   - Criteria for participants
   - Activities to be carried out
3. Request the village officials' help in supporting potato IPM FFS activities in their area. If possible, request village data and maps for preparing meetings with farmers.
4. In addition to meeting village officials, also consult prominent community figures, farmer group leaders, and other individuals who may be able to help with implementing potato IPM FFS. Ask for their help with organizing potato

[1] In Indonesia, government administration units include (from lowest level to highest): village, sub-district, district, province and state. For implementation in other countries of the process described above, the most suitable unit for fied activity implementation and organization under prevailing administrative structure should be determined.

IPM FFS preparatory meetings and inviting other farmers to take part in these meetings.

5. Make logistic arrangements for the preparation meetings and make sure you keep village authorities informed.

3 MEETINGS WITH FARMERS

Following the coordination meetings with sub-district and village officials, hold a series of meetings with farmers. Apart from being a means for identifying potential participants, these meetings are also useful for crosschecking data collected from the field and as forums for participatory identification of problems facing farmers. However, the most important objective of these meetings is that farmers understand what the program is about and they agree to participate.

STEPS

1. To gain an understanding of conditions, constraints, needs and opportunities in the local area, involve participants in PRA[2] exercises to collect data, such as field mapping, seasonal activities, gender analysis, etc. Work together with the participants to analyze the collected data.
2. Having completed the above, provide explanations to participants regarding IPM, sustainable potato production, the learning process through FFS, and the benefits of potato IPM FFS. You could invite a potato IPM FFS graduate to talk about his or her experiences with field schools and how they have been of benefit.
3. After completing all of these steps, agree on potato IPM FFS implementation; who will take part, where meetings will take place, what time they will commence, etc. Pay special attention to female participants encouraging them to take part in IPM FFS studies if they also have a prominent role in potato cultivation.
4. At the end of each meeting, reiterate agreements made and make sure you will meet with potential potato IPM FFS participants again.

[2] PRA = participatory rural appraisal

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POTATO IPM FFS IMPLEMENTATION

2

4 DEVELOPING A CURRICULUM FOR POTATO IPM FFS

As with any other learning process, a curriculum is an essential guide to both IPM FFS participants, as it shows them what they will study throughout the season, and to a facilitator, as it enables him or her to make the necessary preparations before facilitating Potato IPM FFS meetings (see Appendix 1 for an example curriculum).

The following things need to be considered when preparing a curriculum:

- Base it on critical factors affecting farmers' crops.
- Determine an agreeable duration of meeting times.
- Give farmers opportunities to gain relevant knowledge and skills, and don't merely transfer standard recommendations and technologies.

5 ROUTINE ACTIVITIES DURING POTATO IPM FFS

The approach used in Potato IPM FFS is 'learning by doing' meaning farmers can learn from their own experiences. Potato fields become the means for study, the classroom and the source of knowledge.

Each Potato IPM FFS meeting involves the following activities:

1. OBSERVATION
   Participants make observations in the learning plot so they can see for themselves what is happening with their crop in the field throughout the season. These observations cover all aspects relating to potato field ecosystems. The keys to successful observations are willingness, regularity, thoroughness and knowing what to look for.
2. AGROECOSYSTEM ANALYSIS
   Participants discuss observation outcomes. They work together in small groups to discuss their data and draw what they have just observed on a large sheet of paper.
3. PRESENTATION OF DISCUSSION OUTCOMES
   Groups present their findings in order that all involved can look at the agroecosystem in a more in-depth and systematic manner. From these group presentations, the larger group can draw conclusions regarding crop and field conditions, and decide what steps to take.
4. SPECIAL TOPICS
   Special topics are chosen based on conditions specific to the local situation. These special topics are intended to enrich participants' knowledge and to make it easier for them to reach decisions relating to their fields.
5. GROUP DYNAMICS EXERCISES
   If participants become bored or tired, the facilitator can improve group dynamics by conducting activities to suit specific levels of development and requirements in each group. These are intended to help the group become more active, effective and cohesive (See appendices for examples of group dynamics activities).

6 PRELIMINARY AND FINAL TESTS

Preliminary tests are undertaken to get an idea of participants' knowledge and skills in relation to potatoes, pests, diseases and natural enemies. Armed with this information, a facilitator can clearly see what participants need to master and choose appropriate topics accordingly.

Final tests are for gauging participants' progress in relation to the materials taught to them. Some examples of preliminary and final test models used are ballot boxes, group discussions and interviews about progress made.

7 IPM EXPERIMENTS IN FFS EXPERIMENTAL PLOTS

Experiments are meant to provide farmers participating in FFS with the opportunity to find evidence of IPM practices, and to improve their skills in designing and conducting experiments to test new ideas.

Examples of experiments conducted in Potato IPM FFS are:

- Granulosis virus against potato tuber moth
- Natural enemies of leafminer flies
- Examining the qualities of soil and organic fertilizer
- Selective fungicide use for late blight control
- Latent infection of bacterial wilt

8 FOLLOW-UP TO POTATO IPM FFS

When the season has ended, the facilitator can make plans with participants to determine how they are going to follow up on the Potato IPM FFS. Follow-up plans should suit participants' wishes and local conditions.

Possible follow-up activities are:

- Field practice in their own fields
- Disseminating learning outcomes to other farmers
- Facilitating other groups to learn about Potato IPM
- Routine group meetings for further collective learning and action
- Conducting further experiments

9 EVALUATION AND MONITORING

Evaluations are an important means of determining the strengths and weaknesses of the season's Potato IPM FFS. Things to look at when making evaluations are:

- *Crop performance* - The yield from IPM experiments as compared to local methods and productivity levels, ease of implementation, results of economic analyses, etc.

- *Learning process* - Whether the Potato IPM FFS has been running according to plan. This will be apparent from the number of meetings, participant numbers and attendance throughout the season, suitability of special topic choices relating to specific issues in the field, whether participants played a part in determining special topics choices, etc.
- *Impact* - How far the Potato IPM FFS learning process has succeeded in achieving its objectives, i.e. improving participants' integrated potato management knowledge and skills.

10 FACILITATION

A facilitator should not only possess technical skills, but also have a capacity for organization and experimentation and the ability to design and facilitate experiential learning processes. To increase his or her knowledge, a facilitator must seek as much information as possible through reading, doing internet searches, holding discussions with researchers and innovative farmers, etc.

A facilitator's role is to:
- Prepare all necessary requirements for implementing Potato IPM FFS i.e. tools and materials, experimental plots etc.
- Prepare him or herself to facilitate the Potato IPM FFS, and to motivate participants.
- Ensure that group discussions are lively and flowing.
- Involve all participants in discussions so none are either too dominant or are left out.
- Respect all participants, be friendly, warm and responsive so they are not reluctant to express their opinions.
- Provide clear explanations when participants are unable to answer questions through their own observations or discussions.
- Initiate experiments, make critical analyses of ideas, test them and draw conclusions.
- Hold reviews or evaluations on completion of an activity.
- Pay attention to timing so everything goes according to schedule. If timings need to be changed, make sure any changes are agreed by all participants.

Factors that can cause a facilitator to obstruct the learning process:
- Being unprepared for IPM FFS activities, both in terms of materials or mastery of discussion topics.
- An unsympathetic attitude towards participants making them feel uncomfortable during discussions.
- An uninterested, non-committal attitude and having other things on the mind.
- Setting unclear tasks and using unsystematic methods.
- Providing incomplete explanations, or giving incorrect information from being unwilling to admit to not knowing something.

THE LEARNING PROCESS

3

11 THE "WHAT IS THIS?" PROCESS

BACKGROUND

The "What is this?" method is a communication process in which a facilitator builds discussion by eliciting questions from participants and encourages them to think about the answers to their own queries. If a facilitator provides a direct answer to a participant's questions, about an insect's name for example, then the answer will almost certainly be forgotten within a few hours.

A common mistake to make during the "what is this?" process is immediately redirecting a question back to a participant, as in the example below:
Participant: "What is this?"
Facilitator: "What do you think it is?"

In instances like this the participant often becomes annoyed feeling as if he or she is being tested.

A facilitator's questions should encourage answers that provide more information and lead to conclusions being drawn or increased knowledge. Some example questions might be: "Where did you find them? How many were there? What were they doing?" When neither facilitator nor participants can find the answer to a question, the facilitator can initiate a simple experiment with plants and/or insects for participants to conduct and discover the answer to their question themselves.

OBJECTIVES

To train facilitators to pose questions that lead to conclusions being drawn or more information being discovered, and to promote two-way communication during implementation of IPM FFS.

STEPS

1. The training process can take place while observations are being made in the field.
2. If a participant asks a question, direct it away from merely requesting the name of an insect species, but more towards the role that insect plays and the problems it causes. For instance, where did you find it? How many were there? What were they doing? Have you often seen them?
3. Elicit questions, so communication can develop towards a creative thinking process.
4. Practice with other facilitators so you become more skillful at posing questions to participants when the learning process is underway.
5. You can also practice the "what's this?" learning process with participants. Arrange them into small groups, to take turns asking and answering questions.
6. Question groups can take any insect as an example, and begin asking their questions. Those answering should try to answer with further questions, and avoid answering directly.

DISCUSSION QUESTIONS

1. Why shouldn't we give simple direct answers to participants' questions?
2. How can we avoid making participants feel annoyed or tested?

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12 THE LEARNING FIELD

BACKGROUND

In the FFS process, a learning field is required where observations of crop development can be made and experiments be implemented throughout the season. Careful preparation of this field is vital because it will influence learning process outcomes and experiment results. A number of things should be considered when preparing the learning field:

1. The kinds of problems that the experiments should find a solution to
2. Types of experiments and their objectives must be clear
3. Availability of land for activities must be sufficient

OBJECTIVES

For participants to know how to plan and prepare experimental plots for potato trials.

TIME 3 hours

METHODOLOGY Explanation, idea sharing, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Plastic string
- Hoes

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them to talk about any experiences they may have had planning or preparing plots for experiments and discuss their strengths and weaknesses. Write their answers down on a large sheet of paper and discuss them together.
3. Invite participants to identify what you need for experiments, including how to prepare experimental plots for learning.
4. Provide further explanations if necessary. Ask if there are any further questions.
5. Prepare the necessary tools and materials then invite participants to the field to prepare the experimental study plots.

DISCUSSION QUESTIONS

1. How have you been preparing experimental plots up until now?
2. What were their strengths and weaknesses?
3. What considerations should you make when preparing experimental plots?
4. Why should you prepare experimental plots in this activity?

NOTES

13 DEVELOPING THE LEARNING PROCESS

BACKGROUND

In IPM FFS, facilitators are required to create an atmosphere conducive to successful learning, and to actively involve all participants in every activity.

IPM FFS are a means for farmers to learn in a creative and participatory manner, and not merely a tool for demonstrating IPM technology. Frequently facilitators try to prove through demonstrations that IPM methods are superior to the ones farmers commonly use. Consequently, the learning process becomes neglected. To avoid such demonstrations of IPM, a facilitator must always involve farmers in every activity.

IPM FFS learning exercises are designed as vehicles for farmer learning in which a facilitator's role is to create an atmosphere conducive to an effective learning process.

OBJECTIVES

For facilitators to conduct participatory learning sessions together with participants, thus improving and refining their facilitation skills.

STEPS

A. BEFORE AN ACTIVITY COMMENCES
   1. Prepare all necessary tools and materials for the day's activities.
   2. Explain objectives and steps involved in implementing the activity using language easy for participants to understand.
   3. Ask for participants' response and input. Also ask whether participants understand the aims and objectives of the activity.
   4. Invite all participants to involve themselves and play their part in the activity. Agree as to who does what and clarify what the tasks and responsibilities of each participant are.

B. IMPLEMENTATION OF AN ACTIVITY
   1. If required, provide examples of implementation techniques that participants can then continue.
   2. Observe participants throughout implementation noting down any important details.
   3. Use the "what's this?" method for each learning process, so farmers are motivated to find answers.

C. ON COMPLETION OF AN ACTIVITY

1. When concluding an activity, use questions to elicit analysis and conclusions from participants.
2. Ask for participants' response and input on the day's activity and what improvements are still needed. If necessary, review what they have learned.

THINGS TO CONSIDER

1. Did any particular participant(s) dominate the activity, and if so, why?
2. What did you have to do to ensure the activity went well?
3. Were activity techniques implemented in their entirety?
4. Does the activity need to be developed further before being implemented at a different time and in a different place?
5. What should you do to foster active implementation by participants and a process of mutual learning?

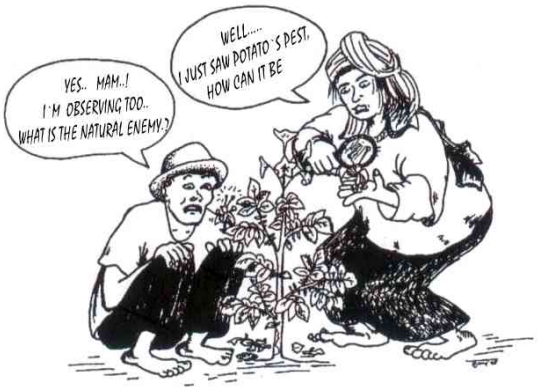
14 AGROECOSYSTEM OBSERVATION AND ANALYSIS

BACKGROUND

Observations mean looking at realities in the crop field and the surrounding environment. With thorough routine observations, farmers will recognize the early signs of pest or disease damage so they can take immediate action to prevent it from spreading further. Observing potato crops during each phase of their growth will greatly help farmers to make decisions such as whether or not it is time to use fertilizer, or whether a pest management measure is required.

Things to look for:

- Condition of the plants, their height, number of leaves, condition of roots, etc.
- Insect pest and natural enemy populations.
- Disease incidence.
- Weather conditions.
- Soil conditions.
- Conditions at the edge of the field.
- Conditions in neighbouring plots.



Observation patterns will develop in stages as potato plants pass through different growth phases during the season.

After making their observations, farmers draw what they have observed, discuss their drawings and analyze the agroecosystem. This is extremely important for understanding the interaction and reciprocal relationships between components in the potato field ecosystem. In this way, farmers can easily make decisions regarding the management of their fields.

OBJECTIVES

1. For participants to understand potato crop ecosystems.
2. To improve participants' observational, analytical and decision-making skills.

TIME 2 hours

METHODOLOGY Explanation, idea sharing, group discussions, field practice

TOOLS & MATERIALS

- Observation forms (A sample observation form is provided in Appendix 2.1)
- Large sheets of paper, adhesive tape, markers, crayons/colored pencils
- Colored cards
- Rulers
- Clear plastic bags

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether it is necessary to observe potato plants, how often they make observations and how they usually go about doing so. Discuss participants' experiences together. Provide further explanations on how to observe potato plants.
3. Ask participants again what they have observed. Use colored cards to help participants write down their answers. Discuss their answers together until they understand what parameters for observations are.
4. When participants appreciate how to conduct observations and what they are looking for, arrange them into small groups and invite them to make observations in the field and to note down anything of importance. Provide plastic bags for collecting leaf, insect or soil specimens from the field ecosystem.
5. Participants draw their observations on a large sheet of paper, showing environmental relationships and the influences of soil, water, weather, pests, disease, weeds etc. on potato plant growth. They use crayons or colored pencils to make their pictures clearer. Each group discusses and analyzes the agroecosystem and adds their conclusions.
6. Each group presents the outcomes of their discussions.
7. When all groups have made their presentations, continue discussions with all participants and make decisions, based on observation outcomes, as to what action to take that week.
8. Keep the ecosystem drawings for comparison with observations made at the following meeting.

DISCUSSION QUESTIONS

1. How often do you make observations?
2. How do you usually make your observations?
3. What do you look for?
4. Are there any signs of disease on potato plants?
5. Are there any signs of pest damage on potato plants?
6. How does the weather affect plant growth?
7. How do conditions in the plot compare with the previous observation?
9. What crop management practices do you plan for the week?

POTATO CROP CULTIVATION

4

15 PREPARING FIELDS

BACKGROUND

Fields are generally prepared for planting by tilling the soil. There are several positive aspects to tillage; it can improve soil conditions, reduce weeds, pests and diseases, and help prevent erosion. However, when done incorrectly tillage can lead to negative effects, soil damage, mineralization of organic matter and increased erosion.

Methods vary depending on the gradient of the land being tilled. On particularly steep slopes, terraces should be formed, taking into consideration the height and direction of seed beds and hilling up practices later in the season.

For potato crops the soil is usually ploughed or hoed to a depth of 20-40 cm. The soil is left to rest for several days to improve aeration, then it is leveled and cleared of weeds. Holes of about 5-10 cm are dug to place fertilizer and seed tubers for planting. The distance between holes depends on the desired planting density.

OBJECTIVES

For participants to appreciate tillage methods before planting their potatoes.

TIME 45 minutes

METHODOLOGY Explanation, idea sharing, discussion

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards

STEPS

1. Explain objectives of the activity.
2. Ask participants to talk about their experiences and how they usually prepare their fields for planting potatoes. Write their answers down on a large sheet of paper.
3. Discuss their answers together then ask them about the advantages and disadvantages of their tilling methods. They can use colored cards to write down their opinions.
4. Discuss and draw conclusions together about effective tilling methods.

DISCUSSION QUESTIONS

1. When do you start preparing land for planting potatoes?
2. What do you do to prepare the land?
3. What happens if you do not till the land?
4. Under what circumstances do you not till the land?
5. What are the advantages and disadvantages of the tilling methods you normally use?
6. What is the best way to till the land?

NOTES

16 HEALTHY SEED

BACKGROUND

Potato is normally propagated vegetatively through tubers. The main prerequisite for obtaining healthy seed tubers is careful selection. Good seed selection implies the selection of healthy mother plants in the field, and of healthy seed tubers at harvest time in the field, in the storage place, and again at planting time.

Most potato farmers already conduct simple seed selection by removing rotten seeds. However, they generally only do so at planting time.

Characteristics of healthy seed tubers are the following:

1. Sprouts are blue in color
2. Sprouts are fresh, firm and thick while only approximately 1.5 cm short
3. There are no signs of rotting on the tubers.
4. The skin color is bright.
5. If a tuber is cut open, the flesh appears fresh and there are no brown colored rings and no exudation of a milk-like sap.
6. The origin (and generation) is clearly known.

Characteristics of unhealthy seeds:

1. Sprouts are rotting.
2. Sprouts are small, soft, more than 2 cm in length, and withered.
3. Tubers have holes in them, and are rotting (wet or dry rot).
4. Skins are dull, mushy and wrinkled.
5. Brown rings can be found inside tubers and if pressed, they will exude a milk-like sap.

Many factors cause unhealthy tubers: bacteria, fungal diseases, viruses, insect pest, nematodes, being stored for too long, inadequate storage temperature or methods, etc.

OBJECTIVES

1. For participants to explain what is meant by healthy seeds and describe their characteristics.
2. For participants to be able to select healthy seeds.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- 2 kg of mixed quality potatoes taken from the market, seed producers and farmers' own seed stock.

STEPS

1. Explain the objectives of this exercise to participants.
2. Ask them where they normally get their seed potatoes and what condition they are usually in.
3. Ask participants about their understanding of healthy seeds and what their characteristics are. They can use colored cards or large sheets of paper to write down their opinions. Facilitate discussions on healthy seed potatoes and their characteristics.
4. After agreeing upon the criteria for healthy seed, arrange participants into small groups of four or five. Give each group several potato tubers of varying quality making sure some are healthy and some are not healthy.
5. Using the criteria for healthy seed agreed upon together, ask participants to separate the healthy tubers from the unhealthy ones, then ask them to discuss the characteristics of both the healthy and the unhealthy tubers. Ask what has caused some tubers to become unhealthy.
6. Present outcomes of group discussions and discuss together. Elaborate on conclusions drawn from the discussion.
7. Selection practicals can be done 2 or 3 times, or until participants are able to make informed selection choices. Give participants some more potato tubers and ask them to categorize them.

DISCUSSION QUESTIONS

1. Where do you get your seed potatoes, and what condition are they in?
2. Are those tubers really healthy? What are their characteristics?
3. Are any of those tubers unhealthy? What are their characteristics?
4. What selection processes do you usually use?
5. Why is healthy seed selection necessary? And how is this done best?

17 RAPID PROPAGATION OF SEED POTATOES

BACKGROUND

Rapid propagation is essential if you want to obtain large numbers of quality seed potatoes in a short space of time. One way of propagating seeds rapidly is by taking cuttings. This technique can reduce infection from diseases that spread through tubers and soil.

There are several cutting methods that can be used:

1. Seed propagation from stem cuttings
   Cuttings are taken from a potted plant using a sterile knife. Shoots and leaves from the bottom sections are removed, then the stem cuttings are dipped into a root hormone and placed in a media of clean coarse sand. Cuttings are watered regularly and after 2 or 3 weeks, they will take root and may be transferred either into polybags or directly to the field.
2. Seed propagation from tuber sprout cuttings
   There are 2 stages to this method. Tubers are stored to maximize development of tuber sprouts and tuber sprout cuttings, then the cuttings are grown in seed beds.
3. Seed propagation from leaf shoot cuttings
   This is usually done in greenhouses at a temperature of 16-21°C with approximately 18 hours of sunlight.
4. Seed propagation from single node cuttings
   Cuttings consist of nodes, leaves and stem sections taken from four week old plants.

Propagating seed from cuttings requires intensive work and special tools and facilities such as greenhouses.

OBJECTIVES

To introduce stem cutting methods as the most practical technique for rapid potato propagation by farmers.

TIME 45 minutes

METHODOLOGY Explanation, idea sharing, field practice

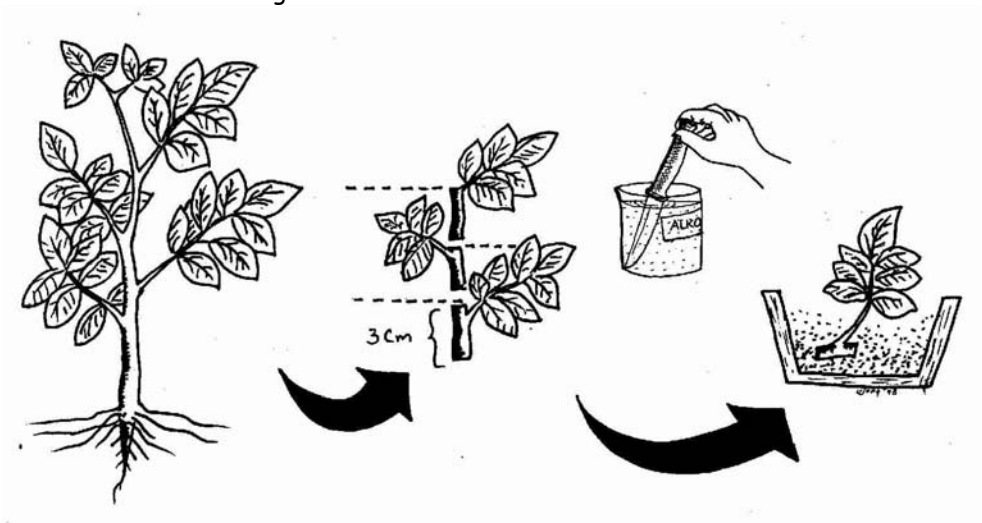
TOOLS & MATERIALS

- Potato plants about 3 or 4 weeks old
- Knives
- Root growth stimulator (liquid or powder, e.g. Rootone F)

- Planting trays
- Manure
- Soil
- Alcohol or lysol

STEPS

1. Explain the objectives of this activity to participants.
2. Sterilize the manure and soil by steaming it or heating it under fire for around 3 hours. Place soil and manure into planting trays and leave to cool for 2 days.
3. Cut potato stems with 2 or 3 leaves on them into 5 cm lengths. Knives must be sterilized beforehand by dipping them into liquid lysol or Alcohol.
4. Dip stem cuttings into a Rootone F solution. Then plant them in the pre-prepared trays.
5. Keep the trays in a cool and shady place with enough sunlight. Protect them from direct rainfall.
6. Water them regularly and observe developments. Note down all observations and discuss them together.



DISCUSSION QUESTIONS

1. What are the benefits of rapid propagation?
2. What effects does the root growth stimulator have on the stem cuttings?
3. Why mustn't stem cuttings receive direct rainfall?
4. What problems are there with this experiment? What are the solutions to these problems?
5. Is the stem cutting method easy to use? Why or why not? How does it compare to other propagation methods?

18 HEALTHY PLANTS

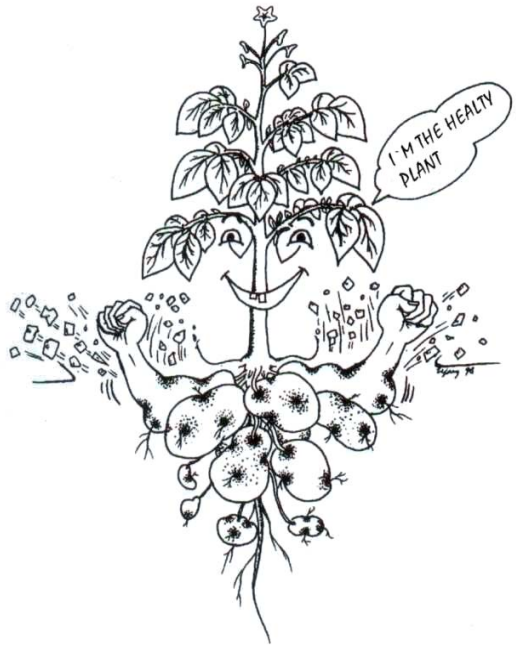
BACKGROUND

To most farmers' eyes, a plant's health is apparent from the color and freshness of its leaves. They consider plants healthy if they are green and are not wilting. However, when farmers see spots, lacerations or holes on the leaves, they assume pests are present and must therefore be controlled.

In fact an understanding of exactly what damage patterns can occur on potato plants is essential for managing potato crops well and ensuring they are always in good health.

OBJECTIVES

To improve participants' understanding of the characteristics of healthy plants and their resistance to pests and disease.



TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Colored cards
- Healthy and unhealthy potato plants

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them about the characteristics of healthy potato plants. Write down their answers on a large sheet of paper and discuss together. Agree on criteria for healthy plants.
3. Arrange participants into small groups of 4 or 5, then invite them to make direct observations of healthy and unhealthy plants in the field. Carefully collect specimens of healthy and unhealthy potato plants.
4. Each group discusses the characteristics of healthy and unhealthy plants found in the field and what has caused the unhealthy ones to be that way.

5. Groups present outcomes of their discussions and talk about what influences potato plant health, and the resistance healthy plants have to pests and disease. Provide additional explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of healthy potato plants?
2. What are the characteristics of unhealthy potato plants? What are the causes?
3. What factors cause potato plants to be healthy?
4. How resistant are healthy plants to pests and disease?

NOTES

19 POTATO PLANT ANATOMY AND PHYSIOLOGY

BACKGROUND

Plant parts are different in shape and function. In potato plants, the main components are the leaves, stems, roots and tubers. The functions of these plant parts are as follows:

A. Leaves
   - For photosynthesis
   - For breathing
   - For transpiration
   - To store nutrients

B. Stems
   - Have an epidermis for protection
   - Have vessels for transporting water and nutrients from the roots to the leaves, and transporting carbohydrates produced by photosynthesis from the leaves to the whole plant.
   - To support the plant

C. Roots
   - To reinforce the stem
   - To absorb nutrients and water
   - To store nutrients

D. Tubers
   - Storage vessels

Damage to any of these plant parts can affect potato productivity.

OBJECTIVES

1. For participants to know the parts of potato plants.
2. For participants to understand the functions of potato plant parts.

TIME 1 hour 30 minutes

METHODOLOGY Discussion and observation

TOOLS AND MATERIALS

- Large sheets of paper, markers, adhesive tape, colored cards
- Potato plants
- Cutting knives

STEPS

1. Explain the objectives of learning about potato anatomy and physiology to participants.
2. Using a diagram of a human body on colored cards, discuss the functions of the body parts with participants.
3. Discuss whether or not the parts are the same as those in potato plants.
4. Participants form small groups.
5. Each group makes observations of potato plant parts and their functions. They may cut open stems or slice tubers to look inside them.
6. Groups discuss the parts of the potato plants and their functions.
7. Present groups' output and discuss.
8. Conclusions should cover the characteristics and functions of leaves, stems, roots and tubers.

DISCUSSION QUESTIONS

1. What are the functions of our eyes, nose, head, legs etc?
2. Are there any parts of potato plants that have special functions?
3. What happens when potato plant leaves, stems or roots are damaged?

NOTES

20 PLANT SELECTION FOR SEED

BACKGROUND

Selection to obtain high quality seed tubers is not only done at harvest time, but also while potato plants are still growing. There are two types of plant selection known as positive and negative selection.

Positive selection is done by looking for plants displaying steady growth and resistance to pests and disease, whereas negative selection involves looking for sick or wilting plants. These sick plants are marked with stakes and then uprooted and destroyed to prevent infection spreading to other plants. The stake markers should be left in the ground to show where the sick plants used to be. These markers will be indicators when selecting tubers for seed at harvesting time. Seed tubers should not be chosen from the four plants to the left or the right of the markers.

Both positive and negative selection will be more effective when combined with a harvest management system. Potato plants positively selected for seed should be harvested before potatoes for consumption.

OBJECTIVES

To increase participants' knowledge of the importance of positive and negative selection in obtaining healthy seed.

TIME 1 hour 30 minutes

METHODOLOGY Explanation, idea sharing, discussion, field practice, experiment

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Hoes
- Stake markers
- Healthy and wilted potato plants in the plot.

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them to talk about their experiences in preparing tubers for seed. Ask them whether they have ever tried plant selection.
3. Discuss their understanding of positive and negative plant selection and the benefits of both. You may use colored cards to help participants express their opinions.
4. Arrange participants into small groups of 4 or 5.
5. Invite them to the field to practice negative selection and ask them to put markers by the wilting or sick plants.
6. Uproot and destroy the sick plants making sure the stake markers remain in place where the plants used to be.
7. Hold further discussions with participants about the selection practical. Direct discussions towards the following:
   - The objectives of stake marking.
   - The criteria used for marking plants.
   - The benefits of stake marking.

DISCUSSION QUESTIONS

1. What does selection mean?
2. Have you ever tried plant selection to obtain healthy seed?
3. How do you carry out selection?
4. What are the benefits of selection?
5. Why can't tubers from plants around the stake markers be used for seed?

NOTES

21 ROTATION

BACKGROUND

Healthy soil is a precondition for healthy plants. One way of ensuring soil health is by carrying out crop rotation. Rotation between potato and other crop species can suppress or even eliminate sources of pests and diseases that would otherwise infect the following season's crop.

If high levels of infestation have not occurred in the field, rotation need only be used for one year before planting potatoes again.

Example rotation pattern:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Potato			Cabbage				Corn				

In cases of heavy infestation, although depending on the type of pests and diseases present, potato crops could be rotated in a cycle of two years as follows:

First year

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Potato			Cabbage				Corn				

Second year

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Cabbage			Caisin				Corn				

OBJECTIVES

For participants to recognize the importance of crop rotation in obtaining healthy soil.

TIME 45 minutes

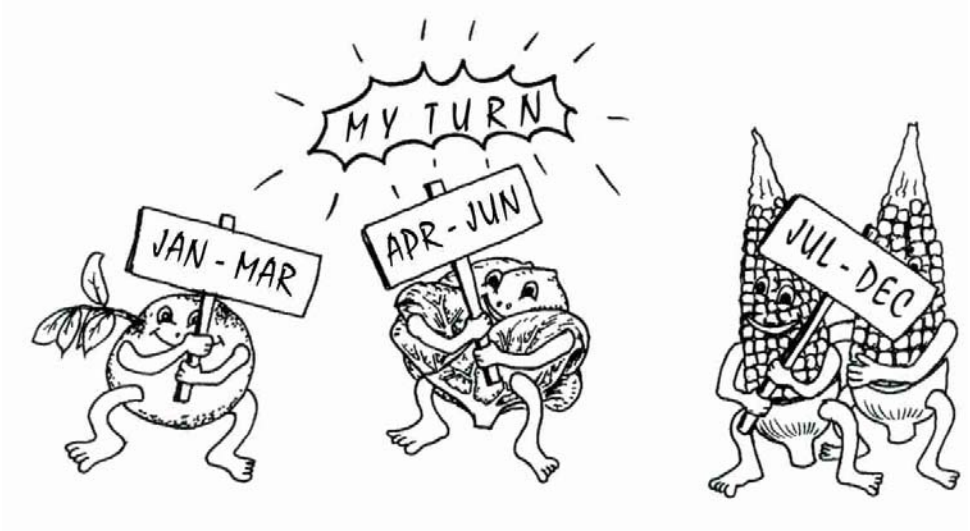
METHODOLOGY Explanation, idea sharing, discussion

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons

STEPS

1. Explain the objectives of this activity to participants.
2. Invite them to discuss their understanding of rotation and its benefits.
3. Supplement discussion output where necessary.
4. Arrange participants into small groups of 4 or 5.
5. Ask each group to talk about their experiences with rotation patterns in their own fields and whether diseases are still present when they use these patterns. Also discuss ideal rotation patterns for preventing diseases from developing in the field.
6. Everyone discusses output from group discussions and draws conclusions together. Make sure participants understand that alternating potato with other crops such as corn or cabbage can help encourage healthy soil.



DISCUSSION QUESTIONS

1. What are the sources of infection in potato plants?
2. How do you usually clear your fields of sources of infection?
3. What does rotation mean? What are the benefits of rotation?
4. What is an ideal rotation pattern to prevent diseases from developing in the fields?

22 SANITATION

BACKGROUND

Sanitation means clearing fields of sources of infection. It begins with planting and continues through plant growth and up until harvesting. Rotten tubers and wilting or sick plants must be removed immediately and destroyed either by burning or burying them. Places where disease infected plants have been pulled up should be marked with stake markers.

Human actions are also an important part of sanitation, for example in preventing to carry infected soil on farming equipment or boots from a diseased field to a healthy field.

OBJECTIVES

For participants to understand the importance of good land management and clearing the land of sources of disease infection.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion and field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them what they understand about sanitation and what its benefits are. If necessary, use colored cards to help participants write down their opinions.
3. Discuss these together providing further explanation or supplementation where necessary.
4. Invite participants to list all sources of infection that can be found in the field. Correct any incorrect answers. The sources of infection are:
   - wilting potato plants or plants that are and otherwise infected by diseases
   - rotten tubers
   - potato plant remnants
   - weeds
5. Arrange participants into small groups of four or five, then give each group the task of discussing ways to clear land of infection sources, and approaches for preventing clean fields from becoming contaminated.
6. Following group discussions, talk about each groups' output in a plenary session.
7. Put discussion output into practice in the field.

8. Draw conclusions together. Conclusions should say:
   - Do not use fresh (uncomposted) manure.
   - Remove all soil carried from other fields on tools, feet, boots or tractors.
   - Prevent water contaminated by infected plants or tubers from flowing into the field.

DISCUSSION QUESTIONS

1. What are the sources of infection in potato plants?
2. How do you usually clear your fields of infection sources?
3. How can you prevent contamination in the field?
4. What does sanitation mean? What are the benefits of sanitation?
5. When does sanitation begin? And how best to do sanitation?
6. How best to destroy disease-infected plant materials?

NOTES

23 WATER MANAGEMENT

BACKGROUND

In order to grow properly, potato plants need water. Therefore, an irrigation system should be considered before planting begins. This system should take into consideration how water will enter and leave the field. The essence of water management is providing water when it is required and removing it when there is too much.

Good water management systems will take a number of things into consideration:
- Maintaining water quality (contamination free).
- Allowing easy entry of water when plants need irrigating.
- Preventing flooding, which causes an increase in late blight, stem rot and bacterial wilt disease.
- Appropriate tillage of soil so water can be available as and when plants need it.
- Building gulleys for water channels and drainage. There should be a minimum of 3 lengthwise and 2 transverse water channels in a potato field, and a minimum of 2 at the edges and 1 in the middle.
- Channels should be deeper than the furrows between rows of plants.

OBJECTIVES

To increase participants' skills and understanding of effective irrigation techniques.

TIME 2 hours

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Watering cans

METHODOLOGY Explanation, idea sharing, discussion, field practice

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them about the irrigation systems they usually use and the advantages and disadvantages of these systems? Discuss with participants.
3. Arrange participants into small groups of 4 or 5.
4. Groups then discuss:
   - When potato plants are watered.
   - How they water them.

- The advantages and disadvantages of the systems they use.
- What an effective irrigation system is like.
- What connections there are between irrigation and pests and disease.

5. Present group discussion outcomes and draw conclusions together.
6. Invite participants to practice flood channel irrigation and using watering cans.

DISCUSSION QUESTIONS

1. What is meant by water management of potato crops?
2. How are they irrigated?
3. When does water management usually take place?
4. Are there any connections between irrigation and pest and disease attack?

NOTES

PEST AND DISEASE MANAGEMENT

5

24 DISEASE MANAGEMENT

BACKGROUND

The following living organisms cause diseases in potato plants:

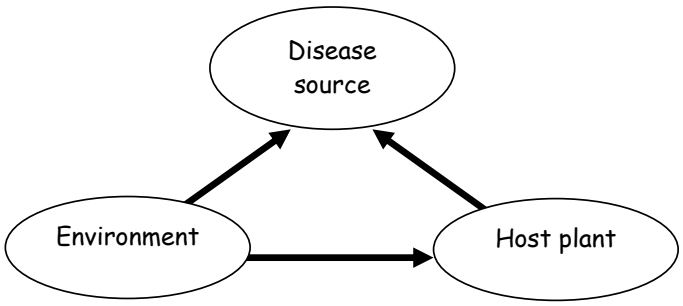
- *Bacteria:* very small in size, invisible to the naked eye, usually cause plants to wilt, affect growth, rot plant parts, etc. Some major potato diseases caused by bacteria are bacterial wilt, soft rot, ring rot, and scab.
- *Viruses:* smaller still than bacteria, they depend on other organisms for survival and transmission. Symptoms may be stunted plants, wrinkled or curled leaves, yellowish or purple leaves. Potato plant diseases caused by viruses are, for instance, potato leafroll virus (PLRV), potato viruses Y and A (PVY and PVA), potato mop-top virus (PMTV).
- *Nematodes:* extremely small worms that live in the plant's root system causing nodules on roots, damage to tuber skins, etc. The most important nematodes causing damage to potato crops are rootknot nematodes and potato cyst nematodes.
- *Fungal diseases:* cause parts of plants to rot, spots to appear, a covering of a powdery layer or fine threads (spores). Major fungal diseases on potatoes include late blight, powdery scab, black scurf, bacterial soft rot, blackleg and Fusarium wilt and dry rot.

Diseases can be carried by wind, insects or water. Sometimes a disease may already be present in a seed potato or remnants left over from an earlier crop may still be present in the soil. The survival and spread of disease organisms is affected greatly by levels of humidity, temperature and sunlight.

There are three factors that influence infections:

- the character of the agent causing the disease.
- environmental factors.
- the character of the plants themselves.

These three factors form the so-called disease triangle. Diseases can be managed by influencing any one of these factors thus obstructing their development.



The best form of disease management is prevention as diseases are normally difficult to control once a plant has already become infected, and they can spread quickly to other plants. Methods for preventing or obstructing development of diseases are:

1. Influencing the disease source through:
   - sanitation.
2. Influencing plants by:
   - using healthy seed.
   - keeping plants healthy.
   - using resistant varieties.
3. Influencing the environment by:
   - organizing plant spacing.
   - investigating planting times in relation to seasons.

OBJECTIVES

1. For participants to be able to explain the causes of disease in potato plants.
2. For participants to be able to explain the processes by which potato plant diseases appear.
3. For participants to understand the principles of disease management.

TIME 45 minutes

METHODOLOGY Explanation, idea sharing, discussion

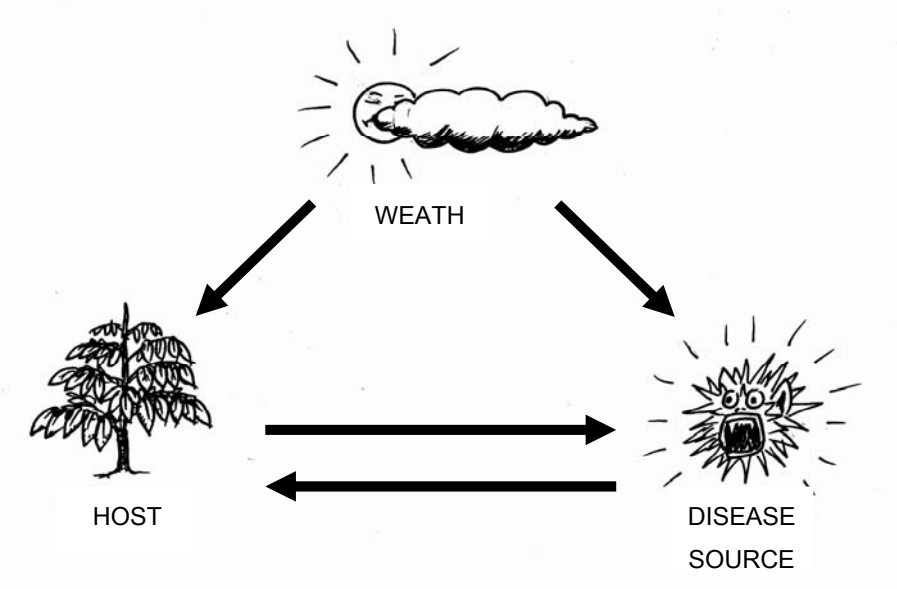
TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons/ colored markers
- Colored cards

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them to list types of diseases that infect potato plants. Use colored cards to help participants write down their opinions.

3. Ask participants what they think the causes of disease in potato plants are.
4. Discuss together and note down output on a large sheet of paper. Notes on causes of disease should include: bacteria, fungal infections, viruses, nematodes, and other causes (lack of nutrients, oxygen etc.).
5. Arrange participants into several small groups of 4 or 5.
6. Ask them to make stories (pictorial or written and preferably based on their experiences) telling how viruses, bacteria, nematodes and fungal infections can spread to other potato plants. Discuss what factors influence the spread of disease and how they can be prevented.
7. Present each group's output and discuss together. Make sure the participants understand the principles of disease management.
8. Ask if participants have any further questions.



DISCUSSION QUESTIONS

1. What diseases affect potato plants?
2. What are the causes of these diseases?
3. How can these diseases appear?
4. What factors influence the spread of disease?
5. How can diseases be prevented?

25 LATE BLIGHT

BACKGROUND

Late blight is one of the main diseases affecting potato plants and damages leaves, stems and tubers. This disease can wipe out a potato crop in a relatively short period of time. The cause of late blight is the fungus *'Phytophthora infestans'*.

Symptoms of late blight infection in potato plants are:

- Early symptoms are small spots appearing on leaves. These may be pale to dark green in color. On the edges or the centers of the leaves these spots appear wet and irregular. Leaves are brown when dry, and black when moist. These spots can spread rapidly at low temperatures and high humidity and infect leaves on other plants. Finally leaves rot and dry out.
- This disease also affects plant stems. Spots appearing on leaf stems will spread to plant stems where they appear long and thin. Infected plant stems will become black and brown then wilt and die.
- When tubers are infected by late blight, their surfaces become brown, irregular and watery. If a tuber is cut open, parts of its flesh will appear brown in color.

A source of late blight could be infections in surrounding fields. Many things can be done to reduce infections or control this disease:

- Integrated management, i.e. management through a combination of preventative measures and use of resistant varieties.
- Use healthy seed.
- Plant during times of relatively low rainfall and hence low humidity.
- Take care of plants by increasing plant spacing, providing the appropriate amount of water, storing tubers correctly.
- Plant varieties that have high levels of resistance to late blight.
- Harvest time management. For example, before harvesting, destroy leaves infected with late blight to reduce the number of tubers becoming infected through contact with infected leaves or stems. Then harvest tubers when they are fully mature to prevent their skins from becoming damaged and infected during harvesting or storage.

OBJECTIVES

1. For participants to explain the characteristics and causes of late blight.
2. For participants to explain sources of late blight infection.
3. For participants to understand ways of managing late blight.

TIME 1 hour

METHODOLOGY Explanation, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Potato plants infected with late blight

STEPS

1. Explain the objectives of this activity to participants.
2. Arrange them into small groups of 4 or 5.
3. Ask them to look in the field for plants showing symptoms of late blight infection.
4. All look at and discuss the plants collected by each group. Invite participants to draw conclusions about the characteristics or symptoms of late blight. Use colored cards for getting the opinions of every participant.
5. Ask participants what the causes of late blight are. Write down their answers on a large sheet of paper and discuss together.
6. Participants return to their groups where they discuss sources of late blight infection and control methods used.
7. Present group discussion outcomes to all participants, discuss together and draw conclusions.
   A summary of management methods is as follows:
   - Use healthy seed
   - Plant at the right time
   - Take care of plants
   - Harvest time management
   - Use resistant varieties
8. Provide further explanations if necessary. Ask if there are any other questions.

DISCUSSION QUESTIONS

1. Has late blight ever affected your potato crops? How far did the infection spread?
2. What are the characteristics of late blight infection?
3. What are the causes of late blight?
4. What are the sources of late blight infection?
5. How can it be controlled?

26 BACTERIAL WILT

BACKGROUND

This disease caused by the bacterium *Ralstonia solanacearum* is one of the most serious diseases affecting potato plants. It develops in high temperatures and high humidity. The primary sources of bacterial wilt infection are:

- Infected seed - Deficient storage systems and tuber selection processes can cause tubers to become easily infected by bacterial wilt.
- Infected soil - Fields in potato producing centers are usually planted continually without consideration for cropping patterns.

It can also spread via water used for irrigation or infected soil carried on the soles of feet or boots or on farming implements. Actual infections of the roots are facilitated when they are damaged by nematodes or tillage.

Bacterial wilt causes wilting to begin on the tips of leaves or where the stems of a plant branch out. Later the whole plant wilts, turns brown and finally dies.

A number of control measures are used preferably in an integrated manner:

- Use of healthy seed.
- Rotation with crops that do not host bacterial wilt.
- Sanitation, destroying remnants of infected plants.
- Tillage.
- Use of well-composted manure.

OBJECTIVES

1. For participants to explain the characteristics and causes of bacterial wilt.
2. For participants to explain sources of bacterial wilt infection.
3. For participants to understand ways of managing bacterial wilt.

TIME 1 hour

METHODOLOGY Explanation, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Potato plants infected with bacterial wilt
- Clear glasses/cups
- Palm leaf ribs, knives, clean water

STEPS

1. Explain the objectives of this activity to participants.
2. Arrange them into small groups of 4 or 5.
3. Ask them to look for plants showing symptoms of bacterial wilt infection in the field.
4. All look at and discuss the specimens collected by each group. Invite participants to draw conclusions about the characteristics or symptoms of bacterial wilt. Ask them what the causes of this disease are.
5. Ask participants to return to their groups, cut pieces of wilted stem about 3-4 cm from the base, then stick lengths of palm leaf ribs through the stem cuttings. Then ask them to suspend stems vertically in glasses of clean water and leave them for several minutes. If a plant is infected with bacterial wilt, the stem will exude a white smoky liquid. This is one sign of bacterial wilt.
6. While waiting, groups can discuss sources of bacterial wilt infection and control methods used.

7. Present group discussion outcomes to all participants, discuss together and draw conclusions. Provide further explanations if necessary. Ask if there are any further questions.

DISCUSSION QUESTIONS

1. Has bacterial wilt ever affected your fields? How far did the infection spread?
2. What are the characteristics of bacterial wilt infection?
3. What are the causes of bacterial wilt?
4. What happened to the potato plant stems in the glasses?
5. What are the sources of bacterial wilt infection?
6. How can you prevent the spread of bacterial wilt in the field?
7. How can it be controlled?

27 VIRUS DISEASES

BACKGROUND

Viral diseases are often widespread as a result of the way farmers use seed. Viral infections are the main form of disease affecting potato plant tissue and anatomy. They are extremely dangerous because they can reduce production, spread rapidly and are difficult to control.

To learn about viral diseases you have to see them first-hand in the field looking at their symptoms and how to detect them, their dangers, how they spread and ways to control them. Viruses are very difficult to detect so observations are made of the symptoms they cause. Viruses are not living creatures because they multiply by splitting themselves inside the cells of their host. Generally to be classified as a living creature, something must breath, eat, drink, reproduce and move.

Viruses are only present inside plants therefore it is highly unlikely they can travel through the air. They spread through parts of infected plants, and through vectors, mainly plant sucking insects such as aphids and thrips. Viruses can multiply rapidly in warm or hot environments.

A number of measures can be taken to reduce contamination or control viral diseases:
- Use healthy seed.
- Use plant varieties with high disease resistance levels.
- Harvest time management. For example destroying infected plants before harvesting to avoid contamination through direct contact.

OBJECTIVES

1. For participants to be able to explain the characteristics of plants infected with viral disease.
2. For participants to be able to explain sources causing spread of viral disease.
3. For participants to understand ways to control viral diseases.

TIME 2 hours

METHODOLOGY Explanation, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Potato plants with viral infections

STEPS

1. Explain the objectives of this activity to participants.
2. Arrange them into small groups of 4 or 5.
3. Ask them to look for plants showing symptoms of viral infection in the field.
4. All look at and discuss the plants specimens collected by each group. Invite participants to draw conclusions about the characteristics or symptoms of different viral diseases. Use colored cards for getting every participant's opinions.
5. Ask participants what caused the viruses to spread to those plants. Write down their answers on a large sheet of paper and discuss together.
6. Participants return to their groups to discuss sources of viral disease contamination and control methods used.
7. Present group discussion outcomes to all participants then discuss together and draw conclusions. A summary of management methods is as follows:
   - Use healthy seed
   - Take care of plants
   - Harvest time management
   - Use resistant varieties
8. Provide further explanations if necessary. Ask if there are any further questions.

DISCUSSION QUESTIONS

1. Have viral diseases affected your crops and to what extent were your crops contaminated?
2. What are the characteristics of contamination by viral diseases?
3. What are the sources of viral disease contamination and spread?
4. How can they be controlled?

NOTES

28 GOLDEN CYST NEMATODE

BACKGROUND

The golden cyst nematode has recently begun to cause problems in certain potato growing regions in Asia and is rapidly spreading. These nematodes cause potato plants to become stunted and produce no or only very small tubers, hence yields are drastically reduced. Additionally, no seed potatoes from infected areas can be sold to farmers in other potato growing areas.

The cysts of the nematodes stay in the soil for long periods, and are hence difficult to get rid of through rotation. They can spread to other fields or other areas through soil on tools, boots and seed tubers.

To identify the presence of golden cyst nematodes, farmers should pull out plants that are stunted and wilted, and observe their root system. Nematode infected plants have short roots and small tubers. At the surface of the roots and tubers small white-yellowish granules can be seen, which are the bodies of immature females.

The best approach is to prevent the potato cyst nematodes from entering the field, hence it is important that farmers can identify its symptoms and presence. Once the nematodes are introduced into an area it is important to limit spread through integrated control measures. Since this is a relatively new disease, it is important that farmers know how to identify the symptoms caused by nematodes and observe their occurence in the field, as to take timely management action.

OBJECTIVES

1. For participants to identify symptoms and presence of the golden cyst nematode in the potato crop
2. For participants to understand the golden cyste nematode's life cycle
3. To provide participants with knowledge on how to manage the golden cyste nematode

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards

STEPS

To observe the presence of the golden cyst nematode, pull up wilting plants and observe their roots and tubers. Roots of infected plants exhibit very small, white bodies, which are the immature females that have erupted through the root epidermis. At very high nematode densities, tubers may become infected, resulting in the appearance of cysts on their surface.

1. Explain the objectives of this activity to participants.
2. Ask them whether the golden cyste nematode have already been observed in their village or in their own fields. Ask them about their characteristics and what the symptoms of golden cyste nematode damage are. Write down their answers on a large sheet of paper. If farmers are not familiar with the term nematode yet, explain what the symptoms are and what nematodes look like.
3. Invite all participants to go to the field to observe potato crops and look for symptoms and presence of golden cyst nematode. Ask them to collect specimens of damaged plants and particularly roots with presence of nematodes.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the golden cyste nematode's life cycle, as far as they can observe from their samples. Let them also discuss at what phases in that life cycle the nematodes damage potato plants, and whether they have natural enemies.
5. Present group output and discuss together.
6. Ask participants what farmers can do to manage golden cyst nematode. Use colored cards to write down their answers. Compile these answers, discuss to what extent they can contribute to prevent or reduce the impact of golden cyste nematode, and complement with additional answers. Emphasize that the most important is to prevent nematodes from entering the field, by being aware of whether and where the pest occurs in the area, and avoiding seed tuber or soil from infected fields to enter a clean field. Make sure that farmers understand that chemical control is of no use.
7. In case infection in the area is already very severe, an experiment could be designed to test biofumigation as a means of suppressing nematode populations in the soil. The idea of biofumigation is that chopped up residues of brassica crops are incorporated into the soil, after which they will release a chemical substance that is poisonous to many soil organisms, including nematodes.

DISCUSSION QUESTIONS

1. What are the characteristics of the golden cyst nematode?
2. What is the golden cyst nematode's life cycle?
3. What are signs of the golden cyst nematode damage on potato plants?
4. How can they be managed?

NOTES

29 INSECT MANAGEMENT

BACKGROUND

In many farmers' eyes, insects are enemies and should be destroyed because they can attack their potato plants. But are all insects actually pests and plant eaters? Are there no insects that eat other insect species? Are all insects really enemies? What if there are insects that in fact help eradicate pests by parasitizing or preying on those insects that do attack crops?

To answer these questions we need to learn how to identify and manage the insects we find in our fields. In this way we can preserve the insects that are beneficial to us and control insect pests.

OBJECTIVES

1. For participants to understand the principles of insect management.
2. For participants to recognize ways of controlling insects and related management principles.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion

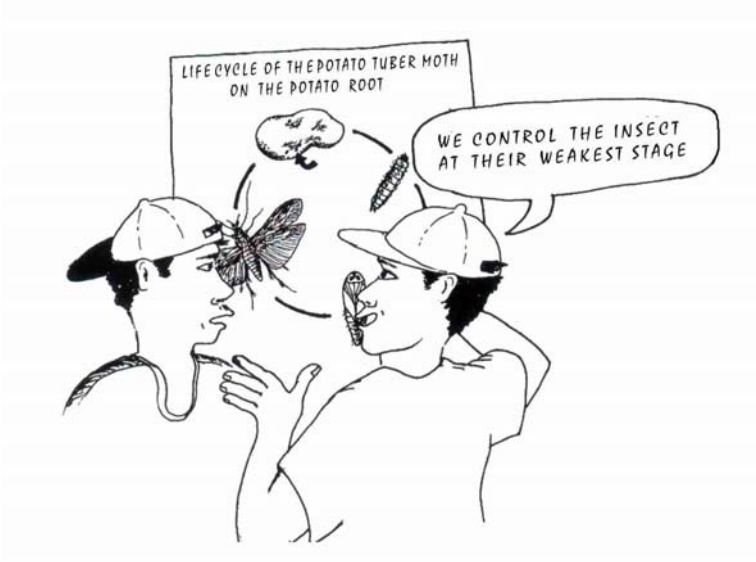
TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Plastic bags
- Nets
- Insects pests that damage potato plants

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them to list some insects that damage potato crops.
3. Arrange them into small groups of 4 or 5.
4. During routine observation time ask participants to collect several insect pest specimens and place them in clear plastic bags. If there are no insect pests present, use a preserved insect collection. Give each group a different insect pest.
5. Ask each group to discuss the life cycle of the insect, what it does to the plants, during which phase of its life cycle it attacks potato plants and how to manage the pest and prevent it from damaging potato plants (make sure they talk about natural enemies).

6. Ask groups to present the outcomes of their discussions. Talk about them together and draw conclusions. Provide further explanations if necessary.



DISCUSSION QUESTIONS

1. Why do we need to manage rather than control insects?
2. When should insects be managed and when should they be controlled?
3. How can we manage natural enemies?

NOTES

30 LEAFMINER FLY

BACKGROUND

The leafminer fly attacks almost all types of crops. Populations develop rapidly as they quickly tend to develop resistance to insecticides. Serious damage caused by this insect can reduce a potato crop's yield by between 40% – 70%.

Adults have white heads with reddish eyes. Their bodies are black and yellow in color. Adult females feed by boring holes into plant tissue.

Damage is apparent from wavy tunnels mined within the leaves causes by the leafminer maggots. Circular 1 mm holes appear on the upper surface of leaves where the flies have been feeding.

Some methods used for controlling leafminer flies:

- Destroying host plants such as cucumber, broccoli, tomato and cabbage before planting potatoes.
- Planting trap crops such as green beans or pulses, after signs of infestation appear in these plants. The leafminer larvae can be eradicated by manually removing and destroying the affected leaves.
- Rotating with crops that do not host leafminer flies.
- Hilling up at the appropriate time can bury pupae that have fallen to the earth and kill them.
- Using tolerant varieties.
- Conserve natural enemies
- Use yellow sticky traps (mainly for monitoring)

OBJECTIVES

1. For participants to understand the leafminer fly's life cycle.
2. For participants to recognize signs of leafminer fly damage on potato plants.
3. To provide participants with knowledge on how to control leafminer flies.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Leafminer flies/insect collection

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether leafminer flies have damaged their fields, using the local term for leafminer fly if necessary. Ask them about their characteristics and what the symptoms of leafminer fly damage are. Write down their answers on a large sheet of paper.
3. Invite participants to look for and make observations of potato plants damaged by leafminer flies, and collect specimens of the insect pest.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the leafminer fly's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present output from each group and discuss together.
6. Ask participants what they usually do to control leafminer flies. Use colored cards to write down their answers.
7. On a large sheet of paper list ways of controlling leafminer flies. Discuss the advantages and disadvantages of each method with the participants. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of leafminer flies?
2. What is the life cycle of the leafminer fly?
3. What are the signs of leafminer fly damage on potato plants?
4. How can they be managed?

NOTES

31 POTATO TUBER MOTH

BACKGROUND

Potato tuber moths are widespread in warm or hot climatic regions. This insect can attack potato leaves and stems in the field, and tubers in the field or while in storage.

Damaged leaves become dark red in color with layers of fine thread covering small grey colored caterpillars. The leaves then curl up, hollow grooves appear inside them and young leaves peel back. In instances of heavy infestation only the dried outer skin of the leaf remains. Moths can lay eggs on tubers while exposed from the soil in the field or during storage. When this happens, the tuber's surface becomes irregular with perforations appearing either inside or just below the skin, and dark brown feces showing on its outer surface.

Several methods can be used to prevent or control this insect pest:
- Using healthy tubers - Eggs, larvae or pupae can remain present inside affected tubers and damage the following year's crop.
- Manual control - Manually removing and destroying affected tubers or leaves.
- Crop rotation – Rotation can break the chain in the potato tuber moth's life cycle preventing it from attacking the following year's crop.
- Crop maintenance - hilling up soil and covering exposed tubers can prevent adult insects from laying eggs on them.
- Using sex pheromones to monitor the population.
- Using a granulosis virus (GV) formulation during storage.

OBJECTIVES

1. For participants to understand the potato tuber moth's life cycle
2. For participants to recognize symptoms of potato tuber moth damage on potato plants
3. To provide participants with knowledge on how to control tuber moths

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Potato tuber moths/insect collection

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether their fields have been damaged by potato tuber moths, using the local term for tuber moth if necessary. Ask them about their characteristics and what the symptoms of potato tuber moth damage are. Write down their answers on a large sheet of paper.
3. Invite participants to look for and make observations of potato plants damaged by potato tuber moths, and collect specimens of the insect pest.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the potato tuber moth's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.
6. Ask participants what they usually do to control potato tuber moths. Use large sheets of paper or colored cards to write down their answers.
7. On a large sheet of paper list ways of controlling the potato tuber moth. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of the potato tuber moth?
2. What is the potato tuber moth's life cycle?
3. What are the signs of tuber moth damage in potato plants?
4. How can they be managed?

NOTES

32 APHID

BACKGROUND

Aphids affect not only potato plants but other crops too. They are about 1-2 mm long, soft and green in color. They are often found on the underside of leaves as they do not like direct sunlight. Aphids suck liquids from plants leaving them weak and can carry and spread viruses as they move from one plant to another.

Symptoms of aphid attack are easily observed on shoots, on tips of leaves or on the underside of young leaves. Damaged plants become crinkly and deformed. Instances of heavy attack can cause plants to wither and die.

Because aphids have many natural enemies such as parasitoids, predators and fungi, these natural enemies can be used in their control.

OBJECTIVES

1. For participants to understand the aphid's life cycle.
2. For participants to recognize symptoms of aphid damage on potato plants.
3. To provide participants with knowledge on how to manage aphids.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Aphids/insect collection

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether their fields have been damaged by aphids, using the local term for aphid if necessary. Ask them about their characteristics and what the symptoms of aphid damage are. Write down their answers on a large sheet of paper.
3. Invite participants to look for and make observations of potato plants damaged by aphids, and to collect aphid specimens.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the aphid's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.

6. Ask participants what they usually do to control aphids. Use colored cards to write down their answers.
7. On a large sheet of paper list ways of controlling aphids. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of aphids?
2. What is the aphid's life cycle?
3. What are the signs of aphid damage in potato plants?
4. What natural enemies did you idenfity in the field?
5. How can aphid populations be managed?

NOTES

33 THRIPS

BACKGROUND

Thrips are very small insects of about 1 – 2 mm in length. Their colors vary from brown to off white; adult insects being darker in color. This pest sucks liquid from the underside of leaves causing plants to weaken and leaves to dry out. Symptoms of thrips damage are irregular bright silvery-bronze colored spots. In cases of extreme infestation, plants can wither, dehydrate and die.

Because thrips thrive in dry conditions, they are commonly negatively influenced by applying sufficient amounts of water to affected plants.

OBJECTIVES

1. For participants to understand the thrips' life cycle.
2. For participants to recognize symptoms of thrips damage on potato plants.
3. To provide participants with knowledge on how to manage thrips populations.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Thrips/insect collection

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether their fields have been damaged by thrips, using the local term for thrips if necessary. Ask them about their characteristics and what the symptoms of thrips damage are. Write down their answers on a large sheet of paper.
3. Invite participants to look for and make observations of potato plants damaged by thrips, and to collect specimens of thrips.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the thrip's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.
6. Ask participants what they usually do to control thrips. Use large sheets of paper or colored cards to write down their answers.

7. On a large sheet of paper list ways of controlling thrips. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of thrips?
2. What is the thrips' life cycle?
3. What are the signs of damage caused by thrips in potato plants?
4. How can they be managed?

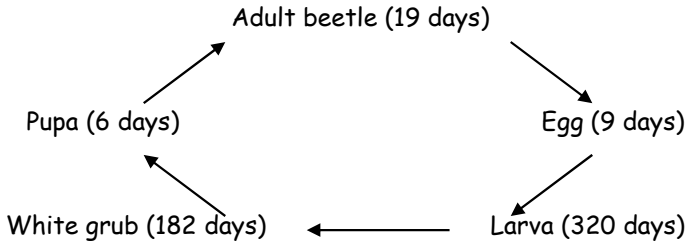
NOTES

34 WHITE GRUB

BACKGROUND

The white grub is another pest that troubles potato farmers. Their bodies are fat and usually curled up like the letter C. They are white in color with orange heads. They have soft short hairs, small mandibles and legs on their thoraxes. White grubs are the pre-adult development phase of the imago. This pest can live in damp soil at a depth of 10 – 30 cm, but during the dry season they are found deeper at about 70 – 80 cm below the surface.

The white grub's life cycle:



A number of things can cause white grub populations to develop: using uncomposted manure which white grubs like to nest in, planting potato crops on fields previously covered with grass, and using inappropriate cropping patterns allowing a constant supply of food for white grubs.

Symptoms of white grub damage are abrasions and irregular holes on tubers, which sometimes become misshapen. This damage can leave tubers vulnerable to infection from diseases.

Common white grub control measures are:
- catching imago/adult insects.
- using cropping patterns to sever the white grub's life cycle.
- managing manure properly to prevent nesting.
- tilling soil deeply so they are exposed to sunlight.
- manually removing white grubs.
- flooding fields.
- making use of bird predators to reduce white grub populations.

OBJECTIVES

1. For participants to understand the white grub's life cycle.
2. For participants to recognize symptoms of white grub damage on potato plants.
3. To provide participants with knowledge on how to manage white grubs.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons, colored cards

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether white grubs have damaged their fields, using the local term for white grub if necessary. Ask them about their characteristics and what the symptoms of white grub damage are. Write down their answers on a large sheet of paper.
3. Invite them to look for and observe potato plants damaged by white grubs. Collect specimens of white grubs.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the white grub's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.
6. Ask participants what they usually do to control white grubs. Use colored cards to write down their answers.
7. On a large sheet of paper list ways of controlling white grubs. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of white grubs?
2. What is the white grub's life cycle?
3. What are the signs of white grub damage in potato plants?
4. How can they be managed?

NOTES

35 CUTWORM

BACKGROUND

Cutworms (*Agrotis spp.*) sever the stems of young plants. They are active at night, and retreat into the soil during the day. They can damage tubers on more mature plants. Symptoms of cutworm damage are broken stems on plants which later die. The larvae are easily identified as they curl into a characteristic C-shape when picked up.

Control measures include:
- Sanitation and thorough tillage can eradicate pupae present in the soil.
- Irrigation before planting.
- Manual control by turning the soil and killing cutworms present around plants.

OBJECTIVES

1. For participants to understand the cutworm's life cycle
2. For participants to recognize signs of cutworm damage on potato plants
3. To provide participants with knowledge on how to control cutworms

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Cutworms

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether their fields have been damaged by cutworms, using the local term for cutworm if necessary. Ask them about their characteristics and what the symptoms of cutworm damage are. Write down their answers on a large sheet of paper.
3. Invite them to look for and observe potato plants damaged by cutworms. Collect specimens of cutworms.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the cutworm's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.

6. Ask participants what they usually do to control cutworms. Use colored cards to write down their answers.
7. On a large sheet of paper list ways of managing cutworms. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of cutworms?
2. What is the life cycle of the cutworm?
3. What are signs of cutworm damage on potato plants?
4. How can cutworms be distinguished from white grubs?
5. How can they be managed?

NOTES

36 MOLE CRICKET

BACKGROUND

Mole crickets usually live below the surface of the soil. They have strong legs, which they use to bore into tubers. Adult insects are 3 cm long and dark red in color. They are active at night and are often attracted to light.

This pest damages the underground parts of plants such as roots, tubers and stem bases. Damage to tubers is more common in the dry than during the rainy season. Symptoms of mole cricket damage are irregular holes in tubers.

Common control measures are removing pests manually, sanitation, and using mature organic compost.

OBJECTIVES

1. For participants to understand the mole cricket's life cycle.
2. For participants to recognize symptoms of mole cricket damage on potato plants.
3. To provide participants with knowledge on how to control mole crickets.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether mole crickets have damaged their fields, using the local term for mole cricket if necessary. Ask them about their characteristics and what the symptoms of mole cricket damage are. Write down their answers on a large sheet of paper.
3. Invite them to look for and observe potato plants damaged by mole crickets. Collect specimens of mole crickets.
4. Arrange participants into small groups of 4 or 5. Ask each group to discuss the mole cricket's life cycle, at what phases in that life cycle it damages potato plants, and whether it has natural enemies during each of its phases.
5. Present group output and discuss together.

6. Ask participants what they usually do to control mole crickets. Use colored cards to write down their answers.
7. On a large sheet of paper list ways of controlling mole crickets. Together with participants discuss the advantages and disadvantages of each of these methods. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What are the characteristics of mole crickets?
2. What is the mole cricket's life cycle?
3. What are signs of mole cricket damage on potato plants? How can this damage be distinguished from that caused by cutworm and/or white grubs?
4. How can they be managed?

NOTES

FERTILIZERS

6

37 ORGANIC FERTILIZER

BACKGROUND

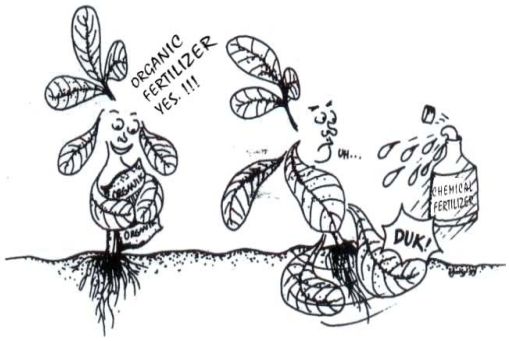
Organic matter such as grass, leaves, hay, rice husks, plant remnants, manure and kitchen waste is freely available all around us. This organic matter can be turned into organic fertilizer, which functions as a nutrient source for plants, and can regulate soil temperature and moisture levels.

There are a number of ways to utilize organic matter:

1. *Direct application to soil:* Organic matter applied directly without processing is usually made into mulch on top of the soil, or buried below the surface.
2. *Burning:* When transporting bulk organic matter is a problem, it is commonly burned after which the lighter ash is applied to the field. Burning, however, causes the loss of several nutrients, particularly nitrogen.
3. *Composting:* Composting is the process whereby organic matter is decomposed by microorganisms to form compost. Composting bacteria are often used to accelerate the decomposition process. Compost helps to increase soil fertility and improve soil structure.
4. *Fermentation:* Manure can be utilized as a source of biogas.
5. *Animal feed:* In some regions, farmers use organic matter such as leaves, straw and hay for animal feed.

OBJECTIVES

1. For participants to understand ways of managing organic matter.
2. For participants to understand how important organic fertilizer is for their crops and soils.



TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- 1 bucket of composted manure
- 1 bucket of uncomposted, wet manure

STEPS

1. Explain the objectives of this activity to participants.
2. Arrange them into small groups of 4 or 5.
3. Give each group some composted and uncomposted manure.
4. Ask participants to make observations of the organic fertilizer for around 5 to 10 minutes and note down what they find in each of the piles of organic fertilizer. Ask groups to discuss what they have found in the fertilizer and whether it can have negative or positive effects on potato plants. Ask them why.
5. Present group discussion outcomes to all participants, discuss together and draw conclusions. Provide further explanations if necessary.

DISCUSSION QUESTIONS

1. What organic matter can we find around us?
2. How can we manage organic matter and make it beneficial?
3. What components are there in the organic fertilizer?
4. What influence do these have on potato plants?
5. What are the benefits of organic fertilizer?

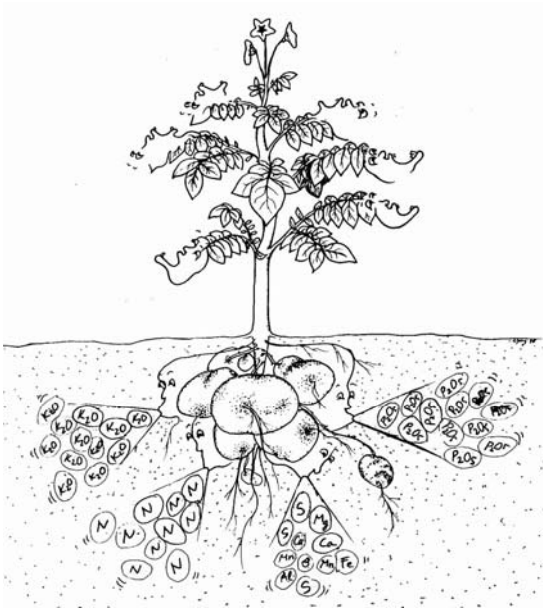
NOTES

38 CHEMICAL FERTILIZERS

BACKGROUND

Plants need nutrients for their growth and development. Some of these, such as Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Magnesium (Mg), Iron (Fe), they require in large quantities.

Function of Potassium (K) on plants:
- encourages leaf growth.
- encourages tuber formation and increases tuber weight.
- plays a part in producing proteins.
- increases vitamin A content.
- increases resistance to disease.



Function of Nitrogen (N):
- component of chlorophyll which helps absorb sunlight.
- encourages leaf growth.
- increases tuber protein content.
- enlarges leaves and tubers.

Function of Phosphorus (P):
- encourages root growth.
- encourages tuber development.
- plays a part in chemical processes.

Function of Sulphur (S):
- plays a part in chemical processes.
- a feature of plant proteins and hormones.

Function of Magnesium (Mg):
- plays a part in producing proteins.
- a component of chlorophyll.

Although these nutrients occur naturally in the soil, concentrated formulations of nutrients are being produced in the form of chemical fertilizers. They are applied to the soil and/or on plants and can be absorbed through roots or leaves. However, because chemical fertilizers are regularly used inappropriately, they often fail to have the desired effect.

OBJECTIVES

1. To recognize chemical fertilizer types
2. To understand the function of the three major nutrients, N, P and K through omission trials

TIME 1 hour

METHODOLOGY Explanation, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Several types of chemical fertilizers (urea, super-phosphate, KCl, NPK, foliar fertilizers, etc.)
- 27 seedlings (tomato, cabagge,)
- 9 plastic cups
- Sand

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them what chemical fertilizers they use in their fields and how they usually apply each of them. Compile their answers on a large sheet of paper.
3. Divide participants into three small groups. Each group receives some chemical fertilizer types and is asked to note down their composition and the percentages of nutrients in each of them. All results are presented to the large group.
4. Each of the small groups will conduct an omission trial for one major element: N, P or K. This means that all nutrients except one will be provided to plants, after which deficiency symptoms of the lacking nutrients will emerge. Each group prepares three pots with sand and three vegetable seedlings per pot. Solutions of urea, Super-phosphate and KCl are made and provided to the groups. Each group regularly water their plants with only two of the three nutrients solutions:
   - The group doing the N-omission trial: only with Super-phosphate and KCl
   - The group doing the P-omission trial: only with urea and KCl
   - The group doing the K-omission trial: only with urea and Super-phosphate
5. All pots are labeled with the treatment and the replication number. The participants should make weekly observations and note down any deficiency symptoms that occur. After 4-6 weeks, the results are presented to the large group and discussed.

DISCUSSION QUESTIONS

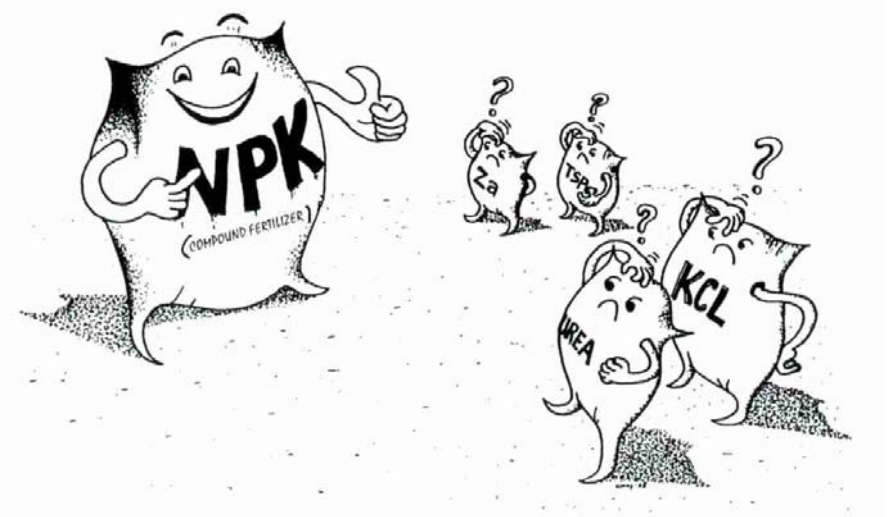
1. What chemical fertilizers do you know and what nutrients do they contain and in what percentages?
2. How and when are chemical fertilizers usually used?
3. What are the deficiency symptoms of the three major nutrients, N, P and K?

NOTES

39 COMPOUND OR SINGLE NUTRIENT FERTILIZERS?

BACKGROUND

Compound fertilizers are fertilizers that contain more than one of the nutrients plants require. Usually compound fertilizers contain N, P and K in certain ratios. Examples of compound fertilizers are NPK, Rustica Yellow, Amophos and Nitrophos-K.



The advantage of compound fertilizers is their easy application to crops as plants generally absorb them more quickly and easily. Nevertheless, they are relatively expensive and contain relatively small amounts of macronutrients (N, P and K).

Single nutrient fertilizers are chemical fertilizers containing only one kind of nutrient. For example urea only contains N, and KCL only contains K. Advantages of single nutrient fertilizers are they are cheap and can be applied to provide the exact amount of a certain nutrient a crop requires at any given time. For example, if a crop only requires N, then you only need to apply urea.

It is possible to replace compound fertilizers with single nutrient fertilizers. To achieve the right mix, farmers should be aware of the crop's nutrient requirements at any given stage in its growth. Farmers should also know what nutrients each single nutrient fertilizer contains in what quantity.

For example:
100 kg of NPK 15-15-15 compound fertilizer contains:

- 15% N x 100 kg = 15 kg N
- 15% P2O5 x 100 kg = 15 kg P_2O_5
- 15% K2O x 100 kg = 15 kg K_2O

If we make our own mix:

- urea = 45% N
- SP-36[3] = 36% P_2O_5
- KCL = 60% K_2O

100 kg NPK 15-15-15 is equivalent to:

- 100/45 x 15 kg N = 33.3 kg urea
- 100/36 x 15 kg P2O5 = 41.7 kg SP-36
- 100/60 x 15 kg K2O = 25.0 kg KCL
- Total: = 100 kg

The price of 100 kg of urea, SP-36 and KLC in the above proportions can be calculated and compared to the cost of 100 kg of NPK fertilizer.

OBJECTIVES

1. For participants to understand the difference between single nutrient and compound fertilizers.
2. For participants to understand the information contained on fertilizer labels or sacks.
3. For participants to be able to calculate equivalent nutrient percentages for replacing compound with single nutrient fertilizers.

TIME 1 hour

METHODOLOGY Explanation, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, adhesive tape, markers
- Colored cards
- Several examples of compound fertilizer
- Several examples of single nutrient fertilizer
- Fertilizer sacs and/or labels

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them what they know about the terms single nutrient fertilizer and compound fertilizer. If necessary use colored cards to help them write down

[3] SP-36 is a super-phosphate fertilizer commonly used in Indonesia, containing 36% P_2O_5. Calculations in the example can be adjusted for locally available types of fertilizers.

their opinions. Discuss answers together directing discussions towards understanding the terms single nutrient and compound fertilizer.

3. Provide participants with a number of empty chemical fertilizer sacks of different types of fertilizer, then ask them to group them into two categories; single nutrient fertilizer and compound fertilizer.
4. Arrange participants into small groups of 4 or 5. Ask each group to take 2 compound fertilizer labels/empty sacks and 2 single nutrient fertilizer labels/empty sacks. Groups then discuss the meaning of the information written on the labels/sacks.
5. Present group discussion outcomes to all participants and discuss together. If their output is incomplete, you can supplement what the participants have said.
6. Participants return to their groups. Ask each group to:
   - Calculate the NPK content in kilograms found in 100 kg of NPK 15-15-15 fertilizer.
   - Calculate how many kilograms of each single nutrient fertilizer are required to replace the compound fertilizer. The NPK replacements could be urea, SP-36 and KCL in the following percentages: urea = 45 % N, SP-36 = 36% P_2O_5, KCL = 60% K_2O, or any other commonly used single nutrient fertilizer.

   Participants can use the following formula:

$$X\ (kg) = \frac{100 * A}{B}$$

   X: the amount of single nutrient fertilizer required to provide the same amount of a nutrient as is found in 100 kg of the compound fertilizer.
   A: content (%) of a certain nutrient in a compound fertilizer
   B: content (%) of the same nutrient in a single nutrient fertilizer
   Example: amount of urea needed to replace the nitrogen in 100 kg of NPK:

$$\frac{(100x\ 15\%)}{45\%} = 33\ kg$$

7. Present group discussion outcomes to all participants and discuss together.

DISCUSSION QUESTIONS

1. What are the differences between compound and single nutrient fertilizers?
2. What are the advantages and disadvantages of compound and single nutrient fertilizers?
3. Under what conditions can we replace a compound fertilizer with single nutrient fertilizers?

PESTICIDES

7

40 WHAT ARE PESTICIDES?

BACKGROUND

The word pesticide originates from the words "*pest*" originally meaning a plague and applying to insects, weeds and disease, and "*cidere*" meaning killing. Pesticides can either be artificially produced chemicals, extracts from plants or animals, or microorganisms (bacteria, fungi and viruses). They are used to kill or inactivate crop-damaging insect pests, diseases, weeds and nematodes.

Pesticides are categorized based on certain criteria:

1. Their intended targets – these are categorized as:
   - Insecticides - pesticides for killing insects.
   - Fungicides - pesticides for killing fungal diseases.
   - Bactericides - pesticides for killing bacterial diseases.
   - Herbicides - pesticides for killing weeds.

- Acaricides - pesticides for killing mites.
- Rodenticides - pesticides for killing rodents.
- Nematicides - pesticides for killing nematodes.

2. Their formulations - these are categorized as:
   - EC: Emulsifiable Concentrates – Active ingredients in thick oil containing an emulsifier in the form of a kind of detergent. The thick solution can be diluted with water for use in sprayers.
   - WSC: Water Soluble Concentrates – active ingredients are water soluble or are already dissolved in organic solvents such as alcohol.
   - WP: Wettable Powder - WP formulations contain a wetting agent and other materials, such as adhesives. The wetting agent acts to provide an even mix of powder and water.
   - G: Granules – the components of this formulation are the active ingredients, and adhesive.
3. Their toxicity classigication - these are categorized as:
   - Class Ia: extremely hazardous.
   - Class Ib: highly hazardous.
   - Class II: moderately hazardous.
   - Class III: slightly hazardous.
   - Class IV: unlikely to present acute hazard in normal use.

Even though pesticides are mostly promoted to be quite safe for non-target organisms, they often tend to poison a lot more than we might expect.

OBJECTIVES

1. For participants to be able to explain what is meant by pesticides.
2. For participants to recognize pesticide categories.

TIME 45 minutes

METHODOLOGY Explanation, idea sharing, discussion

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Colored cards
- Pesticide packaging with labels intact

STEPS

1. Explain the objectives of this activity.
2. Ask participants what pesticides are. They may write down their opinions on colored cards. Discuss their answers and draw conclusions together. If

necessary, provide additional explanations about the meaning of the term pesticide.

3. Arrange participants into small groups of 4 or 5. Give each group an intact pesticide product label and ask them to discuss what information it contains and what that information means.
4. Present each groups' output and discuss together.
5. From this discussion, ask participants what pesticide categories there are. If necessary use colored cards to help participants write down their opinions. Discuss their answers together providing further explanations if necessary.

DISCUSSION QUESTIONS

1. What does pesticide mean?
2. What are the categories of pesticides?
3. What information is found on pesticide packaging or labels?
4. What does that information mean? Is it easy to understand?

NOTES

41 PESTICIDE HAZARDS

BACKGROUND

Pesticides are used to exterminate insect pests, diseases or weeds. Pesticides can travel through air, water, soil or dust and may be carried by living creatures. This means pesticide poisons can affect creatures far away from where spraying has originally taken place. Some pesticides can remain active in soil for many years.

Excessive and continual use of pesticides as part of farming practices can harm farmers and farm workers. Insect pests and diseases can become resistant to the active ingredients in pesticides, and will no longer die after pesticide application. Pest populations can also increase after natural enemies have been exterminated by pestcides, a process that is called resurgence. Residues of certain types of pesticides, particularly the notoriously persistent organochlorines, can remain in soil, water and plants for substantial periods of time.

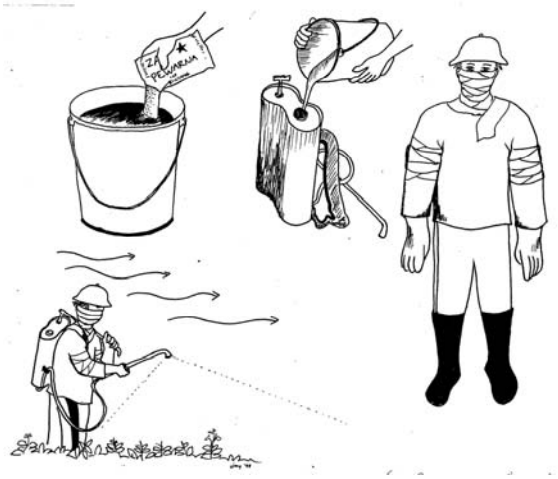
Pesticides can still be hazardous even if all the directions on labels are carefully adhered to. Those directions are no guarantee against what hazards may arise as a consequence of using the pesticide.

OBJECTIVES

For participants to understand how pesticide use can be directly hazardous to humans.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea sharing



TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Sprayer (17 liter)
- 1 roll of toilet paper
- Red dye
- Water
- Field

STEPS

1. Explain the objectives of this activity to participants.

2. Initiate a discussion about pesticide hazards to human health. Let farmers report on their knowledge about the different toxicity levels of pesticides available on the market. There may be farmers in the group who can report on any pesticide poisoning incidents that they have experienced.
3. Invite the participants to conduct a small exercise demonstrating how farmers get exposed to pesticides when they apply them in the field. Explain the purpose of the exercise.
4. Ask them to prepare a mixture of water and red dye. Fill the sprayer with the colored water.
5. Ask a volunteer to step forward. Wrap toilet paper around his or her legs, arms, head and face leaving eyes free.
6. Ask the volunteer to put on the sprayer and spray the field as he/she would normally do with pesticide. Allow this to go on for about 10 minutes.
7. Take off the sprayer and let everybody observe which parts of the body of the volunteer have changed color. Observe the head, chest, back, forearms, elbows, legs and other parts of the body.
8. Ask participants what would happen if the colored water in the sprayer had been real pesticide? What happens to people who spray pesticides? How can pesticide enter people's bodies? Discuss the dangers of pesticides with participants. Provide additional explanations as necessary.

DISCUSSION QUESTIONS

1. What parts of the body did the red water hit?
2. How can pesticides enter the body?
3. Can using protective clothing such as masks, gloves, or boots reduce pesticide poisoning?
4. How does wind affect which parts of the body become exposed to pesticide while spraying?
5. Are pesticides safe? What are their effects on humans?

NOTES

42 FUNGICIDES

BACKGROUND

Fungicides are pesticides used to control fungal diseases. *Contact* fungicides remain on the leaf surface where they are deposited. At most, they spread out slightly on the leaf surface, but they do not move inside the leaf tissue. Leaves or areas of leaves that do not receive fungicide are not protected. *Systemic* fungicides are absorbed into the leaf tissue, and hence protect the whole plant from within.

Preventative fungicides protect the surface of the leaf by inhibiting spore germination and infection. They can be contact or systemic fungicides. *Curative* fungicides kill the fungus and fruiting body within the leaf, and therefore are always systemic fungicides

Choice of which fungicide to use should be made according to conditions in the field. If signs of fungal disease have appeared, it is best to use fungicides that suppress fungal growth or stop it from spreading.

OBJECTIVES

For participants to understand how fungicides work so they become more selective in their use.

TIME 30 minutes

METHODOLOGY Explanation, idea sharing, discussion

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Colored cards
- Fungicide packaging with labels intact

STEPS

1. Explain the objectives of this activity.
2. Ask participants what fungicides are. They can write down their answers on colored cards. Discuss their answers and draw conclusions together.
3. Arrange participants into small groups of 4 or 5. Give each group one intact fungicide product label and ask them to discuss what information it contains and what that information means.
4. Let all groups present their outputs and discuss the results.

DISCUSSION QUESTIONS

1. What does fungicide mean?
2. How do fungicides work?
3. Do fungi disappear after being sprayed with fungicide?
4. What information is found on fungicide packaging?
5. Is the information on fungicide packaging easy to read and understand?

NOTES

43 THE EFFECTS OF INSECTICIDES ON PESTS AND NATURAL ENEMIES

BACKGROUND

Many potato farmers now depend on pesticides when managing their fields. However, excessive and continual use of pesticides can cause insect pests and diseases to become resistant and can lead to resurgences of pests in greater numbers when their natural enemies have been killed.

When an insect pest becomes resistant to a pesticide, farmers tend to use it in greater quantities or mix with other insecticides in the hope to make it more effective at exterminating the pest. But insecticides are poisons that kill pests and natural enemies indiscriminately, therefore knowledge of the effects of pesticides to both pests and natural enemies is extremely important for farmers.

OBJECTIVES

For participants to understand the impact of insecticide use on pests and natural enemies.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards
- Several brands of insecticide with different active ingredients
- Hand sprayers (4)
- Water
- Insect pests and natural enemies
- Mineral water bottles

STEPS

1. Explain the objectives of this activity.
2. Invite participants to conduct a practical experiment. Prepare the tools and materials together. Three insecticide solutions are prepared as follows:
   - one with an insecticide that farmers consider effective
   - one that they find ineffective
   - one with a mixture of these two types in a certain concentration
3. More insecticide types or mixtures can be added to the list if the group would like to test those. Note down the active ingredients, brand names and the year the pesticides were certificated for use. Each solution is put in a separate

hand sprayer. A last sprayer is filled with plain water for the control treatment.

4. Look for plants in the field with insect pests and natural enemies present. E.g. thrips, aphids, leafminer flies, etc.
5. Pick some leaves that have pests and natural enemies on them. Note down the species and number of insects.
6. Place the leaves with the pests and natural enemies into mineral water bottles. Affix a label to each bottle containing the following data: date they were placed in the bottle, the species and number of pests, species and number of natural enemies, and an identity code for each bottle.
7. Spray the prepared insecticide solutions and the control treatment each into a separate bottle.
8. Make observations after one or two hours. Look at what happens to the pests and the natural enemies, and write down the condition that each of them is in. Prod them gently with pencils or small pieces of wood to determine whether they are really dead. Observe which ones die first, the pests or the natural enemies.
9. Ask participants to take the bottles home for further observations during the coming days. Observation notes should be presented at the next meeting.

DISCUSSION QUESTIONS

1. What happened after the pests and natural enemies were sprayed with insecticide?
2. Which ones died first, the pests or the natural enemies?
3. What are the effects of pesticide use on the environment?

NOTES

HARVEST AND POST- HARVEST MANAGEMENT

8

44 HARVESTING

BACKGROUND

Determining the right time to harvest is essential for achieving high quality produce. Usually potato crops are harvested when tubers are mature, but there are some other considerations too. These are:

- *Crop age* – In tropical highland areas, potato crops are usually harvested before they are 90 days old when leaves begin to yellow and plants start to die.
- *Weather conditions* - Harvest should be done in clear dry weather and not when it is raining.
- *Pests and diseases* – Timely harvesting can help avoid serious pests and disease damage.
- *Market price* – Harvesting is best done when market demand causes an increase in potato prices.

Key factors in producing high quality tubers are harvest time management and harvest method. Careless harvesting practices will damage tubers leaving them vulnerable to pests and diseases.

On loose soil without weed growth, potato beds can be dismantled by hand. However, when soil is too hard and is covered with weeds, potato beds should be dug up carefully using a hoe. To avoid any damage to tubers, begin digging from the edge of a potato bed, so the soil loosens and can then be broken by hand.

Leave tubers on the ground for a while to allow any soil caked on them to dry out and fall off, as soil left on tubers can cause them to rot. Tubers should then be sorted, separating healthy ones from damaged ones, and big ones from small ones (depending on what the market demands). Do not leave tubers in the field for too long as they may be attacked by pests such as potato tuber moth, and become a source of infection for other crops. Not long after sorting, tubers should be stored ensuring they are clean to reduce the possibility of pests and disease infestation.

OBJECTIVES

1. For participants to be able to determine appropriate times for harvesting.
2. For participants to be able to harvest and store their produce effectively.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea sharing

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them when they usually harvest and what considerations help them determine appropriate times for harvesting. Use colored cards to help participants write down their opinions.
3. Discuss their answers together. Ask them whether apart from the conclusions drawn together there are any other factors to consider in determining when to harvest.
4. Ask how they harvest and store their produce. Arrange participants into small groups of 4 or 5 to discuss their experiences and discuss the advantages and disadvantages of their harvesting and storage methods.
5. Present each group's outputs and discuss together.

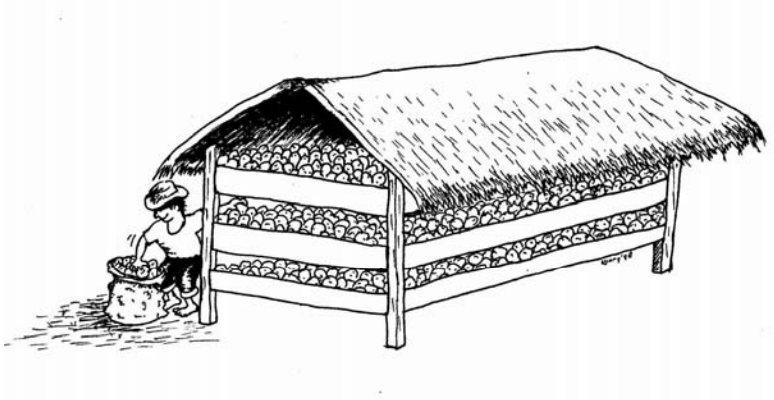
DISCUSSION QUESTIONS

1. When do you begin harvesting?
2. What are signs that a potato crop is ready for harvesting?
3. What considerations are there in determining when to harvest?
4. What happens if you harvest earlier or later?
5. What harvesting methods do you usually use? What are advantages and disadvantages of the different methods?
6. How do you manage your produce?
7. What is a good storage method for your produce?

45 SEED STORAGE

BACKGROUND

Appropriate storage practices are important for ensuring high-quality seed. Seed potatoes can be stored in light or dark conditions and at high or low temperatures, depending on what is required during storage. If the aim is to retard sprouting, they are stored at low temperatures (2°C - 4°C), whereas higher storage temperatures (10°C - 20°C) will have the opposite effect and accelerate sprouting. When tubers are exposed to light during storage, sprouts will be robust, short and dark in color. Sprouts will be longer and lighter in color when stored in dark conditions.



Aspects to pay attention to in the storage place are temperature, humidity and air circulation.

1. Storage temperature
   - If there is only a short period of time between harvesting and planting the next crop, tubers should be stored at high temperatures to accelerate sprouting.
   - If they are stored for a longer time then lower temperatures (2°C - 5°C) are more advisable so they do not sprout too quickly.
2. Humidity
   - Not too low as this will cause tuber shrinkage and weight loss.
   - Overly humid conditions will increase the risk of disease, condensation and rotting. Tubers will become damp and sprout easily.
3. Air circulation
   - Ventilation is necessary to ensure a clean and even flow of air and to regulate humidity.
   - Air flow will be affected by storage practices and whether tubers are stored in piles, kept in sacks or on racks.

Seed potatoes can be stored in a storage area in a number of ways:

- Piled up

- Stored in sacks, boxes or baskets
- Placed on storage racks
- Stored in perforated plastic bags

OBJECTIVES

For participants to use appropriate seed potato storage techniques.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons, colored cards
- 150 kg of potatoes (or any smaller quantity in case local practice allows for storing smaller units)
- 1 plastic sac
- 1 fruit basket
- Storage area

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them how they usually store their seed potatoes. Write down their answers on a large sheet of paper or colored cards. Discuss participants' answers together asking about the advantages and disadvantages of each storage method.
3. Invite them to do a seed potato storage practical.
   - Fill the plastic sac with 50 kg of seed potatoes then tie it up.
   - Fill the basket with 50 kg of seed potatoes, then cover it with a clean sack or plastic sheet.
   - Place the seed potatoes in the storage area.
   - Pile up or leave the remaining 50 kg of seed potatoes in a storage area exposed to daylight.
4. Conduct weekly observations of the stored seed potatoes until planting time. Ask participants to make observations, take notes and present their findings at each subsequent meeting.

DISCUSSION QUESTIONS

1. What storage methods do you usually use for your seed potatoes?
2. What are the advantages and disadvantages of those methods?
3. What is happening to the stored seed potatoes? What visible differences are there between the three storage methods?
4. What is the best method for storing seed potatoes?

46 MARKETING

BACKGROUND

The market place is the meeting point for buyers and sellers; the place to buy the goods we need for our day-to-day lives. It is also the place to find farm produce, including potatoes.

Potato farmers in Indonesia, however, almost never meet consumers face to face because of the physical distances between them. Potato farmers still depend on intermediaries or traders to distribute their produce to consumers. It is these traders that establish marketing channels and determine potato prices leaving farmers, with their weak bargaining positions, in passive acceptance of the prices offered to them. Traders manipulate not only prices, but sometimes weight measurements too, and ultimately it is they, and not farmer producers, who profit the most from farmers' hard labor to produce potatoes!

Factors influencing marketing are the following:

- Quality of goods - High-quality potatoes can command higher prices. Consumers will not buy poor-quality potatoes at high prices.
- Farmer cash needs - Sometimes farmers sell their potato produce for reduced prices because they need money quickly in order to fulfill urgent family requirements.
- Farmer organizations - Farmers who sell their produce on an individual basis are not in a position to demand higher prices because traders can always look elsewhere. However, when farmers group together to form collectives or farmer organizations, their bargaining position becomes much stronger because traders will have fewer sources to choose from.

To command fair prices we need to develop sound marketing strategies, maintain high-quality produce, access market information and strengthen farmer organizations.

OBJECTIVES

1. For participants to know about markets and marketing.
2. For participants to understand marketing strategies.
3. For participants to consider building marketing networks.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea/experience sharing, role play

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons
- Colored cards

STEPS

1. Explain the objectives of this activity to participants.
2. Invite them to role-play farmers and traders. Ask three participants to be farmers and two to be traders or intermediaries, and role-play a transaction between the two parties. Ask other participants to observe and note down any important points arising during the role play.
3. Following the role play, ask participants what factors are influential in marketing. Note their answers down on a large sheet of paper then discuss together.
4. When participants are familiar with factors affecting marketing, arrange them into small groups of four or five. Ask each group to discuss their marketing strategies and how to develop a farmer-based market network.
5. Present each group's output and discuss together. Provide additional explanations if necessary.

DISCUSSION QUESTIONS

1. How do you normally market your produce?
2. What are the advantages and disadvantages of those marketing methods?
3. How do you get access to market information?
4. What are your marketing strategies?
5. How can you develop a farmer-based market network?

NOTES

47 FARM ECONOMIC ANALYSIS

BACKGROUND

A farm economic analysis is done in order to calculate whether farming efforts have been, or will be, economically viable. By doing such an analysis, farmers can compare their profits with their losses and estimate their income and expenditure. Unfortunately, farmers rarely make these calculations, and sometimes their incomes are not enough to cover their high production costs.

The two important points to consider when conducting a farm economic analysis are expenditure and income. When looking at expenditure, determining factors are all goods and services costs, outgoing payments for land rental, labor, inputs (seed, fertilizer, treatments etc.), transport, tax, harvesting, etc. When calculating income, the determining factors are the amount of produce harvested and the market price. All produce is calculated in monetary terms even though some may be consumed by the family or given to neighbors (opportunity cost). All outgoing and incoming amounts are calculated and added up to reach total figures for expenditure and income. The figure for total expenditure is subtracted from the total income to determine actual earnings (net return or profit).

In this activity we discover what factors influence profit and loss, and how best to develop strategies to increase efficiency and profits.

OBJECTIVES

1. For participants to be able to explain the meaning of a farm economic analysis.
2. For participants to be able to do a potato production economic analysis.

TIME 1 hour

METHODOLOGY Explanation, idea sharing, discussion, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape
- Colored cards
- Record keeping and analysis forms

STEPS

1. Explain objectives of this session.
2. Ask participants what the term "farm economic analysis" means to them and what its use is.

3. Write down their answers on a large sheet of paper, and provide a more detailed explanation of a farm economic analysis.
4. Ask participants what they should calculate when analyzing their farming enterprises (e.g. income, expenditure, etc.). Invite them to list what things come under expenditure and income. Using colored cards, give every participant the opportunity to offer his or her opinion. When participants have finished listing all forms of expenditure and income, invite them to analyze their potato production enterprise so they can know how much net profit they actually make.
5. Help participants to do a potato farm economic analysis either of their own fields, or of the experimental plot. Show them an example of how to keep records of expenditures, labor investments and income throughout the season, and how to do the economic analysis using the record data.

DISCUSSION QUESTIONS

1. What is a farm economic analysis?
2. What are the benefits of doing farming economic analyses?
3. How can you do a good farm economic analysis?

EXPERIMENTS

9

48 FARMER EXPERIMENTS

BACKGROUND

Farmer experiments are activities in which farmers can study ideas, new information or compare new technologies with the methods they usually practice.

Through these experiments, farmers can avoid becoming easily influenced by other people or new products and can discover the most appropriate cultivation methods for their fields. To conduct experiments effectively, farmers need to be skilled at designing, implementing, analyzing and evaluating experiments.

There are a number of steps involved in conducting experiments:
- Determining experiment topics and objectives.
- Designing - This can be done simply, but attention should be paid to determining treatments, the number of treatments and replications, experiment plot location, timing, and necessities such as tools and materials.
- Preparing - To ensure experiments run smoothly, before they commence all tools and materials should be ready and everyone involved must know what their roles are.
- Implementing - In order to know how an experiment is progressing, observations must be made of relevant changes that take place. All activities and observation results should be recorded for the duration of the experiment.
- Analyzing results - For appropriate conclusions to be drawn, all results must be analyzed. These analyses can be the basis for formulating follow-up plans.

OBJECTIVES

1. For participants to understand the steps involved in conducting experiments.
2. For participants to be able to design and conduct experiments.

TIME 1 hour

METHODOLOGY Explanation, discussion, idea sharing, field practice

TOOLS & MATERIALS

- Large sheets of paper, markers, adhesive tape, crayons

STEPS

1. Explain the objectives of this activity to participants.
2. Ask them whether they have ever conducted experiments or tried comparing different cultivation methods in their fields. If they have, ask them to talk about what those experiments were and how they were conducted. Write down their answers on a large sheet of paper, then discuss the advantages and disadvantages of their experiments together.
3. From the discussion, draw conclusions together about what experiments are, the steps they involve, and how to design them in a systematic manner. Provide further explanations if necessary.
4. Arrange participants into small groups of 4 or 5. Ask each group to determine what experiment they would like to do and then let them make a design for it using the guidelines developed earlier.
5. Present output from each group's discussion, then agree which experiments to conduct in the learning plot. If more than one group has chosen the same topic they can work on the experiment together.

DISCUSSION QUESTIONS

1. What are experiments?
2. What steps are involved in conducting experiments?
3. How do you design an experiment?

NOTES

49 BACTERIAL WILT BIOESSAY

OBJECTIVES

1. To test whether the bioassay method can be used as a reliable means for farmers to detect the presence of bacterial wilt in their soil or manure.
2. To determine whether manure or soil for the next potato crop is contaminated with bacterial wilt.

TOOLS & MATERIALS

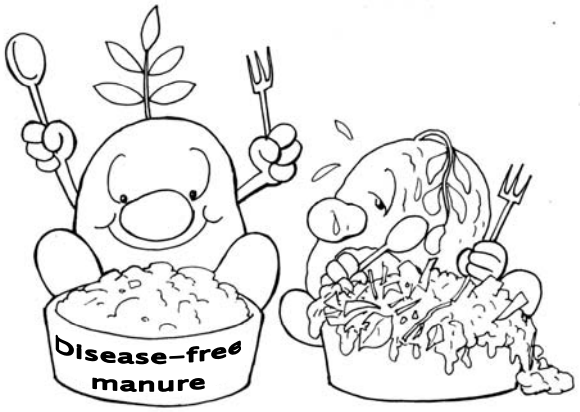
- Hoes
- Plastic cups or polybags
- Bacterial wilt free soil
- Soil contaminated with bacterial wilt
- Bacterial wilt free organic fertilizer (composted manure)
- Organic fertilizer contaminated with bacterial wilt (uncomposted manure with a likely bacterial wilt source, such as oozing potatoes)
- Sterile water
- Three-week old tomato seedlings, grown on BW-free soil/substrate

STEPS

1. Explain the objectives of this activity to the participants.
2. Explain the bioassay method:
   A bioassay is a testing method using live plants to determine whether or not bacteria are present in soil or organic manure. Bioassays can be used to detect the presence of bacterial wilt. Tomato seedlings are commonly used because they are very susceptible to bacteria wilt, show disease symptoms at relatively early crop growth stages and they are easy to prepare or obtain.
3. This experiment contains six treatment (samples of soil or manure), each in three replications:

	Bacterial wilt present	Without bacterial wilt
Soil	A. Soil taken from around potato plants showing symptoms of bacterial wilt	B. Soil taken from fields free from bacterial wilt (with recent history of 2-3 seasons of corn or cabbage)
Soil and Manure	C. Sterile soil with manure containing bacterial wilt (uncomposted manure)	D. Sterile soil with manure free from bacterial wilt (composted manure)
Control	E. Infected control: sterile soil with small pieces of BW infected tuber added	F. Control: sterile soil

4. Make preparations together with participants:
   a. Prepare sixty 2-3 week old tomato seedlings.
   b. Sterilize enough soil to fill 12 plastic cups (treatments C, D, E and F) by heating it for approximately 20 minutes. Do not sterilize the soil for treatments A and B.
   c. Mix manure for treatments C and D with sterile soil at a ratio of 1: 2 (2 cups of manure mixed with 4 cups of soil will provide enough mixture to fill 3 cups per treatment).
   d. Explain how to avoid contamination.
   e. Assign tasks and clarify the order of activities.
   f. Prepare 18 cups (or small polybags or small mineral water bottles with the top cut off) for sample pots. Make sure to label each one according to the sample it contains:
      - 3 with soil contaminated with bacterial wilt = treatment A
      - 3 with soil free from bacterial wilt = treatment B
      - 3 with sterile soil and manure contaminated with bacterial wilt = treatment C
      - 3 with sterile soil and manure free from bacterial wilt = treatment D
      - 3 control samples of sterile soil with pieces of tuber infected with bacterial wilt added = treatment E
      - 3 control samples of sterile soil free from bacterial wilt = treatment F
   g. Each cup should be labeled showing the treatment, experiment starting date and the observers.
   h. Fill the cups with the appropriate samples of soil or organic fertilizer soil mixture.
   i. Place 3 seedlings into each cup making sure they are evenly spaced.
   j. Put all the cups in a safe place with enough light. Water plants regularly making sure the water comes from a source not contaminated by bacterial wilt.
5. Agree who will be responsible for making observations and notes.
6. Make weekly observations oo the tomato plants in the cups. Record how many healthy plants showing no signs of wilting are still present in each cup.
7. Let groups present the final results to the large group and discuss outcomes.



50 FUNGICIDE MANAGEMENT TO CONTROL POTATO LATE BLIGHT

OBJECTIVES

1. To increase awareness of fungicide application methods.
2. To increase farmers' understanding of how to control late blight by managing fungicide use.

TOOLS & MATERIALS

- Potato plants
- Systemic and contact fungicides. Types depend on what is available and what farmers commonly use.
- Clean water
- Sprayers
- Buckets

STEPS

1. Explain the objectives of this experiment to farmers:
2. For the purposes of this experiment, planting should take place simultaneously in the IPM experimental plot and in plots in farmers' fields.
3. Explain to the farmers what observation methods and fungicide application strategy will be practiced. The spraying pattern is as follows:

Systemic – Contact – Contact – Systemic – Contact – Contact – Systemic

4. Apply the following practices in the fungicide management experimental (IPM) plot (reminding farmers to take care during fungicide application):
   - Use high-quality potato seed showing uniform growth and without late blight contamination.
   - Soon after plants grow (around 20-25 DAP), spray them using only one type of systemic fungicide. Stress to farmers that applying mixed fungicides and pesticides can give rise to negative effects.
   - Make observations once a week or if possible once every three days for better results. With each observation record the extent of damage caused by late blight.
   - The next fungicide application will be when observations reveal early symptoms of late blight. If active spots are found - apparent from a coating of white threads or powder - then a contact fungicide should soon be used. Fungicide treatment should be preceded by manually removing infected leaves and destroying them.
   - If active spots are found again the following week, a further spraying of contact fungicide should be applied.
   - If still occurring after another week then systemic fungicide application should be repeated.
   - At 80 days after planting, cut off the tops of plants and destroy them.
5. Keep records of the spraying practices in the experimental plot and also in a selected field of a neighboring farmer. At the end of the season let participants compare the practices and their effects to late blight incidence and severity and impact on yields.
6. Points to consider during this experiment:
   - Each time a fungicide is applied in the experimental plot, make sure it is only one type and not a mixture or combination with other fungicides or insecticides.
   - Fungicides should be applied in appropriate quantities using equipment still in good working order.

NOTES

51 GRANULOSIS VIRUS EXPERIMENT

OBJECTIVES

1. To increase farmers' understanding of insect pathogens.
2. To increase farmers' understanding of the potato tuber moth's life cycle.
3. To increase farmers' awareness of how to control potato tuber moths during storage.

TOOLS & MATERIALS

- GV formulation (5 g/kg potatoes)
- 30 kg of potatoes
- Plastic jars with lid
- Potato tuber moth larvae
- Plastic bags
- Scale

STEPS

Comment [K1]:

1. Prepare some potato tuber moth (PTM) larvae for the experiment. Tuber moth larvae can be found in the fields or in the storage area. Try to make sure larvae used are still in the early stages of development (small in size).
2. Obtain a Granulosis Virus (GV) talc formulation suitable for PTM management from the research centre or from farmers who produce it themselves.
3. Explain the objectives of this experiment to farmers.
4. Discuss PTM biology and ecology, and GV effect on PTM larvae with farmers.
5. Arrange farmers into 3 small groups. Give each group around 25 grams of GV, 10 kg of potatoes, 3 plastic jars and 30 tuber moth larvae.
6. Each group put the GV powder into a plastic bag, followed by 5 kg of potato tubers. Shake the plastic bags until there is an even coating of GV powder covering the tubers.
7. Each group place the GV coated tubers into plastic jars labeled with their group number, add 15 PTM larvae to each one and close the jars. For comparisons they fill separate plastic jars with 5 kg of tubers without any GV, then add 15 potato tuber moth larvae to each.
8. Make two observations, one week and two weeks after treatment. For the first observation, look at the shape of the larvae in each of the samples. Note down the observations. A sample observation form is provided in Appendix 2.2. Ask farmers what the differences are between the larvae in each sample. Ask them what the reasons are for these differences.
9. For the second observation count the number of infected tubers and weigh the potatoes used. Discuss results of the experiment with farmers.

52 EXPERIMENT ON NATURAL ENEMIES OF LEAFMINER FLY

OBJECTIVES

1. To increase farmers' understanding of natural enemy species and the roles they play.
2. To increase farmers' awareness of the effects pesticide use has on natural enemies.

TOOLS & MATERIALS

- 100 plastic cups with lids
- Tissue paper
- Observation sheets

STEPS

1. Explain the objectives of this experiment to farmers.
2. Arrange participants into small groups of 4 or 5.
3. Each group observes *Liriomyza* activity; half of the groups do observations in farmers' fields while the other half observe the IPM experimental plot.
4. Make observations on 10 sample plants in each plot.
5. Each group collects 50 leaves damaged by *Liriomyza*. Try to collect recently damaged leaves still looking fresh, but showing mines of about 2-3 cm long.
6. Place the leaves inside plastic cups already lined with tissue paper and put the lids on.
7. Label each cup with the date the specimen was collected, its original location, and the group number.
8. Make observations three weeks later looking at insect species present and their numbers. Discuss observation outcomes with farmers. Discussions should lead towards conclusions about the types of insects emerging from the leaves, their roles in the ecosystem, and comparing numbers of natural enemies in farmers' fields with those in the IPM plot.

NOTES

53 BACTERIAL WILT INFECTION EXPERIMENT

OBJECTIVE

To explore if bacterial wilt infected potato tubers can spread the disease to other potato plants.

TOOLS & MATERIALS

- Bacterial wilt infected potato tubers
- 9 pots of 30-day old potato plants
- 2 glasses of clean water
- 1 glass of hot water (more than 60°C)
- Knives
- Adhesive labels

STEPS

1. Explain the objectives of this experiment to participants.
2. Ask them to cut the tubers in half and squeeze them so a slime or liquid can be observed exuding from their vascular rings.
3. Place several drops of this exudate into a glass filled with hot water and several into another glass filled with clean cold water. A third glass of clean water should not have any exudate added to it. Stir the two glasses containing exudate making sure to use separate spoons. Wait for the hot water to cool down before watering any of the sample plants.
4. Take 3 pots with potato plants aged 30 days after planting, then use the glass containing the *clean cold water with drops of exudate* in it to water their foliage and the soil around them.
5. Take 3 pots with potato plants aged 30 days after planting, then use the glass containing *the hot water with drops of exudate* in it to water their foliage and the soil around them.
6. Take 3 pots with potato plants aged 30 days after planting, then use the glass containing only the *clean water* to water their foliage and the soil around them.
7. Label the pots as follows:
   1. Hot water with exudate
   2. Clean water with exudate
   3. Clean water with no exudate.
8. Ask 3 participants to observe what happens to the plants and take records for each of the three treatments. They should record the dates when plants begin to wilt.
9. They must report their observations to other participants at the following meeting.

54 POTATO VARIETY TRIAL

OBJECTIVE

1. To increase participants' knowledge of different potato varieties
2. To evaluate the characteristics, productivity and suitability under local field conditions of different potato varieties

TOOLS & MATERIALS

- Seed tubers of several potato varieties locally available
- Stationery

STEPS

1. Explain the objectives of the experiment to participants.
2. Arrange them into four or five groups to make observations. Each group is responsible for observing one or more varieties.
3. Design the experiment and plot layout with the farmers, considering the number of treatments (varieties) and including three replications for each variety.
4. Make weekly observations of each variety noting the following details:
   - growth uniformity
   - foliage, stem, flower, root and tuber characteristics
   - resistance to pests and disease
5. Record observation results. A sample observation form is provided in Appendix 2.3.
6. Groups discuss their findings together and present them to all participants.
7. Draw conclusions making comparisons with previous observations.
8. Draw conclusions about the experiment, particularly with regards to suitability of each variety for local production purposes, and make recommendations for future activities.

NOTES

55 POTATO SEED GENERATION TRIAL

OBJECTIVES

1. To increase participants' awareness of the benefits of knowing the generation of the seed potato to be planted.
2. To recognize the characteristics and productivity of different generations of potato.

TOOLS & MATERIALS

- Potato seed tubers of the same variety but from 4-5 different generations (e.g. 3rd generation, 5th generation, etc.)
- Stationery

STEPS

1. Explain the objectives of the experiment to participants.
2. Arrange them into 4 or 5 groups to plant, care for and observe the potato plants in the different treatments. Every group is responsible for establishing, observing and harvesting one treatment (generation).
3. Design the experiment and plot layout with the farmers, considering the number of treatments (generations) and including three replications for each generation.
4. Make weekly observations of each generation noting the following details:
   - growth uniformity
   - foliage, stem, flower, root and tuber characteristics
   - resistance to pests and disease
5. Record results of observations. A sample observation form is provided in Appendix 2.4
6. Groups discuss their findings together and present them to all participants.
7. Draw conclusions making comparisons with previous observations.
8. Draw conclusions about the experiment and make recommendations for future activities.

NOTES

56 LATENT INFECTION EXPERIMENT

OBJECTIVES

1. For participants to understand that apparently healthy seed tubers may contain hidden bacteria and might not sprout.
2. To prove the existence of latent infection in potatoes.

TOOLS & MATERIALS

- 1 kg potato tubers
- Clear plastic bags
- String
- Labels

STEPS

1. Explain to participants that seemingly healthy tubers might contain hidden bacteria and may not sprout. This phenomenon is known as latent infection and a simple experiment can be done to prove its existence.
2. Arrange participants into small groups giving each one some healthy looking tubers. Several of these tubers should originate from wilted plants but must not show signs of rotting. The rest should be from genuinely healthy plants.
3. Hand out the clear plastic bags between the groups.
4. Groups choose tubers categorizing them as to whether they are healthy or not and fill each plastic bag with one tuber sealing it tightly and labeling it showing the date and the category (healthy or unhealthy).
5. Ask participants in each group to take the plastic bags and place them in a warm place (the kitchen or in the sun) for 2 weeks.
6. They should bring the tubers back at the next meeting to observe what has happened to them. Discuss the results with participants and draw conclusions.

NOTES

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APPENDIX 1
EXAMPLE CURRICULUM FOR POTATO IPM FFS

Timing	Proposed topics
2 weeks before planting	1. Farm Economic Analysis (introduce record keeping) 2. Farmer Experiments (design) 3. Healthy Seed 4. Bacterial Wilt
1 week before planting	5. Preparing Fields 6. Organic Fertilizer 7. Bacterial Wilt
Planting time	8. Experimental Plots 9. Watering
1 week after planting	10. Agroecosystem Observation & Analysis 11. Chemical Fertilizers 12. Compound and Single Nutrient Fertilizers
2 weeks after planting	13. Agroecosystem Observation & Analysis 14. Disease Management 15. Late Blight Management
3 weeks after planting	16. Agroecosystem Observation & Analysis 17. Hazards of pesticides 18. Late Blight Management
4 weeks after planting	19. Agroecosystem Observation & Analysis 20. Crop Management 21. Healthy Plants
5 weeks after planting	22. Agroecosystem Observation & Analysis 23. Plant Selection 24. Bacterial Wilt
6 weeks after planting	25. Agroecosystem Observation & Analysis 26. Insect Management 27. Virus
7 weeks after planting	28. Agroecosystem Observation & Analysis 29. Leafminer Fly 30. The Effects of Pesticides on Insect Pests and Natural Enemies
8 weeks after planting	31. Agroecosystem Observation & Analysis 32. Golden Cyst Nematode 33. Aphids and Thrips
9 weeks after planting	34. Agroecosystem Observation & Analysis 35. Leaf worms/Cutworms/White Grubs/Mole Crickets 36. Bacterial Wilt
10 weeks after planting	37. Agroecosystem Observation & Analysis 38. Organic Fertilizer 39. Healthy Seed

Timing	Proposed topics
11 weeks after planting	40. Agroecosystem Observation & Analysis 41. Potato Tuber Moth 42. What are Pesticides?
12 weeks after planting	43. Agroecosystem Observation & Analysis 44. Pesticide Hazards
13-14 weeks after planting	45. Harvesting 46. Marketing
15-16 weeks after planting	47. Agroecosystem Observation & Analysis 48. Sanitation 49. Rotation
Harvest	50. Harvesting the Experimental Plot
1 day after harvesting	51. Seed Storage 52. Potato Tuber Moth
1 week after harvesting	53. Farm Economic Analysis 54. Farmer Experiments (analysis)

Appendix 2.1
SAMPLE OBSERVATION FORM
AGROECOSYSTEM ANALYSIS

Observation date: Observation no.:
Treatment:

NO	COMPONENT OBSERVED	Plant										AVG
		1	2	3	4	5	6	7	8	9	10	
1	Insect pests											
2	Natural enemies											
3	Diseases											
4	Plant height											
5	No. of Seedlings											
6	No. of leaves											
7	Water conditions											
8	Soil condition											
9	Weather conditions											
10	Weed conditions											
11	Root length											
12	No. of tubers											
13	Tuber weight											

- Conclusions:
- Recommendations:

Appendix 2.2
SAMPLE OBSERVATION FORM
GRANULOSIS VIRUS EXPERIMENT

Observation date: Observation no.:

no	Component Observed	GV Test 1	GV Test 2	GV Test 3	S Test 1	S Test 2	S Test 3
1	No. of damaged tubers						
2	No. of boreholes per tuber						
3	Tuber weight (kg)						
4	No. of sprouts						
5	Others						

Key: GV: Granulosis Virus (biopesticide)
S: Sevin (chemical pesticide)

Appendix 2.3
SAMPLE OBSERVATION FORM
POTATO VARIETY TRIAL

Observation date: Observation no.:

Component	Variable	Variety							
		1	2	3	4	5	6	7	8
Plant growth	Plant height								
	No. of leaves								
	No. of seedlings								
Insect pests	Thrips								
	Aphids								
	Leafminer fly								
	Other								
Natural Enemies	Spiders								
	Hemiptarsenus								
	Others								
Disease	Late blight								
	Other								
Plant characteristics									
Explanation									

- Conclusions:
- Recommendations:

Appendix 2.4
SAMPLE OBSERVATION FORM
POTATO SEED GENERATION TRIAL

Observation date: Observation no.:

No	Component	Generation I			Generation II			Generation III			Notes
		Test 1	Test 2	Test 3	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3	
1	Insect pests										
2	Natural enemies										
3	Disease										
4	Plant height										
5	No. of Seedlings										
6	No. of leaves										
7	Water conditions										
8	Soil condition										
9	Weather conditions										
10	Weed conditions										
11	Root length										
12	No. of tubers										
13	Tuber weight										

- Conclusions:
- Recommendations: