Farmer Field School for Integrated Crop Management of Sweetpotato

Field guides and technical manual

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Field Guides and Technical Manual

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User's Perspective With Agricultural Research and Development

Foreword

There is an increasingly urgent need to help farmers access techniques for both the efficient and sustainable management of crops and livestock. Natural resource depletion and environmental pollution associated with agriculture are accelerating and can no longer be brushed aside as the unavoidable by-products of economic development. On the contrary, long-term economic development of farming populations will depend on management practices, which are both sustainable and profitable. Sustainability surely starts with farmer learning, knowledge sharing and testing of alternative crop management options.

In the field of crop protection this proposition has not always been evident. The traditional approach has tended to prescribe chemical solutions to the presence of pests and diseases above arbitrary thresholds, rather than discuss with farmers ways of managing the problem under locally observed conditions. This prescriptive approach has reflected a broader top-down, linear model of agricultural research and development, which has dominated thinking since the 1950s. It has often led to inappropriate recommendations for specific conditions, uninformed use by farmers of modern technologies, and in some cases has accelerated the very problems it was supposed to overcome.

The Farmer Field School approach, developed in Southeast Asia by FAO for use in rice production, offers a powerful means to avoid these outcomes by focusing on farmers' needs, knowledge and capacity for learning. The field guides and the accompanying technical manual in this volume are the fruits of a careful, systematic adaptation of the rice farmer field school approach to the rather different conditions of growing sweetpotato in East and Central Java. An important element of this project has been the close cooperation between the International Potato Center and its participatory research network UPWARD with both the public and the non-governmental sectors in Indonesia. The Research Institute for Legume and Tuber Crops in East Java has contributed important technical backup to the field schools and Mitra

Tani has been vital in supporting farmer groups in different communities in Central and East Java.

However, one of the most interesting aspects of the adaptive process has been the central role played by sweetpotato farmers themselves and the complementary roles of farmer knowledge and researcher knowledge in defining needs, developing research and training agendas and evaluating alternative technical options. It was this farmer-researcher teamwork which really led to the elaboration of a concept of integrated crop – rather than pest - management as the necessary framework for the sweetpotato farmer field schools. Farmers are concerned about seed availability, not just seed health, about the condition of the soil and its effect on the crop, not just the presence of insects or diseases on the growing plants. And crucially, they are concerned about the marketing of the crop and opportunities for adding value. Without addressing these other dimensions of crop management, effective control of pests and diseases may cease to be relevant for farmers.

This volume makes available field guides and a manual. The guides offer suggestions and options for field school content and the manual provides technical information on different aspects of the sweetpotato crop. The authors are strong proponents of "scaling up" the results of experiences with particular farmer communities to a broader set of users in Indonesia and beyond and this publication will certainly be enormously important in that process. They do not of course offer a cookbook. They offer tools, techniques and principles which can be creatively taken up by other farmer-researcher teams, applied to their own specific conditions resulting in more sustainable, more profitable sweetpotato agriculture.

Gordon Prain
Regional Representative
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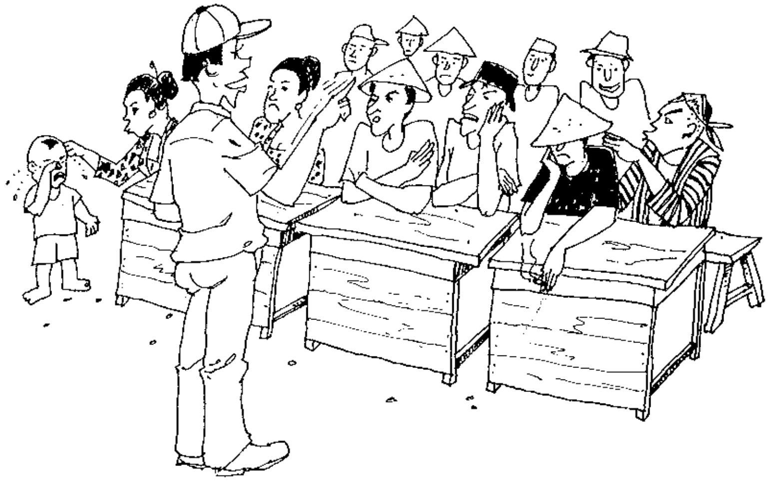
Part I

An introduction to the Farmer Field School for Integrated Crop Management

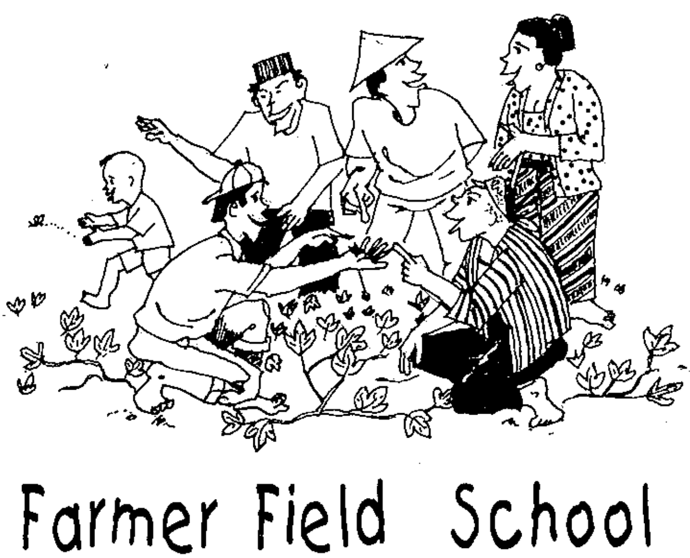
1 Background

The aim of agricultural extension in many countries is to promote technology packages developed by research institutes to a farmer audience. Extension methods usually involve farmer group meetings or demonstration plots, however, small-scale resource-poor farmers rarely implement the new technology promoted by the agricultural extension messages that they receive. Why is this?

Farmers often say that technology promoted by extension services is not fully suitable for their farms. If they try extension recommendations at all, farmers must often adapt them to suit their particular conditions. With such an enormous diversity of small-scale farm enterprises in tropical areas, it is difficult, if not impossible, to generate recommendations that are broadly applicable. Technology guidelines must fit varying local conditions that depend on soil fertility, water availability, household economic realities, and the objectives that farm families wish to achieve.



Inappropriate extension methods are often as much a part of the problem as unsuitable technologies. Farmers spend a good part of their time working in their fields. They may feel uncomfortable sitting indoors listening to extension officers lecturing about a new technology. A demonstration plot managed by outsiders may not convince a farmer to try something new. Farmers need opportunities to experiment with new technologies, to learn how to evaluate different options more systematically, and to decide for themselves which are worthwhile. This realization can be found in the principles of adult education, which recognize that adults learn best from direct experience. Learning by doing adds to farmers' knowledge and experience, and improves their capacity as farm managers in a way that the passive experience of exposure to extension messages cannot. The "Farmer Field School" model is a farmer training approach which is based on these principles of adult education.



Farmer Field Schools (FFS) were first developed in Indonesia for training rice farmers in Integrated Pest Management (IPM). Nowadays, IPM FFSs have been implemented in many countries, especially in Asia, and in crops other than rice. For application in other regions, countries and crops, the rice IPM

FFS model requires adaptation to suit specific environmental, agronomic and socio-economic conditions. A field school for sweetpotato was developed in East and Central Java, Indonesia, over a three-year period, and launched in 1997. The first step in developing the field school was a diagnostic study of sweetpotato cultivation practices and problems over two cropping seasons. Farmers and researchers worked together to analyze problems related to sweetpotato cultivation within the context of the whole farm enterprise. They concluded that pests and their management were not the main problems facing sweetpotato growers, even though pests caused considerable losses in some seasons and in some locations.

It was realized that research institutes and agricultural extension services give the crop a low priority relative to other food crops. Important gaps in basic agronomic information were identified, particularly in nutrient management for the crop. Partly because the Indonesian extension service has not provided sweetpotato fertilization guidelines, farmers were fertilizing the crop the way they fertilize rice, not realizing that root crops and grains have very different nutrient requirements. The diagnostic study in Indonesia showed that there is great potential to improve sweetpotato cultivation through Integrated Crop Management (ICM). A field school for the crop should have an ICM orientation including all the relevant aspects of the sweetpotato farming enterprise, from soil preparation to processing and marketing the final product.

2 Objectives

This training manual was designed specifically as a manual for sweetpotato ICM farmer field school facilitators. During their training of trainers, the future Sweetpotato ICM FFS facilitators will discuss all the materials and conduct all the activities described in this manual, and also learn by doing so that they can replicate the activities with farmer groups. Both ICM guidelines and FFS activities were developed by farmers, extension and community development specialists, and agricultural scientists experimenting together in the context of intensive farming systems under wet tropical conditions of the irrigated rice-bowl areas of Java, Indonesia. Although the manual is biased culturally and technically towards this context, we believe it can serve as a starting point for others who wish to develop an ICM field school for sweetpotato or for another crop. The major objective of the ICM FFS is to enhance farmers' problem-solving and decision-making skills. Therefore, FFS activities all contain elements of observation, analysis and experimentation. In addition, the ICM concept familiarizes farmers with ecological processes they utilize in crop cultivation. These skills can benefit farmers everywhere and are transferable to any crop and any technology. Participatory evaluation of both technology and the FFS process is an integral part of the field school. Consequently, this manual can also serve as a resource for others working in farmer participatory research and extension.

3 ICM Farmer Field School design

3.1 What is an ICM Farmer Field School?

Adults learn best through hands-on experience and when the subject matter they are studying is related to their everyday experiences and activities. In a field school, farmers are encouraged to explore and discover for themselves. Knowledge obtained this way is more easily internalized and put into practice after the training is over. All the sessions take the abilities, knowledge and experience of the participants as their starting point, and FFS activities are designed to deepen them. The FFS should have access to a field throughout the season in which the participants can do observations, analyses and experiments. Farmers work in small workgroups of optimally five people to encourage the learning process.

The focus of the ICM FFS is health: environmental health, soil health, seed health, and crop health. A healthy crop is a prerequisite for achieving a high yield. Seed, soil, and environmental health are prerequisites for crop health, and for sustainability of the farm enterprise.

The field school is a season-long event conducted in the field. The activities follow the different developmental stages of the crop and their related management practices. The training activity schedule developed in Indonesia is presented in Section 3.3, but may need to be adapted to conditions in other locations. In areas where farmers plant two consecutive crops, the ideal time to initiate activities is after farmers have harvested the first crop but before they have prepared new fields for the second crop. Under these conditions participants can:

- Assess the extent of pest sources in the field and its surroundings.
- Practice field sanitation, if necessary.
- Experiment with basal fertilizer application, particularly organic fertilizers, to ensure that plants grow well, storage root formation is favored, and that soil fertility and texture is maintained.

If sweetpotato is planted following another crop such as rice, the FFS should be initiated at field preparation time. In Indonesia, sweetpotato field schools are conducted once a week during the first ten weeks after planting (from crop establishment phase to fertilization), and once every two weeks thereafter.

3.2 Farmer Field School activities

A FFS meeting is designed to cover in principle the following eight activities:

1. Field observation (about 30 minutes).
2. Charting the growth and development of the crop (5 minutes).
3. Agroecosystem analysis (30 minutes).
4. Presentation of results and discussion (30 minutes).
5. Economic analysis (10 minutes).
6. Observing insect behavior (10 minutes).
7. Group dynamics exercise (10-30 minutes).
8. Special topic (30-60 minutes).

Some of these activities are only appropriate when the crop has reached several weeks of age, and hence are gradually incorporated. Conduct of the total set of activities are recommended from the sixth meeting onwards. Each of the eight activities is explained in detail below. In addition to these routine activities, participants may choose to conduct additional experiments on the FFS field. These experiments are designed by the farmers themselves at the second FFS meeting. For more detail see Section 5.4 (Experimentation in the Farmer Field School field).

3.2.1 Field observation

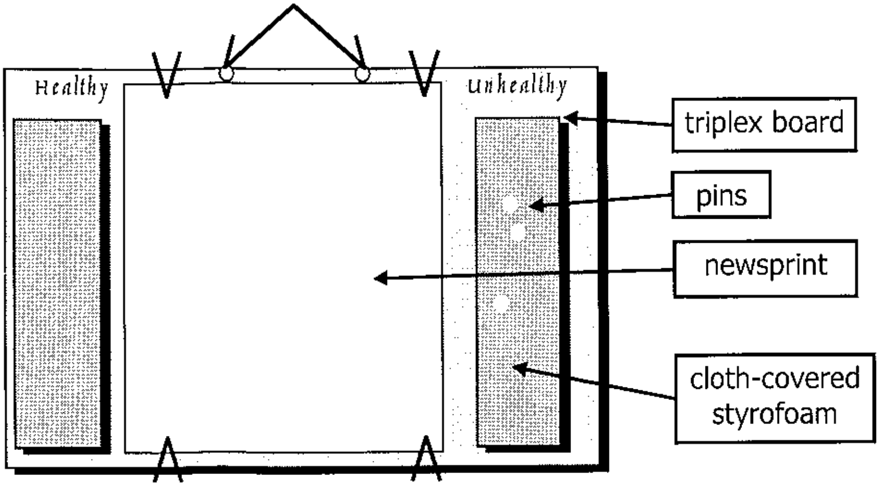
- For this activity each workgroup splits into two smaller subgroups. Each subgroup samples five locations in the field, so that each workgroup evaluates a total of 10 locations.
- Each location consists of an area 0.5 m wide by 0.5 m long, if the crop is planted in wide beds; or a 0.5 m-long segment, if the crop is planted on narrow ridges.
- Observations are made at each location of:
  - ⇒ Soil conditions (from the first meeting onward).
  - ⇒ Plant health status, based on leaf color and presence of water and nutrient deficiency symptoms (from the fourth meeting onward).
  - ⇒ Plant development, based on measuring the growth of the vines and observing the size and number of storage roots.
  - ⇒ Pest and disease attack symptoms, number and types of pests and natural enemies (from the sixth meeting onward).
- The age of the crop is noted and general observations are made of:
  - ⇒ Weather conditions.
  - ⇒ Weed incidence.
  - ⇒ Environmental conditions around the field.
- Unknown insects, leaves with an unfamiliar appearance, with symptoms of unknown diseases, insect damage, or with other damage are collected into plastic bags or stoppered containers and taken to the FFS meeting site for further observation and identification.

3.2.2 Charting the growth and development of the crop

Weekly observation and charting of the growth of the vines and development of the root system is suggested as an activity to enhance farmers' knowledge on ecophysiological processes and their analytic and decision-making skills. The activity does not require much extra time during the crop observation exercise, but an evaluation discussion on the topic should be planned at the end of the season. For more details see Field Guide 7 in Part II.

3.2.3 Agroecosystem analysis

- Conducting an agroecosystem analysis is learned gradually over the first five FFS sessions. Each workgroup pools the information gathered at their sampling sites and discusses the observations, differentiating between positive and negative elements for crop, field and environmental health.
- From the sixth FFS meeting onward, a full agroecosystem analysis is carried out by each workgroup. To facilitate the analysis, a special board could be provided as follows:



- Samples or elements that contribute positively to health are pinned on the left. Unhealthy elements are displayed on the right. Explanations, drawings, comments, questions and conclusions related to the samples or to any of the field observations are written on the sheet of newsprint paper clipped to the center of the board.

- Participants should be encouraged to make a drawing of a sweetpotato plant as observed to illustrate the developmental stage of the foliage and the storage roots. The purpose of making the drawing is to analyze whether plant development has proceeded adequately given the age of the crop, and whether the crop is vigorous enough to withstand stresses caused by pests, diseases, water shortage or nutrient deficiency. Drawing also helps to focus the discussion.
- Each workgroup formulates a summary of their observations and draws conclusions about the state of crop health, after taking into account the balance between healthy and unhealthy elements.

3.2.4 Presentation of results and discussion

- Each workgroup in turn presents their results to the entire group.
- The other workgroups ask questions and raise discussion points.
- After all the workgroups have finished, the FFS facilitator guides the group as they formulate an overall summary of field and plant conditions, and draw conclusions and recommend actions (crop management practices) to be implemented during the upcoming week(s) until the next FFS meeting.

3.2.5 Economic analysis

A main objective of FFS is to develop the analytical skills of the participants. If farmers can determine which factors influence the profitability of their sweetpotato enterprise, they can make better informed decisions about the relative merit of management options. A "Sweetpotato Cultivation Record" form is distributed to each participant to keep a record of the sweetpotato enterprise on their individual farms (see Appendix II for a sample form). Collectively, the group keeps a record of all the activities, inputs and outputs for the FFS field. Field Guide 5 in Part II explains the economic analysis exercise in detail.

Economic analysis is introduced at the third FFS meeting. At each of the subsequent meetings, the participants complete the FFS field record together, and they discuss any problems that may have arisen in record keeping for their own fields.

3.2.6 Observing insect behavior

The purpose of this exercise is to provide opportunities to farmers to discover the ecological roles of insects, particularly the difference between herbivores and natural enemies. From the fifth FFS meeting onward, each workgroup keeps a stoppered container for observing the behavior of insects. Insects collected from the field are placed in the container with what is believed to be their food. Each week one participant is responsible for taking the container home, and for making daily observations of the insects within. The volunteer reports her or his observations at the next FFS session. Detailed information on this activity is available in Field Guide 8.

3.2.7 Group dynamics

Group dynamics exercises develop group cohesiveness and problem-solving skills, and encourage collaboration and creativity. These activities generally begin with an introduction by the facilitator who sets up a problem or challenge for the group to solve. Many are physical and active, while others are brain teasers. The exercises should be fun while providing experience of using teamwork to solve specific problems. This manual contains detailed descriptions of a series of group dynamics exercises that have been used successfully in FFSs in Indonesia (see Section 3.3 above and Appendix I). Other exercises can be adapted or developed as needed.

In order to get the most out of group dynamics exercises, FFS participants should evaluate each one, discussing what they learned from the exercise. They should identify the processes they used to solve the problem posed during the exercises, paying special attention to the role of creativity and cooperation.

3.2.8 Special topic

Special topics support the agroecosystem analysis by delving more deeply into specific issues relating to the agroecology, crop development, IPM or ICM principles, and provide training in basic experimentation methods. After the facilitator introduces the topic and explains the steps to be used in the process, the participants assume the active management of the experiment or activity. Data collection and analysis are emphasized.

A list of special topics to conduct during an ICM FFS season is proposed in Section 3.3 and each topic is described in detail in a Field Guide contained in Part II of this manual. The topics and activities, however, should be adapted as necessary in order to address local problems and issues. Each Field Guide describes a problem, and formulates the objectives for the session designed to foster the learning related to that problem and its possible solutions. Then activity steps are elaborated to help the field school facilitator initiate the process of problem analysis, experimentation and evaluation. A list of materials needed to conduct the session is provided, as well as information about where to find more technical background information on the topic, as contained in Part III of this manual.

3.3 A basic sweetpotato ICM Farmer Field School schedule

A basic schedule for a sweetpotato ICM FFS, based on cultivation activities and problems occurring under normal conditions of a crop with a growth duration of 4.5 months, is provided below. An adapted schedule, however, needs to be made for each planned ICM FFS, considering specific local conditions. The schedule should be flexible for adjustments throughout the season, when unexpected problems occur at certain stages of crop development. In addition to the activities and special topics presented in the schedule below, each FFS session should contain the routine activities described in Section 3.2.

*Wap**	*Session*	*Farm calendar*	*FFS activities and special topics (ST)*	*Group dynamics exercises*
-2	0		▪ Preliminary meeting(s)	
-1	1	Field preparation: hoeing, fertilizing, ridging	▪ Pre-test ▪ Field sanitation ▪ Field preparation and fertilization ▪ ST-1: Introduction to the sweetpotato ICM Farmer Field School ▪ ST-2: A healthy soil	1. Line up 2. Family members
0	2	Preparation of cuttings and planting	▪ Preparation of cuttings and planting ▪ ST-3: Experimental methodology ▪ ST-4: Healthy seed	3. How many squares?
1	3		▪ ST-5: Observing the environment ▪ ST-6: Economic analysis of the sweetpotato enterprise	4. Family reunion 5. Nine dots
2	4		▪ ST-7: A healthy crop	6. The snake sheds its skin
3	5		▪ ST-5: Observing the crop and its environment ▪ ST-8: Natural enemies: the farmers' friends	7. Know yourself
4	6		▪ ST-9: Sweetpotato pests ▪ ST-10: Defoliation experiment	8. Knotty problem
5	7		▪ ST-11: Sweetpotato diseases ▪ ST-23: Sweetpotato storage	9. Follow me
6	8	Soil preparation for fertilizer side dressing	▪ Soil preparation, fertilizer application ▪ ST-12: Weeds: friends or foes?	10. Trust each other
7	9		▪ ST-13: Aphids and other tiny insects ▪ ST-14: Pesticides: medicine or poison?	11. Drawing together
8	10	Apply fertilizer and reform ridges	▪ Apply fertilizer and reform ridges ▪ ST-15: Fertilization	12. Play the rope
10	11	Vine lifting	▪ ST-16: Vine lifting ▪ Vine lifting ▪ ST-17: Field area measurement	13. Mirror game
12	12		▪ ST-18: Sweetpotato stemborer ▪ Defoliation experiment	14. Drawing a house
14	13		▪ ST-19: Sweetpotato weevil	15. Guide the blind

*Wap = Weeks after planting

Wap*	Ses-sion	Farm Calendar	FFS activities and special topics (ST)	Group dynamics exercises
16	14		▪ ST-20: Cropping pattern ▪ ST-21: Variety selection	16. Collector's items
18	15		▪ ST-22: Harvesting and marketing ▪ ST-7: A healthy crop (analysis)	17. Wayward whispers
20	16	Harvesting	▪ Harvesting ▪ ST-22: Harvesting and marketing (yield assessment contest)	
21	17		▪ Field sanitation ▪ ST-24: Sweetpotato utilization ▪ ST-25: Evaluation of the sweetpotato ICM FFS ▪ Closing ceremony	

*Wap = Weeks after planting

3.4 Scheduling the time of the FFS meeting

The day of the week and time of the day to held the FFS meeting should be discussed and agreed with the participants to suit their schedule. However, the participants should understand that morning is the best time to conduct a field school. Insects and other animals are more active while it is still cool, and are more likely to be observed in the morning. It is usually easier to gather farmers together for a meeting early in the day, before they start their routine activities. Although farmers are busy people, and often work their fields in the morning, participating in a field school is a choice that requires a certain level of commitment. A field school meeting lasts about three hours and takes place once every one or two weeks.

4 ICM Farmer Field School preparation

4.1 Preliminary meetings

Experience has taught that farmer field schools are more effective if the participants are from a single village. This way a core group of ICM farmers is established in a community, increasing the chances that they will continue ICM practices after the field school season ends, and extend it to more farmers in the community. Both IPM and ICM are more effective when practiced on a large scale, since the ecological balance in the ecosystem expands over individual fields. Preliminary meetings are therefore desirable to inform the community about the objectives of the ICM FFS, motivate them to participate, and determine together who are the appropriate participants.

Ideally, a request for a field school should come from a farming community. Farmers who request training themselves are usually more motivated and responsible than those appointed by some authority from above. To trigger such requests, field schools can be promoted by conducting a field day where farmers can observe the achievements and process of a previous field school. New requests for field schools are much more likely to arise if farmers see the benefits others are reaping. In areas where field schools are a complete novelty, interest can be elicited by working through a convinced local leader. He or she can help arrange one or more preliminary meetings for interested farmers.

A first preliminary meeting is supposed to be of an informative nature to introduce the ICM and FFS concepts and raise interest for participation. The timing of such a meeting is important. It should be convenient for potential participants to attend. A promotional video[1] that outlines sweetpotato

[1] A video entitled "Learning Integrated Crop Management for Sweetpotato" is available in English and Indonesian. To order copies, or make arrangements for soundtracks in other languages, contact: CIP, ESEAP Regional Office, P.O. Box 929, Bogor 16309, Indonesia. Phone: +62-251-317-951; Fax: +62-251-316-264. Email: cip-bogor@cgiar.org.

cultivation problems in Indonesia, presents ICM as a possible alternative, and describes the field school as a way to learn about ICM, is available to be shown at preliminary meetings. Whether or not the video is shown during this meeting, it is useful to identify and analyze agricultural problems the community is facing, provide information about the objectives and activities of the ICM FFS, and give farmers the opportunity to ask questions. This process can be complemented by mapping exercises to better outline the problems, and a gender analysis to better identify potential participants. An example of the procedures and activities conducted during preliminary meetings by the Indonesian National IPM Program is given in Box 1 below.

During the same or a consecutive meeting, FFS participants are selected by the community itself, and the farmers are invited to prioritize the activities proposed for the FFS. They can also discuss problem-solving ideas and compare these with potential solutions originated outside the village. This process is supposed to result in the preparation of a realistic workplan for conducting an ICM FFS in the village. The workplan should specify:

- The date and time of the weekly FFS meeting.
- The location of the field study site.
- The list of FFS participants.
- A weekly schedule of activities for the entire season.
- Designs for field experiments.

The workplan should also contain explicit arrangements for:

- Provision of a field that will be used as a field laboratory by the FFS participants. The owner of the field should agree to contribute labor for field preparation and inputs such as fertilizer. The planting material for the field and the labor for observation, fertilization, vine lifting and harvesting will be provided by the FFS participants as a group.
- Financial matters. If the costs of conducting the FFS are to be borne by the village, it should be clear where the funds will come from for materials, for transportation and possible honorarium of the field school trainer and who will be responsible for providing refreshments. If the costs are to be borne by a national or local program, the details of what will be provided should be specified.

BOX 1

The Farmer Field School Preparation Process

Source: Kingsley, Mary Ann and Sri Suharni Siwi. 1995. Increasing Women Farmers' Access to IPM Activities: Final Report of Gender Study I, November 1995. FAO Technical Assistance

Activity	Timing	Objectives
Preparation meeting with local officials and village leaders.	Before the planning meeting	• To organize a meeting for planning the field school. • To discuss women's involvement in local agricultural activities and gain local officials' support for women's participation in the planning meeting.
Preparation of a base map of the *hamparan*[1] with 2-3 farmers.	Before the planning meeting	• To prepare in advance for planning meeting. • To get a preliminary understanding of *hamparan* conditions.
Mapping of the *hamparan*[2]	At the planning meeting	• Learn specific conditions of the *hamparan* from farmers and understand farmers' practices. • Identify and discuss problems, their causes, solutions already tried, and new ideas for solving problems.
Division of labor matrix[3]	At the planning meeting	• Understand the division of work and decision-making between men and women in agricultural and household activities. • Identify and discuss the appropriate participants for IPM farmer field schools.
Discuss and agree on a **Learning Contract**, a plan for the field school	At the planning meeting	• Agree on special topics for IPM field school curriculum based on results of discussion from the mapping exercise. • Agree on participants for field school based on results of discussion from the matrix exercise. • Agree on time and location of IPM field school using the map and matrix as a reference.

[1] A *hamparan* is a contiguous area of fields belonging to a village.

[2] The mapping exercise assists in visualizing agricultural conditions and problems in the *hamparan*. The farmers' *hamparan* map can be revised and referred to throughout the field school season, and can be used as a tool to begin focusing field school participants' efforts on the management of the *hamparan*, eventually leading to development of their own IPM follow-up activities based on spread of IPM throughout the *hamparan*.

[3] The preparation of a matrix on the division of labor and decision-making helps to illustrate how women and men are involved in local agricultural activities and their management. Based on this gender analysis, appropriate participants for the field school can be identified. The matrix also helps to identify constraints to women's participation related to their workload. Some adjustments in the field school schedule or location may be necessary to enable women farmers to participate. This should be considered during process of defining learning contract.

4.2 Participant selection

Sweetpotato ICM FFSs are designed for about 20-25 participants. Larger groups tend to become either chaotic or passive. Discussions and sharing of experiences may not develop well in smaller groups. For certain FFS activities such as the agroecosystem analysis farmers work in small workgroups of five. The full group reconvenes to compare results. Experience has shown that 20-25 farmers can constitute a reasonable critical mass in support of further ICM development in the village.

Selection of participants should take place at the first preliminary meeting, attended by all interested farmers from a village. Members should not be selected unilaterally by extension workers or local leaders because this increases the likelihood that some participants are not active farmers or are not motivated to learn about ICM.

Candidates for participation in a sweetpotato ICM FFS should fulfill the following requirements:

1. They should be sweetpotato farmers.
2. They should have an active interest in learning new things.
3. They should be able to attend FFS regularly over an entire growing season.
4. They should be willing to disseminate what they learn to other farmers.
5. Literacy is not required.

If women are involved in cultivating sweetpotato, they should be encouraged to join FFS. In many places agricultural training activities are perceived as the province of men only. Customs and beliefs change slowly, and FFS can contribute to the process of change by promoting the participation of women.

4.3 ICM Farmer Field School requirements

The following are required for conducting a (sweetpotato) ICM FFS:

- One or two facilitators who graduated from a training-of-trainers course for sweetpotato ICM FFS. The facilitators can either be farmers or officers.
- Land that is ready to be cultivated. If a second crop of sweetpotato is to be planted, the FFS is initiated before preparing the soil. If the land was previously planted to another crop the FFS is started afterward.
- The land owner prepares:
  - ⇒ Manure and chemical fertilizer (if needed, see Field Guide 2) for the first FFS meeting.
  - ⇒ Labor for making the beds or ridges, before the third FFS meeting.
  - ⇒ Urea and KCl (if needed, see Field Guide 15), at the tenth FFS meeting.
- Sweetpotato cuttings provided by FFS participants.
- Drinks and snacks for each FFS meeting.

Each facilitator receives a training materials package provided by the sponsoring program. For each field school package includes:

- This training manual.
- Four analysis boards made from plywood, styrofoam and black cotton cloth (see Section 3.2.3), 100 pins, and 20 clothes-pegs
- 150 sheets of newsprint paper; four or five boxes of crayons and black felt-tip markers (as many as the number of workgroups).
- 100 plastic bags of 1 kg capacity.
- Materials listed in the Field Guides for the group dynamics exercises and special topics (see Part II).

5 ICM Farmer Field School implementation

5.1 ICM Farmer Field School facilitation

A FFS trainer or facilitator is more than a teacher or an instructor. He or she plays a complex role as an experienced farmer, a questioner, an organizer, and a coordinator. The roles and duties of the facilitator in the ICM FFS are as follows:

- He investigates the main farming problems in the village before starting the FFS, so that he can plan topics to meet participants' needs.
- Her motivation for guiding the field school is based on a wish to improve her own abilities and those of others. If motivation is based solely on a desire to earn more or attain a higher status it is unlikely that the facilitator will be successful in the long term.
- He arranges for a field to be used for observation and experimentation.
- She prepares all materials required for the special topics and group dynamics exercises before the start of each meeting.
- He always explains the objective and the process before initiating an activity.
- She observes and analyzes the condition of the ICM field with the participants, encouraging them to make in-depth observations by asking relevant questions.
- He is systematic. This implies progressing from the simple to the more complex and from the known to the unknown when trying to help people understand something new.
- She always makes every effort to enliven the discussion and to

keep it flowing. Participants are welcome to share any opinions as long as they are related to the topic of discussion. Sometimes the facilitator has to let people know that when someone is speaking, the others should be listening and paying attention. To restart a stagnant discussion, she can ask questions like: "Is there anyone who still hasn't given an opinion?" She can also give her own opinion. If the discussion is not lively enough, the facilitator can ask a difficult question or voice a controversial opinion to elicit a reaction and to make people think.

- The facilitator should pay close attention to the involvement of all participants, ensuring that no one dominates the discussion, and encouraging silent ones to take part.
- When participants cannot answer a question from their own observations and discussions, she should be able to articulate her own opinion or experience clearly.
- He gives reminders about the time, so that the FFS remains on schedule. Changes to the schedule should be agreed upon by all participants.
- She always shows respect for all participants and their opinions.

Certain behaviors of facilitators hamper the learning process. Some examples are:

- The facilitator seems uninterested, impatient or is unable to focus his attention.
- Her explanations are sketchy or unclear.
- He assigns a task that is not clear.
- She gives incorrect or inaccurate information because she does not want to admit that she does not know the answer.
- He uses inappropriate methods and/or activities.
- She is disorganized and does not work step-by-step.
- He manages time poorly.
- She seems confused, and hesitates to take decisions.
- He has a negative attitude towards the participants.
- She corners the participants.
- He lacks self-confidence.

5.2 Pre- and post-tests

At the first and the last FFS meeting, the participants take a test to evaluate their knowledge level before and after FFS. The pre-test provides the FFS facilitator with some diagnostic information that he/she can use to adjust the FFS curriculum to the knowledge level of the group. The post-test results are an indicator of progress made during the FFS season.

The facilitator prepares each test by formulating ten questions that relate directly to local field problems. To answer the questions, participants choose among three alternatives. When possible, the alternatives should be live samples, for instance leaves with pest damage or nutrient deficiency symptoms, and insect and soil specimens. Each question and its answers are written on cardboard paper and placed in the field on a bamboo stake (see below). The pre- and post-test questions should be of similar difficulty, and in the local language.

FFS participants take turns answering each question by marking (ticking or punching) answer sheets provided by the facilitator (see Appendix II-A/B). After all questions are answered, the sheets are handed to the facilitator, who scores each test and tabulates the results on a form (see Appendix II-C for the form). The test results are shared and discussed among the participants.

5.3 Assignment to workgroups

Most FFS activities are conducted in small workgroups of five participants, which is considered the optimum number for effective group work and learning. Assignment of people to workgroups can be left to the participants themselves, or arranged through a group dynamics activity held during the first FFS meeting. Changes in the composition of the workgroups should be avoided once the field school is underway, unless a participant drops out early on and can be replaced by someone else.

5.4 Experimentation in the Farmer Field School field

During the FFS season, the participants conduct experiments in the ICM FFS field. The objective of this activity is to develop experimentation skills and to provide farmers with experience in the evaluation of ICM practices and alternatives. Three experiments that are suggested and described in detail in the Field Guides in part II are:

1. Manure experiment (see Field Guide 2).
2. Rapid seed multiplication experiment (see Field Guide 4).
3. Defoliation experiment (see Field Guide 10).

The participants should be encouraged to set up additional experiments that will give answers to their own specific questions. Alternative experiments are designed by the participants themselves with the help of the FFS facilitator during the preliminary meetings (see Field Guide 3). The selection of research questions for experimentation in the FFS should be based on farmer priorities revealed through a participatory diagnosis.

6 ICM Farmer Field School evaluation

To identify the strengths and weaknesses of each FFS during the season, an evaluation should be conducted by the participants. The evaluation should focus on results, process and impact:

1. Result: What were the results of applying ICM and conducting experiments in the FFS field?
2. Process: How effective were the FFS activities to learn ICM?
3. Impact: What can participants accomplish by implementing ICM as learned during FFS in their own fields?

The evaluation is held at a special meeting after the ICM FFS field is harvested. The participants should determine the date, time and place of the meeting.

6.1 Evaluation of results

Evaluation of results is aimed at assessing the effectiveness of ICM technology, particularly for FFS participants who may still be skeptical about ICM's merit. The evaluation process can also provide inputs for improving ICM technology and the FFS learning process. Results are evaluated by weighing the yield of all the experimental plots in the FFS field, analyzing and evaluating the data, and conducting an economic analysis.

Yields need to be converted to standard units. The weight of roots per plant is determined by dividing the weight of the roots per plot by number of plants per plot. To calculate yield in tons per hectare (t/ha), the root weight per plot is divided by the area of the plot and multiplied by 10. Calculation formulas are as follow:

$$\text{kg/plant} = \frac{\text{kg/plot}}{\text{number of plants/plot}}$$

$$\text{t/ha} = \frac{\text{kg/plot}}{\text{area of block (m}^2\text{)}} * 10$$

The experimental methodology applied in the ICM FFS encourages farmers to use replications in their experimentation. To calculate the average yield produced by two replicate plots with the same treatment, we use the following formula:

$$\text{Average yield} = \frac{\text{yield of plot A} + \text{yield of plot B}}{2}$$

To calculate the total yield from all FFS plots, there are two alternatives as follows:

$$\text{Total yield (kg/field)} = \text{average yield (kg/plant)} * \text{number of plants}$$

$$= \frac{\text{average yield (t/ha)} * \text{area of field } (m^2)}{10}$$

During a group discussion, participants compare the yields for each experimental plot and formulate conclusions about the treatments of the experiments and about the ICM technology in comparison with farmer practice. The following questions could be raised by the facilitator to stimulate the discussion:

- How did the yield vary with the experimental management practices? Which practices were associated with a high yield?
- What were the production and labor costs (management costs) for each plot?
- What was the net income (gross income less management cost) for each plot?
- Which management practices were easy to apply? Which were difficult?
- How compatible is each practice with the overall farming system practiced by the participants?

6.2 Evaluation of process

The evaluation of process should assess how well FFS met the needs and expectations of the participants. Criteria for analyzing process include:

- The number of meetings held and number of participants present.
- Reasons for canceling meetings or for absenteeism from meetings.
- Congruence between the special topics covered in the FFS and the local field problems.
- Strengths of FFS: What were the most interesting, useful activities?
- Weaknesses of FFS: What was not interesting, useful? What could be improved? What should be added or deleted? How could the curriculum be improved?
- How did the facilitator perform?

The results of process evaluation provide input to the facilitator for planning subsequent ICM FFSs.

6.3 Evaluation of impact

Impact evaluation measures how far the ICM FFS process succeeded in improving farmers' knowledge of ICM for sweetpotato and increasing their capacity to apply it.

We can only measure progress in increasing farmer knowledge and improvement of their skills through a testing process, such as the pre- and post-test, and from their own opinions about the success or failure of the field school expressed during the evaluation meeting. Preparation and administration of the pre- and post-tests are discussed in Section 5.2. Further impact assessment would require follow-up field-level observations and/or interviewing of the FFS graduates.

7 Farmer Field School follow-up and sustained ICM implementation

After a FFS is over, we hope that participants will to continue to practice ICM in their own fields, disseminate it to other farmers, and that the cooperation established among them will persist. Before adjourning the field school it is important to discuss what farmers plan to do with their new knowledge and skills. The planning process for ICM FFS follow-up activities should be based on the intentions expressed by graduating farmers, although the facilitator should encourage that attention is given to the following aspects:

- Implementation of ICM in individual fields.
- Group implementation of activities requiring collective action.
- Continuation of (individual and/or collective) experimentation to adapt ICM guidelines to local conditions.
- Farmer-to-farmer dissemination of the ICM guidelines and methodologies.

To foster dissemination of ICM, farmers who have not yet attended a field school can be invited to the FFS harvest. The invitees could include farmers and community leaders both from within the village as from neighboring villages. At this meeting FFS participants can demonstrate what they have learned during the season to their friends and neighbors. This exposure to the results of the field school will hopefully stimulate new requests for ICM FFSs.

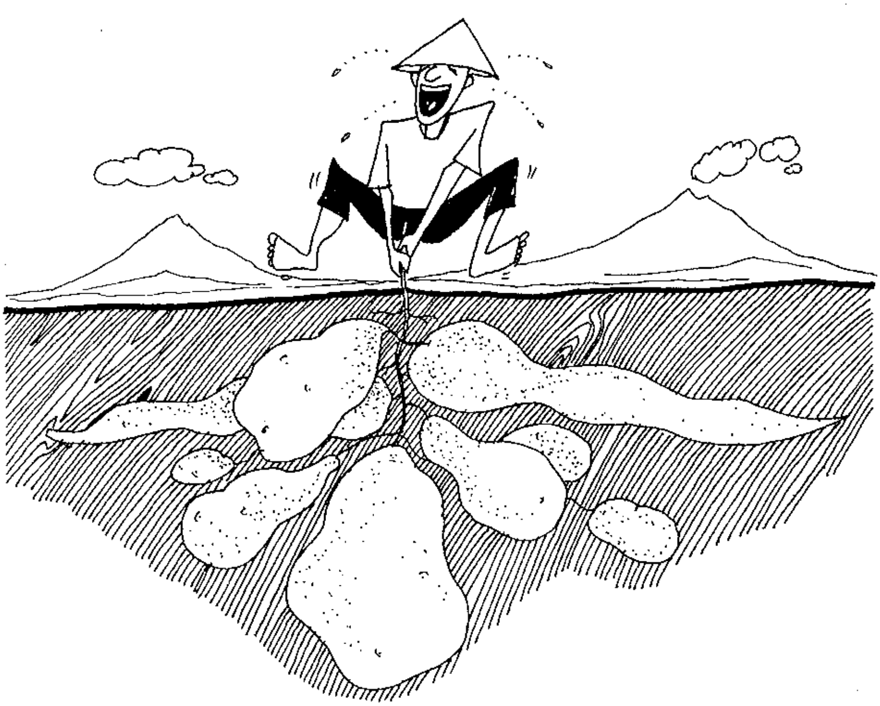
Part II

Field guides for Sweetpotato ICM FFS activities

1 Introduction to the sweetpotato ICM Farmer Field School

Background

Sweetpotato cultivation can be highly profitable for farmers. When market prices are high farmers' profits double or triple compared to those from growing rice. The relatively high yield and low production costs contribute to this profitability, but unfortunately, in many places in the world sweetpotato prices fluctuate widely. Sometimes, when price declines radically, sweetpotato farmers might even lose money. The marketing system may also limit farmers' profits, particularly when middlemen are involved who make contracts with farmers to buy the standing crop. Because farmers rarely know how to estimate the yield of the unharvested crop and are not fully aware of the prevailing prices at wider distribution markets, they are at a disadvantage in price negotiations with the trader and usually accept the



offer with little discussion. Most farmers believe that profit is determined more by their luck in making a sale agreement with the trader than by the yield of the crop.

Highly fluctuating prices and a weak bargaining position influences farmers' attitudes towards sweetpotato cultivation because it provides little incentive to produce high yields. Nevertheless, comparison of yields and profits obtained by farmers in Indonesia showed a tendency for farmers who produced higher yields to earn higher profits. This suggests that farmers can increase profits by increasing their yields through better crop management, and by learning to estimate what the yield is likely to be before entering into negotiations with a trader. How can farmers' knowledge and skills be developed so that they can improve their crop management and business capacities? In this activity, farmers will analyze the relative importance of the sweetpotato enterprise and its constraints. ICM is presented as an alternative to tackle the constraints, and the FFS as a way to learn about ICM.

Objectives

After completing this activity the participants:

- Can explain the relative importance and constraints of the sweetpotato enterprise under the prevailing conditions.
- Understand the meaning of ICM.
- Understand the objectives of the sweetpotato ICM FFS.
- Realize the need for ICM training.

Materials

- Newsprint paper.
- Felt-tip markers.
- Maize seed (100 g).

Activity steps

A *The importance of sweetpotato*

A.1 The facilitator explains the objectives of this activity.

A.2 The facilitator asks the participants to mention the three most important crops grown in their area, and writes these on a newsprint as headers of three columns (leave space on the left side of the columns for the row headers).

A.3 The facilitator asks the participants to mention the main factors that make a crop important to them, and writes them on the newsprints as headers of rows, so that a matrix is formed.

A.4 The participants are divided into three small groups. Each group is provided with newsprint paper and a felt-tip marker. The groups are asked to copy the matrix with the three crops heading the columns and factors determining importance in rows on the newsprint.

A.5 In the small groups, the participants all take a handful of maize seeds. For each factor of importance, each participant individually ranks the three crops by dividing 6 maize seeds among the three crops, representing the proportional value they give to each crop for that factor. After everybody places his or her seeds, the final outcome for the row is reviewed by the participants and they are given the opportunity to move some seeds around, if they believe that the result does not reflect the group's opinion. When everybody agrees to the outcome, the amount of seeds per cell is counted and written in the cell before the next row is ranked in the same manner (see example below).

A.6 After all factors are ranked, the participants count the total number of maize seeds in each column or crop type and write the number in a row labeled "TOTAL".

A.7 Each group presents the results of the ranking exercise.

A.8 The following questions can be posed by the facilitator to stimulate the discussion:

→ Which of the three crops provides the most advantageous enterprise for farmers in this area?

	Crop		
Criterion	Sweetpotato	Rice	Carrot
1. Yield	☯☯☯☯☯☯☯☯☯☯ ☯☯☯☯☯☯☯	☯☯☯☯☯	☯☯☯☯☯☯☯☯
2. Cost of inputs	☯☯☯☯☯☯☯☯☯☯ ☯☯☯☯☯☯☯☯☯☯	☯☯☯☯	☯☯☯☯☯☯
3. Labor required	☯☯☯☯☯☯☯☯☯☯ ☯☯☯☯☯☯☯☯☯☯ ☯☯	☯☯☯☯☯☯	☯☯
4. Price	☯☯☯	☯☯☯☯☯☯☯☯☯☯ ☯☯☯☯☯☯☯☯☯☯	☯☯☯☯☯☯☯
5. Ease of marketing	☯☯☯☯☯☯☯☯☯☯	☯☯☯☯☯☯☯☯☯☯ ☯☯☯☯☯	☯☯☯☯☯
TOTAL	73	49	28

→ What factors make sweetpotato advantageous?

→ What factors make the sweetpotato enterprise risky or reduce its relative advantage?

→ How can the sweetpotato enterprise be improved?

B *What are ICM and FFS?*

B.1 Discussion results about the importance of the sweetpotato enterprise and sweetpotato cultivation constraints and needs are concluded and related to what will be learned in the sweetpotato ICM FFS. The facilitator explains the meaning of ICM and describes the objectives and process of the FFS. Topics to be covered in the FFS are presented and participants are asked for input.

For more information see:

- What is a farmer field school? (Part I, Section 3.1)
- Introduction to ICM (Part III, Chapter 1)

2 A healthy soil

Background

Many farmers in intensive production areas have experienced lately that the yields of their crops are plateauing or even decreasing, although they use the same amount or more chemical fertilizer as they did before. How is this possible? In most cases, this decline of productivity is caused by a decline of soil fertility. Yield increases achieved over the past decades through the cultivation of high yielding varieties have depleted nutrient reserves in the soil that have not been fully replenished by applications of chemical fertilizers. Consequently, the soil is no longer capable of supporting the high yield levels, which is experienced by farmers as stagnant or declining productivity.

Objectives

The objective of this activity is to enhance:

- The participants' awareness on the importance of a healthy soil.
- Their knowledge on the composition, formation and maintenance of soils.

Materials

- Newsprint paper.
- Felt-tip markers.
- Small plastic bags.
- KCl and TSP fertilizers (if needed)*.
- Manure*.
- Hoe (each participant should bring a hoe).

* provided by the owner of the FFS field, if that has been the agreement at the beginning

Activity steps

A *What is the difference?*

A.1 Participants are divided into four small groups.

A.2 Each group observes the soil in two different locations: (1) in the field and (2) on a dirt road. Two of the groups observe the soil of a field that often receives organic manure, while the two other groups observe the soil of a field that is usually only given chemical fertilizer. All groups observe the soil of a dirt road in the field area. The following characteristics of the two soil types should be observed by all participants using all their senses:

→ Color.
→ Texture.
→ Humidity.
→ Smell.
→ Structure of soil layers.
→ Thickness of the upper, fertile soil layer.
→ Animals.
→ Other interesting features.

The findings are written on a sheet of newsprint paper. A handful of soil from each location is put into a plastic bag and taken to the meeting place as a sample.

A.3 The groups present their findings in a plenary session.

A.4 the facilitators leads a discussion in which the three soil types are compared. The following questions could be asked:

→ What is the most obvious difference between the three types of soil?
→ Why have the soils become different?
→ Which of the soils provides the best living place for the crop?
→ What are the characteristics of a good soil and a bad soil?

A.5 Draw conclusions relating to the relationship between cultivation and fertilization practices, and soil characteristics.

B *What is a healthy soil?*

Lead a discussion about the composition and characteristics of a healthy soil:

B.1 The participants are requested to mention all elements contained by soil. Write the answers on a sheet of newsprint paper. Let the participants make up their list first, and add only if necessary:
→ Mineral material: sand, loam, clay.
→ Nutrients.
→ Water.
→ Air.
→ Humus/organic matter.
→ Remainders of plants and animals, compost, manure.
→ Living organisms: animals (insects, earthworms, etc.), fungi, bacteria.

B.2 Draw a table of three columns in a sheet of newsprint paper, with the just mentioned soil elements in the first column. Ask the participants, and write their answers in the two other columns of the table:
→ How did each element get into the soil?
→ Is the element favorable (+) or unfavorable (-) to soil health?

B.3 Discuss together if and how an unhealthy soil can be made healthy again. Draw conclusions.

C *Fertilizers and nutrients*

C.1 The participants are requested to list all the types of fertilizer they know. Add to this list if there is no more answers from them:
- → Organic manure.
- → Compost.
- → Green manure.
- → Urea.
- → TSP.
- → KCl.
- → NPK.
- → Other locally specific fertilizers.

C.2 Explain that NPK fertilizer contains the nutrients "N" (15%), "P" (15%) and "K" (15%). All of these nutrients are important food elements in the total menu for plants, just like rice or potatoes, vegetables, and meat or fish for humans.

C.3 List together the contents of N, P and K in the other fertilizers mentioned before. Extract from the participants' knowledge and add if they do not know. Emphasize that organic fertilizers, such as manure and compost, also contain other elements that are needed for plant development. Explain that all elements are also available in nature, i.e. in the air, water and soil, albeit in very small concentrations.

C.4 Invite one of the participants in front of the group to draw a flowchart (in pictures or words) of what happens to urea from the moment it is bought in the shop. This picture is used to further discuss:
- → The behavior of fertilizers and nutrients in the soil.
- → The loss of nutrients from the soil (through uptake by plants, evaporation, leaching and run-off.

C.5 Discussion:
- → Why do fertilizers have to be applied every season?
- → What are the strengths and weaknesses of organic fertilizers and chemical fertilizers?
- → Why do manure, KCl and TSP have to be applied as a basal fertilizer for sweetpotato?

D *Application of basal fertilizer to the ICM FFS field*

Explain to the participants how basal fertilizer is applied to the sweetpotato field, divide tasks, and fertilize the field as follows:

D.1 Manure:

Ripened manure (at least 400 kg per 1,000 m^2) is applied evenly over the FFS field.

D.2 Chemical fertilizer:

The participants determine together the amount of chemical fertilizer needed by considering the following guidelines:

→ 1) if 400 kg of cow manure per 1,000 m^2 is applied, and

→ 2) the field received TSP during the previous season, and

→ 3) a yield of 40 t/ha is expected, then:

- it is not necessary to apply TSP;
- 5 kg of KCl per 1,000 m^2 should be applied as a basal application (or 50% of the total dose).

AND:

→ If chicken manure was applied, there is normally no need for additional chemical fertilizer at the expected yield of 40 t/ha.

→ If more than 400 kg of cow manure per 1,000 m^2 was applied, the amount of KCl fertilizer can be reduced.

→ If no TSP was applied to the field during the previous seasons, 3-5 kg of TSP per 1,000 m^2 could be applied as a basal application.

→ If the expected yield is more or less than 40 t/ha, the doses of chemical fertilizer should be adjusted accordingly. In the case of an application of basal chicken manure at 400 kg per 1,000 m^2, additional chemical fertilizers only will have to be given when the expected yield is more than 45 t/ha.

D.3 The fertilizer is weighed and broadcast evenly over the field, or applied evenly over the ridges before they are finalized for planting. The fertilizer should preferably be covered with soil to prevent losses from evaporation and run-off.

D.4 Manure trial:

If the participants are interested to observe the effects of manure only on crop development, a simple trial could be set up. In a corner of the field, preferably the place where the organic manure was previously stored and left to ripen, a small ridge of 1-2 m is prepared and applied with a relatively large amount of organic manure which is mixed with the subsoil. No chemical fertilizers are added to this ridge throughout the season. The ridge is marked with a stick. Soil composition (texture, remainders of the manure, living organisms) and plant growth is observed during the season and compared with the rest of the field.

Preparation

Prior to this FFS session the following preparations need to be made:

- Select three locations for soil observation which are close to the meeting place, with the following characteristics: (1) a field with a relatively high organic matter content that is often given organic manure; (2) a field with low organic matter content that is normally only given chemical fertilizer; and (3) a compacted soil on a dirt road or field bund.
- Measure and calculate (in m^2) the exact area of the FFS field.
- Confirm the availability of ripened organic manure for the FFS field at a rate of 400 kg/1,000 m^2.
- Confirm the availability of chemical fertilizers (KCl and TSP, if needed) at a rate according to the guidelines given above. The amount needed for the field school field can be calculated as follows:

⇒ *amount of fertilizer (kg) = dose (kg/1,000 m^2) * field area (m^2) / 1,000*

For more information see:

- A healthy soil (Part III, Section 2.2).

Notes

3 Experimentation

Background

Agricultural research and development of crop management technologies is generally carried out by formal research institutions. The International Potato Center (CIP) is one of the international agricultural research institutes with a mandate for sweetpotato, whilst in most countries where sweetpotato is a major crop there are local research institutes with specific efforts directed to this crop.

When farmers attempt to apply new technology developed by research institutions, they often find that the yields obtained on their fields are not as high as those obtained by researchers on the experimental station. Why does this happen? It is not because farmers are unable to apply the technology, but rather because farm conditions are generally different from those on the experimental station. Moreover, quite often farmers cannot apply a new technology, because inputs or equipment required are either too expensive, or not available on the local market.

In order to develop a management system and practices that suit the specific conditions of the farm, a farmer needs to be able to experiment to test and adjust new technologies. Most farmers actually automatically compare their farming methods with those of their neighbors. Some also compare the results of practices between different seasons or between different plots within their farms. Such comparisons yield insights about the range of

productivity obtainable on the farm, however they do not permit farmers to judge the relative merits of different management practices. For this farmers need to be able to design, implement and evaluate simple experiments in a systematic fashion.

Objectives

After completing this activity the participants:

- Are familiar with the stages of an experiment:
  - Determining the topic and defining the objective of an experiment.
  - Design.
  - Preparation.
  - Implementation.
  - Evaluation.
- Understand the basic principles of systematic experimental design.
- Have gained skills to design, implement and evaluate a simple experiment.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Strengths and weaknesses of farmers' experiments*

The facilitator reviews the results of the group discussion from the previous FFS session about common problems in sweetpotato cultivation. Ask the participants whether they have ever experimented with the crop. If so, let the participants who have describe the experiments they have done. The group should analyze and discuss the strengths and weaknesses of those experiments, and draw conclusions about how experiments should be designed. List their answers on a newsprint sheet.

B *"Rules of the game"*

Present the basic principles of systematic experimentation, drawing wherever possible on ideas that emerged from the previous discussion, and making sure to cover each of the points below:

→ Prioritizing and determining research topics (varying only one factor at a time in each experiment).
→ Setting a clear objective.
→ Determining treatments.
→ Designing the experiment (replications, randomization, lay-out, variables to measure).
→ Planning the implementation (locations, inputs, labor).
→ Implementing the experiment (planting, monitoring, measuring variables, harvesting).
→ Evaluating the experiment (simple data processing, analysis of results, drawing of conclusions).

C *Planning the FFS experiments*

C.1 The participants are divided into four small groups. Each group discusses what they feel are the important topics that they want to investigate on the FFS field. They write their topics on a piece of paper and reach a common conclusion about the ranking of importance of these topics. Each group presents their conclusions to the whole group and then the whole group reaches an agreement about which topic(s) they will choose for the field school experiment (depending on the size of the field they can plan for one or more experiments).

C.2 The group defines collectively the research objective and the treatments for each experiment. The title, objective and treatments for each experiment is recorded separately on a sheet of newsprint paper.

C.3 In the small groups the participants design the experiments. Each group designs one experiment, and one or more groups may be assigned to work on the same trial. The design for each experiment includes: title, objectives, treatments, number of replications, lay-out in the form of a plot map, materials needed, variables to measure, and processing and evaluation procedures. All groups present their design in a plenary session, compare and consolidate them, and come to a final collective design per experiment. The facilitator should watch whether the designs fulfil the criteria discussed previously.

C.4 Plan the implementation of the experiment together with the participants. When are the plots planted and treated? Who provides the materials? Who is in charge of monitoring and recording data throughout the season? Make sure everybody knows what is to be done when.

For more information see:

- Experimentation (Part III, Section 6.2)

Notes

4 Healthy seed

Background

Sweetpotato, like other root and tuber crops, can be multiplied vegetatively through stem cuttings or roots. Vegetative multiplication has several advantages and disadvantages, as follows:

Advantages	Disadvantages
• Seed is easy to obtain from the previous crops or other farmers. • Seed can be planted directly in the field; it does not need to be transplanted from a seedbed. • Desired varietal characteristics are easily maintained. • Planting material with desired characteristics can be easily multiplied.	• Diseases are easily transferred through stem cuttings, and will spread from one field to another. Populations of certain diseases easily built up over several consecutive seasons. • Both stem cuttings and seed roots can contain insect pests. • Stem cuttings easily dry out and can not be stored for long.

Objectives

The objective of this activity is to:

- Enhance the participants' understanding about the important role of healthy seed on crop health and pest management.
- Strengthen their skills in seed selection and seedling preparation.

Materials

- Sweetpotato ICM technical manual (Part III) for pictures of disease symptoms.
- A nearby sweetpotato field ready for harvest where cuttings can be taken to plant in the ICM FFS field.
- Analysis board (see Part I, Section 3.2.3: Agroecosystem analysis).
- Felt-tip markers.

- Newsprint paper.
- Some seed roots for a seedbed of 1-2 m^2.

Activity steps

A *Healthy and unhealthy seed samples*

A.1 The participants are divided into small groups.

A.2 Each small group searches in neighboring fields for examples of healthy and unhealthy sweetpotato cuttings. Unhealthy cuttings should show symptoms of virus infection, scab and insect infestation.

A.3 All sample cuttings are brought to the FFS meeting place. In the small groups, healthy cuttings are separated from unhealthy ones and placed under the analysis board under the column "healthy" and "unhealthy", respectively.

A.4 The analysis boards of the different small groups are compared. Cuttings with resembling symptoms are put together and the cause of the symptoms is determined by the whole group. If necessary, the samples can be compared with the pictures in Part II of this manual showing symptoms of viruses, scab and other diseases and pests.

A.5 The following questions can be used to lead a discussion:

→ What are the characteristics of unhealthy cuttings?

→ What are the characteristics of healthy cuttings?

→ How can we obtain healthy seed?

→ How should we handle seed (storage and planting) in order to maintain good health?

→ How do seed health and method of handling the seed influence (storage) root formation?

B *Healthy seed selection and planting on the FFS field*

B.1 The participants are divided into small groups and asked to collect sweetpotato cuttings in neighboring fields to be planted in the FFS field*. Prior to seed collection, the participants should have agreed on the sweetpotato variety/ies to be planted and the planting density. The amount of seed needed is calculated together, then divided by total number of participants to determine the amount that each participant has to collect. A small excess amount of seed should be collected to replace discarded, unhealthy cuttings. The participants should look for healthy cuttings meeting the requirements as determined by the whole group during the previous activity.

* *In case there are no fields in the nearby area from where sweetpotato cuttings can be collected, or the owners of the fields would not allow it, the facilitator could ask the participants during the previous FFS session to bring cuttings from their own field, or buy cuttings on the market.*

B.2 The cuttings collected by all participants are evaluated and selected together using the previously determined criteria. Unhealthy cuttings with pest and disease symptoms are destroyed.

B.3 Reach a collective agreement about the way how to plant the FFS field (planting distance, direction of cutting in the soil, lay-out of plots for experiments, etc.), before going out together and doing it. The field should be divided into several plots corresponding with the treatments of the experiments planned, including the FFS defoliation experiment (see Field Guide 10), and the seedbed trial (see below).

C *Seedbed trial*

C.1 It is suggested to make a small seedbed with storage roots on the FFS field to provide a demonstration trial of the rapid seed multiplication method explained in Section 2.3 of Part III (Healthy seed). The seedbed trial requires an area of about 1-2 m^2 and several healthy storage roots of a desired variety.

C.2 The facilitator explains the method of seed multiplication from storage roots. Compare this method with farmers' experiences on seed multiplication.

C.3 Explain the objective of seedbed trial, which is to demonstrate and practice how to make clean seedlings from storage roots, and to implement the rapid single-node seedling multiplication method.

C.4 Storage root to be planted in the seedbed are selected together, by choosing big, healthy roots of the same variety.

C.5 The participants are asked to prepare the seedbed and plant the roots.

C.6 The trial is continued during the FFS session about 2-3 weeks later, when the vines emerging from the seed roots have reached a length of 30 cm or more. The seedlings are multiplied by making single-node cuttings, as described in Section 2.3.3 of Part III. The cuttings are planted close together in a newly prepared seedbed which contains compost or ripened manure and ash. Two weeks later the seedlings that have formed roots are moved to the planting ridges prepared in the field, and planted at normal distance. The development of the young plants is observed during the rest of the season and compared with the growth of plants from normal cuttings. Preferably, a few participants are assigned the task of observing the growth development of these plants, and reporting the results to the group.

For more information see:

- Healthy seed (Part III, Section 2.3).

Notes

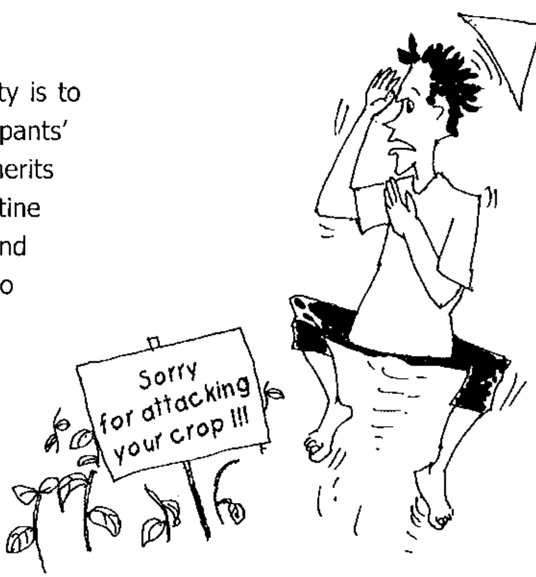
5 Observing the crop and its environment

Background

Farmers are often surprised when they suddenly discover a pest attacking their crop. But is it possible that a high population of a pest appears all of a sudden and destroys a crop over night? Some pests, such as certain kinds of grasshoppers and rats, can indeed rapidly enter an area in large numbers, but more commonly a pest population develops over time in a certain, limited area. This development can be observed if we know what to look for. Population growth of a pest or disease depends on various factors, such as weather conditions, food supply, natural enemies, etc. If farmers understand the development patterns of the crop and the pest, and routinely observe these developments, they will not be easily surprised by a sudden pest, because they know exactly what is happening in their field. Moreover, with this information in hand, they can make decisions more easily and more adequately about what practices are needed in the field.

Objectives

The objective of this activity is to enhance the participants' understanding about the merits and method of routine observation of the crop and its environment, and to increase their field observation skills.



Materials

- Newsprint paper.
- Felt-tip markers.
- Analysis board.

Activity steps

A *Observation habits*

A.1 Lead a discussion about the participants' habits of observing their crops by asking the following questions:

- → At what intervals do you normally observe the sweetpotato crop?
- → How do you observe the crop?
- → Why is it (not) necessary to observe the crop?

B *Observation of the ICM FFS field*

B.1 Explain that field observation is one of several routine activities in the ICM farmer field school. The objective of routinely observing the field is to increase farmers' skills in analyzing crop and environment conditions, and in making informed crop management decisions. During every FFS session, this activity includes:

- → Field observation in small groups.
- → Discussion and analysis of results (agroecosystem analysis) in the small groups.
- → Presentation of results and discussion in the large group.

B.2 Explain that the observation activities in the FFS will gradually develop, as follows:

- → During the FFS session 3: observation of the field conditions and the field environment.
- → During FFS session 4: observation of the field conditions, the field environment and crop health.
- → During FFS session 5: observation of the field conditions, the field environment, crop health and occurrence of natural enemies.
- → From FFS session 6 onwards: a complete observation, including the field conditions, the field environment, crop health, occurrence of natural enemies and pests and diseases.

B.3 The participants are divided into small groups and invited to the FFS field. During each session when a new element is added to the observation practice, the facilitator explains the appropriate way to observe (see Section 3.3 in Part III):

→ During FFS session 3, explain how to observe the field conditions (soil, water condition) and environment.

→ During FFS session 4: explain how to observe crop development and health.

→ During FFS session 5 and 6: explain how to observe pest and natural enemy populations, respectively.

B.4 The participants observe the FFS field. Each small group should sample 10 observation points (see Section 3.2 in Part I).

B.5 Provide small plastic bags for the participants to collect leaves, insects, soil samples, etc. Encourage them to collect both healthy and unhealthy elements that they can find in the sweetpotato agroecosystem.

C *Ecosystem analysis and presentation of results*

C.1 In the small groups, the observation data collected at the 10 sample points are aggregated, discussed and analyzed.

C.2 From the fifth FFS session onwards, after an introduction to the agroecosystem has been made, the participants are encouraged to use the analysis boards for processing and presenting their observation data. All healthy ecosystem elements collected are pasted, pinned and/or written on the left side of the board, while the unhealthy elements on the right side.

C.3 The participants should draw a sweetpotato plant in the center of a sheet of newsprint paper conform to the development stage they observed in the field, and attach the paper sheet in the middle of the analysis board. Let them pay special attention to the development stages of the root system. The elements they could not collect in the field should be drawn or written on the newsprint paper. Each small group draws conclusions about:

→ The conditions of the field and the environment by weighing healthy and unhealthy elements.

→ Crop management practices that need to be implemented during the upcoming week.

C.4 The groups present the results of their agroecosystem analysis and discuss them. The role of the facilitator in these discussions is to always relate the findings of this week with those of the previous weeks to keep track of changing conditions with regard to the development of vines and roots (nutrient deficiencies, number and size of storage roots), and of pest, disease and natural enemy populations (types and numbers).

C.5 Draw a final conclusion about the condition of the field and the environment, and about crop management practices needed during the upcoming week.

For more information see:

- Farmer Field School activities (Part I, Section 3.2)
- Introduction to the agroecosystem (Part III, Section 3.1)
- Observing the crop and its environment (Part III, Section 3.3)

Notes

6 Economic analysis of the sweetpotato enterprise

Background

Many farmers perceive sweetpotato as an unreliable crop when it comes to profit expectations. They believe that the market price is the major profit determining factor, and since prices may fluctuate drastically over the course of a season, they never know how much they will make at harvest day. Farmers rarely take into consideration the other factors determining their profit, and do not know exactly how their expenditures relate to their income. A simple economic analysis of the sweetpotato enterprise may help farmers economize on expenditures and give them better insights on how to exploit factors that broaden their profit margins.

Objective

The objective of this activity is to enhance the participants' skills in making an economic analysis of the sweetpotato enterprise, as a tool for crop cultivation decision-making.

Materials

- "Sweetpotato Cultivation Record" cards, copied from the example form in Appendix II-D on buffalo paper (double-sided), as many as the number of participants plus one extra for recording the management data of the FFS field.
- Newsprint paper.
- Felt-tip markers.

Activity steps

A *The pluses and minuses of the sweetpotato enterprise*

A.1 The facilitator explains the purpose of this activity, i.e. to understand the factors determining the profit of the sweetpotato enterprise, and to present a method for economic record keeping and analysis.

A.2 A discussion is initiated by probing the participants about how much they think their net income per hectare (or any local area unit) from sweetpotato will be. What are the reasons for different profits obtained by different farmers?

A.3 The participants are asked to mention all activities throughout a sweetpotato growing season, from soil preparation to marketing, which are listed by the facilitator on a newsprint. For each activity a cost is determined by the group, including both inputs and labor. Household labor should also be converted to wages. Gross and net income are calculated. The net income is the gross income minus the total expenditures.

A.4 Building on the economic picture created together, a discussion is held, focusing around the following questions:

→ What is the most important factor that determines the net income from sweetpotato?

→ Which expenditures can be reduced and how?

→ In order to obtain a reasonable income, what should the price of sweetpotato per kg be?

→ What is the farmers' daily wage, based on the analysis made? How much should it be for sweetpotato cultivation to become an attractive enterprise?

B *Sweetpotato cultivation record keeping*

B.1 The facilitator distributes the Sweetpotato Cultivation Record cards to the participants. One participant is asked to volunteer for keeping a seasonal record of the FFS field.

B.2 The facilitator explains what the columns and rows on the card mean and how the record should be kept.

B.3 It is recommended that during each FFS session several minutes are spent on jointly determining what has to be filled in on the record for the FFS field by the volunteer participant, and to check whether the participants have problems keeping their private records.

B.4 During the evaluation session at the end of the season, the economic analysis of the FFS field is made in the group, and profit determining factors are discussed. It would be an interesting exercise to compare the economic analysis of the FFS field with that of one of the participants who has already harvested.

For more information see:

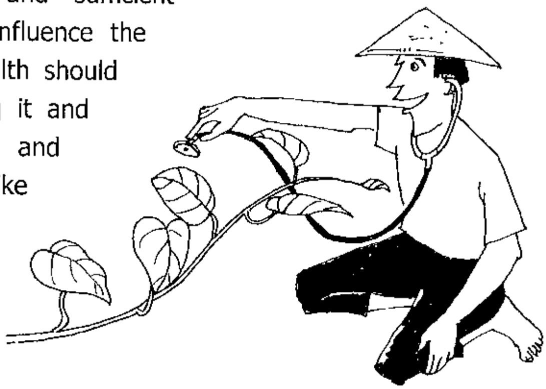
- Economic analysis of the sweetpotato enterprise (Part III, Section 6.4)

Notes

7 A healthy crop

Background

To stay healthy, we have to eat nutritious food and drink sufficiently in a regular manner. Taking unnecessary or inappropriate medicines is dangerous for our health. If a pregnant mother is unhealthy, the health of the baby is definitely affected. All these arguments also hold for crops. A healthy soil, providing good nutrition and sufficient water, and healthy seed influence the health of a crop. Crop health should be maintained by fertilizing it and preventing excessive pest and disease occurrence. Just like human health care, crop health care requires certain attention and practices.



Farmers often perceive a crop healthy if leaves look green and fresh. As long as the leaves are green, fertile and not wilted or curly, they believe the crop is sufficiently healthy. However, when symptoms of stress factors affecting crop health occur, such as a change in color or spots on the leaves, farmers find it hard to determine the cause of the problem. Any kind of spots are normally blamed on insect attack, although they might be caused by nutrient deficiency. A wrong identification of the cause of stress may trigger an inadequate action. Therefore, to make better decisions on what action is needed, farmers should be able to identify the various symptoms and factors that may affect crop health.

Objectives

After completing this activity the participants:

- Have reached a common agreement about the criteria for a healthy crop.
- Have gained knowledge about the needs of the sweetpotato crop for good growth development, and about the visible symptoms caused by stress factors.
- Have increased their skills in evaluating crop health in the field.

Materials

- Sweetpotato ICM technical manual (Part III) for pictures of nutrient deficiency symptoms.
- Pieces of string (@ 10 cm).
- Copies of the sweetpotato vine growth record form (Appendix II-E)
- Newsprint paper.
- Felt-tip markers.

Activity steps

A *What does a healthy crop look like?*

A.1 Ask the participants for their opinion about the characteristics of a healthy sweetpotato crop. List these characteristics on a sheet of newsprint paper.

A.2 Evaluate together leaf samples that were collected during the observation exercise, and let the group determine which are healthy and which are not. Probe for the causal factors of unhealthy leaves.

A.3 Ask for and list the participants' opinion about what a sweetpotato crop would need for good growth. Add to this list, if necessary.

A.4 If fertilizer is mentioned as a necessary factor, ask the participants what kind of fertilizers they would apply to the crop. Explain that NPK fertilizer contains the nutrients N, P and K, while most other chemical fertilizers contain only one nutrient. Refer to the session on a healthy soil (Field Guide 2).

A.5 Elaborate through probing that plants need nutrients for growth, such as:
- → Nitrogen (N).
- → Phosphorous (P).
- → Potassium (K).
- → Many other nutrients, but only in small quantities.

A.6 Let the participants express their opinion about what would happen if a crop suffers from shortage of one of the nutrients mentioned above, or from water. Show leaf samples with nutrient deficiency symptoms and the pictures from Section 2.4 of the Sweetpotato ICM Technical Manual (Part III).

B *Measuring vine growth*

B.1 Draw a column on a sheet of newsprint paper, and write the heading ("weeks after planting") and vertically numbers from zero (planting) until 17 (harvesting). Draw another, broad column on the right side of the previous column with a heading ("indication scores") from 1-10 (see example below). Ask the participants to illustrate the growth of sweetpotato vines from week to week by giving a score from 1 (slowest growth) to 10 (fastest growth). Compare this illustration with the sweetpotato development phases: initial phase, intermediate phase (storage root formation), and final phase (root bulking).

Weeks after planting	Score for speed of vine growth 1 2 3 4 5 6 7 8 9 10	Crop care practices
0	■	
1	■	
2	■■	
3	■■	
4	■■■	
etc.		

B.2 A last column is drawn with the heading "Crop care practices", and filled with activities needed from week to week to support a smooth crop development.

B.3 Throughout the FFS season, the growth of the sweetpotato vines on several sample plants will be followed and measured. Each small group marks one plant with a bamboo stake. During every FFS session the participants count and write down the number of new leaves that have formed (and opened) during the previous week, and tie a piece of string on the tip of each vine just above the last leaf counted (i.e. under the first still closed leaf). The string is moved up every week after new, additional leaves have been recorded.

B.4 Each small group is given a form copied from Appendix II-E to plot the number of leaves counted every week (see example below). The facilitator should explain the vine measurement exercise and recording method during FFS session 4. Make sure that only newly formed, additional leaves for each one- or two-week period are counted, NOT the total, cumulative growth over weeks. When the frequency of FFS sessions is once in two weeks, the vine growth should still be recorded as the number of additional leaves per week, which is the number of leaves counted after two weeks divided by two.

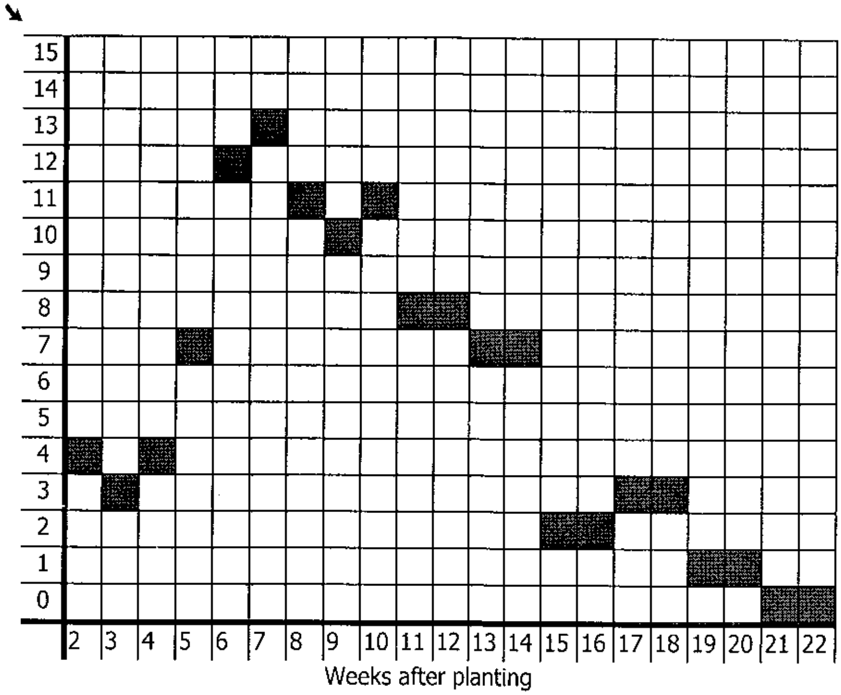
B.5 The vine growth graphs of the small group are kept by the facilitator or clipped to the analysis boards, so they won't get lost or be forgotten at the next FFS session.

B.6 At the end of the season, during the last FFS session before the crop is harvested, all groups present their vine growth graphs. The results are discussed and conclusions are drawn collectively.

For more information see:

- A healthy crop (Part III, Section 2.4).

Number of additional leaves since last week:



Notes

8 Natural enemies: the farmers' friends

Background

The agroecosystem provides the living place for crops cultivated by farmers. The existence of crop plants in a field provides a living place for a range of animals. Many farmers believe that all animals occurring in their fields will damage the plants and, therefore, have to be destroyed. There are kinds of animals that, indeed, eat parts of plants, and these animals are called pests when their eating results in visible damage to the crop. However, in a healthy ecosystem, there are normally more animals that do not eat the crop plants, but live on other kinds of food available in the ecosystem. Many of them even eat other animals, including pests, and these are called natural enemies. These natural enemies help farmers to control pests and should therefore be protected.

Objectives

The objective of this activity is to enhance the participants' awareness and knowledge about the existence and role of natural enemies in the sweetpotato agroecosystem.

Materials

- Newsprint paper.
- Felt-tip markers.
- Small plastic bags.
- Plastic or glass containers, one per small group. The containers should be coated inside with paper, and the lids perforated with small holes or provided with a screen-covered window.
- Sweetpotato roots with and without weevil infestation.
- A knife.

Activity steps

A *Why don't we get drowned under insects?*

A.1 Make a calculation together with the participants of the total number of sweetpotato stemborers that would develop from one pair during six months with the following assumptions:

→ One pair of adults produce 100 surviving caterpillars within one month.

→ The adults die after having produced the next generation.

→ At the age of one month, the next generation also produces 100 caterpillars per pair, and dies afterwards.

→ This cycle is repeated during a total of six months.

The total number of caterpillars produced after six months is given in Section 4.1 (Part III).

A.2 Discussion:

→ Do we normally experience an insect population growth like this within one season in our field?

→ Why does a population growth like this never happen in nature?

→ Have you ever noticed animals (insects) in your field that eat or attack the sweetpotato pests? If yes, what are these?

B *Field sample of natural enemies*

B.1 The participants are divided into small groups. Each group collects insects and other animals from fields around the FFS meeting place that they believe are natural enemies. The samples are kept in small plastic bags. They should try to observe what and how the natural enemies are eating, whether they prey or parasitize. Predation can usually be observed near ant hills. The ants walking in and out of the hill should be observed and can be fed with some small caterpillars.

B.2 After the field observation, the groups take turns in presenting their results.

B.3 Lead a discussion about the three different categories of natural enemies: predators, parasitoids and pathogens. Probe from the participants' existing knowledge and add explanations about how each category lives and functions in the ecosystem. Show samples of each category that were collected from the field.

C *Observation of the behavior of natural enemies*

C.1 Each small group receives a container with a perforated or screen-windowed lid. They can use this container as a life cage to experiment with and observe the behavior of natural enemies. Every FFS session, the group participants should collect a certain type of natural enemy and different kinds of food. During the week,

one of the group members can take the container home and observe whether, what and how much the natural enemy eats. The group members take turns in observing natural enemies at home.

C.2 The results of interesting observations should be reported during the next FFS session, for instance included in their agroecosystem analysis presentation. The following questions could be used to let the participants discover the behavior and function in the agroecosystem:

→ How did the natural enemy behave during the period of observation?

→ What is the function of the natural enemy in the field?

→ Is this natural enemy common in the sweetpotato field or not?

→ How can we utilize this natural enemy in crop management?

C.3 Although it would be better if the participants determine themselves what they want to observe, some suggestions for easily observable pest-natural enemy relationships are given below:

→ *Predation by a rove beetle*

A few rove beetles (Staphilinids) are put in the container which was given a little bit of soil on the bottom. Weevil infested sweetpotato roots are cut into pieces and the weevil larvae are taken out and put in the containers with the rove beetles. Observe what happens with the beetles and with the weevil larvae. How many weevil larvae are eaten a day per beetle? Try also other foods.

→ *Weevils can mould*

Some (pieces of) weevil infested sweetpotato roots are put in the container. Observe the roots for a few weeks. If the weevil begin to emerge, add some fresh, uninfested roots in the container. Observe the weevils every day, and look for the weevils with their skin covered with a whitish powder. The powder is fungus. Observe the behavior of the fungus infected weevils. After how many days do they die?

→ *The existence of parasitoids*

Several different species of insect pests that are likely to be infested with parasitoids (leafeating and stemborer caterpillars, aphids, etc.) are collected from the field and put in a container. Observe the development of the pest insects every day and see whether the pest passes its own life cycle, or whether parasitoids emerge. The following categories of parasitoids can be observed:

- Egg parasitoids: collect sweetpotato leaves with eggs of insect pests from the field. Eggs can normally be found on the back side of the leaves. Eggs of hornworms are usually easy to find since they are quite big, round and green colored. Leaves with eggs are put in a container that is coated with filter paper. Too many leaves in one container may cause high humidity, hence rotting of the eggs. Observe the eggs every day to see whether caterpillars (= pest) or small wasps (= parasitoid) hatch.

- Larval parasitoids: Collect various kinds of leafeating caterpillars from the field and put them in the container with some fresh sweetpotato leaves. Provide fresh leaves to the caterpillars every day. Try to maintain the humidity in the container low. If the conditions are favorable, the caterpillars will become pupae, but some caterpillars may die before they reach the pupal stage. What is the cause of death? Did a parasitoid (a wasp or a fly) appear? Observe all species of parasitoids that emerge.

- Other parasitoids: Collect sweetpotato leaves with aphid, whiteflies, mealybugs, etc., and put them in a container—preferably one container for each species. The containers should be coated with filter paper. Observe the insects every day to see whether parasitoids (small wasps) emerge.

- Leafminer fly parasitoids: Collect sweetpotato leaves leafminer tunnels, and put them in a container coated with filter paper. Larvae of leafminer flies are often infested with parasitoids. After a few days, the larvae will emerge and pupate on the leaf surface. Observe the pupae continuously to see whether flies (=pest) or small wasps (=parasitoid) emerge. The wasps are smaller than the flies. We can calculate the percentage of parasitism as follows:

$$\% \text{ parasitism} = \frac{\text{no. of parasites}}{\text{no. of parasites} + \text{no. of pests}} * 100\%$$

For more information see:

- Natural enemies (Part III, Chapter 4).

Notes

9 Sweetpotato pests

Background

Under normal conditions, most plants in a field will definitely contain one or more insects that are consuming certain parts of the plant. Farmers, whose aim is to cultivate crops with as high a yield as possible, normally do not like to see any creatures in their field. But do all creatures that live in the agroecosystem damage the crop? And do all creatures that, indeed, consume plant parts, cause yield loss? Are all animals that eat plant parts eligible to be called "pests"?

Objectives

After completing this activity the participants are able to:

- Identify the major sweetpotato pests and understand their life cycles.
- Understand that crop eating animals should not always be considered pests.

Materials

- Small plastic bags.
- Containers with perforated or screen-windowed lids.
- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Which one is a pest?*

A.1 Ask the participants to mention the sweetpotato pests they know and list them on a sheet of newsprint paper (vertically).

A.2 If the list is exhausted, draw a table of five columns, with the list of sweetpotato in the first column, and the following headings in the other four columns:

Sweetpotato pests	Frequently occurring in large numbers	Dangerous and damaging	Difficult to control	TOTAL
1.				
2.				
3.				
etc.				

A.3 Per column, the participants rank the pests, by giving the pest that is, for instance, most frequently occurring in large numbers a score of 10, while the other pests are given a proportional score in relation to the number one pest. The same is done for the third and fourth columns. When all columns have been ranked, the total score for each pest is calculated by adding the scores of the three columns. The total scores for all pests are compared.

A.4 Discussion:

→ Which pest could be considered the major problem based on the total score that was determined in the ranking exercise? Does everybody agree?

→ Which of the three factors should be given relatively more weight to consider whether a pest is a major problem or not?

→ What factors determine whether a plant eating animal should be considered a pest or not?

If necessary, the facilitator can add some of the following points:

- Occurrence.
- Type of damage and level of actual yield loss.
- Development stage of the crop.
- Types of natural enemies existent in the field.
- Ratio between number of natural enemies and number of pests.
- Health and genetic resistance of the crop.
- Weather and environmental conditions.

B *Life cycles and food chains*

B.1 By probing the participants, draw the life cycles of the sweetpotato weevil, the hornworm (or any other commonly occurring caterpillar) and the aphid.

B.2 Ask the participants what development phase of each insect attacks the sweetpotato crop. Let them describe the biology of each insect (where does it live, what does it eat at the different phases, etc.), and add their comments in the life cycle pictures.

B.3 Draw a food chain together with the participants, starting with the sweetpotato leaves eaten by a hornworm. The hornworm is eaten by what natural enemy, which in turn is eaten by what other natural enemy? What happens at last with all of the organisms?

B.4 Discussion:

→ How are life cycles of pests related to the infestation of the crop?

→ The attack of which phase of the pest life cycle by natural enemies is most effective to suppress pest population build-up?

C *A pest or a natural enemy: prove it yourself!*

C.1 If the participants find an insect in the field of which they do not know its function, rather than giving a straightforward answer they should be encouraged to prove for themselves whether the insect eats plants or other animals. They can use containers with the perforated lids for this purpose.

C.2 Put the insect in the container and provide it with one or several types of food, such as leaves, root pieces, caterpillars, aphids, etc. One type of food per container is easier to observe, but more types in one container can show whether the insect eats more than one type of food or not, and which one is preferred. Observe what the insect eats. The next day, the food can be replaced by something else.

C.3 The containers are taken home by the participants for further observations. During the next session, the groups present their findings.

For more information see:

- Sweetpotato pests (Part III, Chapter 5, particularly Sections 5.1 and 5.2).

Notes

10 Defoliation experiment

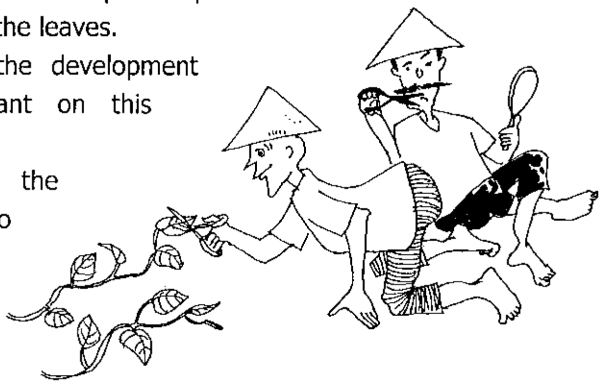
Background

Leaves play a very important role in crop development, since in the leaves important substances are formed that will later be used for the growth of new vines, leaves and roots. Farmers are often worried when they see that insects damage the leaves of the crop, and fear a considerable yield loss. However, sweetpotato plants possess an enormous capacity to compensate leaf damage by forming new leaves. By means of a defoliation experiment, in which damage by leafeating insects is imitated by cutting parts of the leaves, we will demonstrate the effects of leaf damage to vine growth and root yield, and prove the plant's regenerative capacity to compensate for damage.

Objectives

After completing this activity the participants will comprehend:

- The reaction of the sweetpotato plant to insects damage on the leaves.
- The influence of the development phase of the plant on this reaction.
- The capacity of the sweetpotato plant to recover from and compensate for leaf damage.



Materials

- 10 bamboo stakes.
- Scale (at harvest).
- Copies of the Defoliation Experiment form (Appendix II-F).
- Newsprint paper and felt-tip markers.

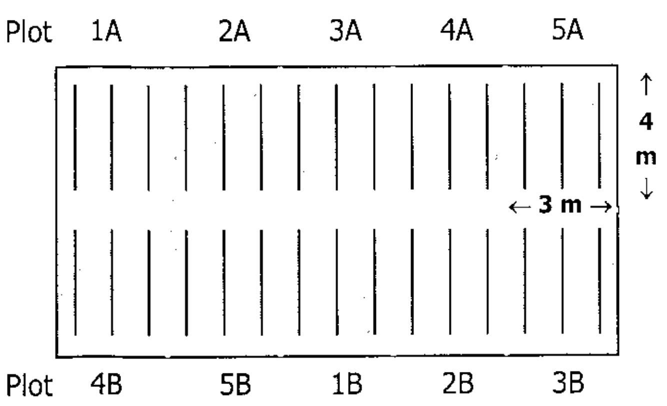
Experiment design

This experiment is carried out in the small groups; each group is responsible for one treatment. It requires a field of 120 m^2. This field is divided into 10 plots, each of 12 m^2 (3 by 4 m; for instance three ridges of 4 meters long). The experimental field should be prepared and planted during FFS session 2.

The experiment described here consists of five treatments with two replications (A and B), but can be adjusted as desired. The treatments compare different variations between percentage of leaves cut with age of the crop when defoliation is done, as follows:

Plot no.	*Replication*	*% Defoliation*	*Crop age (months after planting)*
1	A and B	0%	-
2	A and B	50%	1 month
3	A and B	50%	3 months
4	A and B	100%	1 month
5	A and B	100%	3 months

The field could be laid out as follows:



Leaf cutting is done by picking the leaves and vine tips according to the percentage for each treatment. The stem is left in the field.

Activity steps

A *Leaf damage versus yield loss*

A.1 Ask the participants to mention pests and diseases that damage the sweetpotato leaves, and list them on paper.

A.2 For each of the pests and diseases listed, the participants should come to an agreement on what percentage of leaf damage they would tolerate without expecting yield loss as a result of the damage.

A.3 They are then asked during what development stage the crop would be more or less susceptible to leaf-damaging pests and diseases. Would the percentages mentioned before vary over the season?

B *Defoliation experiment*

B.1 Preparation (FFS session 6):

→ Explain the objective and design of the defoliation experiment.

→ Prepare plot labels using bamboo stakes by marking them with the plot number and treatment. Place them in the plots.

B.2 Treatment (FFS session 6 and 12):

→ The participants implement the first defoliation (one month after planting treatments) during FFS session 6. At that time, they also measure the area of each plot and count the number of plants that are alive. All data are recorded on the Defoliation Experiment form (copied from Appendix II-F).

→ The first defoliation is done on plots 2A, 2B, 4A and 4B by picking off the leaves and vine tips, 50% for plots 2A and 2B, and 100% for plots 4A and 4B.

→ The second defoliation is done on plots 3A, 3B, 5A and 5B when the crop is three months old (FFS session 12).

→ During consecutive FFS sessions, the condition and crop development of each plot is monitored and any striking observations are recorded.

B.3 Evaluation (FFS session 17):

→ At harvest time, the participants count the number of plants alive in each plot. They weigh the root yield of each plot, separately. All data are recorded on the Defoliation Experiment form.

→ The average yield (in kg/plant and t/ha) of the two replications per treatment is calculated.

→ The results of the small groups are compiled, presented on a sheet of newsprint paper, and analyzed by the group.

B.4 Discussion:

→ What percentage of leaf damage is still acceptable since it does not cause yield loss?

→ When is the effect of leaf damage on the root yield greater, when the crop is attacked at 1 or 3 months after planting? Why is this the case?

→ What can we learn from this experiment in relation to the management of leafeating pests?

For more information see:

- The regenerative capacity of plants (Part III, Section 2.5).

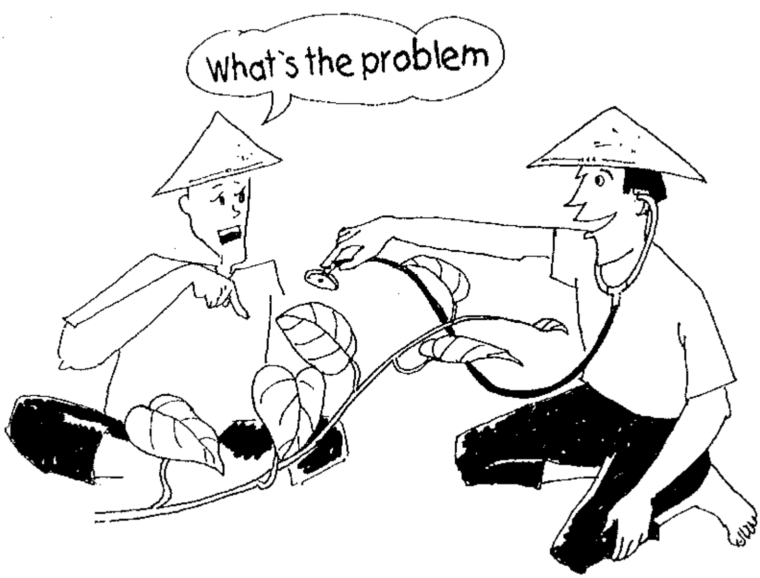
Notes

11 Sweetpotato diseases

Background

Just like any other living organism, sweetpotato plants can become sick. The organisms causing most diseases cannot be seen with the bare eye, because they are too small and live inside the plant tissue. We can only see symptoms of a disease that may emerge on the leaves, stems or roots. There are even diseases that do not show any visible symptoms, except a low yield at the time of harvest.

When they see symptoms on the leaves, the first thing farmers usually think of is insect pests, although the symptoms may very well have been caused by a disease unknown to the farmers. Management practices for diseases are definitely very different from those for insect pests. Therefore, farmers should be able to differentiate between the different causes of symptoms occurring on the plants.



Objectives

The objectives of this activity are to:

- Enhance the participants' awareness and knowledge about the existence and importance of various sweetpotato diseases.
- Improve their competence to identify, prevent, and manage diseases in the sweetpotato crop.

Materials

- Newsprint paper.
- Felt-tip markers.
- Sweetpotato storage root with symptoms of black rot.
- Healthy sweetpotato roots.
- Sack.

Activity steps

A *Various diseases and their management*

A.1 The participants are asked to mention diseases of sweetpotato they know. List their answers on a sheet of newsprint paper.

A.2 Make small groups and invite the groups to look for the following categories of samples with disease symptoms in neighboring fields:
- → Vines and leaves from older crops (they will likely find virus and scab symptoms).
- → Storage roots in just harvested crops (they will likely find root rot, black rot and nematode symptoms).

A.3 The samples are taken to the FFS meeting place and discussed one by one in the whole group. Determine together the local name and the cause of the disease symptoms. The facilitator could add samples with other diseases that have not been collected by the participants to cover all categories of diseases (fungi, bacteria, viruses and nematodes).

A.4 Ask the participants what management practice would be adequate to prevent and/or control each disease. Emphasize the importance of prevention of disease infection by sanitation and the use of clean seed.

A.5 If varietal resistance emerges as one of the possible ways to manage diseases, a variety ranking activity could be suggested to determine together which of the commonly used varieties is most resistant against commonly occurring diseases, such as the example below. For each disease, the varieties listed are given a score for resistance.

Disease / *Variety*	Scab	Black rot	Virus
A			
B			
C			
etc.			

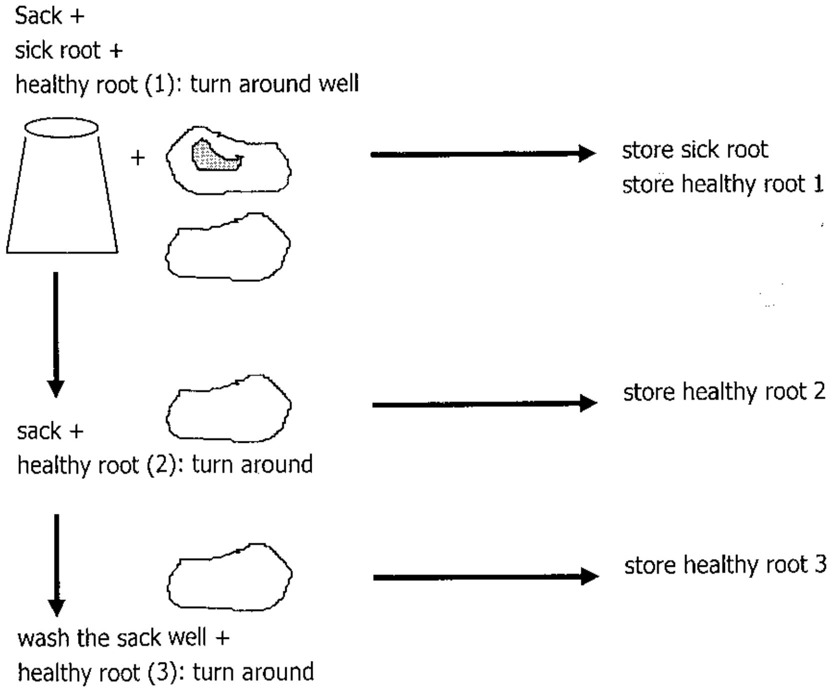
B *Sources of disease infection*

B.1 Ask the participants to list any source of disease infestation they can think of. With a simple experiment we will demonstrate that the major source of infection is a sick plant.

B.2 Put a storage root with black rot symptoms together with a healthy root in a clean sack (see flowchart below). Close the sack and turn the sweetpotato roots around for about one minute. Then take the roots out and keep each of them separately in a plastic bag with a label ("sick" versus "healthy 1").

B.3 Put a healthy sweetpotato root in the same sack. Turn it around in the sack several times, take it out and put it in a clean plastic bag with a label "healthy 2".

B.4 Wash the sack carefully with water until it is totally clean. Put a healthy sweetpotato root in the clean sack, turn it around several times, take it out and put it in a clean plastic bag with a label "healthy 3, clean sack".



B.5 Ask for a volunteer to take the plastic bags with the sweetpotato roots home and observe daily what happens with the roots. The volunteer should record when the different roots start to show black rot symptoms and how the disease develops on the roots.

B.6 During the next FFS sessions, the observation results are presented and discussed by the whole group. The following questions could be used to lead the discussion:

→ What is the difference in development of black rot among the four sweetpotato roots?

→ What is the best way to prevent infection of the disease?

→ If the root which was put in the clean, washed sack still showed black rot symptoms, what would be a better way than washing with water to prevent the transmission of the disease through tools and materials? (For example, sun drying, washing with soap.)

B.7 If the participants are still interested to test these methods, a new experiment could be conducted.

For more information see:

- Diseases (Part III, Section 5.6).

Notes

12 Weeds: friends or foes?

Background

A sweetpotato field with many weeds is in most places considered not well taken care of, and the farmer is labeled "lazy". Nevertheless, a farmer may have very good reasons why she or he lets the weeds grow, for instance, because there is not enough labor in the family to weed the crop, or they believe that the weeds are useful.

Objectives

This activity is intended to:

- Enhance the participants' understanding about the disadvantages and advantages of weeds in the sweetpotato crop.
- Strengthen their capacity in utilizing weeds in the crop.

Materials

- Analysis board.
- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Which one is a friend, which one a foe?*

A.1 The participants are divided into small groups, and invited to collect samples of weeds from the field.

A.2 In the small groups, the weed samples are put on the analysis board by distinguishing between weeds that significantly affect crop development (listed in the column "unhealthy") and weeds that are considered not harmful (listed in the column "healthy"). The (local) names of the weed species are written on a sheet of newsprint paper that is pasted in the middle of the board.

A.3 In turns, the groups present and discuss their results.

A.4 All weed species found by the various groups are written on a sheet of newsprint paper in the first column of a ranking table. Two other columns are drawn with the headings:

- → Causes yield loss.
- → Is difficult to control.

A.5 The various weeds listed are ranked by the group for each of these columns, separately, by giving a score of 10 to the weed causing the highest yield loss or the one most difficult to control, after which the other weeds are scored proportionally. The total score for the weeds is calculated by adding the scores of the two columns.

A.6 Discussion:

- → How can weeds affect the development of a crop?
- → Do all weed species affect the crop negatively?
- → How can weeds in the field be useful?
- → What is the most appropriate way to manage (and utilize, whenever possible) weeds?

For more information see:

- Weeds (Part III, Section 5.7).

13 Aphids and other tiny insects

Background

Ever since pesticides began to be used on agricultural fields, the kind and number of pest species that emerged in the crops changed. Several kinds of insects that previously did not cause economic loss are presently major pests such as, for instance, the brown planthopper in rice crops, and aphids in sweetpotato in certain areas. Typically, these are insects that are small in size and under pesticide-free, normal conditions suppressed by natural enemies.

Farmers often cannot distinguish between the various kinds of tiny insects that occur in their sweetpotato crop, many of which cause similar symptoms, such as curly leaves. But if observed well, the shape of these different species is actually very different, as is their effect on the crop and management practices required to keep the populations low. Therefore, farmers should be able to identify the different species of small pest insects and understand their respective biologies and ecologies.

Objectives

The objective of this activity is to increase the participants' knowledge in regard to:

- The different kinds of small pest insects.
- Factors influencing the population dynamics of small pest insects.
- Management practices for small pest insects.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Small pest insects in the field*

A.1 The participants are divided into small groups and invited to go to the field to collect samples of:
→ small pest insects, i.e. aphids, leafhoppers, thrips and mites,
→ leaves with symptoms of damage due to these small insects, and
→ natural enemies of these small pest insects.
The samples are put in small plastic bags and taken to the FFS meeting place. The appearance of the different species of insects, their biology and the natural enemies collected are observed more closely.

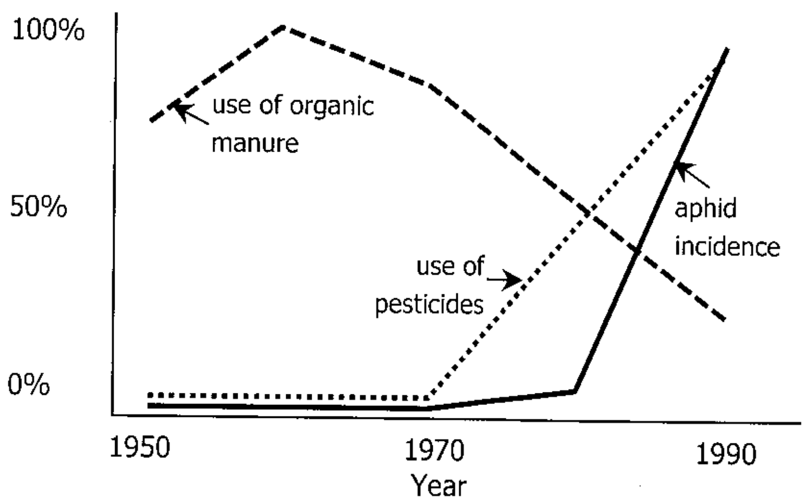
A.2 The samples collected are put up on the analysis board with explanations written on a sheet of newsprint paper. The groups take turns to present their results. Probe and discuss why leaf sucking insects can be more dangerous than chewing insects.

A.3 Suggest to the groups to observe the behavior of various kinds of small pest insects and their interaction with natural enemies in the life cage containers.

B *The cause of the problem*

B.1 Ask the participants when and how aphids, leafhoppers, thrips and/or mites have emerged for the first time on their crops.

B.2 If the relationship between the emergence of these pest insects and the increased use of pesticides emerges, make a "time-and-trend-line graph" together with the participants. Such a graph can clearly illustrate the strong relationship between the emergence of certain pest insects and management factors, such as the changed use of pesticide, manure, chemical fertilizers, and new varieties (see example below). Let the participants try to explain the prevailing conditions at that moment and changing conditions over time. The facilitator captures their points in a chart indicating a relative score versus time periods.



B.3 Lead a discussion about how the small pest insects can be best managed. Emphasize the conservation of natural enemies and the enhancement of crop health.

For more information see:

- Chewing and sucking pests (Part III, Section 5.2).

Notes

14 Pesticides: Medicine or poison?

Background

When we are ill, we often take a medicine to soon get healthy again. Similarly, farmers often say that they have applied a "medicine" to the crop when attacked by a pest or disease. But do these "medicines" really make the crop healthier? Lately, many farmers complain that ever since they used "medicines" on their crops, pests have increased and become more difficult to control. Consequently, the farmers either look for another "medicine" that they hope is stronger, or they mix several "medicines" together in a cocktail. But to their despair, "cure" often does not occur. What happens for sure is that natural enemies are killed and the environment is polluted due to the chemicals they used and call "medicine". It would actually be more appropriate to call these poisonous chemicals, or pesticides, "poison" rather than medicine. In addition to killing natural enemies, many cases are reported every year of farmers being poisoned by pesticides while spraying, or having acquired chronic diseases as a result of repeated exposure to pesticides. Unfortunately, many farmers do not realize the negative side effects of these poisonous chemicals.

Objectives

After completing this activity the participants will have gained:

- Knowledge about the characteristics of pesticides.
- Understanding about the effects of pesticides on natural enemies and pests.
- Awareness about the negative side effects of pesticides on the environment and human health.

Materials

- Half a teaspoon of *monocrotophos* (or any other contact insecticide).
- One and half teaspoons of *carbofuran* (or any other systemic insecticide).
- Four glass jars.
- Two used tin cans.
- Two young sweetpotato plants with roots.
- Two large transparent plastic bags.
- Wristwatch.
- Newsprint paper.
- Felt-tip markers.
- Four photocopies of the "Pesticide experiment" form (Appendix II-G).

Activity steps

During this meeting the participants prove through an experiment that insecticides do not only kill pests but also natural enemies.

A *Preparation*

A.1 Prepare two glass jars filled with water for the pesticide solutions.

A.2 One bottle is given half a teaspoon of monocrotophos and shaken briefly. The other bottle is given half a teaspoon of carbofuran granules and stirred thoroughly until the granules have dissolved.

A.3 Close the bottles well.

B *Treatment*

B.1 The participants are divided into four small groups.

B.2 Each group collects three species of pests and three species of natural enemies that are still alive. One individual per species is enough.

B.3 Each group applies a different treatment to the six specimens collected. Explain the different treatments and divide the tasks among the groups.

B.4 Group 1: Monocrotophos: contact, direct action

→ Fill a glass bottle with a layer of 0.5 cm of the monocrotophos solution. Close the bottle, shake and turn it until all walls of the bottle are wet. Remove excessive pesticide solution from the bottom of the jar by pouring it back into the stock container. Put the pest and natural enemy specimens in the bottle. Shake the bottle so that specimens touch the wetted walls of the jar.

→ Observe what happens. Take notes of the condition of the specimens in the bottle at 2, 4, 6, 8, 10, 15 and 20 minutes after treatment.

→ Write the observation results in the form "Pesticide experiment".

B.5 Group 2: Carbofuran: contact, direct action

→ Fill a glass bottle with a layer of 0.5 cm of the carbofuran solution. Close the bottle, shake and turn it until all walls of the bottle are wet. Remove excessive pesticide solution from the bottom of the jar by pouring it back into the stock container. Put the pest and natural enemy specimens in the bottle. Shake the bottle so that specimens touch the wetted walls of the jar.

→ Observe what happens. Take notes of the condition of the specimens in the bottle at 2, 4, 6, 8, 10, 15 and 20 minutes after treatment.

→ Write the observation results in the form "Pesticide experiment".

B.6 Group 3: Monocrotophos: systemic, indirect action

→ Fill an old tin half with soil. Plant a young sweetpotato plant with roots in the can. Pour some monocrotophos solution on the soil surface around the stem base. Cover the can and plant with a transparent plastic bag with some small holes for ventilation. Put the pest and natural enemy specimens on the leaves of the plant, and close the plastic bag again.

→ Observe what happens. Take notes of the condition of the specimens in the bottle at 5, 10, 15 and 20 minutes, and 0.5, 1 and 2 days after treatment (one of the participants should take the jar home and observe).

→ Write the observation results in the form "Pesticide experiment".

B.7 Group 4: Carbofuran: systemic, indirect action

→ Fill an old tin half with soil. Plant a young sweetpotato plant with roots in the can. Broadcast a teaspoon of carbofuran granules on the soil surface around the stem base. Cover the can and plant with a transparent plastic bag with some small holes for ventilation. Put the pest and natural enemy specimens on the leaves of the plant, and close the plastic bag again.

→ Observe what happens. Take notes of the condition of the specimens in the bottle at 5, 10, 15 and 20 minutes, and 0.5, 1 and 2 days after treatment (one of the participants should take the can home and observe).

→ Write the observation results in the form "Pesticide experiment".

C *Presentation and discussion*

C.1 During the next FFS meeting, the groups take turns presenting their observation results.

C.2 Discussion:

→ What is the difference between the reaction of the pest and natural enemy specimens to the pesticide?

→ What is the difference between the reaction of the insect to monocrotophos and carbofuran?

→ What is the difference between the reaction of the insect to direct and indirect action of the pesticide?

→ Which pesticide and what application method kills the natural enemies? What would be the consequence if this happens in the field?

→ Among the participants, who has ever experienced symptoms of pesticide poisoning after pesticide application? What symptoms did you suffer from? How did you recover?

→ What should we do to avoid poisoning when applying pesticides?

For more information see:

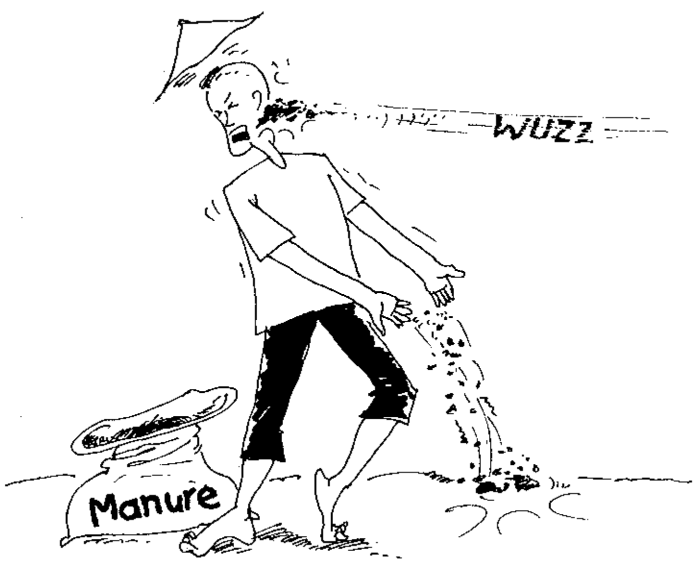
- Natural enemies and pesticides (Part III, Section 4.4).

Notes

15 Fertilization

Background

Before inorganic fertilizers such as urea, TSP and KCl were available, farmers used farm manure to fertilize their soils. Organic manure is an important source of nutrients. It contains all the nutrients that are needed by the plant. In addition, it improves the structure of the soil by adding organic matter, and hence results in better and more efficient nutrient and water availability for plants.



Nowadays, farmers, however, rarely use organic manure in their fields. Some reasons for this often mentioned by farmers are, because:

- They do not keep livestock, because it is a burden.
- Those having livestock often do not have enough labor to bring the manure to the field.
- They are of the opinion that inorganic fertilizers are more practical and more effective.

Apparently, in many places where inorganic fertilizers have been used for decades, soil fertility deteriorated. This happened particularly in areas where unbalanced applications of inorganic fertilizer types were used, and mostly only nitrogen and phosphate were supplied to the soil. These soils have become exhausted and can only be made fertile again by using organic fertilizers, such as farm manure, compost or green manure.

Besides reducing soil fertility, the use of inorganic fertilizers which are becoming more and more expensive is often inefficient, because application methods are inappropriate. Studies have shown that rice crops in wet paddy fields absorb only about 40% of the nitrogen contained in the urea applied by farmers. The remaining 60% is lost through evaporation, washing-off, leaching or adsorption to soil particles. The mineral nutrients not absorbed by the crop are left in the environment and can pollute both ground and surface water.

In order to achieve a balance in sweetpotato cultivation, both from an ecological and an economic perspective, plant nutrition and fertilization are equally important aspects to take into consideration. Therefore, we should seek fertilization methods that result in optimum yields at minimum cost and leaving maximum environmental health.

Objective

After conducting this activity the participants should:

- Understand the factors that determine fertilization needs and practices.
- Be able to apply fertilizers properly, with regard to type, dose, time and method of application.

Materials

- Samples of urea, TSP and KCl (two tea spoons full of each type).
- Small plastic bags (six per subgroup).
- Rubber bands to tie the labels on the jars.

- Urea and KCl according to the dose needed for the FFS field.
- Newsprint paper.
- Felt-tip markers.

Preparation

The amounts of urea and KCl needed for the second fertilizer application on the FFS field should be calculated and prepared prior to this FFS session. For calculating the amount the following formula can be used:

Amount of fertilizer (gram) = dose (kg/1,000 m² x field area (m²)

The recommended fertilizer dose for the FFS field used in intensive production areas in Indonesia, where yields of 40 tons/ha can be expected and a basal application of organic manure is applied, is 5 kg of KCl and 10 kg of urea per 1,000 m^2 (see Part III, section 2.6.2). Appropriate doses will have to be determined in other areas and/or at different yield levels. In case the FFS participants conduct a fertilization experiment on the FFS field, fertilizer application rates should be adjusted to the treatments tested.

Activity steps

This topic is related to the topics discussed in Field Guide 2 (Healthy soil) and Field Guide 7 (Healthy crop). The participants should be reminded of what was discussed previously.

A *The behavior of inorganic fertilizers*

A.1 The participants are divided into small groups. Each group is given small samples of three types of fertilizer: urea, TSP and KCl (or other N, P and K-containing, mineral fertilizers available), and six small plastic bags.

A.2 The facilitator explains the purpose of this activity, i.e. to discover how inorganic fertilizers behave in water and soil, and hence what the consequences of fertilizer application are.

A.3 The participants are invited to observe the following characteristics of the three fertilizer types and note down the results:

→ Look at the color of each of them.

→ Feel their structures.

→ Smell their aromas.

A.4 Each group fills three plastic bags with water and three others with soil. Each bag with water is given one tea spoon full of one type of fertilizer. The same is done with the bags with soil. The fertilizer is mixed well with the water or the soil. The participants should observe the following characteristic of the mixtures:

→ Color.

→ Smell.

→ Solubility.

A.5 The plastic bags with water/soil and fertilizer are kept until the end of the meeting to be observed again, and any changes with regard to the characteristics described above must be noted down.

A.6 In the meantime, the facilitator initiates a discussion about the composition of each fertilizer, and probes for, or explains, the nutrient contents of each type.

A.7 A comparison could be made between the price of organic manure versus inorganic fertilizers, calculated on a basis of price per kg of nutrient content (see example Part III, Section 2.6.1).

A.8 The following questions can be posed by the facilitator to stimulate the discussion:

→ Why should we incorporate inorganic fertilizers, particularly urea and KCl, in the soil?

→ Why should we give TSP and manure as a basal application?

→ What are the advantages of organic manure as compared to inorganic fertilizers?

→ What are the advantages and disadvantages of the different types of fertilizers?

B *Input = output*

B.1 The facilitator explains the purpose of this activity, i.e. to understand the need for the application of appropriate fertilizer doses.

B.2 The participants are asked for their opinion about the actual objective of fertilization. Building on their statements, the facilitator reaches the conclusion that, through fertilizer application, the same types and amount of nutrients should be returned to the soil as have been absorbed by the crop and will be removed from the field at harvest time.

B.3 An inventory is made together of the fertilizer regimes applied by several participants on their previous sweetpotato crop, and the harvest they obtained. The fertilizer rates and yields are converted into standard units (kg/ha or m^2) and compared. Did the highest dose give the best yield? The participants are asked for their opinions on the strengths and weaknesses of the fertilization practices reported.

B.4 The facilitator elaborates on the recommended application rates of manure, urea, TSP and KCl for the FFS field. It should be emphasized that there is no fixed recommendation, but only some flexible guidelines that have to be adapted according to local conditions (soil fertility, expected yields, availability of nutrients from natural sources, availability of fertilizers). The facilitator could remind the participants about the way to do a reliable experiment to determine appropriate fertilizer rates.

C *Fertilizer application on the FFS field*

C.1 The participants are invited to apply the second urea and KCl applications to the FFS field by evenly distributing the appropriate amounts on the side of the ridges before hilling up.

C.2 The fertilizer is covered by hilling up the ridges.

For more information see:

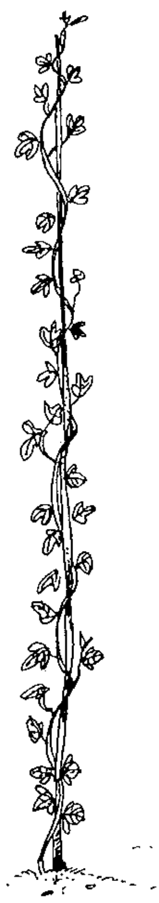
- Plant nutrition (Part III, Section 2.6)

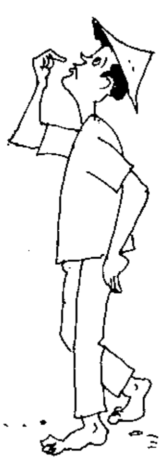
Notes

16 Vine lifting

Background

Some farmers have experienced that the practice of vine lifting positively influences the growth of the sweetpotato crop, storage root formation, and, hence, the yield. It is also often heard that diligent farmers who more frequently lift the sweetpotato vines get a relatively good yield. Why do not all farmers practice this method then, in the hope that they will get a better yield? Apparently, farmers' experiences vary from area to area and from season to season, and the result of a practice seems related to the specific condition in a certain place at a certain time. It may also be possible that certain practices require additional time that not all farmers have to spend.





In this activity we will analyze how vine lifting influences sweetpotato production, and what is the most practical and efficient method for farmers to practice vine lifting.

Objectives

This activity aims at building understanding together about the effects of vine lifting on sweetpotato development.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *The practice of vine lifting*

A.1 Ask the participants, whether and how they usually practice vine lifting of their sweetpotato crop. Lead a discussion on these practices using the following questions:

- → Why should we practice vine lifting, what is the advantage?
- → Why should we not practice vine lifting, what is the disadvantage?
- → What is the appropriate moment or season to lift the vines, and how do we determine whether or not and when we should do it?
- → How many times during a season should we lift the vines?
- → At what growth development stage of the crop should we best lift the vines?

A.2 Ask one of the participants to draw a sweetpotato plant of 3 months of age, including foliage and root system. Particularly the shape of different kinds of roots should be given attention by distinguishing between storage roots growing from the main stem and adventitious roots growing from the vines. Use this picture as an input for discussion:

- → What is the function of vine lifting?
- → What is the most appropriate method to practice vine lifting?

A.3 Invite the participants to the field to observe whether the crop in the FFS plot needs vine lifting. If the group decides that it is time to do so, practice vine lifting using the methods that were determined most appropriate by the group.

For more information see:

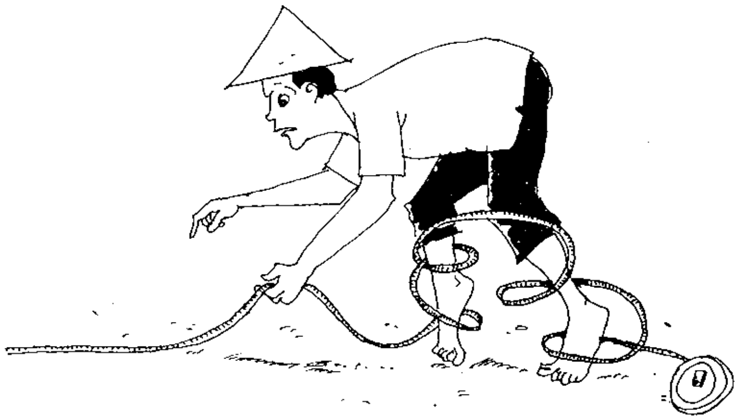
- Vine lifting (Part III, Section 2.7).

17 Field area measurement

Background

Farmers often use local units for area and weight, that have no fixed conversion to standard units. Internationally accepted standard units for area are square meter (m^2) and hectare (= 10,000 m^2), and for weight gram, kilogram (= 1,000 grams) and ton (= 1,000 kg). The *kesok*, a local area unit common in some parts of Indonesia and actually meaning the piece of land that can be ploughed by one couple of buffaloes in half a day, was found to range from 700 m^2 to 1,500 m^2. To know the exact area of a piece of land, we have to measure it in m^2.

But why should we have to know the area of our fields in a standard unit? The most important reason is that it helps when we have to calculate the exact amount of inputs needed, such as seed and fertilizer. The second reason is that it helps when doing experiments. We need the conversion to standard units to make a sensible comparison of treatments and yields among fields. During this activity we will come to understand when and why it is useful to use standard units, and learn to measure a field and calculate the area in square meters.



Objective

After completing this activity, the participants:

- Understand the importance of area measurement in standard units.
- Possess skills to estimate, measure and count the area of a field in square meters.

Materials

- Newsprint paper.
- Felt-tip markers.
- Measuring tape (50 m).

Activity steps

A *Local or standard?*

A.1 The facilitator explains the objective of this activity as stated above.

A.2 The facilitator asks the participants to mention all the local area and weight units commonly used in the village, and lists them on a newsprint. In a second column, an attempt is made to give the conversion rates for each local unit to standard units (m^2 and kg). Are these conversion rates always the same everywhere? Do the participants know how to calculate the amount of seed they would need on their field if an extension officer gives them a recommendation in kg/ha?

A.3 Three participants are asked to separately draw a box of 1 m^2 on the ground. Are their boxes of the same size? How large is a box of 1 m^2? One of the participants is invited to draw a box of 1 by 1 meter on the ground using a measuring tape. The others can try how large a step it would take to cover one meter.

A.4 Four participants are asked to make a square of 100 by 100 meters in the field by standing on its corners. The facilitator explains that the area covered between the four farmers is 100 x 100 = 10,000

m^2 or 1 hectare. What other shapes can a field of 1 hectare have? Does 1 hectare cover the same size everywhere?

A.5 The differences between local and standard units are discussed and an agreement is reached on the importance of knowing the areas of their fields in a standard unit.

B *Length times width*

B.1 The ways to measure and calculate the area of fields that have square, rectangular or irregular shapes are discussed or, if needed, explained by the facilitator.

B.2 The participants are divided into four small groups. Four different fields are selected in the area that are considered of the same size when expressed in a local area unit. Each subgroup is invited to measure and calculate the area of two fields. Two subgroups measure the plots using steps of one meter. The other subgroups use a measuring tape. Each of the four fields should be measured twice by using steps and twice by using a measuring tape.

B.3 The results of the measurements of the different groups and different fields are listed on a newsprint and discussed. The following questions could guide the discussion:

→ How does the method of measurement (using steps or a measuring tape) affect the results?

→ How does the area measured compare to the local area unit used in the village? Was there a difference between the square meter area of fields considered to be of the same size when expressed in local units?

→ Why should we know the area of the field in a standard unit?

For more information see:

- Field area measurement (Part III, Section 6.3)

Notes

18 Sweetpotato stemborer

Background

Sweetpotato stemborer is a pest that we commonly find in a sweetpotato field, where its occurrence does not necessarily cause yield loss, but definitely has a potency to do so. Stemborer damage particularly occurs in fields where sweetpotato is grown for several consecutive seasons. Control is very difficult after the stemborer has entered the stem of the sweetpotato plant, therefore, the key to successful control is prevention. In order to implement preventive measures well, we first have to understand the life cycle of the stemborer.

Objectives

The objective of this activity is to enhance the participants' knowledge about the life cycle of the sweetpotato stemborer, and ways to prevent and reduce its damage.

Materials

- Bamboo stakes to mark stemborer infested sweetpotato plants.
- Glass jars with cover.
- Knife or razor blade to cut open the sweetpotato stems.
- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Field sampling for stemborer*

A.1 The participants are divided into small groups.

A.2 Invite them to look for, and collect specimens of stemborer life cycle stages and symptoms, such as:

- → Swollen stems.
- → Frass under the plant.
- → A caterpillar inside the stem.
- → A pupa inside the stem.
- → The length of the tunnel made by the caterpillar inside the stem.
- → Other animals inside the same stem (natural enemies).
- → Exit holes for stemborer moths on the stems that are still covered and that are open.
- → Adult moths.

A.3 Discuss the field observation results by showing the samples collected from the field.

A.4 Put some of the collected caterpillars and pupae in glass jars that are covered inside with paper. The caterpillars must be kept within the sweetpotato stems. Ask some participants to take the jars home for further observation. The jars are brought back to the next FFS meeting to observe what has emerged from the pupa: stemborer moth or a natural enemy (parasitic wasp).

A.5 Discussion:

- → What is the life cycle of the sweetpotato stemborer?
- → To what extent and when does the stemborer cause yield loss to the sweetpotato crop?
- → What is the best method to control the stemborer?

A.6 Observation of stemborer moths should be done in the evening by bringing a torch to the field. The moths will come to the torch since they are attracted by the light. Suggest to the group to do evening observation, and if there is interest agree on the time and place.

B *Stemborer development in the field*

B.1 Each small group marks two sweetpotato plants with stemborer infested stems in the field. Write the group name and the date on the bamboo stake.

B.2 One of the plants marked by each group is just left to develop, while the other plant is treated by hilling up the soil so that the part of the stem where the exit hole will be made by the stemborer is covered. During the following weeks the small group observes both plants.

B.3 The date when the stemborer moth emerges from the stem is written on the bamboo stake.

B.4 During harvest, the storage roots per plant of the two marked plants and one uninfested plant per group are weighed and compared. The stemborer observation results throughout the season are discussed during the evaluation meeting.

B.5 Discussion:

→ Did the stemborer moth emerge from the stem or did it die inside the stem? Compare the two treatments.

→ What is the effect of hilling up on the stemborer development?

→ To what extent did the stemborer attack affect the yield? How does this compare with the participants' experience in their own fields?

For more information see:

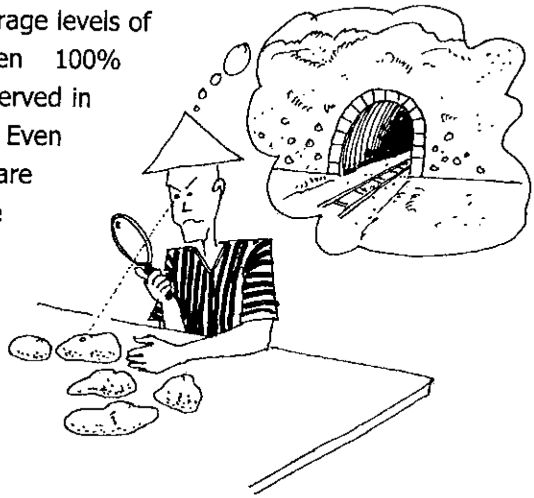
- Sweetpotato stemborer (Part III, Section 5.2.2).

Notes

19 Sweetpotato weevil

Background

Farmers in many sweetpotato growing areas in the world perceive the sweetpotato weevil as their greatest enemy. The weevil larvae cause serious quality damages to the storage roots, making them unmarketable, and the pest is one of the most difficult to control. Considerable loss of marketable yield occurs particularly during the dry season, and can reach average levels of 30 to 50%, and even 100% infestations have been observed in individual fields. Even sweetpotato roots that are partly infested cannot be marketed, or only at a very low price, since the tunneling of the weevil larvae causes the roots to produce a poisonous chemical that makes it unsuitable for human and animal consumption.



Sweetpotato weevil control is difficult since as soon as the larvae have entered the roots, we cannot do anything to stop it from causing damage. The best method is prevention of adult weevils to emerge and lay eggs on the sweetpotato plants. To understand how we can prevent weevil occurrence by disrupting its life cycle, we have to know first how and where it lives.

Objectives

After completing this activity, the participants:

- Have gained understanding about the biology and behavior of the sweetpotato weevil.
- Know what effects are caused by weevil damage.
- Are able to determine and implement the most effective control measures.

Materials

- Some knives or sickles.
- Glass containers covered with screen, as many as the number of small groups.
- Sex pheromone traps (consisting of a pheromone lure, a cover and a container with soapy water), as many as the number of small groups.
- A bucket.
- Some torches for evening observation.
- Maize seeds or any other quantifier for matrix ranking.

Activity steps

A *Weevils in the field*

A.1 The participants are divided into small groups.

A.2 Each group is given a sex pheromone trap to be set up in the field at an observation spot. The participants observe the foliage around the trap for about ten minutes, after which they move to another spot. Each group observes three spots, one of which is at a location where the soil is cracked and roots are exposed, and the two others of which are on soil without cracks and/or rots are not exposed.

A.3 At each spot the participants should observe and count the number of:

→ Weevils on the leaves.

→ Weevils on the soil surface or in the upper soil layer.

→ The storage roots infected by weevils.

→ Male weevils captured in the sex pheromone trap within half an hour.

A.4 The results of all observation spots of all groups are combined and recorded on a sheet of newsprint paper. The groups take turns in presenting their results.

B *Sweetpotato life cycle, behavior and control*

B.1 Each small group collects a root from the field that is infected by weevils. The roots are cut carefully by the group members, and the different stages of weevils that are living within the roots are exposed on the analysis boards. Using these specimens, involve the participants in a discussion about the life cycle of the sweetpotato weevil. Draw the life cycle of the sweetpotato weevil on a sheet of paper, showing the various stages (egg, larva, pupa and adult weevil), the duration of each stage, the place where each stage lives, and the effects caused by each stage on root yield and quality.

B.2 Explain how can we distinguish between male and female weevils, and how do the males and females behave in the day time and at night.

B.3 Put pieces of sweetpotato roots with weevil larvae and pupae in glass containers and let the participants (one representative per group) take them home for further observation. When the weevils become adults, they should provide whole storage roots as food and place for egg-laying. Ask the participants who take the containers home to observe the development of the weevils and infestation of the roots every day, and report the results of their observations during the next meeting.

B.4 Ask the participants to mention all methods they usually apply to control weevils. Draw the format of a table (as example below) and write the four or five most common methods as heading for the columns. In the first column, write the criteria for evaluating the methods, such as effective, easy to implement, or cheap, or any other criteria the participants mention.

	Method A	*Method B*	*Method C*	*Method D*
Effective				
Easy				
Cheap				
......				
TOTAL				

B.5 Conduct a matrix ranking by letting the participants individually divide as many maize seeds as methods mentioned per criteria among the methods. Most seeds are given to the method considered most effective (or easiest, or cheapest, etc.). When all criteria are done, count the total score per method and draw conclusions.

B.6 Discussion:

→ What are the strengths and weaknesses of each method?

→ Are there any other methods to control weevils that they have heard of but have hardly ever practiced? (Bring up important measures if they have not been mentioned such as sanitation and inundation.)

→ Why is field sanitation particularly important in weevil management?

→ What is the most effective method of field sanitation (inundation, burying of roots, etc.)? What is the most practical method?

→ What natural enemies of the sweetpotato weevil can we normally find in the field?

B.7 In case the participants are unfamiliar with the practice of inundation of roots to kill weevils in the infested storage roots, suggest to conduct an experiment. Put seven weevil infested storage roots in a bucket of water. Let one participant take the bucket home and observe one sweetpotato root every day. The root should be carefully cut into small pieces to count how many weevil larvae, pupae and adults in the roots are dead and how many are alive after inundation of 1, 2, 3, 4, 5, 6 and 7 days. The results are presented during the next meeting.

C *Weevil activity at night*

C.1 For those who are interested, evening observation of sweetpotato weevils could be organized (between 6.00 to 8.00 p.m.). Torch and sex pheromone traps should be used to attract and observe the activity of weevils by night. The participants could do the following tasks:

→ Count the number of weevils that are captured in the traps within half an hour. Is it different from the number captured during day time?

→ Catch some weevils on the foliage and determine their sex. What is the sex ratio?

For more information see:

- Sweetpotato weevil (Part III, Section 5.2.1).

Notes

20 Cropping pattern

Background

In areas with fairly reliable irrigation, the dry season is usually considered the most appropriate season to cultivate sweetpotato. The yield is potentially higher since clear weather with lots of sunshine supports the growth of the crop. However, farmers also grow sweetpotato during less favorable seasons for various reasons. One reason may be that they grow the crop for seed supply during the main season, or that they anticipate a high market price, despite a lower yield. When the sweetpotato market price suddenly drops drastically, farmers often loose interest to establish this crop and opt for other crops. On the contrary, when the price is high, sweetpotato may be planted for several consecutive seasons, despite the build-up of pest populations that often occurs under such conditions.

Farmers consciously or unconsciously consider many factors in making a decision on whether or not to cultivate sweetpotato during a particular season. Each season definitely has its advantages and disadvantages. In order to make the best decision, farmers should be able to consciously counter-balance those advantages and disadvantages.

Objectives

After completing this activity the participants will have gained enhanced understanding on what factors to consider when determining the cropping pattern.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Cropping pattern habits*

A.1 Ask several participants to list the three major crops they cultivated over the past few seasons. List their reasons for choosing these crops. Write the answers on a sheet of newsprint paper in the format of a table such as the example below:

Name of farmer	Major crop two seasons ago	Major crop during previous season	Current major crop
1.			
2.			
3.			
Reasons	1. 2. etc.	1. 2. etc.	1. 2. etc.

A.2 Discussion:

→ What factors do farmers normally consider when choosing a crop to cultivate during a particular season?

→ To what extent can farmers influence the various factors mentioned in order to optimize their decision?

For more information see:

- Cropping pattern (Part III, Section 6.5).

21 Variety selection

Background

Farmers are always on the outlook for new varieties with better characteristics, such as a higher yield potential, higher resistance to major pests and diseases, a better taste, worth a higher market price, and with a shorter growth duration. But can we expect breeders to produce a super variety like that? The fact is that a short duration variety has automatically a relatively lower yield potential, and often high yielding varieties lose on taste. Besides, a certain variety performs differently under different situations, depending on location-specific and seasonal conditions. How can farmers choose varieties that fit and perform best under the prevailing farming conditions?

Objectives

After completing this activity the participants better understand the factors to consider when selecting a variety.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Varietal preferences*

A.1 Ask the participants to list all the sweetpotato varieties that are commonly grown in the area.

A.2 Make a table with three columns: (1) name of the variety, (2) strengths, and (3) weaknesses. Let the participants fill out the strengths and weaknesses columns for each variety.

A.3 The strengths of the varieties listed can be interpreted as the desired characteristics of the sweetpotato crop, whereas the weaknesses represent those characteristics farmers preferably avoid. Discuss to what extent the farmers are able to select varieties with more strengths than weaknesses. Point out interrelatedness of some strengths and weaknesses, such as short growth duration and lower yield potential, or high yield and lower taste quality.

A.4 Explain, by probing the participants, what a farmer should consider when selecting a variety. Discuss how farmers can get access to new varieties with potentially better characteristics, such as exchange of seeds with farmers from other areas, or from research stations, and how these new varieties should be tested and evaluated first to assess their suitability.

A.5 Draw conclusions about the role of variety selection in achieving optimal results in sweetpotato cultivation.

For more information see:

- Variety selection (Part III, Section 6.6).

Notes

22 Harvesting and marketing

Background

Farmers will only know what exactly is the result of the care they have given to the crop throughout the whole season at harvest time, when they dig up the storage roots. Did the plants produce many or few, and big or small storage roots, and are they healthy or attacked by pests and diseases? Determining the right harvest time is very important in order to obtain a result of satisfactory quantity and quality.

In certain production systems, farmers contract the standing crop before harvest to a middleman. The price is normally determined in a bargaining session between the farmer and the middleman, but the middleman definitely already assessed what the crop would yield to make sure he or she will not loose on the deal. The middleman has normally good skills to assess the yield and by knowing the market situation, as opposed to the farmer, he or she is in a better position than the farmer to secure as high a profit as possible. Farmers often only know the above ground condition of the crop, and lack the skills to assess the yield and calculate the actual value of the harvest. Therefore, they easily agree to a price offered by the middleman or trader. Consequently, the profit received by those who have cared for the crop the whole season is often not maximal. If only the farmers possessed the same knowledge and skills as the traders, would they still easily surrender in the bargaining process?

Objectives

After completing this activity the participants would:

- Gain knowledge about determining the right harvest time.
- Enhance their knowledge and skills to estimate the yield.
- Change their attitude about their role in the bargaining process with traders.

Materials

- Newsprint paper.
- Felt-tip markers.
- Scales with minimum capacity of 0.1 kg and maximum of 3 kg.
- Some plastic bags.
- Copy of the "Yield Assessment Contest" form (Appendix II-H)

Activity steps

A *A good moment to harvest*

A.1 Involve the participants in a discussion about what factors they consider when determining the time to harvest their sweetpotato crop. List the factors they mention on a sheet of newsprint paper. Discuss to what extent each factor provides flexibility to postpone or move forward the time of harvest in order to optimize the output. If needed, add to the list.

A.2 Calculate together with the participants the income from a sweetpotato crop by comparing a crop of 4 and 6 months. Probe for details considering prevailing conditions with regard to:

→ Root yield of a popular sweetpotato variety with flexible growth duration, when harvested at 4 versus 6 months (kg per area unit).

→ Estimated market price per kg of roots when harvested during the peak season or two months later.

Calculate the income by multiplying the yield times the price at 4 months (during the peak season) and at 6 months.

A.3 Discussion:

→ Which harvest provides the highest gross income?

→ If calculated on a per month basis and considering the opportunity value of the land, does the conclusion change?

→ What are the risks involved when postponing or moving forward the harvest time?

B *Price negotiation: whose right?*

B.1 Initiate a discussion about the problems that farmers normally face when negotiating about the price of their produce with the traders:

→ Do they think they always get a fair deal?

→ Did anyone ever experience to be cheated?

→ What position and attitude do farmers have in the negotiation process?

→ Are they satisfied and if not, what are the problems?

→ How can farmers improve their bargaining power?

B.2 If appropriate, suggest the following ways for farmers to strengthen their position:

→ Gain skills in yield assessment, particularly in cases where the produce is sold as a standing crop.

→ Reinforce group cohesiveness and establish a network through which farmers inform each other about prevailing prices and conditions on the market.

C *Yield assessment contest*

C.1 Invite the participants to take part in a yield assessment contest. Explain the objective of the activity, i.e. to enhance the participants' skills in estimating the sweetpotato root yield of a crop that is still in the field, in order for them to gain bargaining power in the negotiation process with middle men buying the standing crop.

C.2 One plant is randomly selected in the ICM FFS field. The soil is partly removed to expose the storage roots. All participants estimate the weight of the storage roots. Write all of their estimates on the Yield Assessment Contest form (copied from Appendix II-H) or on a sheet of newsprint paper using the same format.

C.3 If all participants have taken their turn in estimating the root weight, the roots are harvested and weighed. The actual weight is also written in a column of the table on the Yield Assessment Contest form. The participants are given ranks according to how close their estimates were to the actual yield, with rank 1 for the one who was closest.

C.4 Select a second plant in the field and repeat the process.

C.5 Repeat as many times as the group likes. It is recommended to estimate and weigh at least ten plants to provide sufficient opportunity for the participants to improve their skills.

C.6 When finished, add the total of ranks per participant and determine who has won the contest (the one with the lowest total score). Discuss whether the participants feel that their skills increased throughout the contest, meaning that they got closer every time.

C.7 The harvested roots for the contest should be returned to the field for later determination of the total yield of the ICM FFS field.

D *Assessment of the total root weight and value*

After having assessed the average weight per plant, farmers should be able to calculate the approximate weight of the whole crop in the field and its value in money.

D.1 Ask the participants what they consider the easiest and most practical way to determine the total number of plants in a field, and reach a group decision. Let them then determine the number of plants in the ICM FFS field.

D.2 Calculate the expected harvest on the field by multiplying the total number or the plants in the field times the average root weight per plant, as assessed in the contest.

D.3 After that, calculate the value of the field by multiplying the expected harvest times the prevailing market price per kg of roots.

D.4 The expected harvest and the expected value are noted down for later comparison with the actual harvest and price obtained from the field.

E *Harvesting of the ICM FFS field*

E.1 The ICM FFS field will be harvested by the group of participants. Explain the harvesting procedure, as follows:

- → Determine who of the participants will take accurate notes of all data. For harvesting the resulting crop of the defoliation experiment, the form provided in Appendix II-F can be used. For other experiments a similar format can be written on a sheet of newsprint paper.
- → Cut the vines and count the number of plants separately per plot of the various experiments. Note down how many of the stems per plot were infested by stemborer.
- → Measure the area of each plot, if this has not been done at planting time.
- → Harvest the roots and weigh them for each plot separately.
- → Calculate the average harvest of the replications per treatment, and convert this into yield (tons/ha).
- → From the part of the ICM FFS field without experimental treatments, six samples of, for instance, 10 plants or 5 m^2 are

harvested, and the roots weighed. Calculate the average harvest of the six samples and convert this into the yield (tons/ha).

E.2 When everyone is clear about the procedure, show the map of the ICM FFS field, or make one if needed. Divide tasks for harvesting the various plots and recording data.

E.3 The group should agree on how to deal with certain pest and disease problems, particularly sweetpotato weevil and root rot if these are important in the area. Do they need to be considered in the harvest? They could, for instance, weigh the marketable and unmarketable roots per plot separately.

E.4 When the task distribution is clear, everyone is invited to harvest the field.

E.5 After harvesting is finished, the facilitator collects the data sheets for further processing and analysis by the group during the ICM FFS evaluation meeting.

E.6 Ask the participants whether field sanitation is needed or not, i.e. are there weevil infested roots left in the field? If there is a need, agree on the method of field sanitation and implement it together.

E.7 Invite the participants to come to the ICM FFS evaluation meeting, explain the purpose and agree on a time and place to meet.

For more information see:

- Harvesting, marketing and storage (Part III, Section 6.7).

23 Sweetpotato storage

Background

After harvest, sweetpotato roots can only be kept for a limited amount of time if not stored properly. Farmers sometimes like to store sweetpotato to wait for a better market price, but damage due to sweetpotato weevil and root rot in stored roots may make storage counterproductive, resulting in a lost opportunity to take advantage of the better price a few months later. Storing roots using a simple but adequate technique may provide a solution to the problems implied by traditional storage, although it requires additional input of materials and labor.

Objectives

After completing this activity the participants:

- Have identified the advantages and disadvantages of sweetpotato storage.
- Gained knowledge and skills on simple sweetpotato storage techniques.

Materials

- Newsprint paper.
- Felt-tip markers.

If the storage technique is practiced:

- 100 kg dry soil powder or dry sand.
- 30 kg newly harvested sweetpotato roots with and without sweetpotato weevil infestation.
- 50 bricks or 5 m^2 fence of bamboo.
- String or sticks to make the fence.
- Sheets of dry paper (e.g. old newspapers).
- Baskets.
- Scale.
- Appropriate and sufficiently large storage place in a participant's home.

Activity steps

A. *Why or why not store sweetpotato roots?*

A.1 The facilitator explains the purpose of this activity, i.e. to identify the advantages and disadvantages of sweetpotato storage under the local conditions.

A.2 The participants are divided into small groups and asked to discuss their experiences with storing sweetpotato roots. Each group should analyze and make a list of advantages and disadvantages of the different storage techniques ever practiced by the group members. The result of the discussion is written on a sheet of newsprint paper.

A.3 Each small group presents the results to the other groups. The facilitator draws some overall conclusions.

A.4 After the discussion, the group decides whether or not they have an interest in testing an (improved) storage technique. This will depend on whether the farmers have the facilities for storage, whether it would benefit them considering the prevailing market and utilization conditions, and how effective their current storage practices are. If there is an interest , the following activity could be scheduled for another session, since it requires preparation of materials. The date for the session and responsibilities for preparing the materials should be agreed upon by the group. The plans should consider that the experiment will last for about two months, and that the evaluation of results should preferably take place during one of the last FFS meetings at the end of the season.

B. *A simple storage technique*

B.1 Materials and location for setting up the store are prepared in advance. Two areas of 1-2 m^2 should be available, one for storing a mixture of infested and clean roots in a traditional manner (the control), and the other for the improved storage technique. Materials needed should have the desired condition at the time of the session, i.e. soil or sand should be really dry and sweetpotato roots newly harvested. The weather should be dry.

B.2 The participants meet at the place where the store will be set up. The objective and design of the experiment is explained, and tasks are divided among the group members. The sweetpotato roots are sorted, and at least 15 kg of clean roots is used for the treatment consisting of the improved storage technique. The other treatment, which consists of a mixture of clean and infested roots is the control.

B.3 The roots for the control treatment are piled in a corner of the house or under the bed, according to local practice.

B.4 The improved storage technique treatment is prepared as described in section 6.7.3 in Part III of this manual.

B.5 One participant is assigned to keep records of the store, including:

- → Date of store preparation.
- → Weight of roots stored in each treatment at date of store preparation.
- → Market price of sweetpotato at date of store preparation.
- → Any observations during period of storage (e.g. occurrence of rats).
- → Date of taking roots out of the store (approximately two months later).
- → Weight of roots stored in each treatment at the end of the storage period, distinguishing between healthy roots, sweetpotato weevil infested roots and roots infected by rot.
- → Market price of sweetpotato at 1, 3, 5 and 7 weeks of storage and at the end of the storage period.
- → Any other remarkable observations.

B.6 During the evaluation session, the recorded data are analyzed and discussed. An economic analysis is made to compare the different treatments:

- → *No storage*: income obtained when directly sold = weight of marketable roots x market price at the date of store preparation.

→ *Traditional storage*: income obtained from the control treatment = weight of marketable roots x market price at the end of the storage period.

→ *Improved storage technique*: income obtained from treated roots deducted by cost of storage = (weight of marketable roots x market price at the end of the storage period) – costs for materials and labor.

B.7 The following questions can be used to stimulate the discussion:

→ What are the advantages and disadvantages of the three methods compared (immediate marketing, traditional storage, improved storage technique)?

→ Which method was the most profitable?

→ Would farmers apply this method in the future? If yes, why? If no, why not?

For more information see:

- Storage of sweetpotato (Part III, Section 6.7.3)

Notes

24 Sweetpotato utilization

Background

Sweetpotato roots and vines can be utilized in many ways. Whether or not farm families utilize the produce on-farm depends a lot on the farming enterprise system, local marketing opportunities of both raw material and processed products, and farmers' familiarity with adapted technologies. Farm-level utilization could add considerable value to the produce, but mostly implies capital and human resource investment. Therefore, opportunities for utilization have to be analyzed on a case by case basis.

Objective

After completing this activity the participants:

- Have analyzed the opportunities of sweetpotato utilization under local conditions.
- Gained knowledge and skills related to simple sweetpotato processing techniques.

Materials

- Newsprint paper.
- Felt-tip markers.

Activity steps

A *Adding value to the sweetpotato crop*

A.1 The facilitator explains the purpose of this activity, i.e. to inventory participants' experience with and analyze opportunities of sweetpotato utilization under the prevailing conditions.

A.2 The participants are divided into small groups and asked to discuss their experiences with utilization of sweetpotato roots and vines.

Each group should list the various types of utilization its members have practiced. The groups should give a multiplication rate representing the additional value of (or increased income from) the sweetpotato crop as a result of utilization, as compared to direct selling of the produce. This should be done for each type of utilization. The result of the discussion is written on a sheet of newsprint paper.

A.3 Each small group presents the results to the other groups. The facilitator draws some overall conclusions.

A.4 After the discussion, the group could decide whether or not they have an interest in learning more about one or more (improved) utilization techniques, e.g. preparation of flour from sweetpotato storage roots, preparation of animal feed from sweetpotato vines, or a cross-visit to a processing enterprise or industry. The activities should be scheduled for other FFS sessions, since they require prior arrangements and preparation of materials. The date of holding the session(s) and responsibilities for preparing the materials should be agreed upon by the group. The facilitator should prepare the session(s) based on information given in section 6.8 (Part III), or involve someone experienced in the technique to be practiced.

For more information see:

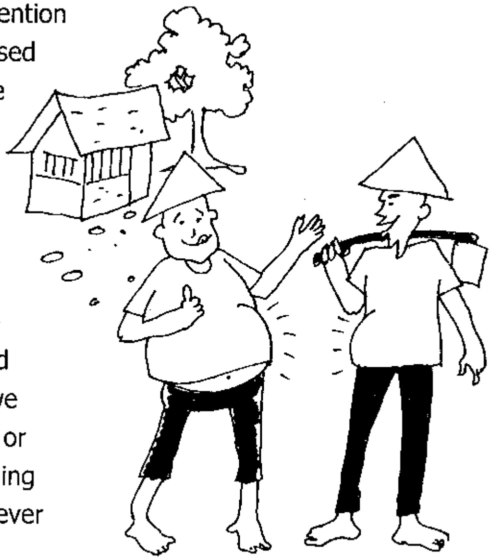
- Sweetpotato utilization (Part III, Section 6.8)

Notes

25 Sweetpotato ICM FFS evaluation

Background

An example: we go for the first time to a restaurant that attracted our attention because of the menu they exposed on a board outside. After we ate and paid, we will judge the restaurant. We may be satisfied because the food was tasty, it was cheap, and/or the service was good. In that case we are likely to visit the restaurant again, and recommend it to others. On the contrary, if we got little food for a high price, or experienced food poisoning afterwards, we will probably never go back to the restaurant.



In the appraisal process illustrated above, we consider the result of an experience we have gone through. This consideration helps us determine what we will do the next time. This is what we call an "evaluation." We normally do not evaluate our daily activities, such as going to a restaurant, in a conscious and planned manner. However, for program activities that required a certain investment in time and money of several parties, such as a Farmer Field School, we should plan and conduct an evaluation together with all stakeholders, in order to assess the output and impact of the program, and to obtain input for improvement. As shown by the example above, the conclusion of the evaluation will determine future action.

Objectives

After completing this activity, the FFS participants:

- Understand the purpose and procedure of evaluating the Sweetpotato ICM FFS.
- Are capable of planning and conducting the ICM FFS evaluation.
- Have planned ICM FFS follow-up activities.

Materials

- Newsprint paper.
- Felt-tip markers.
- Questions and answers sheet of the post-test.
- Map of the FFS field.
- Economic analysis sheets.
- Data forms of observations and harvest of experiments conducted on the FFS field.

Activity steps

A *Preparation of the evaluation meeting*

A.1 The following items need to be prepared for the evaluation meeting:

→ Questions and answers sheet for the post-test (Appendix II-B).
→ Map of the ICM FFS field showing plots of experiments.
→ Economic analysis sheets.
→ Data forms of observations and harvest of experiments conducted on the FFS field.
→ A list of evaluation topics and discussion points.
→ Task distribution among the facilitators.
→ Snacks and drinks for the participants.

B *Evaluation implementation*

B.1 The facilitator explains the objective and activities of the evaluation meeting:

→ Post-test.

→ Evaluation of results (analysis of FFS experiments).

→ Evaluation of Sweetpotato ICM FFS process and impact.

B.2 The post-test is conducted according to the procedure described in Section 5.2 of Part I.

B.3 The participants present the results of the experiments conducted on the ICM FFS field. Discussion:

→ What treatments resulted in the best yields?

→ What are the advantages and disadvantages of the treatments tested, compared to farmer practice?

→ What experiments would still be needed to further test and adapt the sweetpotato ICM technology?

B.4 To discuss the results of the defoliation experiment, see Field Guide 10 (Part II).

B.5 Process together with the participants the economic analysis sheets of the ICM FFS plot, and compare it with one of the participants' records. Discussion:

→ Is ICM more or less profitable than farmer practice?

→ What are the advantages of ICM over farmer practice?

→ How could the ICM technology be adapted to better suit farmers' needs and their profit from sweetpotato enterprise?

B.6 FFS process and impact evaluation is done through open group discussion. The following questions could be posed to lead the discussion:

→ Which topics of the Sweetpotato ICM FFS did you find interesting, and which did you find not interesting?

→ What is the most important thing you have learned in the Sweetpotato ICM FFS?

→ Have you experienced any increase of knowledge and/or skills from attending the ICM FFS? If yes, relating to what?

→ Did this increase in knowledge and skills result in a change of sweetpotato cultivation practices in your own field? If yes, what changes?
→ After attending the FFS, do you feel competent to design and implement an experiment in your own field to further adapt the ICM technology?
→ Do you plan to implement ICM practices in your own field? Which practices seem most applicable? Which do not?
→ Have you shared your experiences in the ICM FFS with other farmers who did not attend? What have you been sharing with them and what was their reaction?
→ What was the reason for possible absence of participants during certain meetings?
→ What suggestions do you have to improve the Sweetpotato ICM FFS?
→ What follow-up action does the group want to take to further implement and expand sweetpotato ICM?

For more information see:

- Pre- and post-test (Part I, Section 5.2).
- Sweetpotato ICM FFS evaluation (Part I, Chapter 6).

Notes

APPENDIX I
Group dynamics exercises

Contents

1 Line up

Objectives

- To acquaint the participants with one another with regard to both physical and personal characteristics.
- To exercise group collaboration.

Duration

10 minutes

Steps

A. The participants form two groups. If the number of participants is odd, the smaller group should be complemented by one of the facilitators.

B. The facilitator explains the rules of game and checks to make sure that everyone understands them. The procedure is as follows:

   B.1 The two groups will compete to see which can line up most quickly according to personal or physical characteristics following the instructions of the facilitator.

B.2 After naming the characteristic and giving instructions for how to form the line (e.g. the characteristic is height: line up from shortest to tallest), the facilitator will slowly count to 10. If a group finishes forming the line before the facilitator reaches 10, the participants should all squat or raise their hands (agree on the movement to make) to indicate that they have accomplished the task. The first group to finish will be the first to check whether the sequence they made is correct.

B.3 The facilitator checks with each group to determine whether the sequence they made is correct.

B.4 The group that lined up most quickly and with the fewest errors is the winner.

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

2 Family members

Objectives

- To form small working groups with simple names that are easy to remember.
- To raise the participants' energy level, especially after lunch or a passive session.

Materials

Pebbles or small pieces of wood, as many as the number of participants minus one.

Duration

10 minutes

Steps

A. Determine the number of groups needed. When assigning groups for field observations, for instance, each group should have four to five members. Place the pebbles or pieces of wood on the ground in a large circle. The number of pebbles totals the number of participants minus one.

B. Request that each participant stands in front of a pebble. The one who does not have a pebble stands in the center of the circle with the facilitator. Mention that this game requires active involvement of everyone.

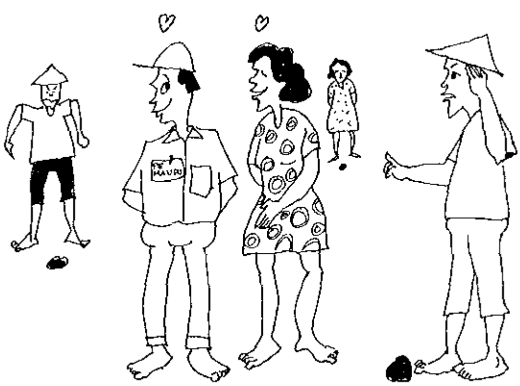
C. Ask the participants to suggest names for the groups to be formed. The names should be related to the activities or themes of the field school, e.g. natural enemy names like dragonfly, spider, or sweetpotato variety names, etc. The facilitator assigns a group name to each person in the circle by counting down (A, B, C, D, A, B, C, etc.), and at last to the person standing in the center of the circle. There should be approximately equal numbers of group members with the same name.

D. To make sure everyone remembers his or her name, the facilitator calls out one of the group names and the persons with that name raise their hands. All the names are practiced once or twice.

E. Explain the procedure of the game and make sure everyone understands the procedure before starting:
   - → The person in the middle calls out one of the group names different from his/her own name.
   - → All group members with that name have to move around and change position to another pebble.
   - → The one in the middle should try to obtain a position behind a pebble, too, causing someone else to be without pebble and stand in the middle.
   - → Then the new person in the middle calls out another name and tries to obtain a position.

F. Continue the game for a few minutes only until all groups have moved around a few times.

G. After the game, the participants form small groups for the next activity, using the names and group composition they used in the game.



Source:
Participatory Learning & Action.
A Trainer's Guide
IIED, London

3 How many squares?

Objective

- To raise awareness about the importance of considering the perceptions and opinions of other people.

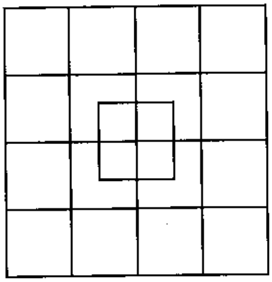
Materials

- Newsprint paper.
- Felt-tip marker.

Duration

5 minutes

Steps



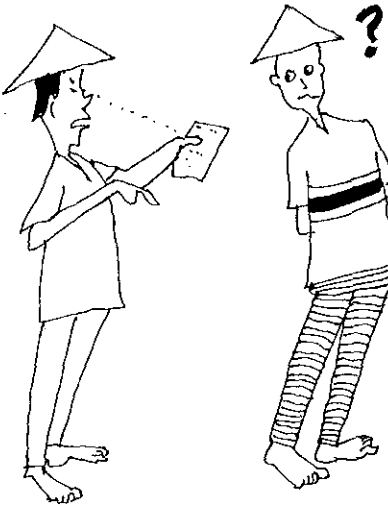
A. Draw a large square on a sheet of newsprint paper. Divide the square into small squares as shown.
B. Ask the participants to count the total number squares. List the various answers on the newsprint.
C. The answers are likely to differ, since some people may overlook some squares. The correct answer is 35.

Discussion

A. Why do the answers differ from one person to another.
B. What does this game teach us about the perceptions of other people?

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

4 Family reunion



Objectives

- To stimulate participation.
- To form small groups.

Materials

- Small pieces of paper.
- Ballpoint pen.

Duration

5 minutes

Steps

A. The facilitator determines the number of groups needed and assigns a family name to each group, e.g. the birds, the insects, the crops, etc.

B. Within each family, each individual is given a name, for example:
  - → Birds: mynah, sparrow, pigeon, owl, eagle.
  - → Insects: butterfly, ground beetle, dragonfly, honey bee.
  - → Crops: sweetpotato, rice, corn, soybean.
  - → Etc.

C. Prepare small pieces of paper and write each individual name on a piece of paper.

D. Explain the procedure of this game to the participants. Everyone will receive a small piece of paper with a name on it. This name is part of a family and the members of each family have something in common. The family members have to find each other by acting out the name they were given, and looking for others performing similar acts. No one is allowed to speak or to show her/his piece of paper to anyone else.

E. Make sure everyone understand the procedure before distributing the pieces of paper.

F. When everybody has received a name, each person should walk around, acting out their name using sounds and movements and looking for the other members of their family.

G. The game is over when all families are united. The facilitator checks whether the groups are able to identify the family name and that all members are in the correct group. The groups that have been formed continue to work together in the next activity.

Source:
Participatory Learning & Action. A Trainer's Guide
IIED, London

5 Nine dots

Objective

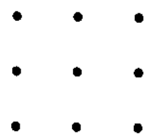
To raise awareness about creativity and the conditions that favor and constrain it.

Materials

- Newsprint paper.
- Felt-tip marker.

Duration

5 minutes

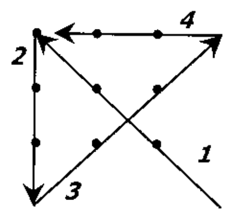


Steps

A. Draw nine dots on a sheet of newsprint paper, as shown:

B. Ask the participants to connect all nine dots using only four lines and without lifting the pen.

C. Let them work individually on the exercise. Request that a few participants work on the problem on a sheet of newsprint at the front of the group.



D. If no one can solve the problem, show them how to do it (see picture). Notice how the participants react.

E. Discuss why they did not manage to solve the problem themselves? Why was their effort limited to the square formed by the dots and did not they dare to go "beyond the borders"? What restricted their creativity? Conclude that for creativity to flourish people must dare to go beyond their habits, should not feel restricted and need a supportive, judgement-free environment.

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

6 The snake sheds its skin

Objectives

- To stimulate active involvement, and to make participants make them feel more active and open-minded.
- To enhance group collaboration.

Duration

5-10 minutes

Steps

A. The participants are divided into two groups which stand in two rows facing one another. The first pair of people are given the name of the village where the field school is being held. The next two select a name of a neighboring village, for instance on the route to the nearest city, the third pair of the next village on that route, etc.

Row 1:	☺	☺	☺	☺	☺	☺	☺	☺	☺	☺
Village:	A	B	C	D	E	F	G	H	I	J
Row 2	☺	☺	☺	☺	☺	☺	☺	☺	☺	☺

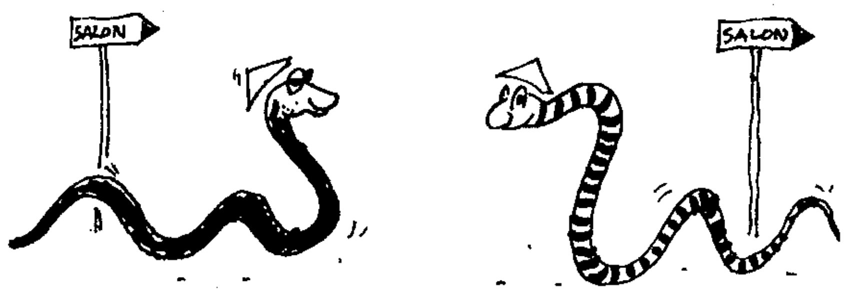
B. The participants hold hands with those to the left and right of them in the row. They should hold on tight so the row will not break up during the game.

C. Explain the procedure of the game:
   - → The facilitator will call: "The snake sheds its skin between village D and E (for example)", after which the two people in each row with that village name should make a tunnel by raising their hands. So each row has its own tunnel.
   - → Both ends of each row (numbers A and J in example above) should run as fast as possible to the tunnel of their row with everyone

following. The two ends move through the tunnel, and then get back in line.

→ The row that returns to the original position first without having broken the line is the winner.

D. Make sure everyone understands the procedure before starting. Do the game several times, calling different names of neighboring villages to have tunnels formed in different places.



Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

7 Know yourself

Objective

To demonstrate how poorly we observe the details of things we often see.

Duration

5 minutes

Steps

A. Ask the participants to form pairs.
B. Ask one member of each pair to close his or her eyes and tell the other person in as much detail as possible what s/he him/herself is wearing (colors, pictures or text, holes, etc.). The one who is looking may probe for details. When they finish, the observer gives a score between 0-10, and together they evaluate the exercise: what was lacking, why was it difficult, etc.?
C. Then the roles are exchanged and the previous observer closes his/her eyes and tells his/her partner in detail what s/he has in her/his pockets or handbag (without feeling). The observer may probe for details. When finished, s/he has to show the content of her/his pockets to check whether the description was correct. The observer gives a score between 0-10, and together they evaluate the exercise.
D. The experiences of the pairs are discussed in the large group. To what extent could we give details of our own clothes/pocket content? Why aren't we more observant? How can we increase our observation skills?

Adapted from:
Participatory Learning & Action. A Trainer's Guide
IIED, London

8 Knotty problem

Objective

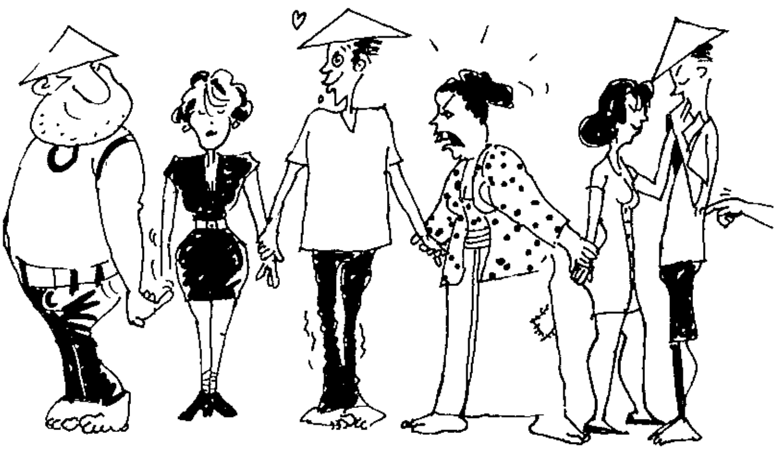
To raise awareness about the importance of a team feeling in group learning and collaboration.

Duration

5-10 minutes

Steps

A. The participants are requested to stand closely in a circle. Everyone should extend their arms and find the hands of two different people. The result will be that the group forms a human knot.
B. Holding hands tightly, the group should try to return to the original position in a circle, without letting go the hands they are holding.
C. Evaluate the exercise. What favored and constrained the solution of this problem by the group?



Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

9 Follow me

Objective

To relax and have fun.

Duration

5 minutes

Steps

A. The facilitator asks the participants to stand up and imitate all his/her movements.
B. Extend arms forward and begin clapping hands, first slowly but at increasing speed until everyone claps mechanically. Then suddenly stop. Notice how many participants continue to clap.
C. The exercise can be repeated by clapping above the head, or with different movements.
D. Evaluate the exercise. Why did some people continue to clap when the person they imitated stopped? Why couldn't they imitate exactly? What can be concluded from this exercise?

Source:
Collection of Games and Group Dynamics Simulations Indonesia National IPM Program

10 Trust each other

Objective

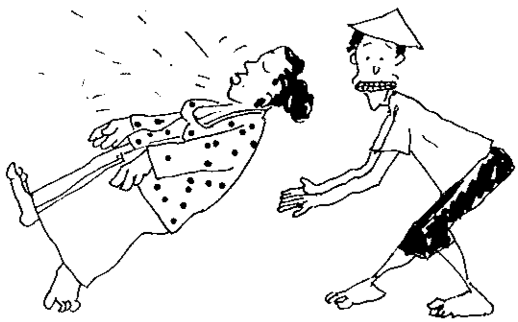
To demonstrate the importance of trust in collaboration.

Duration

5-10 minutes

Step

A. Ask the participants to pair up with partners of the same gender and about the same weight. Let the pairs do the following exercises one by one. The should finish one exercise first before the next one is explained.
B. First, the partners, in turns, massage each other's shoulders.
C. Second, they clasp arms back to back and take turns lifting one another by bending over.
D. Third, in a standing position and with the body stiff, they should let themselves fall back into the arms of the partner (who should catch well).
E. Evaluate the exercise. How did they feel when they had to let their bodies fall. Did they trust that their partner would catch them? Why or why not? What can we learn from this exercise?

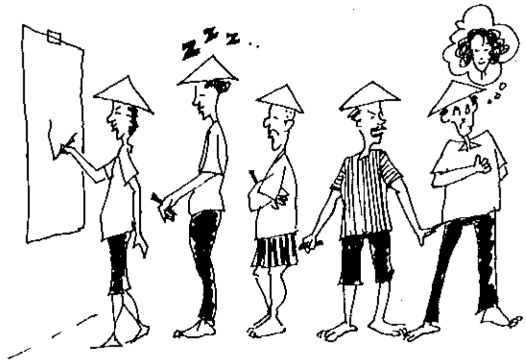


Source:
Collection of Games and Group Dynamics Simulations Indonesia National IPM Program

11 Drawing together

Objective

To raise awareness about the importance of communication within a group.



Materials

- Newsprint paper.
- Felt-tip marker.
- Watch.

Duration

5-10 minutes

Steps

A. The participants are divided into small groups of five members. Each member is given a number from one to five.

B. Each group is asked to make a collective drawing with a marker on sheet of newsprint paper. They are, however, not allowed to speak and each member is given only one minute for his/her part of the drawing.

C. The facilitator gives the start signal for the number ones. After one minute, s/he signals the number twos to take over, and so on until all the members of each group have contributed to the drawing. The results of the various groups are compared and members should explain what they tried to draw.

Discussion

A. How many small groups made a coherent drawing?

B. How did they feel about the collaboration within the group?

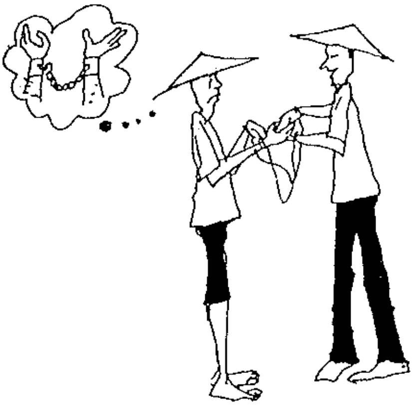
C. How could they have made a better collective drawing?

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

12 Play the rope

Objective

To raise awareness about problem-solving strategies.



Material

Lengths of rope of 1 m, as many as the number of participants.

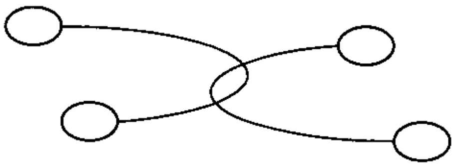
Duration

10 minutes

Steps

A. Cut 1 m lengths of rope and make loops at each end of each, wide enough for a hand to go through.

B. Ask the participants to form pairs and give each pair two ropes. Each participant should move both hands through the two loops of a rope, but in such a way that the two ropes of a pair cross each other and the partners are tied together.



C. The pairs should try to free themselves without removing the ropes.

D. If a pair is successful, ask them to show their solution to the others.

E. Evaluate the exercise. What did we learn from this experience?

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

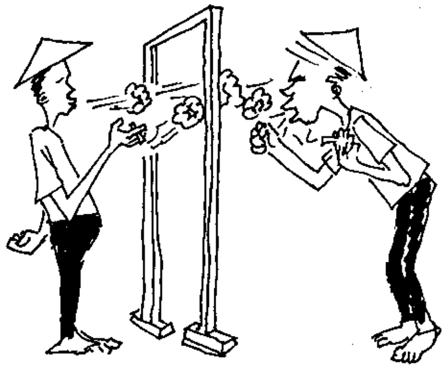
13 Mirror game

Objective

To have the participants experience how it feels to take the lead or follow someone else.

Duration

5 minutes



Steps

A. The participants are requested to form pairs. Each pair stands facing one other at a close distance (about 20 cm) with their hands up in the air.
B. In turns, one member of each pair makes movements that are imitated by the other person, as if looking in a mirror.
C. After both have taken their turn, they repeat the exercise but this time with their hands gently touching.
D. In the last round, they continue to imitate each other in turns, but with their hands holding each other firmly.

Discussion

A. What was the difference between your experiences during the three rounds?
B. How did you feel about leading or following during the three occasions?
C. Have you ever experienced similar feelings about leading or following in daily life situations?

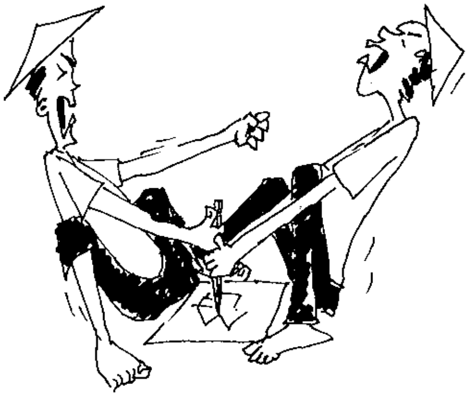
Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

14 Drawing a house

Objective

To raise awareness about collaboration and process control within a group.

Materials



- Newsprint paper.
- Felt-tip markers.

Duration

10-20 minutes

Steps

A. Ask the participants to form pairs.

B. Both partners of a pair hold the same marker in such a way that they are able to draw or write together.

C. The partners draw a picture and write a title together on a piece of newsprint paper. They are not allowed to speak during the exercise.

Discussion

A. How did you feel and react during the exercise?

B. What factors contributed to or constrained the process of joint drawing and writing?

C. What can we learn from this exercise? Have you ever experienced similar feelings and reactions in a real life situation? What constraints do we normally encounter in group collaboration?

Note: The discussion can be done as a small group assignment after which the groups present to the other groups.

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

15 Guide the blind

Objectives

- To have the participants experience how it feels to be "blind", or to lack knowledge of some aspects of what is happening.
- To raise their awareness about the feelings and needs of people who may need assistance.
- To enhance understanding about the requirements for being a good facilitator.

Materials

Handkerchiefs or towels, preferably of dark color

Duration

15 minutes

Steps

A. The participants are divided into two groups, A and B. All members of group A are blindfolded with a handkerchief or towel, so that they cannot see anything.

B. Each members of group B selects a "blind" partner from group A, and leads him/her around for about 5-10 minutes to let him/her experience the use of the other senses when vision is lacking.

C. After they finish, the blindfolds are removed and the participants gather to discuss their experiences.

Discussion

Group A (the "blinds"):

A. How did you feel when you could not see?

B. What was the most impressive experience you had during the time you were guided by your partner?

C. How did you feel about your guide? Did you trust him/her? Why or why not? Did you feel that your guide cared for you or that s/he made a fool of you? Why or why not?

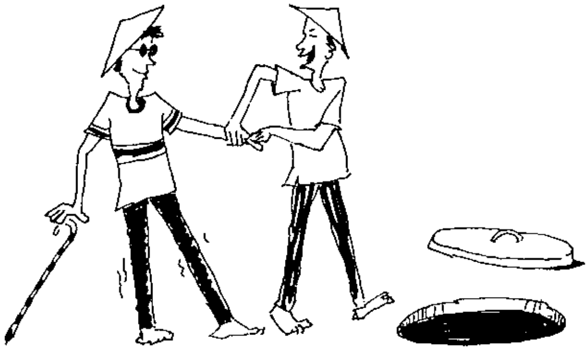
Group B (the "guides"):

A. How did you feel guiding a "blind" person?
B. What special efforts did you make to guide your partner? Did you search for easy or rather difficult things for your partner to experience? Did you give him/her your full attention? Did you supervise him/her tightly or let him/her act freely whenever possible? Did you explain each situation beforehand?

From the answers and comments given by the participants on the above questions, some general conclusions can be drawn regarding leadership and facilitation, for instance:

A good facilitator is someone who:

1. Does not leave his/her group to their own devices.
2. Does not force others into his/her own plans.
3. Gives sensible and timely explanations, does not threaten others, but does not hide constraints either.
4. Acts in accordance with the capabilities and emotions of the group he/she is facilitating.
5. Delegates those tasks and responsibilities that can be accomplished by other members of the group.



Source:
Collection of Games and Group Dynamics Simulations Indonesia National IPM Program

16 Collector's items

Objective

To raise awareness about the importance of planning, collaboration and creativity when doing a collective assignment.

Materials

Small pieces of paper with lists of the items to be collected (see below).

Duration

10 minutes

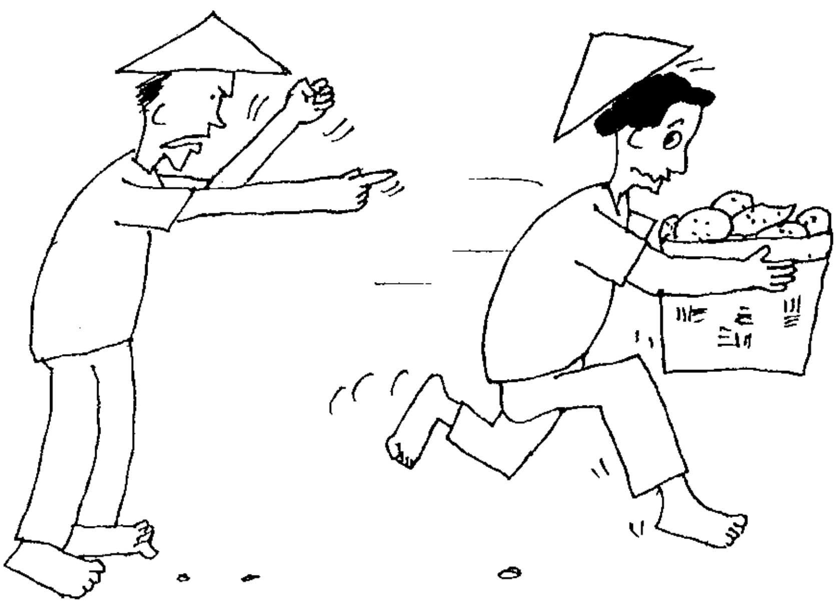
Steps

A. The participants are divided into small groups with an equal number of members (preferably 5-6 per group). The groups will compete to collect a list of items some of which may be difficult to find, for example:
   - A weevil-infested sweetpotato root.
   - A glass of water.
   - A straw hat.
   - A woman's shoe.
   - A sweetpotato leaf with potassium deficiency symptoms.
   - A spider with prey.
   - A broom.
   - A handful of healthy soil.
   - A village map.
   - A sedge plant.

   The lists for the groups are prepared in advance.
B. Explain the procedure of the game. The groups have a maximum of 10 minutes, but those finishing early will receive additional points. When the procedure is clear, distribute the lists to the groups and let them start immediately.

C. After all groups have finished, check the items that were collected and give points for correct items. Extra points should be awarded for creativity (e.g. a map drawn by the group itself). The group with most points for speed, completeness and creativity, is the winner.

D. Evaluate the exercise. What strategies did the groups apply to divide tasks and collect the items? What worked well and what did not? What can we learn from this exercise?



17 Wayward whispers

Objective

To raise awareness about communication processes, especially about how messages can become distorted and to demonstrate how communication can be mad more effective.

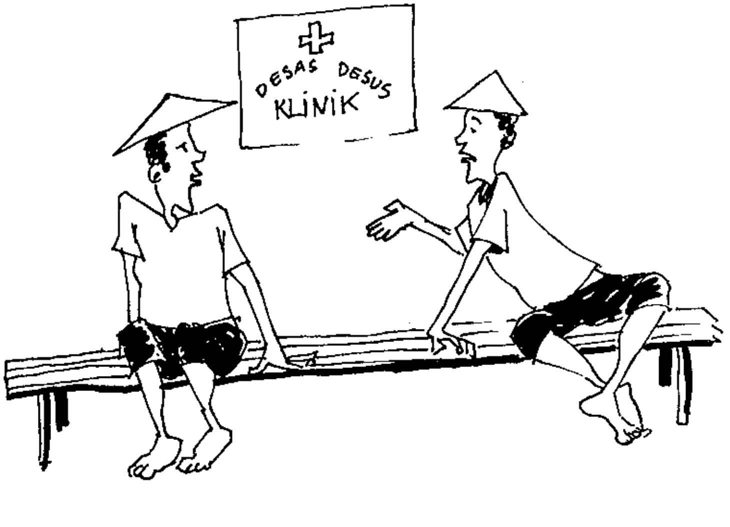
Duration

10 minutes

Steps

A. The facilitator writes a message on a piece of paper. The message should not be more than five sentences long and it should deal with something of interest to the participants. The sentences should preferably not be in a logical order, and should contain several numbers and difficult words.

B. The participants are divided into three groups with 6-8 members each. Separate the groups at a distance of at least 4-5 meters. The group members should line up and are each is given a sequential number.



C. The numbers ones of each group meet with the facilitator at a place somewhat removed from the other participants so they cannot hear the message. The facilitator slowly reads aloud the message written on the piece of paper, and repeats it only once. No questions are allowed.

D. The number ones go back to their respective groups and whisper the message in the ears of the number twos. They may say it only once. The number twos whisper it in the ears of the number threes, and so on until the last person in each row has received the message. The last person writes the message on a piece of paper. In turn, the groups read aloud what the last person wrote. Are the final messages different from the original message, and from each other?

E. Evaluate the exercise. How does the message change when it is conveyed from one person to another? What were the weaknesses of the message itself hampering correct transfer? What were the weaknesses of the people transferring the message? How can we communicate in a better, more effective way?

Source:
Collection of Games and Group Dynamics Simulations
Indonesia National IPM Program

APPENDIX II
Forms for sweetpotato ICM FFS activities

A. Pre-test answer sheet (divide one sheet in two).

B. Post-test answer sheet (divide one sheet in two).

C. Pre- and post-test results.

D. Sweetpotato cultivation record (photocopy double-sided on sheets of buffalo paper, as many as twice the number of FFS participants).

E. Sweetpotato vine growth record (photocopy as many as the number of small working groups).

F. Results of defoliation experiment.

G. Results of pesticide experiment.

H. Yield assessment contest.

PRE-TEST ANSWER SHEET
SWEETPOTATO ICM FFS

Name:

Tick or punch the number corresponding with the right answer (A, B or C).

	A	B	C
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PRE-TEST ANSWER SHEET
SWEETPOTATO ICM FFS

Name:

Tick or punch the number corresponding with the right answer (A, B or C).

	A	B	C
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

POST-TEST ANSWER SHEET
SWEETPOTATO ICM FFS

Name:

Tick or punch the number corresponding with the right answer (A, B or C).

	A	B	C
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

POST-TEST ANSWER SHEET
SWEETPOTATO ICM FFS

Name:

Tick or punch the number corresponding with the right answer (A, B or C).

	A	B	C
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

RESULTS OF PRE- AND POST-TEST
SWEETPOTATO ICM FFS

Season:		Farmer group:	
Village:		Facilitator:	

Name	***Pre-test*** Question:											***Post-test*** Question:											*Increase*
	1	2	3	4	5	6	7	8	9	10	score	1	2	3	4	5	6	7	8	9	10	score	(%)
1.																							
2.																							
3.																							
4.																							
5.																							
6.																							
7.																							
8.																							
9.																							
10.																							

Name	***Pre-test*** Question:											***Post-test*** Question:											*Increase*
	1	2	3	4	5	6	7	8	9	10	score	1	2	3	4	5	6	7	8	9	10	score	(%)
11.																							
12.																							
13.																							
14.																							
15.																							
16.																							
17.																							
18.																							
19.																							
20.																							
Total																							

SWEETPOTATO CULTIVATION RECORD

Name:	
Season:	**Planting date:**
Field area:	**Sweetpotato variety:**

Week/ date	**Activity**	**Labor**	**Inputs**		**Remarks**
		$	**what**	**$**	
Before planting	*Land preparation*				
Week 1	*Planting*				
Week 2					
Week 3					
Week 4					
Week 5					
Week 6					
Week 7					
Week 8					
Week 9					
Week 10					
Week 11					

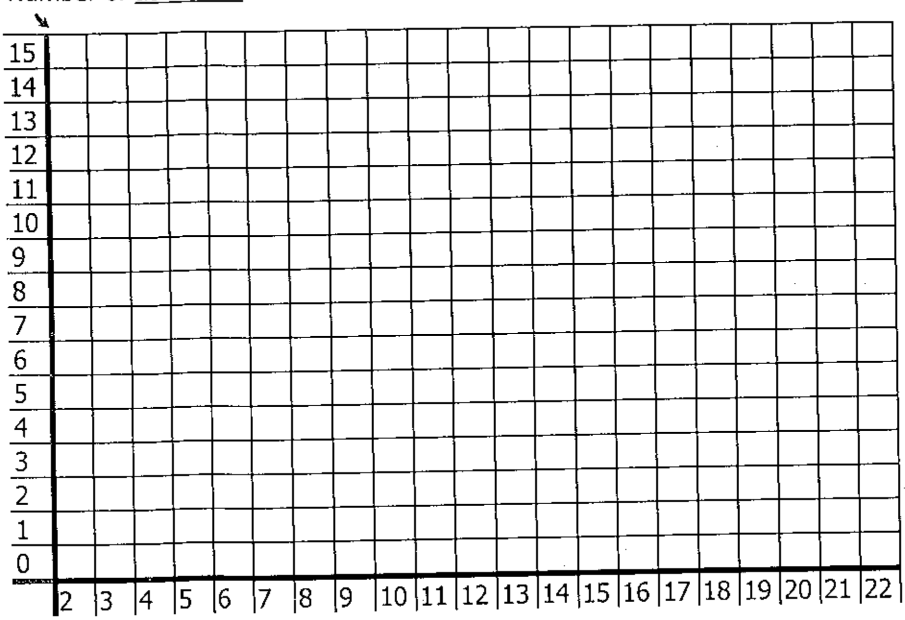
Week/ date	Activity	Labor	Inputs		Remarks
		$	what	$	
Week 12					
Week 13					
Week 14					
Week 15					
Week 16					
Week 17					
Week 18					
Week 19					
Week 20					
Week 21					
Week 22					
Week 23					
Week 24					
Week 25					
Week 26					
Week 27					
Week 28					
TOTAL					

Total expenses: (labor + inputs)
Harvest:
Gross income from harvest:
Net income: (Gross income – expenses)

SWEETPOTATO VINE GROWTH RECORD

Group:	
Members:	1.
	2.
	3.
	4.
	5.

Number of <u>additional</u> leaves since last week



Weeks after planting

<u>Notes</u>:
<u>Conclusion:</u>

RESULTS OF DEFOLIATION EXPERIMENT

Group name:
Village:
Season:
Variety:

Plot	Treatment	Plot area (m^2)	No. of cuttings planted	No. of cuttings harvested	Yield		
					kg/plot	kg/plant	ton/ha
1A	0%						
2A	50% - 1 month						
3A	50% - 3 month						
4A	100% - 1 month						
5A	100% - 3 month						

Plot	Treatment	Plot area (m^2)	No. of cuttings planted	No. of cuttings harvested	Yield		
					kg/plot	kg/plant	ton/ha
1B	0%						
2B	50% - 1 month						
3B	50% - 3 month						
4B	100% - 1 month						
5B	100% - 3 month						

Average yield from two replications per treatment:

Treatment	Yield	
	kg/plant	ton/ha
0%		
50% - 1 month		
50% - 3 month		
100% - 1 month		
100% - 3 month		

RESULTS OF PESTICIDE EXPERIMENT

Monocrotophos: contact mode of action

Target Time						
0 minutes	alive	alive	alive	alive	alive	alive
2 minutes						
4 minutes						
6 minutes						
8 minutes						
10 minutes						
15 minutes						
20 minutes						

Carbofuran: contact mode of action

Target Time						
0 minutes	alive	alive	alive	alive	alive	alive
2 minutes						
4 minutes						
6 minutes						
8 minutes						
10 minutes						
15 minutes						
20 minutes						

Monocrotophos: systemic mode of action

Target Time						
0 minutes	alive	alive	alive	alive	alive	alive
5 minutes						
10 minutes						
15 minutes						
20 minutes						
½ days						
1 days						
2 days						

Carbofuran: systemic mode of action

Target Time						
0 minutes	alive	alive	alive	alive	alive	alive
5 minutes						
10 minutes						
15 minutes						
20 minutes						
½ days						
1 days						
2 days						

YIELD ASSESSMENT CONTEST

Name	Root weight estimate										Actual root weight										Ranking									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1.																														
2.																														
3.																														
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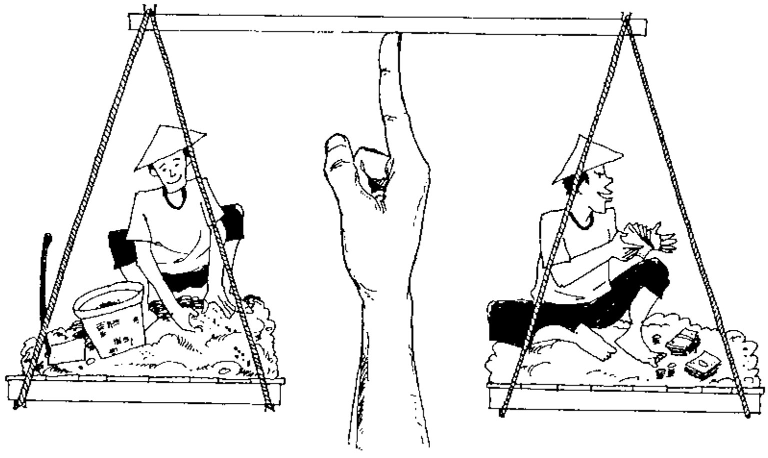
Part III

Sweetpotato ICM technical manual

1 Introduction to Integrated Crop Management

The ecological and socio-economic conditions of a farm are normally very specific, therefore, farming practices differ from farmer to farmer. Technologies offered to farmers should allow adaptation to suit their distinct environmental conditions and farm economics.

Integrated Crop Management (ICM) is a crop cultivation approach in which a balance between ecological and economic aspects of farm management is continuously sought to ensure sustainability of the enterprise. With this principle of balance, the diversity of management among farms must be given particular attention. Integration of farmers' indigenous practices with compatible modern technologies allows a farmer to develop an appropriate management to apply under her or his specific farm conditions. The major goal of this integrated approach is to establish a balance between expenditures and income, and between existing ecological processes and the effects of technology on the farm ecosystem, always keeping in mind the sustainability of the farm enterprise. ICM considers cultivation practices throughout all stages of crop development, from soil preparation to harvesting, and even up to marketing and processing, where appropriate.



ICM is actually nothing new for farmers, since, as long as they have been farmers, they have integrated their own experiences with experiences from other farmers and/or extension guidelines. ICM wants to make use of farmers' capacity to integrate technologies and adapt guidelines, since this is the only way that will ensure successful, farm-specific development of cultivation practices, hence improvement of farm management and output. One element of ICM that farmers are perhaps not fully aware of, or utilizing, is the principle of establishing an ecological and economic balance, requiring some additional problem-solving and decision-making skills. In order to enhance their capacities to implement ICM, farmers should be given the opportunity to gain more experience and improve their existing knowledge through observations, experimentation and analysis directly in the field. The ICM Farmer Field School is designed to provide such opportunities.

2 Crop health

2.1 Introduction

The first principle of Integrated Crop Management (and of Integrated Pest Management) is "*Grow a healthy crop.*" The main requirement for obtaining a healthy crop is to maintain a healthy soil and use healthy seed. Consecutively, we have to implement cultivation practices adequately and timely in accordance with the specific growth stages of the crop. A healthy crop is able to defend itself against pest and disease attack and to compensate for any damage, in order to finally give a satisfactory yield for the farmers.

2.2 A healthy soil

The soil is the place where plants live in and feed from. A fertile soil is characterized by a loose texture, a composition rich of nutrients and organic matter, a high water-retaining capacity, and a high activity of living organisms. Soil consists of the following main elements:

- *Mineral matter* (30-48%), i.e. sand (relatively large granules), loam (medium-sized granules) and clay (small granules). Soil type is determined by the proportions of these three minerals.
- *Organic matter* or humus (2-20%), i.e. plant and animal material at several stages of decomposition. A soil rich in humus has a dark brown color and a loose structure. The total decomposition of organic matter results in water, gases and nutrients, which can then be absorbed by plants.
- *Water* (20% on average) containing soluble nutrients.
- *Air* (30% on average) with varying composition of gases depending on the depth in the soil. The closer to the surface, the more the composition resembles that of the open air.
- *Living organisms*, such as animals (earth worms, insects), plants, fungi and bacteria. Fungi, bacteria and several animals play an important role

in the decomposition process of organic matter in the soil. A dead organism in the soil will be decomposed over time to become humus. Humus is organic matter with simple chemical structures that will be further decomposed to become nutrients, water and gas.

A body of sand or clay can only be called "soil" if it contains organic matter and living organisms. In most soils, we can find the highest concentration of organic matter and living organisms in the top layers. This is because the major influx of dead plant and animal material comes from above the soil and the decomposition process starts on the soil surface. Plant roots absorb nutrients and water most actively in the rich and loose top layers of the soil. The deeper this loose layer, the better is the soil's capability to support a healthy plant growth.

2.2.1 Soil nutrients

Soils contain a variety of chemical elements. The elements needed for plant growth are called nutrients. Some nutrients are absorbed in relatively large amounts (macro nutrients), others in relatively small amounts (micro nutrients). Macro and micro nutrients are given in the following table:

Macro nutrients		*Micro nutrients*	
Type	*Code*	*Type*	*Code*
Nitrogen	N	Ferro (iron)	Fe
Phosphorous	P	Manganese	Mn
Potassium	K	Chlorine	Cl
Sulfur	S	Zinc	Zn
Calcium	Ca	Molybdenum	Mo
Magnesium	Mg	Boron	B
		Cobalt	Co
		Copper	Cu
		Silicon	Si

Manure and compost contain all the types of nutrients mentioned above, since these organic fertilizers derive from plant material. Inorganic, mineral fertilizers usually contain only one or two nutrients, for instance urea contains nitrogen, TSP contains phosphorous and KCl contains K and Cl. N, P and K are the nutrients absorbed by crops in the largest quantities.

Availability of N, P and K in the soil comes from various sources. The table below shows the average amount supplied by various sources, including natural sources and some common types of fertilizers, for tropical areas:

Source		*Content*		
		N	*P*	*K*
Soil (kg/ha/year)		100-170	6-7	90-290
Rain water (kg/ha/year)		50	uncertain	9
Air, dust (kg/ha/year)		Uncertain	3-60	60-900
Compost		0.4%	0.2%	0.7%
Manure:	Cow	0.4-1.7%	0.2-0.5%	0.1-0.5%
	Chicken	1.0-6.3%	0.8-2.6%	0.4-2.7%
Inorganic fertilizer:	Urea	45%	-	-
	TSP	-	46%	-
	KCl	-	-	50%
	NPK	15%	15%	15%

In cases where farmers have limited availability of labor and livestock, farm manure cannot provide the total amount of N, P and K to support a satisfactory yield, and additional sources of nutrients have to be found. Generally, farmers in many irrigated areas in Asia apply only urea and TSP, thereby only providing N and P nutrients to the soil in an inorganic form. Inorganic nitrogen can easily be absorbed by the plants, but it can also be easily lost from the soil through evaporation, running off and leaching. Additionally, by only providing N and P, the other nutrients not provided through fertilizer will be extracted by the plants from the soil reserve. Sooner or later, the soil will become exhausted of these nutrients. Their deficiency will become a limiting factor for plant development. Crops will no longer be able to produce high yields, despite increasingly high application rates of urea and TSP.

2.2.2 Availability of nutrients for uptake

Nutrient uptake by plants depends on both the supply in the soil and availability. A high supply does not necessarily imply a high uptake. Different types of nutrients and fertilizers show a different behavior in soil and water:

- Farm manure and compost contain elements that are for the greater part in organic form at different stages of decomposition. Nutrients are released slowly whenever they reach the stage of total decomposition. In contrast, inorganic fertilizers contain elements in mineral form, meaning that just like salt they dissolve relatively easily. Release, and hence uptake by the plants, can happen immediately after application, as soon as the nutrients dissolve in the ground water. Because of the slow release of nutrients from organic fertilizers, they are best applied as basal fertilizer, so that the nutrients will be available when the crop needs them.
- Nitrogen dissolves very easily in water, and when dissolved it easily becomes gas and evaporates. Therefore, N is easily lost to the environment, because of washing off through surface water, leaching through ground water, or evaporation from the soil surface. Studies have shown that on wet paddy lands mostly only 40% of the applied urea is available for absorption by the plants.
- Phosphorous hardly dissolves in the water, and it cannot evaporate. Therefore, P is not easily lost from the soil. However, P adsorbs easily to soil particles of both mineral and organic matter, particularly to clay minerals. This makes it difficult for the plants to absorb P, unless the soil is saturated with P and more P becomes available in the ground water. When TSP is applied to P-deficient soils, only about 10% of an application will be available for uptake by plants. On the contrary, P-saturated soils will release about 90% of an application. The easy adsorption of P to soil particles and its slow release forces us to apply TSP as a basal fertilizer, so that P will be available when the plant needs it. Increasing the organic matter content of the soil will support the availability of P for the plants.
- Potassium dissolves relatively easily, although not as fast as N. It also easily adsorbs to mineral soil particles, particularly clay minerals, but not

as strongly as P. K cannot not evaporate. The adsorption of K to soil particles keeps it from excessive washing off and leaching, although a certain proportion may be lost depending on the application method and water management practices. On average, about 50% of K applied through inorganic fertilizers will become available for the plant uptake, while the remaining 50% will leach out, wash off or be adsorbed by soil particles. Soils with a high organic matter content can release K for plant uptake more easily. Since K is important for storage root formation, which takes place at 4-7 weeks after planting, half of the K fertilizer application rate is best applied as a basal fertilizer. To prevent excessive loss of K through leaching and washing off, the other half should be applied at a later stage.

2.2.3 Maintaining soil health

Soil preparation by means of hoeing or plowing aims at turning over the topsoil. Plant residues and fertilizers that have been applied on the soil surface are put under the soil, so that they decompose faster. In addition, the oxygen content of the soil increases, which favors the development of bacteria decomposing the organic matter, and the compacted parts that have been trampled become loose again. Particularly for wet paddy lands that have been inundated, soil preparation is very important to make the soil appropriate for the next crop.

The use of heavy machinery, such as tractors, for soil preparation tends to compact the sub-soil. The inevitable result is that the development of animals, bacteria and plant roots in the soil are disfavored.

In addition to soil preparation, the supply of organic matter and nutrients in such a way that it balances the removal of nutrients through harvesting, is very important to maintain soil fertility. Each crop absorbs nutrients from the soil that will be lost from the ecosystem when the harvest is taken out. Different crops absorb nutrients in different proportions. Sweetpotato, for instance, being a root crop absorbs more potassium (K) but less nitrogen (N) and phosphorous (P) than rice does. In certain areas, we may have to apply some additional amount of K fertilizer on sweetpotato crops, whereas to support rice development in the same field enough K may already be provided by nature, e.g. from volcanic ash circulating in the air. The golden rule is that we should provide as many nutrients through fertilization as we expect will be extracted from the ecosystem by the crop we are cultivating. We should remember here that most nutrients can only be provided by organic fertilizers, such as farm manure and compost, and not by inorganic fertilizers.

2.2.4 Enhancing soil fertility

Deteriorated soils can only recover when substantial amounts of organic matter are given. The following sources of organic matter can be used for this purpose:

- *Farm manure*, i.e. the excrements of any kind of livestock, often mixed with leftovers of feed. The manure should preferably be ripened for 1-2 weeks before applied to a crop.
- *Compost*, i.e. decomposed plant material, for instance from kitchen and garden waste, or crop harvest residues.
- *Mulch*, i.e. a ground cover of dead or live plant material, such as rice, straw, weeds or a leguminous cover crop.
- *Green manure*, i.e. an intercrop that does not compete with the main crop and preferably can fix nitrogen from the air. The green manure crop should be trimmed regularly after which the cut parts are left as mulch on the soil surface or incorporated into the soil.

2.3 Healthy seed

Clean and healthy seed is the basis for obtaining a healthy crop. Sweetpotato is propagated through vegetative planting material, hence carrying the risk of transmitting pests and diseases to the next generation. This weakness can be overcome by means of thorough seed selection. To be able to select healthy seed, farmers have to know the symptoms of pests and diseases on the sweetpotato vines and roots. Sweetpotato diseases that spread through seed are viruses and scab, whereas insect pests include stemborer and sweetpotato weevil.

2.3.1 Diseases

A. *Scab* is a fungal disease the symptoms of which start with the formation of small brown spots on the veins of the leaves and the stem. At later stages, the brown spots cover the whole plant, leaves become curled and the tip of the vine heavily deformed. Scab can cause yield loss of more than 50%. The disease is supposed to start attacking the plants at the stage of storage root formation. When we use sweetpotato cuttings with scab symptoms as seed, the next crop will have scab, too. A picture of symptoms of the scab disease, and more information, is given in Section 5.3.

B. *Viruses* are transmitted to plants by sap-sucking insects, for instance aphids, whiteflies and mites. The growth of a virus-infected plant is hampered, because the plant has to spend too a lot of energy to multiply the viruses, instead of maintaining its own metabolism. Heavily virus-infected plants can be detected by their stunted growth and/or yellow leaves of irregular shape, depending on the type of virus infecting the plant. Section 5.3 contains more information on and pictures of virus symptoms on sweetpotato plants. A sweetpotato plant with symptoms of virus infection should immediately be destroyed and never be used as seed. Viruses will remain in the cutting and cannot be removed, they multiply, and are a source of infestation to other plants.

C. Several kinds of *root rot* can be found on planting material, both storage roots and cuttings. The germs of the root rot diseases can stay alive in the soil for many years. When sweetpotato cuttings are taken from the stem base near the soil surface, it is likely that the disease is transferred to the next crop, particularly if soil particles stick to the cuttings.

2.3.2 Insect pests

Most insects infesting sweetpotato seed can directly be detected by their eggs, larvae or adults on the cuttings. The main insect pests of sweetpotato that can be spread through seed are:

A. *Sweetpotato weevil.* The eggs are laid on the leaves and stems, and preferably on older leaves. The majority of weevils in a field (70-90%) can be found in the area from 15 cm under the ground to 10 cm above the soil surface. This means that cuttings taken from the vine tips are likely to contain very few weevil eggs. The use of healthy storage roots without weevil damage symptoms can also help to produce sweetpotato cuttings that are free of weevils.

B. *Sweetpotato stemborer.* The eggs are laid on the leaves. After hatching, the larva crawls to the stem base and eats its way inside the stem. The vines of plants with heavy stemborer damage should not be used for seed. Clean seed can be produced by planting healthy storage roots in a seedbed as explained below.

2.3.3 Production of healthy seed

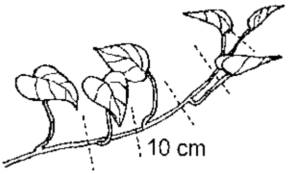
There are several methods to obtain healthy sweetpotato seed:

A. *Pest and disease free vine cuttings.* Vigorous plants without symptoms of pest and disease damage are selected in a crop that is about to be harvested. The first and second tip cuttings provide the best seed and are likely to contains least pests.

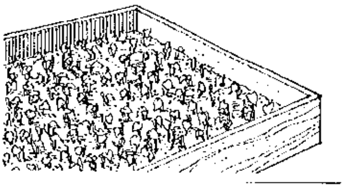
B. *Seedbed preparation.* New, clean seedlings can be produced from storage roots in a seedbed. Cleaning up seed is necessary when the level of pest and disease attack is high and few healthy plants are left in a field to provide seed for the next crop. Healthy storage roots are selected from plants that produced a high yield, and planted in a seedbed located far away from other sweetpotato crops. When the vines have grown long enough, they are cut at the stem base and planted directly in the field. When large amounts of cuttings are needed, rapid multiplication should be done as explained in point C below.

C. *Rapid seed multiplication:*

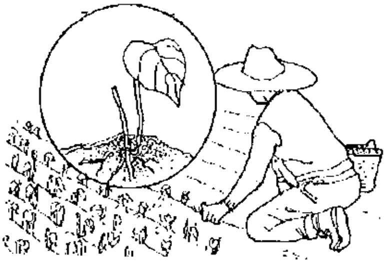
- ⇨ Vines growing from healthy storage roots in a seedbed are cut when they have reached a length of about 30 cm.
- ⇨ Each vine is cut up in single-node cuttings of about 10 cm (although the length of nodes depends on the variety). The leaf is kept on each cutting. The tip of the vine is discarded.



- ⇨ A seedbed is prepared with a mixture of loose, humus-rich soil and rice hull ash. The single-node cuttings are planted at a high density in the seedbed with the node positioned under the soil.



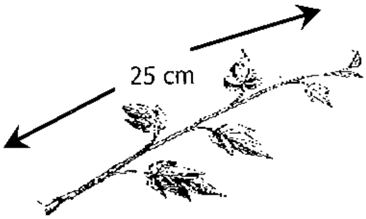
- ⇨ The seedbed is regularly watered and should not become dry, especially not during the first five days after planting.



- ⇨ After 10-15 days the seedlings have developed enough roots and are ready to be transplanted to the field. The seedlings should be removed from the seedbed with care to avoid damage of the roots. Transplanting should be done in the morning or in the late afternoon to avoid excessive evaporation, wilting and transplanting shock.

2.3.4 Seed selection

Healthy seed is selected by, first, detecting healthy, vigorous mother plants, free of pest and disease symptoms. The top 25-35 cm of the vine is the best part to be used as seed. This part most easily recovers from cutting and planting shock, and it grows faster than the lower parts of the vine. In addition, the tip is more likely to be free of sweetpotato weevil and stemborer eggs.

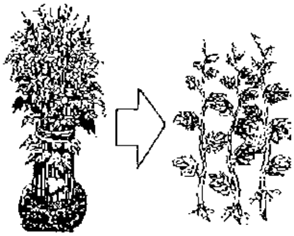


A tip cutting

A second method for seed selection, called positive selection, implies the use of cuttings from plants that produced a high yield. These plants are likely to be free of viruses, and therefore chances of virus transmission to the next generation through seed is very small.

2.3.5 Seed storage

Planting of sweetpotato cuttings is preferably done as soon as possible after they are cut and selected. However, this may not always be possible, for instance when it is too hot and the sunshine is too bright, when the field is not ready yet, or because of any other constraints. Cuttings can be kept for a maximum of seven days. In order to preserve the food reserves in the stem, most leaves on the cuttings should be removed, leaving only a few leaves at the tip. Then the cuttings are tied in bundles with their bases covered with a wet cloth or sack. The bundles are kept in a cool and shady place. During the storage period, roots may develop at the base of the cuttings. The cuttings should then be carefully planted with the roots.



Bundle of cuttings for storage

2.3.6 Planting of cuttings

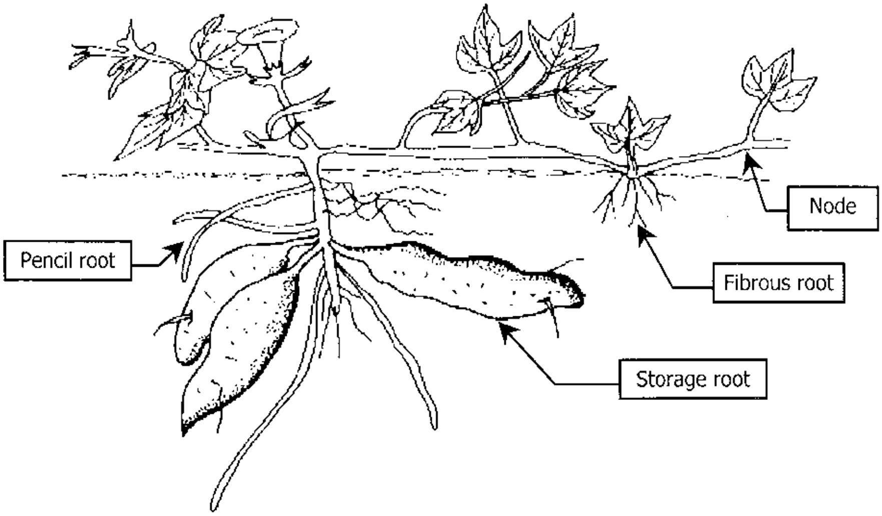
Experiences from research and farmer practice have shown various conditions that should be paid attention to when planting sweetpotato cuttings, to favor crop establishment:

A. *The length of the cutting.* An average cutting length of 25 cm is considered appropriate for most varieties, although some varieties were reported to produce better when longer cuttings (40-45 cm) are used. The conditions of the field may also influence the relation between cutting length and crop development, and farmers should conduct experiments to find out for themselves which is the best length under the prevailing conditions and varieties they use.

B. *The number of nodes under the ground.* Cuttings with 2-3 nodes (5-7 cm) under the ground have produced higher yields than those with 5-6 nodes (12-15 cm) buried. Farmers' experience shows that better yields are achieved if about one-third of a cutting of 20-25 cm is placed under the ground.

C. *Planting distance.* Most sweetpotato varieties tend to produce a lower yield per plant, but a higher yield per hectare, when we plant them at a higher density. The most appropriate planting distance for most varieties that are currently grown is considered six plants per meter of ridge when one row is planted on a ridge. The width of the ridge can range from 60 to 120 cm, depending on the conditions of field and the composition of the soil. Wider ridges are likely to give a higher yield per plant, but a lower per hectare yield. The optimum planting distance in a field should be determined through experimentation.

Soon after planting, sweetpotato cuttings form young adventitious roots that, depending on the soil conditions, develop into either thick or thin roots. Under favorable conditions, thick roots that grow from the nodes will form storage roots (see picture below). Under dry compacted conditions, young thick roots begin to enlarge, but this is soon stopped and they turn into pencil roots. Under unfavorable conditions of high nitrogen and low oxygen levels, and at the internodal areas, thin roots are formed that develop into fibrous roots, or sometimes into pencil roots.



To be able to form storage roots, young thick roots require favorable conditions, including a loose moist soil with an adequate level of oxygen and a sufficient but not excessive level of nitrogen. The number of young thick roots that will develop into storage roots is determined during the period between 4-7 weeks after planting. In that period the crop should not experience drought.

2.4 A healthy crop

2.4.1 The development of sweetpotato

The development cycle of sweetpotato from crop establishment to harvesting the storage roots takes place in three phases within a time span of 100-150 days. The growth duration depends on the variety and on the environmental conditions. The three phases of a variety maturing in four months under tropical conditions are presented below:

Week	Development phase	Characteristics
0	I Initial phase	• Planting
1		• Fast growth of young roots
2		• Slow growth of vines
3		
4	II Intermediate phase (storage root initiation)	• Initiation of storage root development
5		• Fast growth of vines
6		• Large increase in leaf area
7		
8	III Final phase (storage root bulking)	• Growth of vines ceases and finally stops
9		• Rapid bulking of storage roots
10		
11		
12		• Transportation of substances from leaves to storage roots
13		
14		• Reduction of leaf area because of yellowing and falling
15		
16		
17		• Harvesting

Storage root formation may begin as early as four weeks after planting, and on average between 4-6 weeks, depending on the variety and the environmental conditions. Favorable conditions during the first month after planting are of vital important for storage root initiation and will determine the number of roots on a plant. At seven weeks after planting, 80% of the storage roots have already been formed, and between 8-12 weeks after planting the plant will stop forming new storage roots. After that, all energy is devoted to the bulking of the storage roots. When many storage roots are formed on a plant, the weight per root is normally low, while few roots per plant normally results in big roots.

Vine growth of a healthy sweetpotato crop, in which all requirements for maximum development are fulfilled, is extremely abundant. Normal levels of pest and disease attack will neither result in considerable loss, nor will the crop suffer from nutrient deficiency symptoms. Although parts of the leaves may be eaten by certain pests, such as leaffolders, tortoise beetle and grasshopper, a healthy plant is able to compensate for such damage. Vine growth normally reaches a maximum half way through the final phase. At that stage the foliage of the crop looks most lush. After that, vine density decreases, because the plant uses more and more energy to fill the storage roots rather than to form and maintain the leaves. Moreover, the substances produced in the leaves are transported to the storage roots. Vines attacked by pests are no longer replaced. The leaves become old, yellow and fall off.

2.4.2 Sweetpotato requirements

There are some requirements for a sweetpotato crop to grow well. Those include a healthy place to live (soil and environment), a sufficient supply of nutrients and water, and no extraordinary level of pest and disease attack.

Although sweetpotato can grow in almost any type of soil, in most areas it thrives best on sandy loam soils. Heavy clay soils often produce low yields and low quality roots of irregular shape, because storage root formation is hampered in the hard, sticky soil. Light sandy soils carry the risk of high weevil infestation when the soil is washed away by rain and roots become exposed. A very wet soil at the time of harvest can cause a high incidence of root rot, hence a reduced marketable yield and reduced opportunities for storage.

The nutrients most needed by sweetpotato are potassium (K) and nitrogen (N). Other important nutrients are phosphorus (P), sulfur (S), magnesium (Mg) and iron (Fe). The roles of these nutrients in the sweetpotato plant, the amounts absorbed by the plants, and the amounts that have to be supplied to a field are as follows:

Nutrient	Function in the plant	Content in sweetpotato	Supply to the field
K	– Accelerates the growth of the leaves – Supports the formation of storage root, increases the number of storage roots – Increases the weight of storage roots – Reduces the negative effect of excessive P applications – Plays a role in the protein formation – Plays a role in the formation of well-shaped storage roots – Enhances resistance against diseases – Increases vitamin A content	5-6 kg K per ton of storage roots	80-200 kg K/ha
N	– Component of chlorophyll that plays a role in the absorption of sunshine – Component of proteins, increase the protein content of storage roots – Stimulates leaf growth – Enlarges the size of leaves and storage roots	3-5 kg N per ton of storage roots	30-90 kg N/ha
P	– Plays a role in important chemical processes – Stimulates root development – Stimulates storage root development	0.6-1 kg P per ton of storage roots	0->100 kg P/ha
S	– Plays a role in important chemical processes – Component of proteins – Component of plant hormones	little	Usually enough from natural sources
Mg	– Component of chlorophyll – Plays a role in important chemical processes, e.g. the formation of proteins	little	Enough from natural sources
Fe	– Component of chlorophyll	little	Enough from natural sources

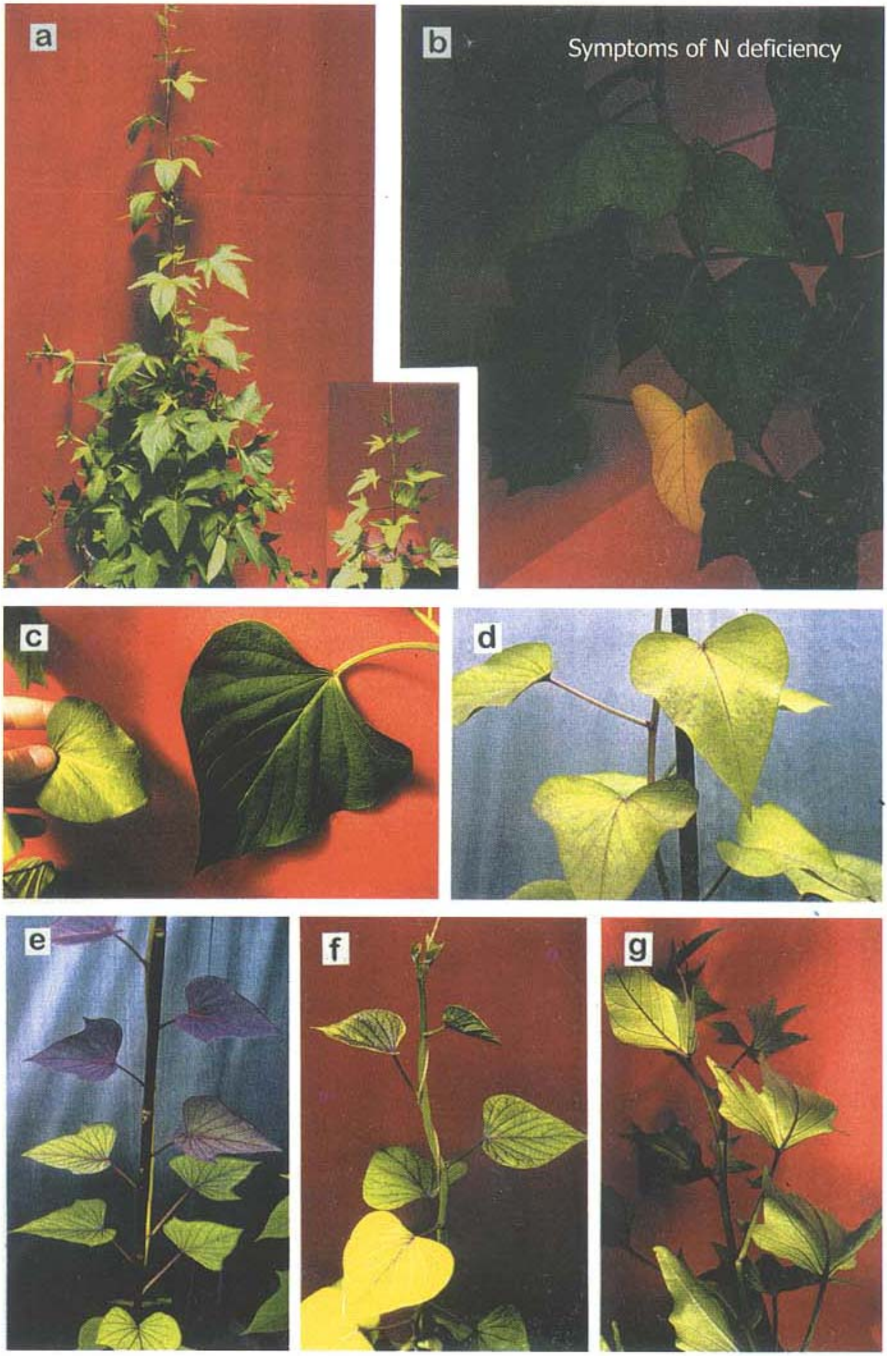
The need of sweetpotato for potassium is relatively high, like in other rootcrops. Not only should we pay attention to the appropriate amount of potassium, but also to the ratio between potassium and nitrogen to be supplied. If the plant absorbs a lot of nitrogen to form proteins, but it has insufficient potassium to support this formation, the substances to form the proteins will accumulate in the leaf sap and can cause poisoning to the plant. The best bulking of storage roots takes place when N and K supply are at a ratio of about 1:3.

Sweetpotato is able to make efficient use of phosphorous and can absorb it relatively well from the soil. In fields where sweetpotato is rotated with rice or other crops that are given substantial amounts of inorganic P fertilizer, normally no additional inorganic P needs to be given to the sweetpotato crop. Perhaps only in the case of loam soils of low organic matter content, P fertilizer may need to be applied.

Plants need nutrients not only for their growth, but also to enhance their resistance against diseases. For this purpose particularly K and P are very important. In comparison to human beings and animals, plants are more vulnerable to diseases when they experience nutritional disorders. When the nutrient supply is insufficient or unbalanced, plants will easily suffer from disease and pest attack, or stress caused by environmental factors.

2.4.3 N, P and K deficiencies

If a plant experiences deficiency of a certain nutrient, it will show certain symptoms, mostly on the leaves but its whole growth pattern might be affected. Each nutrient shows specific deficiency symptoms. If a farmer can recognize the specific deficiency symptoms, he or she will know what to do when the symptoms occur on the plants. Deficiency symptoms of the main nutrients on sweetpotato plants are presented in the pictures and tables below.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Symptoms of N deficiency
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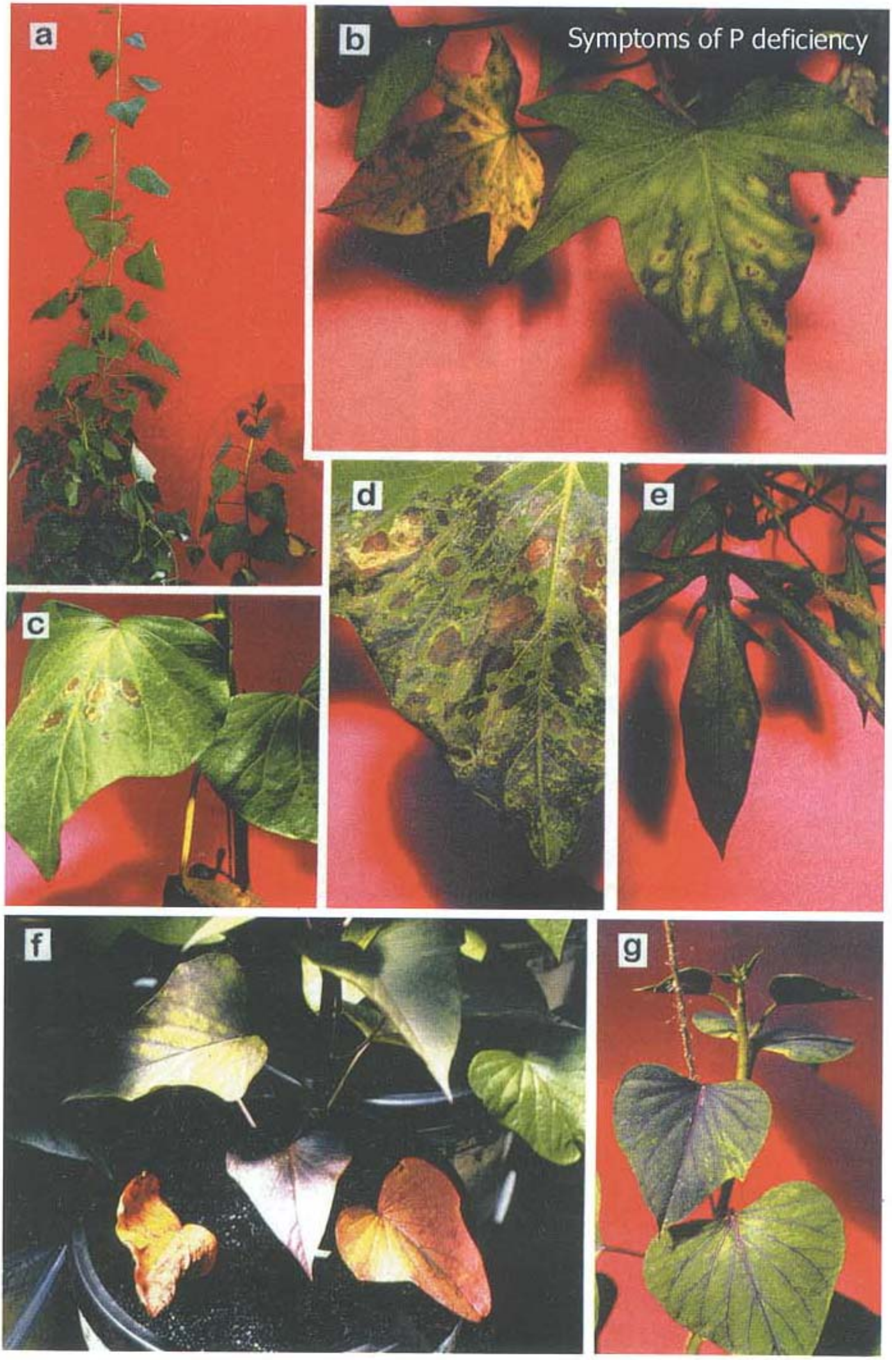
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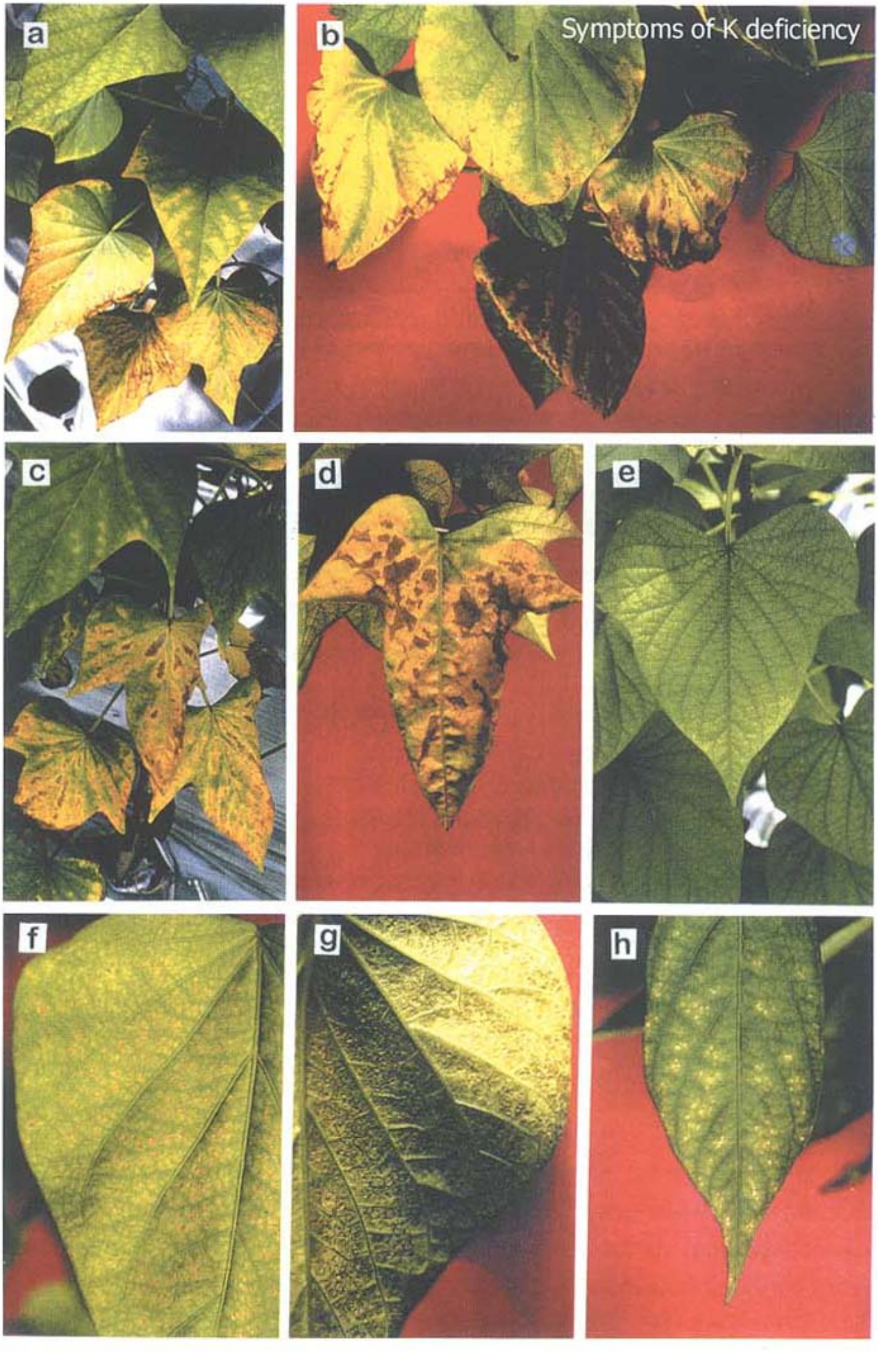
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Symptoms of K deficiency
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(Photographs by J. O'Sullivan)

Symptoms of N deficiency

- Leaves become light green to yellowish
- Reduced growth of the vine
- Old leaves become reddish at the edges, yellowish in the middle, and finally reddish to brown all over
- Stems of old plants become reddish
- Short petioles
- Symptoms develop from the base of the plant to the top

Symptoms of P deficiency

- Leaves are dark green to bluish with purple veins
- Reduced vine growth
- Small storage roots of irregular shape
- Purple color on the storage roots is more obvious

Symptoms of K deficiency

- Short vines with short internodes and small leaves are the first symptoms
- Leaves are of a darker color (dark green), especially at the edges
- Short and pale petioles
- Small, shiny brown spots emerge on the leaves, first on the bottom of the leaves and on old leaves
- Old leaves become yellowish or reddish, starting at the top of the leaves and developing via the edges to the leaf base
- Plants wilt faster and leaves easily fall off
- When experiencing heavy deficiency, the whole leaf becomes yellow except the leaf base and the leaf tissue just next to the veins that become dark green
- Low number of storage roots
- Storage roots are long and thin
- Storage roots are more easily infected by root

2.4.4 Other nutrient deficiencies

Deficiencies of other nutrients can cause the following symptoms on the sweetpotato leaves:

- Yellowing between the veins.
- Yellowing of the total leaf area.
- Leaf edge becoming brown and dying off.

2.4.5 Water deficiency

Sweetpotato is relatively tolerant to drought compared to other crops. However, water shortage, especially at the stage of storage root initiation and for prolonged periods of time, can strongly reduce the capacity of the plants to produce a good yield. The number of storage roots will decrease and roots will be mostly small. Direct symptoms of water deficiency include wilting of the leaves and ceased growth. Water shortage also makes the plants more susceptible to insect pest attack, and to cracking of the storage roots.

2.4.6 Nutrient toxicity

Most nutrients can cause toxicity in plants when applied in excessive amounts. Too much nitrogen fertilizer causes the vines to grow lushly, but initiation and development of storage roots is hampered. At excessive N applications, sweetpotato plants will not flower, although it should be remembered that not all sweetpotato varieties produce flowers. Potassium toxicity is seldom a problem. Sweetpotato is fairly tolerant to acidity of the soil.

2.4.7 Symptoms of virus infection

Plants showing symptoms like stunted growth, curly leaves, and/or changed leaf or vein color are likely to be infected by a virus disease. Viruses are usually transmitted by leaf-sucking insect, such as aphids (see Section 5.3). These symptoms should not be mixed up with nutrient deficiency or toxicity symptoms.

2.5 The regenerative capacity of plants

2.5.1 Leaf damaging agents

Several kinds of pests and diseases can cause damage to the leaves of sweetpotato. Among the insect pests we can find types that suck the leaf sap, while others consume whole parts of the leaf. The leaf-sucking insects have long mouth parts that they can inject into the leaf tissue to suck the plant sap. This way of eating does not only cause damage to the leaves in the form of many small holes, but also results in a loss of the substances produced by the leaf for its growth. If there are many of these mostly small insects on a leaf, the leaf dies off. Examples of the leaf-sucking insects are aphids, leafhoppers, whiteflies and mites.

Leaf-eating insects can be divided into those biting parts of the leaf, such as grasshoppers, hornworms and tortoise beetles, and those scraping tissue from the leaf surface, for instance leaffolders and thrips. The way of eating depends on the shape of the mouth of an insect. Both ways cause a direct loss of green tissue for the plant which has to be compensated by growing new leaves.

Diseases also damage the leaves, because they cause spots on the leaf's surface, thereby reducing the green area. The leaf tissue of the spots is dead and does no longer function. When the number of spots on the leaves becomes abundant, the growth of plant will be disturbed and the plant becomes stunted. A very common disease in sweetpotato causing considerable loss is the scab disease.

2.5.2 When can plants compensate for damage?

Generally, sweetpotato has a high capacity to compensate for pest and disease damage on the leaves, since under favorable conditions the foliage is very lush and vines grow very rapidly. When the plant is healthy, a certain level of damage will not result in economic loss, because soon after the damage has occurred the plant forms new leaves and compensates for the damage.

This ability for compensation, however, depends on the severity of the damage, the development phase of the plant, and the environmental conditions determining crop health. The most sensitive development phases are the initial and intermediate phases when crop establishment and storage root initiation occur, which cover the first seven weeks after planting. If there are a lot of pests that damage the leaves during this period, the yield may be affected. The compensation capacity of a certain variety under certain conditions can be tested in an artificial defoliation experiment.

2.6 Plant nutrition

Plants need various nutrients as food, the most important of which are:

- Nitrogen or N.
- Phosphorous or P.
- Potassium or K.

As was discussed in Section 2.2 (A healthy soil), N, P and K are available in the soil, in irrigation water and in the air. We have to apply additional fertilizer when we cultivate crops intensively, and exhaust the natural reserves of these nutrients. Organic fertilizers such as farm manure, compost and green manure are preferred to replenish these reserves. At high production levels, however, the (often limited) amounts of organic fertilizers available may not provide sufficient amounts of N, P and/or K, and additional inorganic fertilizers or ash may have to be used. Some other important nutrients absorbed by the crops are sulfur (S), calcium (Ca), zinc (Zn) and magnesium (Mg). Generally, these nutrients are sufficiently available in the soil, particularly when a field is often treated with organic fertilizers.

As learned in Section 2.4, we can see from a plant's appearance whether it suffers from a nutrient deficiency. After we have diagnosed the deficiency and analyzed the need for action, we can correct the problem by applying the appropriate type of fertilizer. The need for action will depend on the severity of the problem, the growth stage of the crop, and the expected benefit to be gained from the practice in relation to its cost. It is, for instance, normal that sweetpotato crops suffer from nitrogen deficiency, showing yellow leaves, at the end of the season.

2.6.1 Types, composition and prices of fertilizers

Organic fertilizers are the best food for plants since they contain all the nutrients needed by the plant. A weakness is that their nutrient content is relatively low compared to inorganic fertilizers (see table below). We need to apply a huge amount of manure, for instance, to provide the nutrients needed to support a high yield in intensive cultivation systems, however the availability of manure is often limited. Additional inorganic fertilizer can then provide a solution. Inorganic fertilizers commonly available are urea (45% N), TSP (46% P) and KCl (50% K).

In order to determine ecologically and economically sustainable fertilization levels in a field, we have to consider not only the composition of the different fertilizers, but also their price and the labor and transportation costs needed to purchase and bring them to the field. The table below shows that about two sacks or 100 kg of cow manure are needed to obtain one kg of pure nitrogen plus all other nutrients including 0.8 kg of P_2O_5 and 0.4 kg of K_2O P. The same amounts of N, P and K can be obtained from 5.2 kg of inorganic fertilizer. With the prices prevailing in Indonesia in 1997[1], the total amounts of inorganic fertilizer would have cost Rp. 2,480, in comparison with only Rp. 700 for the two sacks of cow manure. The savings would even be higher if we use chicken manure, of which we would need only 33 kg costing Rp. 660, as compared to 7 kg of inorganic fertilizer for a price of Rp. 3,427. After taking into account the labor and transportation costs we can determine which option is most economical. In view of

[1] US$ 1.- was equivalent to Rp. 2,250.

sustaining soil fertility, organic fertilizer is definitely much better than inorganic fertilizer.

Fertilizer type	*Content (%)* N	P_2O_5	K_2O	*Price*	
Cow dung	1.0	0.8	0.4	Rp. 350/sack (50 kg) ⇒ Rp. 700 for 100 kg of manure containing 1 kg of N, 0.8 kg of P_2O_5, 0.4 kg of K_2O and other nutrients.	
Chicken dung	3.0	3.9	1.9	Rp. 1,000/sack (50 kg) ⇒ Rp. 660 for 33 kg of manure containing 1 kg of N, 1.3 kg of P_2O_5, 0.6 kg of K_2O and other nutrients.	
We need:		*To substitute the nutrients contained by:*		*100 kg of cow manure (Rp. 700)*	*33 kg of chicken manure (Rp. 660)*
Urea	46	-	-	Rp. 400/kg (1 kg N = Rp. 870)	(1 kg N = Rp. 870)
TSP	-	46	-	Rp 650/kg (0.8 kg P_2O_5 = Rp. 1,130)	(1.3 kg P_2O_5 = Rp. 1,837)
KCl	-	-	50	Rp. 600/kg (0.4 kg K_2O = Rp. 480)	(0.6 kg K_2O = Rp. 720)
TOTAL				Rp. 2,480 for 5.2 kg of fertilizer	Rp. 3,427 for 7.0 kg of fertilizer

2.6.2 Amount of nutrients needed by sweetpotato

The nutrient contained in sweetpotato leaves and storage roots is more or less constant. Therefore, we can calculate the approximate amount of nutrients absorbed by a crop when we know the yield. This means that we have to apply a high dose of fertilizer if we expect a high yield, but can economize when the environment does not have the potential for high production. The amount absorbed by the crop is not equal to the amount we have to apply. We should consider the natural reserve available, on the one side, as well as losses due to adsorption, evaporation, washing off and leaching, on the other side. Generally, less fertilizer, particularly urea, can be applied during the rainy season than during the dry season, because the yield potential is lower when the sky is often cloudy.

To calculate the exact amount of nutrients needed by a crop to support a certain yield level is very complicated, if not impossible. We never know the exact reserves in the soil and the amounts provided by natural sources, nor can we predict the exact behavior of the fertilizers in the soil and ground water to estimate the proportion absorbed by the plants. Research done by scientists and farmers shows some important lessons that provide basic guidelines to determine fertilizer application rates under certain conditions:

- Large amounts of nitrogen keep the leaves of sweetpotato lush and green, but result in small storage roots. Too much nitrogen can even cause poisoning in the plants.
- Sweetpotato needs a relatively large amount of potassium, particularly at the stage of storage root initiation. Potassium deficiency can cause other nutrients not to be used optimally, and results in few and small storage roots.
- Sweetpotato develops best when N and K are available in the soil at a ratio of 1:3.
- Sweetpotato makes efficient use of phosphorous and can extract it well from the soil. Usually, P fertilizer does not need to be applied to sweetpotato when organic fertilizer is given and the crop is grown in rotation with rice or other crops that are given inorganic P. Exceptions are cases in which the soil has serious P deficiency and for loam soils with low organic matter content.
- Organic fertilizers provide all the important nutrients needed by the crop and should always be used in as large an amount as available. The possible amount of additional inorganic fertilizer should be adjusted to the organic fertilizer applied.

2.6.3 Time of nutrient application

The faster the growth of a plant, the greater its need for nutrients. Sweetpotato vines grow fastest during the intermediate phase of storage root initiation, which is between four and eight weeks after planting. During this period, all nutrients should be available in balanced concentrations in the ground water. Particularly potassium should not be deficient during this period, since it plays an important role in determining the number of young thick roots to become storage roots. This is the reason why we have to give part of the potassium fertilizer as a basal application to ensure adequate availability from week four onwards.

Organic fertilizer releases nutrients slowly, and, therefore, should be applied as a basal fertilizer. The supply of nitrogen from organic fertilizer and natural sources is normally enough to support the vine growth during the initial and intermediate phases of crop establishment and storage root initiation. During this period, the plants form a dense foliage and rapid vine growth continues during the first part of the storage root bulking phase. The beginning of the bulking phase, when vine growth is at its maximum speed, is the most appropriate moment for additional K and N application, if needed.

Phosphorous is easily adsorbed to soil particles and is only slowly released for plant uptake. Therefore, we should apply P fertilizer at the moment of soil preparation, to make sure that enough P is available when the plants need it during the phase of storage root initiation and bulking.

2.6.4 Sweetpotato fertilization guidelines

Based on the principles described above regarding nutritional requirements and application time, very general guidelines are presented here for fertilizer application rates. It should be remembered that these guidelines were developed in Indonesia, under tropical, irrigated, and relatively fertile conditions with a high yield potential (20-50 tons/ha). Therefore, these guidelines should not be considered a standard recommendation, but need to be adjusted according to prevailing yield potential, soil composition and fertilization history, environmental and socio-economic conditions.

Fertilization guidelines as applied in the ICM FFS in Indonesia, targeting for a yield of 40 tons/ha, include the following application rates:

Fertilizer type	Basal application at soil preparation (kg/1,000 m^2)	Second application at 50-60 days after planting (kg/1,000 m^2)
Cow manure	400	-
TSP	-	-
KCl	5	5
Urea	-	10

The rate of 400 kg organic fertilizer per 1,000 m^2 is considered the minimum amount to be supplied seasonally to arable lands to sustain soil fertility. If chicken manure is used instead of cow manure, nutrient supply is supposedly sufficient, and additional inorganic fertilizer may not be needed unless a higher yield than 40 tons/ha is expected. It is recommended that more organic fertilizer than the minimum of 400 kg/1,000 m^2 is used whenever available and feasible with regard to labor and transportation, thereby proportionally reducing the additional amounts of inorganic fertilizers. To determine the most suitable fertilizer application rate in a certain field, farmers should conduct a series of experiments and find out for themselves. Factors to consider when determining possible treatments include soil fertility, cropping pattern, availability of organic and inorganic fertilizers, labor and capital.

2.7 Vine lifting

Most sweetpotato varieties are characterized by a growth habit of long vines creeping over the soil surface. If the soil is moist and the stem touches it, roots will grow from the nodes. These roots can form storage roots, but only very small ones that are not marketable. Water and nutrients supplied to these useless roots are therefore wasted, and will result in total yield loss. This waste can be prevented by lifting the vines so that the roots growing on the stem nodes are cut off and will not continue to grow. Vine lifting implies that the vines are only uplifted to disconnect the roots from the soil. They should not be turned over because they may cause rotting of the leaves.

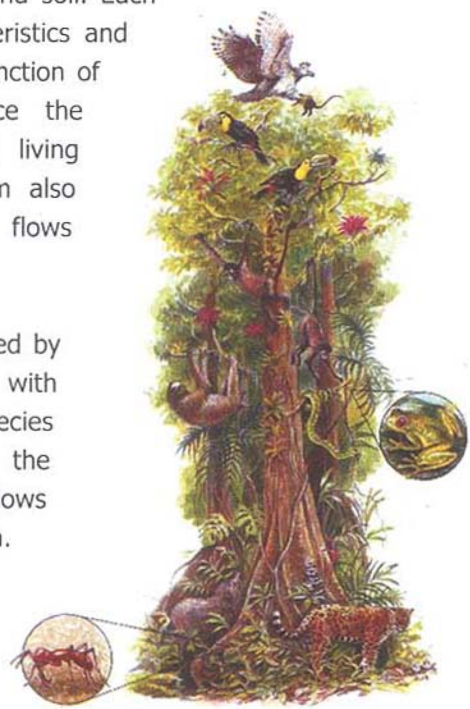
Farmers in certain parts of India were reported to lift the vines every 3-5 days after the field was irrigated. However, this involves a lot of labor while root growth on the stems does not necessarily happen after irrigation, and will depend on how long the soil remains wet and to what extent the stems touch the soil. Indonesian farmers were found to conduct vine lifting 1-2 times during the rainy season, whereas during the dry season the majority (64%) did not do it at all. During the dry season, they did not find many roots to be formed on the stems, because the soil surface is dry most of the time.

Experiments done by Indonesian farmers show that vine lifting at a frequency of more than once during a season only results in a higher yield when the soil is often moist, allowing roots to grow on the stems. Vine lifting during any season should, therefore, not be a routine practice, and is only recommended after root growth on the stem nodes has been observed. During routine field observations, especially after the crop is 60 days old and maximum vine production has been achieved, farmers should pay careful attention to root formation on the stems. Based on these observations, they can decide whether labor investment in vine lifting is worthwhile or not.

3 The agroecosystem

3.1 Introduction

An ecosystem is a natural system that is formed by dynamic interactions between biotic and non-biotic elements in a defined area. Biotic elements include plants, insects (pests, natural enemies, decomposers), microbes and other living organisms, and non-biotic elements comprise weather components such as temperature, relative humidity, wind, sunshine, rain and soil. Each element has its special characteristics and role in the system that, as a function of time and place, will influence the distribution and population of living organisms. The term ecosystem also involves nutrient and energy flows within the system.



An agroecosystem is characterized by a much simpler composition with regard to the number of species residing in the system and the relative simplicity of energy flows than a natural, stable ecosystem. Therefore, the agroecosystem needs energy input to maintain its balance. The wet paddy ecosystem, although an artificial system, has a rather complex composition of biotic and non-biotic elements, providing it with relative stability. Injudicious use of pesticides, however, disturbs this balance due to the killing of natural enemies and other organisms in the rice field.

The IPM and ICM concepts find their basis in the stability of the agroecosystem and in economic efficiency. By maintaining the stability of the agroecosystem, pest populations can be kept at manageable levels. To achieve this, the following important points need to be remembered:

A. Each ecosystem is dynamic with respect to numbers, position, role and intensity of each element within that transform and develop continuously. They form a living, ever-changing system.
B. Each ecosystem contains a hierarchical structure. For example: plants are producers of vegetable food which will be used to feed herbivores. The herbivores (including pests) eat the plants using various modes of attack. The herbivores, in turn, serve as food for the carnivores (including the natural enemies), which again may be eaten by other carnivores. Finally, all organisms serve as food for the decomposers. In the agroecosystem, if no natural enemies exist, the pests will multiply unlimitedly and destroy the crop. But if the crop is finished, the pests will die of starvation. Many natural enemies are not choosy about their food and will eat other organisms, such as decomposers or plankton eaters, when there are no pests. Hence, they form an important protection mechanism in the field.
C. All elements of the agroecosystem are strongly linked and disturbance of one element disturbs the whole balance. Therefore, the task of farmers is to maintain the natural balance among elements in the agroecosystem, ensuring a good environment for the crop to grow well.

3.2 Biodiversity

A healthy ecosystem has a high degree of diversity, both with regard to number of species and to genetic diversity among individuals within one population. In practice, it means that we can see various kinds of plants and animals. Some beneficial animals include earthworms that help increase soil fertility, and natural enemies such as spiders, beetles, frogs and lizards, that help suppress pest populations. If we do not find many of these beneficials in an agroecosystem, there is a problem caused by one of the following reasons:

- Too many pesticides are being used that killed the beneficials.
- There is not enough food for the natural enemies. The larval stages of most natural enemies eat other animals such as caterpillars and leafhoppers, whereas the adults may live on honey or pollen produced by wild plants in the environment. The adults should eat adequate food to be able to produce eggs and, thus, the next generation. Therefore, a variety of plants is needed to maintain the populations of these natural enemies. The more diverse the vegetation in an agroecosystem, the more diverse also the natural enemy populations, hence the more likely that pest populations will be controlled naturally.
- Soil texture does not support the life of earthworms and soil insects. Unfavorable conditions for the soil inhabitants are often caused by low organic matter content or prolonged inundation of a field. The soil becomes hard and/or short of oxygen. The disappearance of the soil organisms will cause further deterioration of the soil.

3.3 Observing the crop and its environment

3.3.1 Why should we do routine observation?

Field observation is the key to make appropriate crop cultivation decisions. By observing the field and its surrounding environment thoroughly and regularly, farmers will know exactly what the conditions in the field are like. Hence, they do not have to be afraid of any unexpected problems, such as a pest outbreak or drought. They can always handle an upcoming problem in time.

For a crop like sweetpotato, weekly observations are considered frequent enough to anticipate problems, unless the weather or water supply conditions are unfavorable, or when a pest population develops more rapidly than the natural enemy populations. After each observation we should determine when we have to do the next observation, based on the conditions found in the field. Field observation can be done best during the morning hours before 10:00 a.m., because later in the day the sun becomes too hot, causing most insects to hide in cool, dark places.

3.3.2 Observation of the environment

Observation of the surrounding environment of the field helps us to identify and understand sources of problems that appear in the field. If there is no obvious problem, observation of the environment can be done superficially by looking at:

- The weather condition.
- The condition of the soil.
- The condition along the edge of the field (bunds, ditches, roads) with regard to potentially harmful plants and animals (weeds, pests) or beneficial ones (natural enemies, plants providing food and shelter for natural enemies).
- The condition of the neighboring fields with regard to crop damage as an indicator of the existence of a source of pests and/or diseases.

3.3.3 Crop observation

In order to draw conclusions about the condition of the crop and actions to be taken, we do not have to observe the entire field. A representative sample would be sufficient. Based on the sample we can make a decision about what has to be done. The sample contains at least ten observation points on an area of 1,000 m^2. These ten observation points in a field are selected randomly on a diagonal line, i.e. from corner to corner crossing through the center of the field. Crossing through a field is important so that both edges and center areas are represented in the sample, since conditions (e.g. water, pest occurrence) may vary from place to place in a field. Some pests only eat at the edges (e.g. mole crickets), while others prefer the center of the field (e.g. rats).

To determine the location of each observation point in a random manner, we could walk a certain number of steps from one point to another and observe the spot in front of our feet at the last step. For instance, if the length of the diagonal line cutting through the field is about 75 m (100 steps), the distance between observation points should be 7.5 m or 10 steps. We should avoid to purposely select observation points with either good or bad looking plants. For sweetpotato, one observation point should cover an area of 0.5 m^2 across the width of the ridge, or 0.5 by 0.5 m in the case of raised beds. Observation should be done in the following sequence:

- Observe anything flying above the foliage (e.g., dragonflies, butterflies), and on the foliage (e.g., ladybird beetles, rove beetles, web spiders, grasshoppers).
- Lift the vines carefully to see what can be found in the foliage and on the soil surface (e.g., hunting spiders, ants, rove beetles, frogs).
- Check all leaves and vines one by one for insects (e.g., leafeating caterpillars, aphids, thrips), diseases and nutrient deficiency symptoms.
- Remove some soil so that the roots are partly exposed, and observe the growth stage of the storage roots. Check for damage by weevil or other insects on the roots.
- Observe the condition of the soil (structure and moisture).

4 Natural enemies

4.1 Introduction

One of nature's laws is that large animals have long generation times and few offspring, while small ones have short lifecycles and many offspring. Insects produce a huge number of offspring. Sweetpotato stemborer for instance, on average produces 150-300 eggs per female. Suppose that a pair of stemborers has 100 offspring, all of which would survive to become adults. If in a month each female produces 100 surviving and productive offspring again, the growth of the insect population month by month would be as follows:

Generation	Number of pairs	Number of insects
0	1	2
1	50	100
2	2,500	5,000
3	125,000	250,000
4	6,250,000	12,500,000
5	312,500,000	625,000,000
6	15,625,000,000	31,250,000,000

Half a year later the number of insects descended from a single pair is more than 31 billion! Suppose that each insect weighs 0.5 g, then the total weight of the insects descended from the first pair and alive after six months will be 15,625 t. Compare this weight to a good crop of sweetpotato yielding 30 t/ha. It would take more than 500 ha to produce the quantity of sweetpotato equivalent to the weight of the descendents of a single pair of insects six months later.

Many insects, like aphids and planthoppers, can produce far more than 100 offspring per female and their generation times can be far shorter than one month. The question is, then, why are we not drowning in insects? The answer is because there are many mortality factors that reduce the growth of insects and all living things. In addition to unfavorable environmental conditions, population growth of all living organisms is regulated by natural enemies.

4.2 What is a natural enemy?

A natural enemy is a living organism that kills, injures or causes disease in other living organisms. There are three kinds of natural enemies:

- Predators.
- Parasites.
- Pathogens.

4.2.1 Predators

Predators are animals that hunt and eat other animals. Examples include: tigers, snakes, spiders, and ladybird beetles. Predators have to consume many prey individuals in order to fulfil their daily dietary requirements. The bodies of predators are designed to hunt, catch, kill and eat prey. Predators generally have strong teeth or mouth parts, sharp vision and strong legs.

4.2.2 Parasites

Parasites also consume other organisms but by entering the body of their victims and obtaining nourishment from their fluids and tissues, which weakens or even kills them. We call the victim a "host." The parasites that attack insects are usually species of wasps or flies. The winged adult is able to search for a host and then lays eggs in or on the host's body. Insect parasites can be classified as follows:

- Egg parasites lay their eggs in the eggs of other insects.
- Larval parasites lay their eggs in or on the larval stage of other insects.
- Pupal parasites develop in the pupal stage of other insects.
- Some parasites develop in the nymphal or adult stage of their hosts.

egg parasite

pupal parasite

parasite of aphid nymph

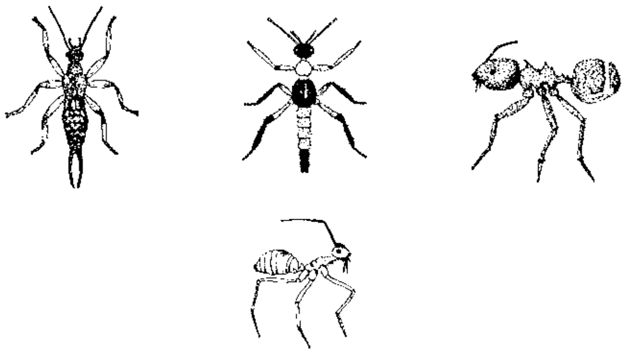
The developing larva of the parasitic insect lives in or on the egg or body of the host, slowly weakening the host insect which, thus, cannot complete its development. The parasite larva, however, is able to enter the pupal stage before killing the host completely. Some pupae are formed within the body of the host, while other parasites pupate on or near the body of the host. The adult parasite emerging from the pupa usually lives on nectar or pollen. Weed flowers are a main source of food for adult parasites.

4.2.3 Pathogens

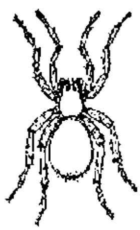
Pathogens are microorganisms that cause disease. They enter the body of their host, living and multiplying within, and hence weakening and finally killing the host. Some pathogens require more than one kind of host in order to complete their life cycle. Bacteria, fungi and viruses are kinds of pathogens. Insects attacked by pathogens are usually swollen, exhibit color changes, move slowly, often stop eating and may be covered with a powdery substance. There is a bacterium called Bt that is produced and used as a biological pesticide (Dipel WP is an example of brand of Bt). Bt kills several kinds of pests but does not affect most natural enemies.

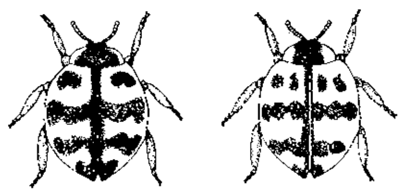
4.3 Common natural enemies in sweetpotato fields

The pictures below show some predators commonly found in sweetpotato fields:



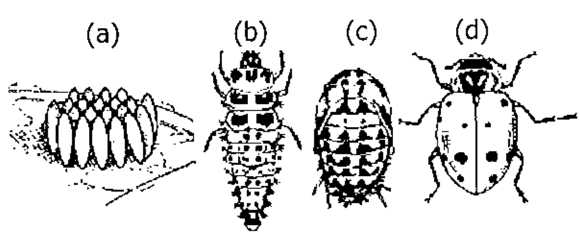
Earwig — *Rove beetle* — *Big-headed ant* (Pheidole) — *Long-legged ant* (Anoplolepis)





Ground beetle — *Spider* — *Two common types of ladybird beetles*

The life cycle of the ladybird beetle: (a) egg, (b) larva, (c) pupa, (d) adult:



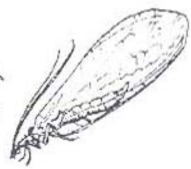
Both the larva and adult of the ladybird beetle are predacious. The ladybird beetle is an important predator of aphids. Generally the wings of the adult beetle are red, but some species have yellow wings. Black markings are usually present on the wing. The eggs are easily distinguished by their upright, oblong, grouped arrangement. They are usually yellow or orange.

Other important predators of aphids are the lacewing and the flower fly (syrphid). The lacewing has only three stages in its life cycle: egg, nymph and adult. Adult lacewings are light green. The wings have a netlike appearance. The egg is on the edge of a long stalk. The nymph is the predacious stage.

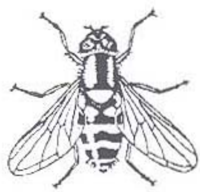
The flower fly is often found hovering around flowers. Both the larva and the adult are predacious. The larva moves slowly, but eats a great deal. During its development, a single larva can consume 420 aphids. Lacewing and flower fly are drawn below. Some more examples of predators are shown in the color pictures below.

lacewing egg

nymph



adult



flower fly

(BK)

(BK)

Predatory ants attacking weevils

(HB)

(ARB)

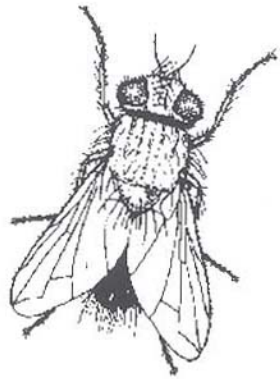
(ARB)

A predatory ant of sweetpotato weevil eggs

The larva of the ladybird beetle is an aggressive predator

AR

Common parasites of sweetpotato pests include several kinds of wasps and flies that attack foliage and stemborer eggs and larvae. The parasitic wasps are normally very small and difficult to identify. The picture on the left shows the pupae of a parasitic wasp on the surface of a larval host. The picture on the right shows a parasitic fly.



Common pathogens of sweetpotato pests include the fungus *Beauveria bassiana*, which is commercially available in some countries, and various viruses, such as the one shown in the picture below.

A sweetpotato weevil killed by Beauveria bassiana, a fungus

(ARB)

(ARB)

A hornworm killed by a virus. The way the worm is hanging indicates that the death was caused by a virus infection.

<u>*Photographs:*</u>

Ann R. Braun (ARB), Bayu Kusuma (BK), Henk van den Berg (HB)

4.4 Natural enemies and pesticides

4.4.1 What are pesticides?

In many local languages words that mean "remedy" or "medicine" to refer to pesticides are often used. Nevertheless, pesticides are not remedies or medicines, but rather poisons that kill. This becomes clear when we look at the formal names and the actual meaning of different kinds of pesticides:

- Insecticide = kills insects.
- Rodenticide = kills rats.
- Fungicide = kills fungi.
- Bactericide = kills bacteria.
- Herbicide = kills weeds.
- Nematicide = kills nematodes (microscopic worms that cause cracking of sweetpotato roots).

Some pesticides interfere with breathing or digestion. Others kill indirectly by interfering with development or reproduction. Whatever the mechanism, the result is the same: the pest is killed. But not only the pest! Other insects, including natural enemies, and even animals and humans can become sick or be killed from exposure to pesticides.

We should avoid referring to pesticides as medicines or remedies and call them what they are: poisons. When we do this we are reminding ourselves and others that pesticides are dangerous and should be avoided whenever possible. If it is absolutely necessary to use pesticides, they should be used very carefully, because they present dangers to environmental and human health.

Insecticides are divided into two main groups based on the way they act. One type is absorbed directly by the insect when it comes in contact with the pesticide; this is called a contact insecticide. The other type must be taken into the body of the insect through food and will poison the insect when it passes through its gut. This is called as a systemic insecticide. Systemic insecticides are usually applied in granular form to the soil and are absorbed by the plants. They are taken in by insects as they feed on leaves. Generally, contact insecticides are sprayed onto plants. Insects come in contact with them as they move around on the plant. Both types of insecticides are toxic to natural enemies.

4.4.2 Pesticides, natural enemies and pests

Generally natural enemies are more susceptible to pesticides than their prey or hosts. Many pests and diseases have become resistant to chemical pesticides. In the case of insect pests, this occurs because insecticides never kill all the insects in the crop. Those that survive pass on their resistance to their offspring. Insecticide use acts to select the most resistant insects, since only these survive each time an application is made. Natural enemies can be killed directly by pesticides. Alternatively they may die because they have eaten prey or have developed in hosts that have absorbed or consumed pesticides. Natural enemies usually have longer life cycles and produce fewer offspring than plant-eating insects, which makes them more vulnerable to the effects of pesticides. Because they are fewer in number they take longer to recover from exposure to pesticides. In the absence of natural enemies, the expansion in the number of pests proceeds very rapidly, what is known as a population outbreak.

Most farmers have observed that the problem with pests such as aphids, and others of small size, have begun to occur since they began to use insecticides. There are two reasons for this:

A. Insecticides never kill all of the pest individuals in the field. The insects that survive are more resistant to the pesticide than those that died. The surviving insects are the ones that reproduce and they pass on their resistant characteristics to the next generation. If the insecticide is applied frequently and at high concentrations, the selection of resistant insects will occur rapidly. Insects like aphids that have short life cycles can develop resistance to insecticides very quickly.

B. Pesticides kill natural enemies. Natural enemies are more susceptible to pesticides than pests are. The life cycle of most natural enemies is longer than that of pests. This means that it will take a long time for natural enemies to recover their numbers after a pesticide application. Without natural enemies to limit their numbers, pest insects can multiply very fast.

4.4.3 Pesticides and human health

The effect of pesticides on human health can be acute or chronic. When acute poisoning has occurred there are symptoms such as dizziness, nausea, vomiting, blurry vision and trembling. When there is repeated use of pesticides over a long period of time, chronic illnesses can occur. The symptoms include blood pressure changes, heart disease, skin problems, nerve problems and cancer. Pesticides can kill human beings. The World Health Organization of the United Nations has reported that about a million people are poisoned by pesticides every year, 20,000 of which die.

5 Sweetpotato pests

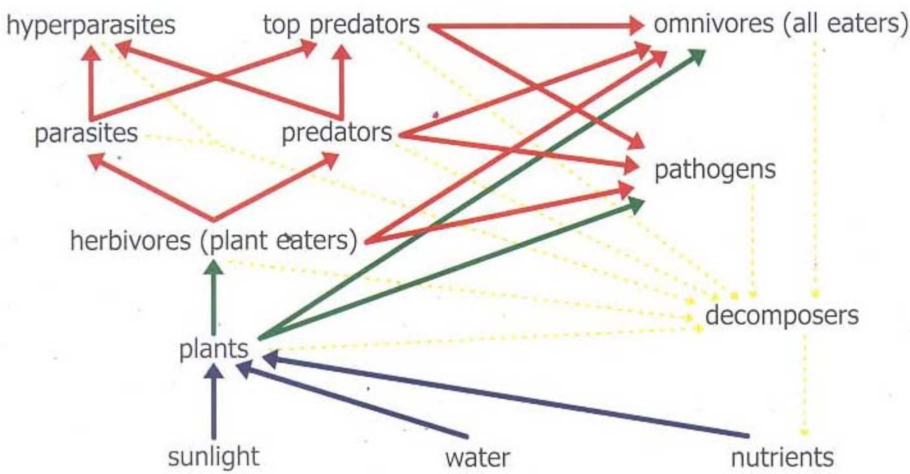
5.1 Introduction

Pests are living creatures that we normally consider harmful because they attack our crops, livestock or other human property. In agricultural fields we can find many types of creatures that live on the plants. But are all of these really pests?

One way of looking at this question is to think about the myriad of life forms in a natural forest. How do the forest creatures live? Trees and other plants absorb water and nutrients from the soil and obtain energy from the sun, and transform these into leaves, stems, roots, flowers, and fruits. Of all the forms of life on earth only plants can produce organic matter from solar energy, water and nutrients. Because of this ability, plants are called *producers.* All other kinds of living things require organic matter as food and are called *consumers.*

Some consumers eat plant parts, such as leaves, fruits or seeds (many types of insects, for example); they are called herbivores. Some eat other animals, and depending on the way they eat (see Section 4.2) they are called predators or parasites. Birds that eat larvae, tigers that eat monkeys, and wasps that parasitize caterpillars are examples. Other animals have a mixed diet of both plants and animals and are called omnivores. Microorganisms that cause disease in plants and among animals are called pathogens. Finally, some life forms eat or decompose dead plants and animals. These scavengers and decomposers include birds such as vultures, insects that live on rotting plant and animals, and many types of fungi and bacteria.

Each species plays an important role to maintain the balance of the web of life. By studying natural systems like forests, which provide an enormous diversity of plants and animals, we can learn a great deal about the behavior and relationships between different kinds of plants and animals. Even though many of them are consumers and exist by eating or parasitizing others, they do not eliminate their hosts. A perfect balance exists between the different life forms in an undisturbed forest. The figure below shows the relationship among producers, consumers, and decomposers in a natural food chain:



In an agricultural field the food chain is much simpler than in a natural forest, since there are only a few kinds of plants (the types planted by the farmer and weeds that invade the field). This narrow diversity of plant life can only support a limited range of animals. Nevertheless, the plants and animals are still linked in a food chain, just as they are in the much more complex forest.

Organisms that damage, or compete with, the crop cultivated by the farmer are normally called pests. These pests can be animals chewing or sucking plant parts, weeds, pathogens or parasites. Each pest has natural enemies, including predators, parasites and pathogens, that keep its numbers in balance. If the pest is a weed, it will have herbivores that reduce its growth, whereas a leafeating insect, for instance, will have a range of predators and parasites attacking it. The presence of natural enemies ensures that pests rarely destroy all of the crop that serves as their food source.

To maintain their life cycles, natural enemies must have some food source. This means that we have to accept the existence of at least a small number of pests in agricultural fields, otherwise natural enemies, especially those that eat only one type of food, cannot survive. If they starve, their disappearance will lead to an explosion in pest numbers.

In a sweetpotato field, insects that eat the leaves will rarely consume so much that they cause a reduction in the yield of roots. We should not call them pests unless we can show that they inflict an economic loss. In determining whether an insect or other animal eating plant parts is a pest there are many factors to consider. These include:

- How many pest individuals appear relative to the numbers of their natural enemies?
- At what stage of crop development they damage the plant, and to what extent the plant can overcome the damage?
- What part of the plant they attack relative to the economic value of that part (e.g., insects that consume sweetpotato roots are much more likely to be pests than those that feed on the leaves)?
- How they may be controlled, how difficult this is and what it costs relative to the loss they are likely to cause?

We can classify sweetpotato pests into three major groups as follows: (1) chewing and sucking pests, (2) diseases, and (3) weeds. Each of these groups will be discussed in sections 5.2-5.4[1].

5.2 Chewing and sucking pests

The sweetpotato plant provides food for many kinds of herbivorous organisms, including human beings. Most of the animals that eat sweetpotato in the field are insects. Apart from insects, rats are also

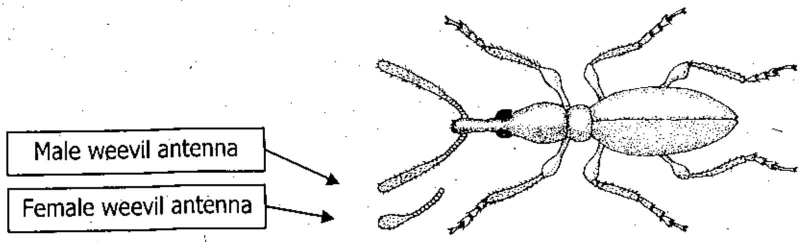
[1] *Photographs: Jesus Alcazar (JA), Merle Shepard (MS), CIP Photo Library (CIP), American Phytopathological Society (APS), Segundo Fuentes (SF); all others by Ann R. Braun (ARB).*

important as a potential pest of sweetpotato in specific areas. The sections below describe the life cycles, biology and control strategies of the main pests of sweetpotato commonly occurring in the wet tropics.

5.2.1 Sweetpotato weevil

A. Biology

The sweetpotato weevil (scientific name is *Cylas formicarius*) is a kind of beetle. The adult stage of the sweetpotato weevil is a reddish-black beetle that looks like a large ant. The male and female beetle can be told apart by the shape of their antennae. The antennae of males are straight, while those of the female are round or club-shaped. When an adult weevil is disturbed, it plays dead.



The female weevil produces a pheromone that attracts the male for mating. Male weevils are active at night; they move around on the foliage to search for females. During the day the weevils hide under leaves or in soil cracks. The females mate at night, but feed and lay eggs during the day. Their egg-laying behavior depends on the growth stage of the sweetpotato crop. The root is preferred for feeding and egg-laying. At the beginning of growing season, when the plants have not produced any storage roots yet, the adult weevils live on the stem and leaves. The adult will feed on foliage, lay its eggs on the vines and leaves, and the larvae will feed on the stem or the leaf and pupate inside the vines.

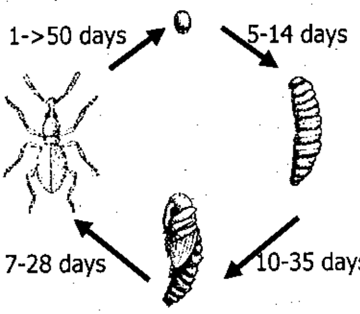
(JA)

(JA)

As the plant gets older and starts to form roots, the weevils search for exposed roots. Most weevils (80-90%) can be found in the foliage from 10 cm above the soil surface to 15 cm below the soil. They cannot dig, so their penetration into the soil layer is limited, not allowing them to reach roots that are well buried. The only way to get to the roots is through cracks in dry soil. When an adult finds a root, it punctures the surface as it feeds. It lays eggs just below the surface of the root and covers them with a plug of excrement. The larva, after hatching from the egg, will bore into the tissue of the root.

B. Life cycle

The weevil has a life cycle of four stages: egg, larva, pupa and adult. After mating, the female lays its egg on the tuber or on the leaf. After 5-14 days (depending on the environmental conditions), the egg will hatch. Larvae live for 10-35 days before pupating. The pupal stage will last for 7-28 days. The development of the weevil from egg to adult takes 33 days on average. When the adult beetle emerges from the pupa, initially it is light brown in color. It takes 6-8 days for the outer surface of the weevil to harden and become dark brown. Once this has occurred, the adult leaves the root zone in search of mates. High numbers of weevils in the foliage usually indicates that there is a high number in the root zone.



The duration of each stage in the life cycle of the weevil depends mainly on temperature: the higher the temperature, the faster the development. Hot, dry weather favors weevil development, because the sweetpotato roots are more easily reached through cracks in dry soil, and the life cycle is faster. The adult weevil can survive for 94 days. Most eggs are laid in the first 50 days of the adult stage and a female can produce 50-250 eggs.

C. Damage

Weevils rarely fly and only for short distances ranging from 500 m (if there are sweetpotato plants) to 1,000 m (if there are no sweetpotato plants). The sources of weevil infestation are infested roots and residues from the previous crop, planting material infested with eggs or larvae, and alternate host plants. The sweetpotato weevil has several host plants of the same plant family as the sweetpotato, for instance the water spinach, *Ipomoea aquatica,* known in Asia as Kankong. The flowers of these plants resemble the flower of the sweetpotato. These plants can harbor weevils between planting seasons and serve as a source of weevil infestation when a new crop of sweetpotato is planted.

When the adult female finds a sweetpotato root, it will make feeding and egg-laying punctures. The punctures containing eggs can be distinguished by their dark color because the eggs are covered with weevil frass (insect excrement). Both the feeding and egg laying punctures lower the quality of the root, and can lower the market price. If roots with egg punctures are stored, they will serve as a source of infestation for the clean roots stored beside them.

After hatching from eggs on leaves and stems, larvae feed and develop in the stems of sweetpotato vines, causing thickening and malformation. Larvae emerging from eggs laid on the root surface tunnel into the roots and feed within them until they are ready to pupate. The tunnels are full of weevil frass. Sweetpotato roots react to the damage by producing a poisonous substance that has a distinctive smell. This poison can cause damage to the lungs and heart of human beings and livestock. For this reason, damaged roots should not be used as food or feed.

Black rot infection is common in weevil-damaged roots, because the roots are more susceptible to the black rot fungus after feeding or egg-laying punctures have been formed by the weevils.

D. Natural enemies

The natural enemies of the sweetpotato weevil include several kinds of predators, parasites and pathogens. The predators are the most easily observed of these. They include ants, earwigs, ground beetles and spiders. Ant nests from banana plantations can be moved to the sweetpotato field to enhance predation.

A fungus (*Beauveria bassiana*) that commonly lives in the soil can infect and kill the weevil fairly effectively. This fungus is easily cultivated on coffee residue, wheat and rice straw, and is commercially available in some countries. The fungal culture can be used for treating the planting material and the soil to reduce the weevil population.

E. Management

Chemical control is not effective because the weevils are protected for, at least part of their lifecycle by their development within roots or stems, where they are not easily reached by pesticides. Pesticides kill natural enemies that under natural circumstances quite effectively control weevil populations, and present health risks for humans and animals.

Breeders have spent many years trying to develop varieties that are resistant to the weevil. So far they have not been successful. However, varieties that form roots relatively deep in the soil are less attacked because the weevils cannot easily reach the roots to lay eggs.

Sweetpotato weevil sex pheromone is produced commercially in several countries. It is produced in a laboratory and applied to small rubber capsules that are placed in traps in the field. The rubber capsules should be placed above the foliage and covered to protect them from rain and sunlight. A container of soapy water is usually placed under the capsule. Male adults that are attracted by the sex pheromone fall into the pail of water and can easily be collected and removed from the field. These traps are useful for indicating how large the weevil population is. In some countries research has shown that mass trapping using sex pheromone traps are an effective means to control the weevil. In Cuba the sex pheromone is often used together with an application of the fungus *Beauveria bassiana*. The fungus is applied on the soil surface beneath the sex pheromone trap or sprayed on the foliage around the trap. Weevils attracted to the sex pheromone will be infected by the fungus and killed after several days. Sex pheromones, however, are not yet widely available at the farm level.

The most effective way to control the weevil is through cultivation practices aimed at preventing infestation, including:

- Sanitation of the field (removing infested plant residues).
- Flooding to drown weevils in the soil.
- Hilling up to prevent or fill soil cracks.
- Routine irrigation to prevent soil cracks.
- Mulching to keep the soil moist and prevent cracks, and provide a more favorable place for natural enemies.

The results of some experiments with cultural practices for weevil control are shown in the table below.

Method	*Where tested*	*Result*
Hilling up	Taiwan, Philippines, Vietnam, America, East Africa, India, Cuba, Indonesia	Works well. Should be implemented before the adult weevil reaches the roots to lay eggs.
Early harvesting	Vietnam, Cuba, East Africa, Philippines, America	In Vietnam, harvesting two weeks earlier reduced the loss due to weevil from over 30% to less than 5%. Also good results in other locations.
Inter-cropping	Philippines, India	At AVRDC (vegetable research center in Taiwan), 103 different crops were tested as intercrops for weevil control. The best results were obtained with coriander.
Routine irrigation	Philippines, Taiwan, America, Vietnam, Indonesia	Effective because soil cracking is prevented. Most practical method for farmers with reliable water supply.
Field sanitation	Taiwan, Philippines	Field sanitation can help to reduce weevil infestation if it is practiced in a larger ecosystem area or community. Infested tubers must be buried under more than 15 cm of soil.
Flooding of the field	Indonesia	Flooding of the field for at least 48 hours can kill the larvae of weevils present in roots that have been left in the field.
Mulching	Taiwan India, East Africa, America	Mulches of plastic or rice straw have shown a reduction of weevil damage. The soil surface should be covered soon after planting and the cover should be maintained until harvest. The mulch not only helps to retain soil moisture, but also prevents the weevils from gaining access to roots through soil cracks.

5.2.2 Sweetpotato stemborer

A. Biology

The adult stage of the sweetpotato stemborer (*Omphisia anastomasalis*) is a moth (white with brownish yellow spots) that is active at night. The female produces a sex pheromone that attracts males. Once mating has occurred, the female lays eggs individually or in small groups on the leaf. The undersides of the leaves near the veins are the preferred location for egg-laying. Sometimes eggs are laid on the vines and leaf stems. The egg of

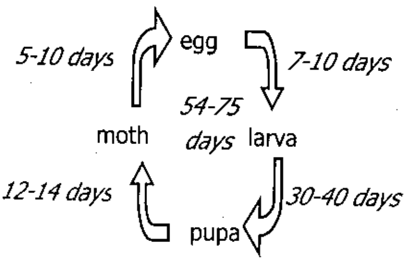
stemborer is greenish and flattened. A female produces 150-300 eggs during her lifetime.

After hatching, the tiny larva bores into the closest leaf stem (petiole). Eventually the leaf turns yellow and dies as the larva grows too large to live in the leaf stem. The larva then migrates to a vine, consuming its tissue and often migrating towards the base of the plant as it grows larger. The final length of the larva is about 3 cm. Some larvae tunnel into the base of the plant or even into the roots. A pile of excrement under the base of the plant is a typical sign of infestation by the stemborer. The pupae are formed within tunnels made in the stem and they are covered with brown webbing. When the stemborer larva is ready to pupate, it prepares a hole that will be used by the adult moth to escape from within the plant. The larva leaves a very thin layer of stem tissue covering the hole.

Since the adults are short-lived and nocturnal, and the larvae develop within the plant tissue, the stemborer is a difficult species to observe. However, we can deduce its presence from some signs. First, leaves that become yellowing and die may indicate the presence of newly hatched larvae.

Thickening and swelling of the base of the sweetpotato plant and piles of light brown frass on the ground under the plant are typical signs of sweetpotato borer infestation. Finally, an exit hole covered by papery thin tissue indicates the presence of a pupa in the vines.

B. Life cycle



Under normal conditions, stemborer eggs hatch after 7-10 days. The larvae feed and grow within the leaf stems and vines until they are ready to form pupae. The larval stage lasts 30-40 days and several molts occur during this period. The pupal stage, which lasts 12-14 days, is passed in a cocoon of brown webbing. After emerging from the cocoon, the adult moth lives only 5-10 days. Most eggs are laid in the first three days of adult life.

C. Damage

Sweetpotato stemborers can infest sweetpotato plants during the entire crop cycle. Planting material infested with stemborer eggs can lead to infestation of the newly planted crop. The adult moth of stemborer can move from the neighboring fields, initiating new infestations. The damage to the stem tissue interferes with the transportation of water, nutrients and organic matter within the plant. Seriously affected plants may wilt and die.

The earlier the crop is attacked, the greater the potential impact of the stemborer. If a newly planted field is heavily attacked by stemborer, yield loss can exceed 50%, since root formation is inhibited. However, the sweetpotato yield does not seem to be much affected when infestation occurs after the crop is about one month old, provided that the conditions for development are favorable.

D. Natural enemies

Earwigs, ladybird beetles, ground beetles, rove beetles, ants and spiders have been observed as predators of stemborer eggs, larvae, pupae and moths. Ants and earwigs enter the stem through the exit hole made by a larva before pupation, and attack the larvae and pupae they find inside. In addition, there are 15 known species of larval parasites and one egg parasite that have been reported to attack the sweetpotato stemborer.

E. Management

Prevention of attack is the best way to control the stemborer, and can be accomplished by:

- The use of healthy planting material that is free of stemborer eggs and larvae. Clean planting material can be obtained by careful selection of cuttings, or by planting roots.
- Destruction of infested crop residues after harvesting.
- Rotation of sweetpotato with other crops to interfere with the life cycle of the stemborer. This must be practiced in agreement by the whole community.
- Use of light traps to catch the adult moths when they are active at night.

Once the stemborer attacks the plant, it is a difficult pest to manage. Most pesticides do not kill the stemborer, because it is protected within the vines during most of its life cycle On the contrary, pesticides will kill natural enemies of stemborer, such as parasites and predators, whereas avoiding pesticide use favors the action of these natural enemies.

Hilling up the plants, which is a common farmer practice in many sweetpotato-growing areas, helps to control the stemborer. If the soil covers the exit holes made by the larvae before pupation, the adults cannot emerge to mate and lay eggs.

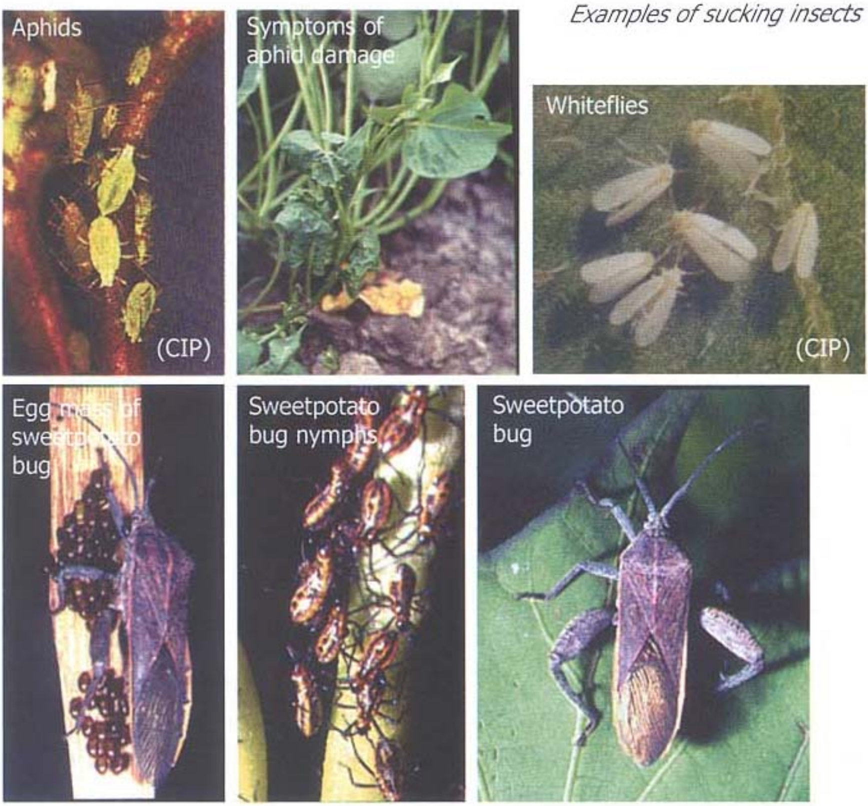
5.2.3 Sucking insects

Some insects suck plant juices with their tube-shaped mouth parts. These include aphids, whiteflies, planthoppers, thrips, mites and bugs. Most of these insects are very small and difficult to identify. When they pierce the plant tissues with their mouth parts they can spread virus diseases to the sweetpotato plants. The virus diseases normally cause more serious effects than the feeding of the insects that transmit the virus. The various groups of sucking insects will be discussed separately in the sections below, as well as some ways how to manage them. But let us first analyze why these insects are becoming an increasing problem in certain areas.

Increased occurrence of small-sized, sucking insects as pests has been observed in intensive sweetpotato growing areas. What causes the explosion of these rapidly multiplying insects? The species discussed here are characterized by very short life cycles and very high numbers of offspring. In some cases reproduction can occur without mating, leading to even faster growth in these female-only populations. Under undisturbed conditions, these species are kept from fulfilling their biological potential for population increase by a great diversity of predators, pathogens and parasites, but when pesticides are used, this natural control is seriously disrupted. Natural enemies are usually more susceptible to pesticides than their hosts or prey. Their population growth rates are lower and they are less numerous.

Farmers often say that their problems with insects like aphids and thrips have begun to occur since the advent of pesticide use on the sweetpotato crop, but they may not know why this happens. Farmers may not be familiar with the idea of insect resistance to pesticides. When we spray pesticides, we never kill all the insects. Those that survive to breed transmit their resistance to their offspring. The more we spray the more quickly we select insects that are difficult to kill with pesticides. The shorter the pest life cycle, the more quickly resistance to pesticides can develop. If a pesticide is used frequently and for long enough, it will eventually fail as a means to control pests.

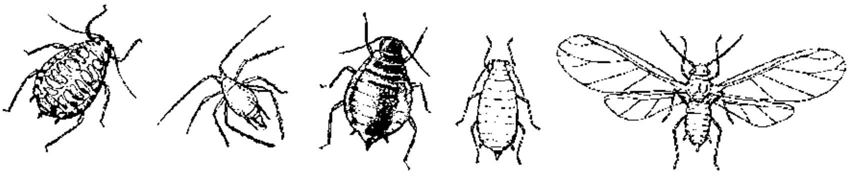
We can conclude that people can create new pests through pesticide use. In the absence of their natural enemies, pesticide-resistant insects with a high capacity to multiply cannot be controlled unless we recreate environmental conditions that favor the action of natural enemies and minimize the development of pests.



Examples of sucking insects

A. Aphids

Aphids differ in shape and color, measuring about 2-4 mm. Many species, including *Aphis gossypi*, feed on sweetpotato. Aphids exude a sticky honeydew from two small tubes that protrude from their bodies. This honeydew makes the leaves sticky and ants are often attracted to it. Some species of ants protect the aphids and harvest their honeydew; other ants are predators of aphids. Aphids can pick up viruses when they feed on infected plants. Viruses are carried from one plant to another on aphid mouth parts.



Several types and stages of aphids

Aphids can develop from egg to adult in only a week. Newly hatched aphids are called nymphs. Both nymph and adults suck plant juices from leaves and stems. Nymphs are wingless and do not move far. After molting several times, the nymph becomes an adult. Environmental conditions determine whether adult aphids will develop wings. The winged forms appear when the aphid population is overcrowded; at this point the wings facilitate their dispersal to other plants. An adult female can produce 50 eggs per week. Imagine the increase of aphid numbers in a month, if females survive to reproduce!

Aphids have many natural enemies including ladybird beetles (adults and larvae), lacewings and parasitic wasps and flies, which under undisturbed conditions are very effective in suppressing aphid population development. Aphids, with their short life cycles, often only cause serious problems after pesticide application killed most of these natural enemies, leaving them to multiply rapidly.

B. Whiteflies

The scientific name of a whitefly species common in sweetpotato is *Bemisia tabaci*. Female whiteflies lay their eggs on the underside of leaves. The greenish-white nymphs are thin, oval and thorny in appearance. The adult is very small and a white layer of wax covers its body. The life cycle of whitefly is completed in 3-4 weeks.

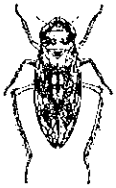
A high population of whitefly in a sweetpotato field can cause the yellowing and death of leaves. Nevertheless, the most dangerous aspect of whitefly infestations is the spread of virus diseases. Only a few whiteflies can infect a whole field very quickly.

C. Planthoppers

Planthoppers often appear in large numbers at night. The winged adults disperse to colonize new crops where they start laying eggs immediately. The nymphs hatching from the eggs molt several times and become successively larger before becoming an adult. Planthopper nymphs and adults suck plant juices from the leaves and stems of sweetpotato. Like aphids, they produce honeydew, making the leaves sticky. A black fungus often develops on the honeydew. Some planthoppers can spread viruses.

Nymph and adult close to the leaf vein

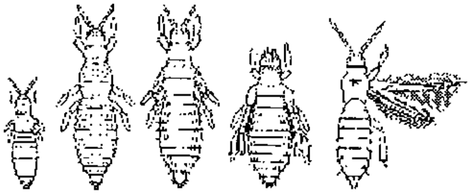
Symptom of planthopper attack



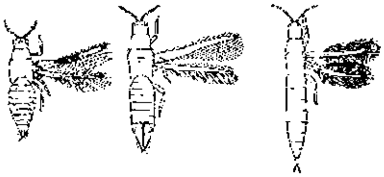
A kind of planthopper that transmits virus

D. Thrips

Thrips are tiny, thin, flat insects of only 1-2 mm in length. Adults are usually black, and may have red or white lines or spots. Generally the nymphs are white, yellow, or greenish. Although the adults have wings that have a feathery appearance, they cannot fly well. Wind helps thrips to disperse over long distances. Generally dry weather favors the growth of the thrips population. However, for optimal proliferation, thrips need high relative humidity. In the rainy season, the population of thrips decreases sharply since many individuals are washed off the plants by raindrops.



Development stages of thrips: nymph, pupa and adult



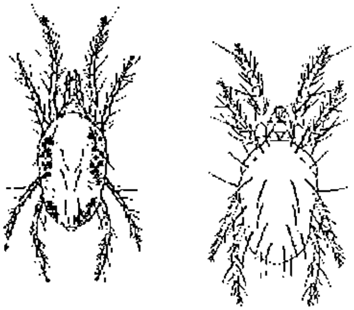
Several kinds of adult thrips

Thrips lay their eggs within the plant tissues. The most active stages are the first and second nymphs. Thrips develop through two or three nymphal stages before pupating in the soil or on the plant.

Thrips damage is characterized by the formation of small silvery spots on the leaves. When the population is high, the small spots unite and the leaves may die.

E. Mites

Mites are eight-legged relatives of the spiders, and therefore strictly speaking not insects. They are less than 1 mm in length and almost invisible to the naked eye. The growth of mites is favored by hot, dry weather. A hard rain can reduce their population sharply since they are easily washed away. Mites are wingless. Some disperse



Adult mites

by spinning a silken thread that is blown by the wind and enables the mite to travel on air currents.

F. Bugs

Large numbers of sweetpotato bugs (*Physomerus grossipes*) are often found feeding together on sweetpotato vines. The adults lay groups of eggs on the undersides of leaves or on the stems. The mother bug guards her eggs and the young bugs. Development from egg to adult takes about 85 days.
Bugs have only three stages in their life cycle: egg, nymph and adult. The nymphs are similar in appearance to the adults, except that they have no wings. The adults and nymphs both feed on sweetpotato foliage with their sucking mouth parts, causing wilting and stunting.

G. Natural enemies of sucking insects

There are many kinds of natural enemies that attack small sucking insects and mites. Some are parasitic, and others, such as the ladybird beetle, the lacewing and the larvae of flower flies (syrphids) are predators. Predators may feed on the eggs, nymphs and adult stages. Parasites lay their eggs on or in the bodies of their hosts. The larva of the parasite burrows into the body of its host and develops within. The host insect usually dies by the time the adult parasite emerges. Pictures and drawings of common natural enemies of sucking insects are shown in Section 4.3. Natural enemies provide the most effective mechanism to suppress populations of small sucking insects.

H. Management

The following methods provide some guidelines for controlling small sucking insects and mites:

- Avoid using pesticides! If you have to use them, choose carefully. Use a pesticide that is specific for the pest problem in order to minimize its impact on natural enemies. Do not apply pesticides for control of

whiteflies since they are usually resistant to pesticides. Controlling whiteflies as a way to reduce the incidence of virus disease is useless since only a few whiteflies can infect a whole field, whilst we can never kill 100% of the whiteflies present in a field.
- Maintaining plant health can reduce the effect of sucking insects and mites because the plants can compensate for insect attack. Avoid using excessive nitrogen fertilizers. Overfertilization with nitrogen makes plants highly nutritious and more attractive to most sucking insects.
- Use healthy planting material that is free of insects, and of disease symptoms.

If regular field observation is practiced, a farmer will not be taken by surprise by insect attack, although some insect populations can develop rather quickly. Monitoring the field can help us locate infestations that are just beginning. In the early stages, an infestation can be managed by:

- Collecting and destroying the plants or leaves where the invading insects are beginning to multiply.
- Collecting and transferring natural enemies such as ladybird beetles and spiders to the part of the field where the pests insects are concentrated.

5.2.4 Leaffolders

There are several kinds of leaffolders that feed on sweetpotato. In Asia, two of the main species are *Brachmia convolvuli* and *Herpetogramma hopponalis*. The adult is a butterfly that lays its eggs on the leaves of sweetpotato plants. After hatching, the larva encloses itself in a folded leaf by spinning a silk thread to hold the leaf closed. Safe from exposure to pesticides, it feeds by scraping the tissue on the leaf surface, leaving only the skeleton of the leaf. The larva makes a cocoon in the folded leaf. The larval stage is the only one that damages the sweetpotato plant.

Natural enemies include spiders, earwigs, ants, dragonflies, ground beetles and parasitic wasps. Often when we open a folded leave, we will find a natural enemy inside, rather than a leaffolder caterpillar.

5.2.5 Hornworms

There are several hornworms that attack sweetpotato. The most common one is called *Agrius convolvuli*. The adult stage of the hornworm is a large butterfly that can migrate long distances. The pictures below show the life cycle stages of the hornworm.

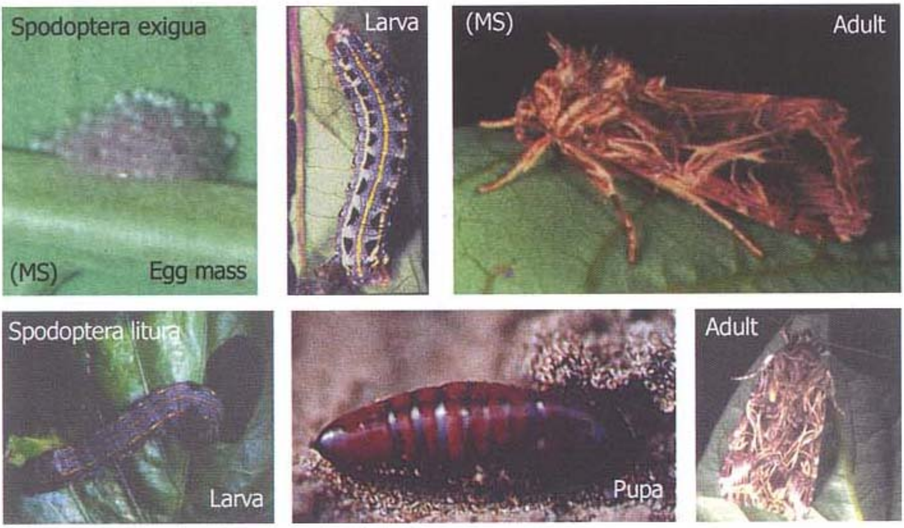
The butterfly lays its eggs on sweetpotato leaves at night. The newly hatched larva is very small, but grows very quickly. The coloration of the larval stage varies considerably as shown in the figures above. The larval period lasts 3-4 weeks. After reaching its full size (up to 9.5 cm), the larva drops to the soil and burrows underground. It forms a pupal case in the soil. Pupation takes 5-26 days, depending on the temperature.

Hornworm larvae have many natural enemies including parasites (wasps and flies) and pathogens. Diseases caused by viruses are especially important. Nevertheless, the long distance migration capability of the adults means that when an area is newly invaded, the natural enemy numbers may be very low and an explosion of the population of hornworm larvae may occur. This situation can threaten a sweetpotato crop since a large population of larvae can defoliate a whole field very rapidly. If this occurs during the early stages of growth of the crop, or during the time of root formation, yield can be seriously reduced. When the population is still low, handpicking the larvae from the leaves is usually sufficient. Plowing the land between crops exposes the pupa, drastically reducing their chances of survival.

5.2.6 Armyworms

Another kind of sweetpotato foliage feeder is the armyworm. The most important species in Asia are *Spodoptera exigua* and *Spodoptera litura*. The eggs of armyworms are laid in clusters and may be covered with a layer of a felt-like substance. The caterpillars hatch after 3.5 days and take about 2 weeks to reach the pupal stage. The larvae prefer moist sites and may hide in the soil during the day, emerging to feed on plants at night. Initially larvae feed by scraping the leaf surface. As they grow larger, they begin to feed more extensively, leaving only the veins. Pupation occurs in the soil. The development of the common armyworm species from egg to adult takes about 3.5-4 weeks. A *S. exigua* female adult can lay up to 1,000 eggs, whereas *S. litura* can produce as many as 2,000-2,600.

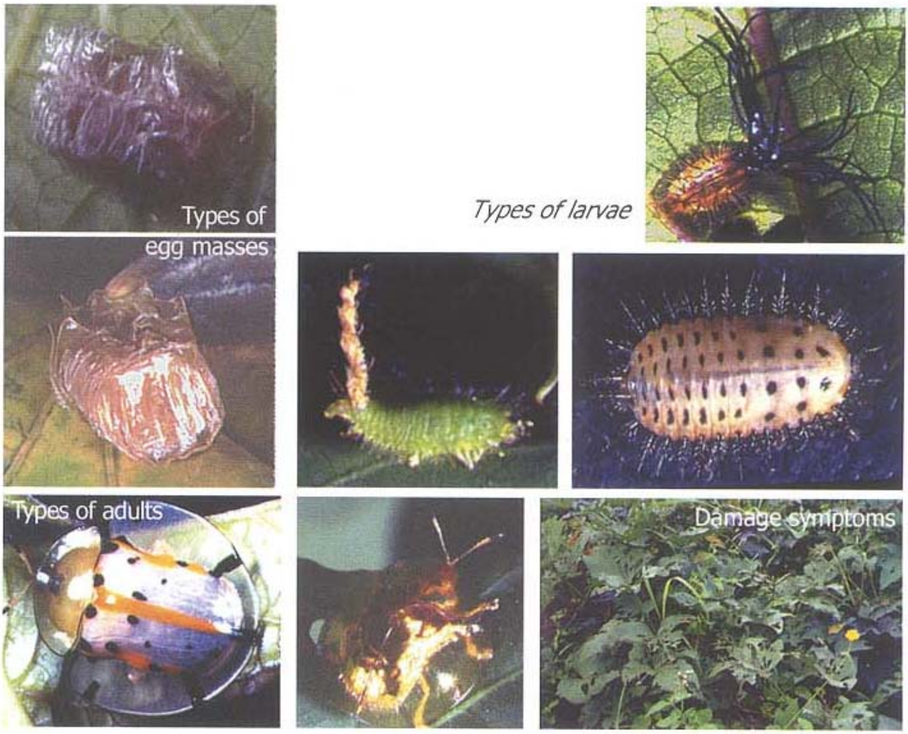
Natural enemies include pathogenic fungi and viruses, predatory bugs, wasps, ground beetles and spiders. More than 40 species of parasitic wasp and flies are known. Several weeds (e.g. amaranthus, water spinach) are hosts for armyworms and should be eliminated when armyworm populations become too high. Caterpillars are susceptible to the biopesticide Bt which at severe infestation could be used for spot application.



5.2.7 Tortoiseshell beetles

The tortoiseshell beetles (*Aspidomorpha* spp. and *Cassia* spp.) and their larval stages leave round holes in sweetpotato leaves as they feed. Some tortoiseshells lay eggs in a series of tissue-like layers that form a box-like mass. The larvae are flattened and spiny, and some hold their tails up over their bodies as they walk about. The pupa is less spiny than the larva and is fixed to the leaf. All the life stages are found on both sides of sweetpotato leaves.

The life cycle of the gold tortoiseshell beetle (*Aspidomorpha elevata*) ranges from 3 to 6 weeks, depending on environmental conditions. Several natural enemies including egg and larval parasites and predators have been reported. Control of tortoiseshell beetles is rarely warranted, since the damage on the leaves seldom causes economic root yield loss.



5.3 Diseases

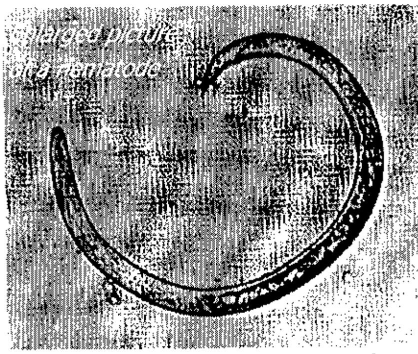
5.3.1 Types of diseases

Diseases of plants, like those of humans and animals, may be caused by:

- Nematodes.
- Fungi.
- Bacteria.
- Viruses.

A. Nematodes

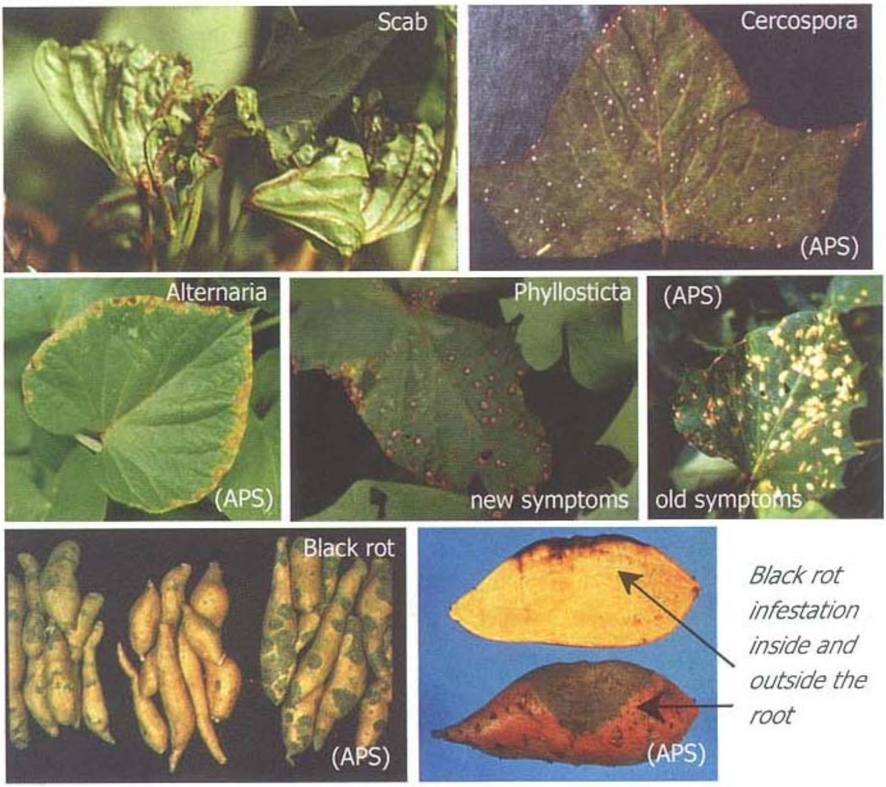
Nematodes are tiny worms that live in the soil and in root tissues. Some species are visible to the human eye with the aid of a magnifying glass, but most can only be seen with a microscope. Their presence is suspected from the symptoms they cause. They cause blister-like swellings or cracks on the edible roots, gall-like swellings on the fibrous roots, and large portions of the root system may die. Nematode egg masses survive in the soil and rotting plant material may harbor the juvenile stages. They can be transported by irrigation water and disseminated through infested planting material.



B. Fungi

Fungi usually cause affected plant parts to rot. Other symptoms include the appearance of spots, powdery areas, or masses of filaments. Powdery growths are composed of fungal spores that can spread to other plants. Fungal spores are like the seeds of green plants—when we observe them, we can be sure that the development of the fungus within the plant has already occurred. Common sweetpotato diseases caused by fungi include scab, root rots and black rots. Some other fungal diseases infecting the leaves are *Alternaria*, *Cercospora* and *Phyllosticta*. See pictures of symptoms of fungal diseases on the next page.

Symptoms of fungus infections



C. Bacteria

Bacteria are smaller than nematodes and fungi. They are not visible except under a microscope. Bacteria can cause the formation of wound-like lesions, rotting, and plant death.

D. Viruses

Viruses are different from other organisms because they are much smaller than any other creature. They can only live and multiply inside their hosts (or victims). Once a virus enters a cell in the body of its host, it will take over the management of the cell's processes, and force the cell to produce more viruses identical to itself. These viruses can then infect more cells. Viruses can attack both animals and plants, but specific types of viruses mostly have specific targets. Each virus causes a specific disease, for example the *influenza* virus causes flu in humans, the *tungro* virus makes rice plants sick, and the *sweetpotato featherly mottle virus (SFMV)* attacks sweetpotato.

The symptoms of virus attack on plants include dwarfing, leaf curling, and the appearance of purple pigment, yellowish spots, yellow veins or mosaic patterns. Heavily virus-infected plants can be detected by their stunted growth and/or yellow leaves of irregular shape. Many viruses are transmitted by aphids or other sucking insects and only a few insects can infect an entire field with virus.

Symptoms of virus infections

"Witches' broom" is a symptom caused by a virus-like organism (a phytoplasma). Plants containing this organism show dwarfing and abnormal development of flowers.

5.3.2 Common sweetpotato diseases

A. Scab

Scab is also called scabies. The causal fungus is called *Elsinoe batatas*. The early symptoms of scab are small brown lesions on the leaf veins and stems. As the scab fungus spreads, the lesions spread and curling and deformation of the foliage occurs. Scab can cause yield losses as high as 50%. Formation of the roots may be affected by the disease.

The resistance level of sweetpotato varieties to scab varies greatly. Some varieties are very susceptible. However, highly resistant varieties also occur, and some show little damage even during the warm, moist conditions that favor the development of the disease. Infected planting material can result in the infection of a whole field, and the disease spreads easily from one field to the next. Planting of infected cuttings is the main way of spreading scab.

B. Root rots

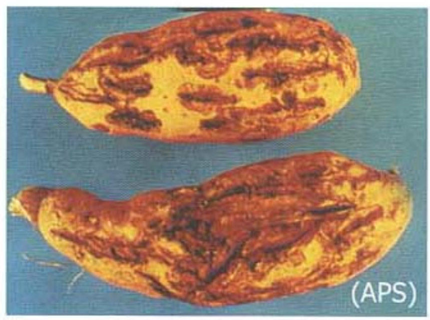
Several fungi and bacteria cause root rots. Once a rotting occurs it cannot be reversed. Infected plants must be destroyed to prevent further spread of the disease. Cuttings should be taken from vine sections that have not been in contact with the soil, since the soil can harbor root rot organisms. Planting material should not be obtained from fields where there are many rotten roots. Since the fungi and bacteria that cause root rots can survive in the soil for a long time, sweetpotato should be planted in rotation with other crops in order to avoid a build-up of disease.

Black rot is a root rot caused by a fungus, but in this case the rotting is dry. Sunken grayish-black lesions form on the surface of the root. Black spine-like structures of the fungus sometimes protrude from the lesions. A smell of alcohol like that of fermenting fruit is often present. In severe infections, yellowing, wilting, stunting and death of affected plants can occur. The use of planting material infected by the black rot fungus perpetuates the disease.

As with wet rots, cuttings taken from plant parts in contact with the soil surface may be infected or harbor fungal spores. The black rot fungus can survive in the soil for 1-2 years. The spread of black rot at harvest time is a particular problem since spores from infected roots are easily transferred to hands, tools, vehicles and other equipment, from which they can spread far and wide. The sweetpotato weevil also spreads black rot. Females can infect roots as they puncture the surface to feed and lay eggs. Weevils can also spread black rot spores to the foliage.

C. Root cracking

Nematodes are only one of the causes of root cracking. Cracks often occur after alternate rainy and dry spells. Roots developing in dry soil tend to have thin skins that crack easily as the root enlarges. Fungi and bacteria easily infect cracked roots.



D. Feathery Mottle virus

Feathery mottle is the most widespread viral disease of sweetpotato. The disease may reduce yields without causing any visible symptoms. When symptoms do appear, they may be difficult to detect or easily confused with other problems such as nutritional disorders. Faint, irregular yellowish spots, yellowing along the central vein of the leaf or the appearance of purplish pigment may be related to infection with Feathery Mottle virus. Many different aphids can transmit the disease.

5.3.3 Where do diseases come from?

Except for nematodes, which have limited mobility, disease-causing organisms cannot actively search for host plants. Diseases are spread by:

- Water.
- Wind.
- Insects.
- Infected planting material.

Most diseases can often survive in the soil for long periods. Nematodes can survive for a long time in the soil until host plants become available. Fungi and bacteria often have a life cycle stage that is specially adapted to survive unfavorable conditions. They are spread by water, wind and insects. Certain insects with sucking mouth parts can spread viruses from infected plants to healthy ones. Diseases are perpetuated when infected plants are used as planting material.

The development of a disease in a crop depends on many factors, including:

- The level of resistance of the sweetpotato variety.
- The general health of the plant, particularly in relation to nutrition, in that too much N often leads to more intense fungal infections.
- The soil type and composition.
- The temperature and the humidity of the environment. Generally, warm, humid weather and soil favors the growth of fungi.

5.3.4 Sweetpotato disease control

Prevention is the best method to control diseases. Once a disease infects the plant, it is difficult or sometimes even impossible to control it, and it is easily spread to healthy plants. Prevention of disease can be accomplished through:

- Field sanitation practices.
- Use of healthy, uninfected planting material.
- Use of resistant varieties, particularly in the rainy season.
- Maintenance of plant health through good management of fertility and water.

A sweetpotato plant with symptoms of virus infection should be immediately destroyed. Viruses are transmitted from infected to healthy plants through insects that suck the plant sap, such as aphids, planthoppers and whiteflies. Therefore, the control of a virus should include the control of the insect that transmits it. In addition, sweetpotato viruses can spread to the next generation when cuttings or roots of infected plants are used as seed. Sweetpotato plants with the symptoms of virus infection should never be used as seed. In China and South Africa, yield increases of more than 30% have occurred as a result of planting virus-free planting material.

5.4 Weeds

Weeds are unwanted plants that may compete with crop plants. We usually think that they have no beneficial effects when they grow on cultivated land, however weeds are not always harmful. Weeds can be divided into three categories:

- Grasses.
- Sedges.
- Broad-leaved plants.

Weeds can cause losses when:

- They compete with the sweetpotato crop for nutrients, light, water and growing space.
- Their removal is costly.
- They provide a refuge for insect pests allowing their survival during periods when there is no crop growing in the field.

Weeds may be beneficial when:

- They provide a source of green manure that supplies nutrients and organic matter improving the soil structure, when applied as fertilizer.
- They form a covering layer over the soil (a mulch). Mulches protect the soil from the light that causes the loss of water and organic matter.
- They provide a source of food (honey and pollen) and act as a refuge for natural enemies.
- They can be harvested to feed livestock.

Whether weeds are harmful or beneficial depends on their type and numbers, and whether they have alternate uses as mulch or green manure or for feeding. Different types of weeds vary in how much water and nutrient they extract from the soil, their shape and growth habits.

Careful weeding can minimize losses and increase the benefit of weeds. Factors to consider when weeding include:

- Timing: Weeding should be accomplished before the sweetpotato vines cover the soil.
- Selective weeding: Eliminate weeds that compete with sweetpotato, leaving plants that harbor natural enemies. Useful weeds can be cut back if they are too vigorous and can be left on the field as mulch.
- Utilization: Try spreading the cut weeds on the field as a mulch or use them as fodder for livestock.

In places where sweetpotato is planted on ridges, farmers often move down the soil from the sides of the ridges at about five weeks after planting, in order to remove weeds, aerate the plant roots and provide a place for side dressing of fertilizer. The weeds are left in the field as a green mulch. When sweetpotato is planted in beds or straight away in the soil, farmers often leave the weeds in the field and they compete with the sweetpotato crop. Selective weeding could increase the yield in this case.

6 The sweetpotato enterprise

6.1 Introduction

Taking into consideration the diversity of environmental and socio-economic conditions of farms in sweetpotato production areas, Integrated Crop Management (ICM) emphasizes the adjustment of cultivation practices according to the farm-specific conditions in order to achieve ecological and economic balance. To apply the ICM effectively in the field, a farmer should have strong problem-solving and decision-making skills. This chapter discusses several tools and methods to assist farmers in the decision-making process.

6.2 Experimentation

Experimentation at the farm-level is a major tool to test and adjust technologies according to the local conditions. Several guidelines are suggested here for designing an experiment that provides reliable information for decision making:

A. Prioritize and determine the main **research topic**. One experiment should only test one topic at a time, e.g., crop variety, application time of potassium fertilizer, dose of organic manure.
B. Define a **clear objective** of the experiment to be conducted, as detailed as possible. What is to be tested and what result do we expect?
C. Determine the **treatments** to test. Too many or too few treatments will not result in useful information. The optimum number of treatments is 3-5 per experiment. First, determine a control treatment, which could be a standardized practice with known results, such as farmers' practice, or the standard recommendations of the Agricultural Extension Service. The other treatments contain variations from the control, taking into consideration the conditions of field and the capacity of the farm household.

D. To ensure reliability of the experiment, each treatment should be replicated. Replications help reduce the effect of variable factors in the field, e.g., soil, water availability and sunshine. In farm-level experiments, two replications per treatment is considered sufficient.

Example:

Objective:	*To test to what extent urea dose can be reduced without resulting in sweetpotato yield loss*
Research topic:	*Urea dose*
Treatments:	*50 kg urea/ha*
	100 kg urea/ha
	150 kg urea/ha
	200 kg urea/ha (farmers' practice = control)
Replications:	*2 (A and B)*

The treatments are determined based on the control dose of 200 kg urea/ha which is the prevailing practice of the farmers. Considering that the objective aims at reducing urea dose since the farmer cannot afford to apply more, all other treatments are lower than the control. A follow-up experiment could look at smaller differences between the treatments within the range of doses that gave the best yields in this experiment.

E. Prepare a field with plots for each replication at a size of at least 10 m^2 each. The shape of each plot should preferably be the same and as square as possible. In a sweetpotato field, for instance, we could make plots of three ridges wide and 4 m long. If the shape of the field does not allow to make square plots of the same size, the area (m^2) of each plot has to be carefully measured and the treatment adjusted accordingly. The different treatments should be placed in the field in such an order that the two replications per treatment are not adjacent.

F. A simpler but less accurate way is to make plots with the same number of plants, for instance, one ridge with 60 plants forms one plot. However, planting distance may vary, thus providing advantage or disadvantage to certain plants. When we evaluate the result, we have to determine the yield per plant. The best is to keep both area and number of plants constant.

Example of the layout of the above urea dose experiment with two replications (A and B):

Treatment	*50 kg/ha*	*100 kg/ha*	*150 kg/ha*	*200 kg/ha*
Replication	*A*	*A*	*A*	*A*
Treatment	*150 kg/ha*	*200 kg/ha*	*50 kg/ha*	*100 kg/ha*
Replication	*B*	*B*	*B*	*B*

4 m

3 m

G. Each plot is provided with a label (a bamboo stake, for instance) on which the treatment and replication are clearly written with a waterproof marker.
H. Observe the plots regularly during the course of the experiment, and note down any remarks relating to the development of plants and the conditions of the field. This is necessary to interpret the results of the experiment later.
I. Measure all variables at the time needed.
J. Process the data by calculating the average of the replications per treatment, analyze the results and draw a conclusion.

6.3 Field area measurement

Farmers often use local units to express the area of their field, which vary from place to place. A unit with the same name may even imply a different area when applied in different places. The same holds for local weight units. The only standardized and internationally accepted unit for area measurements is the square meter (m^2), and for weight the kilogram (kg), or other units that can be immediately derived from these two. If we want to compare yields and treatments across fields, we will always have to express area and weight in standard units.

6.3.1 Standard units

Standard area units are:

1 m^2	= 1 m by 1 m, or 0.5 m by 2 m
1 hectare	= 100 m by 100 m = 10,000 m^2

Standard weight units are:

1 kg	= 1,000 g
1 ton	= 1,000 kg

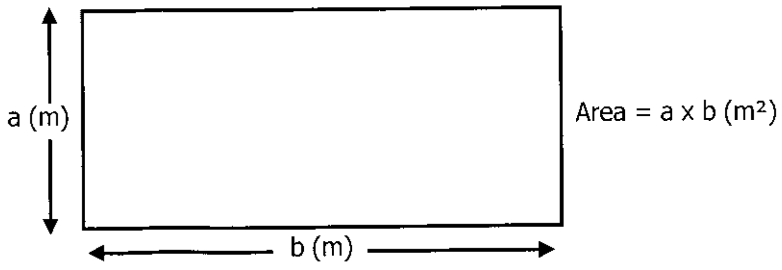
Inorganic fertilizer recommendations are normally given in kg/ha. Yields are normally expressed in t/ha.

6.3.2 How to measure the field and calculate the area?

To measure the field area we need a long measuring tape, preferably at least 50 m long. If we use a rope the length of which has been measured first, it is likely that there is a small error that becomes larger as we start multiplying in the case of large fields. Before measuring the field, it is advisable to draw a map of the field. The length of the edges can then be written on the map for easy calculation later.

A. Rectangle

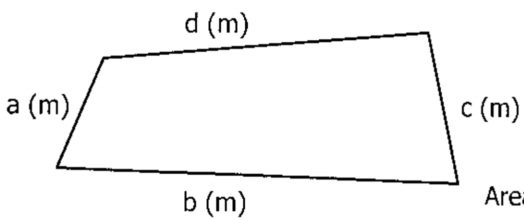
The easiest to measure is a field of a rectangular shape. It is sufficient to measure the length and the width, each on one side only. The area can then be calculated by multiplying length times width.



Unfortunately, exactly rectangular fields with right angles are rare. Fields of more irregular shapes are more difficult to measure. We have to follow some rules, use more complex formulas and sometimes need to make estimates.

B. Trapezium

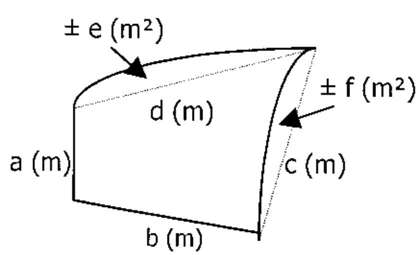
Of a field with four straight edges but no right angles, we have to measure all four edges. Next, we calculate the average of the two short edges, and the average of the two long edges, which are then multiplied.



$$\text{Area} = \frac{(a + c)}{2} \times \frac{(b + d)}{2} \quad (m^2)$$

C. Fields with curved edges

In a field with one or more curved edges, we first draw straight lines from corner to corner. The area enclosed by four straight lines can be measured and calculated using method B above. The small areas between the actual curved edge of the field and the straight line drawn should be estimated and added to or deducted from the area of the trapezium.



$$\text{Area} = \frac{(a + c)}{2} \times \frac{(b + d)}{2} + e\ (m^2) - f\ (m^2)$$

6.4 Economic analysis of the sweetpotato enterprise

The net income, or profit, of sweetpotato cultivation is determined by the difference between income from the produce and expenditures:

Income	Expenditures
• From harvest of storage roots = total weight of roots (kg) multiplied by the price per kg or opportunity value; or the price offered for the standing crop • From harvest of vines for seed and feed, or the opportunity value if used on the farm	• Rent for land • Seed • Organic manure • Agrochemicals (fertilizers, pesticides, etc.) • Implements • Labor: - hired labor - opportunity cost of family labor • Transportation when purchasing inputs • Costs of harvesting (transaction costs, marketing, labor, transportation, tools, etc.) • Other costs

The level of income will depend on the quantity of the harvest and the price at harvest time, whereas the total expense depends on the quantity of inputs and services used and their price per unit. For income and expense, farmers tend to consider only those activities where money is directly involved. They hardly ever consider the opportunity value of products or services, such as the family labor, or the vines used for feed on the farm. This means, for instance, that they do not pay themselves a salary. However, it is important to realize what the value of these opportunities are in order to make the right farm management decisions, especially when alternative opportunities are available, for instance off-farm employment or a market for sweetpotato seed.

In the Sweetpotato ICM FFS, the participants will make an economic analysis of the ICM FFS field on the Seasonal Cultivation Record form (see Appendix II-D), and are encouraged to do the same for their own fields throughout the season. For learning purposes, this analysis will at first only consider concrete, real money items, i.e.:

- Activities: practices implemented.
- Labor: amount of money paid for hired labor.
- Purchase of inputs: cost of inputs, transaction cost (labor, transportation).
- Remarks: interesting observations.

At the end of the season, the two columns containing labor and inputs are added in the column of total expense. After the harvest is sold, the economic analysis can be made by filling and calculating the lower rows in the cultivation record form, as follows:

- Total expense: the sum of all expense columns.
- Harvest: in kg.
- Price: total price for the standing crop, or the market price per kg multiplied by the total quantity (kg) harvested (including share sold to the market, and share for own consumption).
- Net income: price of produce deducted by the total expense.

6.5 Cropping pattern

The term "cropping pattern" is normally used to describe the sequence of crops on a certain farm throughout the year. Selection of crops is determined by a variety of factors, for instance:

- Suitability with the season.
- Suitability with the soil conditions and water supply.
- Market demand.
- Anticipated market price.
- Socio-economic aspects of the farm household (labor, capital).
- Condition of the previous crop(s).

6.5.1 Season, soil and water conditions

Conditions relating to the season, soil and water supply can hardly be influenced by farmers' practices; they have to take them as they are. Only by selecting a suitable crop and variety considering these conditions can we take advantage of the given situation. There are several aspects, however, that can be anticipated.

During the rainy season, the sky is often cloudy and the air humid. Water supply is normally sufficient from rain, but lack of sunshine does not support maximum growth of the crop. The high air humidity and temperatures induce fast development of fungal disease. Therefore, to reduce risk during the rainy season, we should select varieties that are tolerant to commonly occurring diseases, and reduce the plant density.

During the dry season, the sky is generally clear, and the air hot and dry; these conditions are very favorable for fast crop growth development, provided there is enough water. Insect development is favored, as well, by these conditions. Although the presence of relatively high insect populations does not necessarily mean economic crop loss at harvest time, due to the crop's enormous ability to compensate for damage, populations may have considerably built up at the end of the season, which might be a threat for a consecutive sweetpotato crop. In a situation like this, sanitation of the field is of utmost importance.

6.5.2 Market conditions

The prevailing market price often influences the farmers' decision whether or not to plant sweetpotato at a certain time. A high price encourages farmers to plant, while a low price normally discourages them. However, before being too much influenced by the price prevailing at that particular moment, we should try to understand why the price is high or low. Market principles often follow a supply and demand mechanism, meaning that prices will go down when the supply is high at low demand, and vice versa. When the price is low, leading to fewer farmers planting sweetpotato at that moment, 4-5 months later at harvest time the supply will have considerably decreased until it does not meet the demand anymore. At that moment, prices will go up again. It is very likely that farmers who plant when the price is low, will catch a higher price and, thus, earn a higher profit than those who plant when the prices are peaking, but gone down again at harvest time due to over-supply.

Farmers who sell the standing crop to a trader are normally not aware of the exact market conditions, which puts them in a weak bargaining position. Where possible, farmers should join efforts to inform each other about prevailing prices at various markets in the area, so that they do not easily become a victim of power games played by the traders. This would also help them to anticipate too large fluctuations in the market price.

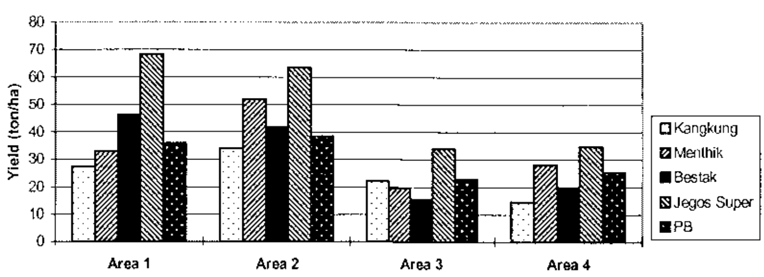
6.6 Variety selection

6.6.1 An experiment

A comparative variety trial conducted during the dry season of 1995 by farmers in four major sweetpotato growing areas in Indonesia (see picture below) revealed various interesting findings. The performance of the varieties, which consisted of the most favorite varieties from each of the four locations, considerably varied from place to place, indicating compatibility between variety and environmental conditions.

Only one variety, *Jegos Super*, gave the highest yield in all places, showing a genetic capacity for high yield. All varieties produced best in Area 1, indicating favorable environmental conditions for sweetpotato. Marketability of the varieties also varied from place to place, depending on the preferred color, shape and taste by consumers.

Yields of five sweetpotato varieties grown in four areas in Indonesia



6.6.2 Preferred sweetpotato characteristics

To earn an optimum income, farmers need sweetpotato varieties possessing certain characteristics. The importance of each characteristic will depend on local conditions and may imply certain effects, as shown below:

Desired characteristic	*Determining factor*	*Effects that may occur*
High yield	1. Varietal potential: - Growth duration - Favorable vine-root ratio - Compatibility with environmental conditions (soil, water, weather) 2. Crop care	- Not tasty - Root shape unfavorable - Low market price - Low price for standing crop
Tolerance to insect pests (dry season) and diseases (wet season)	1. Varietal potential 2. Season 3. Crop care (health)	- Tolerance may vary from place to place - Tolerance only to one or a few species at a time
Resistance to drought/flood	1. Varietal potential 2. Field conditions	- Resistance tolerance may vary from place to place
Short growth duration	1. Varietal potential	- Relatively low yield - Unfavorable if growth duration cannot be prolonged when market price is low
Good taste	1. Varietal potential 2. Field conditions 3. Crop care, particularly fertilization and water supply	- Relatively low yield - High market price - Easy marketing
Certain skin and flesh color	1. Varietal potential	- Needs to meet market demand
High market price	1. High market demand 2. Good taste	- Price will decrease when demand is met
Easily marketable	1. Characteristics need to meet market demand	- Less easily marketable when demand is met

6.6.3 Variety selection

The following aspects could be considered in selecting a variety:

- Desired characteristics of the crop and produce, taking into consideration the advantages and disadvantages mentioned above.
- Availability of seed.
- (Prediction of) market demand at the time of harvest.

In order to determine the suitability of new variety under prevailing field conditions, farmers should conduct a small-scale field trial first, as outlined in Section 6.2 (Experimentation).

6.7 Harvesting, marketing and storage

6.7.1 Determining the time of harvest

In order to determine the optimum time of harvest, the following factors could be considered:

- Variety's growth duration and its capacity to be prolonged.
- Environmental conditions (water supply, soil condition, weather, etc.).
- Pest and disease incidence.
- Market demand.
- Market price.
- Need of land to plant the consecutive crop.
- Economic value of the consecutive crop.

As a general rule, it can be stated that yield potential is higher at a longer growth duration. However, yield increment does not necessarily outweigh loss of time for the consecutive crop. The optimum growth duration is when the profit per unit of time has reached its maximum, which will depend on the variety in interaction with the environmental conditions. Additionally, the longer the crop remains in the soil, the larger are the chances that the storage roots are attacked by pests (particularly sweetpotato weevils) and diseases (particularly root rot). To determine the optimum harvest time, farmers should weigh the various factors mentioned above in the context of the prevailing conditions, and find a balance between advantageous and disadvantageous factors, in relation to the potential and needs of each individual farm enterprise.

6.7.2 Assessment of yield and crop value

If farmers are able to assess the sweetpotato yield in their fields and are informed about the market price at harvest time, they will be in a stronger bargaining position with the traders, and cannot be easily deceived. An experienced eye, such as the traders', can estimate the amount of roots in the soil by looking at a few plants only. Farmers should be able to do the same and calculate the value of their crop.

The quantity of storage roots in a field can most easily be assessed by estimating the average root weight per plant and multiplying this by the number of plants in the field. Another way is to assess the average root weight per square meter and multiply this by the field area (in m^2). The average root weight per plant or per square meter should be assessed by observing (and weighing if possible) a representative sample across the field. The second method using weight per square meter is more difficult than the first one using weight per plant, particularly when the field has an irregular shape and the exact area is difficult to measure. Therefore, only the first method is discussed in detail here.

One sweetpotato plant produces on average 0.5 kg of storage roots, but ranging from about 0.2 to 1.2 kg of roots per individual plant. To estimate the average root weight per plant, we need to observe a sample of at least 10 plants per 1,000-2,000 m^2 to represent the whole crop. These ten plants are selected randomly across the field. Digging up and weighing the roots is the most reliable way to determine the weight per plant, but this is time consuming and might not be acceptable to potential buyers. In that case, the soil covering the roots is partly removed to observe the storage roots and estimate their total weight. Estimate the weight of roots in the soil is a skill that can only be developed with practice. After having assessed the total sample, the average weight per plant is calculated by totaling the weight of the individual plants and dividing this by the total number of plants observed.

The plant population in the whole field can be determined by counting all productive plants, which is the most accurate way, but very time consuming. A simpler but slightly less accurate way is to determine the average number of plants per step along a ridge, hence to count the total number of steps across all ridges in the field. If the shape of the field is regular and allows easy division into equal parts, we can suffice to count only a half or a quarter of the field. The plant population in the field can be calculated by multiplying the average number of plants per step by the total number of steps in the whole field.

Example:

A. *Weight of tuber per plant:*
   1. *0.35 kg*
   2. *0.50 kg*
   3. *0.40 kg*
   4. *0.75 kg*
   5. *0.50 kg* → *Average: 0.49 kg/plant*
   6. *0.55 kg*
   7. *0.60 kg*
   8. *0.20 kg*
   9. *0.65 kg*
   10. *0.40 kg*

B. *One step along a ridge contains 5 plants.*

C. *The field can be divided into four equal parts; a quarter of the field contains 125 steps, which means that the field contains 500 steps.*

D. *The plant population of the field is 500 * 5 = 2,500 plants. The average root weight is 0.49 kg/plant. Hence, the total harvest is estimated at 2,500 plants * 0.49 kg/plant = 1,225 kg.*

E. *The total (underground) crop value can be calculated by multiplying the total harvest (kg) by the prevailing market price per kg of storage roots.*

This method is less accurate when the crop is planted in raised beds instead of ridges, since it is more difficult to determine the average number of plants per step along a bed. Besides, it is difficult to observe and estimate the root weight of plants in the middle of the bed, which is likely to be different from the edges. The best method for yield assessment in raised beds is to harvest a sample area of 1 m^2 and weigh the storage roots. The average weight of 10 sample spots is then multiplied by the total field area (in m^2) to determine the total harvest of the field.

6.7.3 Storage of sweetpotato

Storing harvested sweetpotato roots at the farm level is not an obvious practice, since the produce is bulky and perishable. Therefore, storage requires special methods and facilities. Farmers identified several advantages and disadvantages of storing sweetpotato roots on the farm, as follows:

Advantages	*Disadvantages*
• The period during which fresh roots are available for home consumption (both for humans and animals) is prolonged. • Labor pressure for marketing and farm-level processing during peak harvest seasons is reduced. • A better market price can be obtained. • Field is made available for other crops. • Quality (taste) of roots is enhanced, therefore more attractive to consumers.	• Without adequate storage methods, roots are often damaged by sweetpotato weevil and root rots, reducing both quantity and quality of the roots. • Total weight declines over time due to evaporation. • Storage requires space in or near the house. • Good storage techniques require labor and materials. • Roots bring soil from the field into the house. • When infested by weevils or rot, roots smell bad.

Traditionally, sweetpotato roots are stored in a dark place in the house, for instance in a corner or under the bed, without being covered or treated. Sweetpotato roots can be kept this way for about 4-6 weeks, but infestation by sweetpotato weevil is often very high and may even reach 100% at the end of the period. An improved but simple technique, tested under farm conditions in Vietnam, involves the following steps for storage:

A. Determination of suitable harvest time:

- The crop should be harvested under dry weather and field conditions.
- The harvest is sorted to select roots that are free of sweetpotato and rot symptoms.
- The roots should be cleaned by hand to remove as much soil as possible before placing them in storage.

B. Selection of a suitable place for storage:

- A dry, cool place of adequate size is selected for the storage.
- The place should not be exposed to direct sunlight.

C. Preparation of materials:

- To prevent excessive evaporation and reduce pest and disease attack, the roots should be covered by dry soil powder or sand. Therefore, a sufficient amount of soil or sand should be sun-dried in advance. If soil is used, it should be pounded to powder after drying.
- A supply of bricks, rattan or bamboo sticks should be prepared to make a fence around the store.

D. Preparation of the store:

- A fence of 60-80 cm high is made from bricks, rattan or bamboo. The width should be adjusted to the quantity of roots to be stored.
- Sheets of paper (e.g. old newspaper) are spread out on the floor within the fence. A layer of 4-5 cm of dry soil powder or sand is put on top of the paper sheets.
- A layer of 20-25 cm of clean roots is placed on the soil/sand layer.
- Alternating layers of 4-5 cm of soil/sand and 20-25 cm of roots are added until all roots are stored.
- The final layer of soil/sand should cover all holes between roots and the fencing material (bricks or bamboo stick) and be at least 5 cm thick.
- The store should be checked daily for rats or leaking rain water.

A well prepared store can be kept for at least two months without experiencing sweetpotato weevil infestation or root rots. In addition, weight loss due to evaporation is somewhat reduced. Whenever the sweetpotato market price is good, the roots can be taken from the store and sold.

6.8 Sweetpotato utilization

In addition to fresh consumption, sweetpotato can be utilized in a number of ways:

- As animal feed: currently this is perhaps the most common utilization.
- Processed into starch: currently most of the starch is further processed into noodles.
- Processed into flour: used as a substitute for imported wheat flour.
- As snack food: mainly in the form of chips, strips, dehydrated snacks, and candies.

The appropriate utilization depends on market demand and farmers should be encouraged to experiment with any of these options only after market potential has been thoroughly explored.

6.8.1 Sweetpotato as animal feed

Both sweetpotato roots and vines are good materials for animal feed. The roots provide starch and energy while vines provide protein and fiber. Roots are generally fed to pigs while the vines are feed for a variety of animals, including pigs, cows, rabbits, chickens and goats. A few considerations need to be kept in mind when using roots as pig feed:

- *Trypsin inhibitors*: Some sweetpotato roots, depending on the variety, possess chemical compounds that inhibit the important digestive enzyme trypsin. When a trypsin inhibitor is present, nutrient absorption from sweetpotato roots or other feeds consumed simultaneously is significantly reduced. Trypsin inhibitors can be broken down in high heat, thus, farmers generally cook sweetpotato roots before feeding to pigs. Unless the specific variety has been screened for trypsin inhibitors and proves to be free of them, it is a good practice to cook the roots.
- *Starch digestibility*: The starch of some sweetpotato varieties is difficult to digest and absorb. Slicing and drying the roots seem to break down

the starch structure and improve the digestibility and rate of absorption, although this practice is only feasible when weather conditions permit.

- *Starch yield* (starch content multiplied by storage root yield): For the purpose of animal feed, given the same starch yield per hectare, it is better to choose varieties that are high in starch content and lower in yield, than those low in starch but high in yield. Low starch content means high water content in the roots. Pigs can become bloated if the root moisture content is too high.

By the same token, when using sweetpotato vines as animal feed, it is good to consider the following factors:

- *Vine production*: If vines are the objective of production, the sweetpotato should be planted on flat fields instead of mounds. Depending on the rainfall levels, vines can be harvested 30-45 days after planting and every 15-25 days after that. The optimal way to cut multiple vines is to cut 1-2 of the longest branches of each plant, leaving about 10 cm for resprouting.
- *Vine feed*: Vines can be fed fresh, dried, fermented, or made into silage. The most common practice is to feed fresh vines during harvest season (if sweetpotato is grown for roots or root/vine), and to dry or make silage the vines after harvest.
  - Drying: some farmers like to cut the vines before drying because the dried vines are difficult to cut, while others hang the whole vines on trees, fences, walls, or other structures that are strong and high enough to support the vines.
  - Fermentation: this is a newly introduced method of feeding vines. Fermented vines are most preferred by pigs and provides protein at the lowest cost. The feed is made from a mix of chopped vines, rice bran, and salt and is ready to be fed after 10 days of fermenting..
  - Silage: this method is less common, but also an option for storage. In this case, vines are firmly pressed into a tank with a layer of salt placed on top before covering the tank.

6.8.2 Sweetpotato starch

Sweetpotato starch extraction can add value to fresh roots, if there is market demand for starch, and if the market price of starch exceeds the expense of raw material and processing costs. Once marketability and profitability have been examined, the method of processing needs to be considered in order to improve starch quality and profitability. Currently, sweetpotato starch is mainly processed into noodles, which have a market in some countries (e.g. China), and which can be more profitable than starch. Other applications have been investigated, but market demand is not yet established. Profitability is calculated by the following formula:

Profit = starch price - raw material cost * *- labor cost - processing cost* **

* Raw material cost = Fresh root price * (100/extraction rate)
** Processing cost = Cost for electricity, water, etc.

The formula for raw material cost shows that extraction rate has significant effect on profitability, thus, it is important to calculate first at what extraction rate would starch processing be profitable. This is because extraction rate can be improved by selecting varieties with high starch content and by improving processing methods.

The method for starch processing includes the following steps:

- *Washing*. The roots are washed by hand or machine.
- *Shredding*. A hammer mill is best in ensuring a high extraction rate.
- *Separating*. This can be done a number of ways:
  - By hand: put starch slurries from the shredder through a screen cloth and manually knead the slurry until starch and other material separates. This is time-consuming, labor-intensive, low-yielding, but requires no machinery.
  - Shredder/separator combined machine: some shredders have a built-in separator, and after shredding, slurries are run through the system in 2-3 times.

  - Separator: the slurries can be separated in one, two or even three separators, each with a higher screen mesh size to improve starch quality.
- Settling: once separated, starch water is channeled into a tank to settle for about 24 hours. The tank can be a wooden tub, plastic buckets or may be made of cement.
- Drying: once the starch has settled on the bottom of the tank, water is drained away and the starch can be removed for drying.

6.8.3 Sweetpotato flour

Sweetpotato flour so far has no established market anywhere in the world. It is being investigated as a substitute to imported wheat flour as a way of reducing costs. Therefore, this option has market potential mainly in tropical countries where wheat cannot be produced. In substituting wheat flour, sweetpotato flour is most suited for cookies, cakes, and snacks and less suited for dough-based products like bread or donut because of its lack of gluten. For cookies, cakes and snacks the substitution rate can be as high as 80-100%, while for dough-based products only up to 25-30%. The largest potential market is substitution in flour noodles, and in this case, a substitution rate of up to 30% is possible, although for better results 15-20% is recommended.

To determine the profitability of sweetpotato flour production, apply the same formula as for starch processing. The extraction rate of flour is highly correlated with dry matter content of the roots and depending on the processing method, it should reach 85-90% of the dry matter. Again, extraction rate varies with variety and processing method, therefore, profitability needs to be calculated based on these specifics.

Processing method for flour is quite different from that of starch and involves the following steps:

- *Washing*: This is necessary to ensure clean peeling, if the quality of flour is of concern.
- *Peeling*: Peeling is necessary to ensure high quality flour (i.e., white and free of oxidation). Most of the substances that cause oxidation are in the

skin, so heavy peeling is recommended. This does not reduce the recovery rate since little dry matter is stored in peels and it increases the speed of peeling. While peeling, the roots should be rinsed in clean water constantly to avoid oxidation.

- *Shredding*: Shreds dry faster than slices, so shredding is preferred over slicing. A simple shredder with stainless steel blade is necessary to avoid oxidation.
- *Cleaning shreds*: The purpose of cleaning shreds is to get rid of oxidating substances. This can be achieved in two ways:
  - Repeated rinses: rinse the shreds in clean water three times. This requires a great quantity of clean water.
  - Soaking in metasodium bi-sulfite: dissolve bi-sulfite in clean water and soak shreds in the water for 30 minutes. This method should be employed only if farmers are well-trained in measuring the sulfite and the water requirement.
- *Spreading to dry*: Once cleaned, the shreds are spread on bamboo mats to dry out in the sun. If the humidity is low and the temperature is high, the shreds can dry within 4-6 hours. To achieve good quality of flour, drying within one day is important, so an early start to take full advantage of the sun is essential.
- *Milling*: The dry shreds are milled, preferably with a screen of mesh size no less than 70. The higher the mesh size, the finer the flour. If the screen mesh size is lower than 70, the flour will need to be hand sieved which is time consuming and results in reduction of recovery rate.

The flour can be marketed either as flour to flour users, or processed into flour products. Flour and processed products can be targeted in different markets (see Table 6.1).

Table 6.1: Potential users of various processed sweetpotato flour products for marketing.

	Noodle factories	Bakeries	Home industries	City groups*	Rural groups*	Stores	Market
Flour	√	√	√		√		
High quality products		√		√			
Low quality products		√			√	√	√

* These include women's group, schools, local institutions, etc.

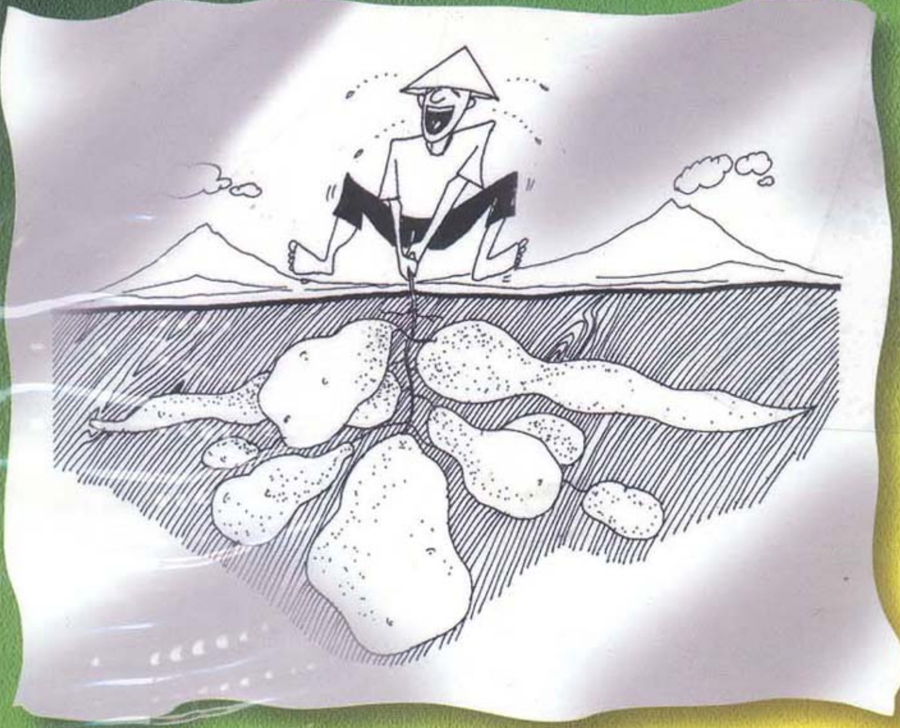
6.8.4 Sweetpotato snacks

The easiest snack to make is sweetpotato chips and these can be made two ways:

- Slice, boil, dry and fry in oil. The quality is good and has a shelf-life of six months.
- Slice, dry, and fried. The quality is not so good, but this method is more convenient.

If the sweetpotato is not naturally sweet, sweetener can be added in the oil to avoid having to spread raw sugar on the surface of the chips.

The strips, like "french fries", are made by cutting the roots into the french-fry shape and frying them in a vacuum fryer. After that the strips are run through a centrifuge machine to draw out the oil before they are packaged.



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