

# HORTICULTURE TRAINING MANUAL FOR LAO PDR



DED LAOS  
ENGLISH VERSION 1.2



**LAO PDR**



## Table of Content

### Foreword

<b>Part A Introduction.....</b>	<b>1</b>
- Background: .Why this manual has been compiled?'	
- Potential users and target groups	
- Objectives: "How this manual is structured?"	
a) Idea and advantages of modules	
b) Technology leaflets (for possible handout)	
c) Training guidelines and methods for trainers.	
d) Exemplary case studies of small-scale farming in Lao PDR	
e) Extension possibilities: "How this manual could be continued.	
 <b>Part B Guidelines for Training .....</b>	 <b>5</b>
- Principles of Participatory Training	
- Methods of Training	
- Gender Issues	
 <b>Part C Farm Development .....</b>	 <b>19</b>
 <b>Chapter 1 Background Information .....</b>	 <b>19</b>
- Most important fruit and vegetable species in Lao PDR	
- Basic knowledge of botany	
a) Phenotypes and Reproduction	
b) Botanical Classification	
 <b>Chapter 2 Survey of Farm Conditions .....</b>	 <b>29</b>
- Preliminary Thoughts	
- Topographic and Soil Conditions	
- Water Availability	
- Climatic Conditions	
- Infrastructure	
 <b>Chapter 3 Perspectives and Challenges .....</b>	 <b>43</b>
- Economics	
- Principles of Multi-cropping	
- Diversification and Niche Produces	
- Tools	

**Part D Crop Management ..... 61**

**Chapter 4 Nursery ..... 61**

- Seedbed Preparation
- Sowing
- Seed Germination
- Caretaking of Seedbed
- Container Raising
- Vegetative Propagation

**Chapter 5 Transplanting ..... 76**

- Land and Bed Preparation
- Transplanting of Bare-root and Container Plants
- Sunlight and Rain Prevention

**Chapter 6 Staking, Training and Pruning ..... 87**

- ...in Vegetables
- ...in Fruit Crops
- Fruit Inducing Methods for Fruit Crops

**Chapter 7 Fruit Crop Propagation ..... 96**

- Sexual Propagation
- Vegetative Propagation
- Cuttings
- Growth regulators
- Layering
- Air-layering
- Grafting/Budding
- Grafting Methods
- Fruit Crop Propagation

**Chapter 8 Soil Improvement and Conservation ..... 114**

- Soil Productivity
- Nutrient Elements
- Fertilizers / Fertilizer Application
- Organic Sources of Nutrients - Mulching
- Green Manuring
- Composting
- Bio-Extract / EM / IMO
- Agro Forestry
- Contour Lines and Terraces
- Hedges, Windbreaks, Living Fences

<b>Chapter 9 Crop Protection.....</b>	<b>161</b>
- Introduction	
- Diseases	
- Pests	
- Pest Control	
- Weeds	
<b>Chapter 10 Water Management.....</b>	<b>196</b>
- Irrigation	
- Drainage	
<b>Chapter 11 Harvesting and Post Harvest Technology.....</b>	<b>200</b>
- Reasons for Damages and Yield Losses	
- Techniques for Reducing Post Harvest Losses	
<b>Chapter 12 Obtaining Own Propagation Material.....</b>	<b>210</b>
- Harvesting and Processing of Seeds	
- Farm Level Packaging and Storage	
<b>Part E Proposals for Organizing Trainings and Workshops.....</b>	<b>216</b>
- Schedule for Vegetable Training	
- Schedule for Fruit Crop Training	
- Schedule for Integrated Farming Training	
- Exercises for Introduction, for Energizing and Teambuilding Processes	
<b>Part F Case studies .....</b>	<b>226</b>
- Northern Lao PDR	
- Central Lao PDR	
- Southern Lao PDR	
<b>Part G List of References about Horticulture in Laos.....</b>	<b>241</b>
- Institutions and Organizations	
- Access to literature and Media about Horticultural Subjects	



## Foreword

The need to have a Handbook/Manual like this was felt after having worked in the sector of agriculture, rural development, agriculture education and natural resource management for more than 10 years in Lao governmental stations and education institutions.

The authors and editors are experienced development workers of German Development Service, DED, and have special long-term expertise in horticultural production such as vegetables, and fruit-trees, as well as a profound background in education systems and extension approaches. All this expertise was used on mainly voluntary basis to produce a Lao specific horticulture manual with information and links (within the country to force and feed the horticulture development of the country).

The author and editors are aware of that many vegetable and fruit tree handbooks and professional information exist already. These are available as paper bags, folders, and hardcover and as CD-Room or online publications. Nevertheless, the author and the publisher felt the strong need to meet the specific local situation and requirements in Lao vegetable and fruit production. That's the reason why practical lessons, field exercises, case studies have been implemented into the overall layout.

Furthermore the modular system and especially the folder version help to keep information up-to-date and to add own notes, remarks, experiences considering Lao institutional and training capacities.

A partly realized translation into Lao language turned out to be too difficult because interpretation of English subject matter terms into Lao language was very complicated. Finally there is the possibility to translate the book or just parts of it if found useful.

At the end of a two years production period a first version is published as Handbook and in a small edition as folder to simplify the integration of new information and results etc.

The author and DED Laos are grateful to Haddokkeo Horticulture Research Center Mr. Thavone, Northern Agriculture and Forestry School Mr. Uthay, Pakse Southern Agriculture College, Mr. Soullith for their help in carrying out the case studies and supporting the Horticulture Training Manual for Lao PDR.

A special thank is given to the Dongkhamasang Technical Agricultural School where EH Dorothea Dietrich worked as Technical advisor. She was free to / given off all the time she needed to compile all the data and materials now available in this manual.



The author/editor team appreciates the commitments from PADECT, Mr. Noukone for initial translation into Lao language and the Department of Agriculture and Extension in supporting the idea to produce a Lao version at a later stage.

Last but not least the author/editor team would like to thank all colleagues from DED for their constructive inputs and ideas as well as critical remarks during the process of compiling and writing. In special (EH) Klaus Dietrich, Gerry Duckitt, Harald Kreuscher, Holger Grages, Karin Tränkner-Benslimane, Thomas Bergmann, Basanta Adhikary, Ines Wiedemann, Chris Wood, and Ursula Schmid, should be named for this first version.

EH Dorothea Dietrich would like to thank for the supervision KOR RD/RM Silke Stöber and Lars Düerkop and support and motivation.

Vientiane, November 2001

Lars Düerkop  
Coordinator Rural Development and Resource Management Program



**Why this manual has been compiled**

In the agricultural extension sector of Laos, although there are several descriptions and detailed instructions for fruit and vegetable crops (see: list of references; access to literature), a complete and comprehensive work about horticulture in the Lao language, adapted to the conditions predominating in Lao PDR, has been missing.

Therefore, due to the special needs of extension work in the horticultural sector of Laos, the intention surfaced to create a handbook, making the best use of existing English language literature from several Southeast Asian countries.

The most important intention was to exploit sources that are compatible and applicable to Lao conditions and exclude those which seemed to be too sophisticated or different.

**Potential users and target groups**

This manual is primarily intended to serve agricultural extension workers, i.e. PAFO and DAFO staff, for preparation and structuring of training workshops for farmers.

As well, teachers and students of Agriculture Schools and Colleges may use it for preparing lessons, students' practical education and examinations.

The presence of both English and Lao versions might help Lao users to become more confident in reading English and thereby access to English language literature concerning horticulture.

On the other hand it might encourage extensionists involved in international cooperation to become more familiar with related publications in the Lao language and to use this material for their own preparations.

The English version is the basis for the manual. It provides an introduction and overview about the actual situation and perspectives in Laos for all those people interested in this subject.

**How this manual is structured**

First of all the manual is in a format that offers the most flexibility for many purposes, such as making photocopies, choosing certain subjects, adding new matters and remarks, etc.

It has been divided into seven parts (A to G) in order to differentiate the technical from the more theoretical contents.

The horticultural technical aspects have been organized into two parts, with the aim to separate more general but essential observations (Part C) from more practical considerations (Part D). These two parts, C and D, in turn have been divided into chapters concerning periods and/or areas of techniques and strategies (especially in chapters 1 to 3).

The various aspects of each chapter are represented in „subchapters“ indicated by dashes. This has been done in order to make sure that the each chapter remains a separate entity from the others.

The box at the top of each page indicates the part and name of the chapter it belongs to. Below this the number of chapter („subchapter“) plus subject is given in bold letters.

**How to make best use of the manual**a) The idea and advantages of using modules

The form of modules has been chosen because

- frequently the time of a workshop is too short and it is undesirable to hurry through complicated and complex subjects; therefore one or two modules may be the subject of each training
- farmers need special information and explanations at certain times or distinctive periods of time
- the necessary contents of workshops and interests for trainings may differ significantly from one region to another
- options are given for different types and lengths of trainings
- the manual can easily be broadened by adding further modules, which may consist of complete chapters or „subchapters“ referring to not yet mentioned aspects, or even by enclosing single pages with further or new information
- in cases where chapters are unsuitable, complete chapters or parts can be revised and adjusted, or taken out

### b) Technology leaflets and trainers' sheets in parts C and D

The information is given in the first pages of each chapter and „subchapter“. Whenever possible, these pages have been illustrated with pictures, so that in some cases they may be used for handouts to the participants at the end of the workshop. The brief description plus drawing might help the trainees to remember the lessons and transfer them into practice.

The last page of most chapters or „subchapters“ might help the trainer and later the trainees to reflect on the subject and to consolidate the information taught, by answering questions regarding comprehension.

In chapter 2 there are additional questions given on the information sheets. The objective is to make you as a trainer feel confronted by the farmers' problems and questions concerning their special farm conditions. Try to slip into his or her „shoes“ and to imagine you are in his or her position.

These additional questions may be asked as introductory questions, or used when reflecting the lesson.

The trainers' sheets should motivate trainers to make trainings active, to raise attention and interest, and to find ways for all participants to actually participate.

### c) Training guidelines and methods

It is hoped that this chapter will encourage trainers to try other ways of instruction than didactic teaching („chalk and talk“) and to keep in mind some principles when preparing a training. The given guidelines and methods should be practicable for trainers who have some experience in running workshops and are interested in trying out different forms of teaching and learning.

Examples and instructions are given, as well as links for finding further information.

### d) Exemplary case studies

The intention of adding exemplary case studies of small-scale farming in Lao PDR is first to describe how vegetable and fruit crops can be integrated into farming systems.

Special focus is given to multiple cropping, integrated farming and how, for the most part, to do without chemicals.

While the case studies may be representative of different regions in Laos, all the farms described are located near to urban centers and do not deal with the various and manifold difficulties of very remote areas.

Descriptions printed in italics ask the participants what they do on their farms, in order to interchange opinions and experiences.

These case studies can be read or told, or even better be distributed, to work groups in order to initiate a lively discussion about:

- how to organize a farm,
- advantages and disadvantages of multiple cropping,
- advantages and disadvantages of integrated farming, etc.

They should never be used without being linked to the theoretical chapters and hopefully will be followed by farm visits, where the practices can be demonstrated in a favorable light.

#### e) How this manual can be continued

The authors hope to hand over a practicable and comprehensive handbook that suits the needs of many persons working in agricultural education and extension.

It is left up to the readers to add own conclusions, practical experiences, references, etc. that might be considered for a future edition.

The modules and loose leaves make it easy to add any subject of horticultural interest. Especially those subjects that have been found incomplete should be updated according to current needs and demands.

This manual is directed to small-scale farming conditions. Some readers therefore might miss “more modern”, “more progressive” and “more specialized” statements and instructions. These might be found easier in other sources, which should not change the characteristic approach of this manual.

### Principles of Participatory Training

The trainer should be aware of the fact that adults are voluntary learners and that they perform best when they have decided to attend the training for a particular reason.

Adults have usually come with an intention to learn. They have experience and can help each other to learn. If the sharing of that experience is encouraged the sessions will become more effective. That means also, that adults learn best in an atmosphere of active involvement and participation, and that they are taught best with a real-world approach, close to their own tasks or jobs.

#### **Each participant is a resource person.**

To achieve success, trainees should be encouraged to take responsibility for their own learning experience, so that it continues long after the training workshop or course has ended.

The basic principle is to use the experience and knowledge of the participants as the starting point.

**Your** challenge as a trainer is to draw out that your participants know a great deal already, and to add new ideas, principles and concepts.

The essential element of encouraging participation requires that everyone understands supports and is willing to join actively the process.

There are many ways to increase participation:

- Communicate clearly what the training program will entail. The participants must be convinced that it will be relevant, and that specific skills achieved here will fulfill needs in another context.
- Use active rather than passive, and practical rather than theoretical methods. Assign tasks which ensure that everyone is involved or has a chance.
- Ensure that there are plenty of practical exercises. If adult participants are „doing“, their self-confidence increases and they are able to adapt what they are learning to their own circumstances.
- Use small groups whenever possible, as large groups may intimidate the less bold, and may inhibit spontaneity.
- Provide meaningful data and information. Simple graphics, models, numbers and charts should be used.
- Continue to relate new material to information and skills which they got already.
- Respect and encourage individuality since people learn at different rates and have different styles.



## Principles of Participatory Training

### Preparation of a course

It is important to think carefully about the participants:

- Which people are invited (farmers, women, young and/or elder people)?
- How many women will attend, or have any be invited?
- When was the last time they were in a workshop or a classroom?
- How much practical experience do they have?
- How many trainees can participate?
- Will you need a translator for Lao Sung?
- What will the workshop or classroom facilities be like?
  - How many rooms are available, of what size? Where are these situated?
  - What sort of tables and chairs, are they movable?
  - What about electricity supplies?
  - How the conditions are for practical exercises, possibilities for field work, farm visits etc.?
  - What arrangements have to be made for accommodation, food and transport during the training?
  - How will documentation and follow-up be arranged and assured (e.g. handouts)?
  - How to send invitations in time, and to whom?

The **time** fixed for training as well as the time table should be according to the needs and possibilities of the potentially interested people. Whenever possible, it should be coordinated with certain labors related to the subjects of the intended training.

Trainings about subjects or topics especially interesting for women, such as, for example, food processing should take place at a time adequate to women. The presentation of samples and practical instructions are probably more appropriate than lectures and theory.

### Seating arrangements

Although many people are used to sitting in rows, enabling them to daydream or fall asleep even, training should not be like school. So, be creative with **seating arrangements**. They should not be seen as static and rearranging chairs and tables can help to keep participants active.

For group work and exercises, i.e., table trios and banquet style are recommendable, while role-plays, games or discussions may require a circle or semi-circle of chairs only.

**Methods of Training**

When the trainer wants the participants to provoke their learning process in a positive manner and gain their attention he/she should ask open questions, starting with „why....“, „what about...“ or „how...“.

Always there should be enough time to think about the question and to answer then, to avoid that trainees get frustrated. If they don't answer but keep quiet they probably didn't understand and the question should be formulated again, in a simpler way, to give the chance to advance in thinking and learning.

**Good questions**

- raise the interest of the trainees,
- will be answered excitedly and spontaneously,
- create transparency of the different opinions
- touch common interests,
- take the „ego“ or „self“ of the participants into account, and
- have a strategic link.

**Good questions should be followed by answers that**

- don't end, but proceed,
- show aims,
- clarify intentions,
- include confirmations about willingness and intention of action,
- appreciate achievements of the group, and
- lead to a further question.

To be criticized is not easy to accept for most people, however, a trainer has to guide self-reflection and give constructive feedback immediately, in order to address some mistakes from the past, as same as give praise as soon as possible. Give praise before offering negative comments, but don't correct mistakes as a trainer, let participants learn by doing it themselves. And criticize the performance, not the person.

Good facilitation leads to good group feeling and empathy between participants and trainers but it is also tiring. Participants may lose concentration or daydream, but as a trainer, you will have to be sufficiently concentrated to follow every idea, nuance and intervention.

## Methods of Training

As a trainer you are not only a facilitator, but you should be also a performer, as more than 50% of the message is conveyed by **how** you say the words. The tone of your voice and your body language play a big role, too. You should face the audience, move calmly and controlled, but not stiff, and from time to time to the participants' side. Speak clearly and don't be afraid of pauses. Both a loud and a quiet voice can add emphasis or drama to the statement.

It has been said that trainees remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they hear and see. As the Chinese proverb attributed to Confucius says,

**„I hear I forget, I see I remember, I do I understand“.**

In the following the term **media** will not be limited to the „classical“ meaning of audio and/or visual media, but will comprise also auxiliary aids, such as drama, exercises etc. Those are especially important to reach illiterates and make them participate actively, too.

A medium has to facilitate the transfer of information. As the only heard message is of little impact, media of visualization play an important role:

### General rules of visualization are:

- Each picture requires a title, each text its headline.
- Few statements per picture.
- Comparisons are put side by side.
- The most important fact has to be in the centre.
- Little text, and a good relation of text and drawing, with a lot of open space in between.
- Colors raise attention; but don't use more than 3 colors per picture!
- Same colors and/or symbols are to be used for same facts.
- Clear writing and drawing, and big enough for all participants to read.

### The levels of abstraction of technical facts are of the following order:

- the original or sample
- the model ( in original, reduced or enlarged form)
- the film, video and photo
- the naturalistic or perspective drawing
- the sketch, outline or plan, and the drawing in detail
- the drawing in several perspectives
- the schematic drawing, and
- the symbolic and black box depiction.

## Methods of Training

According to the habits and development of special and abstract thinking, you as a trainer have to choose that level of abstraction that is understood by the participants.

## Pro (+) and contra (-) of some visual tools and aids:

<b>Board (whiteboard partly included)</b>	+	available in almost every class-room, in general no additional costs; much space for writing and for developing facts; spontaneous use possible	-	trainer can't face the audience most of the time; use of board requires much time, as the preparation of the picture is often not possible before training; this can't be saved or re-used
<b>Pin wall (meta plan technique)</b>	+	quite easy to make it; as mobile, it can easily change places and perspectives; together with cards and pins ideal for visualization and participation of participants, very flexible	-	needs other aids such as cards, pins, pens; requires ability of (clear!) writing and some discipline
<b>Flip-chart</b>	+	little time needed for presentation, charts easy to prepare in advance; spontaneous implementation possible; colorful arrangement easy to make; trainees can be active and creative; technique of hidden parts can be used; information stay present; no electric power necessary; useful for visualization in group work and for resuming of most important points	-	standardized paper is rather expensive; handling of flip-chart is somewhat complicated; no possibility to correct incorrect drawings or presentations, nor to copy; not adequate in very large rooms
<b>Wall paper / cardboard</b>	+	cheap and easy to get; very flexible; can be prepared very good in advance; very utile to integrate participants, especially for group work information are kept present	-	difficult to make corrections; needs further aids and walls to hang on; danger of „paper attack“
<b>Overhead projector</b>	+	not much time needed for presentation, easy to prepare transparencies, spontaneous use possible; trainer / facilitator keeps in touch with the audience, as facing them is possible	-	expensive equipment and materials, electric power needed, somewhat noisy
<b>Slides projector</b>	+	same as above, but appropriate for big audience, too; realistic presentation	-	relatively stiff, not as flexible as overhead projector; darkening is tiring for participants, expensive equipments, materials; electric power necessary
<b>Video</b>	+	very popular, realistic presentation possible, including processes, development of facts, flexible	-	expensive equipment and materials, electric power needed; „danger“ of „only consumption“ without learning effects
<b>Leaflets / handouts</b>	-	Leaflets or hand-outs for the participants should contain little, but precise text, and clear drawings to memorize the facts and procedures or actions of the training.		

## Methods of Training

**Non-audio-visual** forms of presentation may be done by using games or practical exercises:

### „Learning by doing“

is one of the most important principles, as human beings learn best, when many senses are active and multiple activities carried out.

There is a big variety of methods related to interactive and process focused training. Perhaps, best known is to copy the craft, apply it to a new situation, and train it by doing it again and again.

Other **methods** are:

- talk/ discussion/ debate;
- Role play/ plan game/ case study;
- excursion/ study trip;
- interview;
- documentation/ presentation/ publication;
- team work;
- practices and projects.

An ordinary lecture is not mentioned here as it is not an interactive approach, but probably the most commonly practiced method in trainings. Some more detailed ideas and descriptions are given below.

A proposal for how to structure a **training unit for practical skills** may be the

### Four-Step-Method

**Step 1:** Raise attention, explain reasons for and purpose of the instruction; possibly, make aware of dangers.

**Step 2:** Show the procedure step by step, and explain in detail:

What is going to happen?

How does it happen?

Why does it happen?

Make trainees aware of possible accidents, mistakes, etc.

Make sure that trainees understood well.

**Step 3:** Make trainee copy the procedure without interruption, make repeat trainee the procedure, explain „what“, „why“ „how“, and possible reasons for accidents; make corrections done by trainer or trainee.

**Step 4:** Deepen the learnt process by repeating the procedure in a fluent way.

Some examples of how to make people get used to approaches of problem solving strategies:

## Methods of Training

**A) „Map your neighborhood“**

**Objectives** To give participants the opportunity to experience diagramming, and so understand some of the processes  
To give them the opportunity to appreciate issues of scale, symbols, direction and omission in diagramming

**Materials** Pen and paper; variation: floor / backyard, pebbles, sticks, straw

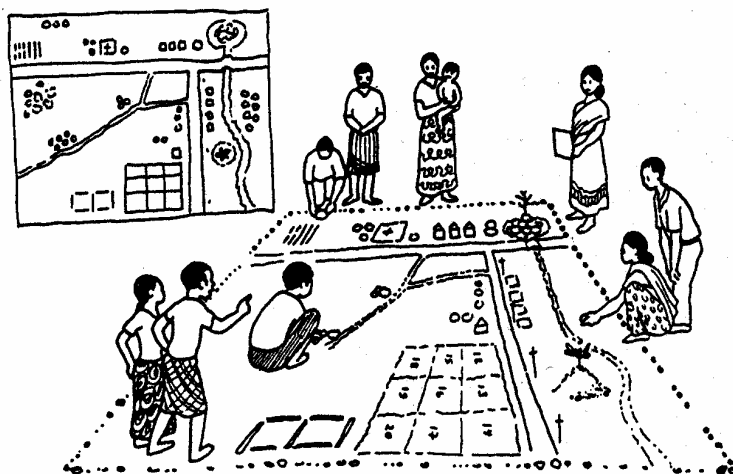
**Time** 10 minutes

**Procedure:**

1. Ask participants to think about where they live and then to draw their neighborhood. They should include major landmarks, resources of importance and transport routes.
2. After 5 minutes, stop the drawing and discuss what happened.
3. Ask for all maps to be exhibited (on the wall), so that all can observe the different styles and symbols.

**Comments**

- This is a very short exercise that can be used as a very first introduction for a session on mapping, and a form of expression for illiterates. You can use the following questions to help in the debriefing:
- Where did you put your house? (in the middle, at the edge)
- What happened when you came close to the edge of the paper? (edge of paper is a false boundary; scale gets distorted; elements omitted)
- What did you draw first?
- Which direction is north on your map?
- Which of you have lived in your house for more than 5-10 years? How does your detailed knowledge compare with anyone who has only just moved to their neighborhood?
- Variation: Ask participants to draw the neighborhood in which they were living when aged 10.



## Methods of Training

**B) „Flow diagram for systems and impact analysis“**

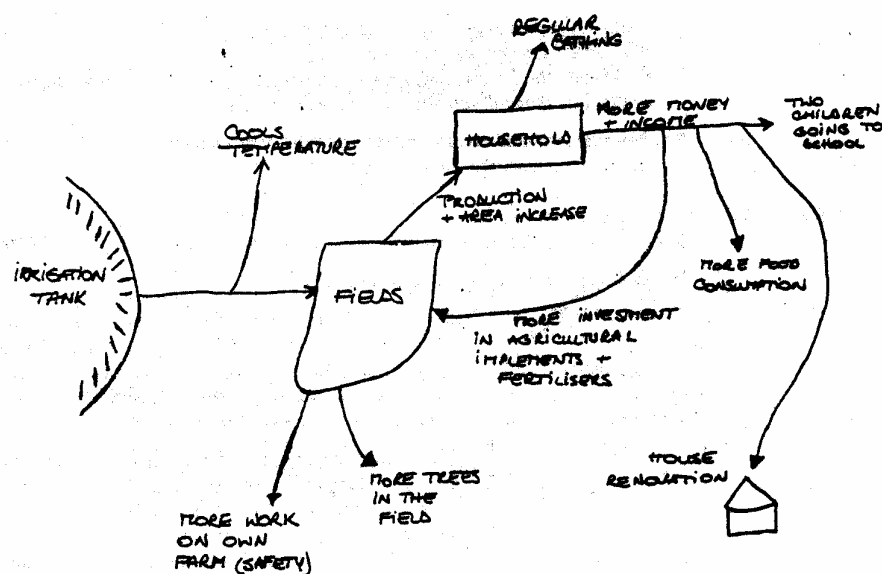
<b>Objectives</b>	<p>To illustrate how farm and livelihood systems can be shown on a diagram, leading to a better understanding of the complexities of linkages and relationships at the local level</p> <ul style="list-style-type: none"> <li>- To illustrate how the impact of an intervention or process can be represented on a diagram, leading to a better understanding of the anticipated and unexpected effects from local people's perspective</li> <li>- To describe the basic principles and procedures of flow diagrams</li> </ul>
<b>Materials</b>	Large sheets of paper, pens; or board, chalk, or floor and wooden sticks
<b>Time</b>	1 -2 hours
<b>Procedure:</b>	<p>First divide participants into groups, using a group-forming exercise</p> <p><b>for systems diagrams:</b></p> <ol style="list-style-type: none"> <li>1. Ask them to consider a typical farming system in an area they know well. The first step is for them to identify and represent the components of the farming system</li> <li>2. Then ask them to show the linkages between the different components (such as manure from livestock to fields, fuel wood from trees to home-stand)</li> <li>3. Next they should show the linkages that the farm has with markets, hospitals, seed stores, distant towns, etc.)</li> <li>4. Discuss with the groups whether the system they have depicted has changed over time. What happens if certain linkages break down?</li> </ol> <p><b>for impact diagram</b></p> <ol style="list-style-type: none"> <li>1. Ask the teams to select an activity or event, the impact of which they wish to explore. This may be the impact of a program (such as an irrigation project), or of policy changes (such as structural adjustment program), or of household changes (such as disabling illness in a family member). They could also consider the impact of the training on their lives or work.</li> <li>2. Ask them to represent the impact on paper, (board, floor), and then identify the consequences of the activity or event. This could be both positive and negative. Ask them to link the consequences, using arrows to indicate the direction of flow.</li> <li>3. Encourage them to think of primary, secondary and tertiary effects, grouping these into different sub-systems</li> <li>4. Ask them to exhibit their flow diagrams and have a debriefing session</li> </ol>



## Methods of Training

**Comments** Show the results of the group work by having a roving exhibition, with all the participants visiting each group in turn. Use these presentations to allow participants to reflect on actual findings and on methodology:

- How will the process differ in the field?
- What have you learned as a group from this exercise?
- What problems do you anticipate?
- What possible applications can you think of for your work?



Notes:

## Methods of Training

## C) „Seasonal calendars“

**Objectives** To demonstrate ways to explore changes during the year

**Materials** Locally available materials (stones, sticks, seeds, beans, etc.), pens, chalk,...

**Time** 20 minutes to 1 hour

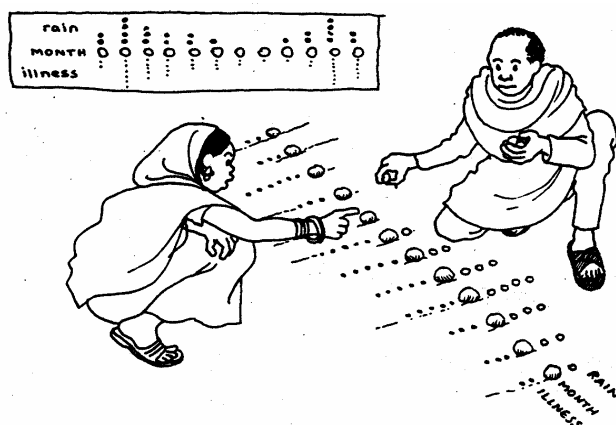
**Procedure:**

1. Divide the participants into small groups of between 3 and 5 people by using a group-forming exercise
2. Each group may be asked to create a calendar of a certain pattern, e.g. a typical cropping pattern, or one about the rising of certain pests and diseases, during a year, or over a range of time, agreed upon in advance. Agricultural labor, and income and expenditure calendars for men / for women, or daily activity diagrams for particular groups (young men, young women, older men, mothers, etc.), and/or daily activity calendars, comparing the situations before and after some intervention or introduction of a new technology, may be of interest, too.

**Comments** After the diagrams have been completed (usually 20-30 minutes), ask each group to present its „findings“ to the others. Encourage the groups to concentrate on the process they went through, not just the final product.

Talking about the **analytical potential** of visual representation of seasonality may raise issues including

- their use in the analysis of intra- and inter-household differences in daily activities, which can lead to the identification of constraints and appropriate times of day to schedule meetings with various groups;
- their value in identifying trends and changes over time;
- their utility in discovering correlations and connections between different seasonal patterns (such as precipitation, and possible disease or pest attacks, and income and expenditure) which might help to understand causes and effects;
- their power in conveying useful information that everyone -literate and non-literate- can understand and assess;
- their value for monitoring the impact of interventions or projects



## Methods of Training

## Examples of exercises for energizing and forming groups

## 1 “Fruit salad“

<b>Objectives</b>	<p>To get the group active and awake, especially good after lunch or to break a long passive session</p> <p>To form sub-groups, each with an easily remembered name, for further group work</p>
<b>Materials</b>	Chairs arranged in a circle, one fewer than total number of participants and trainers.
<b>Time</b>	10 minutes
<b>Procedure:</b>	<ol style="list-style-type: none"> <li>1. Decide on the number of groups that are needed, as this will determine the number of fruits selected. Set up a closed circle of chairs, one fewer than number of people.</li> <li>2. Ask the participants to sit in the chairs. The trainer begins the game by standing in the middle. Explain that this is an energizing exercise which will require their (very!) active participation.</li> <li>3. Let the participants name as many fruits as you need sub-groups, and let one person choose a fruit, their neighbor another fruit, the next neighbor another, and so on, repeating the fruits in same order, until everyone has a fruit name.</li> <li>4. Before you start, ask all the „orange“ to put up their hands, the all the „melons“, etc. This will just remind everyone once again of their fruit.</li> <li>5. The person in the middle calls out the name of one fruit. All those participants who are that fruit must change chairs - no exceptions! The person in the middle will also try to get a seat!!</li> <li>6. One person will be left in the middle, who then repeats the process by calling out another fruit.</li> <li>7. When “fruit salad“ is called out, then everyone must change chairs!</li> </ol>
<b>Comments</b>	<ul style="list-style-type: none"> <li>• This exercise can be a great deal of fun. Participants will be fully active in a couple of minutes of organized chaos. It does need someone to stop the game, and as the trainer, you should conclude by allowing yourself to be left in the middle. This is easiest after “fruit salad“ has been called.</li> <li>• Assign fruit names to tables and ask everyone to sit in their new groups. There is no debriefing. If group work is required at a later stage these fruit names can be used again.</li> <li>• This game mixes hierarchies and relaxes participants. It also divides friends and colleagues into separate groups as they tend to sit together in the circle. There are endless variations to “fruit salad“, including “vegetable soup“ (kinds of vegetables), “farm yard“ (farm animals), “fish pond“ (fish species), “rainbow“ (colors), depending on the training subjects, or local preferences.</li> </ul>

## Methods of Training

**2 “Robot”**

<b>Objectives</b>	To energize the group To demonstrate how difficult it is to manage two things at once
<b>Materials</b>	None
<b>Time</b>	15 minutes
<b>Procedure:</b>	<ol style="list-style-type: none"> <li>1. Divide the participants into groups of three, in which one person is to be the robot controller and the other two the robots. The controllers each manage two robots. They move the robot to the right by touching the right shoulder/arm and to the left by touching the left shoulder/arm.</li> <li>2. Begin by telling the robots to walk in a specific direction.</li> <li>3. The controller must try to stop the robots crashing into obstacles like tables, chairs and walls.</li> <li>4. After about 2-3 minutes ask the controllers to switch roles with one of the robots of their group, and after 3 minutes again, so that everyone has experienced to be controller once.</li> <li>5. Ask participants what it felt like to be a controller trying to control two robots at once.</li> </ol> <p>Ask what it felt like to be a robot.</p>
<b>Comments</b>	<ul style="list-style-type: none"> <li>• Changing roles after a few minutes is essential so that no one gets frustrated about playing a particular role.</li> <li>• The debriefing should focus on what is good and bad about being a controller and a robot.</li> </ul>

Notes:

## Methods of Training

**3 “Animal Conference”**

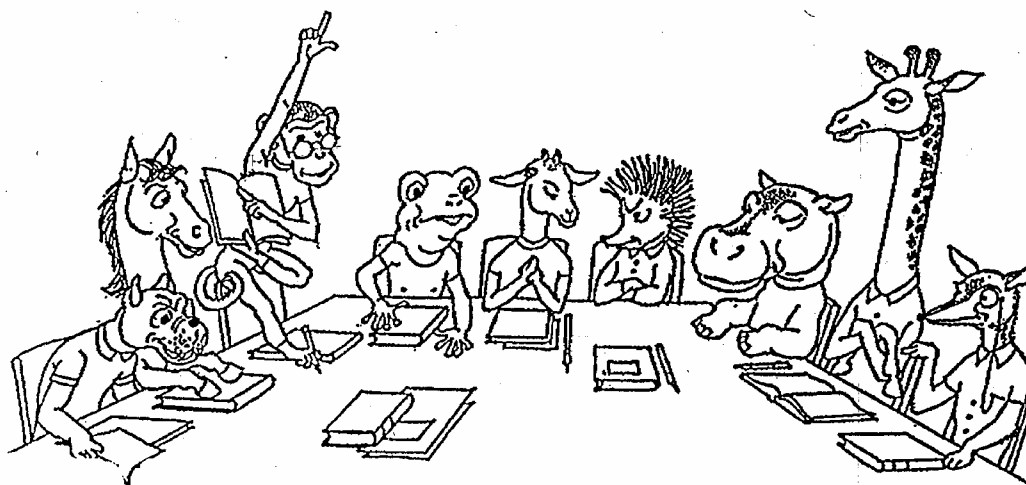
**Objectives** To energize the group  
To form sub-groups

**Materials** Slips of paper with animal names on it, one for each participant

**Time** 5 minutes

**Procedure:**

1. Prepare sufficient cards with animal names in groups of 4 or 5. Choose animals that have recognizable noises, such as dogs, cats, sheep, cows, etc.
2. Let each participant pull one slip of paper, out of a basket or your hand, and ask everyone to walk around the room, exchanging their animal's typical sounds as they meet other people.
3. Tell them that when you call out “meeting” everyone should try to form a united animal species group. Everyone will start to make noise of their animal in effort to be done first.
4. Collect paper slips and mix them again, for starting a new game.
5. When you feel the group is energized and relaxed, stop and proceed with sub-group work, keeping the “animal families” together.



Notes:

**Gender Issues****Some thoughts about gender**

The training should be directed to those people who are mainly touched by its' subjects and contents.

That means that for some topics priority is to be given to men, for other to women, and in several other cases to both sexes in equal parts, as these are practically carried out by men and women. As the sexual division of tasks and labor may vary regionally these should be figured out in advance, to prepare a training or workshop to the best use of all people involved. Along with the people themselves, take a good look at what women and men are actually doing in agriculture, including labor for self-consumption, as well. What are their specific needs and interests? What will be the differing impact and effects on women and men, transferred by the training? How can be worked in such a way that all members of a community are empowered?

Notes:

**Chapter 1****Background Information**

Lao PDR, covers an area of 236.8000 km<sup>2</sup> with 80 % hilly to mountainous topography and with borders to China, Vietnam, Cambodia, Thailand and Myanmar. The agriculture production area for vegetable and other agriculture crops, without rice, comprises 350.000 ha and can be mainly distinguished in production systems in urban and rural production areas, where the rural systems generally covers upland/sloping land production techniques. In both areas production, infrastructure, marketing, and consumption are different.

Horticultural production is mainly provided by small, self sufficient farmers supplying urban markets with their excess products when available. During recent years, changes in production economy and trade system have stimulated food production and -processing, but it is likely considered that in mid term run small farms will remain the basic source of foods in Lao society. The structure of production and employment is dominated by subsistence agriculture, which accounts for about 51% of GDP and it is estimated that 85% of the population rely on farming practices.

Vegetables and fruits play a vital role in the nutrition of Lao people and in providing an income for small holders. Every part of the country grows horticulture products. Growers make small plots near their houses, in river banks, and in islands along the Mekong River and its tributaries. In urban areas, mainly on flat-land and alluvial soil along the river banks, private gardeners produce on farms with up to 2 ha different vegetables for local markets. Production systems are fairly out of date and consider through lack of manpower and investment the conventional way of production. Especially here a big potential should be seen in environmentally sound production, taking in account all parts of the production chain up to the final product.

There are many types of vegetables grown in Lao PDR from 15 April, along the Mekong River and its tributaries, until water from the river has submerged all the growing areas along its banks. Common vegetables grown in dry seasons are: asparagus, cabbage, carrot, cauliflower, chayote, cowpea, cucumber, eggplant, garlic, ginger, hot pepper, onion, potato, pumpkin, tomato, watermelon, yam, yardlong bean.

Due to the largely topographic, significant variations occur in climate, demography, accessibility and socio-economic conditions. Thus both geography and climate represent major



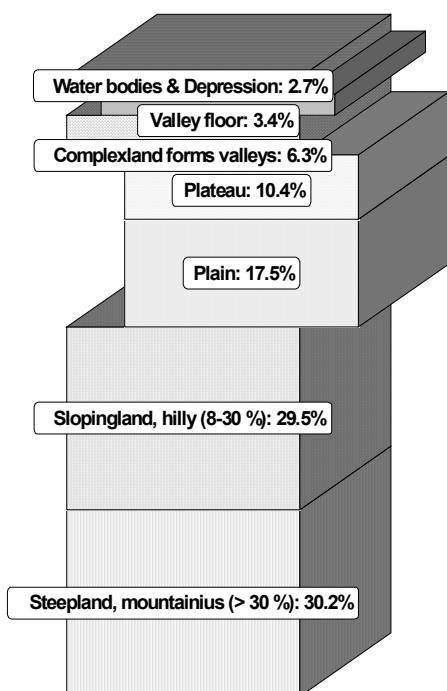
constraints for communication and access. The Mekong River and its tributaries divide the

country into the lowlands of the Mekong Valley (up to 200 m above sea level), which comprise the principal agricultural areas, suitable for rice growing and into the forested mountain areas (up to 2,800 m above sea level). The Annamite Chain of mountains runs parallel to the Mekong River and has rugged peaks between 1,600 m and 2,800 m with the Nakay Plateau at the center. Towards the southern end is the Bolaven Plateau, which rises about 1,000 m and covers an area of about 100,000-km<sup>2</sup>. The northern half is made up of mostly broken steep sloping mountain ranges. The alluvial plains and terraces of the Mekong River and its tributaries cover about 20 % of Lao PDR, the remaining 80 % being mountainous, with altitudes generally ranging from 1,000 to 3,000 m. The Mekong River traversing Lao PDR from north to south. Its flow varies greatly according to season, with highest levels from August to October where flooding of the surrounding is common and the

lowest levels from February to April.

The climate is classified as wet/dry monsoon tropical climate. And it is characterized by two distinctive seasons, dry- and rainy (wet-) season. The rainy season starts from May to October and the dry season from November to April with high temperatures and humidity. The average temperature varies from 10° - 25°C in the winter and 25° - 40°C in the rainy season. Highest temperatures are recorded during March and April, reaching 40°C in provinces of the Mekong River valley. Lowest temperatures are recorded during December to January when, in the same provinces, it can drop to less than 15°C; in more mountainous northern areas temperatures below 0°C are sometimes recorded.

The annual Asian monsoon cycles of mainland South-East Asia produce a dry season which can be divided in two more seasons which are the hot dry season and the cold dry season. The cool dry season arrives in November after the wet season with cooler weather and reduced humidity. The average temperature may drop to 18°C. The weather can continue



**Chapter 1****Background Information**

The tropical lowlands receive an average annual rainfall of 1.250 mm (mainly during the rainy season extends from April to October over 60%), while in the highlands the annual rainfall can reach more than 3.000 mm. Also the rainfall decreases from south to north. Savannakhet in the south and Vientiane in the central region receive between 1500 and 2000 mm. Luang Phrabang, Xayabury and Xieng Khuang in the north receive between 1000 and 1500 mm. The Mekong river traversing Lao PDR from north to south. Its flow varies greatly according to season, with highest levels from August to October where flooding of the surrounding is common and the lowest levels from February to April.

Until February when the hot dry season begins, with temperatures up to 40°C in March-April, only broken by the odd “mango-shower” of rain. A built-up of storm activity in April-May with increasing humidity, heralds the wet (rainy) season during June-October, typified by a more consistent pattern of rain and cloudy days through June, July and August (average temp 29°C).

Nevertheless, taking in account the potential of cultivating vegetables and fruits in Lao, the country depends on imported fresh products mainly from its neighboring countries. Estimates indicate that 40 to 70 % depending on the season and the species, have still to be imported. Those imports are traded via the borders of the neighboring countries, mainly Thailand, China and Vietnam. Local production is forced to respond to those imports with more quality and cheaper products. Some products such as marmalade, juice, and others are currently exported to European countries.

In the rural areas the “family business” in home-gardening and some small scale production areas for vegetable and fruits have been established primarily to enrich the daily diet with fresh healthy vegetables and fruits. A potential for production of appropriate niche products (e.g. low chilling fruits in Xieng Khouang) can be considered.

Figures about fruit production and consumption are fairly limited and can be only estimated through own observations and experiences. Local nucleuses are developing market oriented fruit plantations of e.g. papaya, mango, lemon, tamarind, sapodilla, bananas, pineapple ly-chee, coffee and some others which are common for the country. Also some low chilling fruits in highland areas with elevations between 1.000 to 1.200 m.a.s.l., e.g. Bolaven Plateau (coffee, banana, cabbage) Xieng Khouang (peaches, plums) feed the Lao Fruit production.

## Chapter 1

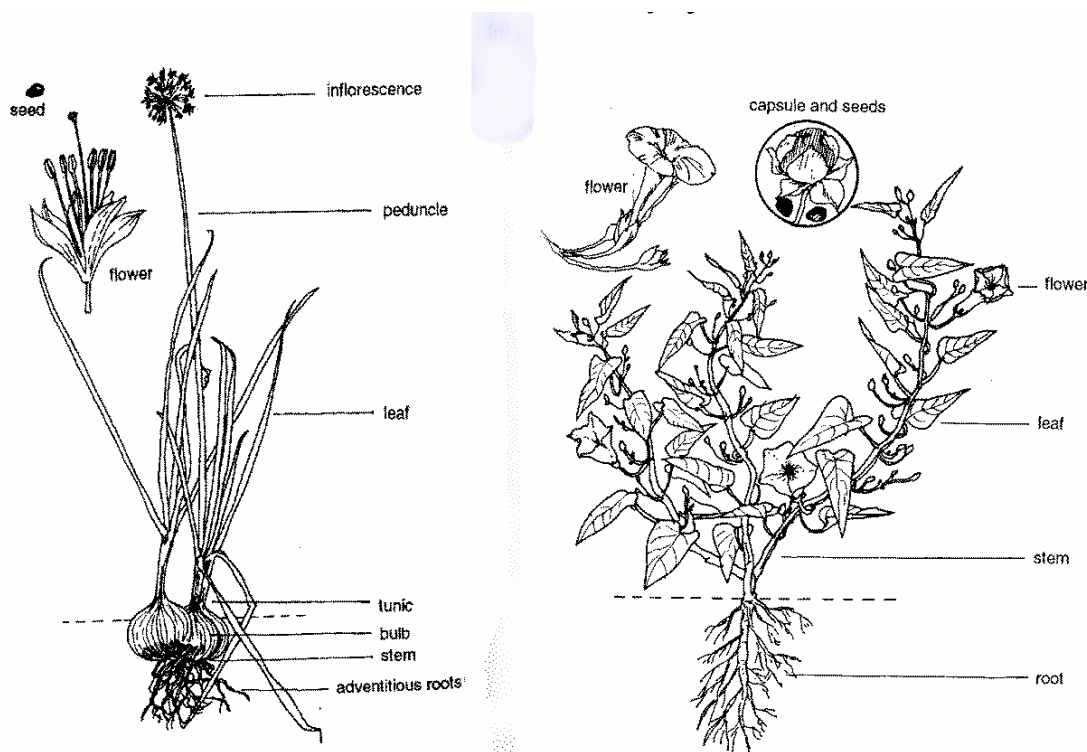
## Background Information

## Basic knowledge of botany

## Phenotypes and Reproduction

The plant can be divided into two parts: The stems, leaves, flowers and fruits make up the **shoot** that is the part of the plant we see above ground.

Although the **root system** is largely unseen, it plays an important role in the growth and development of the plant. It absorbs the necessary water and mineral nutrients, aside from anchoring the plant to the soil. In many crops, roots associate with fungal or other soil organisms, resulting in a complex but generally beneficial relationship. Roots also serve as storage of food materials as in the case of root crops, such as sweet potato and carrot.



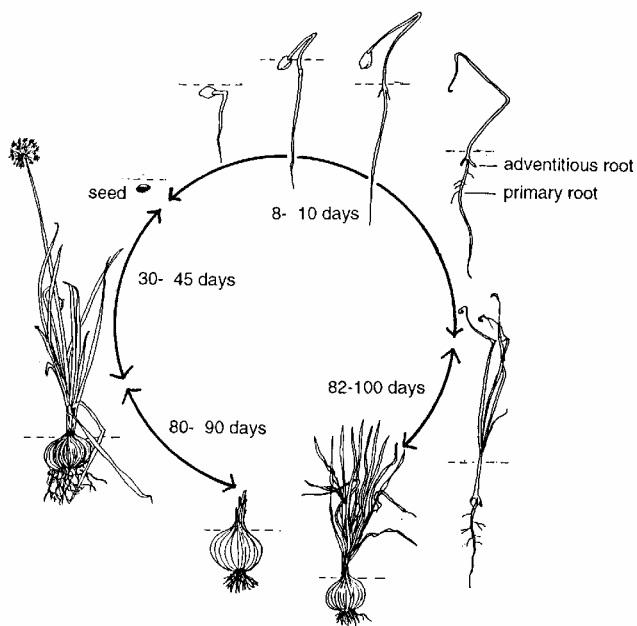
The root and shoot system tend to balance each other.

The **flower is the reproductive organ** of the plant. A plant will flower to produce seeds that will reproduce the plant. Normally, it has passed through a juvenile stage and produced a minimum amount of vegetative growth, thus reached a certain stage of development when it is ready to flower, provided the conditions are right.

Some vegetable crops are very sensitive to day length, they flower when exposed to specific periods of light and dark. Flowering starts when the vegetative growing point deep inside the bud is transformed into small flower parts. Then the individual floral parts form and develop and finally the flower opens.

## Chapter 1 Phenotypes and Reproduction

Life cycle of onion

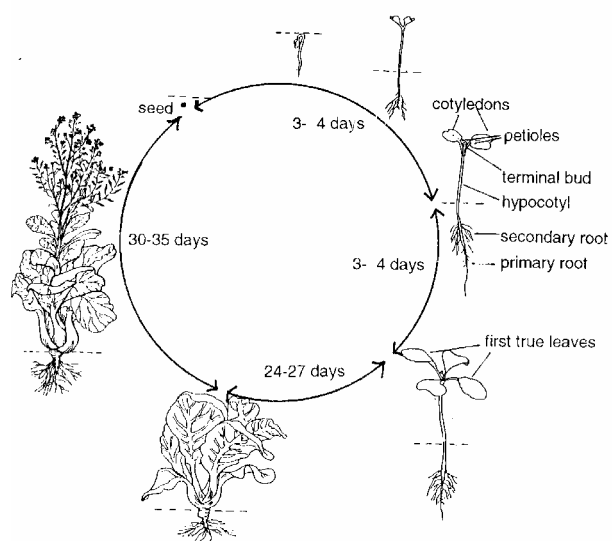


Days from seed to bulb = 90-110 days

Days from stored bulb to seed = 110-135 days

Newly harvested bulbs are kept in cold storage for about 3 months before planting for seed production.

pechay



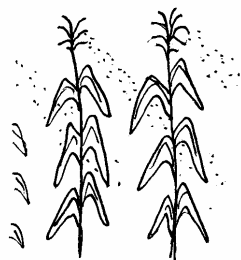
Days from seed to seed = 60-70 days

## Chapter 1

## Phenotypes and Reproduction

**Pollination** and fertilization have to take place before seeds can form and grow.

A flower is pollinated when the pollen from the male (part of the) flower is transferred -by wind, insects or birds- to the female (part of the) flower. Inadequate pollination results in mis-shapen fruits (as in gourds), missing kernels (as in sweet corn), or low fruit set.

**pollination by wind**

sweet corn, spinach

**self-pollinated vegetables**

tomato, lettuce,  
legumes

**pollination by insects**

asparagus, broccoli, celery, cabbage, Chinese cabbage, carrot, cauliflower, cucumber, eggplants, gourd, kale, melon, mustard, onion, pepper, pumpkin, radish, squash

**Fertilization** is the successful union between pollen (male) and egg in the ovary (female). The seed starts to form once fertilization has taken place.

Some vegetables and fruit crops produce fruits without seeds. This may happen even without pollination. The fruit may have what appears as small seeds but are actually just seed coats of undeveloped seeds. Seedless fruits occasionally occur naturally in cucumber, pepper, pumpkin, tomato and eggplant.

The change of the ovary of a flower into a young fruit is called **fruit set**. Low fruit set results in low yields. A too high fruit set may result in small and poor quality fruits. Hence, removal of some fruits (thinning) is practical (see also Chapter 6).

**Hybrid seed** is the result of plant breeding aiming for high quality and yields. Hybrid seed should be bought every season new, as the special characteristics get lost when propagated again.

**Open pollinated seed** of selected plants can be used for reproduction.

## Chapter 1

## Phenology and Reproduction

**Questions**

What are the principle parts of a plant?  
What are the main tasks of the roots?  
What is necessary to get fruit set?  
What does pollination mean?  
What does „hybrid“ mean?

**Practice**

After having given a short introduction distribute entire plants to teams of 4-6 participants; they may figure out the main plant parts and their functions (and give a brief presentation to the plenary).

**Materials**

Several entire crop and/or herb plants  
enlarged copies of drawings of flower, shoot, root system, fruits

**Time  
required**

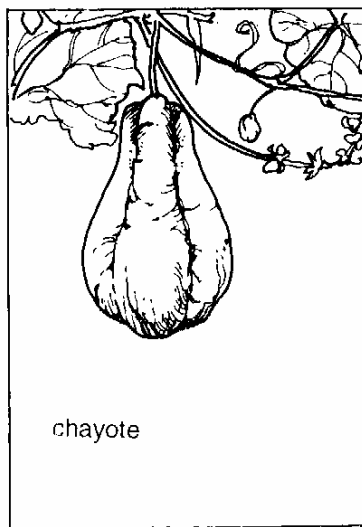
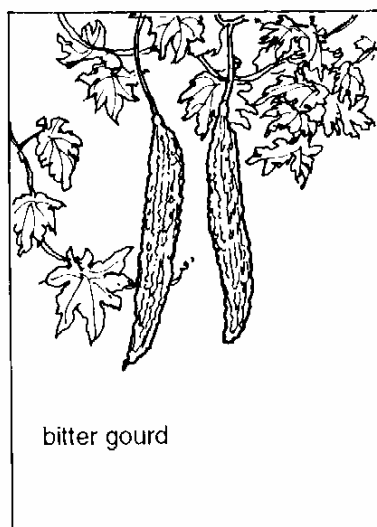
10-20 minutes

Notes:

## Chapter 1

## Botanical Classification

For practical purposes, a vegetable or fruit crop is classified starting from the **family** group. Crops belonging to the same family are subject to similar pests and diseases. Therefore it is very useful to know to which families the crops grown belong to, and to avoid accumulations of pests and diseases by mixed cropping and rotation (see: Principles of multi-cropping).



#### The family of *Cucur-*

*bits* comprises e.g. Cucumber (*Cucumis sativus*), squash (*Cucurbita maxima var. maxima*), bitter gourd (*Momordica charantia*) and chayote (*Sechium edule*).

Other crops belonging to this family are muskmelon, pumpkin, bottle gourd, sponge gourd, wax gourd and snake gourd.

The name of a plant is composed of **genus** (= „surname“) and **species** (= “first name“), and specified by **cultivar** or **variety** (=“nickname“).

<i>Alliaceae</i>	<i>Apiaceae</i>	<i>Brassicaceae</i>	<i>Poaceae</i>	<i>Fabaceae</i>	<i>Solanaceae</i>
chives	celery	(chin-) cabbage,	bamboo	all kinds of	tomato, pep-
onions	carrot	broccoli, cauliflower,	sweet corn	beans (ex-	per, egg-
garlic	parsley	Kale, mustard, turnip,		cept yardlong	plant, potato
		radish, watercress		bean), peas,	
				tamarind	

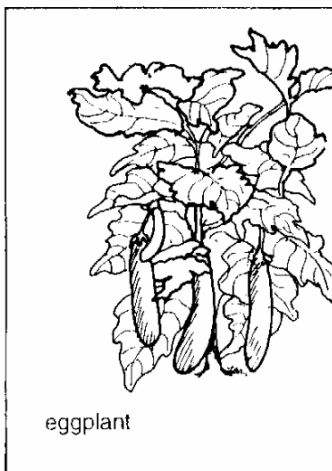


## Chapter 1

## Botanical Classification

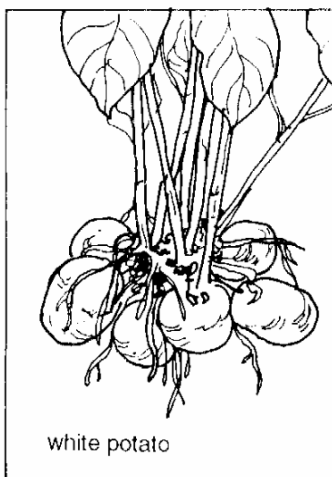
Species of the same genus may differ considerably, in phenotype, geographical distribution and uses. Varieties of one species may be distinguished because of their adaptation to certain climatic conditions (local varieties!) or of being heat-, drought-, salt-, or shade-tolerant.

The family of *Solanaceae* includes the following crops:



Tomato  
*Lycopersicon esculentum*

Eggplant  
*Solanum melongena*



Sweet pepper  
*Capsicum annuum*  
var. *annuum*

White potato  
*Solanum tuberosum*

## Chapter 1

## Botanical Classification

## Questions

What is botanical classification?  
Why is it useful to distinguish plants of different groups?  
(for further information see: Multiple cropping, rotation)

## Practice

Have samples (or pictures) of different crop plants ready to let the participants assign these to botanical families, and explain.

## Material

Samples of minimum 10 different crop plants or  
pictures of minimum 10 different crop plants

## Time

## required

15-30 minutes (depending on number of groups and samples or pictures)

## Games /

## Exercises

Each participant gets a sample or picture of a crop plant and its name.  
Now, similar to „Fruit Salad“ shout out names of botanical families and let the participants form groups („Get up all of the *solanaceae*! - Get up all that are not of the *cucurbitaceae* family!“, etc.)

## Media

E.g. advertisement posters of seed producing companies, catalogues, etc.

## Chapter 2

## Preliminary Thoughts

„Regardless of farm size, managerial experience, or productive resources, farmers throughout the world are made up of physical, psychological, social, and political components which identify them as human beings. Their farm operations are not machines which may be replaced by more efficient models or which, if left unchanged will replicate last year's results this year. This is not only due to the variability inherent in producing crops and animals, but also because of the frequent decisions unrelated to farm production which the farmer makes in his larger role as a human being.(...)

Significant differences appeared between lowland and upland farms in regard to resource endowment, water availability, and the ranking of agricultural problems...(P. H. Calkins, 1984).

Before starting a new cropping season, and even more before making larger innovations, the farmer (or just: I !) should know about the actual limitations of the farm and about the hidden potentials as well.

Many farmers are used to grow always one and the same vegetable or field crop they have experience and been successful in for a couple of years.

If paddy rice, for example, is considered the standard of growing practice, then the traditional knowledge of mixed cropping may become meaningless.

If livestock is considered a symbol of welfare and prestige, and to look for food on its own, instead of keeping it fenced in and supply it with fodder, then consequently cropping systems must be designed different.

Free-roaming cattle causes probably more damages, thus economical losses or costs, than an equal number of flocked animals that are fed with fodder crops (and supply with manure by the way) if done right.

Remember: In general, it takes 7 times the energy (received from plants or plant parts) and land to produce the same amount of animal protein, as plant protein got immediately!

People, who grew up in the uplands have different views and experiences, deeply founded in that specific natural and social environment, from those grown up in the lowlands and formed by distinct needs, values and living conditions.

Traditional agricultural practices make sense as long as the preconditions do not change. When they change may problems arise that require solutions different of those found in the past. And it might be necessary to change minds, too: In view of highly rising population and rapidly decreasing forests practices such as „slash and burn“ or shifting cultivation are not longer adequate, but „out of fashion“. Jumping out of middle ages just into high-tech modern times is also not adequate at all, but sustainable agriculture is „in“.

A definition about what does sustainable agriculture for Laos mean:

**Sustainable Agriculture (SA)** is agricultural activities which use appropriate techniques adopted by farmers, do not destroy the environment, are not hazardous to human beings, are

## Chapter 2

## Topographic and Soil Conditions

profitable for the farmers themselves and maximize the use of local resources such as agricultural by-products. Priority is offered to poor farmers.

SA is a system that aims to work in a balance with all elements in the natural ecosystem, people, soil, water, crops, animals and health.

Concretely does it involve, e.g. soil fertility and nutrient management, cropping patterns, indigenous knowledge, integrated farming, pest and disease management, IPM, and many other aspects (K. Lexayavong, 1999, in: Lao PDR country profile).

**Topography** refers to the levelness or roughness, the degree of slope on hillsides, and the general form of the earth's surface. An example of the modifying effect of topography on climate is the greater amount of sunlight received by a slope facing the sun compared to that facing away from it. A large body of water near a farm reduces fluctuations in temperature.

How much flat land do I have on my farm, how much slope land, and how steep?

How many depressions and where?

How deep these are and what shape do they have?

### How are soils formed?

Soils are derived from the decay of various kinds of rocks

#### 1. by decomposition:

Alternate heating during the day and cooling at nighttime makes the rock surface brittle and later chips. Rain water enters developing crevices, creates series of chemical reactions inside the cracks and allows later seeds to germinate and their roots to grow in order to break it up. Further breaking down of rock fragments leads into various grades of soil textures.

#### 2. by distribution:

Soils from the decay process are transported and laid down or by running water or streams, or by gravity from the top slope downwards, or by the wind, thus forming a new soil body.

#### 3. by enrichment:

As soils are eroded and transported to other land surface, the receiving soils are enriched with fresh sediments carrying various materials, like un-decomposed and decomposed organic matter.

The soil holds up the plant and acts as a reservoir for water. It is also the main source of plant nutrient elements. The mineral parts tend to group together so that there are spaces or

## Chapter 2

## Topographic and Soil Conditions

spores which are partly occupied by air and partly by water. The solid part of the soil is composed of mineral particles of different sizes originating from broken down rocks, and of organic matter, that is the remains of plants and animals at different stages of decomposition. The mineral particles are called sand, silt and clay, and loam is a mixture of these in more or less equal proportions.

**Why is soil important?**

Not only, because we walk, build and plant on it, but good soil is essential for us because it feeds us, our animals and wildlife, and almost all plants we eat. And only if we take care of the soil, it will provide us with food and all the materials we need.

Plants can't choose their „home“, and they can't run away aiming to look for better „housing“ conditions. We as growers have to provide for their „accommodation“ if we want high yields and tasty fruits and vegetables.

Let's try to compare a plant root's "home" with our household.

**Soil fertility** is a complex term including

<b>soil depth (depth penetrable to roots)</b>	deep	= house big enough to feel well and stretch the body
	shallow	= house too small and narrow
<b>soil texture (proportion of mineral particles)</b>	good	= walls and roof to protect from wind, rain and sun, but ventilation
	bad	= defect walls and roof don't protect from sun and wind
<b>soil structure (prop. of solid matter and pores)</b>	good	= windows and doors to look and go out, to breathe
	bad	= dark and musty rooms
<b>soil reaction (acidity)</b>	low	= a kind and friendly neighborhood
	high	= neighbors unfriendly and dishonest
<b>Humus content/ composition (Decomposed organic matter)</b>	high	= grass and straw for buffalo, or: fuel for machines
	low	= lack of grass, straw, fuel, etc.
<b>Activity of microorganisms (depends on org. matter content)</b>		= number, willingness and capacity of helping family members or workers, or amount, kind and availability of tools, machines or draft buffaloes
<b>Nutrient content</b>	high	= diversity of foods available
	low	= only rice to eat
<b>Storage capacity for nutrients</b>	high	= secure storage place for rice, maize, fruits, nuts, beans, flour
	low	= no storage means: no food security
<b>toxic/detrimental substances</b>	absent	= clean and sound surroundings
	present	= poisoned waters, stinky wastes, scrap metals, diseases, mosquitoes

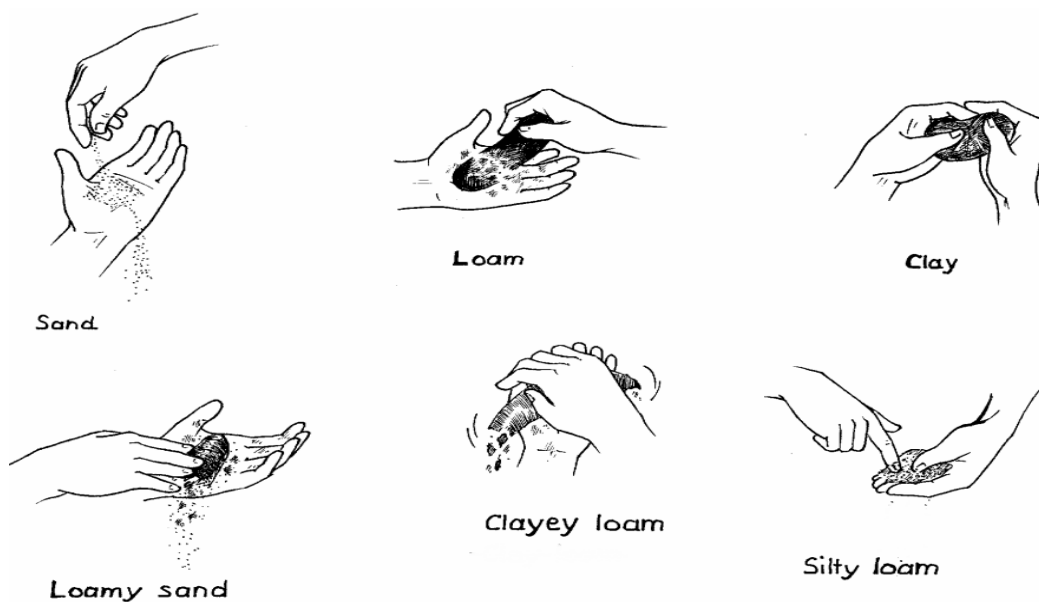
## Chapter 2

## Topographic and Soil Conditions

We must always be aware that rice is **not** a crop comparable to any other: Rice roots are capable to withdraw oxygen from soil water, that's why rice grows in flooded and compacted paddy where even weeds don't like to grow! All other crops need better soil conditions.

The **feel method** can be used to determine **soil texture**. The soil is first moistened, then rubbed between one's fingers to feel how smooth or gritty it feels. Then it is tested whether it can be shaped, whether it is sticky, or whether it can be stretched.

Sand	- does not stick together, is coarse or gritty
Loamy sand	- tends to stick to each other; if shaped and handled, it will easily break.
Loam	- easily crumbles, breaks up when rolled out into a ribbon; sand grains cannot be felt in a moist sample.
Clayey loam	- somewhat crumbly but somewhat plastic; rolls out into a ribbon between the thumb and forefinger when moist.
Clay	- powdery when dry; tough, plastic, sticky; and rolls out into a ribbon between thumb and forefinger when moist.
Silty loam	- soft and floury when dry, has smooth feel, will not form into a ribbon if rolled when moist.



## Chapter 2

## Topographic and Soil Conditions

**Sandy soils** are best suited for the root, bulb, and tuber crops provided rainfall is adequate or irrigation is available.

**Loamy soils** are ideal for vegetable production and most fruit trees as well. They have a good mixture of sand and clay, so they have good nutrient- and water-holding capacities and provide good aeration.

**Clayey soils** are difficult to work, and although they absorb high quantities of water and nutrients, these are not easily available. Root penetration is more difficult than in loamy soils, just favorable for paddy rice.

**Questions**

- What does topography mean?
- How are soils formed?
- Why is soil important?
- What does soil fertility mean?
- What does soil structure mean?
- What are the components of soil texture?
- What are possible problems related to certain topographical conditions?
- Which crops are suitable for which kind of soil?

**Practice**

For demonstration of water erosion problems pile up some soil in a vessel or sink; form first a shallow „slope“ and pour water out of a can or glass, then repeat the procedure at a steeper „slope“ and note the difference in effects, discuss.

If possible go out and take a shovel or prepared iron water pipe with you. Dig 20-50 cm deep or bore into the soil to take soil samples out and get an idea about structure of the topsoil. Use the feel method (as described in the text) to get an idea about the soil texture.

**Materials**

Shovel or „drilling“ iron water pipe (if soil soft) of diameter 1“ that has been cut over the length of 1m and a breadth of nearly 1cm, pointed below and sharpened on the edge, which has a handle of 40-50 cm long, a big vessel or sink, a watering can, bucket or hose, soil of different types.

**Time required** 30-60 minutes

**Games /Exercises** See above under Practice.

**Media** Video „Poverty and the Environment“ (PADETC; Haddokkeo Horticulture Research Center)

**Chapter 2****Water Availability****Why water is important?**

As human beings have to drink to live, plants depend on water as well and even more: Vegetables in general consist on more than 90% of water. The fact, that leaves, stems, bulbs, roots, flowers and fruits are soft and easily palatable is one reason why we like to eat vegetables and fruits.

Plants act like water pumps: The roots soak the water from the soil, the included nutrients are transported within the plant to where they are needed, and the various plant parts are hold saturated with water if possible. Now water is transpired from the leaves (comparable to sweating in human beings) and transferred to the air. This happens continuously, but the transpiration rate depends on the actual weather conditions mainly.

During the rainy months there is more water than is needed. During the dry months, there is hardly any water for growing crops, thus irrigation is necessary. Drought occurs when there is too little water.

In general plants with big, soft leaves and shallow root systems suffer more from drought. Some plants are less sensitive than others: Most of the vegetable legumes are good drought avoiders (e.g. cow pea and yardlong bean), as their hairy leaves and pods reduce water losses. Waxy leaves and leaf curling have the same reduced light absorbing effect, thus decreasing transpiration rates. Wilting is a symptom of extreme drought stress.

Where do I get water?

How far away is the water source from the garden?

Is there any possibility to increase water availability by digging a dam, making a channel, drilling a well, making an aqueduct (bamboo construction) to use spring water?

Is water available the whole year round?



## Chapter 2

## Water Availability

**Questions**

Why water is important?  
Which role does water play in agriculture?  
When is most water needed?

**Practice**

Take a lightly wilting lettuce or similar crop plant and put it into or sprinkle with water to demonstrate the „turgor pressure“ within plant cells, that makes plants look smooth and tight. If the turgor pressure is high all processes within the plant can proceed well. Get herbs or weeds, too and compare leafy and woody plant parts.

(If you want to, make a comparison with the custom to fill beer glasses or “laolao” glasses again, immediately after having sipped only once or twice....).

Form small groups and choose key informants. These should draw maps of their gardens. Within the groups the questions of page 6 are answered and an irrigation plan or proposal discussed. Results are presented to the plenary and discussed.

**Materials**

Lettuce and/or just herbs and weeds; seedlings and mature plants (!).  
Paper and pens, or whiteboards, or blackboard and chalk, or even a sandy place and sticks.

**Time****required**

10-20 minutes each

**Games /****Exercises**

„Guessing game“ or „hands up“: Think some questions up, for example about how much water trespasses a plant to build up 1kg of dry organic matter? (depending on the crop: 300-800 liters!)

- what are the main tasks of water within the plant ? (answer: transport of nutrient elements, transpiration)
- when is the best time of the day to water or irrigate ? (answer: when transpiration is low, that is in the early morning or / and in the late afternoon)
- when is irrigation highly urgent ? (answer: .when plants are wilting).

Give several options and let the participants „guess“.

**Media:**

Videos: „Water an environmental good“ (Lao language; PADETC) and „Harvest the rain“ (Engl.; PADETC).

**Chapter 2****Climatic Conditions**

Each crop has certain **climatic requirements**.

Unfavorable climatic conditions produce stress or strain for the plant resulting in lower yields.

The climate of a particular location comprises temperature, rainfall, light intensity and duration, wind direction and velocity, and relative humidity. Over the year these factors follow a certain pattern. The daily fluctuations or variations, the weather, can be significant, and also determine when to undertake farm operations.

**Rainfall** is the key element of our climate, as it divides the year into two different seasons. Too much rainfall causes direct damage to shoots, high incidence of pests and diseases, physical destruction of flowers, and less activity of pollinators. It also brings nutrients down to a level beyond the reach of roots by leaching.

Heavy rainfalls also create flooding or water logging in poorly drained soils.

Water logging can be reduced or eliminated by drainage and protected cultivation (see: Seedbed Preparation; Water management).

**Temperature** is in general the most important factor to consider in deciding what crops to grow in a place. It affects flowering, fruit set, maturation, quality, yield and harvest time, and shelf life of the edible product.

Temperature is related to altitude. As plants have different temperature requirements, certain vegetables can successfully only be grown in the highland regions or during cool season in the lowlands. There are varieties often available that differ in certain characteristics so that they may be adapted to other climates, too.

Soil temperature determines seed germination, organic matter decay, root development and microbial growth.

Very high temperature causes heat stress expressed by symptoms and injuries like blank tips in sweet corn, cracks at the stem side and „puffy“, holly fruits in tomato, stubby roots of carrots, „hot“ pungent taste of radish, dead areas in leaves of onion, cabbage and lettuce.

High temperature on the leaf surface can be reduced by sprinkling water, thus cooling down by transpiration (comparable to „sweating“ in human beings).

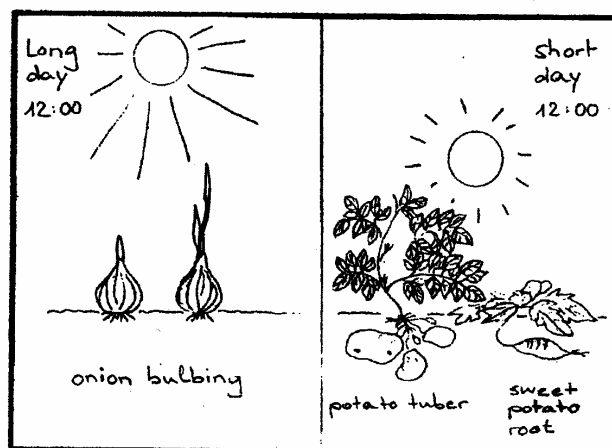
## Chapter 2

## Climatic Conditions

**Light** duration and intensity are not constant the year round.

Some plants are more sensitive to day length/ photoperiod than others. Rainy season in Laos is also long-day period that means that vegetables like lettuce, or potato and carrot are going to flower, and reduce their root, leaf and stem growth.

Others like amaranth, sweet potato and beans start to set flowers and fruits in short-day period. Day-neutral plants don't respond to photoperiods.



Long days hasten bulbing in onion, short days hasten tuber formation in potato, root enlargement in sweet potato and corm formation in taro.

Cucumber, melons and pumpkin e.g. respond to long days **plus** high temperature by producing more male, not fruit bearing flowers, while short days and low temperature favors female flower production.

„Sun plants“ like corn or eggplant require high light intensity, which is much lesser during the rainy season, than during dry season due to cloudiness.

When plants are greatly shaded, e.g. seedlings overly protected from sunlight to prevent wilting, they become tall and thin, and are light (pale) green in color.

Growing recommendations for some vegetables: + = favorable, ~ = tolerable, but not always suitable

Short Day (Oct.-Mar.)		Day Neutral	recommended	Long day (Apr.-Sep.)	
Amaranth	+	Corn / Maize	short day	Spinach	~
Sweet Potato	+	Cucumber	short day/long day	Sugar beet	~
Mungbean	+	Sweet pea	short day	Onion, garlic	~
Cowpea	+	Tomato	short day/long day	Cabbage	~
Soybean	+	Sweet pepper	short day	Carrot	~
Winged bean	+	Eggplant	short day/long day	Chinese cabbage	~
Tropical spinach	~	Artichoke	short day	Lettuce	~
Garland chrysanthemum	+			Radish	~
Chayote	+			Potato	~

**Chapter 2****Climatic Conditions**

Sun leaves are thicker and stronger than the more delicate shade leaves - be aware of when pruning!

Leafy or salad vegetables, such as celery and lettuce, have generally better quality and are tendered when grown under partially overcast skies. There are few vegetables that can tolerate shade, such as taro and ginger. They yield as much under partial shade as well as under full sunlight.

A slight **wind** is desirable for gas exchange and to dry leaves up after rains. But more than moderate wind causes increased evapo-transpiration, thus higher water consumption in consequence.

Wind is a limiting factor in vegetable and fruit production in regions, where strong winds frequently occur.

The use of windbreaks and shelter belts (trees grown for this purpose) will minimize damage by a relatively slow wind. They are layed out across the main wind direction.

Which are the predominant climatic constraints on my farm?

How could I improve growing conditions?

Which appropriate materials and tools are available on or near to my farm?

Which crops and what amounts of them fit into my actual cropping plan?

Where do I see capacities (or the necessity) to change or to extend the cropping plan due to climatic conditions?

## Chapter 2

## Climatic Conditions

## Questions

What is the difference between climate and weather?

Which factors are determining the climate?

Which are the effects of climate factors on the plant?

## Practice

Difficult to demonstrate as normally at least a few hours are necessary to show differences due to climatic conditions or their changes. Form small groups and let participants choose key informants who would answer the above mentioned questions (of page 10) after having described their farm conditions. Find answers within the groups, let all participants contribute from their own experiences.

Gather and visualize results of group work.

## Materials

Paper and pens or cardboard plus charcoal, or board and chalk

## Time

## required

30-40 minutes

## Games /

## Exercises

Let the plenary figure out the factors comprising climate. Form groups, one for each factor, for example. Ask them to think about the factors' effects on the plants and to make a drawing or, even better: play these in a pantomimic role play and let the other groups find out the meaning.

## Media

**Chapter 2****Infrastructure**

Many factors apart from natural conditions of a certain place have to be kept in mind, when planning, re-organizing or advertising vegetable and fruit production for income generating purposes. Among others there are:

**Road access**

Remote areas are disfavored, as merchants preferably operate along the roads. When growing fresh perishable products, access must be assured during harvest time. Big quantities and heavy weighing products (like water melon, coconuts, pummelo) may require animal-draft or motorized transport.

- Are roads easily and all year round accessible?
- In what conditions are these over the year?

**Access to markets**

This means not only the locality, but demand for certain products, and possibly „open-mindedness“ for uncommon produces and practices.

- What to produce for the market?
- When to produce? At what price?
- How to form producer and marketing groups?

**Access to transport**

Vehicles include all types of man-moved, animal-draft, and motorized transport.

- Which kinds of transport are available?
- How can transport be improved?
- Are there possibilities to share vehicles with neighbors?

**Packing materials**

Considering the market value of the produce, packing material must be safe, cheap and easily available.

- How frequently might it be used?
- What materials are yet available on or near to the farm?
- Is it possible to get re-usable and recyclable packing material like wooden boxes and baskets?

## Chapter 2

## Infrastructure

**Storage**

It might be helpful to store produces, to gain a better price, or to get over bad weather periods.

- What kind of storage is useful, and where should it be situated?
- Are there possibilities to improve storage facilities?
- Are pests a problem for storage (rice weevils, etc.)?
- Is food processing a viable way?

**Access to credits**

It may be difficult to think of new ways of crop production, facing the costs and innovations to be made. Without any financial and technical support it might be very hard, even if there is a lot of interest and enthusiasm on the farmers' side.

It should be the **rule** that all kinds of input are valued and therefore be appreciated. That means definitely, that **not any supply** neither seedlings nor fertilizer nor transport for marketing purposes **should be given free of charge**. Only in that case the farmer decides independently and is free to adopt a new technique, he/ she will be able to manage it successfully.

- Are there possibilities to get credits at all?
- What are the conditions to get a credit?
- If there are no possibilities right now, how can they be created?

**Chapter 2****Infrastructure**

<b>Questions</b>	What factors are meant when speaking about infrastructure?
<b>Practice</b>	<p>Ask participants to find the meaning of infrastructure, the related constraints and possible solutions. List all factors and note down potentials, constraints and solutions found in the discussion.</p> <p>Try to have an animated discussion!</p> <p>(Make use of the given questions and try to find more.)</p>
<b>Materials</b>	<p>Get information about Microfinance Institutions (MFI)</p> <p>Paper, cards and pens</p>
<b>Time required</b>	Minimum 30 minutes
<b>Games / Exercises</b>	<p>Role play:</p> <p>Select one participant who plays the owner of a tractor. He or she offers transport of the products to the market. The other participants produce vegetables or fruits, but have no transport means. They are interested in a cheap transport fee. The owner of the tractor wants to earn money from transporting the products.</p> <p>Let them agree upon a reasonable transport fee, which is satisfying for all participants.</p>
<b>Media</b>	<p>Book keeping records</p> <p>Rules and regulations of village revolving funds (in cash and kinds, such as seed banks, seedling banks, animal banks, etc.).</p>



## Chapter 3

## Economics

**Importance of Bookkeeping /or Recording**

If the objective of vegetable and/or fruit production shifts from providing food for the family to supplying a market or processing plant, there arises a need to become more aware of the costs and profits involved.

Plans are made first, and then a budget is set up based on the plan. An alternative plan may, therefore, be made and subsequently budgeted again. Budgeting means to determine farm requirements, allocate resources of different activities, and estimate the results. Two or more of such plans and budgets will enable the farmer to choose wisely.

The first step in planning is to make a list of resources. The land, labor, goods, money, building, and equipment available for use by the grower are collectively called resources. Inputs include everything utilized for or put into the production of vegetables and/ or fruits such as seed, fertilizer, manure, pesticides, etc.

The main means of production are:

- Land - area that could be used including type of soil, topography, availability of water, drainage, and land tenure arrangement
- Labor - amount and availability of labor that can be brought in easily, like family members
- Capital - land and farm value; condition and uses of buildings;
  - kind, number and value, condition, and use of tools and equipment;
  - cash, and amount of money that the farmer may borrow (credit)

The second step in planning is to make a survey of farm conditions (see: Chapter 2).

Costs are involved in every operation. It is necessary to get the value of costs to identify inputs that are bought or paid for, unlike family labor or manure obtained from the farm. But these also have some value when used in alternative enterprises, and therefore must be taken into account. The cost of family labor is estimated by the current wage rate.

Bookkeeping: Recording

A record of farm expenses is called a cost record. The purpose of this record is to keep data of farm operations and associated expenses in order to evaluate the performance of farm management and to help in sound farm planning.

**The data of farm expenses and receipts should be recorded  
whenever an operation takes place.**

## Chapter 3

## Economics

**Why to keep cost records?**

For example, the same product of insecticide or fungicide should **not** be used **continuously** in order to enhance the effectiveness of these inputs. Therefore, a farmer needs to know what product was previously used. The answer can be found in a well-kept farm cost record.

Prices of inputs and agricultural products may change quite a lot from one season to the next. The yields are rising or descending due to many reasons, as weather conditions e.g. In order to avoid mistakes and, even better to optimize cost-benefit-relations it is helpful and necessary to observe and record carefully: prices, product names, planting data, emerging pests and diseases, weather characteristics, etc. and their effects.

**How to fix the selling price?**

A farmer has to know the price below which there is no profit for production efforts. This is the break-even price and it is the cost of producing the crop. So if it costs 5.000 kip per kg to produce the crop, it should sell above this value. The higher the selling price above this value, the higher is the profit or net income. If the vegetables or fruits go to the market, the costs of handling, transport, and marketing should be added to the cost of production to get the break-even price, also called gross margin.

**e.g.: Gross margin / Net income calculation for tomato (here without labor costs!)**

Description	Unit in m <sup>2</sup>		Quantity in kg	Price/kg in kip	Total in kip
Tomatoes in rainy season	100 m <sup>2</sup>		2 000	4 000	8 000 000
Variable Costs	Month	Unit	Quantity	Price / Unit	Total in kip
seed	May		1 kg	25 000	25 000
fertilizer	May + July	4 bags	100 kg	125 000	500 000
pesticides	June	2 bottles	2 l	85 000	170 000
irrigation	---	----	-----	-----	-----
transport	Aug + Sep	Fuel	200 l	2 800	
marketing	Aug + Sep	baskets	20	5 000	100 000
others	?	?	?	?	?
<b>Total variable costs</b>					- 795 000
<b>Net income/ Loss</b>					+ 7 205 000

**Chapter 3****Economics**

To be able to determine a reasonable selling price in an open market or to a trader, the farmer should know the price of the product in the market where he or she intends to sell the crop, and in other markets where it can be sold, too. This requires **market transparency**, which a small farmer cannot get by him or herself. This service must be provided by a specialized agency of the government. Extension services of Agriculture and Forestry offices can be asked for a better understanding of the prices.

Without price monitoring, a farmer is at the mercy of a trader and will not know what to ask or bargain for.

**Individual marketing or group marketing?**

Basically, farmers can market vegetables and fruits individually or as a group. Individual marketing permits a maximum amount of freedom of decision making by the individual farmer. Group marketing involves decision making by the members, thereby limiting personal choice. Group marketing by producers is part of a general attempt to balance the power of farmers, on the one hand, and vegetable buyers and processors, on the other.

The most common type of marketing association is the marketing cooperative. Agricultural marketing cooperatives are voluntary membership organizations formed by groups of farmers to provide self-help in marketing, marketing services, and related needs.

## Chapter 3

## Economics

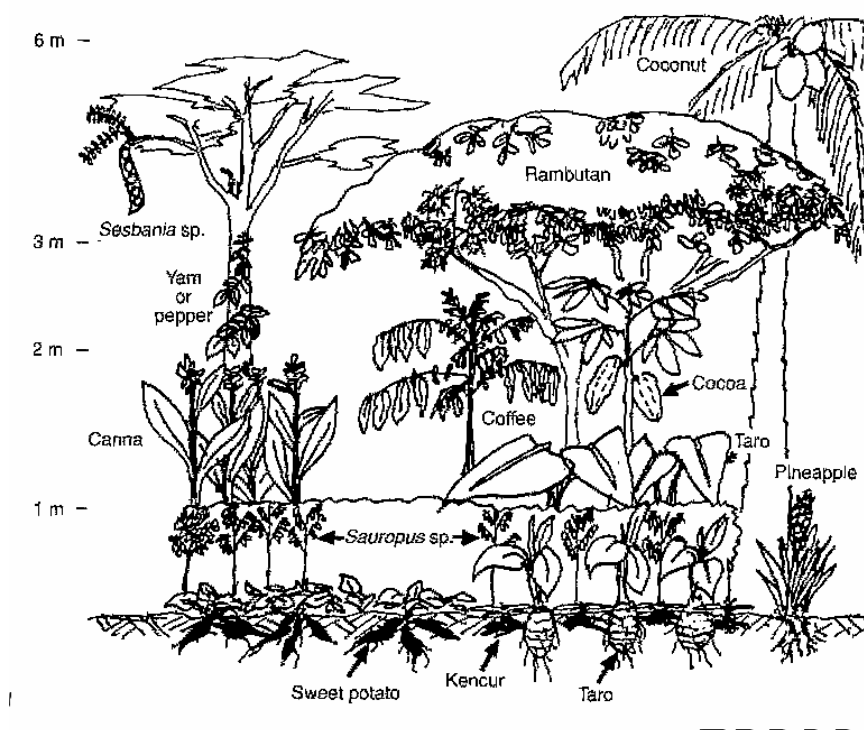
<b>Questions</b>	Why do farmers grow what they do? What are the determining reasons for this decision? What are the main means for any (agricultural) production? What is the farmer's and what is the merchant's interest? How do their interests fit together?
<b>Practice</b>	Cost and return/net income calculations Labor input calculation
<b>Materials</b>	Paper and pens, blackboard or whiteboard plus accessories
<b>Time required</b>	Minimum 30 minutes
<b>Games / Exercises</b>	Role play „farmer - merchant“ and „farmer group - merchant“ and a lively discussion
<b>Media</b>	

## Chapter 3

## Principles of Multi-cropping

The tropical rainforest marks the ideal stage (climax) of a plant population. It needs many decades or even centuries to develop that specific kind of ecosystem. It is very fragile and decays when few factors (like high appreciated timber trees) are taken off, because each part of it depends on another. That's the reason why soil fertility decreases rapidly when „slash and burn“ is practiced, and the ideal stage will probably never be reached again.

The natural forest is the model for **multilayer** (multistory) **cropping**, which comprises fruit and timber trees, medicinal plants, vegetables, tuber crops, and others to make best use of



space, light, water and nutrients.

In the wild, plant species grow in a mixed, seemingly chaotic manner, equivalent: mixed or inter-cropping.

**Mixed cropping, or multi-cropping imitates the natural plant growth.**

Yet, there are successions of species with the changes in season (sequential cropping), some of them overlapping in space and time (relay cropping).

All these multi-cropping systems have something in common: they are labor-intensive because it is difficult, if not impossible, to mechanize these crop production systems.

## Chapter 3

## Principles of Multi-cropping

**Sequential or rotational cropping** is the planting of two or more crops, one after the other, in the same field in order to maximize land productivity.

**The advantages of crop rotation are the following:**

1. Pest control

Crops belonging to the same family should not be planted in succession to prevent accumulation of pests. For example, eggplant should not follow tomato or pepper because this may build up bacterial wilt, a soil-borne disease that affects all of these crops. Radish should not follow cabbage because both are hosts to diamondback moth, an insect pest that is very difficult to control.

In a rotation system with paddy rice, the flooded condition in the rice crop effectively reduces soil-borne diseases which may affect vegetables, and plays an important role in the control of dry-land weeds

Weeds are controlled effectively when the farm land is used continuously for growing crops. A prolonged fallow or rest period between crops increases weed population, if the soil is not covered. An improved fallow with legumes is a good alternative (see: Chapter 8 Green manuring).

2. Full use of residual soil moisture and nutrients

After the wet-season paddy rice crop, residual soil moisture (and fertilizer) is usually adequate to support the establishment of a short-season vegetable crop like mungbean under rain fed conditions. With irrigation, two short-season vegetable crops may be grown between two rice crops with the use of early-maturing rice varieties.

To make full use of soil nutrients from different depths, deep-rooted crops should be grown in **rotation** with shallow-rooted crops.

Average effective root-zone depth of vegetable crops in deep, well-drained soils:

Shallow rooted crops	(cm)	Medium Rooted Crops	(cm)	Deep rooted crops	(cm)
bush beans	45	cabbage, celery, garlic	60	tomato	120
lettuce	30	carrot, cucumber	90	melon	155
onion	30	sweet corn	90	okra	110
radish	45	cauliflower, eggplant	90	snap beans	110
		pepper, squash	90		

3. Sustained soil fertility

The balance in the soil can be maintained by rotating crops of different nutrient utilization patterns. Additionally leguminous vegetables can fix atmospheric nitrogen, and return more of

## Chapter 3

## Principles of Multi-cropping

this nutrient than other crops to the soil when stems and leaves are incorporated after harvesting.

Crops like melon or creeping vegetable cowpea, by virtue of their spreading habit, smother weeds and protect the soil from erosion.

The high cropping intensity of a **sequential cropping system**, growing up to four crops a year, requires sustained application of compost or manure to replenish the organic matter in the soil and improve its biological and physical conditions. Usually one or two applications per year will be sufficient to maintain the soil in good condition.

When planning a crop rotation system, crops which can be transplanted should be grown in the seedbed before the current crop is harvested. This shortens the growing period of the succeeding crop. Crops should be carefully selected, taking into account their most favorable planting date (temperature, day length).

Species that will fit into a **three-month rotation** (thus, making up to four vegetable crops per year) are as follows (the italic terms indicating the plant family):

- 1 *Brassicaceae* cabbage (8-10 weeks), Chinese cabbage, kaai lan and Chinese radish (6-8 weeks), pak-choy and choy sam (4-6 weeks)
- 2 Lettuce (*Compositae*), water spinach or kangkong (*Convolvulaceae*), and Chinese spinach (*Amaranthaceae*) (4-6 weeks)
- 3 *Cucurbitaceae*: cucumber (10 weeks), bitter melon, luffa, snake melon, squash, cantaloupes (12-14 weeks)
- 4 *Solanaceae*: sweet pepper, tomato (14-16 weeks)
- 5 *Alliaceae*: spring onions (8-10 weeks), bulb onions (12 weeks from transplanting)
- 6 *Fabaceae*: French or garden bean, yardlong bean (12 weeks), groundnut, mung bean (10-14 weeks)
- 7 Okra (*Malvaceae*) (10-16 weeks), sweet corn (*Poaceae*) (10 weeks)

The weeks noted in the examples below are the total times for which each crop occupies the bed. For example, the total „bed time“ for cucumbers is 10 weeks (lowland) but the crop will yield over a period from about five weeks onwards. Each of the rotations described below includes a cucurbit, a legume, a crucifer and a vegetable of another family; this

**rotations of species of different plant families minimizes  
the problem of build-up of soil pathogens.**

## Chapter 3

## Principles of Multi-cropping

Example I	(weeks)	Example II	(weeks)	Example II	(weeks)
Cucumber ( <i>Cucurbitaceae</i> )	(10)	Luffa ( <i>Cuc</i> )	(14)	Cucumber ( <i>Cuc</i> )	(10)
Replanting	( 1)	replanting	( 1)	Replanting	( 1)
yardlong bean ( <i>Fa- baceae</i> )	(12)	French bean ( <i>Fab.</i> )	(12)	yardlong bean ( <i>Fab.</i> )	(12)
replanting	( 1)	replanting	( 1)	Replanting	( 1)
Chin. cabbage ( <i>Brassicaceae</i> )				pak choy ( <i>Bras.</i> )	
(two crops)	(12)	cabbage ( <i>Bras.</i> )	( 8)	(three crops)	(12)
replanting	( 1)	replanting	( 1)	Replanting	( 1 )
bulbing onion ( <i>Alli- aceae</i> )	(12)	Okra ( <i>Malvaceae.</i> )	(14)	Tomato ( <i>Solanaceae</i> )	(14)
total	49	total	(51)	total	(51)

**Relay-cropping** is the planting of a second crop before the first crop is harvested.

It is done to

- reduce time that is necessary to grow several crops in the same piece of land,
- utilize the residual soil moisture and fertilizer,
- protect the seedlings from the second crop from intense sunlight, and
- utilize solar radiation more fully by increasing the ground cover between consecutive crops.

Although relay-cropping may reduce the yield of the first crop, the benefit from this practice usually outweighs the loss in yield. But certain conditions must be met:

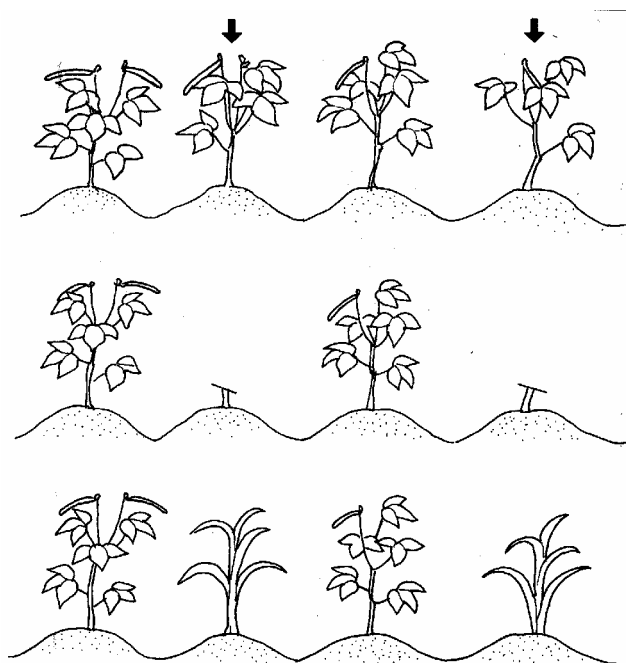
Land should be prepared thoroughly for the first crop, and this must be planted and evenly spaced in straight rows to facilitate field operations during planting and initial growth of the second crop.

The relay crop must be shade-tolerant and, if not irrigated, must be drought-tolerant, too. Shade-tolerant crops and trailing species should be combined with erect growing ones, like okra. Removing its lower leaves permits more sunlight to reach the relay crop.



## Chapter 3

## Principles of Multi-cropping



**Intercropping** is the practice of growing two or more crops in the same field at (or about) the same time, and offers

Yield advantage,

- as there is better use of light, nutrients, and water by allowing the intercrop to utilize these resources that may otherwise be wasted. It can reduce the growth of weeds and prevent these from competing with the crops, if the soil is rapidly covered.

Yield stability,

- if for example cabbage is intercropped with corn and cabbage is attacked by diamondback moth, the performance of corn will not be affected because corn is not a host of diamondback moth. If cabbage is mono-cropped, then the entire field can be lost. On the other hand, if corn is affected by corn borer, the performance of cabbage will not be affected because corn cabbage is not a host of corn borer. On the contrary, the loss of the corn crop may create a favorable condition for cabbage, because the shading effect and possible competition of corn with cabbage for nutrients and water will be reduced.

The component crop may also serve as a host for natural enemies of pests of the other crop. This is the reason why groundnut (peanut) is a good intercrop for corn: the spiders that thrive on peanuts serve to control the corn borer population in the corn crop.

In the case of tomato and cabbage intercropping, the tomato is believed to serve as repellent against diamondback moth.

## Chapter 3

## Principles of Multi-cropping

Intercropping may serve as an insurance against the uncertainties of the market: If the price of one crop happens to be too low at harvest time, then the profits can hopefully be obtained from the intercrop.

Soil erosion control

- Some forms of cover on the soil surface are needed to protect against the run-off and soil loss. Intercropped fields usually have a higher combined population density and produce a better ground cover than mono-cropping.

Enhanced employment opportunities,

- as intercropping is a labor-intensive type of farming. A stable employment and a more equal distribution of labor force are also provided by two or more crops that have different peaks of labor requirement. In a mono-crop situation, a lot of labor is required during some stages of crop growth, but these may not be necessary during other stages.

**Companion planting** is a form of intercropping in which the space-sharing plants are selected on the bases of their ability to enhance one another through pest control and other mechanisms. In selecting crops for intercropping, it is better to plant companion crops and avoids competition.

“Companion” plants have complementary physical and chemical demands. They will grow well together. “Antagonistic” plants have a negative effect on one another. Plants although interacts with the plant density. Find the right plant density for your cropping system..

Some crops produce root exudates which may remain in the soil and harm the next crop. Decomposed residues may also cause damage to the next crop (see: antagonism in intercropping).

## Chapter 3

## Principles of Multi-cropping

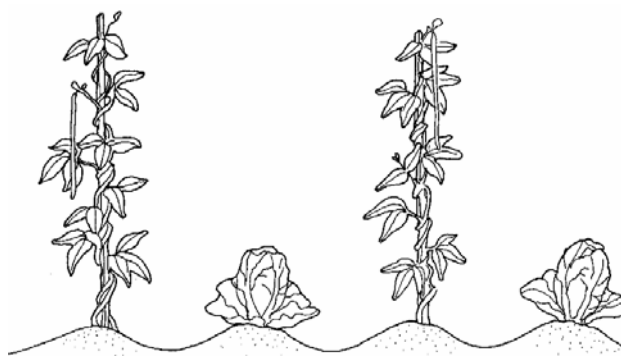
VEGETABLE	COMPANION	ANTAGONIST
asparagus	tomato, parsley, basil	
Beans (except: pole beans)	corn, potato, cucumber, carrot, cabbage and most other vegetables and herbs	onion, garlic
Beets	onion, garlic, kohlrabi	pole beans
bottle gourd	sponge gourd, cucumber, bitter gourd	
cabbage family	potato, celery, beet, onion, garlic, herbs	strawberry, pole beans
Carrot	peas, lettuce, onion, chives, leek, tomato	dill
Celery	leek, tomato, bush beans, cauliflower, cabbage	
Chives	carrot	peas, beans
Corn	okra, tomato, bush beans, pole beans, cabbage, peanut, vine squash, potato, peas, cucumber	
cucumber	pole beans, radish, okra, eggplant, beans, corn, peas, sunflower	potato, aromatic herbs
eggplant	beans, kangkong, vine squash, sweet potato, Chinese cabbage, radish, lettuce, pechay, pepper	
kangkong	tomato, okra, corn, eggplant, amaranth, taro, cassava, sweet potato, any crop on trellis	
Leek	onion, celery, carrot	
lettuce	carrot, radish, cucumber, strawberry	
luffa gourd	bottle gourd, cucumber, bitter gourd	
Moringa (horseradish)	kangkong, Chinese cabbage, nightshade, jute, lettuce, bush squash, amaranth	
mungbean	corn	
Okra	kangkong, vine squash, Chinese cabbage, radish	
onion, garlic	beet, strawberry, tomato, lettuce, carrot, chamomile	peas, beans
parsley	tomato, asparagus	
Peas	carrot, turnip, radish, cucumber, corn, beans, most vegetable and herbs	onion, garlic
Potato	beans, corn, cabbage, sunflower	squash, tomato raspberry, cucumber
Radish	peas, beans, cucumber, lettuce, water cress	
soybean	grows with anything, helps all crops	
spinach	strawberry	
squash	corn	potato
tomato	chives, onion, parsley, lettuce, asparagus, marigold water cress, carrot, radish, Chinese cabbage, kangkong, vine squash, pechay, sweet potato	potato, fennel cabbage, kohlrabi
Taro	sweet potato, kangkong	
Turnip	peas	

## Chapter 3

## Principles of Multi-cropping

**Resume:** Selection of intercropping (and mixed cropping in general) must take the following into consideration:

- allelopathy (= mutual influencing of plants) and residue problems,
- depth of rooting,
- combining crops with different nutrient demands,
- combining tall crops with short but shade-tolerant crops; tall crops such as corn and okra, and crops that are grown on stakes such as indeterminate tomato, pole beans, bitter gourd, and cucumber can be intercropped with shade-tolerant such as celery, Chinese cabbage, green onion, and cabbage,
- growing short-season crops between late-maturing ones; for example, the fast-growing leaf type of Chinese cabbage (pak-choy) is transplanted and harvested within 30 days between the rows of eggplant, even before the eggplant begins to flower.



Intercropping of pole bean with Chinese cabbage

Intercropping of slow-growing eggplant with fast growing Chinese cabbage which is ready for harvest when first fruits of eggplant are setting.

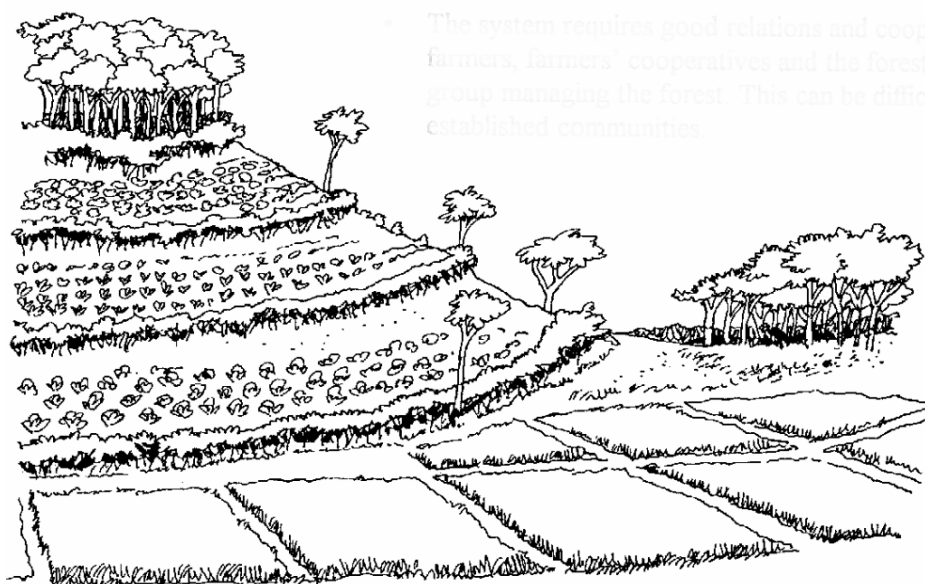


Vegetables can also be intercropped with long-season field crops, such as sugar cane, or with perennials, such as coconut.

## Chapter 3

## Principles of Multi-cropping

A special form of intercropping with perennials is called **alley cropping**. It is also known as hedgerow intercropping system. Hedgerows of fodder or timber trees or shrubs are planted at intervals of minimum 4-6 m each, and the alleys or strips between the hedgerows are planted with vegetables, pasture grasses and/or perennial crops, such as coffee or fruit trees (see: Soil Improvement and Conservation).



**Light** is considered the most critical factor in intercropping. The spacing and arrangement of associated crops should be planned carefully to reduce inter-specific competition (among different species) and enhance light penetration. For example, row spacing should be increased but plant spacing decreased for tall crops to improve the availability of light to an associated crop grown between the rows.

However, this should be done without increasing the intra-specific competition (among plants of the same species) for nutrients and water, thereby, reducing the yield of the tall crop significantly.

In intercropping, competition for soil nutrients between component crops does not occur until there is an overlapping of depletion zones of their roots. A crop tends to “avoid” areas that have already been depleted of resources by associated crops; hence, the component species often occupy different niches. High nutrient-absorption periods should not overlap in associated crops, e.g., their reproductive stages should not occur at about the same time.

## Chapter 3

## Principles of Multi-cropping

<b>Questions</b>	<p>Where does <u>naturally</u> „mono-cropping“ occur?</p> <p>Why do farmer grow mono-crops?</p> <p>What is multi-cropping like?</p> <p>Where is multi-cropping practiced, and why?</p> <p>What are the advantages and disadvantages of both systems?</p> <p>What does <u>rotation</u> mean?</p> <p>What does <u>companion planting</u> mean?</p> <p>What does <u>alley cropping</u> mean?</p>
<b>Practice</b>	<p>Make a drawing of a natural forest, with as much components as you can find, together with all the participants or in working groups.</p> <p>Make another drawing of a crop, for example paddy rice, with all the components you can think of.</p> <p>Compare these and discuss!</p>
<b>Materials</b>	<p>Board and chalk; cardboard plus pens, charcoal or chalk, whiteboard and pens or paper and pens</p> <p>a ball of string 3-4 m long, 3 chairs.</p>
<b>Time required</b>	Take time! 30-60 minutes
<b>Games / Exercises</b>	<p>„<u>The ecology ball</u>“: A group of participants gather in a circle. One person starts with the question „What things are in nature?“ and throws the string ball (keeping the end tight) to another person who answers by naming some element and throws the ball to another that names something else, and so on until they are all interconnected by the string, and nobody finds another element.</p> <p>Now let the participants figure out: What does the string represent? What happens when one of them lets go of the string? What if the string is cut? What do all the participants represent?</p> <p>Talk about what happens when we affect one element? Do we always know what the effect will be? How do we define „ecology“ (all elements in nature, in our natural surroundings and the relationships between them)?</p>

## Chapter 3

## Principles of Multi-cropping

„The environmental chain“: This game may „illustrate“ the critical links in an ecosystem, that is for example, a forest, or the fishpond and its surroundings, or our garden.

A group of 4-5 persons hold hands to form a circle, but one connection is made only by the forefingers of the two persons (the „critical link“!). Each person represents an element of the environment, e.g. water, soil, trees, animals, etc.

Other participants enter the circle, exclaiming their „pressure factor“ (such as deforestation, drought, erosion, economic crisis, migration, etc) and exert pressure outwards. The „chain“ will break when it can no longer support the pressure of so many factors. Now, let the participants discuss about: What does the chain represent? Where did it break? Why? What does this mean? How to avoid breaking?

„Equilibrium“: Developing agriculture and protecting the natural environment in order to have better life for us and future generations means **sustainability**.

One person may have the task to hold **2** chairs - one represents agriculture, the other nature or environment. How does he/she do?

Now, another person may hold **1** chair (**or** agriculture **or** environment) and try to do anything else with the other hand. How does he/she do?

Find out with all participants: What is the best way to hold the chairs?

Try to find interpretations for each position (holding one chair higher than the other, holding it at the back rest, or supporting = **sustaining** both chairs at the time....).

**Media**

## Chapter 3

## Diversification and Niche Product

**Diversification** in agricultural means is to grow more than one or two cash crops in order to minimize risks of production. If a farm depends on the income of only one or few cash crops losses caused by high populations of pests or diseases, or by adverse weather conditions may ruin the farmer's family economy. This implies that the crops must be of different kinds (e.g. in botanical terms) and have different strengths (regarding susceptibility to diseases, pests, climatic changes, etc).

Diversification on a farm specialized in growing grain crops may be done by growing them on rotation with legumes and vegetables. In addition, early bearing fruit trees along with timber trees may be planted on slopes or in depressions.

Specialization in only one crop often brings about problems of soil deterioration and concentrated occurrence of pests.

Some advantages of diversification are

- to be on the safe side in critical times (security)
- increased income in good seasons
- improved self-supply

Diversification products should sell well even in times when staple crops and current products are in abundant supply. Therefore, a farmer should look for "niches" in the market, in order to benefit from a "new" product. As fresh horticultural products cannot be kept for long they may sell better in a processed form.

Potatoes, banana, jackfruit may be processed to chips.

Many kinds of fruits can be sun-dried or processed to juice and jam.

Vegetables can be processed to pickles, herbs be dried and packed.

Particular "ovens" operate on a solar energy, and are therefore independent from electrical power.

For the interested reader there are links in Part G that can be used to obtain further information.



**Chapter 3****Tools**

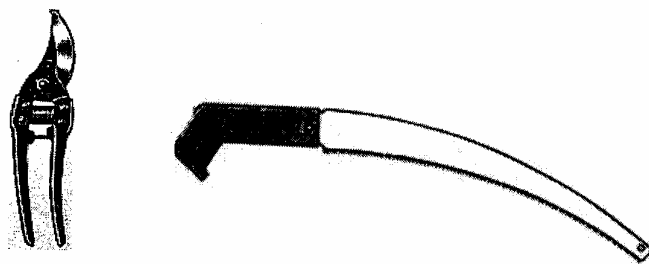
Tools have been invented to make work easier, which means in many cases just to make it physically easier. Traditional tools and instruments have been found appropriate over a long time. Since new technologies and materials often give promising results some of the well accepted and proven tools might be improved under these aspects.

When traditional tools and implements are transferred to climatically and topographically different regions (e.g. in consequence of migration) and used under those conditions, they might not longer be adequate.

In general horticultural soils are cultivated intensively. That means that soil conditions must be good and cultivation methods optimal in order to benefit for the long run from the land. In this context tools for exact and fine soil cultivation are needed and recommended. Also aids for planting and transplanting of seedlings are important tools. Especially for pruning and grafting of fruit trees light saws, handy scissors and knives, all of good quality are essential to avoid injuries and further damage.

A strong digging spade is very useful for composting and cultivation, but very little known in Laos. For shallow and effective cultivation of already well prepared fields or seedbeds a small hoe with a long handle and a wide working angle is surprisingly favorable.

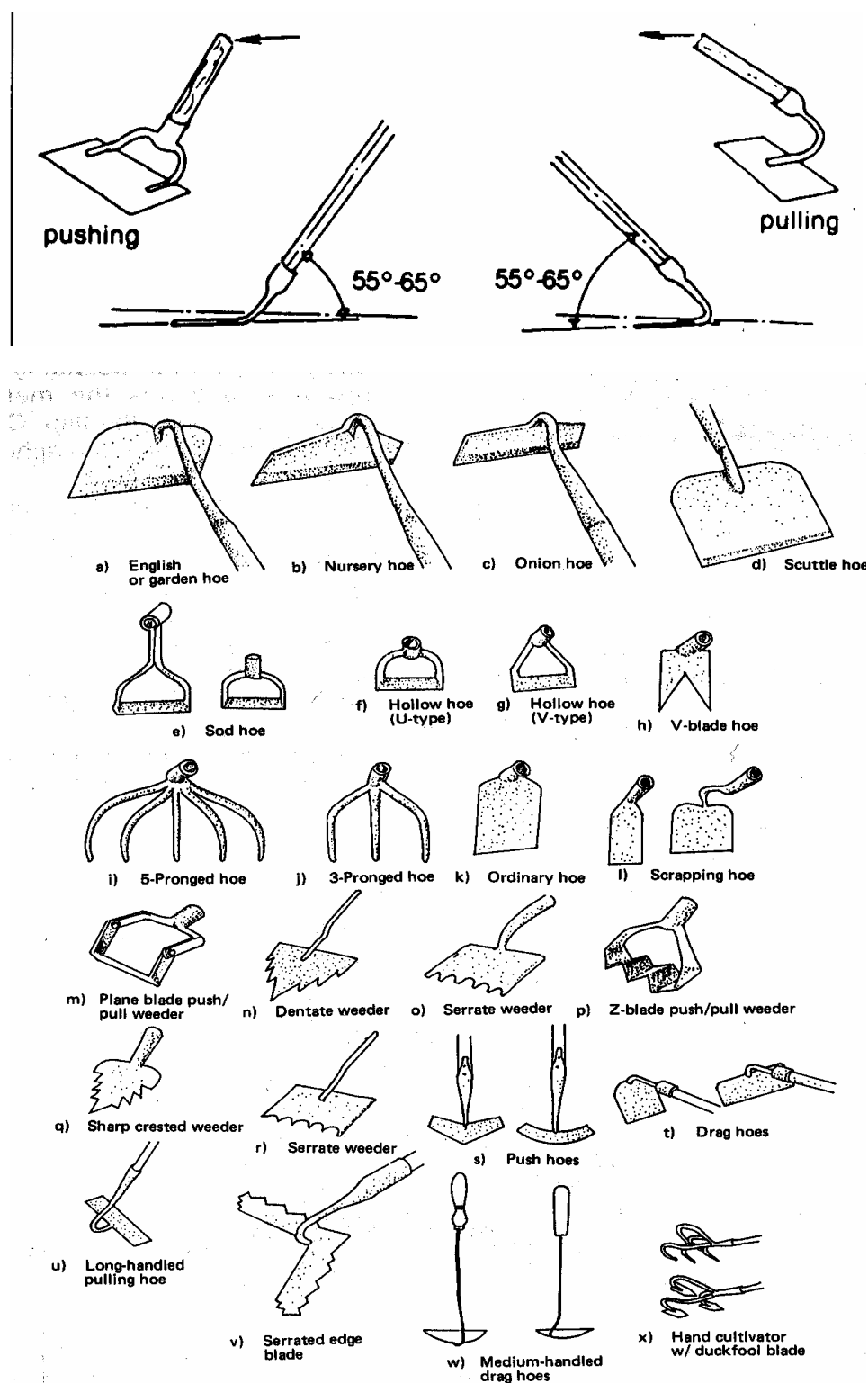
Many well proven examples of improved tools for any activity related to agriculture from all over the world can be found in a guide to appropriate equipment for smallholder farmers mentioned in Part G.

**Tools for Fruit Tree management**

## Chapter 3

## Tools

Tools for Vegetable production



## Chapter 4

## Seedbed preparation

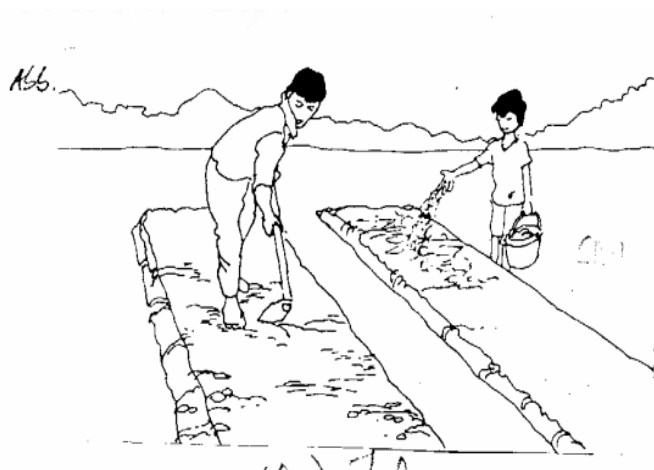
Carefully prepared seedbeds create favorable conditions for seed germination, seedling establishment and development at later stages. The best place for a seedbed is in a sunny place where the soil is moist, but not too wet. Weeds must be slashed and removed from the seedbed area. After the rainy season and under wetland conditions the soil should be dug up at least 25 cm deep and should dry for a week. After seven days the weeds are removed again and the soil is piled for another seven days of drying. Proper drainage and aeration are necessary to prevent soil-borne diseases like damping off. Raised seedbeds will dry more quickly than flat field plantings. Trenches between the seedbeds facilitate drainage of the

seedbed.

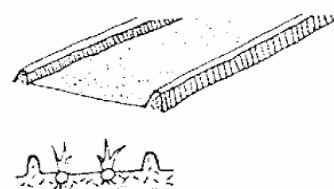
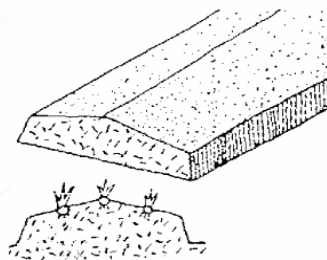
A raised seedbed is to be made from the piled soil, mixed thoroughly with well decomposed compost, or dry farmyard manure. Washed sand may be added if the soil is still heavy, and the bed is leveled with the rake.

The seedbed should be 15-20cm high and not wider than 120cm to work it comfortably from the path, without stepping onto it.

The length depends on the quantity of seedlings needed.



While in and soon after the rainy season and under wetland conditions raised seedbeds will be highly recommended, the opposite is true in dry season or under dry environmental conditions:

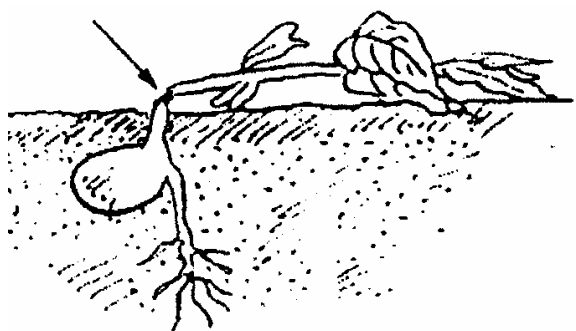


Then small dikes for retaining water should be made. Good drainage and aeration of seedlings' roots are essential and must be provided.

## Chapter 4

## Seedbed preparation

Damping off is a fungal seedling disease favored by warm and wet nursery beds. It can be



"Damping off"



Seed rot

Root rot

controlled by keeping the seed bed relatively dry at night by avoiding watering in the late afternoon

- soil sterilization
- growing in seed flats or containers for easy isolation of diseased spots
- full exposure to the sun to quickly dry the soil.
- proper plant nutrition to mature more quickly; seedlings gradually develop resistance to damping-off as they become more mature.

The soil contains millions of different kinds of microorganisms; many of these are helpful to the plant, but some are disease-causing. The nursery mix should retain only the beneficial types. To achieve this, the nursery mix is often sterilized, either with the use of heat or chemicals. Burning straw on top of the seedbed sterilizes the topsoil to a depth of about 5cm.

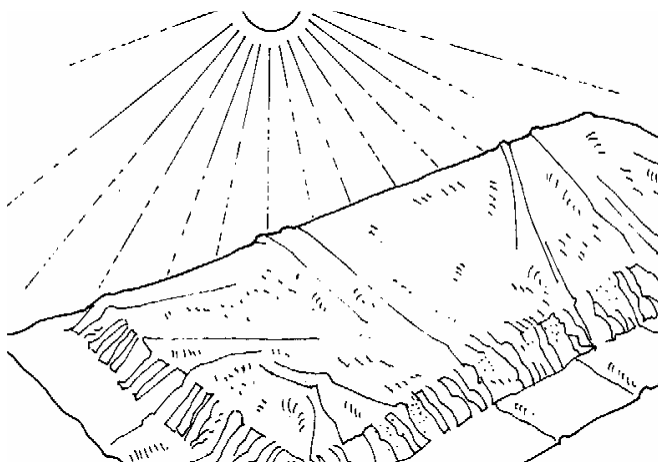


## Chapter 4

## Seedbed preparation

Another method of sterilization is **solarization** by covering moist seedbed with transparent

plastic film and exposing to direct sun for three weeks. The heat of the sun increases the temperature of the soil, killing pathogenic microorganisms and weed seeds. After taking off the plastic sheet the sterilized soil should not be used immediately, to avoid the harmful effects of toxic chemicals which may be released during heat sterilization.

**Hot plate sterilization:**

Unlike in the first method, the soil does not come in direct contact with the fire and thus is exposed to lower temperature. The soil mix is moistened, so that the steam generated by the heated soil serves as the sterilant in addition to the effect of the hot plate itself. During sterilization, the soil is constantly stirred to ensure even heating. Sterilization is completed when the soil has dried up.



**Heat sterilization** of the potting mixture destroys weed seed, pests and pathogens and will prevent seedling diseases such as „damping-off“. Soil is by no means always sterilized on vegetable farms, however. Whether it is practicable or necessary to sterilize the soil will depend on local conditions and the incidence of disease and weed problems in the nursery.

ize the soil will depend on local conditions and the incidence of disease and weed problems in the nursery.

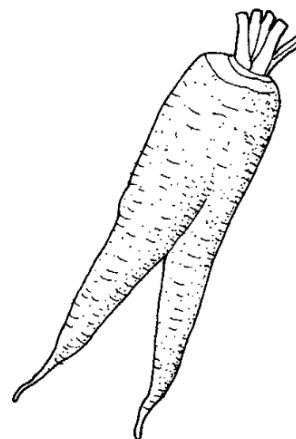
## Chapter 4

## Seedbed preparation

Why are some vegetables direct-seeded into the bed or field?

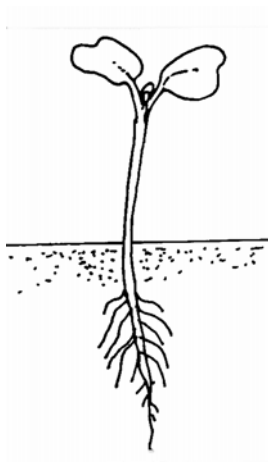
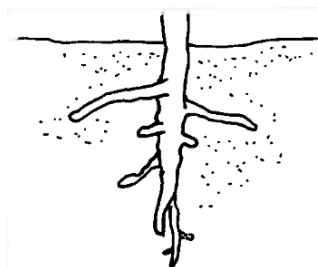
Some vegetables such as radish, carrot, beets and turnips form tap roots, which are the edible products they are grown

for. If the tips of the tap roots are damaged, they will deform and thus decrease the products value. If sown in rows thinning out is easy and allows good root growth.



Crops that are usually direct-seeded are watermelon, cantaloupe, squash, cucumber, corn, all kinds of beans, peas and bitter-gourd. These seeds are big and full of reserves, thus able to establish under field conditions.

The fine seeds of aromatic herbs, e.g., but legumes as well are direct seeded because their roots don't easily regenerate, hence, do not easily recover from transplanting shock.



Some seeds germinate rapidly and their seedlings grow fast in the initial stage, such as sweet corn, cucumber and yardlong bean, but also pakchoy and kangkong, e.g. If drill-sown, picking out is easily made to give each seedling space to grow and develop safely.

Direct-seeding always requires three to four times more seed than transplanting. When the cost of seed is high, as in hybrid seed, transplanting may be recommended instead of direct seeding.

## Chapter 4

## Seedbed Preparation

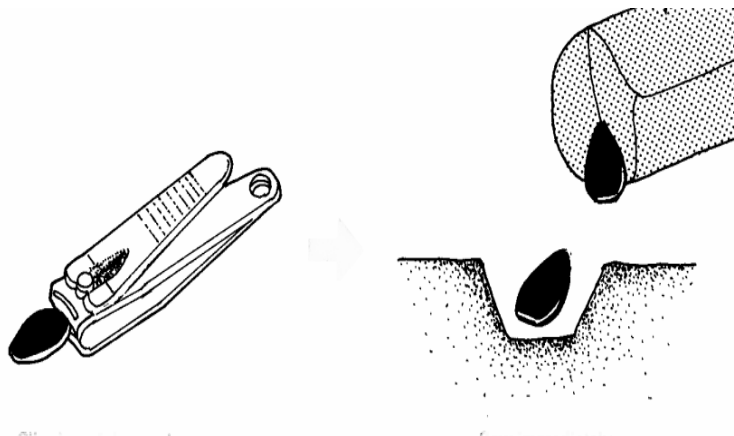
<b>Questions</b>	<p>How are crops propagated or planted?</p> <p>What kinds of seeds (or propagation material in general) do the farmers know?</p> <p>Why are some of the „true“ seeds direct-seeded ones?</p> <p>Why others are preferably transplanted?</p> <p>How much are seeds covered with soil?</p> <p>Which kinds of protection would the farmers apply to their own seedbeds?</p>
<b>Practice</b>	<p>Let form working groups and practice first the good filling (and even mixing!) with seedbed medium (soil mixed with sand, rice husks, etc.).</p> <p>Let carry out broadcasting; and sowing in drills or rows, in seed trays or wooden boxes, etc. Do this practice preferably on the floor (!) for more real (seedbed) conditions.</p> <p>But you may talk about the advantages of upright working, wherever possible, too!</p> <p>Fine seeds, such as amaranth, carrot and lettuce should be mixed with fine sand for more equal distribution.</p> <p>Talk about necessity and advantages of covering the seeds!</p>
<b>Materials</b>	<p>Trays, wooden boxes or other useful containers that allow drainage; different kinds of seeds and fine pre-washed sand, a plain level slat of wood, and possibly a sieve.</p>
<b>Time required</b>	<p>15-20 minutes for practice, around 45-60 minutes in total.</p>
<b>Games / Exercises</b>	<p>If you cannot provide the materials, do the practice as an exercise without real trays, boxes, seeds, etc. Mixing the medium without real shovel may be even more fun!</p> <p>Remember - also the participants will remember best and be able to do, what they have <b>physically</b> (and not only in theory) done before!!</p>
<b>Media</b>	

## Chapter 4

## Seed Germination

There are several reasons for the inability of seeds to germinate under favorable conditions, called **dormancy**.

Methods to overcome seed dormancy for hard-coated seeds, such as okra and some legumes, are

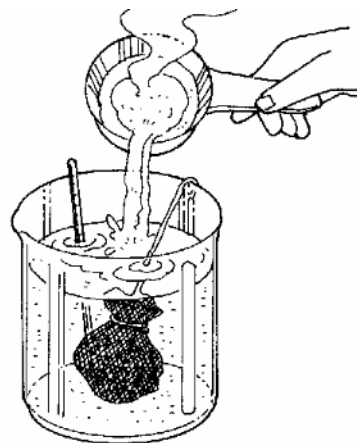


**cutting**, clipping mill-

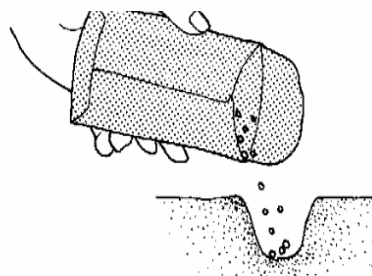
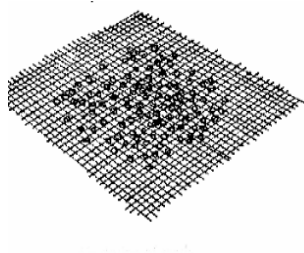
ing or so called scarification, e.g. sandpapering by abrasion (or by chemicals):

The principle is to soften or make a wound on the seed coat so that water can be easily absorbed by the seeds, thus hastening germination.

**soaking** for 24–48 hours in water before testing



**plunging** seed in water of 45°C for up to 20 minutes, for example, in cabbage to control black rot; but heat treatment is not normally a good practice as it tends to reduce germination.



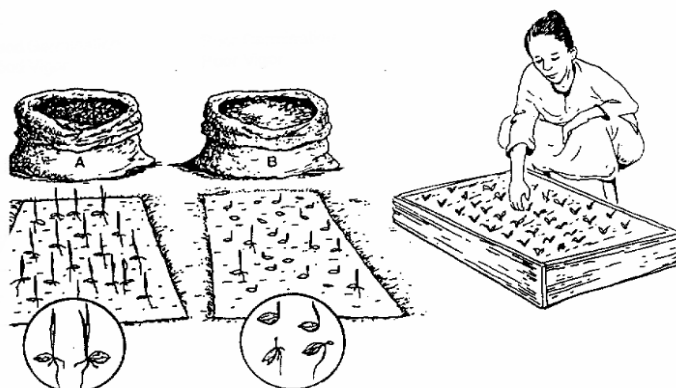
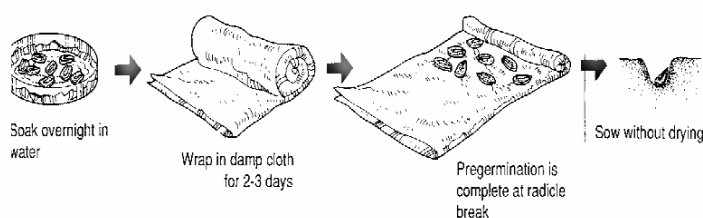


## Chapter 4

## Seed Germination

A **germination or vigor test** predicts field emergence better, and should be made in time: The germination test gives information about seed germination and seedling health. Germination results could serve as a guide as to whether the seeds could still be stored, immediately planted or discarded. Also, they give an idea as to how much seed is required for planting. Seeds with low percentage germination will not keep long and will produce less vigorous plants.

Representative seed sample is taken from the seed lot are sown in moist, clean, absorbent cloth or paper. The cloth or paper is loosely rolled (rag doll method) or kept on a flat surface covered with the same material.



The medium must be kept constantly moist by watering, taking care not to flood it. Too much water encourages mold and bacterial growth. Alternatively, seeds could be kept moist by carefully dipping the rolled medium in a pail of water, then putting it in a partially opened plastic bag.

Seeds being tested must be kept in the shade and away from mice, ants and rain.

Count normal seedlings after 4 – 5 days. Percentage germination is calculated as:

$$\% \text{ Germination} = \frac{\text{No. of normal seedlings} \times 100}{\text{Total no. of seeds tested}}$$

$$\text{Total no. of seeds} = \frac{\text{No. of normal seedlings} \times 100}{\% \text{ Germination}}$$

For instance, if the required number of plants is 1000 and the germination percentage is 85%, then calculate:

1000 plants divided by 85 and multiplied by 100 equal 1176 seeds that must be planted. If germination is below 80%, but above 60%, use more seeds. Do not use or store seeds if germination percentage is below 60%.

## Chapter 4

## Seed Germination

<b>Questions</b>	<p>What are the major constraints for emerging seedlings?</p> <p>How can these be prevented?</p> <p>How can the farmer know what quality the seed is like?</p> <p>How can he/she figure out which quantity of seeds is necessary for a certain piece of land?</p> <p>Which are the possibilities to make germination of hard-coated seeds, for example, easier?</p> <p>What further kinds of inhibiting and impeding factors exist, and how can they be overcome?</p>
<b>Practice</b>	<p>Sow a distinct amount of seeds, for example, 100 seeds in moist, clean, absorbent cloth or paper. Roll the cloth or paper loosely (rag doll method) or keep it on a flat surface covered with the same material.</p> <p>Do the same procedure some days in advance to show the germination rate as result, too!</p> <p>Count the germinated seedlings and make up the calculation as described.</p> <p>If possible, compare different samples to demonstrate differences in vigor.</p> <p>If possible show damping off-seedlings and explain soil sterilization methods.</p> <p>Demonstrate stratification by clipping, or cutting, and abrasion, and let the participants be <b>active participants!</b> Hand out sand paper, nail cutters and knives</p> <p>and explain also the soaking methods and cold storing methods as well!</p>
<b>Materials</b>	<p>One or better more pure seed samples, absorbing cloth or paper (thicker toilet paper or newspaper, for example), possibly a vessel or container, water.</p> <p>Nail cutter(s), knife(s), sandpaper</p>
<b>Time required</b>	10-30 minutes
<b>Games / Exercises</b>	See above!
<b>Media</b>	

## Chapter 4

## Sowing

**Direct sowing** of small-seeded crops such as lettuce and celery is not practical, as large soil clumps make it difficult to control depth of seeding, resulting in poor emergence.

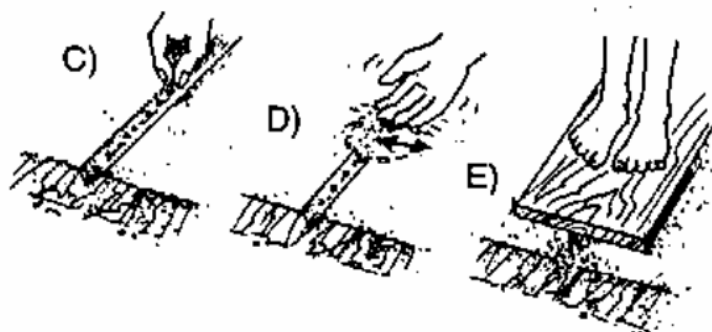
Also when land preparation is inadequate, weeds can be a serious problem in direct sowing, slow growing crops, such as pepper, onion and celery.

Solanaceous crops, such as tomato, eggplant and pepper, and crucifers (cabbage, cauliflower, kale e.g.) respond very well to transplanting, due to stimulated root growth. Cucurbits (cucumber, squash etc.) are immediately in rooting behavior and can be successfully transplanted, if the procedure is done early enough (before setting true leaves).

**Broadcasting** (or broadcast sowing) is very common in small scale farming, as it is the least labor-intensive method, but the seedlings are often not evenly distributed – some of them are too crowded. These must be pricked out, a proceeding that may damage their roots considerably!

**Drill sowing** with uniform spacing gives better starting conditions for all seedlings and makes transplanting easier. Seeds are placed at reasonable distance and depth, according to their size.

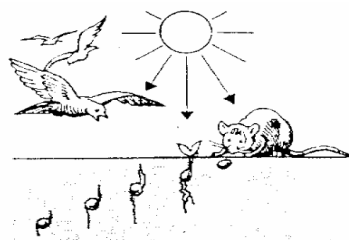
Small seeds (e.g. celery, amaranth, lettuce) are sprinkled in the row and lightly covered (0.5 cm). For even distribution they may be mixed with fine clean sand.



Medium seeds (e.g. tomato, eggplant, cucumber, okra) are put one by one in rows (or 2 to 3 seeds respectively in a hole or cluster) and covered (1-2cm).

Close contact with the moist soil must be assured for an even germination, and it can be reached by lightly knocking down the soil and/or by putting a flat board on the seed rows and standing on it.

Big seeds are put twice as deep as their own thickness and are also covered with soil to protect them from drying out and being eaten by birds and mice. As a rule of thumb, the soil cover after setting should be about two times the diameter of the seed for small and medium-sized seeds, too.



## Chapter 4

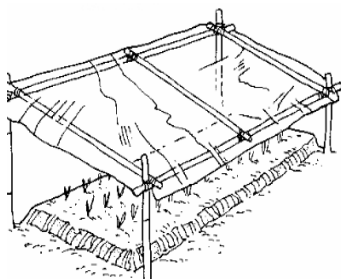
## Caretaking of Seedbed

**Watering** of the seedbed should be done very carefully until the seedlings have emerged, especially when the seeds are small. Large water drops tend to erode the thin soil covering of the small seeds. Using a fine sprinkler is recommended.

Water for the seedbed or flat / tray must come preferably from the tap or from a deep well. Surface water may carry weed seeds, as well as plant pathogenic microorganisms.

Mulching of the seedbed immediately after sowing helps prevent erosion of the soil cover and conserves moisture. The mulch (rice straw, coconut fronds, or even banana leaves) also keeps the soil temperature favorable for germination. The mulch can be very thick (5 cm) but it should be removed at seedling emergence to prevent etiolating. It may be left between the seed rows to suppress weed growth.

Watering during seedling production should be done preferably in the morning and, if needed to be repeated, in the early afternoon. Watering in late afternoon causes the surface of the seedbed to remain moist at night, a condition favorable to the development of damping-off disease.

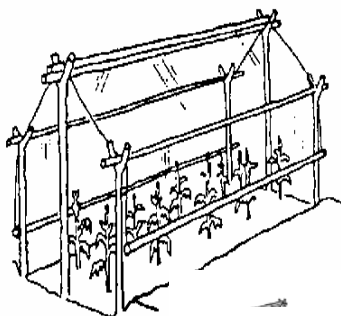
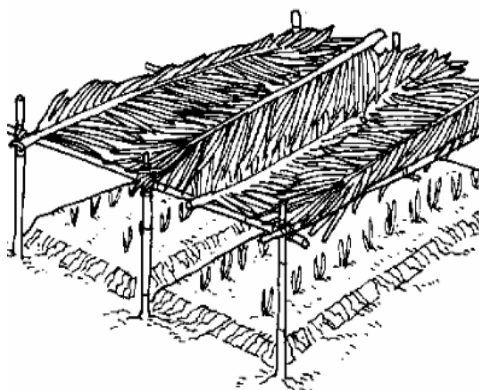


Seedlings must be protected from chicken and pigs by fences and/or (fish-ing-) nets. Fine mesh enclosure keeps many insect pests away. Protection from sun and rain may be provided by coconut



leaves, nylon screens, clear plastic sheets or nets.

However, the shade should be removed as soon as the seedlings are established, as prolonged shading may result in spindly and weak seedlings.



## Chapter 4

## Container Raising

As the **seedbed method** has certain disadvantages, especially for fruit tree seedlings, e.g.

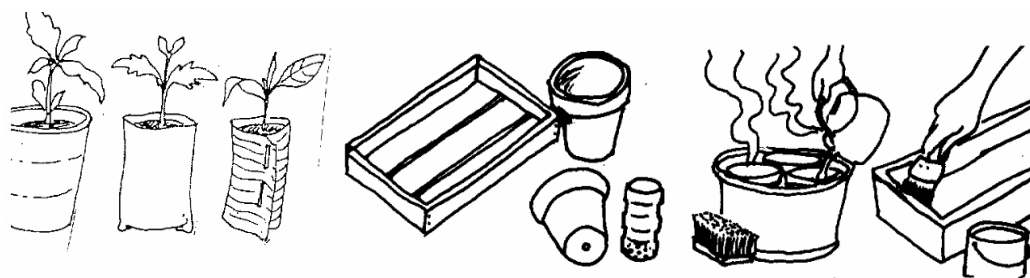
- pulling the seedlings during transplanting causes a lot of damage to the roots
- pulling the seedlings with a ball of soil can be laborious and cause transport problems
- spread of diseases within the seedbed is difficult to control

the use of containers is recommended. **Seedling containers** for vegetables can be made of rolled leaves, paper pots or small perforated plastic pots or bags. Wooden boxes, pottery, cut and perforated plastic bottles may also be used for bigger seedlings (and re-used: that results cheaper and is better for the environment!).

Any kind of container that was in use before must carefully be cleaned and possibly disinfected.

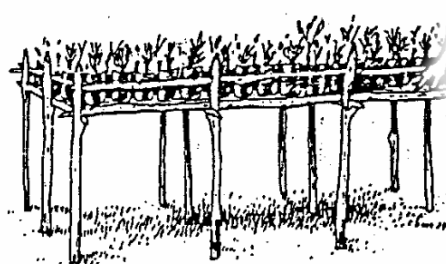
The ground / floor and tools used for making pot mix must be clean. A pot mix is made of water holding and aeration proliferating materials as the roots of the seedlings need both water and air.

Smoked rice hull (or husk) is an excellent material for planting medium, as it provides a bacteria- and fungus- free material, has good water holding ability, holds its shape for a long time, and supplies some nutrients to the plant. Coconut coir dust, mosses, dried (fully decomposed) manure, compost, fertile soil and washed sand are other useful components. The available materials should be mixed in a reasonable proportion, and eventually be sterilized before use.



One major advantage of seed flats or containers is that they can be set on tables with slatted tops of wire mesh or bamboo, thus exposing them to light and air, and preventing outgrowth of roots from the drainage holes.

Raising seedlings in separate containers gives 100% survival in the field since root injury is minimized.



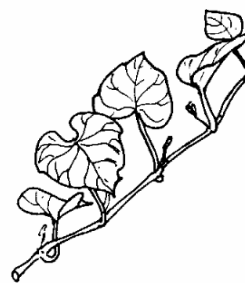
## Chapter 4

## Vegetative Propagation

Some vegetables and many other crops are easier and better grown by plant parts better than seed. **Asexual or vegetative propagation** is possible using

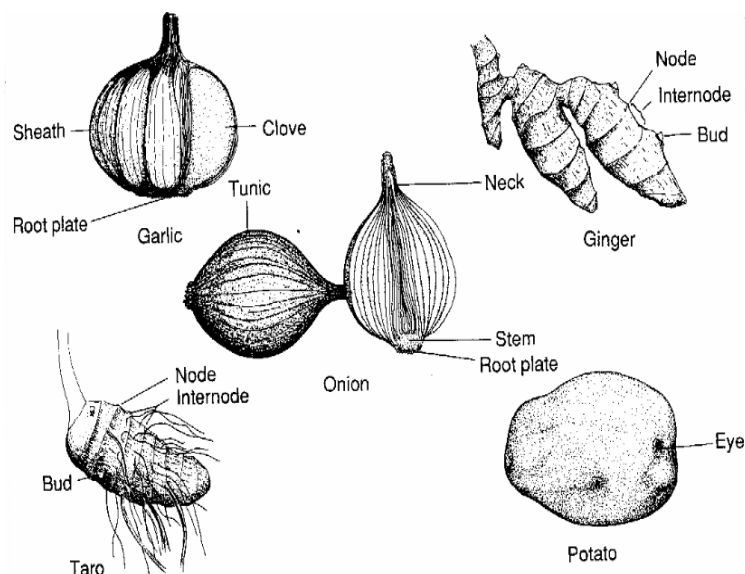
**cuttings:** sweet potato, kangkong (water spinach), e.g. are propagated by vine cuttings 15–20cm, cassava and sugar cane by cuttings that count with 2 buds minimum, or by root tops with shoot buds, respectively.

In general, for propagation purposes cuttings can be taken from root, stem and leaf (see: fruit crop propagation).

**shoots or suckers:**

banana, pineapple,  
bamboo, taro

**bulbs:** onions may be propagated by bulbs, and garlic by cloves, that are segments of the compound bulb. Different ornamentals are propagated by bulbs.



**corms:** taro, banana  
(possibly)

**tubers:** potato, yams

**rhizomes:** ginger, turmeric, cardamom

Vegetables that are propagated by vegetative means include taro and tannia (*Colocasia esculenta* and *Xanthosoma sagittifolium*), ginger, sweet potatoes and yams. The taro species are grown from corms and ginger from pieces of the rhizome. Sweet potatoes and cassava are both grown from stem sections and potatoes generally from tuber pieces. All these vegetables are planted directly in the field without a nursery phase.

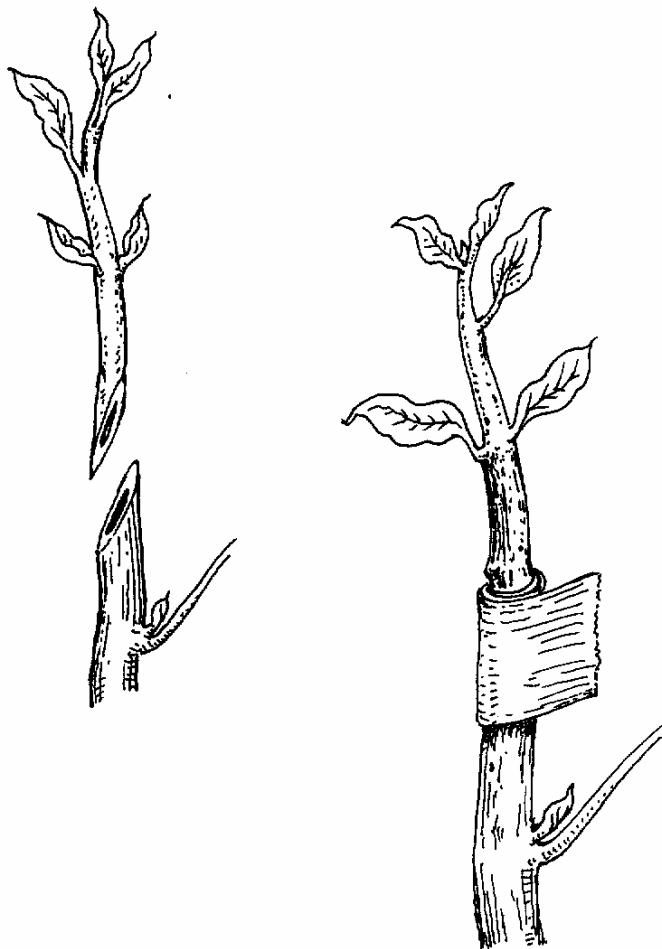
## Chapter 4

## Vegetative Propagation

The materials commonly used for cuttings are stems and tuber pieces. Stem cuttings may be soft and vegetative, such as sweet potato cuttings, or hard and woody, such as cassava cuttings. In the former case it may be necessary to prune off most of the leaves to reduce water loss while the cuttings are rooting. With sweet potato cuttings, pieces of stem of about 30 cm are planted with about half the length in the soil. Woody cuttings of cassava are easy to establish and are again planted completely in the soil so that the problem of moisture loss is not encountered. With tuber pieces the main problems are pests and diseases. These include nematodes, bacterial rots and various other diseases, and also insect pests.

The bulb and tuber crops utilize the lowest part of the stem or leaves to store food reserves and modify it into a storage organ (which may serve for human consumption, too). Some of the modified organs have relatively tough coverings that cannot be penetrated by water but could be used for vegetative propagation.

**Grafting** is used chiefly for propagating tomatoes and sweet peppers on rootstocks of wild eggplants or chilies, respectively, that are resistant to bacterial wilt (*Pseudomonas solanacearum*). The wild eggplants *Solanum torvum*, *S. ferox* and *S. melongenae* are highly resistant to the lowland strain of bacterial wilt. Locally adapted hot chilies may also be fairly resistant to bacterial wilt (though not completely so) and it may be possible to include grafted sweet peppers in a rotation every one or two years under lowland conditions. The subject of grafting is mentioned here because of the general problem of bacterial wilt in the lowland tropics. Grafting is a very simple operation, and a high degree of success can be expected if a little care is taken.





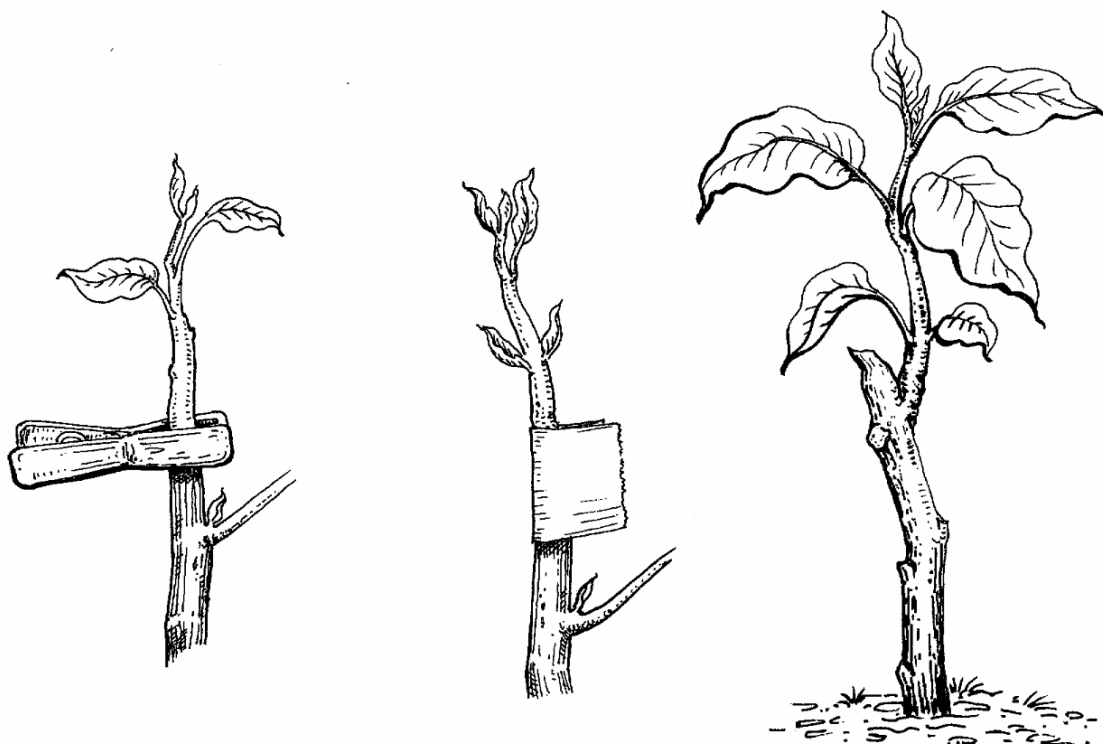
## Chapter 4

## Vegetative Propagation

Rootstocks for grafting can be raised in paper tubes of diameters about 8 cm and 12 cm high. For the first few weeks volunteer shoots on the stock should be pinched off, but the main stock leaves should be left to help the scion grow.

Rootstocks should be cleft-grafted when they are about 20cm high and 3-5mm thick. The rootstock is cut back to a height of 10-15cm and a wedge-cut scion consisting of the apical portion of the desired variety is inserted into a vertical cut. It is held in place with a light clothes peg or a length of tape.

The scion leaves are clipped back to avoid moisture loss, and the graft is given over head shade in a humid atmosphere for one week. The union is complete after about seven days, after which the scion begins to grow rapidly when shade is removed. The graft can be planted when it is growing strongly.



Because the operation of grafting puts up the cost of seedling production, it is best to allow seedlings to become fairly large and to plant at a rather wider spacing than usual to encourage plants to grow well. Furthermore, if very small plants are grafted the union will be close to the ground and roots may establish from the scion.

The soil around grafted plants should be mulched with straw to prevent rain drop and irrigation splash of soil on the union, possibly allowing pathogen entry.



## Chapter 4

## Vegetative Propagation

<b>Questions</b>	<p>What is asexual or vegetative propagation?</p> <p>Which plant parts can be used for vegetative propagation, why?</p> <p>What has to be present for successful reproduction?</p> <p>When is it appropriate to make use of this kind of propagation?</p>
<b>Practice</b>	<p>Take different kinds of appropriate plant parts and examine these carefully in smaller groups. Let the participants discuss about how to plant these and how to prepare the plant parts for planting. Find out if there are regional differences of methods (regarding size of propagation material, for example, or stages).</p>
<b>Materials</b>	<p>Different kinds of propagation materials, knives</p>
<b>Time required</b>	<p>10-20 minutes, possibly more</p>
<b>Games / Exercises</b>	<p>„Guessing game“ or „hands up“ (for example, which crop is propagated by which plant part, giving three options) or variation of „fruit salad“: every participant gets the name of a crop plant (all different kinds) and gets up, when his/her crop fits into the answer of the exclamation of the person without chair, and has to run for another still not occupied chair; for example, „ all crops get up that are propagated by suckers!“ or „ all crops get up that are not propagated by tubers!“ etc.</p>
<b>Media</b>	

## Chapter 5

## Land - and Bed Preparation

Often vegetables are grown during the cool, dry season immediately following the wet-season flooded rice crop, or on the river banks. Then presence of weeds and soil-borne diseases are minimal because of the prolonged anaerobic conditions which are unfavorable to the survival of weeds and pathogenic microorganisms.

Consequently, the need for **land preparation** is diminished. Under rain fed conditions, land preparation may actually be inadequate because the soil tends to dry faster. Thus it is not practiced in traditional garlic production, and only partially done in watermelon production after paddy rice.

The upland field is entirely different from that of the paddy field, but on steep hillsides thorough land preparation easily causes problems of erosion.

After a field is free from obstruction (e.g. cleared after a prolonged mismanaged fallow period) **ploughing** is required for a heavy soil, but may not be necessary for light soils. Loosening of soil improves internal drainage.

Success in ploughing is determined to a large extent by the soil moisture: ploughing wet soil may result in hard soil clods that may not easily be broken by succeeding equipment. Dry clay soil may be too hard for hand tractor or animal-draft machines.

A disc harrow or even rotor tiller serve for the same purpose in light soils. The rotor tiller breaks the soil into small particles, but it is not necessary to pulverize the soil thoroughly for transplanting or for direct-seeding large-seeded crops.

Generally, the **soil must be considered a living organism**: disturbing it too much and too often causes more harm than good. It should be supported with good treatment and nourishment (see. Soil improvement and soil conservation).

**Leveling** is necessary only if furrow irrigation is used. It can be also important to remove low areas which may be waterlogged during the wet season. But these can be used for species tolerant to water logging, too!

**Ridging** is the final step to make the furrows or beds in preparation for planting.

The standard bed width for fields that are watered by overhead irrigation (hose, watering can) and manually operated is 1.5m including the pathways / furrows. Narrow beds minimize compaction of the soil, as the workers move only in the canals between the beds.

In lighter soils, narrower beds are recommended. In heavy soils, wider beds (maximum 1.5m) can be used, because the lateral movement of water under furrow irrigation is easier done.

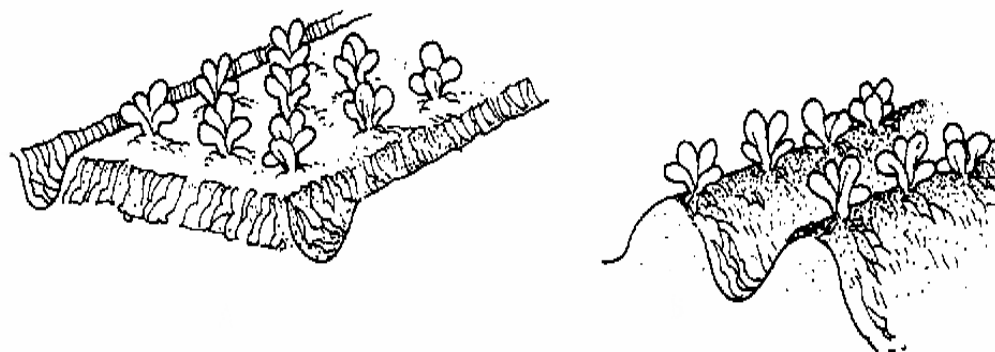
## Chapter 5

## Land - and Bed Preparation

During the wet season, single-row planting is recommended to minimize competition for space between rows of luxuriantly growing (a lot of space requiring) plants.

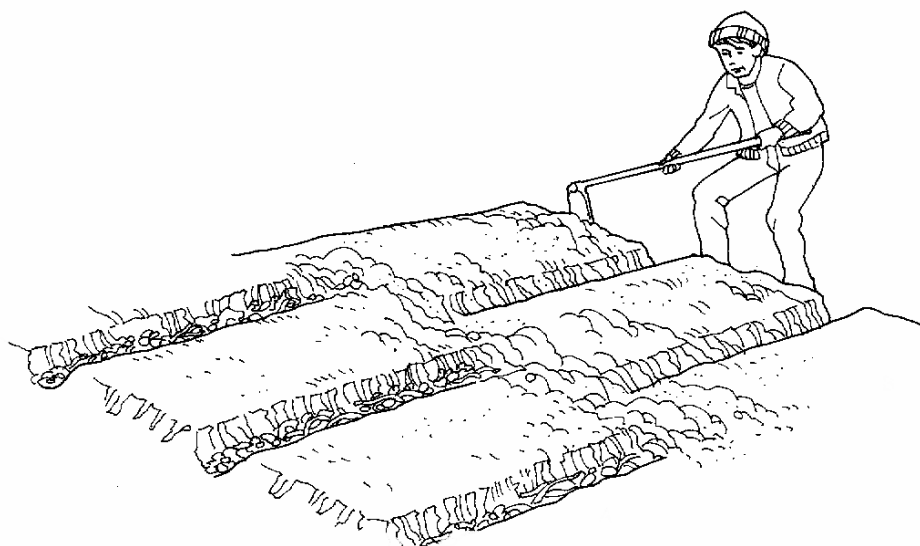
Consequently, narrow beds are prepared at all.

The reverse is true during the dry season when plants tend to be less vegetative. Multiple-row



beds tend to reduce irrigation water loss by evaporation; hence, it is preferred for the dry season crops.

The usual problem with manual land preparation is inadequate depth. Soil must be loosened well at least 20cm deep below canal level.



**Chapter 5****Land - and Bed Preparation**

Land preparation involves putting crop residues in the drainage canal and digging the new beds by covering the residues.

Lime (if necessary) is applied approximately one month before planting to allow enough time for it to react with the soil.

Manure can be applied immediately before planting if the material is sufficiently dry and decomposed. Fresh manure tends to generate heat and ammonia during decomposition, and may directly harm the crop. Furthermore, decay microorganisms which are active in the decomposing manure may compete with the plants for nutrients, causing mineral deficiency.

For **fruit trees** the **holes** are usually dug a month before the trees are to be planted and left exposed to the sun and wind until planting time. This exposure helps the interior of the holes to get properly „heated up“ and weathered.

The size of the hole varies with the kind of fruit, variety and the soil type (minimum about 50x50x50cm)

The filling of each hole is done with (only!) the top soil mixed with compost (and/or decomposed manure) to give the tree a good start.

If the plant bed or field is dry, it must be irrigated thoroughly a few hours before transplanting.

This can be done using a hose or watering can with fine nozzles, and/or furrow irrigation.

Straw or grass mulch is put as a layer, leaving rows open for transplanting. Sugarcane wastes may be used as well.

**Mulching** serves several purposes:

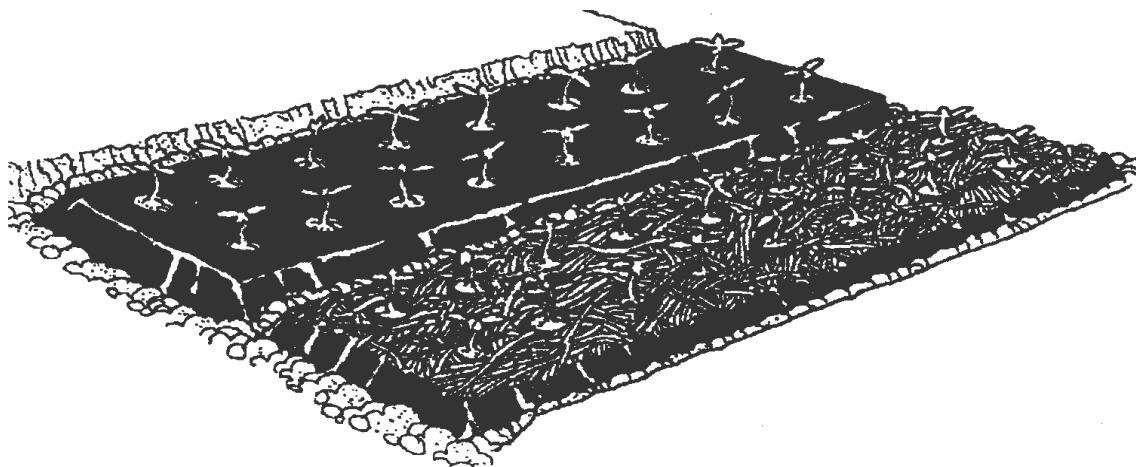
to control soil temperature, either by keeping it cool (for example, by using straw mulch in a tropical environment) or keeping the soil surface warm (by using clear plastic during spring-time for planting in the highlands) to prevent loss of soil moisture to control weeds by shading them, and diseases by preventing soil contact with the plant foliage

Dark-colored plastic is effective if used in combination with rice straw. Rice straw serves to insulate the plastic from direct sunlight and prevents the build up of soil temperature during the day. Dark plastic prevents sunlight from reaching the soil surface and heating it, and weeds from growing, too.

## Chapter 5

## Land - and Bed Preparation

Black plastic mulch is applied before transplanting of tomato, e.g. at transplanting, holes are made on the plastic where tomatoes are planted. Subsequently, the plastic mulch is covered



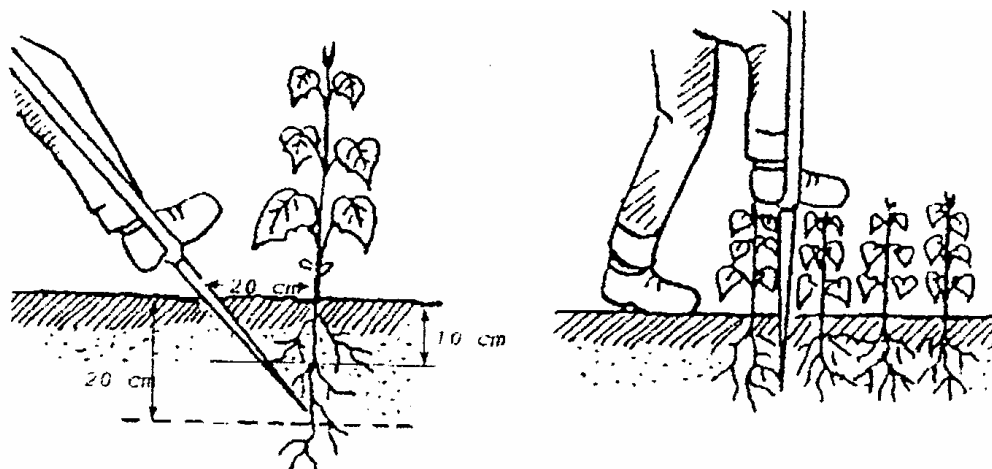
with straw mulch.

Especially when dry and sunny weather is expected immediately after transplanting, seedlings must undergo the hardening process:

10 days before transplanting, watering should be decreased to allow the shoots to grow slower and the roots grow faster.

The seedlings should also be exposed fully to the sun if they have been kept under partial shade.

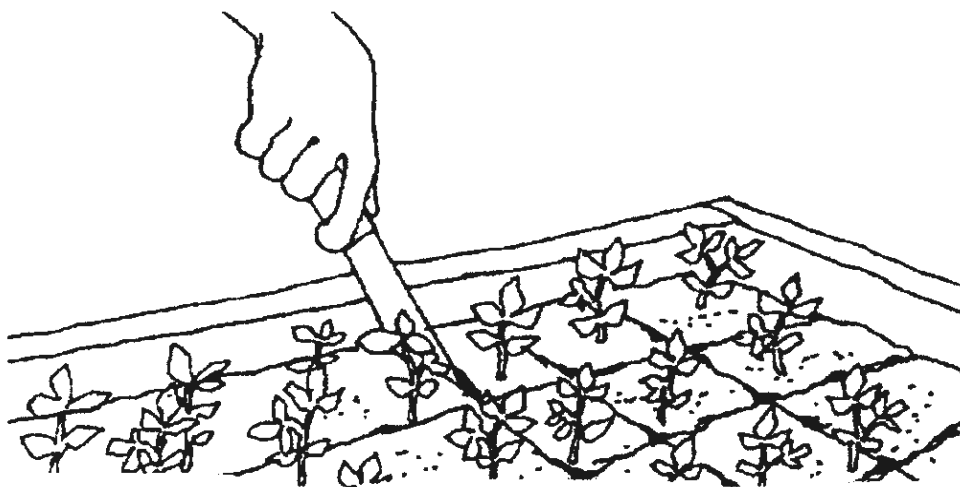
In order to prevent the secondary roots of fruit crop seedlings getting tangled up in seedbeds, it may be necessary to trim them; the distance between the plants will determine how frequently this needs doing, to dig to a maximum depth of 20cm.



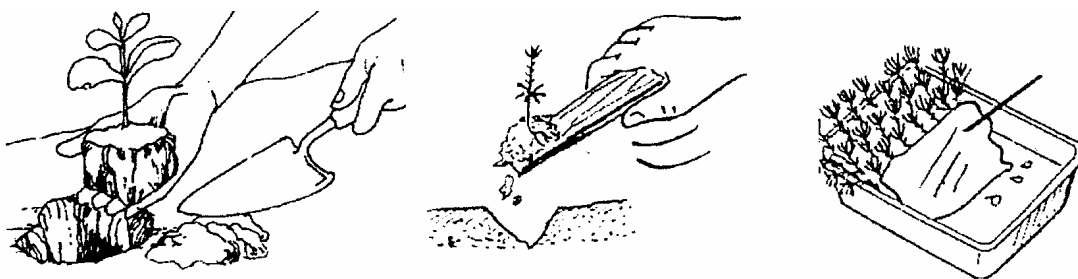
## Chapter 5

## Transplanting of Bare-Root and Container Plants

In seed flats (and seedbeds possibly, too) it is a good practice to prune the roots one week before transplanting, by passing a sharp knife around each seedling; root branching close to the main root is stimulated and therefore bare-root transplanting prevented.



A cloudy, cool weather and a moist but not wet soil are ideal for transplanting. During sunny days transplanting is best done in the late afternoon.

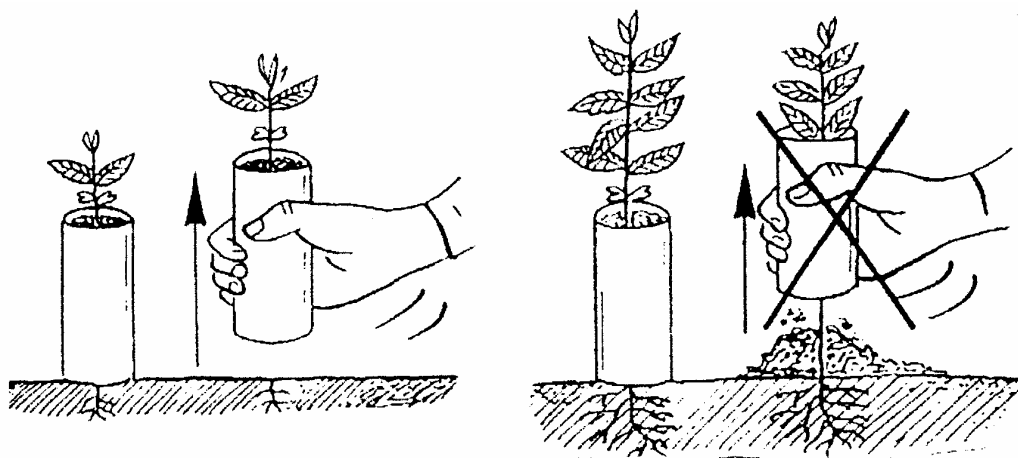


If grown in seedbed, seedlings are lifted carefully with a trowel or with a split bamboo stick. It is reasonable to take off just as many seedlings as can easily be planted within the next quarter of an hour. When still hot and dry the seedlings should be covered with a wet cloth or plastic to avoid suffering from water loss.

## Chapter 5

## Transplanting of Bare-Root and Container Plants

If grown in containers correct timing permits „shocking“, means pulling the bag or container jerkily:

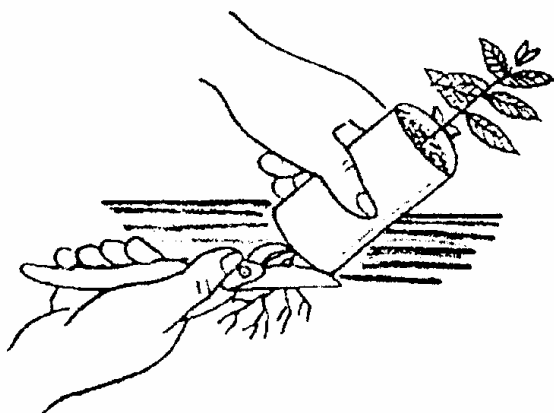


If the roots grew into the ground, they should be pruned with a spatula or with wire drawn right below the containers, in order to divide the roots with a clean cut.



## Chapter 5

## Transplanting of Bare-Root and Container Plants



In case of small quantities bags or containers may be lifted carefully on one side, and the roots pruned with shears.

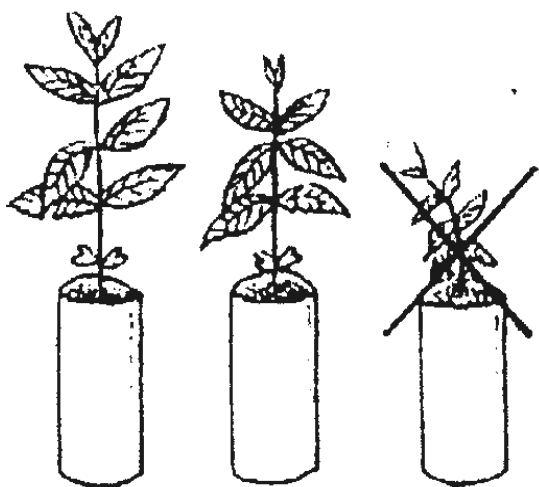
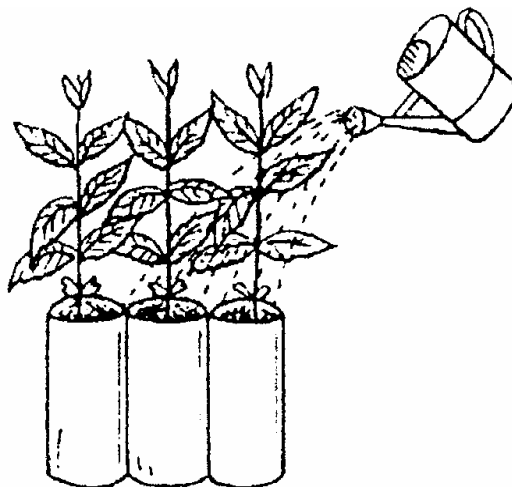
Pruning usually only takes place when the plants have grown too large, either through bad planning or an unforeseen delay in the planting season.

With fast growing plants, it is often worth trimming a long shoot down to 30cm (about twice pot height). This encourages even growth of both leaves and roots.

The rainy season is the best time for planting tropical and subtropical fruit crops because trees planted early in the wet season soon get established, grow quickly and require no irrigation for 2-3 months.

The night before planting in the field, water the seedlings thoroughly.

Before transplanting into the definite place, the weak small and spindly plants should be sorted out.



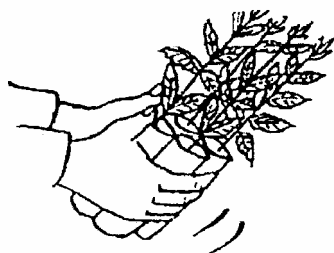
A further selection of the best plants should be made to get homogeneous, sound and well conditioned plantations.

Afterwards plants of second choice are gathered to complete plantations.

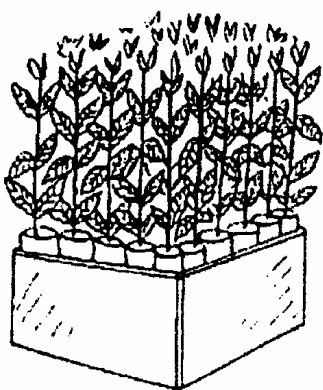


## Chapter 5

## Transplanting of Bare-Root and Container Plants

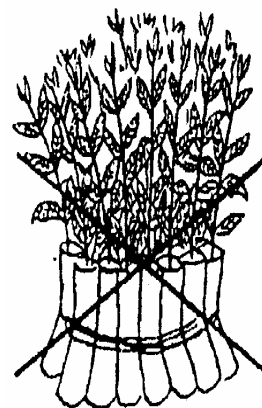


To prevent damages of the graded plants on their way to the planting hole, the bags (or other kind of containers) are to be hold, but never the shoots shall be pulled!



Use trays or boxes should be used for transport to the field.

But never shall bags or other containers be tied with rope, to make transport „easier“ that might result in unnecessary losses of plants!



Before planting the plastic bag must be removed, whereas containers made of bamboo or banana leaves or other decomposing materials may be left. It is recommended to collect the bags as plastic is rubbish that does not decompose easily, and burning them releases detrimental gases.

Whenever possible preference should be given to recyclable materials!

Taking special care when planting seedlings or grafted trees will help them to establish quickly and safely. Tree roots should never be left exposed to sunlight or left where they will dry out.

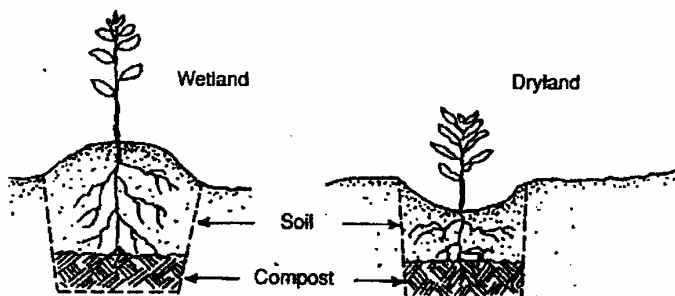
The planting hole should be watered first, if transplanting has to be done before the rainy season has started. Roughly the third part (bottom) of a hole almost twice as deep as the length of the seedlings' roots shall be filled with top soil mixed with compost. While holding the plant in the centre of the hole, this is to be filled completely with top soil and compost.

## Chapter 5

## Transplanting of Bare-Root and Container Plants

When planting in a dry area, or on hill slopes, the tree should preferably be planted in a basin.

If the area is wet, the tree should be planted in a mound of soil higher than the general surface. A small circular trench around the bottom will provide good drainage.



Soon after transplanting the young trees are irrigated and staked to prevent damage caused by wind.

The **spacing of fruit trees/crops** varies with the kind of fruit, variety, soil type, rainfall, etc.

The spacing should be such that it provides the optimum space for the fruit trees.

Close spacing makes trees grow tall and slender without a proper spread. Such trees are weak and liable to injury from strong winds and the fruit borne by them are of low quality.

Mango:	on slopes: 9x11m; dry regions: 8-10 m apart; under ideal conditions: 12-14 m apart
Pine apple	single row system: 60 x 75cm; double row system: 30-45 x 60cm fresh fruit: 60.000-70.000 per hectare; cannery fruit: 40.000-50.000 per hectare
Sapota:	9-10 x 9-10 m
Jackfruit	10 x 10m
Custard apple	5 x 5 m
Jujube:	11m in row, and 12m between rows

### Spacing of vegetables

The correct stage of transplanting varies with the density of sowing or the size of containers, and with the vigor of the seedlings.

For cabbages three-week-old seedlings are convenient to handle, although much larger seedlings up to five weeks old can also be planted and will establish very quickly. They should be widely spaced in the nursery, however, so as not to become etiolated (long and pale).

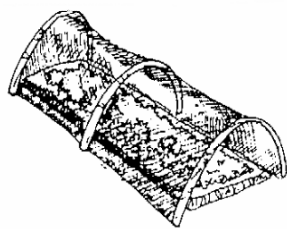
Where paper tubes of diameter 2.5-3cm and length 5-7cm are used, the seedlings will also be ready to plant out at three or four weeks old.

## Chapter 5

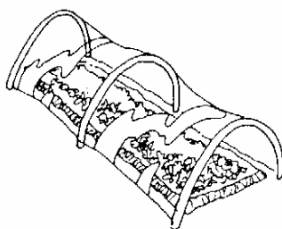
## Sunlight and Rain Prevention

Onions are planted out as bare-root seedlings at an age of 6-8 weeks in multiple-row beds with a spacing of 20cm between rows. Squash is planted in single rows with an inter-row distance of 1.5 - 3.0 m, depending on the variety.

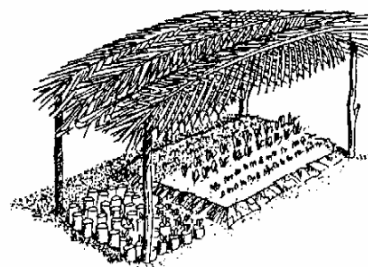
Seedlings of the fast-growing Chinese crucifers pak choi and choy sam (*Brassica chinensis*) can be transplanted when two or three weeks old. Because of the close spacing and the large number of seedlings required, these non-heading cabbages are best grown as seedlings for bare-root planting and not in paper tubes. If transplanted as bare-root seedlings, they will need shading in the hot part of the day for the first week.



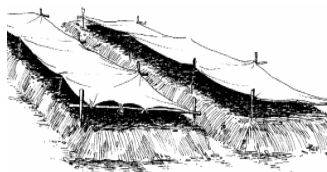
nylon net



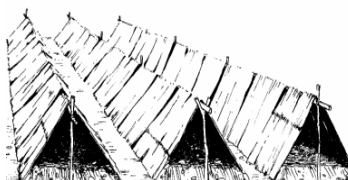
clear plastic sheet



palm fronds



plastic nets



movable shade mats



individual shades

Seedlings grown in paper tubes do not need shading after transplanting.

Seedlings of tomato, chili (hot pepper) and eggplant grow more slowly, and should be transplanted when the plants are fairly large (at least 15cm tall).

They establish much more rapidly when sown in paper tubes (or other small individual containers) which should be of diameter about 7cm and about 10cm long.

## Chapter 5

## Transplanting

<b>Questions</b>	<p>What is the first step towards transplanting? What is to be achieved?</p> <p>What are the purposes of mulching?</p> <p>What are good practices to prevent bare-root transplanting?</p> <p>What should the weather conditions be like for transplanting?</p> <p>What can be done to prevent root damages at transplanting?</p> <p>What should be taken into consideration during transport to the fields?</p> <p>What measurements should be taken into account when transplanting into wetland?</p> <p>What should be done immediately after transplanting?</p>
<b>Practice</b>	<p>Get some containers and soil mix for potting. The participants shall practice to fill the containers right, without airbags (that hinder close contact between roots and soil) and neither too loose nor compacted.</p> <p>When inserting the plant, make sure that there is close contact between roots and soil, and that the roots are not tangled, but straight and completely introduced into the medium. The shoot should be at the same height as before, but exceptions are made in cabbage (and similar crops) which grows better and upright if inserted almost up to the leaves into the soil.</p>
<b>Materials</b>	Some bags or containers and potting mix, and simple plants, may be herbs or weeds.
<b>Time required</b>	30-45 minutes (possibly more)
<b>Games / Exercises</b>	See above!
<b>Media</b>	

## Chapter 6

## ...in Vegetables

With few exceptions, all climbing vegetables can be staked. There are three types of plants for purposes of staking:

- plants (such as cucurbits) with special structures such as tendrils which allow them to climb
- plants that twine (such as yardlong beans)
- plants (such as tomatoes) that do not have the natural ability to climb and must, therefore, be tied to the stakes



**Staking** facilitates management operations, such as irrigation, inter-row tillage, pest control, and harvesting. It also helps produce better products. For wet-season tomatoes, staking is necessary. Where labor and materials are cheap, it is always desirable to stake.

In staked crops, **training** is necessary in the initial stages to keep the vines off the ground. In insect-pollinated crops, such as watermelon and squash, dense vines and foliage may interfere with insect activity and reduce fruit set.

**Fruit thinning** is done to control fruit size, so some fruits are removed before they enlarge. Some plants, particularly cucurbits, produce female flowers and set fruit so early that vegetative growth is still insufficient to support the normal growth of the fruit. When this happens, further vegetative growth is restricted, while additional fruit setting and development is equally affected.

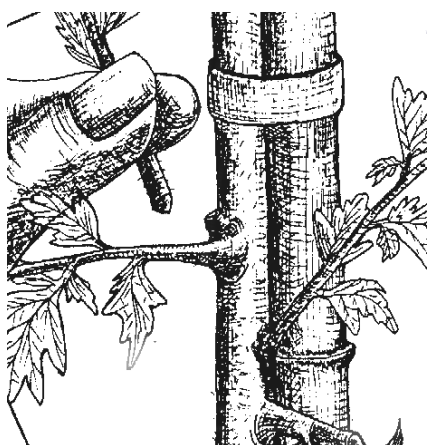
To promote the formation of bigger and better fruits, the first one or two fruits on the vine are removed. The number of fruits is subsequently limited to one. The practice of fruit thinning is widely used in melons and watermelons.

## Chapter 6

## ...in Vegetables

But - in watermelon the first and sometimes the second fruit on the main stem will have the greatest ability to draw assimilates (sugars) and will, therefore, suppress the rest of the fruits. Although any of the fruits may be removed from other plants, in watermelon only the first and sometimes the second fruit are allowed to develop.

In cucurbits, each lateral branch can support a fruit, or a few fruits. **Pinching off** the growing tip will result in many lateral shoots and consequently result in more fruit yield. However, total weight of the fruits produced by the plant remains the same. It is especially useful when small



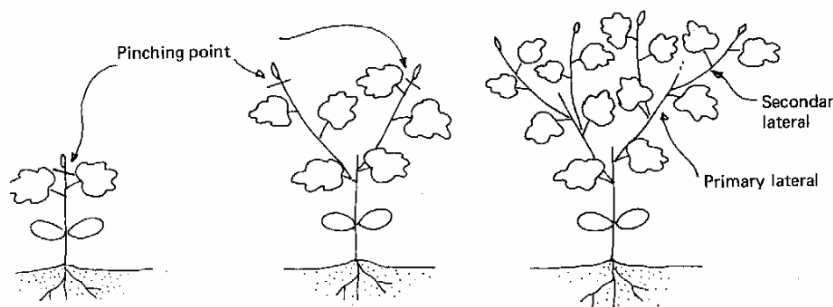
fruits sell better than large ones (for example, small zucchini are more appreciated than big ones) and when small fruits are required for special purposes, such as cucumbers for pickles.

In indeterminate tomatoes, **pruning** results in single-stem plants which can easily be tied to the stake. The fruits are consequently larger because the plant's nutrients are not diverted to the branches.

Another benefit of shoot and foliage removal is more efficient air circulation and, by preventing direct contact with the soil, avoiding fruit rot and

spread of fungal diseases.

Pruning of side shoots may reduce total yields but enhances early and marketable fruit yield.

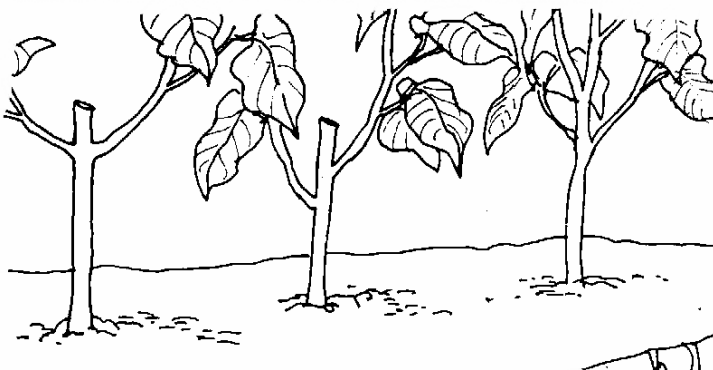


In the case of cucurbits, such as *Luffa*, pruning of the tip of the seedling stimulates early branching and fruiting on lower nodes.

## Chapter 6

## ...in Vegetables

**Ratooning** is resulting from a distinct method of pruning which is done on mature plants that have declined in productivity. In this case, the main stem is cut 20cm from the ground and stimulated to produce new

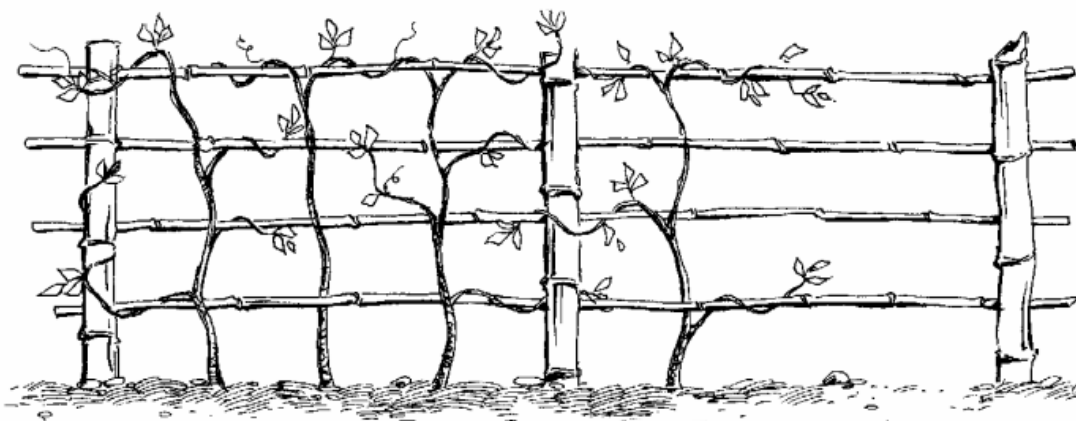


branches by applying fertilizer and irrigation.

The result is a ratoon crop, which starts to produce fruits sooner than if seed planting is done instead. However, the yields are usually lower.

Ratooning works very well with some varieties of okra and eggplant during the wet season.

If bitter melon or cucumber, for example, is trained on a vertical rack of bamboo the lower shoots are pinched off until the stem reaches the top of the rack (which may be 1.8-2m high). This procedure allows the plant to grow healthy and makes harvesting easier.



Pruning should be done with a sharp blade to minimize damage to the plant and to facilitate recovery.

To prevent spread of diseases, the blade should be dipped regularly in detergent solution.

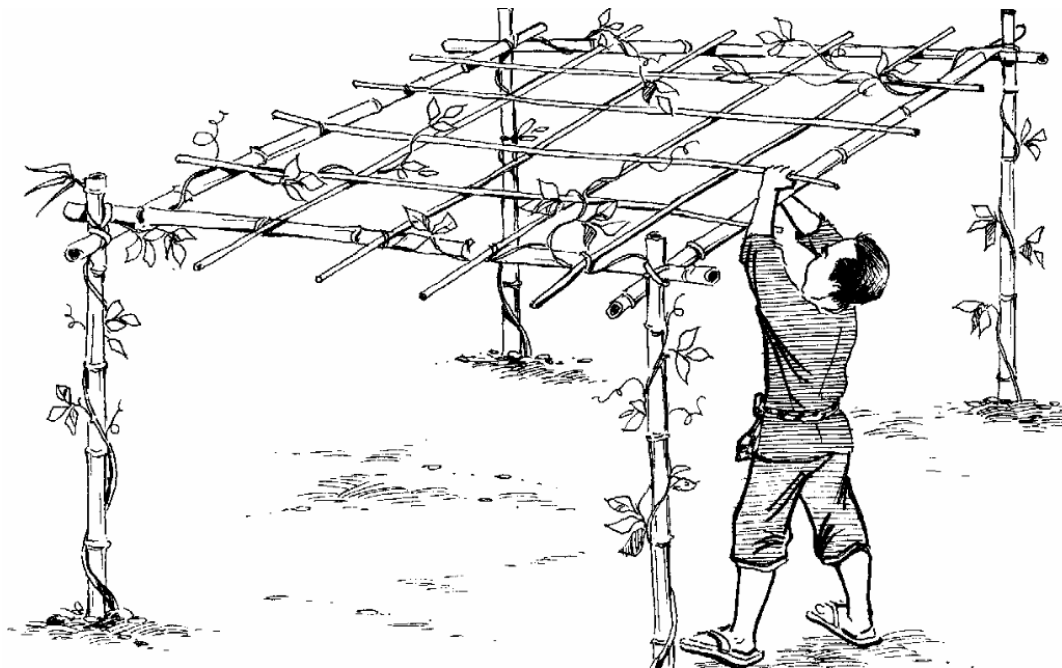
## Chapter 6

## ...in Fruit Crops

**Climbers** such as passion fruit must be trained on a **trellis** or on stable roofs, decaying trees, etc., if available.

An overgrown trellis may be a nice shady resting place or an adequate place for the initial stage of nursery. Shadow-tolerant crops, such as taro may be grown, and fish may be raised below a trellis, too.

Passion fruit i.e. is preferably grown on vertical racks or wires (4-5 wires up to a height of about 2.5m) for commercial purposes, as less space is needed, and aeration of plants is better than on a horizontal trellis.



**Pruning fruit trees** includes, due to the growth stages

- a kind of training to form a good symmetrical branching system in young trees,
- a removal of shoots appearing on the stock part below the graft joint,
- an inducing fruit-bearing by root-pruning,
- a periodically cutting of dead and/or diseased plant parts and,
- a thinning out of branches in order to increase aeration and light exposure, thus preventing fungal diseases and die back.

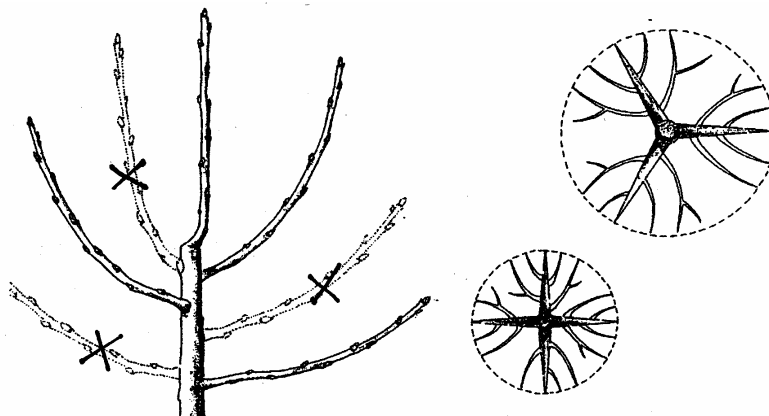


## Chapter 6

## ...in Fruit Crops

Within the first year after planting the crown has to be shaped: Three to four guiding branches should be distributed equally, the other branches have to be pruned. Only one will form the top.

Training and pruning in **guava**:



Training is needed to provide the proper shape of the tree:

First year: All the side branches that arise from the main stem are allowed to grow.

Second year: One or two lower most branches are removed (in May) about 45cm from ground level to give the tree a clear stem.

Only 3-4 good, healthy and strong branches are allowed to grow from the future permanent framework of the tree.

Third year: The few shoots that arise vertically from the main framework, are removed to allow more sunlight to enter in the centre of the tree.

After 4 years, the main framework gets properly built up.

In **guava**, a light annual pruning is essential to induce growth and flowering. The heavy or severe pruning has been found to reduce the yield, so it is not recommended.

The previous seasons' growth is cut off leaving a stem of 8-10cm in length carrying a few buds on it. These buds are stimulated and put forth new sprouts. The new sprouts blossom and produce the new season's crop.

The pruning is done in the beginning of the rainy season. If it is not raining irrigation is necessary 15-20 days after pruning, when the buds start growth, in order to blossom in about one month.

In **mango** pruning is not usually done, except for the removal of weak growth, and dead and diseased wood and **parasitic plants**. It may assist in shaping the tree in early life. Also, all flowers appearing during the first three years should be removed as soon as they are seen because their presence suppresses the growth of the plant.

## Chapter 6

## Fruit Inducing Methods

In **banana** the aim of pruning is to maintain a balance between plant growth and yield. All unwanted suckers are removed, this reduces internal competition, so that bigger bunches of better quality are produced.

In **custard apple** pruning is done to avoid over-crowding and to encourage well-spaced branches. Only 5-6 strong side branches are allowed to grow from the main stem.

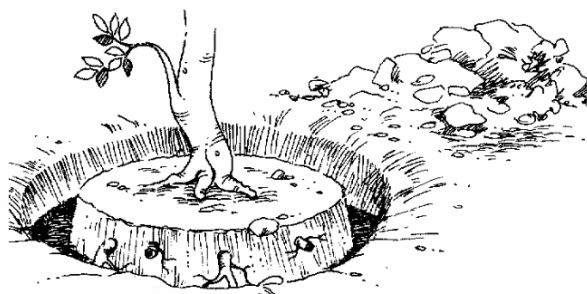
Budded or grafted plants require little or no pruning because of their uniform growth, but the removal of shoots arising below the union is necessary.

**Litchi** plants require little pruning; heavy pruning is not recommended because it causes profuse vegetative growth and less flowering. The customary method of picking the fruit by breaking with its branches 25-30cm long, provides itself a form of pruning which is necessary for the continued productivity of the tree.

In **sapota** no pruning is required except the removal of stock growth.

**Root pruning** has long been practiced by fruit growers to induce flowering in young vigorous trees which are shy in bearing. It is done at least 60 days ahead of the normal flowering time. The normal practice is to dig a circular trench 10-15cm deep and 30-40cm wide around the trunk. Some of the larger roots are exposed and smaller ones are cut. Some weeks after the

exposure and cutting of the roots, fresh soil, or the old soil mixed with manure, is put around the roots. They are irrigated, lightly (!) at first, and after a few days, more heavily.

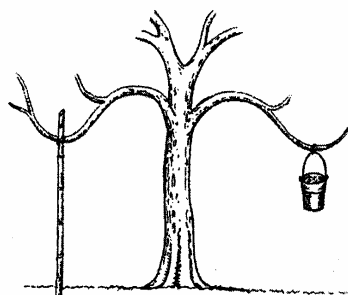


In principle, the practice reduces the entrance of water and nutrients, thus retarding the vegetative growth.

A **light** irrigation stimulates the tree

to burst into bloom.

**Bending** is practiced to increase the fruiting area of **guava** (also useful in apple), especially in the erect growing varieties. The large upright branches are bent horizontally, using posts or stakes, or even tins filled with sand, or stones, of an adequate weight. Several side shoots, on which fruits are borne come out from these bent branches.



## Chapter 6

## Fruit Inducing Methods



**Girdling or ringing** involves the removal of a ring of bark (just without wood!) from the trunk or the branch. Girdling is practiced on trees, which are vigorous in vegetative growth. It is not useful for a weak plant.

Ringing stops the downward movement of carbohydrates and their accumulation above the cut, which brings the favorable condition for fruiting.

For example, sometimes vigor-

ous mango branches are ringed to force flowering.

**Notching** is similar to ringing, but it affects only one bud at a time.

The process involves the removal of a small narrow strip of bark just above or below the bud.

**Thinning of blossoms** is a method in which excess flowers are removed from a tree which produces too many flower buds, flowers and fruits, but a few vegetative shoots in the cropping season.

Usually one third of flowers are removed. If thinning is not done, the tree bears heavy crops in that season, gets exhausted and bears little or no fruit in the succeeding year.

Thinning diverts some of the energy of the plant from fruit formation activity to vegetative growth:

A proper balance between the amount of new shoot growth and flower bud formation, is established.

Complete thinning of blossoms is very important in immature fruit trees, in order to get strong trees at a later stage.

**Thinning of fruits** from heavily bearing fruiting branches is done just after the natural drop is complete. Otherwise the thinning may be more than desired.

Thinning improves the size and quality of the fruit, but reduces the total yield of the tree. It is usually done by hand.

**Chapter 6****Fruit Inducing Methods****Floral induction in pineapple**

There is no regular flowering in pineapple, but it can be regularized using:

**ethylene:**

5ml = 1 teaspoon of ethylene is added to 5 liters of water and then 200g (about the content of a soft drink tin) is added, and all thoroughly mixed.

Now, 50ml = 5 Chinese spoons full of this solution is poured into the heart of each plant in the beginning cold season (in November). This treatment induces almost 100 % of flowering three months later (in February).

**calcium carbide:**

1g (one „tip“ of a knife) of calcium carbide (which is found in smoke) is applied to the axils of upper leaves where it gradually reacts with moisture to produce acetylene which is responsible for floral induction. This treatment induces more than 60 % of flowering.

## Chapter 6

## Staking, Training, Pruning

**Questions**

What does the term staking mean, and what is meant by training a plant?  
 Which crops are staked and trained?  
 What are the advantages of staking and training in general?  
 What is meant by pruning? When and where is it done appropriately?  
 What different kinds of pruning exist?  
 What is meant by bending, and what is this technique aiming?  
 What does girdling or ringing mean, and why is it employed?  
 What is aimed by thinning of blossoms? Which effects has thinning of fruits?  
 What is floral induction, and how can it be manipulated?

**Practice**

Take any plants appropriate for demonstrating different pruning, training and thinning techniques. You can use weeds and shrubs for practical purposes, but make sure, that the participants practice what you are talking about. Supply with knives and tape or strings, and get bamboo and fiber for staking purposes.  
 Provide some popular detergent for disinfection of tools.

**Materials**

Entire plants or plant parts, bamboo and plant fiber or vine  
 knives, string, tape, detergent solution

**Time  
required**

30-60 minutes

**Games /  
Exercises**

See: Practice

**Media**

**Chapter 7****Sexual Propagation**

The probably easiest and cheapest propagation method is done **by seed**.

It is called **sexual propagation**.

Seeds of litchi, jujube, avocado, mangosteen, and sapota, e.g. give rise to only one plant which is **not** identical to the parent.

Some citrus species and some mango varieties produce 3-4 seedlings out of one seed (poly embryonic seeds). One of these seedlings is weak and small in size and should be sorted out.

The others are well developed and behave **exactly like their parents**.

Treatments of seeds to stimulate germination

- Rubbing the seeds on sand paper, cutting with a file or cracking carefully the seed are simple methods to modify hard or impervious seed coats, e.g. in jujube. Seeds are sown immediately after treatment.
- Soaking seeds in water prior to sowing hastens the emergence if the seeds are slow to germinate, e.g. guava (about 15 days).
- Placing seeds in boiling water for about 5 minutes accelerates the germination also (e.g. guava).
- Moist-chilling is necessary for germination of seeds of apple, cherry, plum, peach, and pear, etc; they are stored in moist sand layers in the refrigerator (0-10°C for about 2 weeks).

**Sowing of seeds**

Seeds are sown in lines in nursery beds, or directly in containers; spacing depends on the type of seed (for soil mix etc. see: Seedbed Preparation). Containers or bags should be filled well with soil mix and be put upright to prevent deformed growth.

**Advantages of sexual propagation**

- A seedling plant is usually long lived, hardy and a heavy bearer.
- In papaya, mangosteen, etc. large-scale vegetative propagation is not possible or economical.
- Chance seedlings may come up.
- Rootstocks are usually raised from seeds.

**Disadvantages of sexual propagation**

- A seedling tree is not as uniform in growth, yield and fruit quality as compared to the grafted tree.
- It takes more time for the first bearing than the grafted trees.
- It becomes large, so the costs of spraying, pruning and harvesting are comparatively higher than the grafted ones.

## Chapter 7

## Vegetative Propagation

When plants are propagated by plant parts other than seeds **asexual or vegetative propagation** is carried out (or taking place as a natural process).

For fruit trees some propagation methods are common that include the following:

- Separation or Division

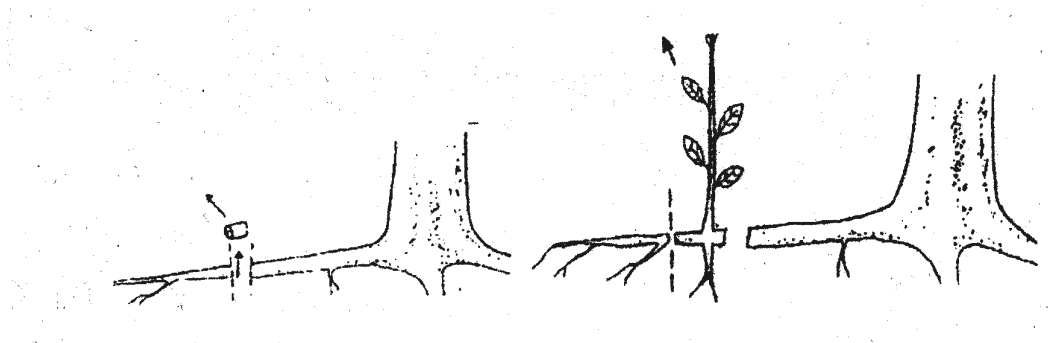
This simply involves the separation of several vegetative parts such as rhizomes, slips, crowns, suckers and runners from the mother plant. Among fruit crops, pineapple is propagated by suckers, crowns and side shoots or slips, banana by suckers and rhizomes, strawberry by runners and date palm by suckers.

- Root cuttings

The roots of some fruit trees, such as guava, plum, persimmon, e.g., and shrubs, such as blackberry e.g. can be used for cuttings.

The size of the root taken should be 10-15cm in length and 0.5cm in diameter at least. In order to speed up the development of root cuttings the end of a tree root is cut off using a spade or shovel. From the piece of root cut off new shoots will form.

Some tree types such as breadfruit tree can be propagated by taking root cuttings of a few centimeters in diameter cut off in lengths of 1m. These cuttings are then planted horizontally in sand or soil in the nursery. After one or two months shoots will form, and the rest of the root will be cut off.



By far the most important type of cutting is the **stem cutting**. According to the nature of the wood used in making the cuttings three different types may be distinguished:

- **Hard wood cuttings** are prepared from the previous season's growth. In deciduous trees, cuttings are made during the early spring or rains.

Cuttings are taken from healthy, vigorous stock plants that contain enough stored foods to nourish the developing roots and shoots until the new plant becomes self-sustaining.

## Chapter 7

## Cuttings

At least two nodes are included in the cutting, the basal cut is usually just below a node and the top cut about 2cm above a node. The diameter may range from less than 1cm to 2.5cm or even more.

The cuttings are planted in beds or containers. In the beds, they are planted 10cm apart in rows of 30cm apart in a slanting position, usually buried half to two thirds of their lengths in the soil.

The beds must be kept moist by daily watering.

It is a suitable propagation method for mulberry, grape, currant, gooseberry, pomegranate and some plums.

- **Semi-hard wood cuttings** are usually made from woody, broad-leaved evergreen species. A few fruit species e.g. citrus and cacao can be started in this way, taking cuttings from new shoots which are partially matured.  
If the leaves are very large, they are reduced in size to lower the water loss and to allow closer spacing in the nursery bed. These cuttings are best rooted under frequent sprays with very fine nozzles and possibly covered with perforated plastic sheet.
- **Softwood cuttings** are not made in fruit crop propagation.



## Chapter 7

## Growth Regulators

**Treatments of cuttings with growth regulators** (hormones) are used for species whose cuttings root with difficulty.

**Indole butyric acid** is probably the best material for general use, because it is non-toxic over a wide concentration range and is effective in promoting rooting of a large number of plant species.

Dry application: The base of the cutting is dipped into the powder. To avoid brushing off the powder, a trench may be made in the bed (holes in containers, respectively) before cuttings are inserted immediately after treatment.

Dilute-solution-soaking method: The basal end of the cutting (2-3cm) is soaked in a dilute solution of indole butyric acid for 24 hours just before planting in the nursery.

Concentrated-solution-dip method: The basal ends of the cuttings are dipped just for a few seconds and immediately inserted into the rooting medium.

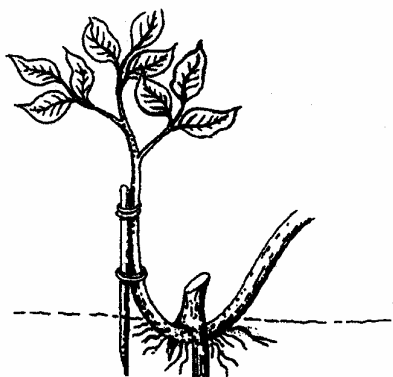
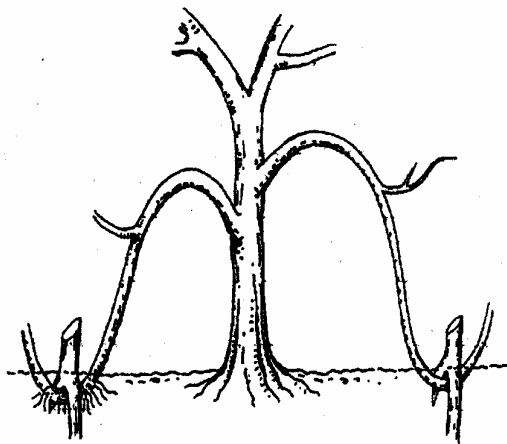
An ideal **rooting medium** should provide high porosity to allow good aeration, and a high water-holding capacity as well. It should be well drained and free from harmful fungi and bacteria.

A well-aerated sandy loam is good for deciduous hard-wood cuttings and root cuttings. For evergreens, sand is the best medium for rooting. Clean sharp plaster sand, free from organic matter and soil is excellent. Some peat moss may be added to increase water-holding capacity.

## Chapter 7

## Layering

**Layering** is the development of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached to become a new plant growing on its own roots. A layered stem is known as a layer.



**Simple layering** is done by pulling a branch to the ground and covering it partially with soil or rooting medium, but leaving the terminal portion uncovered. The terminal end is bent sharply to an upright position about 15-30cm back from the tip.

The sharp bending is sufficient to induce rooting, although loosening of the bark adds success. Cutting or notching the underside of the stem is often practiced.

A wooden peg, bent wire, or stone may be used to hold the layer in place, and a bamboo stake beside the layer to hold it upright.

The usual time for layering is before and during rainy season.

Layers become ready to separate after 60-70 days from the date of layering.

The rooted layers can be planted in pots or in a shaded nursery bed. The top is trimmed to a size corresponding to the root system

Fruit commonly propagated by this method are guava, lime and lemon.

## Chapter 7

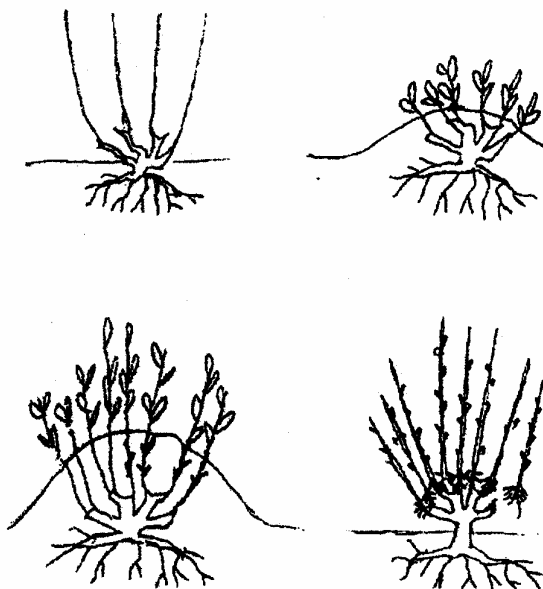
## Layering

**Mound layering** can be used for propagation identical to the mother plant in guava, cinnamon and pear.

The trunk is cut off very low to the ground. The cut off trunk surface is then covered with soil and new shoots grow out.

A ring of bark of each shoot is removed, before covering again with soil. The shoots develop roots in this ringed lower part that remains covered with soil.

After a few months the shoots are pulled up from the trunk, and are planted out.



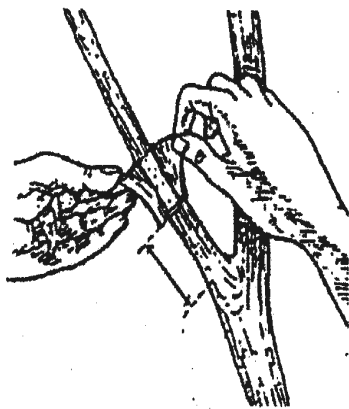
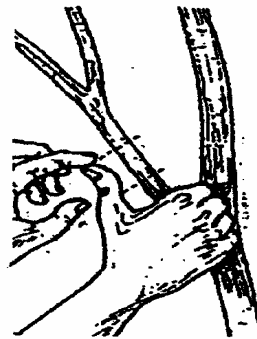
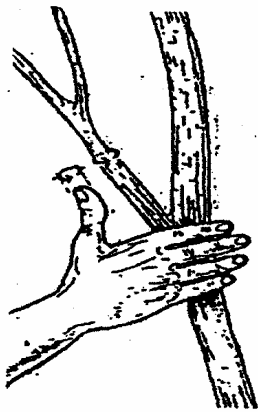
## Chapter 7

## Air-layering

**Air layering**, also known as marcottage and gootee, is the best known propagation method for a number of tropical and subtropical fruit trees, such as litchi, lemon, guava, pummelo, cashew nut, avocado, sapota, loquat, and pomegranate.

It is done before or during the rainy season on a one-year-old, healthy and straight shoot. For each tree, although it may have best qualities for multiplication, only a few branches should be selected to be air-layered. If too many branches are chosen at the same time, the tree will become weak and grow poorly.

Air-layering should be carried out near a fork in the branch or at least 20-30cm from the tip of the branch. This will result in better growth and help the new tree to root better after the branch has been cut and transplanted.



First, the bark is girdled and peeled off over a length of about 3cm. Outer and inner layers of the bark must be removed by scraping with a sharp knife, to make sure that quick healing is prevented, as it inhibits rooting in a layered branch.

Application of indole butyric acid to the exposed stem is beneficial but not always necessary.

The peeled section should be left open for three days before being packed with the moist material.

## Chapter 7

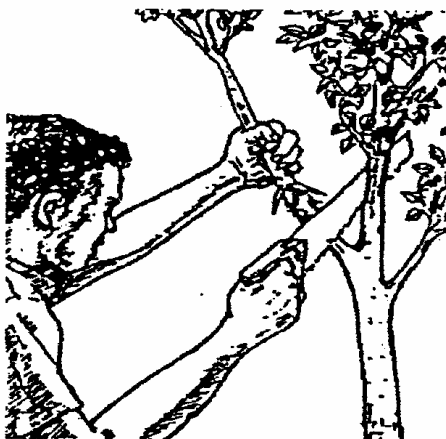
## Air layering

About two handful of only lightly moistened sphagnum (peat) moss, or soil covered with moist but not wet coconut husk, or clay mixed with cow dung and wrapped with gunny bag, are placed around the stem to enclose the peeled surface.

The packing is then wrapped with plastic, and bound strongly so it is air and water-tight. Normally it should not be necessary to water the layering packages. Using transparent plastic will make it easier to check root growth.



In about 30-100 days, the roots on the air-layered branch should have grown enough so that the plastic can be removed. It is not necessary and not recommendable to take off the soil/husk packing of the roots, as these might break. If sphagnum moss has been used which is difficult to get it may be removed carefully and stored for re-using.



The air-layered branch can then be cut off near to the fork in the branch and carefully transplanted into a container. It is advisable to keep (or plant) the rooted layers in the nursery for close attention. At the time of separation, a few leaves (and possibly small shoots) should be removed from the rooted layers to keep an optimum balance of root and shoot.

These layers can be planted in the fields some months later as long as there are favorable conditions for transplanting.

## Chapter 7

## Grafting/Budding

When **favorable characteristics** of one variety (or species) **shall be combined** with good qualities of another, two plants (plant parts) are joined in such a manner that they continue their growth as one plant.

Any technique that involves the connection or fitting of two pieces of living plants for the purpose to unite and subsequently behave as one plant is called **grafting**.

Two plants are involved in grafting: one is called **rootstock** and the other **scion** (or mother plant).

The rootstock is the lower portion of the graft, which provides the root system of the grafted plant. It may be a seedling, a rooted cutting or a layered plant.

The scion is the upper part of the graft, which forms the fruit bearing top of the tree.

Cambium is a thin layer of the plant located between the bark and the wood. For successful graft union, it is essential to keep the cambium of the scion in close contact with the cambium of the rootstock.

Callus develops from and around wounded plant parts. It occurs at the junction of the graft union and plays an important role in the healing process of a successful graft.

Grafting is commonly done in trees of cooler climates in dormant stage, and in tropical and subtropical species, such as mango, sapota, guava, loquat, etc., in active growth.

**Requirements of successful grafting**

- The rootstock and scion must be compatible.
- The cambial region of the scion must be in intimate contact with that of the stock.
- The grafting operation must be done only when the environmental conditions are favorable.
- Immediately after grafting, all cut surfaces must be protected from desiccation.
- Proper care must be given to the grafts for a period of time after grafting.

Graft **incompatibility** is the inability of rootstock and scion to produce a successful union.

Species of different families are never compatible, but symptoms like

- failure to form a successful graft or bud union,
- yellowish foliage, early defoliation, die back of shoots, generally poor health of the plant,
- marked difference in vigor of scion and rootstock,
- overgrowth at, below or above the graft union,
- necrotic (dead) areas and mechanical weakness at the point of union, and even
- that the tree dies soon, after one or two years may occur and are considered to be related with incompatibility between scion and rootstock of the same species. The reasons for it are not evident, although several theories have been put forward to explain the phenomena.

## Chapter 7

## GraftingBudding

**Rootstock-scion relationships**

The interaction of stock and scion produces various kinds of effects. Some of them are useful and can be utilized commercially while others are detrimental and are to be avoided.

The **rootstock influences** the size, growth habit, hardiness, disease resistance, early bearing and yield, quality of fruit and longevity, etc. of the scion variety.

If the rootstock is dwarf the resultant tree becomes dwarf. On the contrary, if the rootstock is vigorous, the budded or grafted plant also becomes vigorous. So grafting influences directly the **size** of the tree.

For example, sweet orange and mandarin budded on rough lemon grow vigorously compared to plants on a rootstock of citron (*Citrus medica*).

Certain rootstocks have been found to influence the normal **growth habit or shape** of the tree. A low and spreading or upright form may develop. Sweet orange on rough lemon is believed to assume a tall upright form.

In terms of **hardiness** it is known that a mandarin tree on trifoliate rootstock is capable of tolerating low winter temperatures better than on other rootstocks.

Grape fruit trees on „Rangpur“ lime rootstock survives much better than on rough lemon or sour orange.

Whenever possible rootstocks are to be chosen, that are **resistant to diseases**, such as, for example, in citrus: sour orange (resistant to „gummosis“), rough lemon (resistant to „tristeza“) and sweet orange (resistant to „scab“ and „tristeza“).

**Local varieties** are often best suited to serve as rootstocks for improved varieties.

In many cases, the rootstock stimulates **early bearing and yield**. Rough lemon rootstock generally increases the production of citrus fruits more than those grown on sour orange rootstocks.

Vigorous strongly growing rootstocks in some cases produce a larger and more vigorous tree which yields greater crops over a longer period of years.

Early bearing has been noticed in sweet orange, sour orange, grapefruit, trifoliate orange and rough lemon - and has successfully been done in lemon in Ban Thine, Luang Phrabang, too; see case study- when they are budded **on their own rootstocks**. Non-budded trees are two seasons behind in bearing compared to the budded ones.

Certain rootstocks affect **fruit quality** of the scion variety. If sour orange is used as the rootstock, fruits of sweet orange, tangerine and grapefruit are smooth, thin skinned, and juicy, of excellent quality, and they store longer.

**Chapter 7****Grafting Methods**

Citrus fruit on grapefruit rootstocks are usually excellent in size, grade and quality. But when rough lemon is used as a stock, the fruits are often thick-skinned, somewhat large and coarse, inferior in quality, and low in both sugar and acid.

A good and strong compatibility between scion and rootstock results in a **long-lived and productive** tree.

Some **scion varieties** have been reported to influence the rootstock regarding to size, root development and cold hardiness:

If a strongly growing scion variety is grafted on a weak rootstock, the growth of the rootstock is stimulated. Conversely, if a weakly growing scion is grafted on a vigorous rootstock, the growth of the rootstock is lessened from what it might have been if left non-grafted.

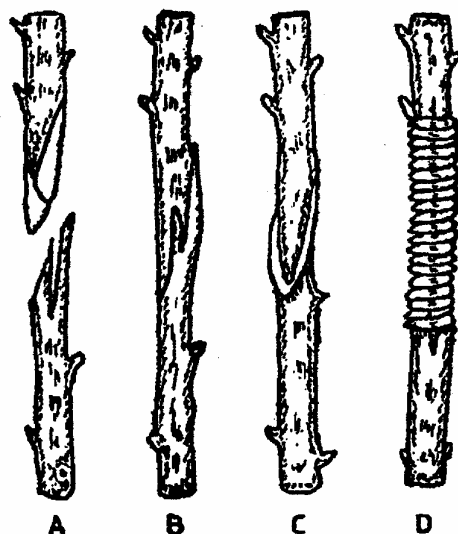


## Chapter 7

## Grafting Methods

**Tongue grafting** is very useful for grafting nursery stock. Top working (pruning to form a canopy) with tongue grafting can also be done when the plants are quite young with branches only 1 cm in thickness. In this method, stock and scion should be of equal diameter. The cambium layer of at least one side of the stock and scion must unite together. This is then wrapped with polythene stripe.

- A Diagonal cuts on stock and scion
- B Side view of graft
- C Face view of graft
- D Tying of graft

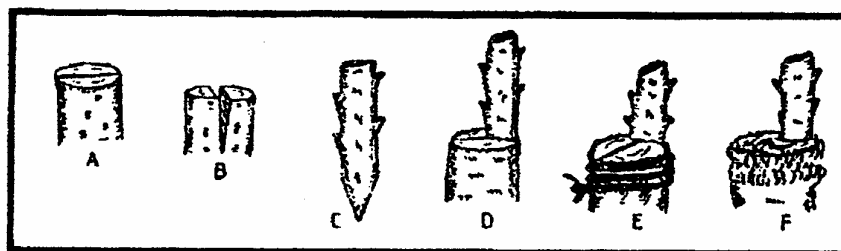


**Splice grafting:** This method is the same as tongue (or whip) grafting except that the second or tongue cut is not made in either the stock or the scion. A simple slanting cut of the same length and angle is made in both the stock and scion. These are wrapped or tied together as described for the whip graft. It is particularly suited for plants with a very pithy stem.

**Cleft grafting** (or wedge grafting) is useful in the nursery where the rootstock is quite thicker than scion, and tongue grafting cannot be employed successfully. The stock up to 8 cm in thickness can be grafted with this method. Usually this method is used for top working of temperate fruits, either in the trunk of small tree or in the scaffold branches of a larger tree. It can be done any time during the dormant period. The scion is fitted well into the stock making sure that the cambium layers of both the stock and the scion are perfectly matched. The grafts are tied and waxed reasonably (picture next page).

## Chapter 7

## Grafting Methods

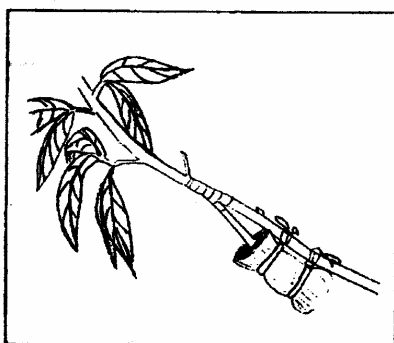
**Cleft grafting:**

- |  |                                       |
|--|---------------------------------------|
| A Cut given in the centre of the stock | D Insertion of the scion              |
| B Cut-spread to insert the scion       | E on the side of stock tying of graft |
| C Scion prepared in the form of wedge  | F Waxing of graft                     |

**Inarching** is also called approach grafting as the scion remains attached to the parent tree till the union is completed and the stock plant raised in pots and placed on raised platforms are brought in contact with the scion shoots. Alternatively, the mother plants are trained to be low headed and the stock is sown under their canopy. When these root stock plants become ready for grafting, the inarching is done right there.

In this method, the diameter of the rootstock and scion should be approximately the same that is about 1-1.5cm. A slice of bark along with a thin piece of wood about 4cm long is removed from matching portions of both the stock and the scion.

They are then brought together making sure that their cambium layers make contact at least on one side. These grafts are then tied firmly with polythene stripe or any other tying material. The stock and scion plants are watered regularly to hasten the union.



The union is complete in about 2 to 3 months. A cut is then given to the scion shoot about half way through its thickness. If the shoot does not show any sign of wilting for a week or so, it is completely detached from the mother plant. In case the scion starts wilting, it shows that the union is not complete. In such a case the scions are detached from the mother plants after some days when the union is complete. The inarching method is commonly used for propagation of mango, guava, sapota and jackfruit.

## Chapter 7

## Grafting Methods

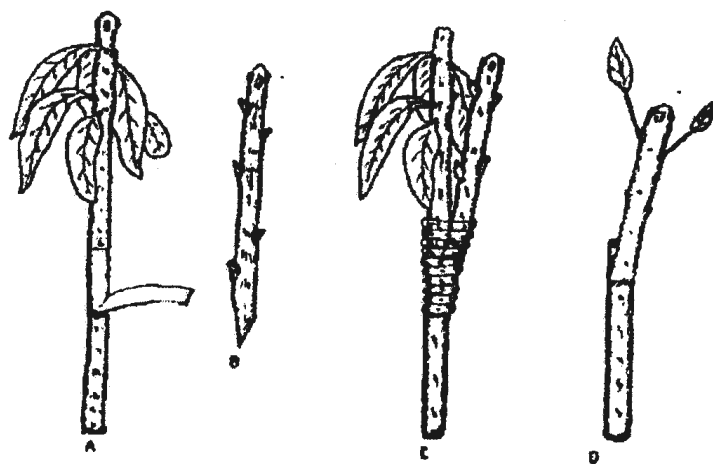
**Side grafting** is a very successful method for propagation of mango and it has replaced veneer grafting in the commercial multiplication of mango plants. This method is more efficient and cheaper than even inarching.

The stock is prepared by giving at a height of about 15 – 20 cm from the ground level a shallow downward and inward cut of about 3 to 4 cm length on the side of the stem.

At the base of this cut, a second short inward and downward cut is made, intersecting the first cut, so as to remove the piece of wood and bark.

The scion is about 10 cm in length. It is prepared with a long cut along one side and a very short one at the base of the scion on the opposite side. The scion cuts should be the same length and width as those made on the stock so that the cambium layers can be matched as closely as possible.

The cut end of the scion is inserted into the graft stock and tied with waxed string. The newly grafted plants may be placed in a cool humid place for healing. After healing, the stock is cut back above the scion either in gradual steps or all at once.



A Prepared stock

B Prepared scion

C Tying of graft

D Ready graft

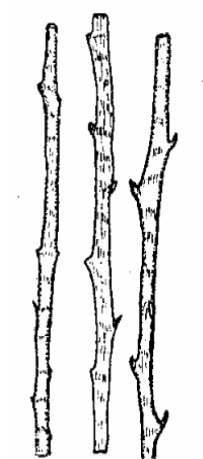
## Chapter 7

## Grafting Methods

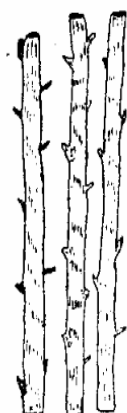
**Budding**

is a form of grafting in which only one bud is inserted in the rootstock. This method is very easy and fast. In budding, the bud wood is greatly economized as compared to grafting. Budding is done in citrus, peach, almond, pear, and plum. This method is generally employed during spring and rainy season. As soon as the bark starts slipping both on the stock and scion, this is considered to be the optimum time for budding. This shows that the cambium which is the tissue responsible for union is active.

The use of budding is confined to young plants or the smaller branches of large trees. It is very important where the propagating material is scarce, as it makes more economical use of it than grafting, each bud potentially being capable of producing a new plant. It results in a stronger union than some of the grafting methods.



Angular Wood  
(Not good for budding)



Round Wood  
(Good for budding)

A true-to-type, healthy mother plant is selected and be checked whether it is free from insect-pest and diseases. The bud-wood should be round because this sets perfectly on the stock whereas the angular wood does not make satisfactory union.

Water sprouts or long shoots in the centre of a tree which bear light crops of poor quality should not be chosen for taking bud-wood.

Bud-wood should be obtained only a short time before budding and is usually cut into pieces having 8-10 buds.

Care should be taken to prevent the bud-wood from drying by keeping it wrapped in plastic or moist gunny bags.

The rootstock should be prepared by removing the leaves and thorns around the place where the bud is to be inserted. The rootstock should be uniform, healthy and of a diameter equal to that of a pencil.

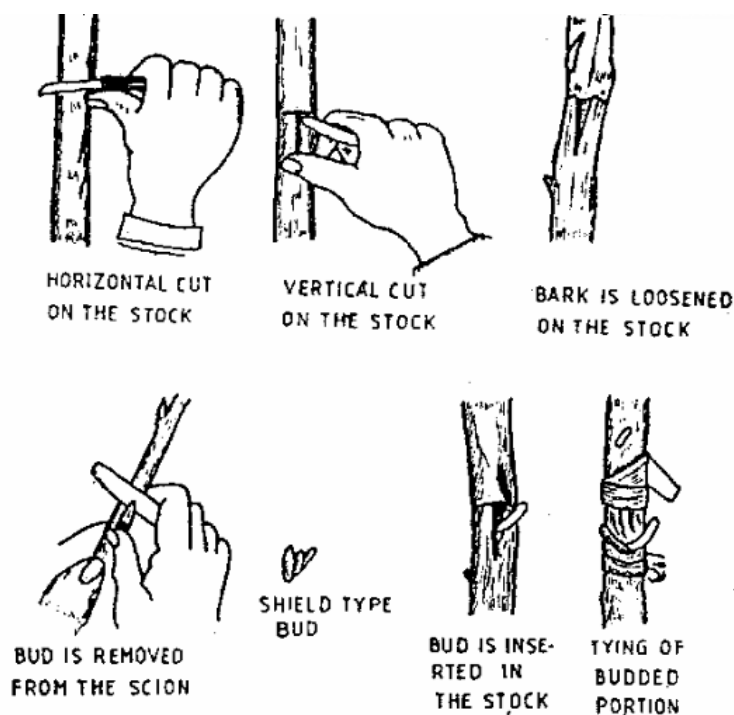
The rootstock should be actively growing so that the bark will separate readily from the wood.

## Chapter 7

## Grafting Methods

**T-budding** is also known as **shield budding**. This method has derived its names from the T-like appearance of the cut in the rootstock, and from the shield-like shape of the bud piece to be inserted in the stock.

The stock is prepared by giving a vertical cut, 3-4 cm long on its side. At the top of this, a small horizontal cut is given, thus completing the „T“. The bark is then loosened with the back of the knife.



The bud is prepared by starting a cut at a point on the bud-wood about 1cm below the bud, continuing under and about 2-3 cm above the bud. A second horizontal cut is then made above the bud, thus allowing the removal of the shield piece.

The shield bud is then immediately pushed under the two raised flaps of bark until its upper horizontal cut matches the same cut on the rootstock.

The bud joint is then wrapped with plastic tape, leaving the bud uncovered. It may be covered, too and surely be opened 1-2 weeks later! (Any fiber instead of tape may be used for wrapping the bud but tape is easy to handle).

Immediately after budding the rootstock is cut about 5-7 cm above the inserted bud. The union gets completed in 3-4 weeks time. Then the remaining stub of the rootstock will be cut and the tying material is then removed. In high rainfall areas the „inverted T-bud“ method is widely used in citrus. The bud is then pushed upwards, from the lower part of the incision.

## Chapter 7

## Fruit Crop Propagation

**Advantages of asexual or vegetative propagation**

- Plants that are propagated are true to type.
- Some fruits such as bananas, pineapple (normally), grapes and oranges that produce no viable seeds, are propagated only by this method.
- Vegetative propagated fruit plants start bearing earlier than the seedlings.
- In some cases, plants are propagated vegetative to increase their resistance to a certain disease or pest.
- Top working of inferior varieties or old unproductive plants is possible.
- Composite trees can be raised: This type of tree bears several varieties or types of fruits (e.g. apple and pear).

In vegetative propagation, the tree size, precocity, fruit quality, etc. can be regulated by the use of suitable rootstocks.

**Disadvantages**

- Trees are less vigorous and short lived.
- The chance of producing new varieties is not given.

<b>Vegetative Propagation Method</b>	<b>suitable for</b>
separation or division	pineapple, banana, strawberry, date palm
root cuttings	guava, plum, persimmon, blackberry
hardwood cuttings	mulberry, grape, currant, gooseberry, pomegranate, some plums
semi hardwood cuttings	citrus, cacao
Simple layering	guava, lime, lemon
Mound layering	guava, cinnamon, pear
air layering	litchi, lemon, guava, pummelo, cashew nut, avocado, sapota, loquat, pomegranate
grafting	mango, sapota, guava, loquat, sweet orange, rough lemon, grapefruit, sour orange, apple, pear, plum, peach, apricot
especially inarching:	mango, guava, sapota, jackfruit
esp. side grafting:	Mango
esp. budding:	citrus, peach, almond, pear, plum, apple

## Chapter 7

## Fruit Crop Propagation

<b>Questions</b>	<p>What are the two basically different propagation methods in fruit crops, and what are their principle advantages and disadvantages, respectively?</p> <p>Which are appropriate plant parts used for vegetative propagation?</p> <p>What does <u>layering</u> mean? Which different kinds of layering are distinguished?</p> <p>What is the main reason for <u>grafting</u>?</p> <p>Which components are involved in a grafting?</p> <p>What does graft <u>incompatibility</u> mean?</p> <p>Which are the mainly used grafting methods, and when or where are these applied?</p> <p>What can be said about the involved plant parts in regard of influencing each other?</p>
<b>Practice</b>	<p>Practice the different propagation techniques as described in the text. Make sure that the technique correlates with the material provided (for example: tongue or splice grafting has to be carried out with plant parts of the same diameter, while cleft grafting requires parts of actually different diameters!). The participants should be able to distinguish clearly which technique fits to each fruit crop!!</p>
<b>Materials</b>	<p>Entire plants and plant parts of different sizes, of woody herbs, ornamental shrubs and weeds, for example, knives, indole butyric acid (if available), tape, strings and/or fiber, peat moss or similar material, plastic bags.</p>
<b>Time required</b>	<p>At least 60 minutes.</p>
<b>Games / Exercises</b>	<p>„Hands up“ game aiming to consolidate knowledge about the techniques and applications to certain kinds of fruit crops. Ask questions like: „Which fruit crops are propagated by seed only?“, „what are the different grafting methods?“, „what are the advantages of vegetative propagation?“, „which fruit crops are propagated by air layering?“ etc. and give several options, among these also wrong ones in order to check the comprehension of the participants.</p>

Media:

## Chapter 8

## Soil Productivity

**Soil fertility** can be defined as the quality of the soil that enables it to supply the proper kind and amount of the chemical elements needed for plant growth when other factors such as light, temperature, and soil characters are favorable.

**Soil productivity** is defined as the capability of soil to produce a specific crop (or sequence of crops) under a specific management system which includes planting date, fertilization, irrigation, tillage, and pest control. Actually, it is the economic view considering inputs, outputs, and soil type.

**Soil as the natural base** for production must be protected and, on the other hand, also be used more intensively. Soil must be considered the main factor in determining the growing conditions for a crop. Although other conditions may be far from optimum, or even adverse, the well-being of the crops depends mostly on the particular soil characteristics: a sound soil „buffers“ other constraints caused by weather, pests, etc.

Soil of arable land must accomplish certain requirements: it should not only be fertile but productive.

**Limiting factors in soil productivity** which are

1. Physical factors

- depth of topsoil - limited by rocks, hard pans and/or water pans, and gravel layers
- soil compactness and macro porosity
- available water-holding capacity in the major root zone

2. Chemical factors

- pH or soil reaction - depends on proportion of soluble acid and alkaline (salt) components, as extreme concentrations are often toxic to plant roots,
- natural fertility - like nutrient-holding capacity, ability to fix phosphate and attract other nutrients,
- abundance of nutrients – natural abundance, as same as added ones by fertilization
- presence of noxious substances - such as heavy metals and waste water

**Soil has three major components or phases**, which are

- **solid phase:** is the main nutrient source, consisting of mineral particles & organic matter
- **liquid phase:** pores filled with water (the optimum content of water, reached when 2/3 of pores are filled with water, is called field capacity; the minimum content available to plant roots is called permanent wilting point)
- **gaseous phase:** pores filled with air (or gases)

Liquid and gaseous phases are in a continuously balancing movement. The liquid phase or soil solution makes biological and chemical processes happen, that make nutrients available to plant roots.



## Chapter 8

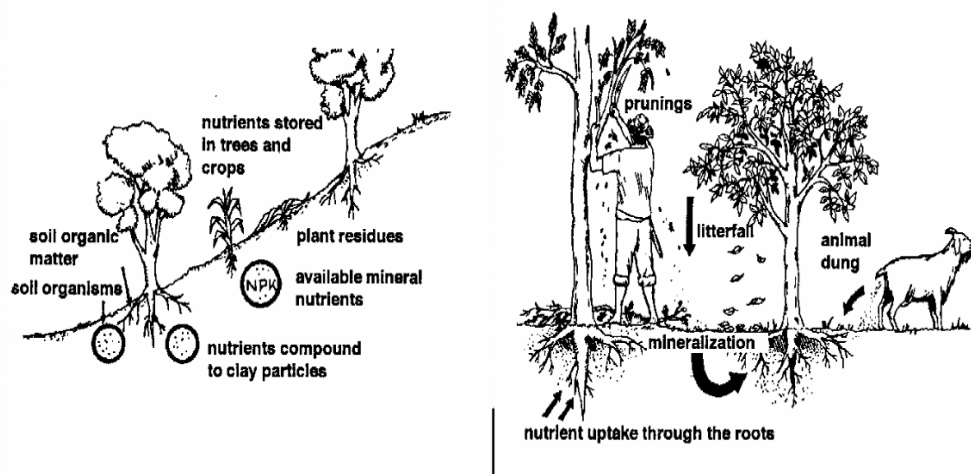
## Nutrient Elements

When a previously forested land area is used for growing crops for the first time, the soil usually contains all the nutrient elements that the plants need. However, as it is continuously used for producing a crop, the amount of nutrient elements decreases to levels which are not enough to support growth and development.

Without giving back organic matter to the soil (as the forest did before by litter fall, decaying trunks and the „manure“ of wildlife) the yield is expected to decrease.

The nutrient elements in the soil, however, are not always immediately available, but possibly fixed. Hence, even if the total amount of nutrient elements in the soil is high, deficiency symptoms still occur.

Plants require 16 nutrient elements, 13 of which come directly from the soil (mineral elements). Not all are required for all plants but all have been found essential to some, hence are termed as essential elements. (Comparable to the human body that also needs certain foods for being well, strong and healthy, and many of these such as vitamins, minerals and proteins, e.g., are taken in by eating vegetables, grains, legumes and fruits).



The **essential nutrients** are divided into

**macro-nutrients** (as these are required in relatively large amounts), which are nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S) and calcium (Ca), and

**micro-nutrients** (required in relatively small amounts), as there are iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo) and chlorine (Cl).

The missing three are hydrogen (H), oxygen (O), and carbon (C), that are taken from water and air, partly from the soil pores.

Due to the parent material and the organic matter content these are present in certain concentrations, may be some excessive and others deficient.

## Chapter 8

## Nutrient Elements

Functions	Deficiency symptoms
<u>Nitrogen (N)</u>	
<ul style="list-style-type: none"> <li>• increases growth, and development of all living tissues</li> <li>• improves the quality of leafy vegetables and fodders and the protein content of food grains</li> </ul>	<ul style="list-style-type: none"> <li>• stunted growth</li> <li>• appearance of a light-green to pale-yellow color on older leaves, followed by dieback and/or dropping</li> <li>• in acute deficiency, flowering is greatly reduced</li> <li>• lower protein content</li> </ul>
<u>Phosphorus (P)</u>	
<ul style="list-style-type: none"> <li>• e.g. necessary for cell division, stimulates root development</li> <li>• necessary for meristematic growth, seed and fruit development;</li> <li>• stimulates flowering</li> </ul>	<ul style="list-style-type: none"> <li>• overall stunted appearance, the mature leaves have characteristic dark to blue-green coloration, restricted root development</li> <li>• in acute deficiency, occasional purpling of leaves and stems; spindly growth</li> <li>• delayed maturity and lack of or poor seed and fruit development</li> </ul>
<u>Potassium (K)</u>	
<ul style="list-style-type: none"> <li>• e.g., regulates water utilization</li> <li>• improves utilization of light during cool and cloud weather and thereby enhances plants to resist cold and adverse conditions</li> <li>• enhances the plant's ability to resist diseases</li> <li>• increases size of seeds and improves quality of fruits and vegetables</li> </ul>	<ul style="list-style-type: none"> <li>• chlorosis (yellowing) along the leaf margins followed by scorching and browning of tips of older leaves, proceeding gradually inwards</li> <li>• slow and stunted growth of plants</li> <li>• weak stalks, plants lodge easily</li> <li>• shriveled seeds or fruits</li> </ul>
<u>Calcium (Ca)</u>	
<ul style="list-style-type: none"> <li>• necessary for stability and growth of plant cells, e.g. acts as a detoxifying agent by neutralizing organic acids in plants (being component in lime, e.g.)</li> </ul>	<ul style="list-style-type: none"> <li>• young leaves of new plants are affected first, these are often distorted, small and abnormally dark green</li> <li>• leaves may be cup-shaped and crinkled</li> <li>• root growth is markedly impaired; root rotting occurs</li> <li>• desiccation of terminal buds under severe deficiency</li> <li>• buds and blossoms shed prematurely</li> <li>• stem structure weakened</li> </ul>

**Functions****Deficiency symptoms**Magnesium (Mg)

- constituent of green pigment
  - necessary for activation of many enzymes involved in carbohydrate metabolism- promotes uptake and translocation of phosphorus
  - helps in movement of sugars within plant
- interveinal chlorosis, mainly on older leaves, causing a patchy effect; with acute deficiency affected parts dry up and die
  - leaves small, brittle in final stages, curved upwards
  - marbling with tints of orange, red and purple
  - twigs weak and prone to fungus attack, usually premature leaf drop

Sulfur (S)

- involved in many metabolic activities
  - component of some proteins and vitamins
  - required for N-fixation by leguminous plants
- plants appear uniformly yellow, or light green
  - plants are shorter than normal
  - plants are thin-stemmed and spindly

Zinc (Zn)

- involved in many build-up and metabolic processes
  - assists the utilization of phosphorus and nitrogen in plants
- deficiency of zinc is common: in beans, leaf interveinal chlorosis between green veins; necrotic areas appear if deficiency is severe
  - in eggplant, leaves become mottled with interveinal chlorosis
  - in maize, from light yellow striping to a broad band of white or yellow with red-dish purple veins between the midrib and edges of the leaf, occurring mainly in the lower part
  - in citrus, irregular interveinal chlorosis; terminal leaves become small and narrowed (little-leaf); fruit bud formation is severely reduced; twigs die back

Copper (Cu)

- component of many enzymes, thus important for many metabolic processes, e.g. protein and green pigment
  - promotes formation of vitamin A in plants
  - N-fixation
- in general, the demand for Cu in plants is small
  - in citrus, die back of new growth; pockets of gum develop between the bark and the wood, the fruit shows brown excrescences

Iron (Fe)

Functions	Deficiency symptoms
<ul style="list-style-type: none"> <li>• necessary for the build-up and maintenance of green pigment</li> <li>• essential component of many enzymes</li> </ul>	<ul style="list-style-type: none"> <li>• typical interveinal chlorosis; youngest leaves first affected: in pepper, upper leaves turn light yellow to white with green veins</li> </ul>
<u>Manganese (Mn)</u>	
<ul style="list-style-type: none"> <li>• involved in enzymatic and physiological reactions</li> <li>• involved in the plant's respiratory process</li> <li>• activates enzymes concerned with the metabolism of N and build-up of green pigment</li> </ul>	<ul style="list-style-type: none"> <li>• symptoms of deficiency popularly known in peas as „marsh spot“, in sugar cane as „streak disease“</li> <li>• small necrotic spots are seen on pepper leaves</li> <li>• greyish areas appear near the base of younger leaves and become yellowish</li> </ul>
<u>Boron (B)</u>	
<ul style="list-style-type: none"> <li>• essential for cell division and development</li> <li>• important for cell wall stability</li> <li>• essential for protein synthesis</li> <li>• involved in germination and growth of pollen</li> <li>• important for translocation of sugars (carbohydrates)</li> </ul>	<ul style="list-style-type: none"> <li>• death of growing plants (shoot tips)</li> <li>• the leaves have a thick texture, sometimes curling and becoming brittle</li> <li>• flowers do not form and root growth is stunted</li> <li>• „brown heart“ in root crops, with dark spots or splitting at centre</li> <li>• in cauliflower, curd is loose and purplish-brown in color, stem is hollow</li> <li>• fruits such as apple develop „internal and external cork symptoms“</li> </ul>
<u>Molybdenum (Mo)</u>	
<ul style="list-style-type: none"> <li>• associated with nitrogen utilization and N-fixation</li> <li>• essential for metabolism of nitrogen</li> <li>• required by <i>Rhizobia</i> for nitrogen fixation</li> </ul>	<ul style="list-style-type: none"> <li>• Mo-deficiency is markedly evident in leguminous plants</li> <li>• chlorotic interveinal mottling of the lower leaves, followed by marginal necrosis and in-folding of the leaves</li> <li>• in cauliflower causing the „whiptail syndrome“</li> </ul>
<u>Chlorine (Cl)</u>	
<ul style="list-style-type: none"> <li>• stimulates the activity of some enzymes and influences carbohydrate metabolism and water holding capacity of plant cells</li> </ul>	<ul style="list-style-type: none"> <li>• wilting of leaflet tips, chlorosis of leaves and subsequently bronzing and drying</li> <li>• usually not a problem as the presence of Cl in rainwater is enough</li> </ul>

## Chapter 8

## Fertilizers

N is the most commonly lacking nutrient, followed by P and K, hence, they are the most common components of commercial fertilizers. In the following the term fertilizer refers to actually chemical fertilizer. The most common types in Lao PDR are Urea and Ammonium phosphate, a mixed or „compound“ fertilizer.

**Urea** is a popular, dry N-carrier. It is more expensive than Ammonia, but its nitrogen content is 46%. It can be stored, handled, and applied without the use of special equipment. About 20-30% N gets lost through volatilization when Urea is applied on the soil surface and is not moved into the soil by water!

**Mixed fertilizers** contain at least two of the fertilizer elements, and usually all three (then called complete fertilizer). The amounts of the three major elements N, P, and K, in the fertilizer are indicated in percentages by three numerals designating the fertilizer grade (e.g., 15:15:15).

When a fertilizer is applied, it reacts with the soil (and the crop) and its efficiency to supply nutrients either **increases** or **decreases** depending on some conditions. E.g., any factor of weather that tends to limit plant growth will also reduce fertilizer efficiency and the crop's response to the fertilizer.

Theoretically, the amount of fertilizer needed is the difference between the crop's nutrient requirement and the amount supplied by the soil. It is difficult to quantify this, since the plant and the soil are constantly changing and interacting with many other factors.

The **time, frequency, and amount, of fertilizer applications** are influenced by the kind of crop(s), climate, soil, and nutrients. The need for nutrients will vary depending on the crop, especially as regards the growth and development of the plant part that is of nutritional and economic importance.

Vegetable crops that remove:

relatively big amounts	medium amounts	relatively small amounts
cabbage	tomato	lettuce
broccoli	potato	cucumber
cauliflower	carrot	bush beans
sweet corn	peas	onions
pole beans		

## Chapter 8

## Fertilizers

- Intensity and frequency of rainfall affect the availability of the nutrients to the plants.
- Temperature also affects the release of nitrogen, phosphorus, and sulfur from organic matter. Likewise, it affects nitrification and absorption of phosphorus and potassium by plant roots.
- The soil type is important because of different percolation rate, fixing capacity, and nutrient availability.

Generally, fertilizers are applied at planting or before planting, called basal application. Applications during the growing season are called side-dressing or topdressing.

Average composition of chemical sources of nitrogen fertilizers available in Lao PDR:

Source	% N	% P <sub>2</sub> O <sub>5</sub>	% K <sub>2</sub> O	% CaO	% MgO	% S	% Cl
Ammon. phosphate	16.5	20	-	-	-	15.0	-
	15	15	15	-	-	-	-
	16	8	8	-	-	-	-
	13	13	21	-	-	-	-
Urea	46	-	-	-	-	-	-
	0	46	0	-	-	-	-

**Methods of application** depend partly on the form or consistency of fertilizers.

There are solid (mostly water-soluble granules, powders or dusts) and liquid forms (solutions, blends) available.

The efficient use of fertilizers is the placement of the material in relation to the plant. The fertilizer should be placed in the soil zone where it will serve the plant to the best advantage.

The right amount of nutrients should be made available at all times during plant growth, taking into consideration the varying needs during plant development.

The common methods of **application** are as follows:

**Broadcast** - The fertilizer is applied uniformly over the field / bed before planting (as granule) and is then incorporated by tilling or cultivating.

**Banding** - The fertilizer is applied in bands on one side, both sides, or below the seeds or transplant (as granule). Care should be taken not to injure the seedlings through contact with the fertilizer.

## Chapter 8

## Fertilizer Application

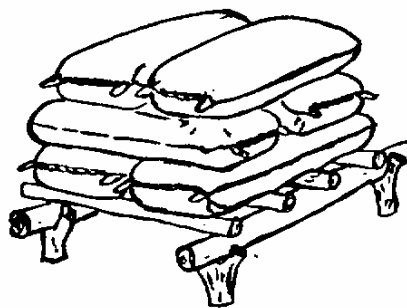
**Topdressing** - Topdressing means broadcasting the fertilizer on the crop, while **side-dressing** means applying the fertilizer beside the rows of the crop. Both are done after emergence (or as granule, or diluted and sprayed). Top dressing must **not** be done when leaves are wet from rain or dew because the fertilizer may burn the leaves.

**Fertigation** - This is the application of fertilizer through the irrigation water. Nitrogen and sulfur are the principle nutrients commonly used. Potassium and highly soluble forms of zinc and iron can also be readily applied this way. When an element forms an insoluble complex with another substance commonly found in the irrigation water, it is not advisable to use this method. (Phosphorus and anhydrous ammonia may form such a complex in water with high calcium and magnesium content).

**Foliar applic.** - This method can be used with fertilizer nutrients readily soluble in water. It is also used where there is a soil-fixation problem. In this method, however, it is difficult to apply sufficient amounts of the major elements. Nutrient concentrations of 1-2% can be applied without injury to foliage. It is, therefore, commonly used only to apply the minor elements or supplements of the major elements.

The **phosphates** should be applied at or before planting because an ample  $P_2O_5$  supply is especially important for early development and root formation. Phosphate fertilizer applied in the later part of the growth stage as a side dressing has little or no effect on the existing crop. If the time and available labor permits it is recommended to apply nitrogenous fertilizers in split dose rather than all as a basal dose.

As most of the fertilizers are water-soluble and some even hygroscopic, means attracting any moisture or humidity from the environment, it is highly recommendable to store them in a shelter on elevated racks away from the ground.



## Chapter 8

## Organic Sources of Nutrients

**Organic materials** such as dried poultry and cattle manures, peat, composted organic residues, and some food processing by-products such as ground bone meal, dried blood, oil seed meals, and fish scraps are valuable sources of plant nutrients and most of them are commercially available. But these and others may be found in the own farm or neighborhood, even for free.

Organic materials contain relatively low amounts of nutrients, but they slowly release available essential elements and improve the physical conditions of the soil.

Average composition of some natural organic materials:

Source	%N	% P <sub>2</sub> O <sub>5</sub>	% K <sub>2</sub> O	% CaO
Blood, dried	13.0	-	-	0.5
Cocoa meal	4.0	1.5	2.5	0.5
Fish scraps (dried)	9.5	6.0	-	8.5
Peat	2.7	-	-	1.0
Soybean meal	7.0	1.2	1.5	0.5
Cattle manure	1.5	1.0	0.94	0.2
Poultry manure		1.9	2.32	1.6

Likewise, green manure is a good source of organic nutrients and organic matter.

Average composition of some green manure crops:

Material	Oven Dry Basis *		
	% N	% P	% K
<i>Sesbania aculeata</i>	2.18		
<i>Sesbania speciosa</i>	2.51		
<i>Crotalaria juncea</i>	1.95		
<i>Crotalaria usarmoensis</i>	5.30		
<i>Melilotus indica</i>	3.36	0.22	1.27
<i>Pisum sativum</i>	1.97		
<i>Desmodium trifolium</i>	2.93	0.14	1.30
<i>Calopogonium mucunoides</i>	3.02		
Water hyacinth	2.04	0.37	3.40
<i>Azolla</i> sp.	3.68	0.20	0.15
Algae	2.47	0.12	0.37

\* in completely dry state



## Chapter 8

## Mulching

The term **mulching** means any covering placed over the soil surface to modify soil physical properties, create a favorable environment for root development and nutrient uptake, and reduce soil erosion and degradation.

Thus, an inorganic material, such as plastic or stones, is included but, in the following mulch refers to **organic mulches**, if not indicated differently.

Materials used for mulches comprise cereal (e.g. rice) straws and stalks, crop residues, leaves, grass, maize and sugarcane stems, sawdust, manure, weeds, reeds, and various aquatic plants.

Generally these are left, or spread, or spread and incorporated into the soil.

If grown particularly to serve as mulch the terms green manure or cover crops are used (see: next topic).

**Positive effects of mulching are**

- the use of mulches is one of the most effective ways that erosion can be reduced on steep hillsides,
- mulch decreases evaporation of soil moisture, thus conserving moisture and protecting against drought,
- increases infiltration (water absorption) rates,
- reduces erosion and water runoff by maintaining soil cover,
- reduces and balances soil temperatures,
- increases earthworm populations and activity,
- increases soil organic matter,
- increases soil nutrients, especially nitrogen from leguminous plants,
- improves soil tillage,
- protects seedlings and young plants from the impact of rain, hail and wind,
- reduces rain splashing, which is an important means of dissemination for numerous bacterial and fungal pathogens.

**Chapter 8****Mulching**

- Strengthens resistance of soils to soil-borne pathogens such as fungi and nematodes in some areas.
- Aids in weed management by out competing and shading.
- Protects seedlings and young plants from birds and other animals using for example *Artemisia vulgaris* for mulching.
- Reduces labor, as there is generally much less labor involved in mulching than in the incorporation of plant material or in weeding (nevertheless, the cost and labor will vary greatly, depending on the plant material used and on the distances it has to be transported).
- Usually increases crop yields over time.

**Negative effects of mulching**

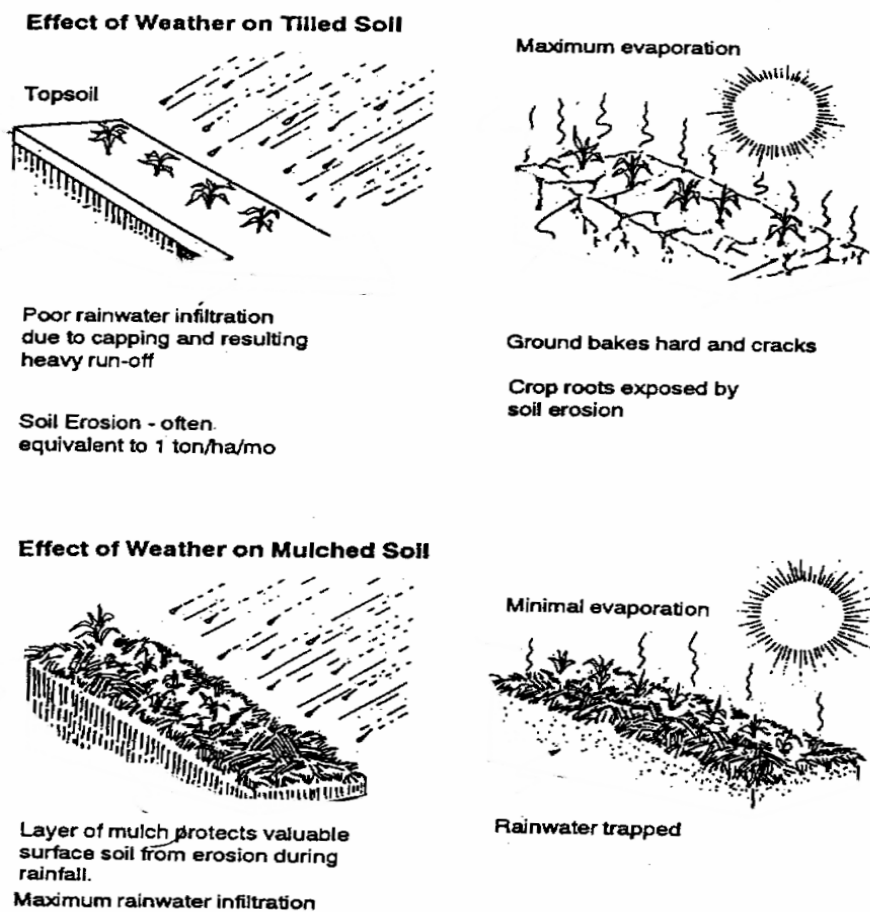
Unfortunately, the effects of mulches are not entirely positive; some of their potential drawbacks are as follows:

- Especially in perennial or tree crops in drier areas mulch may be unfavorable because shallow root systems are developed due to the moisture concentration near the surface, while anchorage by deep roots is neglected.
- Mulches may provide a good environment for the multiplication and survival of slugs, which sometimes cause serious losses to crops such as beans when mulched.
- Various pests such as mice, rats, rabbits and snakes may also find thick mulches an attractive habitat.
- Mulches may increase the populations of some insects.
- Mulches may also provide nutrition and a suitable environment for certain plant pathogens.
- As mulch is to be decomposed by microorganisms that require nitrogen for the decomposition process, strong or woody materials, such as straw, sawdust, sugar mill wastes should be amended with manure or fresh young plants, especially legumes, that contain relatively much nitrogen by themselves (close C:N proportion).
- Losses of nitrogen by volatilization may occur.

## Chapter 8

## Mulching

One of the major benefits from mulches is the fact that they prevent soil erosion, and simultaneously improve soils and increase crop productivity.



Many small farmers use **no-tillage** or **minimum tillage systems** and hand tools such as planting stick, and, in such cases, mulch would cause no problems.

The considerable labor needed to incorporate plant material into the soil often makes this operation impossible or extremely difficult for resource-poor farmers.

In humid regions the **efficiency of phosphorus fertilizer** can be greatly **increased** by applying it to mulch.

## Chapter 8

## Mulching

The use of cover crops and green manure systems (see: next topic) can often eliminate or **reduce the need to burn** in traditional shifting cultivation systems. In addition to enriching the soil, as burning does immediately, substitution of mulching for burning can also reduce soil erosion and the risks to neighboring farms and forests. Thus, mulching should be considered as an alternative to burning.

**Slashed weeds** are commonly used as mulch in tropical agriculture. Weeds are normally cut and left in place or piled as mulches, recycling nutrients previously removed from the soil.

**Again** - soil erosion is a major environmental problem throughout the developing world. The problem is increasing rapidly, not only because more land is being cleared, but because farmers are being forced onto steeper, more fragile land as arable land on gentle slopes becomes unavailable.

**Soil losses of hundreds of tons per hectare per year are real.**

The use of various soil covers, especially mulches, to prevent erosion is recognized as one of the most effective strategies for reducing soil erosion on steep hillsides.

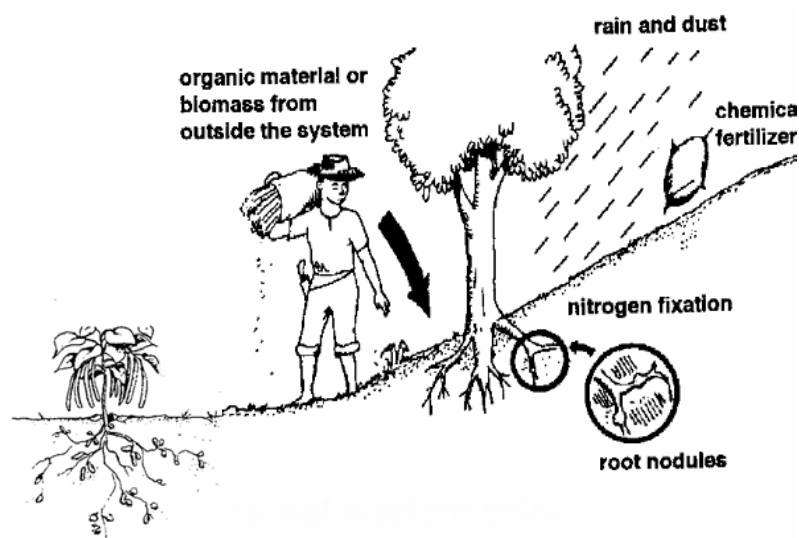


## Chapter 8

## Green manuring

**Green manuring** in the strict sense of the word is the cultivation of a crop with the purpose of using that crop to increase the fertility of the soil, or to fertilize the main crop, or both of them.

The main crop usually requires nitrogen and/or phosphate. Green manuring can provide the nitrogen, if a leguminous crop is grown that lives in symbiosis with certain bacteria:



**Nitrogen fixation** can only take place when a leguminous plant is combined with the right species of *Rhizobium* bacteria. When this species does not exist in the soil, symbiosis can be achieved by inoculating the seed with this species. In order to check if nitrogen fixation has taken place, one can dig up the plant and check its roots. The nodules are active when they are pink on the inside.

When there are no nodules at the roots, or when they are small, hard and white, yellow or green on the inside, no effective symbiosis has taken place.

1. Inoculation is the active supply with the right bacteria or effective root nodules may be ground and mixed with the seed. (*Rhizobium* inoculants for several crops are available in Thailand, but yet not easy to get in Lao PDR).
2. The seed may be inoculated by mixing it with the soil of a field where the same crop actually did fix nitrogen.
3. Finally, the farmland may be inoculated with soil that already contains the right *Rhizobium* species. This can either be done by scattering that soil over the farmland, or by ploughing it under.

## Chapter 8

## Green manuring

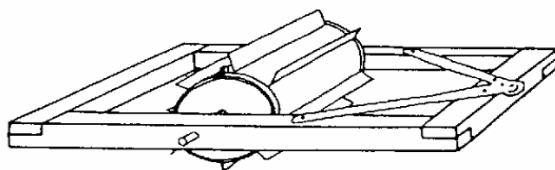
If rock phosphate is available (it is much cheaper than chemical fertilizer, such as super phosphate) it is recommended to use with such legumes that are good absorbers of rock phosphate. These are in particular legumes that can grow at a low pH level: stylo, centro, and cowpea.

(A number of tropical grasses are known to accumulate phosphate within a few months to a year: *Pennisetum purpureum*, *Panicum maximum* and *Tripsacum laxum*. This is applicable to *Tripsacum* accumulates potassium, too).

In general, green manuring serves for providing the main crop with the nutrients that have been accumulated in the green manure. The decomposition of the green manure by fungi and bacteria is a rapid process, especially in the humid tropics. The nutrients are leached into the subsoil, vanish in the air or are taken in by plants.

In order to benefit from the green manure, the main crop is best grown right after.

Fresh leaf and stalk material of a green manure has a low C/N ratio, or in other words: high nitrogen content. As a result, nitrogen is released during the decomposition process, as well



as phosphate and other nutrients that can be used by other plants. This is why planting the new crop should be done a few days after the green manure has been ploughed under. To facilitate the settling of the green manure in the soil it is best to cut it into smaller pieces. For this purpose an ingenious apparatus has been developed, called blade roller.

Care should be taken that the green manure is ploughed into the soil, before decomposing it will be dry and withered. For then the C/N ratio is high, and the main crop will be harmed, since the decomposition of the green manure will extract nitrogen from the soil.

Dead material does contribute more to the formation of humus (thus to the good structure of the soil) than green material, but green material is more important for the supply of nutrients (especially nitrogen) to future crops.

## Chapter 8

## Green manuring

After a crop has been harvested the soil still contains some nutrients, which could be leached by the rain. Green manure as an extra crop can make use of these nutrients. After this crop has been ploughed under, either in its green or in a dead state, the accumulated or „intercepted“ nutrients of the plants are slowly released into the soil. Interception of drained nutrients is essential, particularly in rainy climates.

When two or more crops are grown simultaneously, they must necessarily compete for light, water and nutrients. On the other hand, together they can form a more favorable microclimate, and be more resistant to diseases and pests. This reduces the risk for the farmer.

If green manure is wanted to be used for the main crop, it must mature before the main crop, and then be ploughed under, in separate rows. In case, that the main crop, e.g. maize, and a legume, e.g. a climbing bean, are grown close together, it may be better to cut the legume instead of pulling it off to make better use of the nitrogen fixing nodules, remaining in the soil.

In another technique legume shrubs are grown in rows along the main crop. They are regularly trimmed and the green leaves ploughed into the soil, or applied as mulch (see: Agroforestry or Alley cropping, respectively).

The first method has immediate fertilizing effects, whereas mulching gives slower results. But the advantages of mulch are that it suppresses weeds, protects the soil and keeps it moist (see: Mulching).

**Mulching, cover crops and no-tillage or minimum tillage systems can really work under tropical conditions.**

Cover crops are often employed in tree crops with superficial roots, to be slashed down as a mulch.

**Cover crops** are any crops grown to produce soil cover, regardless of whether they are later incorporated or not. They are used to cover and protect the soil surface, although they may be turned under as **green manure**.

Leguminous cover crops or green manures are especially valuable because they can fix nitrogen from the air in collaboration (symbiosis) with *Rhizobium* bacteria. These plants form hundreds of root nodules in which the bacteria fix nitrogen and make it available to the plant roots. In this way a legume crop can

**fix several hundreds of kilogram of N per hectare.**

## Chapter 8

## Cover Crops / Green Manuring

Below are listed a few of the more **promising species for the lower tropical areas**:

Common Name	Botanical Name	Description
lablab bean	( <i>Dolichos lablab</i> /Lablab pur- <i>pureus</i> )	drought-tolerant; intolerant to water logging
jack bean	( <i>Canavalia ensiformis</i> )	drought-tolerant, shade-tolerant, fairly tolerant of water logging and salinity
pigeon pea	( <i>Cajanus cajan</i> )	
sword bean	( <i>Canavalia gladiata</i> )	
greenleaf	( <i>Desmodium intortum</i> )	
Centro	( <i>Centrosema pubescens</i> )	
rice bean	( <i>Vigna umbellata</i> )	
winged bean	( <i>Psophocarpus tetragonolobus</i> )	not good for drought, water logging, salinity!
Kudzu	( <i>Pueraria phaseoloides</i> )	
velvet bean	( <i>Mucuna spp./ Stizolobium spp.</i> )	grows on wide range of soils; drought tolerant
sunhemp	( <i>Crotalaria juncea/ Crotalaria spp</i> )	high herbage yield, not shade-tolerant
Soybean	( <i>Glycine max</i> )	
lima bean	( <i>Phaseolus lunatus</i> )	
Calopo	( <i>Calopogonium mucunoides</i> )	
Cowpea	( <i>Vigna unguiculata</i> )	
Stylo	( <i>Stylosanthes guianensis</i> )	
Wild peanut	( <i>Arachis pinta</i> )	

Some legumes suitable **for the semi-arid tropics and higher elevations** are mentioned below. They have usually deep root systems, that enable them to extract water from deep soil layers. It is advisable to grow them right after.

Bambara groundnut	( <i>Voandzeia subterranea</i> )	tolerant of excessive rain, not of water logging
Marana bean	( <i>Tylosema esculentum</i> )	
Moth bean	( <i>Vigna aconitifolia</i> )	
Tepera bean	( <i>Phaseolus acutifolius</i> )	
Scarlet runner bean	( <i>Phaseolus coccineus</i> )	
Alfalfa	( <i>Medicago sativa</i> )	suitable for cooler climates



## Chapter 8

## Cover Crops / Green Manuring

**Advantages of cover crops**

- nitrogen fixing
- increased organic matter content
- e.g., velvet beans can be planted on acid, aluminum toxic soils
- erosion control
- weeds are suppressed
- the systems generally have low labor costs
- some green manures supply nutritious food for humans (e.g. lablab bean, scarlet runner bean)
- legumes such as velvet beans and lablab beans provide good animal forage
- crop damage by free-roaming livestock can be reduced by providing reliable sources of forage, thereby allowing animals to be penned

**Disadvantages of cover crops:**

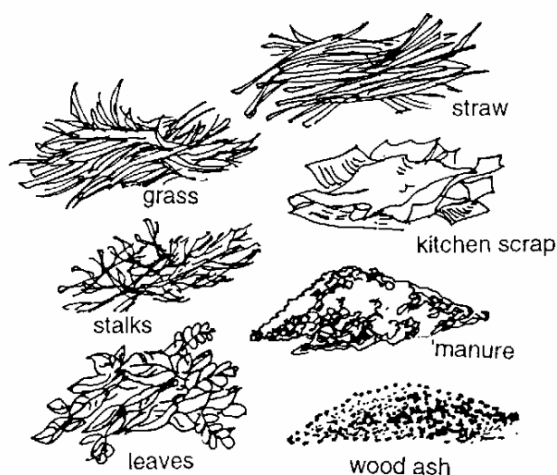
- most well investigated cover crops can only be used with tall main crops such as maize or sorghum
- crop damage by rats, mice, and slugs may increase
- rabbits and leaf cutter ants may feed on cover crops
- snakes may inhabit cover crops
- diseases, insects, and other important pests of cover crops are not well known. (For example, the use of introduced *Leucaena leucocephala* has been abandoned in many areas of Asia, because it was seriously attacked by a native psyllid. Introduced species generally(!) must be carefully tested in different areas first, before promoting them, to avoid possible devastating damages).

**Advantages and disadvantages must be carefully weighed up**, and own experiences have to be made until one is able to judge a system in a definite world.



## Chapter 8

## Composting



Compost is obtained by decomposition of a mixture of vegetable wastes, manure, kitchen scraps, cooled ashes, sweepings, weeds (possibly without seeds!), leaves, straw, grass, groundnut or cotton cake, feathers, eggshells, etc.

Anything that cannot decompose, such as plastics, tins, cans, glass, wires, etc. should be removed.

For composting a shady place, near to a source of water, should be chosen and cleared, to make

## Pits (in dry climates, in dry season)

a pit of 1-1.5m broad and 0.5m deep has to be dug

near to it should be dug another one (or two) of the same size to pass the compost there later on, or it may be one

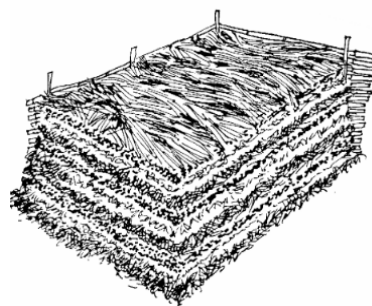
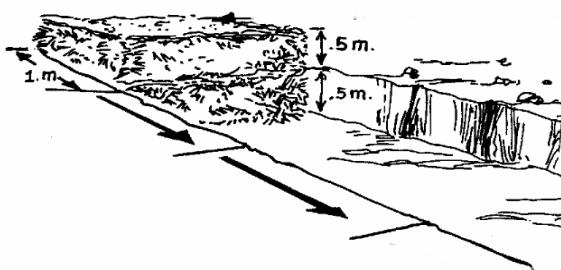
long trench to move it just inside

## Heaps (in humid climates, in rainy season)

a rectangular place of 1m broad and about 1-2m long will be staked at the 4 corners

it is recommended to stabilize with a barrier on 2-3 sides, that can be extended to move the compost further on; a drainage trench may

be useful around each spot



## Chapter 8

## Composting

- The first layer should be made of old branches, cane stalks or bulky material, for drainage and aeration.
- Subsequently should the above mentioned materials (cut into pieces to enhance the process of decomposition) be added, in alternate layers of soft and juicy, with compact and drier matter. Garden soil should be added also, as it contains many of microorganisms necessary for proper decomposition.
- Woody wastes and diseased or insect-infested plants must be burnt, and their ashes may be put onto the compost heap.
- The layers should be perforated a few times with a bamboo stick, e.g., for better aeration.
- Compost must be kept moist, to enable the microorganisms to work properly.
- At the height of 1m approximately the compost pile (in pits at 0.5m above ground level resp.) should be covered with soil, straw or leaves.
- To protect it from excessive rains it can be covered on top with a layer of banana leaves, a gunny cloth or plastic.
- After about a month the contents have to be moved to the next spot or pit, and be mixed well. It must be watered and packed well, again.
- The now emptied place may be refilled with new materials.
- After another month the compost is to be moved to the third spot (if not really decomposed yet).
- If the decomposed materials are then passed through a wire lattice, a nicely crumbling product is acquired to be spread readily where needed.

Composting has the advantage to produce high temperatures (when properly managed) that kill diseases, insects and weed seeds. Inserting a stick into the heap, and touching this when pulled out after a couple of minutes it is easy to check whether the heating process is going on, (in the beginning) or, if it is cooling down.

**But** - making a compost heap takes a considerable amount of work. Compost will often pay in a home garden, but it is normally not an adequate technique for larger scales.

- A compost heap requires water, and considerable amounts of materials.
- Compost cannot be used as a food source, either for animals or humans.
- Compost degenerates very quickly in tropical climates.

**Compost mounds**

Decaying compost generates nutrients for crops and heat, which maintains temperature at optimum levels for tuber formation, despite very low night temperatures at high altitudes.

## Chapter 8

## Composting

As mounds (and compost heaps as well) are good for tuber forming since the volume of rooting zone is increased, crops like sweet potato, but also pumpkin, squash or cucumber may be grown on top.

The decomposition process must have started few days before sweet potato vines or cucurbit seedlings are planted.

As these crops extract nutrients, the remaining material may provide less to soil fertility but more to soil structure.

The same mound may be piled up several times and be used for a couple of years.

Another method to benefit from waste components is to make a **permanent compost bed**.

The most important factor to consider is to balance materials that contain relatively low amounts of nitrogen (straw, twigs, stalks, sugarcane trashes, paper, cardboard, coconut fiber, sawdust, peanut hulls, eggshells, tree leaves, etc.) and those that contain relatively high nitrogen (animal manure, tender young plants, fresh young grass, bone meal, kitchen scraps, feathers, etc.).

#### How to make a permanent compost bed



- The bottom layer is made from any slowly decomposing material, such as rock phosphate, twigs or whole straw mixed with manure, etc. It should be watered, but not too much, and covered with soil. This layer will release nutrients slowly to plants.
- The second layer is also consisting of slowly decomposing materials such as cardboard or newspaper, which are laid perpendicular to each other. This thin layer may also serve as a barrier to weed growth.

perpendicular to each other. This thin layer may also serve as a barrier to weed growth.

**Chapter 8****Composting**

- The third layer consists then on partially rotten manure mixed with sawdust or straw. Chopped corn cobs may also be used. It should be 7-10cm thick after wetting and compressing
- Chopped leaves, dry chopped straw and rice hulls mixed with topsoil make up the upper layer, and cover the edges, too.

The heat resulting from starting decomposition may be checked by inserting a stick for a few minutes and touching it. If it feels hot, some water should be poured over the bed.

A pointed stick should be plunged into the pile several times to provide good drainage and ventilation, making sure that the cardboard is perforated. After one week seeds can be sown or seedlings transplanted. It is highly recommended to plant different types of vegetables (see: Mixed cropping).

The upper two layers are built up again after harvesting, as described before, and replanted subsequently.

## Chapter 8

## EM / BE / IMO

EM is the short form of Effective Microorganisms which is widely spread and accepted in many countries, including Laos. The concept and technology originated in Japan.

EM is mixed cultures of naturally occurring species of beneficial organisms ready to inoculate soils for creating a more favorable microbiological environment for plant growth.

There are three different ways to apply EM: 1. dilution, 2. powder (an inoculated organic matter that undergoes a fermentation process and multiplies EM underway), and 3. fermented solution.

If it is received as a powder (EM Bokashi) it can be multiplied several times, but each time its efficiency is reduced. EM is a powerful agent in soil improvement which has its price, too.

That is why people tried to find good but cheaper alternatives. One of these is IMO.

IMO stands for Indigenous Microorganisms and can be produced the following way:

- use a flat container, fill 500 g of cooked rice to 3 cm height
- cover with white paper and tie in place with a string
- bury container under moist tree leaves in a shady place
- after a few days rice gets wet and you will see white hyphen
- add then 150 g of brown sugar and mix
- bury container again under moist tree leaves in a shady place
- cover top again, now with plastic sheet against rain
- after one week the microorganisms are readily cultured in a thick liquid called IMO;
- fill into bottles and store in the fridge.

In this form IMO can be stored for several weeks. Before using IMO will be multiplied as follows:

- mix 4 g of IMO with 1 liter of water
- moisten 2 kg of bran with this liquid
- if necessary add more water till you can form balls with the dough in your hands (moisture content should be about 65 %)
- store in a cool dry place and protect it from rain
- after 3 days the mixture will become hot
- add then 80 kg of fresh manure and 16 kg of topsoil
- cover this final mixture with straw or leaves and protect it from rain
- first it will heat up, but after a few weeks it will become mature compost
- apply 1 kg per m<sup>2</sup> of land
- spray mixture of 1 teaspoon and 1 liter of water on plants for pest control.

## Chapter 8

EM / BE / IMO

Another product is called Bio-Extract (BE) and also made of “wastes”.

During recent years a material similar to EM has been created and investigated in Lao PDR which is now at anybody’s disposal, because it can be made easily in every household:

Bio-Extract is the liquid of fermented vegetables and fruits with sugar that contains vitamins, minerals, hormones, enzymes, organic substances and effective microorganisms.

Bio-extract transforms soils containing organic matter into fertile soils and makes nutrients available for plants.

**Uses** of bio-extract are e.g.

- spraying plants aiming to fertilize and strengthen crops
- making compost which is ripe within few days
- avoiding foul odor from garbage and excrement
- applying to fishponds in order to avoid pollution and diseases
- improving soil fertility

**How bio-extract is made**

Fresh vegetables and fresh fruits are cut into small pieces. Fruits and their skins, respectively, that cannot be eaten (papaya, banana, mango, water melon, pineapple, cucumber, etc) should be ripe. They are put into a plastic bucket (or another appropriate plastic container) that can be closed tightly with a lid. Any kind of sugar (black, brown, white sugar or molasses) is added, as much as one third of vegetables and fruits in weight. The bucket has to be covered tightly for 7 days.

After seven days one starts to collect the liquid from the bucket, everyday until it is finished. The liquid is bio-extract, with a pH of 3-5, that can be kept up to 6 months if stored in a cool, shady place.

The fermented wastes should be composted and later be applied to plants as an organic matter of high quality.

Bio-extract can be multiplied by diluting one part of bio-extract plus an equal part of sugar in 10 parts of water. This dilution should be left for 3 days until a new generation of microorganisms in the extract has developed (but of less quality).

New kitchen wastes can be mixed every few days and sugar be added to get pure bio-extract as described above.

## Chapter 8

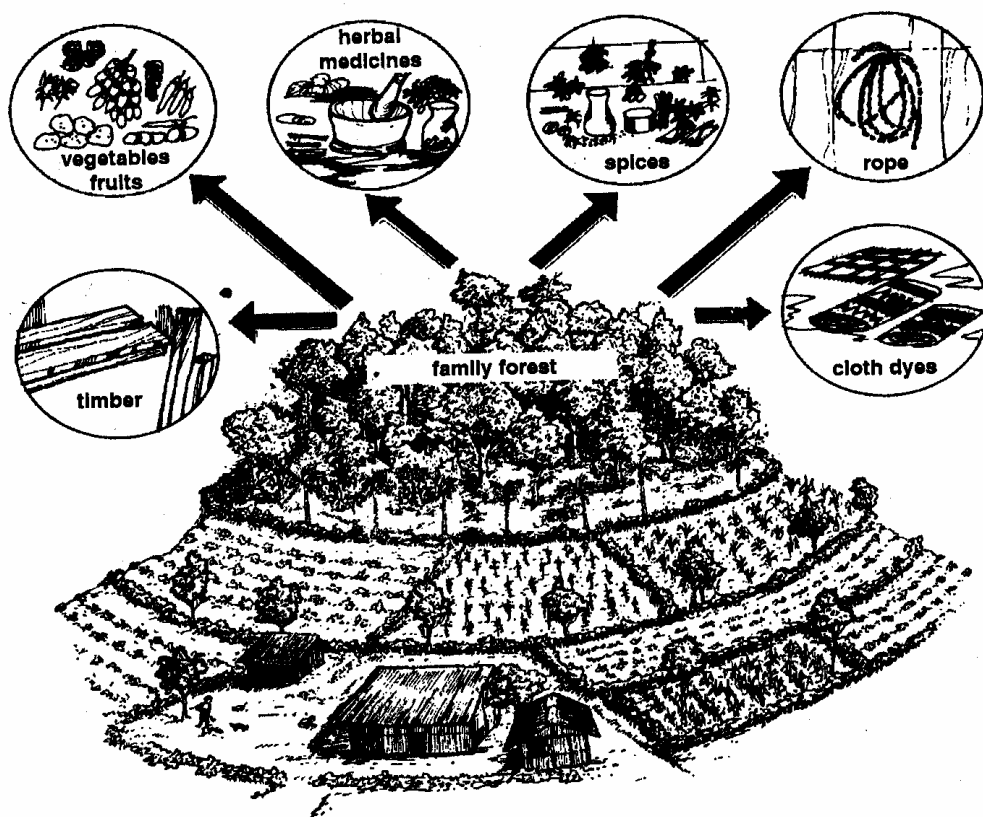
## Agro forestry

Reasons for losses of soil productivity by erosion and run-off

Erosion, the removal of soil from the location where it first developed, brings limiting horizons progressively nearer to the surface. A reduced soil depth with reduced water available to plant roots, depletion of nutrients, losses of organic matter, decline in structural stability and increase in bulk density that will influence seedling emergence and root development, is considered more critical than the loss of soil itself.

Soil degradation is caused by water, by wind, by structural deterioration in consequence of inadequate tilling practices, or by impact of raindrops, or by livestock hooves. Land degradation is followed by deterioration in the quantity and quality of surface and groundwater resources, in particular when accompanied by vegetative degradation. Increased run-off encourages upland erosion. Large-scale over-cultivation, overgrazing and deforestation influence climate in a negative way, increasing the likelihood of droughts.

The rich natural forests of Lao PDR have been regarded in the past solely as a source of income and foreign exchange, which led to a steady decline of forest cover.





## Chapter 8

## Agro forestry

In southern Central Laos overgrazing by livestock accompanied by annual burning of the grazing lands on fragile soils contributes serious volumes of sediment to the Mekong River. In many tea and coffee and other plantations, tree-rows are aligned up-and-down the slopes, rather than across. This, combined with the common practice of scraping all weeds from the soil surface and burning them, leads in many cases to serious sheet erosion of topsoil. When population pressure leads to strongly reduced bush-fallow phases, weeds and grasses gain a foothold. „Fire tolerant“ grasses become dominant, as they are able to regenerate quickly from underground rhizomes. These grasses do, in fact, support fierce fires, affecting nearby forests and plantations.

Better or **sound land husbandry** as a concept signifying understanding, management and improvement (as in crops and animals) can help to sustain and enhance the land's productive potential. Control of erosion then becomes a consequence of good land husbandry, as erosion is a consequence of how the land is used.

Plant yields are reduced more by a shortage or excess of soil moisture (i.e. flooding) than by loss of soil. Agronomic measures are potentially more significant than mechanical measures in preventing erosion and run-off. Improved organic matter management is the key to maintaining soil productivity.

To be attractive to farmers, proposed soil conservation activities must provide very large short-term benefits, without increased risk or forgone benefits such as loss of land. **Sustainable** rural development requires a „bottom-up“ approach, that means conservation activities must be planned and implemented from the outset with the full knowledge, co-operation and involvement of the farmers and local communities.

**Agro forestry** may be one of the best approaches, as the component of forest or wood stands for permanence, which is essential for soil and water conservation, and for soil improvement often, too.

**Agro forestry means**

- use of trees in farming systems
- the deliberate growth and management of trees along with agricultural crops and/ or livestock in systems that are ecologically, socially and economically sustainable
- a philosophy of integrated land use particularly suited for marginal areas and low-input systems,
- with the underlying principle to optimize the combined production of an agricultural and a forest crop,
- and to conserve and improve the site at the same time.

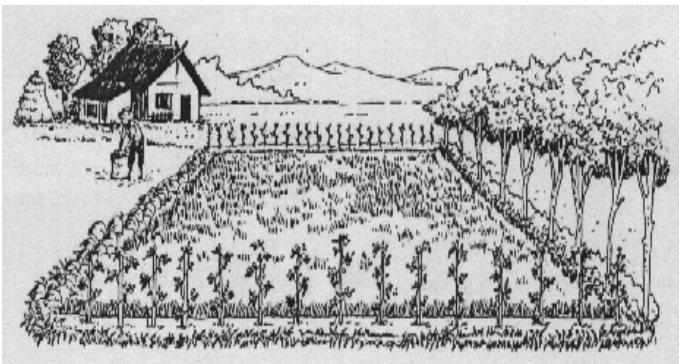
## Chapter 8

## Agro forestry

**Agro forestry can help in**

- decreasing pressure on the last tropical natural forests,
- changing lost and vast land into productive area,
- improving sustainability and productivity of yet degraded pastures,
- stabilizing and rehabilitating over-exploited land.

**Agro forestry systems** are manifold, and many of these have potential to diversify products and increase productivity for small-scale farms. Farmers know their needs best, and should be given full support in whatever systems are chosen. Species selection and planting instructions depend on the particular system that farmers want. The agro forestry systems presented below are based on planting niches available on farms:

Trees around the house**Home gardens**

Typically trees are planted near the home for food products, dyes, medicines, and for shade and beauty. Home gardens include diverse planting schemes including small vegetable gardens, and complex, multi-storey gardens.

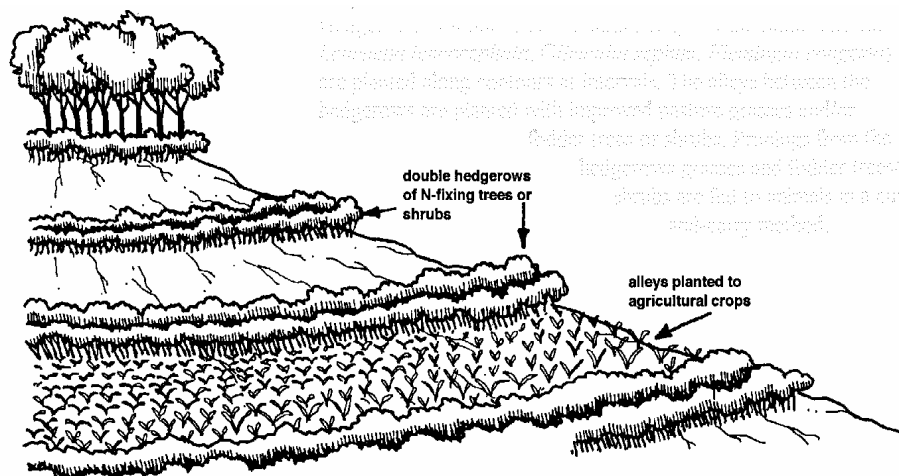
- **Shade and Ornamental** Trees around the house give shade and cool down the atmosphere, especially in hot climates, thus making humans and animals feel more comfortable.

Fruits and playgrounds provided by trees are highly appreciated by children. The beauty of flowers and leaves alleviates some tristess in dry season and increases the esthetics of a site.



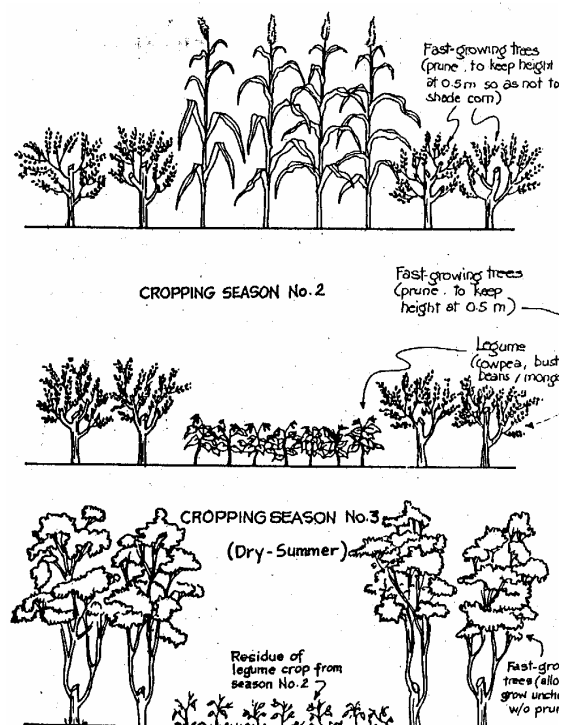
## Chapter 8

## Agro forestry

Trees in Crop Fields**- Hedgerow intercropping or alley farming**

means that rows of trees are planted 2 to 6 meters apart with crops cultivated between the rows or in the „alleys“, respectively. During cropping season the hedgerows are kept pruned. Leaves and green stems are used for mulch or incorporated into the soil. If not lopped between cropping seasons hedgerows may produce considerable amounts of fuel wood.

**- Wide Row Intercropping** is recommended if principally tree products, such as poles, timber, or fruit are intended. Trees are grown to large sizes, that's why wide spacing of rows (10 to 20 m or even more) is important to avoid negative impacts to associated crops. Initially trees can be planted fairly close within rows (1-2 m), and later thinned. Tree canopy management by pollarding during cropping season is useful, when shade competition is getting high. In sloping lands, trees should be planted on contours.



## Chapter 8

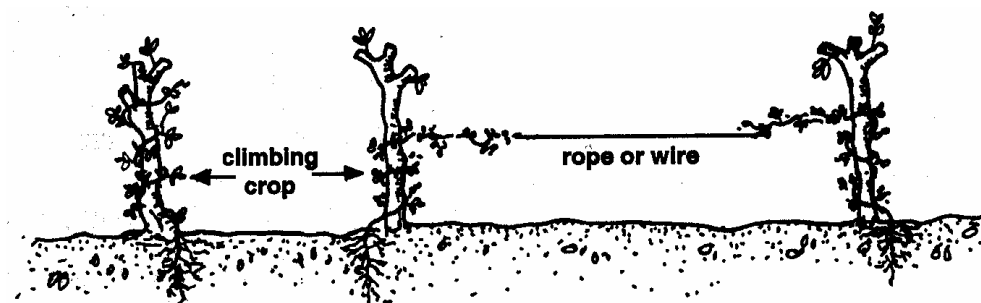
## Agro forestry



- **Shade and Nurse Trees** are grown with shade-loving trees such coffee, tee, and cacao, for micro-climatic and soil improving purposes. In order to ensure regular shade the spacing within and between rows should be about equal. Wherever land is undulating trees are to be planted along the contours.

### - Support Trees

Many crop plants, e.g. passion fruits, pepper, vanilla, and yams, require some kind of support. If trees are used for this purpose, the vining crop can benefit from the live support, while some tree products might also be harvested. Spacing depends on the vine crop. The tree canopy can be pollarded to control shading.



### Trees in Livestock Systems

Procuring fodder for livestock is a burden, particularly during dry seasons. Livestock systems can be improved by incorporating nitrogen fixing trees.

### - Fodder banks

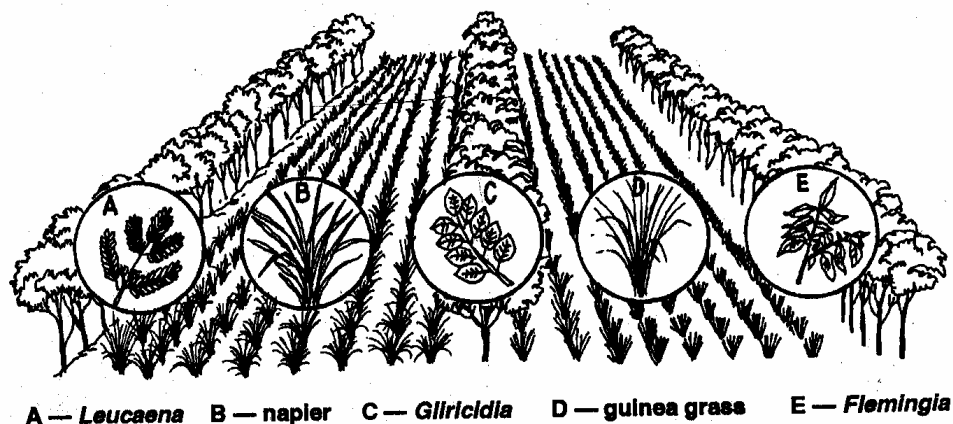
Intensive plantings of fodder trees, may be or not in combination with fodder grasses and herbaceous legumes, can provide nutritious diets, even in times of shortage. Especially some nitrogen fixing trees, resistant to drought and heat, have leaves or pods with high protein contents. Fodder banks must be protected by directly fencing off or strictly controlled browsing.

## Chapter 8

## Agro forestry

Branches can be cut and carried to feed the animals in enclosure, or livestock may get restricted access in times of need.

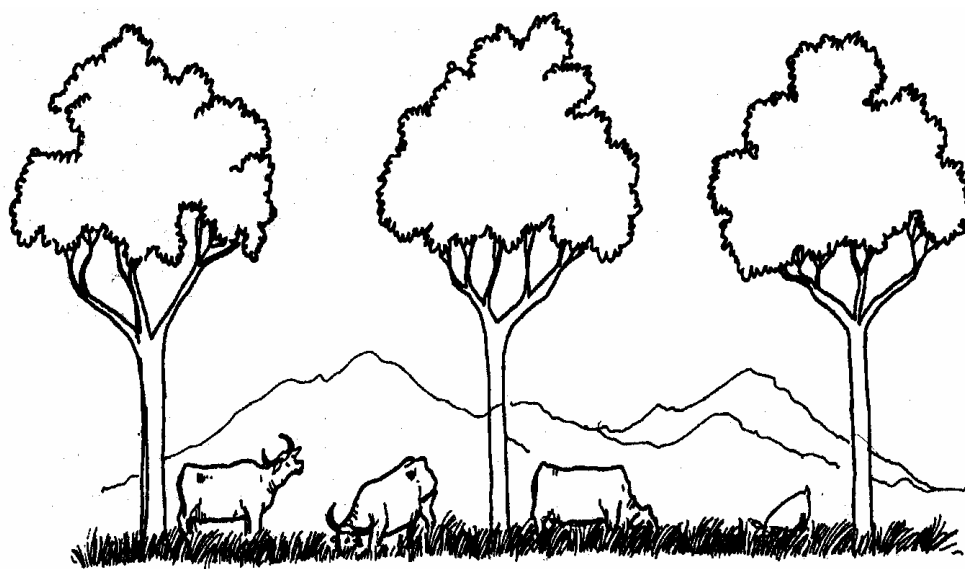
Trees in fodder banks are planted very close for maximum productivity.



## - Pasture Improvement

Trees, planted in wide spacing (and along contour lines!) in pastures are important components in enhancing livestock production: Light shading leads to increased grass production, while leaves and pods procure fodder of high energetic value.

Livestock digest food more efficiently lying in the shade, particularly in hot climates.

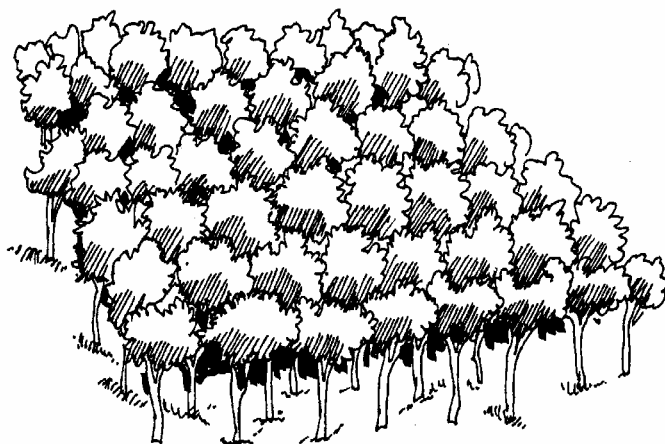


## Chapter 8

## Agro forestry

Pure Stands of Trees

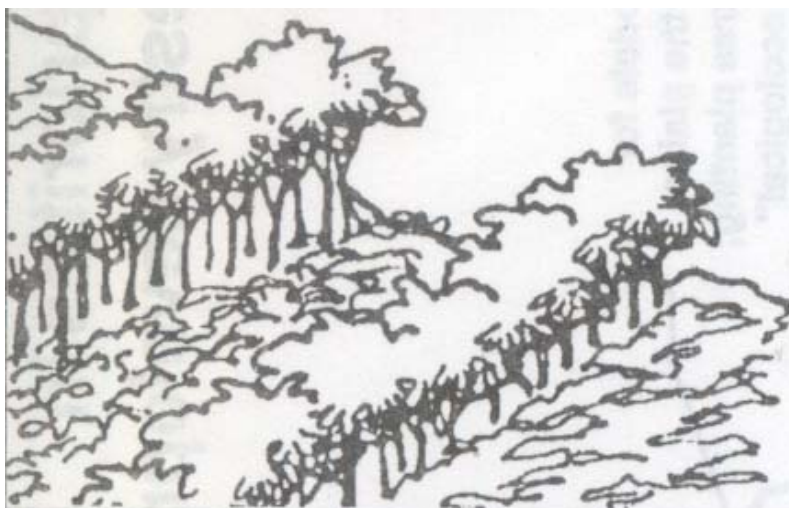
Small-holders often have insufficient land to devote solely to tree plantations. Where land is not a limiting factor, and particularly when part of the farm is less productive, solid stands of trees may be a viable option.



- **Woodlots** are sometimes very small parcels of land. Trees are planted close together and are typically uniformly spaced. Woodlots are often harvested on a rotational basis providing a constant supply of fuel wood, poles and other products. Desirable species for woodlots grow fast and regenerate easily.

**- Improved Fallow**

In shifting cultivation areas trees, especially nitrogen fixing trees, can be planted to improve fallow periods by enhancing soil melioration and thus reducing fallow periods. When abandoning the land a few handfuls of seeds are scattered, preferably on contour lines. Once the



soil has been rejuvenated trees can be cut and the branches piled along the contours to form a barrier structure, which traps the eroding soil. In between these barriers agricultural crops are grown on cleared land.



## Chapter 8

## Agro forestry

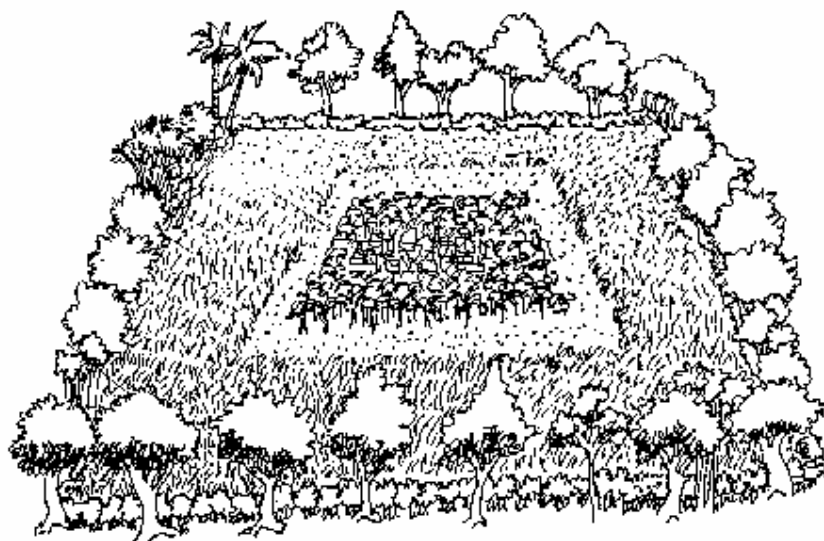
## - Taungya



This system has been proven effectively in establishing forest tree plantations and is widely used by national forest departments in the tropics. For one or more cropping seasons, as long as competition for light is not limiting productivity, agricultural crops, such as corn, manioc or pepper, are intercropped. The tree seedlings benefit from tillage, weeding, fertilizer application, etc., and thus get a good start.

Farm borders:

Farm borders are very interesting sites regarding tree planting. Borders with neighboring lands might require protection against invading livestock, or people, or wind. Internal borders or boundaries may be suitable to separate different productive areas, and the house including garden from the fields and paddocks. Generally farm borders include agriculturally unproductive land that for this reason is predestinated for tree and hedge planting.



## Chapter 8

## Contour Lines and Terraces

Water erosion (soil erosion caused by water) followed by loss of soil productivity is probably the most acute problem of upland agriculture in the tropics. In order to protect the soil from harm caused by rain and hail, the infiltration rate and soil stability must be increased by reducing run-off and safe disposal of run-off water.

Providing a vegetative (or even stony) soil cover, increasing organic matter content in the soil, cutting the length of a slope, and reducing the magnitude of a slope are important means of erosion control.

Mulching and green manuring with organic matter obtained from hedges, i.e. of nitrogen fixing species, are important techniques to increase infiltration and reduce run-off.

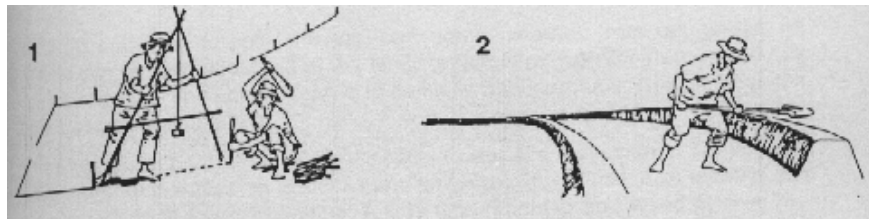
Contour cropping that is reinforced by hedges along the contour, and construction and stabilizing natural terraces with hedges are useful measures for the long run.

Contour tillage / Contour planting

„A contour is an imaginary line connecting points of equal elevation on the ground surface, perpendicular to the direction of slope.“

If tillage and planting is practiced along the contour, soil losses by water erosion and run-off are considerably reduced, and infiltration rate increased.

Contour lines can roughly be estimated by sight, but for determining them more accurately a simple tool can be made and used: the **A - Frame**.

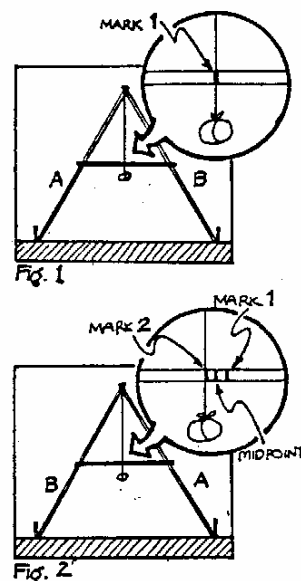
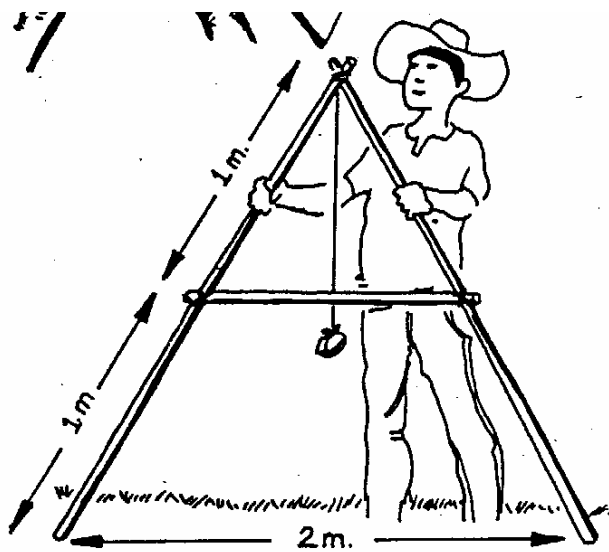


Material required includes 3 poles made from whatever material is available: two approximately 2.1 m long and one approximately 1.2 m long. These are tied together so that they form an A-shape. A medium sized weight (often a stone is used) is tied with a string at least 1.2 long to the uppermost junction of the A. The „feet“ of the A-frame are placed on a relatively flat surface. Where the string crosses the short pole in the middle a mark is made. The positions of the „feet“ are then exchanged (i.e. the right foot is placed where the left foot was and vice versa) and a new mark made. The spot between the two marks is the midpoint.



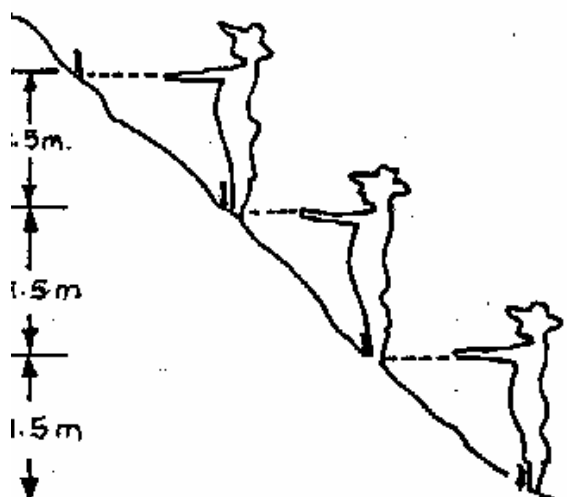
## Chapter 8

## Contour Lines and Terraces



The A-frame is turned on one „foot“, swinging it around 180°. When the string crosses the crossbar at the midpoint the A-frame is again level. The new position of the „foot“ is the next point on the contour line. By swinging the A-frame from one „foot“ to the other, the contour line is determined. These „step points“ are marked with sticks, and the contour line will be fixed for further operations.

The first contour line is close to the top of the slope. The next is about 1.5 m further down or roughly the height of a persons extended arms after stepping down the slope.



Work has to be carried out carefully, as improperly laid-out contour lines can increase the risk of erosion.

## Chapter 8

## Contour Lines and Terraces

On moderate slopes contour tillage and contour planting supported by mulching, cover crops, crop rotation and hedgerows, is the cheapest and most applicable way of conserving soil productivity.

An explanation of some erosion control systems follows. In actual practice combinations of systems and intermediate forms exist and may be even more appropriate.

Soil barriers

Where shifting cultivation is still practiced, slash and burn can be modified into „**reduced** slash and **no** burn“ practice. While the underbrush is cut and most of the trees felled, certain trees are left. Only the branches and leaves are cut and slashed, and laid along the contour lines. The trunks are important to support horizontal barriers of wood and stones, that are filled up with grass, twigs and leaves to act as sediment traps. The width between barriers varies according to the slope gradient; usually 4 to 8 m on cropland. In the long run soil barriers may develop into natural terraces and thus be even more effective in reducing run-off and maintaining soil productivity.



Slash and no burn



Slash and burn



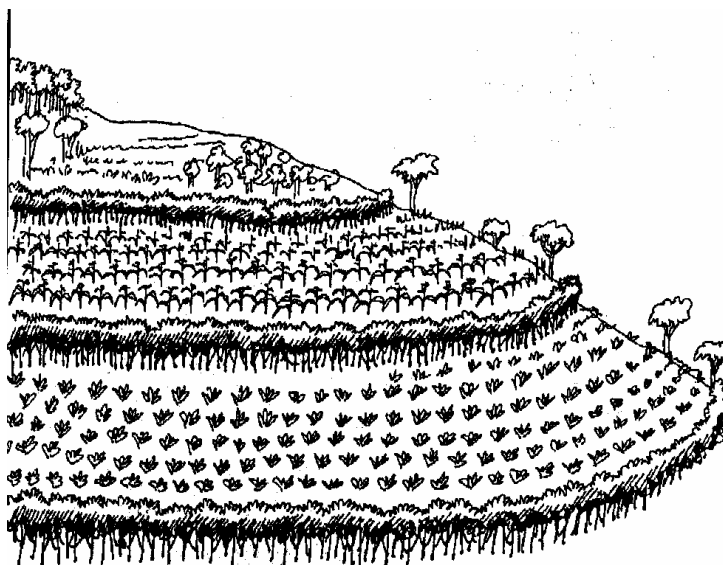
On very steep slopes minimum or zero tillage is most appropriate to prevent and avoid erosion. Hoes and dibble sticks are the only tools used in land preparation and sowing. Weed control is done by hand or machete. The vegetative cover is not removed, but kept low.

## Chapter 8

## Contour Lines and Terraces

Hedgerows

Fruit trees, nitrogen fixing trees and leguminous shrubs, or bananas, pineapples and grasses, are suitable for hedgerow growing. The alleys in between are planted with annual agricultural crops, while perennial hedgerows stabilize the soil for the long run. Hedgerows may have many more benefits, such as providing biomass for mulching and green manuring, shade for young plants, fodder, fuel wood, and poles.



Double rows have proved more reliable than single rows. A combination of several species is necessary to prevent or minimize damages from pests. Suitable species for humid lowlands include *Leucaena leucocephala*, *Erythrina* spp., *Flemingia macrophylla*, *Gliricidia sepium*, *Sesbania sesban*, *Casuarina equisetifolia* and *Calliandra calothyrsus*.

In semi-arid zones *Acacia* spp., *Agave* spp., cashew, neem, pigeon pea, jujube, *Euphorbia balsamifera* and *Cassia* spp. give good results.

In order to diversify and stabilize production and income one alley out of four or five can be planted with permanent crops, such as fruit trees. With non-permanent crops (e.g. corn, vegetables, tuber crops) it is most useful to carry out a rotational system to maintain productivity (see: Chapter 3 Multicropping).

Hedges are cut monthly down to a height of 1m. Trimming of lateral roots helps to prevent them from spreading and competing with crop plants. Twigs and leaves are mulched underneath crop plants, while stalks, branches and stones are piled up at the hedges' bases. Soil and water are trapped and conserved.

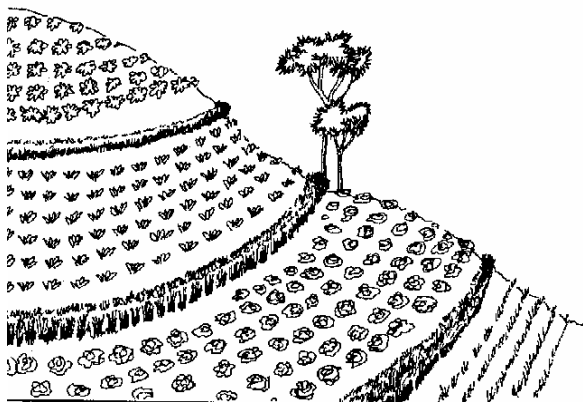
Density of hedgerows can be increased by climbers, such as *Dolichos lablab*, *Vigna acontifolia*, and by fodder grasses, such elephant napier, or vetiver grass.

## Chapter 8

## Contour Lines and Terraces

Grass strips

Grass planted along contour lines reduces erosion and run-off considerably within a short time. Soil is trapped, and water run off is reduced to a trickle.

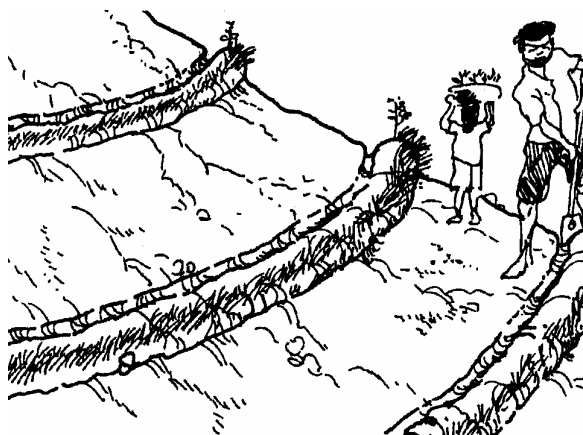


Grasses have to be trimmed every 2 to 4 months to prevent them from flowering, shading out crops and spreading out. Fresh cut grass can be used for „cut-and-carry“ fodder and as mulch for crops.

Seeds or tillers of setaria (*Setaria anceps*), ruzi grass (*Brachiaria ruziensis*), napier or elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximum*), lemon grass

(*Cymbopogon citratus*) and vetiver (*Vetiveria zizanoides*) are planted in double rows (50 cm apart) along the contour. Silt is trapped behind the grass barrier, forming over the years a natural terrace made up of soil that would have been lost to the farmer. Grasses can also be grown densely in ditches and on risers of bench terraces in order to stabilize them (see: Bench terraces).

Vetiver grass is adapted to elevations from sea level to over 2000 m, and is extremely drought-resistant. Vetiver strips are to be kept short (30-50 cm), and the fresh growth can be fed to livestock.

Ridge terraces

Along contour lines on sloping land furrows are dug. The soil from the furrows is used to form ridges. Water and soil are trapped during wet season. These sediments are put back onto the crop-land when the rains stop. Ridges can be stabilized by grasses or leguminous trees, but banana, cassava and fruit trees are also good for this purpose.

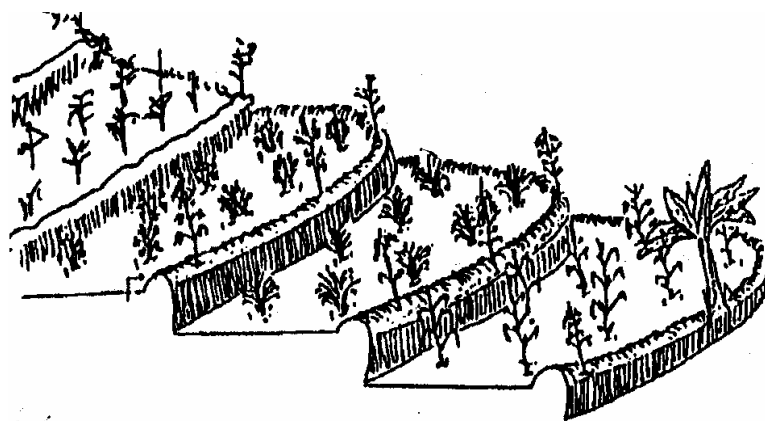
Ridge terraces are especially of interest where upland soils are shallow and the slope is less than 15°, where land tenure is a problem and where labor is limited.

## Chapter 8

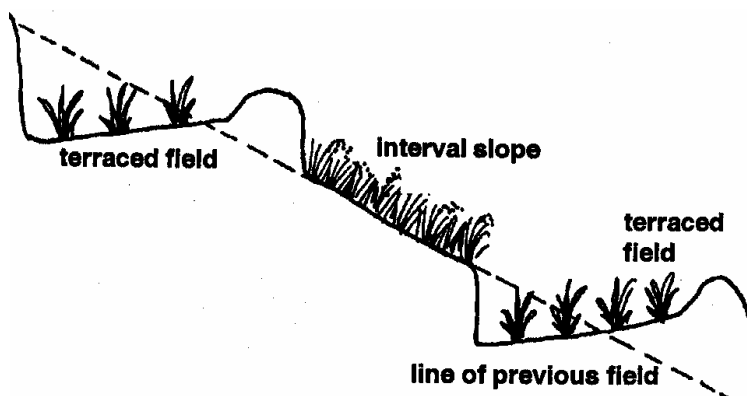
## Contour Lines and Terraces

Bench terraces

Bench terraces require relatively deep soils as they are constructed by cutting and filling to create level steps or benches. This is an effective soil and water conservation measure where land tenure and labor are not a problem, and where steep slopes have to be protected. The forward edges must be strengthened with stone, sand and/or soil, and may be stabilized with grass and perennial crops or shrubs.



Typical



Modified with internal slopes

Where rainfall is low, and where labor and manure are lacking, interval slopes planted with perennials and grasses may be alternated with individual bench terraces. Sediments are trapped along the drainage ditches at the end of each terrace. Bench terraces tend to absorb and hold amazing amounts of water where clayey or silty soils are prevalent. Cultivation of tuber crops may be limited due to this fact. Correct lay-out of benches is essential to withstand the forces of water.

## Chapter 8

## Contour Lines and Terraces

Comparison of some characteristics of the above mentioned erosion control measures:

Characteristics, consequences, advantages and limitations of soil and water conservation measures	Contour tillage	Soil barrier	Hedge-rows	Grass strips	Ridge terraces	Bench terraces
reduces run-off and erosion	xx	xx	xxx	xxx	xx	xxx
reduces nutrient loss	xx		xx			xx
increases infiltration and productivity	xx	xx	xx			xxx
traps sediments	x		xxx		xxx	xxx
improves soil fertility over the long run	xx	xx	xxx	xx	xx	xx
improves soil structure and infiltration	xx	xx	xxx	xx	xx	xxx
provides a source of „cut-and-carry“ fodder, mulch, green manuring material, tree products, and crops		xx	xxx	xxx	xx	xx
suitable for steep slopes	x	xxx	x	x	x	xxx
suitable on moderate slopes	xxx	x	xx	xx	xxx	x
mechanized cultivation faster along contour lines	xx		xx			xx
uncomfortable cultivation using hand tools	xx		xx			
labor-intensive maintenance	xx	xx	x	xx	xx	xxx
improperly laid-out measures can increase risk of erosion	xx	x	xx	x	xx	xxx
needs skills for proper construction	xx	xx	xx	xx	xx	xxx
intensive labor and investment for construction	x	xx	xx	x	x	xxx
(in)convenient where physical structures are not allowed, land tenure a problem	+	+	+-	+-	+	--
(not) suitable for shallow and slipping up-land soils	+	+	+-	+	+-	--
compete with food crops (light, nutrients, water)			xx	xx	x	
occupy land otherwise used for food production			xx	xx		xxx *
(no)disturbance of soil, initially reducing productivity	+	+	+	+	+	--
may be refuge for rodents or other pests			xx	x		
(not)applicable where long-duration rain-falls occur	+	+	+	-	-	+ *
retention of excess water may result in soil slippage on steep slopes			xx		xx	
suitable in areas with little rainfall	+	+	-	-	+	+

xxx = strong/much; xx = medium; x = little/ weak; + = positive; - = negative;

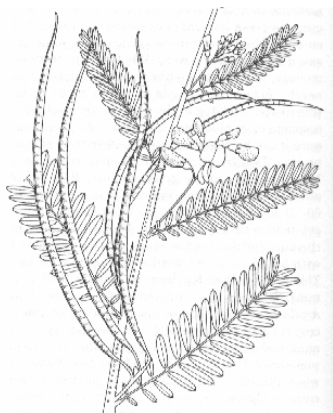
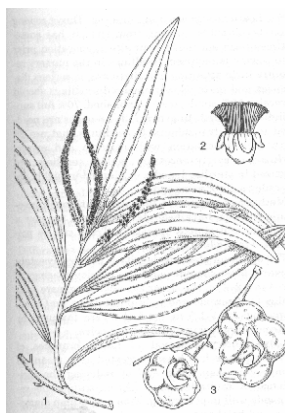
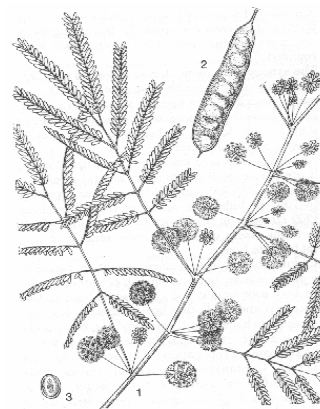
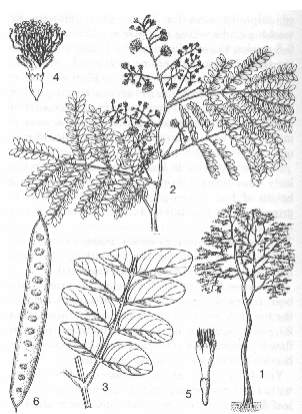
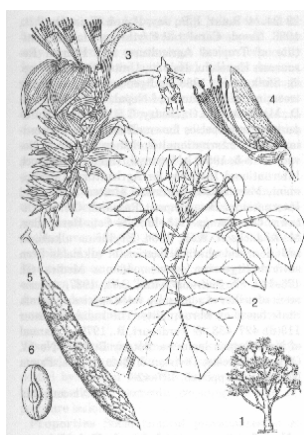
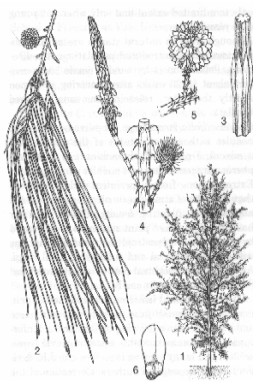
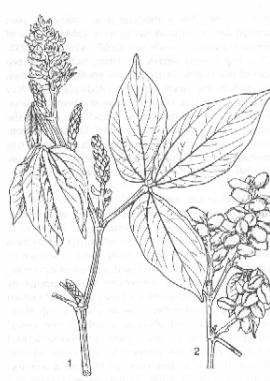
\* = bench terraces plus internal slopes; blank = no indication given / not reported



## Chapter 8

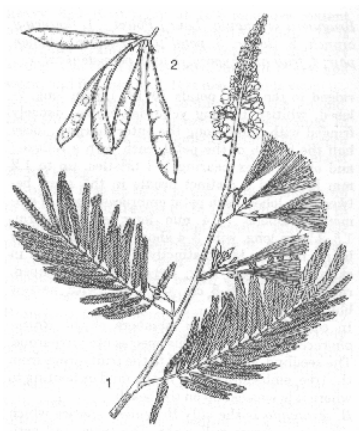
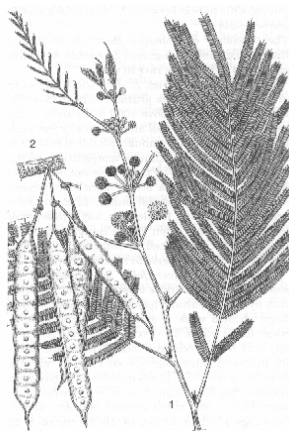
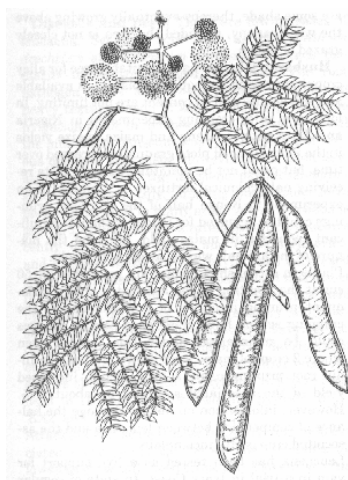
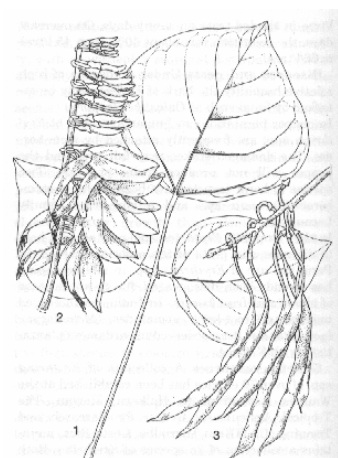
## Agro forestry

## Samples

*Sesbania rostrata**Acacia auriculiformis**Acacia glauca**Albizia procera**Erythrina variegata**Azadirachta indica (Neem)**Casuarina equisetifolia**Flemingia macrophylla**Glyricidia sepium*

## Chapter 8

## Agro forestry

*Calliandra calothyrsus**Leucaena diversifolia**Melia azedarach**Leucaena leucocephala**Erythrina poeppigiana*

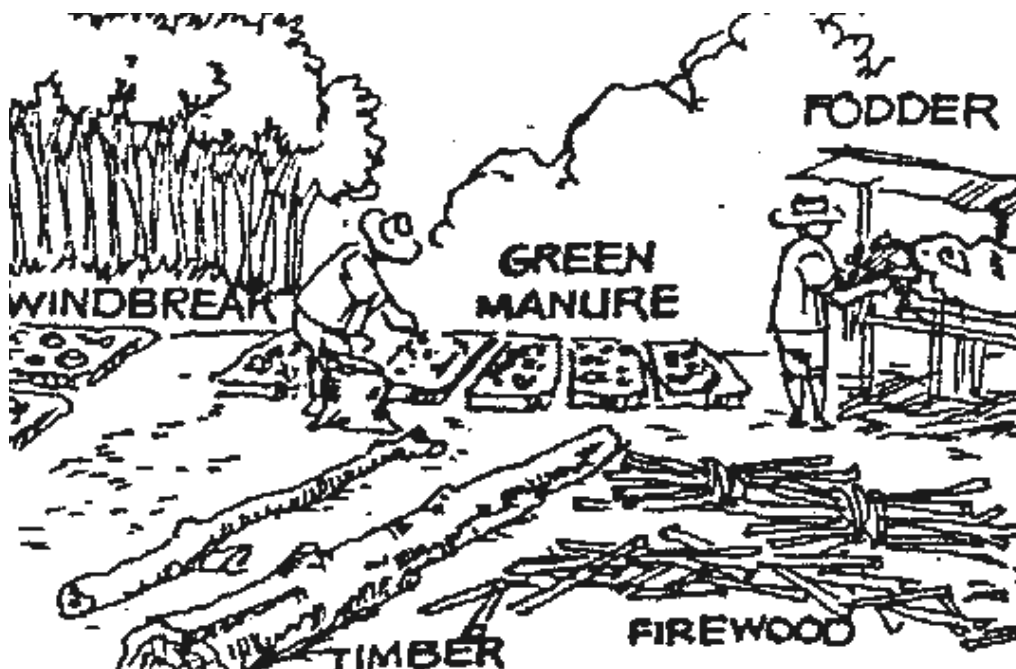


## Chapter 8

## Hedges, Windbreaks and Living Fences

Hedges, living fences and windbreaks are reasonably shaped and purposefully planted shrubs and trees, in order to solve or prevent problems of crops' damage and losses.

But hedges may provide even much more:



### 1) Food from hedges

As hedges require little space, many different fruits, nuts, flower and leafy vegetables can be harvested from hedges in relatively big amounts. Suitable species to be integrated into hedges are papaya, custard apple, mulberry, cashew, Sesban, maniok, horseradish tree (*Moringa oleifera*), jujube, pigeon pea, taphok, a.o.

### 2) Forage from hedges

may be of interest where there is a shortage of land, or where fodder for dry season survival must be produced, and where fodder for cash is an income generating possibility.

Forage is got from trimmed hedges (i.e. *Leucaena leucocephala*, *Gliricidia sepium*, *Albizia lebbek*) for „cut-and-carry“ supply, or from controlled browsing.

### 3) Timber from hedges

can be achieved by *Casuarina*, *Leucaena*, *Gliricidia*, *Acacia spp*, *Eucalyptus spp*. and bamboos planted in hedgerows.

**Chapter 8****Hedges, Windbreaks and Living Fences****4) Fuel from hedges**

Hedges consisting of e.g. *Leucaena*, *Calliandra*, *Erythrina spp*, *Gliricidia*, *Cassia*, neem, can directly supply fuel wood and release farmers from time consuming fuel wood collecting.

**5) Green manure and mulch production from hedges**

Biomass obtained from pruning hedges can contribute significantly to improve weed control, and soil moisture and fertility. The organic matter obviously reduces negative impacts of rain, hail and wind to the soil, as well (see subchapters above).

**6) Security from hedges**

When passage of animals or people are to be prevented or controlled, fences or barriers are needed. As barbed wire, wire mesh, etc. are expensive, security and privacy at low cost level may be provided by thick and thorny hedges. Appropriate species are *Acacia spp.*, *Phitecellobium/Albizia lebbeck* and jujube (*Zizyphus jujube*). When (dead) fence posts are replaced by living tree trunks live fences are created (see: subchapter living fences).

**7) Water erosion control**

will be discussed in detail in the following subchapter, see there.

**8) Wind erosion control from hedges**

Strong wind raises consumption of water in irrigated areas, and can affect sensitive crops like cereals, and contributes to soil losses by erosion.

Barriers of mainly woody vegetation that serve to break down the force of winds are generally called windbreaks or shelterbelts. By slowing wind speeds down, windbreaks can help conserve soil moisture and prevent wind erosion, therefore increase crop yields.

## Chapter 8

## Hedges, Windbreaks and Living Fences

As multi-row shelterbelts require space they should be of further benefit to the farmer, including tree products such as poles, mulch material, fuel, etc.

Windbreak trees do not necessarily require extensive management, but they can be pollarded to encourage lateral growth and provide needed tree products.

Wind „funneling“ through gaps that are created by taking trees out of the windbreak should be avoided, as negative impacts to crops are provoked. Thus harvesting of trunks for poles must be carefully planned.



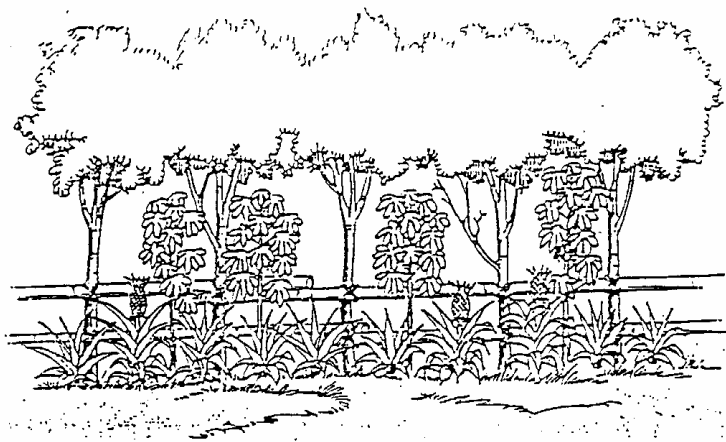
The minimum length of a windbreak is 12 times its height. The height depends on the species chosen, but is supposed to be the 10<sup>th</sup> to 20<sup>th</sup> part of the distance to be protected.

A windbreak must be well furnished from the base to the top that means multilayer of vegetation in one or more lines.

The lay out of rows is perpendicular to the prevailing wind direction.

Windbreaks, shelterbelts can be planted with a wide range of species including *Acacia*, *Calliandra*, *Leucaena*, *Albizia*, *Casuarina*, and with indigenous tree species, as well.

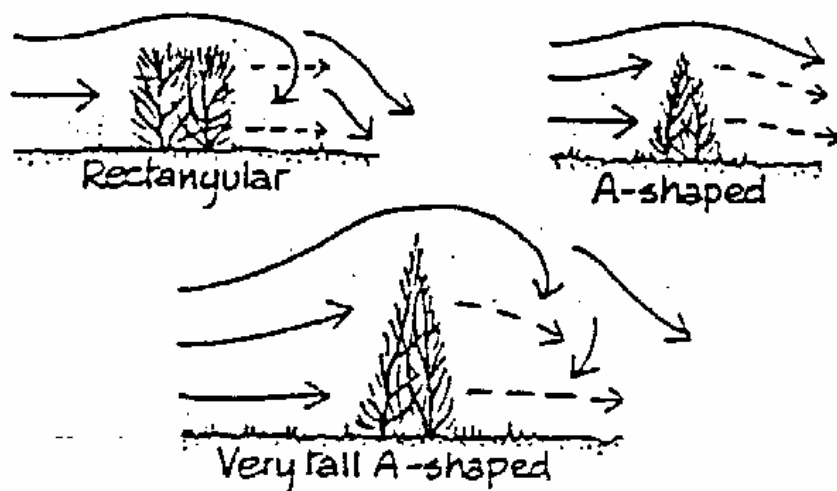
Density can be created by close set plants and heavy trimming (especially of a one row hedge), but density can also be achieved by the structure of a natural hedge. Hedges are generally dominated by low and tall growing shrubs and occasional trees.



## Chapter 8

## Hedges, Windbreaks and Living Fences

The most effective windbreak is A-shaped or topped A-hedge, if not very tall, because it allows wind to pass over it, causing less turbulences than flat-fronted shape.



Planting hedges does not differ much from planting other plants, but special initial care is needed. Protection from free-roaming animals is necessary and only then effective, when animals are definitely kept away.

#### 9) Hedges as an ecosystem

Once they are established hedges can be a refuge and important ecological reservoir for wildlife, and a beneficial ecosystem. Hedges often host birds, spiders and mammals that are predators of agricultural pests.

Hedges may be also important sources of food for „semi domesticated“ insects like bees, lac lice, silk worms and butterflies.

Hedges attract pollinating insects that are of great value for agricultural crops, too.

## Chapter 8

## Hedges, Windbreaks and Living Fences

A special aspect of security fencing is the high costs for material and maintenance. Where timber is scarce and expensive, where termites damage fence posts within short time periods, and where up to two thirds of total work in arable cropping is spent on construction and maintenance of traditional wooden or bamboo fences - there must be sought new solutions to solve these problems.

Live fences shall demarcate and form barriers, **including** or **excluding** mainly animals in order to protect the homestead, garden, and agricultural and forestry areas.

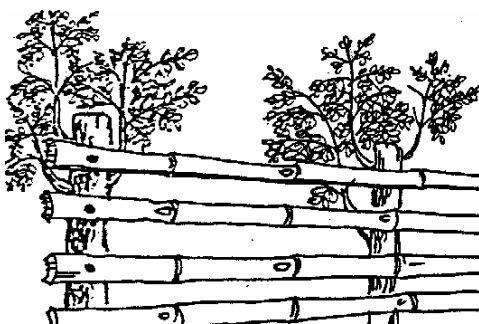
Woody perennials can provide fence posts for supporting wire, or be planted very close in a line. Thorny shrubs or palms, yuccas and dense rows of non palatable plants may be useful to keep animals away.

For **particularly fencing purposes** plants are required that combine several especially important characteristics, such as

- growing quickly to medium height and high impermeability, but being long-lived, too,
- easy to propagate by cuttings or direct seeding,
- capable of growing under adverse conditions and closely spaced,
- non-invasive by seed and/or rhizomes.

*Acacia spp.*, *Euphorbia spp.*, *Citrus aurantifolius*, *Gliricidia sepium*, *Leucaena leucocephala*, *Jatropha curcas*, *Pithecellobium dulce*/*Albizia lebbbeck*, *Zizyphus spp.*, *Bougainvillea glabra*, *Agave spp.*, *Yucca spp.*, have been proven successful.

**Live fence posts** have a longer lifespan, compared with wooden (dead) posts. They can be of multiple uses and are less capital intensive. Barbed wire is attached to existing trees wherever adequate, or forest trees like teak, *Eucalyptus spp.*, etc are planted for this purpose. Barbed wire or bamboo slices (depending on the kind of animals to be kept in or out) to **large cuttings** (about 2,5m long) that root easily and are spaced at intervals of 1,5 to 3.0m.



## Chapter 8

## Hedges, Windbreaks and Living Fences

*Leucaena leucocephala*, *Gliricidia sepium*, *Jatropha curcas*, *Bougainvillea glabra*, and *Hibiscus tiliaceae* are among the species that can be used for large cuttings. Within 24 hours after getting cuttings, stems are to be planted. In order to have good rooting results, basal ends are cut diagonally just before placing. Cuttings must be completely surrounded by soil, with no air pockets. The diameter of cuttings should be 1 to 2 cm minimum, and the best planting depth is 20 to 40 cm in the ground.

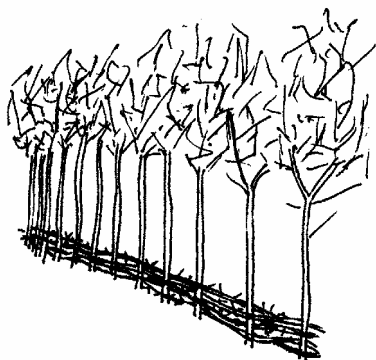
Where there is a shortage of sufficient and appropriate cuttings, where soils are too degraded or shallow, impeding easy establishment and quick growth of cuttings, a **stock proof security fence** may be the better option. In this case suitable indigenous plants can make a cheaper fence, if because of their characteristics it can be done without barbed wire. Desirable qualities are

- sturdy growth of woody or succulent shrubs or small trees, being multi-stemmed or low-branching,
- density achieved by rigid or entangling branching and a spreading canopy,
- thorns, pickles or spines, and small sparsely distributed leaves, that will cast only little shade,
- to require little attention and caretaking after planting, and be capable of easy regeneration if damaged,
- be resistant to fire, trampling and browsing, and - in the most favorable way -
- be also irritant due to stinging hairs, latex or other agents.

A stock fencing hedge must be high enough and as durable as possible, including an enhanced long-term growth. Heavy pruning may be one measure to avoid shading and stimulate permanent growing.

In particular, thorny hedges decline rapidly in strength once they are shaded underneath the umbrella of mature trees. At the same time cattle looks for shade and relief from flies, thus trampling the ground and pushing each other, aggravating pressure to the hedge.

During establishment phase animals must not get access to the hedge, if success shall not be endangered.



By intertwining cut off branches between the stems or intertwining the stems themselves the fence will be strengthened. Woven living fences are efficient barriers to protect fields from river flooding, and trap sediments from those floods.

## Chapter 9

## Introduction

Increasing population and losses of agriculturally suitable land are two seriously challenging tendencies for agriculture today. As the demand for food is rising, intensity of food production is also increasing, but including threats for people's health and risks for the natural environment, if done without knowledge and awareness - or even scruple less.

Indigenous knowledge includes many measures adapted to the place, and can be a valid source for responsible and sound ways to deal with weeds, pests and diseases.

In nature, damages in plants are seldom that obvious as they are in organized agriculture. Actually, where crop plants are produced in a more concentrated form, out of season, irrigated, monocultures or on sites that are not best suited to the plants' normal requirements, there happens to be greater incidence of diseases and pests.

Under adverse climatic regime plants can be mechanically damaged by strong winds, rains, hail, frost, etc., but be stressed by heat, drought, floods, too. Stress raises the susceptibility and probability of pests and diseases in consequence.

Climatic conditions do also influence the occurrence of mass populations of insects, snails, and rodents.

Enhancing natural enemies of crop pests by providing refuge like hedges, and preventing the accumulation of pests and diseases by avoiding mono-cropping and specializing in only one species (one plant family, respectively) are important preventive measures.

In conclusion, there are many causes for damage and / or depletion of crops and thus, economically relevant for the farmer, and sometimes for whole regions:

- **diseases** caused by fungi, bacteria and viruses, which are transmitted in many cases by crop pests
- **pests**, such as sucking and biting insects, but also rodents, snails, nematodes, etc.,
- **larger animals** (cattle, goats, chicken, and birds or other wildlife in some cases),
- **adverse climatic or site conditions**,
- **weeds**

In order to minimize costs and labor, but also keep harms to men's health and to the environment low, selective and appropriate measures must be undertaken. To do so, good knowledge and observation of not only single pests or weeds, but of correlations and interrelations of the crop plant and its environment is essential.

This chapter shall give a more integral approach, while detailed descriptions of pests and diseases can be found in more specific literature.

Farmers must be aware of the fact that by starting horticultural activities, the existing balance in the soil will be completely disturbed, and must settle down by the time.

## Chapter 9

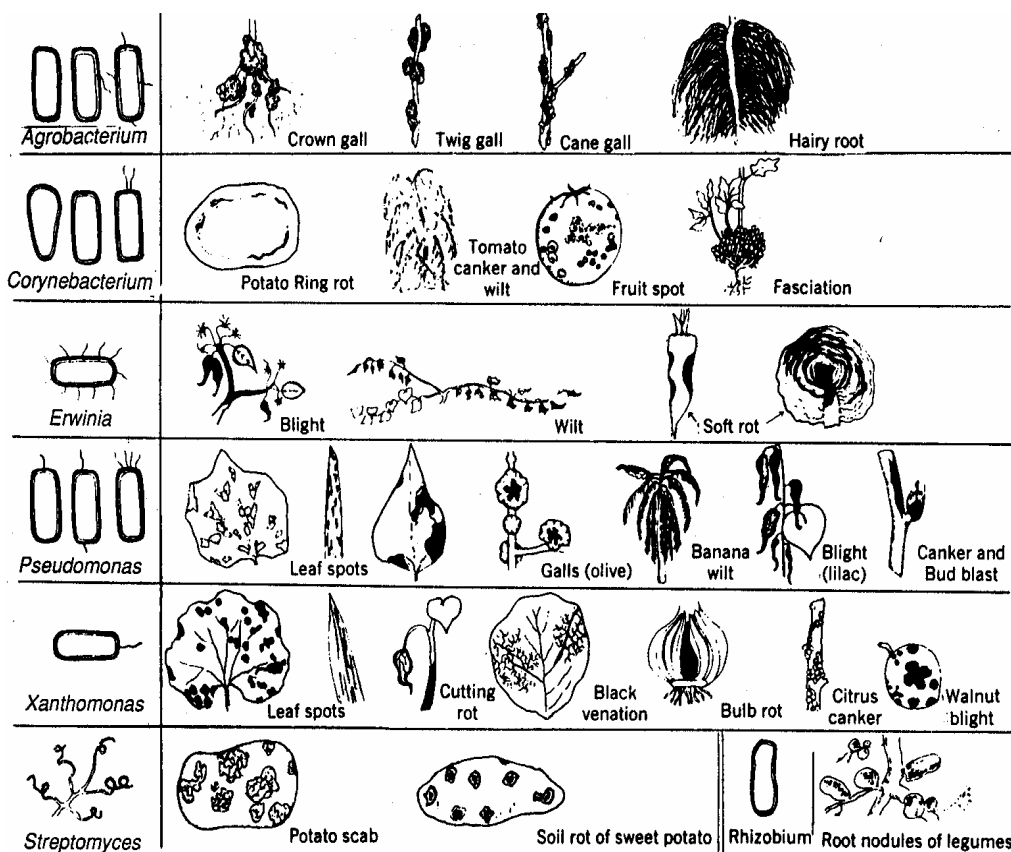
## Diseases

Pathogenic bacteria

are diminutive simple organisms only to be seen by microscope. Bacterial ooze can be found sometimes on stem cankers, rotten produce and cuttings taken from wilted plants.

Symptoms of bacteria include leaf and fruit spots, soft rots, scabs, cankers and overgrowth.

Most common bacteria diseases and their symptoms



Bacteria live parasitically in plants, causing rots and wilts, destroying roots or blocking plants' water conducting tubes. When the host plant dies bacteria live on dead plant material and decline in number.

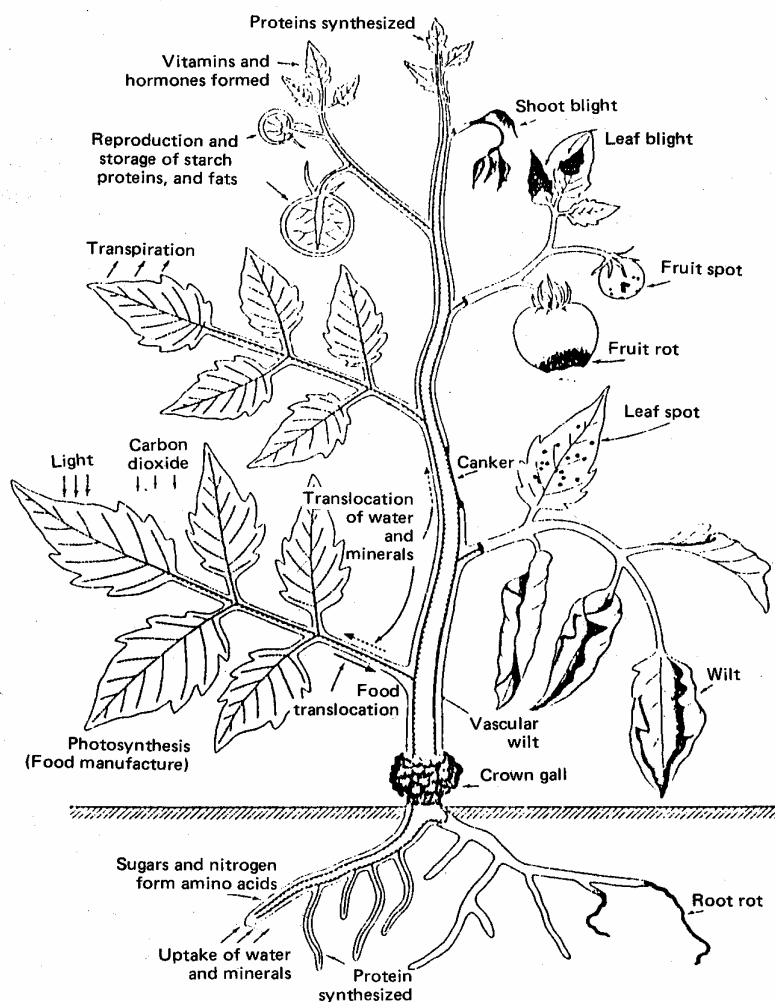
Some kinds surround themselves with a protective coating to prevent them from drying out. Such protected they can survive in the soil for a long time, until the appropriate host is available again. Actually, bacteria need wet conditions for growing and dispersing, but some are transmitted by insects, or seeds, and higher animals, men and transplanting material can be carriers, too.



## Chapter 9

## Diseases

Schematic representation of the basic functions in a plant and of the interference with these functions caused by some common types of bacteria diseases



There are several ways to suppress bacteria:

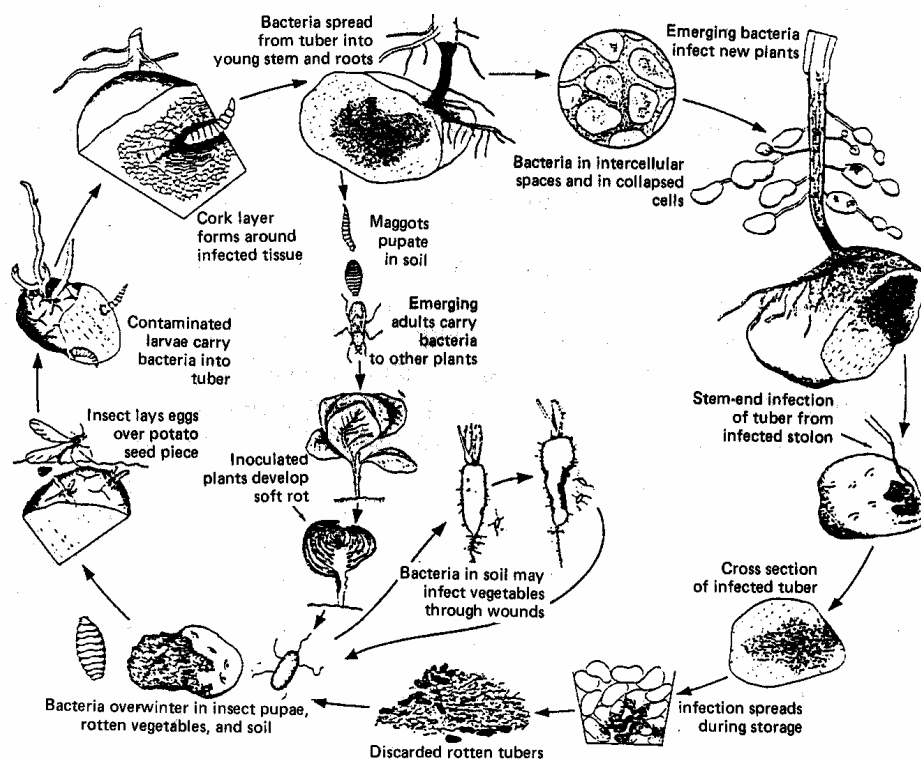
- As (most) bacteria cannot withstand dry conditions for long, **bare fallow** during dry season can be practiced, where bacterial wilt is a problem. This should be followed by
- **Crop rotation:** As most bacteria are specialized to certain crop plants, crops of the same botanical family are replanted only after 3 to 4 seasons (see: Chapters 1 and 3). Bacteria remain in resting stage, but are further reduced until population is cut to very small numbers.
- Susceptible transplanting material, such as banana root sections and sugar cane stems, and grafting material is **dipped in a 0.5% solution of disinfectant** before transplanting or propagating.

## Chapter 9

## Diseases

Somehow exceptional and especially dangerous is the bacterial soft rot of vegetables as host plants of **different** plant families are affected. The initial infection usually occurs through wounds from insects or mechanical damage.

When insects are attracted to the rotting material they transmit the disease to other hosts. Bacteria may also over season in the soil until the next crop is grown.



## Chapter 9

## Diseases

Plant Pathogenic Fungi

Most vegetable diseases are caused by fungi, and can damage up to 100% of a crop in the field, at transport and in storage.

The fungus' body is the mycelium, comparable to a loosely woven piece, made up of innumerable elongated, continuous hyphens, like threads. For dispersal, **fruiting bodies** filled with **spores** are formed. As these are of characteristic shapes, fungi are identified by them under the microscope. Host plants are sometimes helpful indicators, as some fungi are specialized to certain crop plants or plant families. Spores are spread by air and water.

As evidence of disease caused by fungi is easily mistaken with signs produced by poor nutrition, water shortage, or cold, etc., the real cause may be hidden until the plant lodges, or until at harvest the rotten, discolored interior of stem or stalk becomes evident. **Symptoms** such as yellowing, wilting, withering, may be misleading and not be taken in serious.

Farmers may just note the diseases, or perhaps a powdery mat of spores that covers lesions or diseased plant parts.

Many microscopic fungi are beneficial, as they break down dead plant parts in the soil, these are called **saprophytes**. Other are feeding on living plants, as they are **parasites**, and such causing wilts and other diseases.

Many fungi have **alternating** parasitic and saprophytic **stages** during their live cycle.

Once, pathogenic fungus appears in a crop it is too late to achieve a cure. In best case the damage and spread can be reduced. Fungi must be controlled in advance, that is preventive. Fungi are generally fostered by humidity. In rainy season their growth can be very rapid and even be visible to the observer.

Thus, cultural methods aiming for a dry micro climate, i.e. rain shelters, ridging, watering **below** the leaves, etc., can help to avoid fungus encouraging conditions.

A rotation of crops of different plant families is most important and effective to keep evil populations low.

In seedbeds, **seed rot** and **damping off** are frequent diseases, caused by fungi species of the *Pythium*, *Rhizoctonia* and *Sclerotium* genera. These root system attacking fungi can be prevented and controlled to certain extent by soil and seed treatment with appropriate fungicides.

Fungi that attack plants **above** ground level can be controlled by prophylactic / preventive spraying **and** by cultural methods.

Fungi, same as bacteria, may develop protective coatings and survive in a resting stage in the soil, until germination conditions for the spores are adequate.

## Chapter 9

## Diseases

Disease transmitting Nematodes

Plant diseases can also be caused by pathogenic nematodes. In general, nematodes have elongated and non-segmented cylindrical bodies, but during their life cycle some species become nearly round or kidney-shaped. As they are very small (0.5 - 2mm) their evidence may be ignored. Nematodes live in the moist soil and invade plant roots. By causing injuries to root cells, these may die, or form necrotic lesions, or convert into giant cells and galls.

Such injuries reduce the take up of water and nutrients, leading to deficiencies in stems, leaves and fruits. Wounds caused by nematodes weaken plants, make them susceptible to infections and give entry to other plant pathogens, such as viruses.

Plant pathogenic nematodes feed on plant roots, inserting only their style (ectoparasite) or bigger part of their body (semi-endoparasite, respectively). Other species live and move completely within the plant root (endoparasite) destroying cell walls.

**Larvae** move in soil water through pore spaces, attracted by root exudates of their host plants, and damaging these mechanically or with chemical secretes.

**Symptoms** of nematodes' activity include root knot, lesions, prolific branching and necrotic root tips. Above ground symptoms of nematodes attack may be yellowing of plants, reduced growth and lack of vigor, which are too unspecific, to identify the cause easily.

Nematodes are difficult to control as their presence and spread depend on many factors. Root exudates of Marygold (*Tagetes*) are said to repel nematodes.

Extremely toxic chemicals are used in plantation farming.

## Chapter 9

## Diseases

Virus Diseases

Viruses are extremely small agents, but able to disturb and disrupt any process by which the plant grows and maintains itself. Viruses depend on living cells for multiplication - viruses are potential parasites!

Many viruses also depend on vectors, such as insects, nematodes or fungi, as plant viruses cannot penetrate the cuticle of their hosts. Other viruses enter plants following mechanical damages caused by wind (abrasions, lesions) or wounds (done by tools, or hands, or teeth). Transmission of viruses through seed, pollen, and vegetative propagated plant parts, such as cuttings, tubers, runners and bulbs, is frequent.

Viruses can be recognized only by their **effects**, which are manifold: abnormal color, stunting, rosette forming (bunchy appearance), „witches’ broom“ (excessive budding and branching, stunting, and shortening of internodes) decline (gradual loss of vigor) of the whole plant or parts, malformation of plant parts, necrosis and plant death.

Viruses cannot be controlled so far by chemicals, but **indirect control measures** can be undertaken:

**Control of vectors**, chemical control:

Some (persistent) viruses need hours or even days to establish in the vector - those are blocked as the vector (aphid, thrips, mite, etc.) dies. Other (non-persistent) viruses can be transmitted immediately by the sucking insect, before it is killed by an insecticide. If using insecticides, neighboring plants should be also sprayed, as they might be alternative hosts.

Non-chemical control:

- Barrier crops (e.g. corn cropped around papaya) can help to reduce infection with non- persistent viruses evidently.
- Insect traps, such as color traps, light traps, suction traps, are effective in reducing vector population. As aphids are attracted to the color yellow, sticky yellow sheets erected towards the main wind direction within the crop have been proven useful. Simple sheltered containers filled with sugary water attract moths and flies.
- Raising and /or growing crops in insect-free glass or net-houses is the safest, but seldom a practicable way.
- As young plants are particularly susceptible to virus infection, sowing time should not coincide with high insect populations.

## Chapter 9

## Diseases

**Elimination of sources of infection** is possible by several means:

- Visibly virus infected plants must be removed and burnt, because they serve as a source of infection for secondary virus spread.
- Many **weeds** commonly found near crop plants are **potential reservoirs of viruses**, and should therefore be eradicated within and around the crop.
- In intercropping and mixed cropping systems the **vicinity** of susceptible crop plants of the same botanical family (such as tomato, potato, eggplant, tobacco and chili; or: cucumber, pumpkin, melons and gourds) should **be avoided**.
- The continuous planting of tomato or other solanaceous crops (see above) might lead to a high incidence of tobacco mosaic virus, to name one example. In order to avoid the build-up of this particular very resistant virus, a **consequent crop rotation** from the beginning is necessary.
- **Tools** for cutting and pruning must be cleaned or better **disinfected** after having been used for virus-infected plants. A 10% tri-sodium phosphate ( $\text{Na}_3\text{PO}_4$ ) solution is recommended. To prevent contamination and spread of viruses, during pruning and grafting work knives and/or razor blades should be flamed with alcohol regularly, before passing on to another plant.
- Since many (especially legume -) viruses are seed-borne, **seeds** should be **selected** only from virus-free (symptom-free) plants.
- Only **virus-free mother plants** can be used for vegetative propagation, as all progenies originating from a virus-infected plant will be diseased, too.
- Whenever possible, **virus-resistant material** or cultivars should be chosen.

#### Disease Development

Same as human and animals, plants get „sick“ when their physiological balance is disturbed. Several aspects have to coincide to induce an infection and the disease cycle, which is the host and pathogen interaction:

The first step of the infection cycle is the **inoculation**, when the pathogen (bacteria cells, fungi mycelium, spores or resting forms, nematodes larvae) gets into contact with the plant.

The second step called **penetration** through wounds or by use of stylets plus secretions may lead to the **infection**, if host and pathogen are compatible. Then pathogens establish within the susceptible plant cells, „steal“ nutrients for their own growth and multiplication, thus weakening the plant. Discolored, malformed, or necrotic areas are signs of effective infection, but not always immediately after. An infection remains latent, when symptoms are observed later, due to changing environmental conditions or altered plant's physiology. The time interval between inoculation and appearance of symptoms is called **incubation** period.

## Chapter 9

## Diseases

By **growth of the pathogen** it spreads into healthy plant cells until cellular structures block it or the plant dies. As often pathogens reproduce in the vessels, cells or spores are carried within the sap stream, causing wilts at a later stage.

The **dissemination** (spread of pathogens to other host plants) is usually a passive process.

Most fungal spores are spread by air currents, like smoke particles, over long distances. Dew, irrigation water and natural precipitation move them towards the host plant, washing them downwards or splashing them all around. Bacteria are mainly disseminated by water.

Important vectors of diseases are insects, mites, nematodes, as they carry bacterial cells and fungi spores from plant to plant. Mammals and birds may spread pathogens by direct contact or carrying seeds, but man can transfer pathogens in many different ways: By handling diseased and healthy plants successively, by contaminated tools, through transportation of contaminated soil, containers, propagation material and even food stuffs.

To close the cycle **over seasoning and survival** of pathogens is the last step.

#### Disease Management

This cycle can be interrupted in every stage, after each step, by adverse conditions to the pathogen, thus reducing its' number and efficiency in consequence. Knowing about the specific host-pathogen-interactions enables the farmer to find ways of efficient and cost-effective control.

1. **Crop management** includes the following practices:

- a) Green manuring with legumes or marigold, e.g., in tender stage adds fertility and produces healthy plants resistant to fungal attacks, as biological activity in the soil is increased (see: chapter 8). Manuring with fresh dung or mixtures, that contain fresh dung, raises soil fertility and additionally suppresses fungi, as plants then produce protective compounds. When compost, containing fresh dung, is ripe after 2 to 3 weeks (make the test by sowing some seeds on the pile!), a spade of compost may be added to roughly 8 l of water. The container has to be covered for 6 to 8 days for fermentation. The extract will be of a dark brown color. It must be filtered, but not diluted. By adding a handful of soap for better sticking to the crop plant, this extract is then sprayed, obtaining effects very similar to those of BE (see: chapter 8).
- b) Crop rotation interrupts life cycles of plant parasites, fungi spores are starved if no suitable host is accessible. Paddy rice or dry fallow can reduce the beginning of build-up of soil borne diseases. As most fungi will parasitize no more than one plant family, alternating between crops of minimum 3 plant families reduces diseases obviously (for crop rotation examples, see: chapter 3 Multi-cropping). Intercropping means that crops are separated by space while rotation separates them by time. The crops used in intercropping systems must

## Chapter 9

## Diseases

be of different family groups. Spreading of spores by rain splash can effectively be limited by intercropping.

2. **Sanitation** means crop hygiene **practices** such as removing residues from the previous crop in order to clear the fields of parasitic spores in a resting stage. It means also removal of plant debris while the crop is growing, because diseased leaves and fruits otherwise became centers from which infection could spread. Infected plants and plant parts have to be burnt or hot-composted, as heat kills the spores.
3. Use of **disease-resistant and tolerant varieties**, wherever possible.
4. **Planting dates** should whenever possible be adjusted, to avoid seasons of high risk.
5. **Clean seed and planting materials** together with careful cultural methods at least give a good start for a crop. Initially disease-free crops are stronger and faster growing. Seed obtained from healthy mother plants that has been kept in a dry, insect-free storage is appropriate for propagation. It is placed in a bag with a spoonful of fungicide powder and shaken to provide a protective coating.
6. **Chemical control:** There are many synthetic fungicides under several trade names available, that have to be used due to the instructions given. Fungicides are not very toxic to mammals, but non-persistent and, thus expensive, as they must be applied weekly to be somehow effective. There are cheaper - and in remote areas more viable ways - to protect crops from diseases with homemade fungicides. Remember: Only preventive action can protect crops from fungi. Apart from crop management practices, only **prophylactic spraying, soil drenching or seed dressing with dusts** that starts long before any appearance of disease, can be effective. Not knowing what might attack crops, wide-range fungicides are preferable: **Bordeaux mixture** can be used as a foliar spray **against all fungi except mildews**. To prepare 10 liters of Bordeaux mixture, dissolve 150 g of copper sulphate in 2 liters of water, and 100 g of lime in other 2 liter of water. Mix the two solutions thoroughly and add 6 liters of water, stir in a handful of soap and filter the mixture through a cloth or through the basket filter of the spray tank. Crops are safe to eat 3 days after spraying!

**Mildew fungi** are recognized by their white or greyish growth on plant surfaces. They can be controlled by sulphur and sodium bicarbonate: **Sulphur** is sold as rocky lumps, but is crushed to a smooth powder by pounding for use. To prepare 10 liters measure 50 g (6 rounded table spoons) of powder and mix into 1 liter of cold clean water. Add a handful of soap and stir so that the powder is well dispersed, and suspended throughout the water. Fill the spray tank quarter full of water, filter in the suspension, then top up to half tank level. While spraying shake the tank every few minutes to keep the powder dispersed in water. Crops are safe to eat 2 days after spraying!



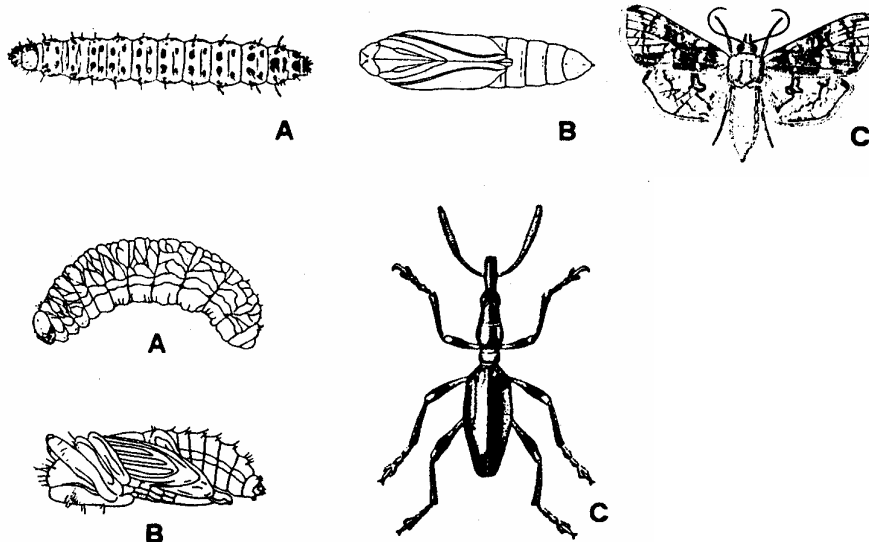
**Sodium bicarbonate** appears to be a useful, all purpose fungicide. White powder (baking powder) or (ant acid) tablets, readily soluble, can be found in general stores and pharmacies. To prepare 10 liters dissolve 100 g sodium bicarbonate in 1 liter of cold clean water. Stir in a handful of soap, filter through a cloth or the basket filter of the spray tank. Add 9 liter of cold clean water (or half fill tank) and spray or apply with twig-bunches to the crop. Sodium bicarbonate doesn't harm, but has a sour taste. Food should be washed to get rid of that, but can be eaten immediately after application. In the field it persists for a long time. Fungal spores are in the air and on the ground all the time, and as soon as they get in touch with their hosts they will establish themselves. That's why upper and lower leaf surface must be sprayed, especially near to the soil surface: To give good protection, **fungicides must cover a plant completely**.

7. **Control of insect vectors and weed hosts** is often necessary as these are frequently responsible for spreading pathogens.

## Chapter 9

## Pests

Among the pests that harm crop plants, insects are most numerous and serious. Insects lay thousands of eggs and grow rapidly, passing several stages. Larvae and pupae need plenty of food to survive and overcome the pupa or transformation stage. The resulting adult insect has a 3-segment-body, 6 legs and very often wings. In many cases the adult (butterfly, moth, fly or beetle) is not harmful, but beneficial, as it feeds on nectar and helps in pollination.



A Larvae, B Pupae, C Adults of Vine borer and Sweet potato weevil

Insect pests can be divided into several groups (due to their eating habits):

- Caterpillars and leaf miners are feeding from plant parts above ground (defoliators).
- Fruit worms and stem borers (and pod borers) burrow into the plant.
- Cutworms and termites (root feeders) chew plants at or below ground level.
- Sap sucking pests like aphids (soft bodied insects) and scale insects (mealy bugs, e.g.) harm plants by „stealing“ the plant's food (assimilates) and weakening it. At the same time can inject toxins and provide entry to disease organisms. Aphids reproduce very fast and in very large numbers. They are particularly feeding on buds, thus hindering normal growth of affected leaves and flowers. Ants do stimulate aphids to excrete sugary wastes that are the ants breed feed. But on these wastes now fungi start to flourish, that cover the leaves with black spores, and prevent photosynthesis, thus aggravating the case. Aphids hide on the underside of the leaves. They and the fungi can be washed off by heavy rains or with soapy water.

## Chapter 9

## Pests

Disease carriers or vectors, such as aphids, plant hoppers, thrips, e.g., carry virus diseases, fungi and bacteria from one plant to another.

Another seriously damaging group is mites, tiny spiders (not segmented body and 8 legs), that are multiplying enormously and weakening plants by sap sucking on the undersides of leaves and on flowers. Thrips scrape the cuticle and drink the excreting sap causing pale or transparent patterns.

Mealy bugs and whiteflies are covered and protected with waxy or scaly coats.

Most of these sap suckers are encouraged by hot and dry weather, and may almost vanish with the rains. When there are only few insects, the damage is also small. But as soon as they seem to appear in masses, they must be controlled.

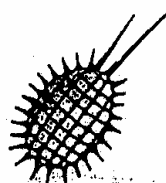
Aphids or  
Black or  
Green flies



Cutworms



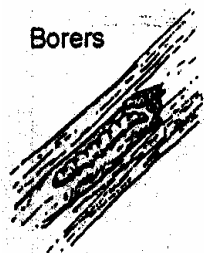
Mealy bugs



Squash bugs



Borers



Fruit Flies



Nema todes



White flies



Caterpillars



Leaf miners



Root Maggot flies



## Chapter 9

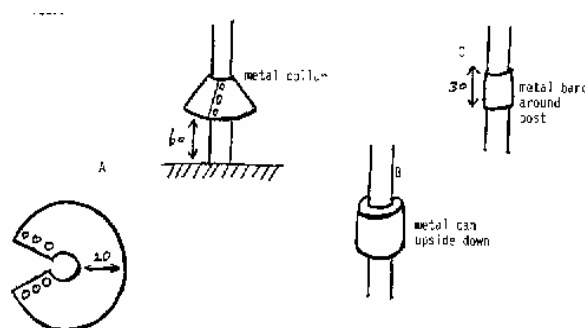
## Pest Control

Apart from the tiny, but nasty pests there are also the taller ones, such as snails, rodents and „harvesting“ birds. The precise identification of the kind of pest and of its damage means to have half the problem solved.

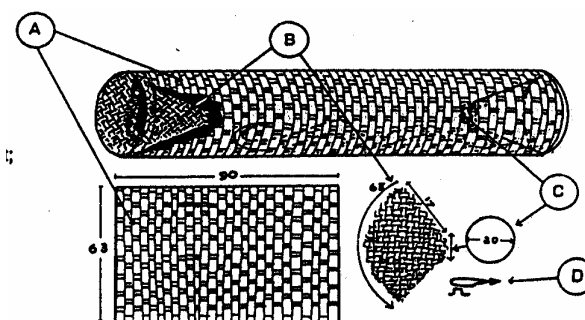
Depending on the kind and quantity of pest there are several methods of control:

1. Cultural and mechanical methods have always been used to directly destroy or interrupt the normal biological processes of a pest (i.e., different stages of insect pests). Another intention is to make the environment unpleasant for the pest, e.g. by

- **sanitation**, to make the field clean and free of material favorable for over seasoning: plant residues, manure and vegetable wastes are to be covered with soil,
- **crop rotation** (see: chapter 3 multi-cropping),
- **cultural practices**, such as cultivating the soil to kill or injure insects and weeds, proper timing of planting, transplanting instead of direct seeding, etc. Any measure to prevent stress from plants (by drought, competition, e.g.) helps to keep crop plants strong and less sensitive to pests,
- regular **handpicking** before the critical stages start: Worms, snails and beetles can be handpicked and crushed, egg clusters may be crushed or washed off,
- putting **physical barriers**, such as sticky lime or grease rings around fruit tree trunks against up crawling ants and caterpillars, and plastic barriers around seedlings to protect them from snails and low flying beetles, i.e. in melons; „barrier strips“ made of ash or dry grit keep snails away, too; ditching around seedlings is effective against cutworms and army worms, as they cannot crawl up a sheer slope - once trapped in a 10cm deep ditch they can easily be crushed or sprayed.



- **traps** made of bamboo are effective to control rats and mice; poisoned bait in a tin or bamboo tube may be alternatively put near the damaged crop, or pitfall traps be arranged; snails are attracted by containers filled with sugary water.



## Chapter 9

## Pest Control

- **scaring** birds with humming tapes and reflecting stripes of aluminum,
- use of **vegetable oils, soaps and detergents**: soaps seem to destroy insect membranes so that soft bodied aphids die instantly at a concentration of 5 g soap per 1 liter of water; caterpillars and beetles will need around 8 g per liter. But be careful: concentrations above 1% (10 g per liter) may damage or even kill plants. One day in advance the mixture should be tried out with a few plants only. The insecticidal power of a soap and water solution can be improved by adding a few milliliters (or drops) of disinfectant. Vegetable oils from peanut, coconut, cotton seed, maize or soybean act as a deterrent, as insects avoid their smell. A thin coating protects grain and seeds from weevils and seed borers as both eggs and larvae of these pests die when treated with oil.

2. Biological control makes use of living organisms. Only some insects (and other animals) are plant pests, many other insects are beneficial (for pollination, i.e.) to the grower, who has to know well to distinguish them. Many insects are predators or parasites of insect pests, e.g. small wasps lay their eggs into harmful worms or larvae. The emerging youngsters eat them up from inside.

Certain parasites (*Bacillus thuringiensis*, e.g.) for pests of major economical importance are produced in great numbers by specialized companies and can be ordered when needed.

Real spiders catch insect pests in their nets or jumping onto them - therefore they must not be killed!

Insect hunting birds can be attracted by hedges, as other wildlife, too.

3. Chemical control includes synthetic and natural or botanical pesticides. Botanical pesticides are made from plants, and they are as toxic to pests as synthetic ones. But there is one important difference: While insect pests develop resistances for synthetic insecticides, botanical pesticides remain efficient - probably due to the complexity of effective substances.

Maybe numbers of pests are heavily reduced by use of synthetic pesticides, but later recover and increase. Maybe the focused pest is eradicated, but another insect takes its place. Insects may survive and „get used“ to the chemical - then more frequent spraying of stronger mixtures is needed. Useful animals like honeybees and birds, also fish, die and disappear, while plant and cattle pests arise or increase.

As all organisms are interrelated the bad effects fall back to men, if the biological balance was disturbed.

## Chapter 9

## Pest Control

## a) Disadvantages and risks of synthetic pesticides

When large-scale production of one crop is practiced year after year, specialized pests become easily a severe problem, and their control may demand ever increasing amounts of chemical pesticides and fertilizers. The decision of the grower, what to grow, where and when to grow and mainly, how to grow is always affecting the neighborhood and even the whole region around. Contaminated birds and other predators, polluted water, spraying dusts, etc., don't stop at the farm border, but influence the surroundings, too.

Years ago already some of the most dangerous pesticides have been banned or severely restricted in most industrialized countries. But still they are sold in developing countries under numerous trade names. The effective substances that should be prohibited completely, and really not be used any more, are the following:

**1. Aldicarb**

Commercial products: Aldicarb, Temik 10 G, Temmic 10 G.

Mode of action: Systemic insecticide, acaricide, and nematicide with contact and stomach action. Absorbed rapidly through the roots, with translocation acropetally. Cholinesterase inhibitor.

Uses: Soil application for control of chewing and sucking insects (especially aphids, whitefly, leaf miners and soil-dwelling insects), spider mites and nematodes in glasshouse and outdoor ornamentals, sugar beet, fodder beet, strawberries, potatoes, onions, hops, vine nurseries, trees nurseries, groundnuts, soya beans, citrus fruit, bananas, coffee, sorghum, pecans, cotton, sweet potatoes, sugar cane and other crops.

Toxicity to mammals: Acute oral LD<sub>50</sub> for rats 0.93 mg/kg. Acute percutaneous LD<sub>50</sub> for rabbits 5.0, guinea pigs 2400 mg/kg. Inhalation of the dust at a concentration of 0.2 mg/l air for 5 minutes is fatal for rats. In 2-year feeding trials, rats receiving 0.3 mg/kg/day showed no ill effects. WHO Class Ia; EPA Toxicity Class I. ADI (man) 0.005 mg/kg

Degradation in plants: In plants, the sulfur atom is oxidized to sulfoxide and sulfone groups. The highly soluble sulfoxide acts systemically on the plant, and is 10-20 times more active as a cholinesterase inhibitor than aldicarb itself. Further degradation leads to the formation of oximes, nitriles, amides, acids and alcohols. The metabolites are present in the plant only in conjugated form.

**2. Aldrin**

Commercial products: 3-FT-30/7-FT-50, Aldrex 2, Aldrex 40 WP, Aldrite (21.1%), Aldrite Super (37.8%)

Mode of action: Non-systemic insecticide with contact, stomach and respiratory action.

**Chapter 9****Pest Control**

Use: Control of soil-dwelling insect. Control of termites and ants. Also used for wood preservation.

**3. 3,BHH/HCH**

Mode of action: Highly persistent insecticide with contact, stomach and respiratory action.

Use: Control of mites, soil insects, and pests on cotton.

Compatibility with other products: Always test mixture before use.

Toxicity to mammals: Oral LD<sub>50</sub>: 100 mg/kg, Dermal LD<sub>50</sub>: n.a.

**4. Camphechlor**

Mode of action: Non-systemic insecticide. Also rodenticidal stomach poison. Some acaricidal activity.

Compatibility with other products: Always test mixture before use.

Toxicity to mammals: Oral LD<sub>50</sub>: 80 mg/kg, Dermal LD<sub>50</sub>: 800-2,300 mg/kg (rat).

**5. Chlordane**

Commercial products: Amrin Traveetong, Chlordane, Chlordane 40, Chlordane 75 EC, Chlordane S.O.K, Chlordix, Chlordrite 40, Chlordrite 40 EC, Chlordite 75 EC, Dinhun, Mart Satan-glookloke, Memory, Mixture, Newchlordrin, Osmon 40, Osmon 72, Osmon D-40, Stray-V No. 88 Trapratutong, Tailob D. Dedrin, Teracid 40 Dust, Terminate, Woodlast Black, Zesdane.

Mode of action: Non-systemic insecticide with contact, stomach, and respiratory action. Long residual activity.

Use: Used on land for control of ants, grasshoppers, subterranean termites, Coleoptera, Noctuidae larvae, and other insect pests; for control of household insect pests; and to reduce earthworm populations in lawns. Also used as a wood preservative.

Compatibility with other products: Compatible with some other pesticides, but incompatible with alkaline materials.

Toxicity to mammals: Acute oral LD<sub>50</sub> for rats 457-590, mice 430, rabbits 300 mg/kg. Acute percutaneous LD<sub>50</sub> for rabbits 200-2000, rats 217 mg/kg. Extremely irritating to eyes; mild skin irritant (rabbits). Non-sensitizing to skin (guinea pigs). In 2-year feeding trials, no-effect level for dogs was 3 mg/kg diet. Serious chronic and cumulative toxicity, including liver and kidney damage. Accumulates in body fat and lipid-containing organs. Produced hepatocellular carcinomas in mice (S.S. Epstein Sci. Total Environ. 1976, 6, 103-154). Non-mutagenic. WHO Class II; EPA Toxicity Class II. ADI (man) 0.0005 mg/kg.

**6. Dibromochloropropane (DBCP)**

Manufacturers: Shell; Dow; Amvac

Mode of action: Nematicidal soil sterilisant.

**Chapter 9****Pest Control**

Use: Used against nematodes on berries, citrus, grapes, groundnuts, cotton, soya beans, vegetables, ornamentals, etc.

Compatibility with other products: Always test mixture before use.

Toxicity to mammals: Oral LD<sub>50</sub>: 170 mg/kg Dermal LD<sub>50</sub>: 1420 mg/kg

**8. Dieldrin**

Commercial Products: 3-FT-30/7-ET-50; D15; Dieldrex 15, Dieldrex 50 WP, Dindeth, Protim 80WR Concentrate 1; Shell Dieldrin 75 WP.

Mode of action: Persistent insecticide with contact and stomach action.

Use: Insecticide having a wide spectrum of activity.

Toxicity to mammals: Oral LD<sub>50</sub>: 37 mg/kg, Dermal LD<sub>50</sub>: 60-90 mg/kg (rat)

**9. Endrin**

Mode of action: Persistent insecticide with contact and stomach action. Also has a rodenticidal property.

Compatibility with other products: Always test mixture before use.

Toxicity to mammals:

Oral LD<sub>50</sub>: 7 mg/kg, Dermal LD<sub>50</sub>: 15 mg/kg (rat)

**10. Ethylene Dibromide**

Use: Nematicide, soil insecticide, and fumigant.

Compatibility with other products: Always test mixture before use.

Toxicity to mammals: Oral LD<sub>50</sub>: 146 mg/kg, Dermal LD<sub>50</sub>: n.a.

**11. Parathion**

Commercial Products: Duiliulin (China), Folidol, E 605

Mode of action: Non-systemic insecticide and acaricide with contact, stomach and some respiratory action. Cholinesterase inhibitor.

Use: Control of sucking and chewing insects (including soil insects), and mites in a very wide range of crops, including cereals, fruit (including citrus), vines, hops, vegetables, ornamentals, cotton, and field crops. Also used for control of nematodes in beet and ornamentals.

Compatibility with other products: Compatible with other insecticides and fungicides, but incompatible with alkaline materials.

Toxicity to mammals: Acute oral LD<sub>50</sub> for rats 3.6-13, mice 12, guinea pigs 16-32 mg/kg.

Acute percutaneous LD<sub>50</sub> for rats 6.8-21 mg/kg. Readily absorbed through the skin. No accumulation in tissues. Acute inhalation LC<sub>50</sub> (4 hours) ca. 0.05 mg/l (aerosol). In 2-year feeding trials, rats receiving 10 and 25 mg/kg showed no ill effects. WHO Class I; EPA Toxicity Class I. ADI (man) 0.005 mg/kg.



## Chapter 9

## Pest Control

**12. Paraquat**

Commercial Products: A.B. Zone, Aggrizone, Agrozone, Badezone, Bankzone, Best-zone, Betazone, Biozone, Blackzone, Cabezone, Capzone, Carazone, Centerzone, Champion, Check-THRU, Clearazone, Combozone, Complete, Condozone, Corizone, Cymazone, Dara-zone, DT-Zone, Eartzone, Eclipse Paraquat, Ecoparade, Ekazone, Erazone, Famcozone, Farmerzone, Fastzone, Fieldgo, Fuzone, Garden Clear, Glaszone, Gramoxone, Grandzone, Greenleafzone, Greenzone, Hi-Zone, Jicazone, Karazone, Kemozone, Kendo, L-Zone, Magzone, Mejorzone, Melazone, Metrozone, MP-Zone, Naturezone, Noxone, Noxone M, Nuzone, Omazone, Paraquat, Paraquat Ast, Paraquat Dichloride, Parkzone, Pentazone, Perazone, Planzone, Polyzone, PS-276 Green, Q-Zone, Quat Special 200, Quickzone, Rutazone, S-Zone, Safezone, Sanvate, Siamzone, Sparta, Starzone, Sunzone, T-Cot, Thanazone, Thipzone, Topzone, Trulazone, Tungtongzone, Unizone, Vistazone, Vizone, Winzone, Worldzone, Wupazone, X-Zone, Yipinzone, Zinizone, Zona.

Mode of action: Insecticide, fungicide and non-selective contact herbicide.

Use: Control of termites; as a wood preservative to protect against fungal rots and wood-boring insects; as a pre-harvest defoliant in cotton; and as a general pre-emergence herbicide.

Toxicity to mammals: Acute oral LD<sub>50</sub> for rats 210 mg/kg. Irritating to skin, eyes, and mucous membranes. No deaths occurred amongst dogs and rats receiving 3.9-10 mg/day for 70-190 days. WHO Class Ib; EPA Toxicity Class II.

**13. Pentachlorophenol**

Commercial Products: Celbrite NAP, Cryptogil NA, Cryptogil OL, Impralit BS, Mapa PCP, Protim 80 WR Concentrate 1, Wesbrite 500, Wescocide-B.

Mode of action: Insecticide, fungicide and non-selective contact herbicide.

Use: Control of termites; as a wood preservative to protect against fungal rots and wood-boring insects; as a pre-harvest defoliant in cotton; and as a general pre-emergence herbicide.

Toxicity to mammals: Acute oral LD<sub>50</sub> for rats 210 mg/kg. Irritating to skin, eyes, and mucous membranes. No deaths occurred amongst dogs and rats receiving 3.9-10 mg/day for 70-190 days. WHO Class Ib; EPA Toxicity Class II.

**14. 2,4,5-T**

Mode of action: Selective systemic herbicide with hormone-like action. Absorbed via leaves, bark, and roots. Mode of action similar to that of 2,4-D.

Use: Control of woody weeds, brush in grassland in non-crop lands; of tree shoots in forestry; amine formulation used in weed control in rice.

Toxicity to mammals: Oral LD<sub>50</sub>: 500 mg/kg Dermal LD<sub>50</sub>: >5,000 mg/kg (rat)

**Chapter 9****Pest Control**

Many insecticides in particular are dangerous for humans during application and afterwards, when treated plants and their products are touched and eaten. If there is not enough time for decomposition of harmful substances given between application and consumption, the consumer's health is affected.

b) Appropriate application of chemicals

Most chemicals need to be diluted in water and are best applied as spray, as every plant part above ground can be covered by spraying. The knapsack sprayer is most useful for this purpose. Where not available, tight-closing plastic bottles can be prepared with tiny holes in the cap.

Both, user and environment must be protected when chemicals are being applied, whether homemade or purchased products. Insecticides can also act on men's nervous system, provoking numbness, itching or worse sickness, when exposed for a prolonged lapse of time.

To avoid health problems rules for safe spraying must be followed:

1. Never spray that way that you risk breathing in the spray, but so that the wind carries the spray away from you. Stepping backwards is recommended.
2. Avoid walking through the spray cloud and through plants wet with spray. Put gumboots and extra cloth to avoid chemicals being rubbed into the skin.
3. Spray always close to the crop, not high above.
4. Mask the face with a cloth and make sure to keep it dry. If by chance it gets wetted with spray, remove it at once.
5. Mix solutions by stirring with a stick, never with the hand.
6. Wipe the outside of the tank dry before hoisting it onto the back.
7. Don't drink, eat or smoke while spraying and before having hands and face washed thoroughly after spraying. Even small amounts of chemicals may cause sickness later.
8. After use clean the knapsack sprayer or bottle by pumping clean water through. Do that far from wells and creeks or ponds. Store the equipment upside down out of reach of children or animals.
9. Do not use the vessels for anything else than for mixing chemicals and spraying, and keep them separate for that purpose only. Make sure that everyone knows about the exclusive use.
10. Store synthetic pesticides, powders and dusted seeds in a dry and safe place, and note that a skull indicates dangerous contents.

## Chapter 9

## Pest Control

To protect the environment

- avoid monocultures
- farm in accord with the environment
- know to distinguish beneficial from hazardous organisms
- know all aspects of a pest's life cycle and its critical stages
- monitor the crop regularly and decide when damage needs controlling and how far it can be tolerated
- don't throw empty pesticide containers, nor other not decomposing materials to the ground, but collect and bury them in a definite waste place
- don't empty spraying equipment into water flows
- make use of botanical pesticides whenever possible

c) Integrated Pest Management (IPM)

**Integrated** refers to the approach of combining cultural practices with carefully chosen sprays (threshold approach) in order to strengthen, but not interfering with the existing natural controls. Normally, natural control factors suppress pests to that extent that often less than 5 % of insect eggs survive to become adults.

Birds, carnivorous and parasitic insects, poisonous plants or plant parts, genetic resistance, temperature, humidity, fire, floods and frost are insect numbers limiting natural factors, among others.

**Management** shall describe the kind of control that aims for keeping pest populations below the economical level (at which crop losses are noticeable), but not for eradicating them.

Cultural practices to control pests are

- selecting healthy seed and cuttings
- storing seed cleanly (see: chapter 12)
- taking care in transplanting, and in planting dates
- weeding within and around the crop production area
- cultivation with the hoe and
- ploughing for exposing grubs and pupae
- crop hygiene during crop life cycle and after harvest
- crop rotation
- intercropping
- using resistant varieties - ridging the soil for better drainage
- manuring

## Chapter 9

## Pest Control

**Tomato** intercropped with **cabbage** (1:1, cabbage planted 30 days later than tomato) reduces egg laying by diamond back moth and the incidence of leaf webber because of the volatiles of tomato.

**Mustard** used as a trap crop attracts diamond back moth, aphids, leaf webber, stem borers and bugs because of the presence of a substance that stimulates them to lay eggs. Mustard is grown as paired row at the borders and in between several cabbage rows. The first of the paired rows is sown 15 days prior to cabbage planting, and the other 25 days *after*. The trap crop may be sprayed or removed when eggs have been laid, while cabbage may be treated with a less potential or safer insecticide.

Spreading of **blue cloths** will attract larvae of the **tobacco caterpillar** (army worm, *Spodoptera litura*) that can be handpicked and destroyed. Use of **poison bait** during evening hours attracts the caterpillar and kills it.

The adults of common cutworm (*Agrotis ipsilon* and *A. segetum*) and fruit borer (*Leucinodes orbonalis*) are attracted by **light and pheromone traps**.

Planting of African tall variety of **marigold** (*Tagetes erecta*) yellow and orange color as trap crop in **tomato** at 1:14 (marigold: tomato) reduces fruit borer incidence remarkably. Marigold has also the potential to attract leaf miner.

In **sweet potato** the weevil (*Cylas formicarius*) is a serious pest that can be controlled by

- removal and destruction of alternate hosts or harbouring plants, such as *Ipomoea bilota*, *Tynospora purpurea*, *T. hispida*, and previous sweet potato residues
- mulching with leaves of *Chromolaena odorata* or *Clerodendron infortunatum* (3 t ha) at 30 days after planting
- re-ridging at 50 days after planting
- putting cut sweet potato tubers as traps during 50 to 80 days after planting at 10 days intervals, always in the late afternoon, for collecting and crushing the adults next early morning
- crop rotations with rice and legumes

**Fruit fly** (*Bactrocera cucurbitae*) in **cucurbits** can be controlled by

- collection of infested fruits and dry leaves, and consequent burning in deep pits
- exposing the pupae by ploughing and turning soil after harvest
- using attractants like citronella oil, eucalyptus oil, vinegar, dextrose and lactic acid in traps
- poisoned baits (Fermented palm juice or sugar solution plus insecticide) in severe case of infestation
- using fly traps consisting of 5 g of wet fishmeal in PE bags with six small holes, and insecticide in a cotton plug put inside

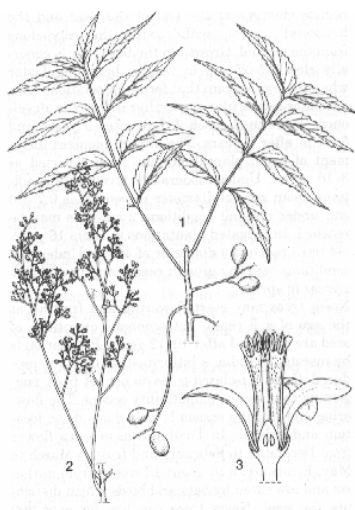
## Chapter 9

## Pest Control

Only then, when by cultural practices the increase of insect numbers to crop destroying levels due to climatic factors, e.g. can't be prevented, selective chemical control must start. But still, avoid insecticides known as broad spectrum (Folidol, e.g.), because these kill birds, spiders and mammals as well. Also, avoid use of persistent compounds e.g., but choose a product particularly effective to the actual pest. Try to use botanical pesticides whenever possible.

d) Botanical pesticides

Well known and easy to get for preparing botanical pesticides are neem, bittervine, lemon grass, *Gliricidia*, turmeric, garlic, custard apple, tobacco and marigold, also *Derris*.

1. Neem (*Azadirachta indica*)

Especially the seeds, but also leaves and bark of the tree contain several insecticidal components that repel and also kill many serious insect pests, but spider mites, bacteria, fungi and nematodes, too.

Neem oil prevents feeding and deters egg laying, inhibits growth - thus interrupting the development of insects. As neem extract is a stomach poison and less a contact poison, the effects are slower, not immediately visible, but strong and sure.

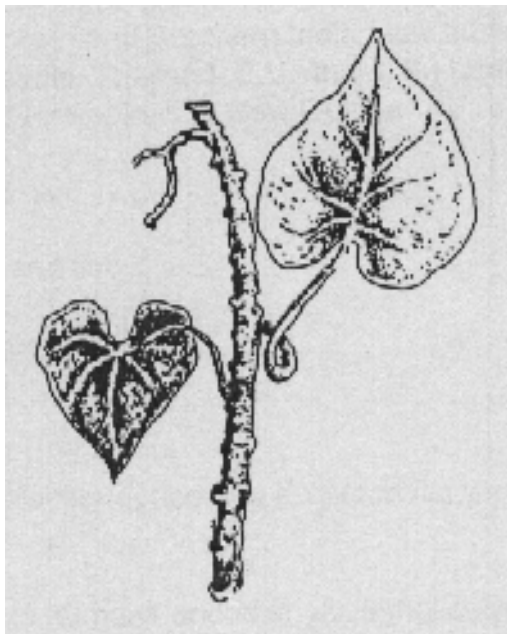
Extracts from seeds and seed kernels are more potential than from leaves, but leaves are available whole year round. Sunlight breaks the effective components gradually down, but the liquid (extracts are soluble in water and in alcohol) can be stored in the dark for 3 to 4 days without losing its insecticidal properties. Carefully dried seeds and cleaned kernels that are stored in darkness keep their killing power for more than one year.

Neem is a very useful tree to have in the farm or garden, or just around the house.

Leaves and seeds should not be eaten by humans and warm-blooded animals (toxic to rabbits and guinea pigs) but there are no hazardous effects when touching. Whole leaves are put among stored grain intended for eating. Pulverized kernels in storage are mixed with seeds for sowing. Spiders, ants and birds were reported not to be affected by neem products.

## Chapter 9

## Pest Control

2. Bittervine/Makabuhay/Boraphet (*Tinospora rumphii* or *T. crispa*)

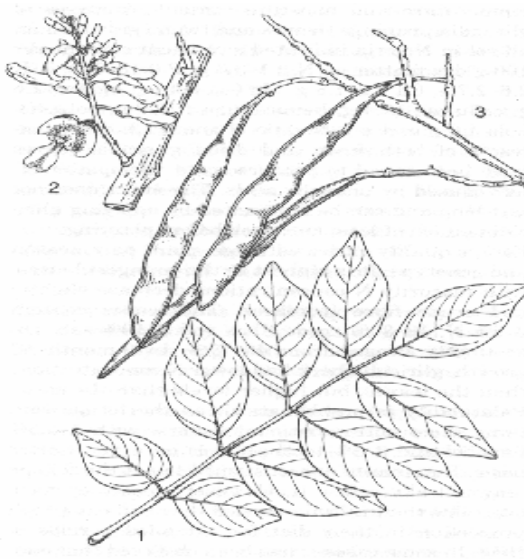
Bitter vine is systemically acting: the effective compounds are absorbed by the roots of crop plants. Vines older than 10 months have a sufficient amount of chemical substance to be used as pesticide. Chopped *Tinospora* submerged in water or soil, broadcasted in the field and aqueous extract of bitter vine are used to control stem borers, green and brown plant hopper in rice.

For root soaking chopped and pounded vine is mixed with water (1liter for 200 g), thoroughly stirred, and the seedlings soaked overnight before planting.

3. Gliricidia or Kakauati **khê noyz, kê falang** (*Gliricidia sepium*, Leguminosae)

All parts of this leguminous tree can be used for botanical insecticides. The modes of action are numerous: anti-feedant, repellent (including ticks), killing insects and rodents as a stomach poison. Reported target organisms are accordingly multiple: aphids, caseworm, coccids, caterpillars, fleas, armyworms, ticks, whorl maggot, stem borer, rodents, and termites in tea plantations.

Seeds, bark, leaves and roots may be used as a rodenticide and insecticide after fermentation. Branches are staked into rice fields, leaves are broadcasted, mulched, or pounded, extracted and diluted (1:5 to 1:7) used as a spray.



## Chapter 9

## Pest Control

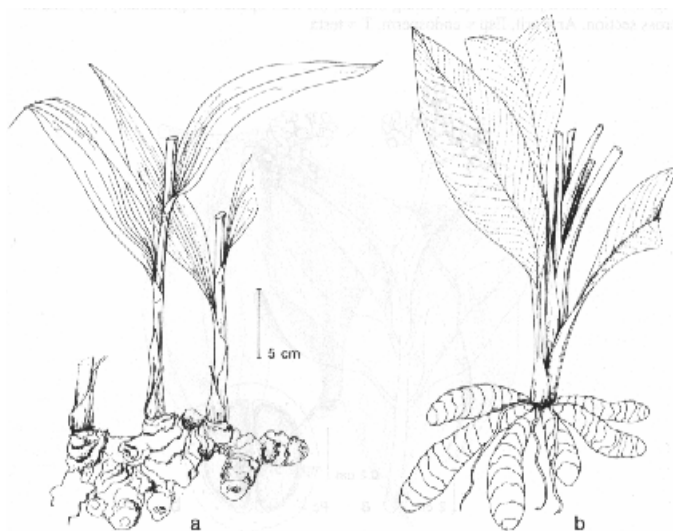
4. Turmeric (*Curcuma domestica*, Zingiberaceae)

Fig. 86. (a) *Zingiber officinale*, (b) *Curcuma longa*. Lower part of plants with rhizomes

The rhizome contains antibacterial and insect repelling and killing compounds. In vegetables, it may be used for prevention and control of diamond back moth, beet armyworm, ants and mites.

Oil of turmeric stains the skin, but so far no damage to animals is reported.

In storage, turmeric powder is mixed with rice and wheat at a ratio of 2 %. For spraying, 500 g turmeric is soaked overnight in 2 liters of water, and filtered

next morning. It is diluted 1:10 extract in water.

5. Wild ginger or Galangal (*Alpinia galanga*, Zingiberaceae, no figure)

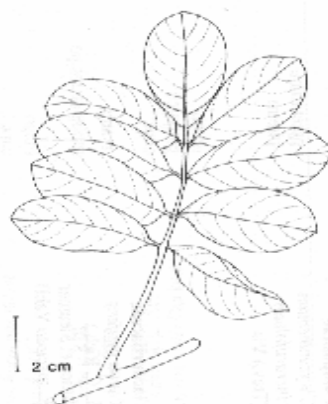
Same as turmeric, the rhizome is used to repel and kill insects, such as diamond back moth and army worm (*Spodoptera litura*). The pounded or chopped rhizome will be applied in mixture with citronella or lemon grass and neem leaves.

Soaked in vinegar, it can irritate the skin.

6. Derris (*Derris elliptica*, Leguminosae)

The roots of this woody vine contain rotenone, a contact and stomach poison, which is toxic to pigs, fish, silkworms and honeybees. But it also kills fungi, insects (moths, beetles, armyworms, fruit worms, leaf folders, etc.), spider mites and nematodes, and acts as a repellent, too. **Attention: Humans can die from drinking derris extracts!**

Constant exposure to rotenone dust is likely to result in a numb feeling in lips, tongue and throat, which may last for 2 to 4 hours.





## Chapter 9

## Pest Control

Roots of 4 to 10 mm diameter contain highest concentration of rotenone. Powdered roots are added to water (1 kg : 100 liters minimum) and also or gum, or bentonite ( a sticky clay), or commercial non-alkaline sticker or soap, for better suspension. When derris is used as dust, flour or loam may be added for easier handling.

Effectivity lasts longer under shade (2 to 3 weeks), as sunlight deteriorates the active compounds (within 5 to 7 days). All derris raw materials should be stored inside and in tightly closed containers that indicate the toxic content.

7. Marigold (*Tagetes erecta*, *T. patula*, *Compositae*, no figure)

Marigold is reported to control whiteflies very well when grown in between vegetable beds. The strong smell of the plants' leaves is repellent and probably cause of non-palatability to the pest. Marigold roots are known to „clear the soil“ from nematodes, or just to repel them.

8. Chili pepper **mak phêd** (*Capsicum annum*, *C. frutescens*, *Solanaceae*, no figure)

The insecticidal compounds are found in ripe fruits and seeds. These are ground to fine powder that is highly irritant but effective to control aphids. Grounded chilies are soaked overnight in cold water, and after filtering, the solution is sprayed onto the plants. Soap can be added, for better dispersion (or spreading) on the leaves.

9. Garlic **pak tiam** (*Allium sativum*, *Alliaceae*, no figure)

Garlic has repellent and insecticidal action when used immediately after making the watery extract: For 10 liters of water (half a knapsack sprayer) 100 cloves are steeped into 2 teaspoons of kerosene for 24 hours. 10 g of soap and half a liter of water are added and, after stirring well, the solution is filtered through a cloth. This extract is diluted in 10 liters of water.

10. Lantana (*Lantana camara*, *Verbenaceae*, no figure)

This woody weed is often used as an ornamental because of its decorative orange, bright yellow, white or pink flowers (sometimes several colors can be seen in one plant). Leaves and seeds contain insecticidal compounds.

11. Tobacco (*Nicotiana tabacum*, *Solanaceae*, no figure)

Nicotine is a powerful nerve poison extracted from the tobacco plant that kills insects by contact, when inhaled and when eaten. Nicotine does not only kill aphids, thrips and caterpillars, the eggs of moths and butterflies, it is also extremely poisonous to all livestock, and **can even kill people!**



## Chapter 9

## Pest Control

When preparing or applying a spray or dust, any contact and inhalation of nicotine must be avoided. Children and animals must be kept far from it. All vessels employed for this purpose must never be used to prepare or to store food.

Two to three days after spraying the efficiency breaks down and disappears. Afterwards the treated crops can be eaten or sold or fed.

Aphids die by contact with the spray. But sap sucking soon after they don't die, because nicotine is found only in the water carrying xylem cells, not in the sugar carrying phloem cells!

### 12. Custard apple and Soursop **khan thalot, khièp thét (Kiang falang)**

(*Annona squamosa* and *A. muricata*, *Annonaceae*)

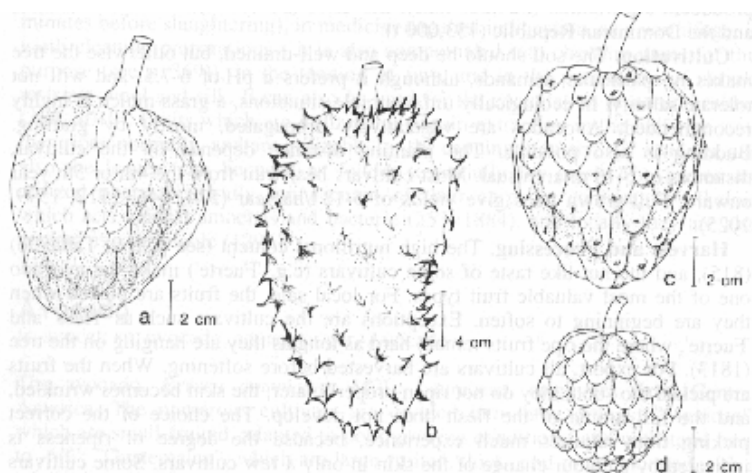


Fig. 46. *Annona* species. (a) *A. reticulata*, (b) *A. muricata*, (c) *A. cherimola*, (d) *A. squamosa*

All parts of these common fruit trees contain insecticides, except the ripe fruits.

### 13. Lemon grass and citronella grass (*Cymbopogon citratus*, *C. nardus*, *Graminae*, no figure)

Lemon grass and citronella grass are found to be repellents and insecticides, and used in several mixtures.

Other insecticidal plants reported from Asian countries are:

- Chinese Yam (*Pachyrhizus erosus*, *Leguminosae*)
- **Non dai yang** (*Stemona tuberosa*, *Roxburghiaceae*)
- Purging Croton, Maksala (*Croton tiglium*, *Euphorbiaceae*)
- Sapsya (*Eupatorium odoratum*, *Compositae*)
- Thundergod vine (*Tripterygium wilfordii*, *Celastraceae*)

## Chapter 9

## Pest Control

In the following are given several „recipes“ which may be useful, and inspire the fruit and vegetable growers to experiment with own resources on themselves.

Diamond back moth (*Plutella xylostella*), large cabbage worm (*Pteris brassicae*), common cutworm (*Agrotis segetum*), groundnut aphid (*Aphis craccivora*), cabbage semi-looper (*Trichoplusia ni*) and cabbage flea beetle (*Phyllotreta sp.*) may be controlled by any of the indicated methods.

**Method I**

Gliricidia leaves	5 kg
neem leaves	5 kg
lemon grass	2 kg
custard apple leaves	2 kg
washing powder	100 g
lime	5 kg

Mix the lime with 40 liters of water and leave to settle. Pound the leaves and the lemon grass together and add to the lime solution. Leave for about 24 hours and then filter. Boil the soap and then mix it all.

Dilute with water (1 liter of solution: 3 liters of water) and then spray it in the morning and evening for 3 days. If the pest is still numerous repeat treatment after 7 days.

**Method II**

Tobacco	1 kg
water	20 liters
soap	100 g

Boil the tobacco in 20 liters of water and then leave to cool. Boil the soap separately and then mix together. Before use, dilute 3 liters of concentrate solution with 14 liters of water. Spray in the evening.

**Method III**

mature fresh neem leaves	2 kg
galanga rhizome	2 kg
mature leaves of citronella grass	2 kg

Grind the three ingredients together, and then soak in a pale of water (20 liters) overnight. The next morning strain the refuse out of the concentrate solution and dilute 1 liter of solution with 20 liters of water. Spray immediately after preparation for maximum effectiveness. The solution may be more concentrated if infestation is high. More neem leaf may be used and soap can be added as a sticker.

## Chapter 9

## Pest Control

This preparation controls aphids, scale insects, mealy bugs, thrips, red spider mites, leafhoppers, leaf miners and army worm. It does not harm predators and parasites or birds and fish, not the ecological system as a whole, neither producers nor consumers. It is vulnerable to sunlight and thus effective for only 5 to 7 days in fruit and vegetables.

**Method IV**

Bittervine	5 kg
Gliricidia	25 kg
chili	1 kg
tobacco	10 kg
citronella grass	25 kg

Ferment all these ingredients in a drum of water (200 l) for 1 month. Dilute (1 liter of stock: 20 to 23 liters of water) before use.

**Method V**

Neem seeds finely ground or pounded 2kg

The pounded seeds are soaked in 16 to 20 liters of water for one or two nights. After filtering, dilute 1 liter of extract with 10 to 20 liters of water. This solution is ready to be sprayed every 7 days preventatively or when infestation occurs.

**Summary**

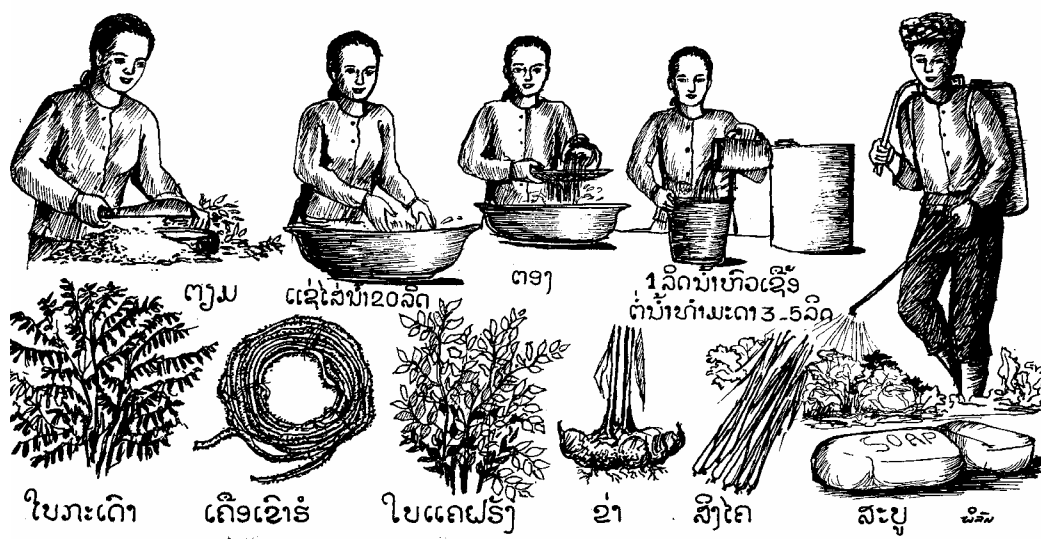
Botanical pesticides must always be applied before the pests get established as they are slower acting than chemical pesticides.

Due to their sensitivity to sunlight and (in some cases) to oxygen botanical pesticides need to be stored (if necessary) in a cool and dark place, out of reach of children.

Several of the mentioned insecticidal plants are well known medicinal plants, too. They contain up to 15 % natural chemical substances to protect themselves. Those substances must not be toxic, but they protect the plant by stopping the pest to eat it (non-palatability), by repelling it, by altering the life cycle of the pest or making it sterile. However, some substances actually kill pests by contact or after having eaten the plant and some do additionally defend from fungal attack. The overall advantages of botanical pesticides are:

- to get good safe and healthy products, without persistent detrimental substances for the producer's and the consumer's health
- (in most cases) safe use and availability for the grower
- (in general) no burden for the environment, which otherwise might be caused by poisonous and persistent residues that get into the soil, air, or water courses, and
- usually no harm to beneficial organisms

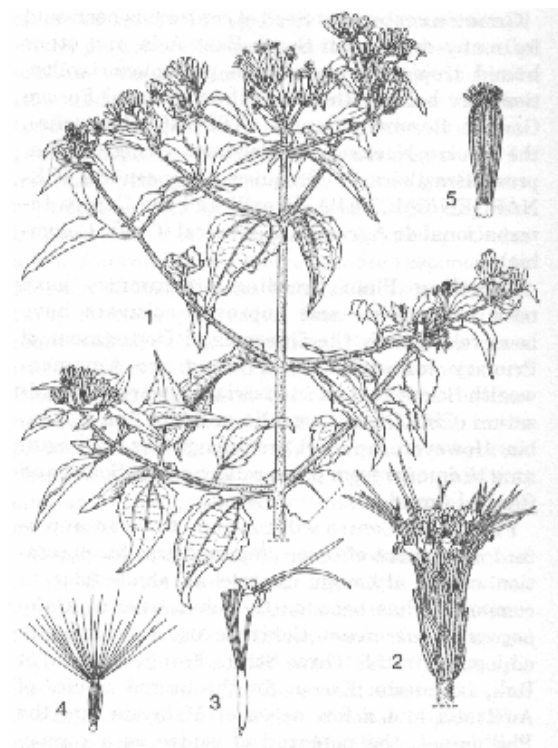
## ຢາສະມຸນໄພປາບສັດຕູພືດ



## Chapter 9

## Weeds

Sometimes it is not easy to classify plants or other organisms correctly, as in the case of **Siam weed**, hnhaaz falang, *Chromolaena odorata*.



While on one hand it is considered one of the most noxious weeds in agriculture and pasture management, on the other hand Siam weed is regarded as a most useful fallow crop and recommended for the control of *Imperata cylindrica*. It is also used for a very good mulch and green manure, and even as botanical pesticide and medicinal plant.

In terms of plant protection, *Chromolaena* has been reported to be useful to control the weevil *Cylas formicarius* and the butterfly *Phthorimae operculella* in sweet potato, the nematode *Heterodera marioni* in black pepper, and other nematodes in sugar cane and tomato.

Normally, those plants growing where and when **not desired**, are called weeds. In some agricultural areas and crops weeds cause worse problems than pests (following slash and Burn, e.g.).

Due to characteristic survival mechanisms and adaptations they are able to exist also under unfavorable conditions. The continuous production of seeds, and - often additionally - of strong rhizomes, or tubers, or runners enable weeds to disseminate very effectively and numerously. In many cases, their seeds and vegetative propagation organs resist adverse conditions by dormancy, too.

Weeds are well adapted to their habitat, and do often **indicate** certain characteristics of site (stony underground, salinity, occurrence of water logging, fertile soils, etc.). Very fast they invade and cover areas where conditions changed by logging, burning, floods, etc. But in permanently cultivated and somehow balanced fields weeds don't get easily the chance of superior dissemination.

However, there are many ways to **spread** weed seeds. They can be mixed with crop seeds, feed grains and straw, or be carried on feet, fur or cloths. Some seeds must be eaten and in-

## Chapter 9

## Weeds

gested by animals, and may be taken far by birds and rodents. Mechanisms such as hooks, barbs, spines or special coatings help to be carried by wind and water.

There are **annual weeds** that complete their life cycle within one year or season. They reproduce mainly by abundant seeds.

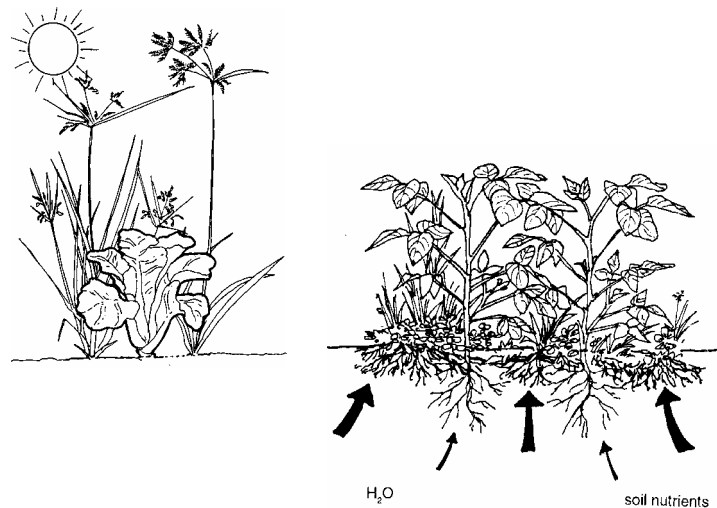
**Biennials** establish their stem, leaves and storage organs, while in the second year (or period) fruits and seeds are produced. During the first stage or period they can be easier controlled.

**Perennials** continue to live for many years, because they possess food storing vegetative organs. Those are difficult to control, unless the favorable conditions radically change.

Weeds can be distinguished also by their phenotype as broadleaved, grasses and sedges, which often have triangular stems and leaves arranged in rosette form.

Weeds **compete** with crop plants for nutrients, water and light, and this competition reduce yield and quality of horticultural products. In general, weeds are more competitive than cultivated crops are, and that is why weeds must be controlled in the „critical period“ to avoid economical losses.

The time of weed removal is as important as the removal itself. Usually, the sooner the weeds are removed, the better.



## Chapter 9

## Weeds

For most vegetable crops - and generally this is true for fruit crops, too - the critical weed-competition period is the first third of the crop life cycle. Seedlings are transplanted to reduce it, and to give them an advantage over the weeds.

Another reason why to control weeds in and around crop plantations is the fact that many weeds also harbor crop damaging insects and plant pathogens.

But, the grower must observe and know which weeds in particular attract pests and which don't. Generally, natural enemies or „biological agents“ are more abundant and diverse in weedy fields, as they are attracted by their preys. Some weeds can be used as trap plants for insect pests and nematodes (e.g., common purslane *Portulaca oleracea*, and tropic ageratum, *Ageratum conyzoides*). However, hosts of virus diseases, such as horse purslane (*Thrianthema portulacastrum*) and spiny amaranth (*Amaranthus spinosus*) which harbor the tobacco mosaic virus should not be tolerated near to solanaceous crops (tobacco, tomato, potato, eggplants).



Following some guiding principles, weed control may systematically and successfully be implemented:

1. Don't aim to eradicate weeds, but rather to decrease to a tolerable density without losses in crop yields.
2. Control weeds particularly during the first days and weeks of the crop life cycle, and continue until the crop can effectively compete with weeds.

## Chapter 9

## Weeds

3. Control weeds before flowering, and avoid definitely that they shed seeds. That may be done by frequent slashing down. Be aware of still unripe seed clumps, they may ripen and germinate, although separated from the plant.
4. Focus control methods on runners, rhizomes and layers as well as on inflorescences. Be aware that some weeds can be fairly reduced by continuous cutting off their vegetative propagation organs, while others respond with heavier growing. Some seeds need the heat of fire for germination, and many weeds withstand burning easily. Some are best controlled by covering them with mulch as they are sensitive to light shortage, others by frequent hoeing.
5. Use planting materials free from weed seeds, clean weeding implements after finishing one plot, prevent spread of weeds through irrigation channels, machines (tires) and shoes.

Weed control methodsa) **Mechanical methods**

- Hand pulling is labor intensive but very effective, as long as weeds don't shed seeds, and conditions are not too wet. Within crop rows it is recommended, to avoid damage by tools and implements.
- Shallow hoeing from the beginning keeps crops clean. Use sunny days, so that the weeds dry off quickly, otherwise it is better to remove them from the field.
- Cultivation with animal- or tractor-drawn implements makes sense in bigger areas and within wide stands of crop plants, as roots and stems otherwise get damaged easily.
- Mulching with organic matter is effective in controlling weeds if the layer is reasonably thick and dense, but pervious to air. Mulching conserves soil moisture, adds nutrients to the soil and reduces fruit rot in some vegetables and fruit (cucumber, tomato, strawberry, e.g.). In rainy season, mulching with plastic cover is effective and useful (see chapter 8).

b) **Cultural methods** are given with

- thorough land preparation with implements and tools, when the soil is neither very wet nor very dry,
- multiple cropping (see chapter 3),
- closer spacing within rows, and
- use of well adapted and competitive species and cultivars.

c) **Chemical control** is done with herbicides that kill weeds. There are moderately environmentally friendly herbicides, such as glyphosates, available. Selective herbicides that – de



## Chapter 9

## Weeds

pending on the crop plants! - control of broadleaved, or grassy weeds should always be given priority, as non-selective herbicides are toxic to all plants.

The action and effectiveness of herbicides depends on many factors: Age, morphology or constitution of the plants, kinds of absorption and translocation, and physiological processes do all influence.

Furthermore, many factors related to the soil such as microorganisms, soil type, temperature, moisture, etc. determinate the effectiveness of herbicides.

There are several kinds or types of chemicals: **Contact herbicides** with acute effect, mainly against annual weeds, while perennials get only their tops burnt.

**Growth regulators** act systematically, leading to a more gradual decay. These chemicals do imbalance plant growth and metabolic processes.

Most herbicides are emulsions, wettable powders or granules.

Emulsions appear often milk and are easy to spray, after having mixed and stirred thoroughly.

Wettable powders are finely divided solid particles dispersed in liquid (water or oil-like substances, i.e.) that require agitation before and during spraying.

Granules need carriers such as sand, clay or finely ground plant parts. Water and spray equipment are not needed, and granules fall off the leaves easily (when dry), but they are bulky and difficult to apply uniformly.

d) A **combined management approach** makes best use of the different weed control methods during the whole cropping period. An integrated approach may include

- sanitation as one of the most important preventative measures,
- proper and thorough land preparation,
- application of pre-emergence herbicide (if available),
- repeated hand weeding or mechanical weeding in short intervals when crop plants have been sown or transplanted, but latest after 30 days; application of post-emergence selective herbicide,
- cultivation in two main operations: off-barring (removing soil from the row) followed by hilling-up (throwing soil towards the base of the plants), with timing depending on weed growth,
- hand-weeding within the crop rows.

## CHAPTER 10

## Irrigation

Water management consists in irrigation and drainage, in order to get a balanced water supply for the crop plant. Especially leafy and shallow-rooted vegetables need always sufficient water to keep them tight and erect. On the other hand, they are delicate and sensitive to excessive water, causing root and leaf rots, e.g.

Lao PDR has a marked wet season, and a cool and hot dry season. Some vegetables such as yardlong bean, winged bean, morning glory and kale are fairly well adapted to and easy to grow in rainy season. But for most vegetable species the dry season provides much better conditions: If irrigation water is available, all tropically adapted cultivars can be grown.

Some fruit trees such as lychee show distinct reaction to watering at certain stages. Without irrigation during dry season lychee trees don't produce flowers, even less fruit.

Irrigation**Why** has to be watered

The final product of horticultural effort is in most cases a juicy fruit, or tuber, or fresh leaves and stem (exceptions are nuts or seed kernels). The high water content of generally more than 90 % in vegetables is characteristic. That means, that water and a good water management in particular determine the weight and yield and quality of vegetables and fruits. Fresh tender and crispy products sell better!

The inner pressure (turgor) is hold by constant water flow through the plant, carrying nutrients into leaves and blossoms, and is regulated by the stomata to avoid excessive water losses by transpiration. Irrigation water is cooling down the temperature of the leaves' surface, as naturally caused by dew, mist and rain.

**When** has to be watered

Much depends on the „wright feeling“, on the most favorable timing for watering. Generally, every time the soil is dry, it needs to be watered. This can be checked easily by simple hand proof. Get a handful of soil, squeeze it fairly hard and then open your hand: If the soil crumbles there is need to water; whether a ball with wet outline is formed, there is no need to irrigate.

Another indicator is the sunflower: As soon as the leaves get limp there is need to water. In some crop plants it is difficult to see and almost too late, when they do show signs of water stress. When this happens normal physiological processes have been interrupted or disturbed already, and damages can be seen in consequence.

After sowing, after pricking or thinning, and after transplanting irrigation is „a must“/essential.

Watering should **not** be done

- just after weeding within the crop (weeds shall dry off)

## CHAPTER 10

## Irrigation

- when sunshine is very strong around midday, because water drops may stand and cause burning
- spots in leaves and fruit, and when transpiration rate is very high
- too late in the evening, so that plants can't dry up
- when soil and air are saturated with water

**How much and how often** has to be watered

Crop plants having shallow root systems, such as cabbage, morning glory, lettuce, spring onion, e.g., need to be watered more often, steady but light.

Deeper-rooting vegetables like tomato, eggplant, chili and melon have access to water at lower levels, too. In fact, they may be watered less frequently but more heavily.

Sandy soils have to be watered more often because of their poor water holding capacity. Clayey soils generally need less frequent watering, as they hold water in their numerous small gaps. But certain amount of water is stored that tight, that it is not available to plant roots.

The amount of water to be irrigated should be enough to cover the real consumption of the crop, and additionally the water which is „wasted“, depending on the efficiency of the irrigation method.

The **consumptive use** varies during the cropping season and is usually highest near to flowering stage. Weather conditions, irrigation practices, development stage of the crop, soil conditions and site properties, and many other factors influence the actual consumption rate.

Weather: High temperature, wind and sunshine rise the transpiration rate, cool and damp weather decrease it.

Stage: During vegetative growth, the building process is accelerated, nutrients and assimilates are passed through the plant; after flowering gradual decomposition takes place, and less water is transferred.

Position: Solitary and marginally growing plants are more exposed to wind and sun; they need to be watered relatively more or more often compared to plants within the field.

Watering: is a special skill and must be learnt by experience and observation, how the plants react.

**How** watering should be done

In dry season vegetables are watered in the morning and in the afternoon, by overhead irrigation or „artificial rain“. This cools temperature on leaves' surfaces down.

In rainy season, leaves of all species sensitive to fungus must not be moistened. It can be avoided through watering below the leaves, with hose or watering can **without nozzles**. This

## CHAPTER 10

## Irrigation

is especially true for crops under plastic protection. Care must be taken to draw off all excessive water.

Watering of seedbeds and seedlings after transplanting has to be done very carefully to prevent splashing up and washing out the soil. A **fine nozzle** hold that way, that allows the water falling in a gentle bow is recommended.

**With what** watering is carried out

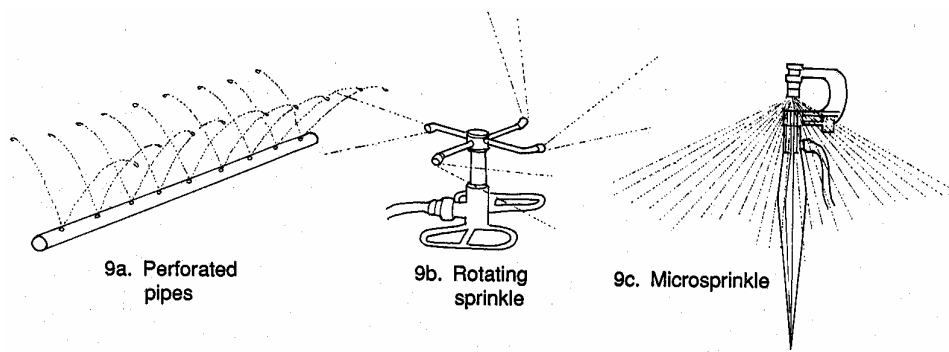
Basically, there are two different methods given: Overhead and surface irrigation. The choice of one of these depends on different factors, such as kind(s) of prevalent crop(s), soil type, topographic conditions, water source, etc.

In small areas and in young stands of fruit trees the **watering can** is an appropriate implement. If conditions are favorable to use a **hose** (tap water, well pump) watering can be done much easier. The hose should be of strong but flexible and colored material. Transparent plastic favors undesirable algae to grow in the tube.

At the edges of each bed wooden or metal stalks are stuck / put into the ground (about 20 cm above ground, 20 cm below) to keep the hose on the path during watering or when moving the hose.

In bigger and more prosperous farms, where labor is short and facilities are given, there are several options for mechanizing irrigation of crop plants.

**Mechanized overhead irrigation** includes perforated pipes, rotating sprinkles and micro sprinkles in fix or moving systems.



While perforated pipes and micro sprinkles are more static, rotating sprinkles can be handled very flexibly and therefore preferred in vegetable production. Their nozzles are relatively large, and thus not really appropriate for seedbeds; but water can be applied at a quite slow rate which is desirable in heavy soils. Big nozzles permit the use of water containing silt and other particles.

## CHAPTER 10

## Irrigation

**Sprinkler irrigation is favorable where / when**

- crops, such as bulbs or leafy vegetables, are grown that require light and frequent irrigation,
- very closely spaced crops are grown,
- topography prevents proper leveling for surface irrigation,
- on steep slopes erosion might be caused by surface irrigation,
- sandy or porous soils cause water losses (through percolation),
- temperature during hot days needs to be reduced to improve quality and yield of some crops,
- easy application of fertilizer and pesticides is intended,
- frost is a problem.

**Surface irrigation** is the better option for vegetables that withstand less frequent but heavier watering without problems, such as solanaceous crops, legumes and cucurbits. In the opposite, these are sensitive to diseases that prefer moist conditions.

Where water is abundant, and the soil surface and texture are appropriate, **furrow irrigation** may be used, if the terrain is plain. Small rills or **corrugation method** (rills and depressions altering in close distances) is appropriate for closely spaced crops, on slopes of up to 8% and for fine-textured soils with low water-intake rate.

Where water has to be saved **drip irrigation** supplies water just there where it is needed - close to the crop plant. So-called emitters are holes in a plastic hose that gradually release water wetting only small areas in the rooting zone. As stem and foliage are kept dry spread of diseases is prevented. Water logging, causing root problems can be avoided by controlled water release.

Weed seeds get little chances to spread and emerge.

Water is distributed uniformly, and fertilizer or systemic pesticides can easily be applied by the system.

The high initial costs can gradually be saved by reducing labor costs for irrigation, weeding and other operations, and by decreasing material costs of water, fertilizer and pesticides.

A drip irrigation system can be run by gravity flow, but a filter must be included, if the water source is not very clean.

**Irrigation water** must not damage crop plants, neither by high salt content, nor elevated sodium concentration, nor by toxic components, such as boron, e.g.

Crop plants' tolerance to salinity, alkalinity and certain chemical elements are different, and also vary within a life cycle.

When doubts about the quality do exist, irrigation water has to be analyzed.

## CHAPTER 10

## Drainage

Growing vegetables or fruit trees in waterlogged or poor drained soils results in root damages, weak growth, disease and pest problems, and probably plant death in the end. When due to bad soil conditions mechanical operations and treatments cannot be done in time, secondary problems such as rising water table and presence of soluble salts harmful to plant roots, may come up.

Properly drainage makes soil warm up quicker, permitting earlier planting and better germination. The effective root-zone depth is increased, and excessive noxious salts can be leached by good subsurface drainage.

**Surface drainage** means to collect, and to dispose excessive water via furrows and channels leading to a reservoir. Drainage ditches remove the run-off of ordinary rains to prevent damages in fields and crops.

Where precipitation (rain water), irrigation and leaching water, and / or seepage from higher areas cause a high water table in the ground, additional **subsurface drainage** might be necessary.

Drainage with stones, brushwood, ceramic tiles, plastic or bamboo perforated poles put about 60 cm deep into the ground is expensive and labor intensive, but does definitely improve soil conditions, if well done.

The design - distribution of drainage ditches, distances between ditches, material of drain core, etc. - depends on topography, size of cultivation area, soil type, and very much on the knowledge and skills of the grower.

The investment is justified in that case, that price and quality of the product(s) do obviously improve.

Important issues to keep in mind

- Don't waste, but save water!
- Prevent and avoid all kinds of water pollution!
- Collect and store rain water in reservoirs - from the roof of your house in drums or pits, e.g.!
- Recycle water! Use washing water for watering your garden - it contains lots of nutrients!
- Protect and conserve water catchments areas, respect their importance for people and wildlife!

## CHAPTER 11

## Reasons for Damages and Yield Losses

Crop production ends with harvesting the crop, and all efforts, time and money spent on producing a crop may be wasted, if harvesting itself and post-harvest handling are not done carefully. Vegetables and fresh fruits are very perishable products. To a big extent, post harvest losses are due to mechanical damages, caused by rough and careless picking, packing, loading and unloading.

Cutting with blunt or damaged knife, leaving stalks long enough to injure other fruits, putting commodities too close, etc., causes cracks, splits, punctures, bruises, distortions and abrasions - all these give entrance to microorganisms provoking rots.

Harvesting wet fruits and vegetables should be avoided, since moist and hot conditions of packed or piled-up products do favor rotting even more.

Ways from the field or garden to the kitchen or market should be as short as possible, since changes in physiological processes - or just ripening processes - result in losses of weight and quality. Once the fruit, stem, leaf or root is harvested, it is not supplied with water and nutrients any more, and the reserves end up quickly, as respiration („breathing“, or consuming food reserves) is going on (see table next page).

**Respiration** is particularly high in fast growing plants - such as asparagus and mushrooms - and growing plant parts, like flower buds (broccoli), immature fruits (baby corn) and developing seeds (peas). Whereas storage organs like potatoes, carrots, onions, and garlic do have food reserves and, thus a slowed down respiration.

Fruits and leafy vegetables, in general, have longer post harvest life than growing plant parts, but less than storage organs.

Well balanced supply of water, nutrients and light, and control of pests, diseases and weeds - that is **good production practices** - is the **best guarantee to get good products with greater reserves**.

## CHAPTER 11

## Reasons for Damages and Yield Losses

Maturity indices of vegetable crops

**Root, bulb and tuber crops**

Radish and carrot	Large enough and crispy (over mature if pithy)
Potato, onion, and garlic	Tops beginning to dry out and topple down
Yam bean and ginger	Large enough (over mature if tough and fibrous)
Green onion	Leaves at their broadest and longest stage

**Fruit vegetables**

Cowpea, yard-long bean, snap bean, sweet pea, winged bean	Well-filled pods that snap readily
Lima bean and pigeon pea	Well-filled pods beginning to lose their greenness
Okra	Desirable size reached and tips snapping readily
Snake gourd, dishrag gourd	Desirable size reached and thumbnail can still penetrate flesh readily (if not possible over mature already)
Eggplant, bitter melon, chayote or slicing cucumber	Desirable size reached but still tender (over mature if color dulls or changes and seeds are tough)
Sweet corn	Exudes milky sap when thumbnail penetrates kernel
Tomato	Seeds slipping when fruit is cut, green color turning pink
Sweet pepper	Deep green color turning dull or red
Musk melon	Easily separated from vine with a slight twist leaving clean cavity
Honeydew melon	Change in fruit color from a slight greenish white to cream, aroma noticeable
Watermelon	Color of lower part turning creamy yellow, dull hollow sound when thumped

**Flower vegetables**

Cauliflower	Curd compact (over mature if flower cluster elongate and become loose)
Broccoli	Bud cluster compact (over mature if loose)

**Leafy vegetables**

Lettuce, pechay	Big enough before flowering unless flowers are desired
Cabbage	Head compact (over mature if head cracks)
Celery	Big enough before it becomes pithy



## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

Respiration, transpiration (emission of water), and ongoing ripening processes such as sprouting, elongation and seed germination of already harvested products must be slowed down. To keep the commodity fresh and desirable, the **environmental conditions must be favorable**:

- Low temperature reduces respiration, transpiration, growth of microorganisms and insects. During respiration, oxygen is used up, and water, carbon dioxide and heat are produced. If the heat cannot escape (by good ventilation, i.e.), it increases faster and destroys the product very quickly.
- High relative humidity (moisture of the surrounding air) prevents shriveling and wilting in fleshy fruits and storage organs, and leafy vegetables. (Grains pulses and seeds require dry storage of less than 15 % relative humidity).
- Low content of gases which provoke faster ripening and deterioration (ethylene and acetylene - both are given off from ripening fruits, from injured fruits and vegetables, from some leaves, smoke and exhaust gases of vehicles) is reachable through consequent hygiene and separation of different ripening stages, and by avoiding air pollution during storage and transport.
- Absence of microorganisms, rodents and insects, as these feed on fruits and vegetables, causing mechanical damages and rots, and spoil the commodities with excrements.

**Post harvest losses are considerably high** and do occur from harvest through collection, transport, storage and distribution to the final purchaser.

Producers must be aware that such losses - at least big part of them! - can be prevented.

There are quite a few **techniques for reducing post harvest losses**, which are

1. producing good quality fruits and vegetables from the beginning:

- choosing varieties, that are tasty, well adapted to the site, comprising the characteristics wanted by the consumer (...but not only high yielding),
- avoiding adverse conditions, such as heat, competition, water shortage, etc., and
- trying to execute best cultural management: Well cared crops give better quality products!

2. proper harvesting:

- picking at right stage of maturity, that is when fruits or vegetables developed the size, or shape, or color, softness or texture preferred by the consumer. Harvesting „just in time“ is very important to prevent yellowing, softening, sprouting, rotting, pithiness or toughening. Not only the commercial value, but also the nutritive value of vegetable and fruits is decreasing very soon after the most convenient picking stage. Decaying,

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

- yellowing, wilting and shriveling commodities are more sensitive to secondary damage, and easily affect further products. On the other hand, prematurely harvested fruits don't ripen any more, and don't develop neither size nor taste of a ripe fruit.
- picking properly means, for example, to use a knife or scissors instead of pulling, twisting or bending the fruits or vegetables. Not only the commodity itself may be affected by squeezing, cracking or splitting, but the whole plant and further cropping as well. The use of tools implies to keep them sharp and clean!
- picking at the most appropriate time of the day is important for some products. Leafy vegetables and cucumbers, e.g., are less brittle and thus, more resistant to injuries when harvested in the late morning or afternoon. Sweet corn, peas, etc. lose their sweetness with rising temperatures, and are best harvested in the early morning. In general, fruits and vegetables should dry up after rain and dew, before they are piled up and packaged.

3. avoiding physical damages:

- products must be handled carefully, and
- workers should be trained, not to throw, step on or sit on, and not to pack commodities by force very close. Sometimes damages caused by bouncing, dropping and throwing cannot be seen immediately; also those induced by weight or pressure of containers or other surrounding commodities may be hidden for a while. Careless handling provokes rapid deterioration of injured products, and at least, less attractive appearance to the buyer.

4. trimming, that is removing those plant parts, that are not needed, and not desired:

- trimming of leaves reduces water losses in carrots, radish and cauliflower,
- „topping“ of still green leaves at 2-3 cm above the neck prevents microbial growth in onion and garlic,
- trimming cabbage and corn leaves reduces weight and volume, but 2 to 3 wrapper leaves should be left to protect the product from bruises and lesions during transport.

5. sorting out those products, which are damaged, discolored and obviously diseased.

- A whole load may get ruined because one or few infected fruits or vegetables remained among the sound ones and spoilt them. Whenever products are brought from one place to another, sorting out bad ones is obligatory.

6. proper packaging, that has two main aspects:

- to use appropriate containers; the ideal container is, depending on the product, light but strong to resist mechanical damages, is easy to handle, cheap and made of

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

locally available material. Straw, banana leaves or paper provide protection from sharp edges and sides, and from bruising.

- to use the best packing method, which is closely related to the applied container, because using **no** container is a very insufficient method. Shallow and easy stacking containers are required for one or few layers of delicate fruits or vegetables. Products can be presented more favorably, and strength of material can be less than in big and deep containers. The more the products are moved (packed in and out) the more they suffer from mechanical damage. Hygienic handling is essential for food stuffs!

7. safe and fast transportation:

- to prevent heating and thus, faster deterioration, transport should be executed during the coolest hours of the day, or during night time. Under, around and above each container has to be left space for ventilation.
- fastening of the containers in / on the vehicle is essential to secure the goods from bouncing around and causing unnecessary damages.
- adequate protection from rain and sunlight must be provided.
- room for passengers and baggage must be separate and clearly divided from store room of commodities, to prevent them from extra pressure, weight and pushes.

8. Favorable storage conditions, to extend the lifespan of products when they can't be consumed or sold immediately, and to get over times of scarcity on the market, which means more profit (but also more labor) for the producer.

Since refrigerated storage will always be the best, but exceptional method to keep products fresh and pleasant, simpler and cheaper but effective alternatives are the following:

a) Delayed harvest and in-ground storage for potatoes, sweet potato, taro, cassava and yam during dry season may be viable, as long as the occupied land is not needed for other crops. To prevent rotting in cassava, all foliage is pruned 1-4 weeks before the intended harvest, and a stalk of approx. 20 cm is left.

b) Clamp storage in pits or trenches in the soil is useful in cool and temperate zones for vegetables such as potatoes, carrots and cabbages, and for fruits like pears and apples. The sound and cool products are put carefully into the hole (carrots can be stored in washed moist sand, also) and covered with dried straw and a layer of soil on top.

(Potatoes should always be stored in the dark to prevent greening, because these green parts are bad for humans' health and must be cut off before boiling or frying.)

For bigger amounts ventilators should be inserted (see below [e]) ).

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

c) Adequate construction of store rooms and silos include a roof big and far enough to protect at all times the walls from full sunlight. This is important to lower the actual inside temperature and especially the differences in day and night temperature, as those raise the risk of local heating. Hot spots cause condensation in other cooler spots which consequently lead to fungus growth. White paint or white wash reflect sunlight, and insulating materials such as mud brick, straw and cardboard help to balance temperature changes.

A well-made overhanging roof protects from rain, but contact with moisture from the ground can be prevented by additionally placed bricks or wooden poles, or even racks made of timber or bamboo. There should be also some distance between the stored goods and the walls, which may be permeable to water and mist.

d) Evaporative cooling is particularly important for easily wilting, shriveling or softening vegetables and fruits under dry (and hot or windy) conditions:

- Sprinkling commodities, floor and walls with water from time to time,
- keeping products in moist earthen jars,
- putting open containers filled with water, and
- cooling by passing air through wet and water absorbing materials, such as jute sacks or charcoal, are helpful, where small quantities need to be stored and where water is not lacking.

e) Storing in plastic bags is an easy way to keep some fruits and vegetables fresh for a couple of days, even if temperature is high. Green leafy vegetables i.e. require some light to prevent yellowing. PE bags allow the accumulation of carbon dioxide, and high - not easily reached! - concentrations of this gas may cause injuries in the commodities (brown stain in lettuce, e.g.), bad odor and flavor. Small amounts of this gas make storage in low temperature even more effective, but a few perforations should be done for better ventilation.

f) Providing good ventilation is very important to control gases that are responsible for ripening and deterioration of fresh products, mainly oxygen and ethylene. Ethylene is emitted by ripening fruits, that's why ripening fruits never should be mixed or stored together with leafy vegetables, green fruits, tubers and bulbs!

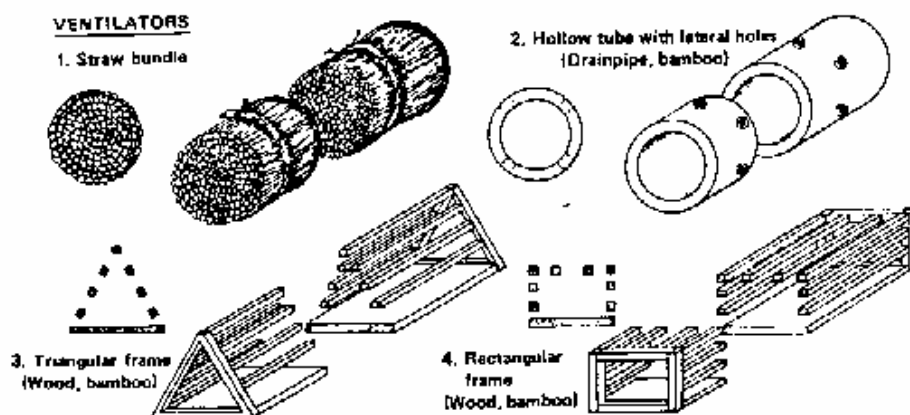
Hot air must be emitted for the reasons discussed above; that's why continuous exchange of air should be facilitated.

- Containers have to be placed not too close to allow air flow at all times. For example, rectangular boxes can be placed in a quadratic shape that leaves an open space in center for air circulation.
- All containers should be put onto pallets or similar frames to get air flow underneath.

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

- Baskets may be better than using deep containers with solid walls. Shallow boxes with stump support/pillars can be stapled and allow good ventilation.
- Ventilators or air ducts made of wood or bamboo in triangular or rectangular frames should be inserted into pits or big containers, especially if filled with loose produces. (Otherwise the recommendations mentioned before should be followed.) Alternatively, straw bundles or hollow tubes with lateral holes made of drainpipe or bamboo may be used.



g) On the other hand additional or fast ripening may be desired in storage. When natural ripening processes shall be accelerated to get better prices, e.g., then

- ripening fruits (such as banana, passion fruit, tomato) are put together with still unripe fruits (particularly in tomatoes), for about two days
- smoke of joss sticks or other slow-burning materials may be used for small quantities,
- ethylene-releasing leaves (i.e. of *Gliricidia sepium*) are inserted in enclosed containers together with the commodity.

h) Cleanliness and hygiene in all procedures and areas is essential to get sound products and a good price in the end. Clean and neat fruits and vegetables, presented in a tidy way are much more appealing than those covered with soil, bruises, spots, etc., packed in dirty boxes or baskets, and all - big, small, ripe and immature, diseased or injured - mixed up.

- Picking must be done with care and clean hands, tools and containers. Whenever possible, bad rainy weather should be avoided for harvesting.
- Containers, tools and implements, vehicles, storage, and packing areas should be cleaned with hot water or water plus detergent, or household bleach before re-using.
- Produces must be washed with water after harvest to remove microorganisms from the surface, and to give them a pleasant appearance. (**Exceptions** are root and bulb

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

crops which must **not** be washed until to be sold to the final consumer, since washing hastens sprouting and rotting.) One to two tablespoons of bleach for cloths may be added to 20 liter of washing water, if decay due to particular rot organisms is likely to happen.

- For packaging, transport and storage the commodities must be superficially dry to prevent growth of microorganisms. This may be supported by using a fan or natural wind.
- Abrupt transfer from a cold to a warm environment results in sweating, or condensation of water on the surface of the commodity which should be avoided (see above!).
- Sorting products and taking any diseased fruit or vegetable away has to be done to minimize contamination. Diseased products must not lay around, but have to be burnt or buried consequently.
- High temperature together with high humidity will favor fast growth and multiplication of harmful microorganisms - hot and moist post harvest conditions must be avoided!
- Just after harvesting, non-diseased cabbages are treated preventively against bacteria by pressing their butts into lime powder spread on a flat surface. Lime serves as physical barrier against the disease organisms.
- „Curing“ is a special treatment to make tubers more suitable for storage. For few days or up to two weeks are stored under very warm and very humid conditions to form a layer of cork cells which protects them from desiccation (drying) and largely from diseases. The tubers are put outside in the sun, but protected from full sunshine by a cover of banana or other big leaves.

**h) Control of insects and rodents** requires appropriate protective installations, repairs and good maintenance, and thorough cleaning of storage buildings or departments. Also the outside area around the store place must be clean; all organic wastes should be removed as they attract insects, termites and rodents. Frequent inspections of the store are necessary!

- Only sound and insect-free products should be stored.
- Plants such as neem and derris act as a repellent or insecticide, and often local plants are known with similar qualities. Their leaves, roots, flowers and/or fruits can be put into the storage, to prevent insect infestation.
- Ants and termites can be kept far by putting products onto racks with poles standing in containers filled with water or waste oil. The posts may also be covered with fat or waste oil or coal tar, or be surrounded by a layer of sieved wood ashes.
- Fine-meshed wire netting protects against insects, snails and rodents, when carefully fixed and closed.
- Rat baffles made of metal or glass bottles around the posts of high store rooms or silos are helpful as long as rats can't jump onto the roof from another roof or tree.

## CHAPTER 11

## Techniques for Reducing Post Harvest Losses

If all above mentioned instructions have been followed, then there should be not really a need for further applications. Waxing may render in some products, but requires extra skills and facilities. Chemicals should not be used for post harvest control of pests and diseases as only few are accepted non-toxic to the consumer.

### 9. Farm level food processing

The possibility to sell produces out of season when they are scarce on the market obviously increases their profitability, but also the labor and risk to have them available.

To be more on the safe side, fully ripe or still unripe fruits and vegetables can be processed to avoid economical losses.

- Many kinds of fruit can be processed to jam, juice and chutney. Ripe fruits are peeled, cut into pieces and boiled with sugar. Most important is to keep all stuff clean and to use air-tight containers, such as jam glasses with screw lid. The longer the cooking and the more sugar are used, the longer jam keeps good. Chutneys are preserved with spices. Fruit juices must be heated to 70°C for 15 minutes minimum. Containers must resist heat and have to be washed with boiling water just before using them. After filling in the hot mass into the glasses or bottles, these are put on top/turned for one hour round to „seal“ them, to prevent them from penetrating air.
- Other fruits which are less juicy, such as banana, peaches, apples, star fruit, tamarind, papaya, mango, plums, etc. can be processed by drying to make a kind of paste, fruit slices or pieces. Sun drying, or drying in the oven at low temperature are viable methods, also for peanuts, cashew, and other nuts, and for mushrooms.
- Immature or very young vegetables such as cucumber, cauliflower, carrots, onion and baby corn can be pickled, preserved in vinegar solution. Vinegar, salt, and a little bit of sugar are boil with water. Vegetables are separately short-boiled with water and salt, drained, and loosely filled into glasses, which just have been clean before with boiling water, and also drained. They are filled up with vinegar solution until all vegetables are covered.

**CHAPTER 12****Obtaining own Propagation Material**

Crop plants are propagated by seeds (sexual propagation) or by different plant parts (vegetative or asexual propagation). Most vegetables are propagated by seeds, while with fruit trees mainly vegetative propagation is implemented (see chapters 4 and 7).

This chapter will focus on some principles, skills and experiences for self supply with seeds.

There are many traditional and self-developed technologies on how to determine, maintain and improve seed quality, which over time and experience have been proven effective. Willingness for experiment by trial and error, patience, intuition and good observation are some of the required virtues farmer should possess in order to obtain their own seeds. The results depend mainly on the given conditions of the farm, and are not easily transferable to other places. But nevertheless, good results should be documented and passed on to a greater public.

**1) Selection:**

True-to-type crop plants that have outstanding positive characteristics or reactions to certain environmental influences (such as extreme cold, excessive rains, pests, etc.) should be marked with sticks or colored plastic bands.

**2) Documentation:**

The observations of characteristics and reactions are noted down, so that later they can be described and explained to other people.

**3) Data collection:**

Simple data are taken which can easily be counted, measured, seen or tasted, such as:

- yield (weight in kg per area in square meters, rai or ha)
- early maturity (by counting days from planting to maturity or harvest)
- resistance to pests and diseases (by rough comparison with the average for the crop)
- growth habit (by measuring changes in height, girth over time; describing, e.g. whether the plant is erect“ or „slender“)
- quantity of seeds, thickness of fruit flesh and juice content in fruits
- size, shape, evenness and symmetry of the produce (by comparing or measuring)
- taste (sweetness, acidity, etc.)

**4) Separation:**

Crop plants with one or more outstanding characteristics are not harvested, but allowed to ripen completely, until the seeds are completely developed and ready to be shed. Then paper bags may be put over the seed capsules and closed tight to prevent shedding. Seed capsules



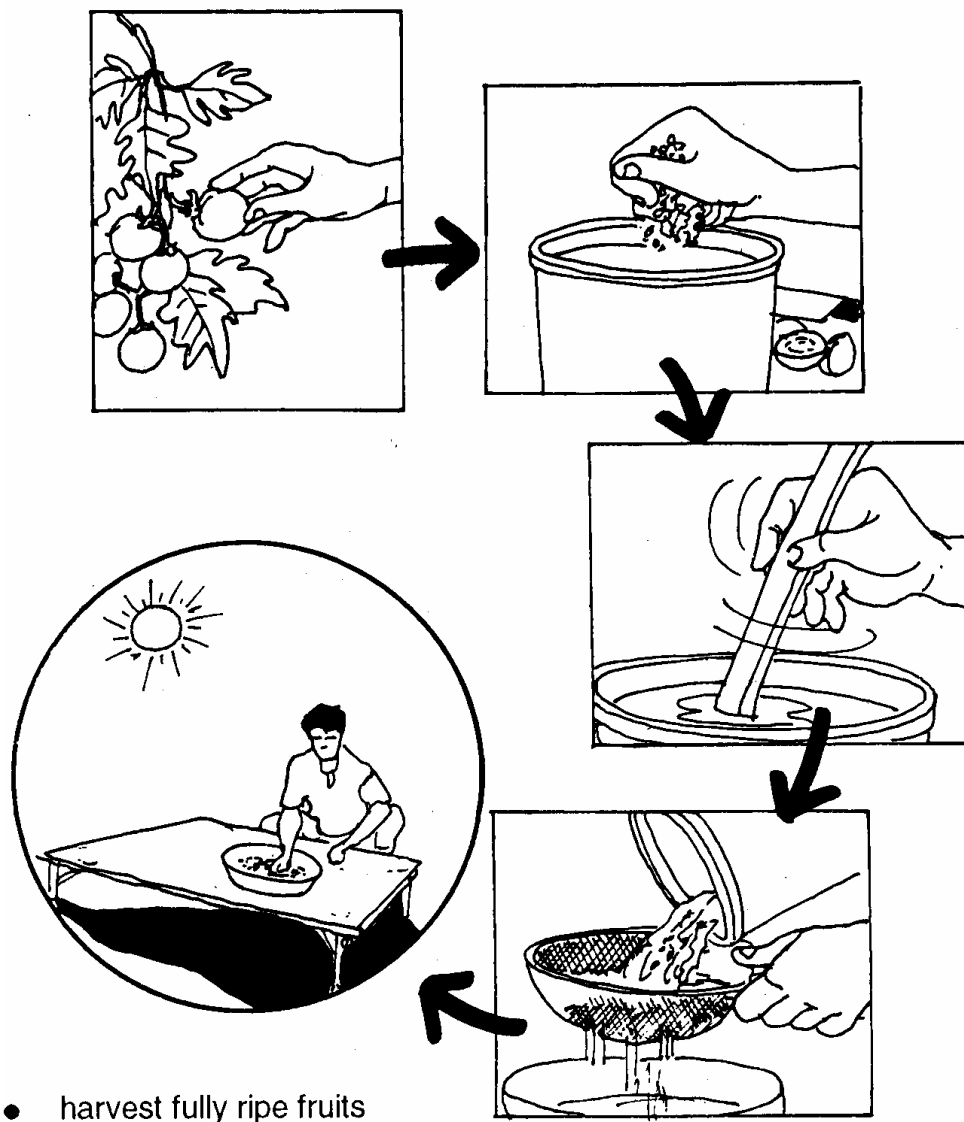
## CHAPTER 12

## Obtaining own Propagation Material

are harvested when conditions are favorable, and kept separate with indication about the provenience.

5) Seed processing:

First seeds must be extracted from dry or fleshy fruits.

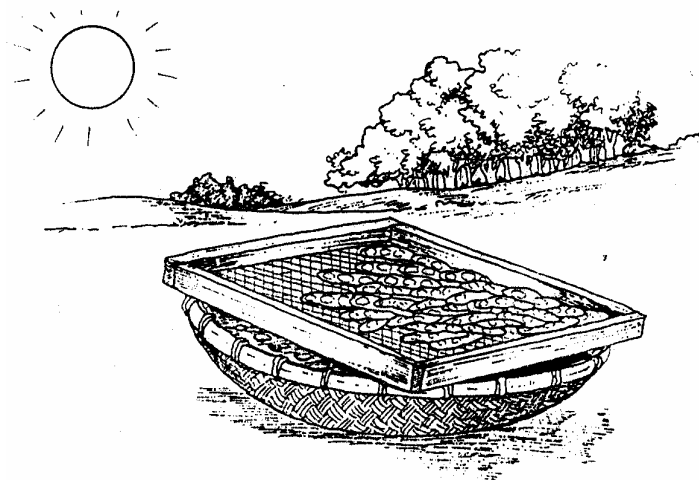


Legume pods and cones are sun dried over concrete or plastic sheets, on wire mesh with a container below it to collect the seeds, or within cloth sacks. The separation of seeds and capsules can be accelerated by tossing, beating, and opening them by hand. Seeds

## CHAPTER 12

## Obtaining own Propagation Material

are cleaned by blowing and/or winnowing, and immersed in a container with water, to separate the good from the bad ones: floating seeds are too light and must be discarded. For storage, seeds have to be drained and re-dried.



- Selected fleshy fruits must not be piled up and stored, but processed as soon as possible, as heating and fermentation damage or even kill the seeds. Fleshy fruit are immersed in water as a whole (tomato, chili, cucumber, etc.) or just the seed-containing pulp (melon, passion fruit, e.g.) for 1-2 days. Then the fruit flesh has become soft, and can be lightly rubbed, scraped or crushed to separate the seeds carefully by hand. After removing all floating seeds, coats and pulp the seeds are drained, re-washed and air dried for another 2 days, to be sown later.
- For storage purposes the seeds' moisture content must be lower than seeds that are sown. Thinly and evenly spread on mats, screen or light-colored plastic sheets the seeds are sun dried for 1-3 days, depending on how wet they were in the beginning. During the hottest hours from noon to around 3 pm the seeds should put in a shady place or a structure should be built over them to provide shade. Before it starts raining or getting dark, the seeds have to be brought inside the house to maintain low moisture content.

6) Seed quality:

- Seeds for propagation have to be stored in most cases. They must be well-dried to avoid heating, further accumulation of moisture, unwanted germination and growth of fungi and storage insects.

## CHAPTER 12

## Obtaining own Propagation Material

- To maintain seed purity weed seeds, vegetative parts and stones, etc., diseased, defective and infested seeds must be removed in order to prevent problems in storage and later in the field.
- The seed germination and the seedlings' health are proven - before storing!- by the germination test (described in Chapter 4) with the rag doll method. The germination rate should be above 80 %. The seedlings should be vigorous, free of spots, lesions, blighting and streaking, as these are symptoms of potentially serious crop diseases.

7) Farm level seed storage:

With few exceptions, seeds can be stored and kept viable at low temperature and moisture content.

- To keep temperature low, storage should be in a place that never is heated by the sun, preferably near to the floor or ground below a building.
- To maintain dryness for small amounts of seeds, air-tight containers such as glass jars with tight-fitting lids or tin cans should be used. Since seeds easily absorb moisture, water-absorbing materials such as toasted and cooled down rice, dry charcoal or scraps of dry newspaper should be placed on the bottom of the container. Before filling up a container with seeds, a separating sheet of paper is introduced. These kinds of containers allow frequent opening and long use, while plastic bags need to be heat-sealed again. As every opening includes penetration of humidity, the water-absorbing material has to be re-dried or replaced.

Only well-dried, healthy, mature and new seeds should be stored! Old and new seeds must not be mixed up. Labeling with the dates of harvest or purchasing and start of storage helps to keep things tidy. Also the percentage of germination can be noted down.

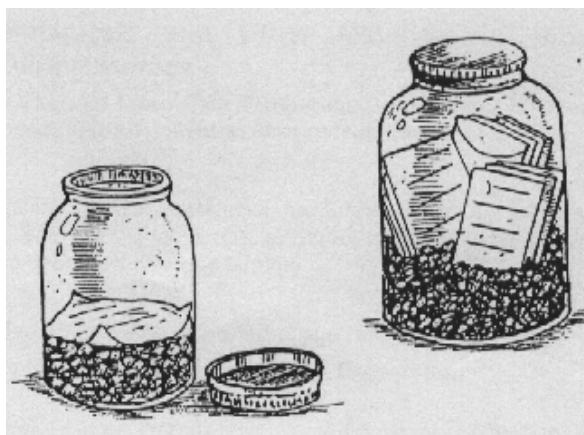
As damage caused by storage insects has been found to be the worst problem when storing seeds and air-tight containers and facilities without access for insects are very limited, they must be controlled by different measures:

- one or two naphthalene balls per 10 kg of seed,
- 10-20 g of powdered neem seed, chili, 20 g of powdered rhizome of Turmeric, or 5 g of powdered leaves of black pepper mixed with 1 kg seed, neem leaves and other botanicals, act as insecticides or repellents,

## CHAPTER 12

## Obtaining own Propagation Material

- 10-40 g of wood ash or paddy husk ash, 10 g of lime or half gram of fine sand mixed with 1 kg seed, which prevents movement, impairs breathing and enhances water loss of insects by abrasion,
- one teaspoon of plant oil from coconut, neem, peanut, castor or cotton, prevents insect eggs from hatching and anchoring in seed coats,
- keeping seed bags in areas where they are always stepped on, as constant disturbing discourages insect infestations,
- sun-drying of stored seeds from time to time, since insects don't like the disturbance and larvae are killed by the heat.



Seeds that don't tolerate drying and don't resist cold temperatures can be kept in half-filled and inflated plastic bags which are opened once a day for aeration. The moisture content may be maintained or increased by inserting moist charcoal, saw dust or sand. If stored at about 15°C, the storability of well-cleaned(!) seeds of mango, jackfruit, mangosteen, durian, rambutan, avocado, and some other kinds of fruit can be prolonged for some weeks.

Some figures for seeds available next page

CHAPTER 12

Obtaining own Propagation Material

SPECIES	TKM [g]			SEEDS / g.			MEAN SEEDS / g.			LIFE EX-PEC-TANCY [year]			SOWING RATE [kg/ha]			SEED YIELD RANGE [kg/ha]			RELATION SOWING RATE / SEED YIELD RANGE		
	from	-	to	from	-	to	from	-	to	from	-	to	from	-	to	from	-	to	from	-	to
Asparagus	20	-	40	25	-	50	33	3	-	7											
Broccoli	2.0	-	4.0	250	-	500	333	4	-	5			0.5	-	1.0	800	-	1000	1	:	800 - 2000
Bush bean	175	-	350	3	-	6	4						50	-	150	250	-	1500	1	:	2 - 30
Carrot	0.7	-	1.5	667	-	1429	909	3	-	4			1.5	-	2.0	200	-	600	1	:	100 - 400
Cauliflower	2.5	-	3.5	286	-	400	333	4	-	5			0.5	-	1.0	100	-	350	1	:	100 - 700
Celery	0.3	-	0.5	2000	-	4000	2667	3	-	4											
Chinese cabbage	2.5	-	3.5	286	-	400	333						2.0	-	3.0	500	-	600	1	:	167 - 300
Cucumber	20.0	-	29.0	34	-	50	41	4	-	8			3.0	-	5.0	300	-	400	1	:	60 - 133
Eggplant	3.6	-	4.4	227	-	278	250	4	-	5			2.5	-	7.0	80	-	150	1	:	11 - 60
Groundnut	300	-	1,000	1	-	3	2						30	-	40	500	-	6000	1	:	13 - 200
Head cabbage	2.8	-	3.7	270	-	357	308	4	-	5			0.5	-	2.0	200	-	300	1	:	100 - 600
Kohl rabi	2.8	-	3.7	270	-	357	308	4	-	5											
Leek	2.2	-	3.7	270	-	455	339	2	-	4											
Lettuce	0.7	-	1.4	714	-	1429	952	3	-	4			2.0	-	2.0	100	-	400	1	:	50 - 200
Maize	130	-	280	4	-	8	5						15	-	20	600	-	3000	1	:	30 - 200
Onion	3.0	-	4.0	250	-	333	286	2	-	3			4.0	-	8.0	300	-	400	1	:	38 - 100
Pea	100	-	360	3	-	10	4	3	-	5			30	-	150	400	-	1200	1	:	3 - 40
Pepper	6.0	-	7.3	137	-	167	150	3	-	4			0.5	-	0.5	25	-	150	1	:	50 - 300
Pumpkin	250	-	300	3	-	4	4	4								400	-	500			
Radish	5.0	-	10.0	100	-	200	133	4	-	5			8	-	10	200	-	600	1	:	20 - 75
Soybean	80	-	160	6	-	13	8						35	-	45	1000	-	2000	1	:	22 - 57
Spinach	8.0	-	14.0	71	-	125	91	3	-	5			10	-	12	800	-	1000	1	:	67 - 100
Sweet melon	22	-	28	36	-	45	40									200	-	300			
Tomato	2.3	-	3.0	333	-	435	377	4	-	6			0.5	-	0.5	15	-	80	1	:	30 - 160
Water melon	85	-	95	11	-	12	11	5	-	8			1.0	-	2.0	200	-	250	1	:	100 - 250

**1. Schedule for Vegetable Training**

<b>N°</b>	<b>TASK</b>	<b>TIME</b>		<b>h:mm</b>	
<b>1</b>	<b>GENERAL</b>	<b>8:00</b>	<b>-</b>	<b>9:45</b>	<b>1:45</b>
	Introduction				
	General Vegetable Production Conditions in				
<b>1.1</b>	Lao PDR.				
	Common vegetable in the region and nutri-				
<b>1.2</b>	tional value.				
<b>1.3</b>	Climatic requirements				
<b>1.4</b>	Soil Requirements				
	Coffee break	9:45		10:00	0:15
<b>2</b>	<b>SOIL PREPARATION</b>	<b>10:00</b>	<b>-</b>	<b>10:45</b>	<b>0:45</b>
<b>2.1</b>	Targets				
<b>2.2</b>	Plowing				
<b>2.3</b>	Harrowing				
<b>2.4</b>	Digging				
<b>2.5</b>	Seedbed Preparation				
<b>2.6</b>	Mulching				
<b>3</b>	<b>SEEDING METHODS</b>	<b>10:45</b>	<b>-</b>	<b>11:15</b>	<b>0:30</b>
<b>3.1</b>	Broadcast				
<b>3.2</b>	Drilled				
<b>3.3</b>	Direct in the field				
<b>3.4</b>	Sowing in prepared fields				
<b>4</b>	<b>PLANTING</b>	<b>11:15</b>	<b>-</b>	<b>11:45</b>	<b>0:30</b>
<b>4.1</b>	Up Rooting				
<b>4.2</b>	Spacing				
<b>4.3</b>	Crop Interaction				
	Lunch	11:45		13:00	1:15
<b>5</b>	<b>WATER MANAGEMENT</b>	<b>13:00</b>	<b>-</b>	<b>14:30</b>	<b>1:30</b>
<b>5.1</b>	Manual Spraying				
<b>5.2</b>	Calculation				
<b>5.3</b>	Sprinkler Irrigation				
<b>5.4</b>	Furrow Irrigation				
<b>5.5</b>	Drip Irrigation				
	Tea Break	14:30	-	15:00	0:30
<b>6</b>	<b>FERTILIZATION</b>	<b>15:00</b>	<b>-</b>	<b>16:30</b>	<b>1:30</b>
<b>6.1</b>	Kind of Fertilizer				
<b>6.2</b>	Nutrient value				
<b>6.3</b>	Soil analysis				

	Evening free	16:30	-	-	
	Breakfast	7:00	-	8:00	1:00
<b>7</b>	<b>PESTS AND DISEASES</b>	<b>8:00</b>	-	<b>11:45</b>	<b>3:45</b>
7.1	Plant protection with observation				
	Coffee Break				
7.2	Practice, Methods				
7.3	Integrated Pest Management (IPM)				
	Lunch	11:45	-	13:00	1:15
<b>8</b>	<b>HARVEST</b>	<b>13:00</b>	-	<b>13:45</b>	<b>0:45</b>
8.1	Conditions				
<b>9</b>	<b>POST HARVEST</b>	<b>13:45</b>	-	<b>14:30</b>	<b>0:45</b>
9.1	Marketing				
9.2	Processing				
9.3	Crop Rotation				
	Tea break	14:30	-	15:00	0:30
<b>10</b>	<b>FINAL DISCUSSION</b>	<b>15:00</b>	-	<b>16:00</b>	<b>1:00</b>
	Mobile team leave	16:00	-	17:30	1:30
	<b>SUM LESSONS [h:mm]</b>				<b>12:45</b>

**ADDITIONAL POSSIBILITIES:** EXTENSION, YEARLY CALENDAR, SEED MULTIPLICATION, SELECTION, SEED STORAGE, etc.

## 2. Schedule for Fruit Crop Training

### Example 1: ORCHARD MANAGEMENT

Day	Part	Topic	Time	Hours
MON	1	Integrated Pest Management (IPM)	a.m.	3
	2	Plant protection (general issues)	a.m.	2
	3	Pests and diseases	p.m.	2
	4	Weed control	p.m.	1
TUE	5	Field trip to orchards around Haddokkeo	a.m.	4
	6	Soil classification	p.m.	1
	7	Fertilization	p.m.	2
	8	Water supply for fruit trees	p.m.	2
WED	9	Effective Microorganisms (EM) / Bio-Extract (BE)	a.m.	4
	10	Preparation and use of compost	p.m.	3
THU	11	Inter-cropping	a.m.	4
	12	Pruning of different fruit trees	p.m.	3
FRI	13	Economics for fruit tree farmers	a.m.	3
	14	Nursery management	p.m.	3

### Example 2: NURSERY MANAGEMENT

Day	Part	Topic	Time	Hours
MON	1	Theory - Basic facilities: size, area, construction infrastructure	a.m.	3.5
	2	Practice –Planning of nursery: calculations, etc.	p.m.	1.5
	3	Equipment: tools, bags, irrigation, etc.	p.m.	2
TUE	4	Theory - Soils, soil mixtures	a.m.	1.5
	5	Techniques for obtaining propagation mat.	a.m.	2
	6	Practice –Care taking of seedlings: watering, plant protection, fertilization, tipping, pruning, cutting	p.m.	3.5
WED	7	Theory - Economics: data, marketing, price calculations	a.m.	2
	8	Table of seed collection, Table of propagation	a.m.	1.5
	9	Cooperation between fruit tree nurseries Final discussion	a.m.	2
	10	Practice – Field trip to a market and a nursery	p.m.	open



### 3. Schedule for Integrated Farming

#### Example: Program for a 5-days training course

Monday morning	Registration, opening, self introduction, participatory set of course regulations, get to know the project, general information about poultry breeding/farming
Monday afternoon	poultry breeding/farming, pig farming, pig breeding, fish farming
Tuesday morning	Review of the last theme of the training, cattle breeding/farming vaccination
Tuesday afternoon	Practice vaccination
Wednesday morning	Review of the last theme of the training, suggestions: sustainable agricultural production
Wednesday afternoon	Rice planting; instructions for making compost and natural pesticides
Thursday morning	Review of last topic; fruit tree propagation
Thursday afternoon	Practice fruit tree propagation
Friday morning	Review of last topic; project visits in Houaython Station and for family activities in Ban Thaotan and Ban Nongpoung
Friday afternoon	Review of the training course, remarks and perspectives; certificates

Exercises for Introduction, for Energizing and Teambuilding Processes, all adapted from „Participatory Learning and Action - A Trainer's Guide“ (see: references), some have been slightly modified.

A) Introduction: Starting a training requires providing a good and relaxed atmosphere so that participants feel welcome and comfortable, thus willing to actively participate. Here are some „icebreakers“, to relieve the tension and make people feel becoming part of a group.

### 1. *First Name Introduction*

Each participant is asked to introduce themselves in turn by simply adding an adjective before their name that begins with the same letter. For example:

„I am lucky Lucy!“ -- „I am serious Surinder!“ -- „I am jolly Jenny!“ -- „I am glorious Gloria!“

This can be done when seated, but becomes more fun and active if the participants stand in a circle. Ask each person to accompany their name with a movement or gesture (jumping, shrugging shoulders, twirling) while stepping into the circle. When they step back it is the next person's turn.

There is no need to debrief after this exercise. It can serve as a reference point for the remainder of the training session or course, as participants will remember amusing adjectives. Most importantly, an atmosphere of informality is established. The physical movement relaxes participants and puts them at ease with others.

### 2. *Symbolic introductions*

Ask participants to form groups of two or three and find an object, perhaps outside, that they feel symbolizes their country, region, or organization. Ask them to bring the object back and to introduce themselves and explain why they chose this object as their symbol.

This exercise is useful for encouraging participants to open up and share feelings early in the workshop. Introductions are made while searching for and agreeing on a symbol.

These symbol groups can be used for later exercises which require sub-group work. If you are not familiar with the region or country, hearing about the symbols is a good introduction to the local value system. Examples of objects might include a tool, a woven or embroidered shawl, a plant, etc.

### 3. *The Seed Mixer*

You will need enough seeds, beans, raisins, pebbles or beads for each participant to have the same number as there are people (including the trainer!), and cups or plastic containers for any participants who do not have pockets.

Give each person one bean or seed, or...or... for each person in the room. The trainer should also participate in this exercise. Ask them to place the beans or seeds in one pocket and leave a second pocket empty. Small cups or containers, or just the hands can be used instead.

Participants are standing or sitting in a circle. You as the trainer may start to introduce yourself by going slowly around. You will face every participant and hand over a bean while talking which he or she will place in the empty pocket or cup. At the same time you will accept one bean or seed from each person and place it in your second pocket or cup.

Same as you, every participant is asked to introduce themselves briefly but without hurrying. At the end of this exercise, each person should be left with one bean or seed in their first pocket (representing themselves) and a second pocket filled with beans for the total number of persons in the room minus one.

This is suitable for up to about 30 participants. There is no need for a debriefing after this exercise. It is a very effective way for each person to have an informal, face-to-face encounter with everyone else in the training. It also creates an atmosphere of informality and conviviality.

### B) Exercises for Energizing, Enhancing Group Dynamics, Improving Listening and Observation:

#### 1. *Fruit Salad*

The objectives are to get the group active and awake (especially good after lunch or to break a long passive session), and to form sub-groups, each with an easily remembered name, for further group work.

Set up a closed circle of chairs, one fewer than the number of people who will join the exercise. (Decide on the number of groups needed, as this will determine the number of fruits selected).

Ask participants to sit in the chairs. The trainer begins the game by standing in the middle. Explain that this is an energizing exercise which will require their (very!) active participation. Let the participants name as many fruits as you need subgroups. Ask one person to choose a fruit, their neighbor another fruit, the next neighbor another, and so on until the desired number of sub-groups is reached. The next person in the circle takes the first fruit, the next the second, and so on until everyone including the trainer has a fruit name.

Before you start, ask all the „oranges“ to put up their hands, then all the „melons“, etc. This will just remind everyone once again of their fruit.

The person in the middle calls out the name of one fruit. All those participants you „are“ that fruit must change chairs - no exceptions! The person in the middle will also try to get a seat. One person will be left in the middle, who then repeats the process by calling out another fruit. When „fruit salad“ is called out, then everyone must change chairs.

This exercise can be a great deal of fun. It does need someone to stop the game, and as the trainer, you should conclude by allowing yourself to be left in the middle. This is easiest after "fruit salad" has been called. This game mixes hierarchies and relaxes participants. It also divides friends and colleagues into separate groups as they tend to sit together in the circle.

There is no debriefing.

There are endless variations to „Fruit Salad“, e.g. „Jungle“ and „Farm“ (with animal names), „Vegetable Soup“ (types of vegetables), „Agro forestry“ (tree types), „Rainbow“ (colors).

## 2. Robots

Divide the participants into groups of three, in which one person is to be the robot controller and the other two the robots. The controllers each manage two robots. They move a robot to the right by touching the right shoulder and to the left by touching the left shoulder.

Begin by telling the robots to walk in a specific direction.

The controller must try to stop the robots crashing into obstacles such as tables, chairs and walls.

After about 3 minutes ask the controllers to switch roles with one of the groups of robots. Start again. After another 3 minutes ask the last group of robots that have not been controller yet to switch places with a controller.

Ask participants what it felt like to be a controller trying to control two robots at once. Ask what it felt like to be a robot.

## 3. Breakthrough

This exercise may be chosen to energize the group, and to illustrate the importance of coordination and communication.

Divide the participants into two groups of equal size and have them stand in two lines facing each other (about two meters apart).

Group A is asked to break through Group B. No one is allowed to talk.

When the breakthrough occurs, the two groups are told they have five to ten minutes to plan a second breakthrough or defense.

Repeat the attempt.

Ask the participants to reflect on the difference between the two breakthroughs. The first breakthrough usually occurs fairly early. The second is more difficult.

Ask the participants to reflect on the importance of coordination and communication, and what can be achieved as a group compared with a set of individuals.

### C) Exercises for Enhancing Group Dynamics

#### 1. *Knotty Problem*

Not only an energizer, but an exercise to demonstrate to participants that groups empowered to solve their own problems are much more successful than if instructed by outsiders.

One, two or three participants are asked to leave the room while you instruct the rest of the group.

Ask the remaining participants to hold hands in a circle and tie themselves into as entangled a knot as possible. They must not let go of each other's hands at any cost.

- Tell the participants to follow the „manager's“ instructions literally and not make it easier for them by doing what they have not been told to do.
- Once the knot is complete, the „managers“ are asked to return and to unravel the knot within three minutes, using verbal instructions only.
- Instruct the „managers“ to hold their hands behind their back. They are not allowed to touch the group, only instruct them verbally.
- The first attempt is generally not successful and sometimes even produces a more complex knot.

Now repeat the exercise with the „managers“ participating in the knot. When the knot is ready, simply ask the participants to *„get out of the knot yourselves“*.

The second untying process is usually much quicker. Ask participants to comment on what relevance this has to the real world. You can raise various issues, such as:

- *What does the game tell us about the role of „outsiders/managers“ and „insiders (in the knot)“?*
- *What does the exercise tell us about the effectiveness of „outsiders“ and „managers“ in organizing people?*
- *What does the game imply for facilitating participation in community development?*

## 2. *Trust Walk*

This exercise may help to illustrate the importance of trust in the way people build relationships, and give an opportunity for individuals to look at their leadership and rapport-building skills.

Divide participants into pairs asking individuals to select someone they have not yet worked with.

In each pair one person leads and the other follows, keeping their eyes closed. The leader takes the follower by placing one hand on their shoulder or under their elbow and guiding with a supportive hand.

The exercise is carried out in silence!

The leader takes the follower around the area at the follower's pace, and guides him or her towards touching, feeling, holding, sensing any object or surface that is safely available.

After few minutes, partners swap roles.

Feedback can be in plenary, or in new pairs. After both trust walks, participants are asked how they felt in the two roles. During the debriefing, discuss issues such as trust, awareness, inner dialogue, sounds, smells, touch, feel, mental pictures, rapport building.

The chosen area must be safe and free of interruption from outsiders.

## 3. *Chairs*

The objectives of this exercise are

- to show participants how to manage conflict by turning it into cooperation
- to help them focus on the possible differences in the interpretation of instructions
- to make them aware of cultural differences in handling conflicts

Explain to the participants the relevance of this exercise by referring to its objectives.

Have prepared slips of paper with the following instructions:

- a      *Put all chairs in a circle. You have 15 minutes to do this.*
- b      *Put all chairs near the door. You have 15 minutes to do this.*
- c      *Put all the chairs near the window. You have 15 minutes to do this.*

Then give each participant one set of instructions (either a, b or c), distributing equal numbers of the three different instructions. Tell them, not to show their slip of paper to other participants, as this will defeat the purpose of the exercise. The trainer tells everyone to start the exercise; following the instructions they were given.

The analysis focuses on aspects of non-aggressive conflict resolution. The instructions cannot be carried out unless people with identical instructions cooperate. The sub-groups cannot carry out their instructions unless they cooperate. Several solutions are possible:

- Putting all the chairs in a circle, between the door and the window.
- Consecutively putting all chairs in a circle, then near the door, then near the window.
- Disobeying part of the instructions, by putting one third of the chairs in a circle, one third near the door, one third near the window.
- Renaming the situation, by hanging two newsprint sheets in the middle of the room, on one of which is written „window“, and on the other „door“.
- Disobeying the instructions entirely.

This exercise has great scope for creative conflict resolution. Groups often burst into frantic action, use force and sometimes carry chairs with others desperately sitting on them to their corner. When some participants are trying to find a cooperative solution, others can be seen continuing to collect and defend their chairs. This in turn frustrates the cooperators, who forget their positive intentions and join the argument.

**Northern Lao PDR**

Mr. Thongvanh in **Ban Hnouiphai near Luang Phrabang** owns a 7 ha farm. In 1990 he noticed a serious lack of fresh fruit in Luang Prabang markets and began to grow fruit such as lychee, custard apple, mango, tamarind, jackfruit, star apple, coconut, lemon, guava, papaya, banana, and jujube for sale.

Around 1,5 ha on the farm is planted with upland and paddy rice, mainly for self consumption. There are also 3 fishponds at different levels, a chicken house for 50 to more than 100 chickens and a pig pen in construction, all part of an integrated farming system. The latter project (raising white landrace pigs) was stopped because of the extremely high cost of concentrated feed. The chicken roam free during the day and are locked in at night. A vegetable garden of approximately one rai, surrounded by a channel on three sides and fenced in, supplies the family with fresh vegetables, legumes and herbs.

The land is mostly gently sloping with a small hill in the background. The higher land is planted partly with papaya and banana, the slopes with rice, and the bottom with paddy rice and fishponds. The upper hillside is not cultivated. The lowest and most fertile spots are planted with fruit trees and supplied with water by an unfinished channel that is connected with the Mekong river.

Lack of water in the dry season (a credit for completing the irrigation system failed) and an area heavily infested by *Mimosa diplotricha* (Lao: *hnhaa:z khèè:z ngu:*) are the main problems on the farm.

Mr. Thongvanh does not make use of pesticides or chemical fertilizers on the crops he grows and when possible applies chicken manure in place of chemical fertilizer.

*Weeding is done continuously. Three to four times a year 8 adult members of the family join together to help on the farm, and additional workers are hired when necessary, especially for weed control. This is carried mostly by slashing, depending on the crop and stage of growth. Recently planted fruit tree blocks are intercropped with cabbage, older ones with maize (of an improved variety used for chicken feed), at least 1.0 m distant from the trees to avoid competition for water and nutrients. This is done in order to provide profit from the young orchard and to keep the land under cultivation. Banana trees are planted afterwards in order to help control weed growth.*

*In the beginning Mr. Thongvanh planted one plot with lychee only (and few sapota) at a spacing of 3x3 m, resulting in a dark shady plot, now without any weeds. But the trees have lots of dead branches, disease infected twigs, and no fruit. Recently he intercropped coconut trees, aiming to subsidize the unproductive trees.*

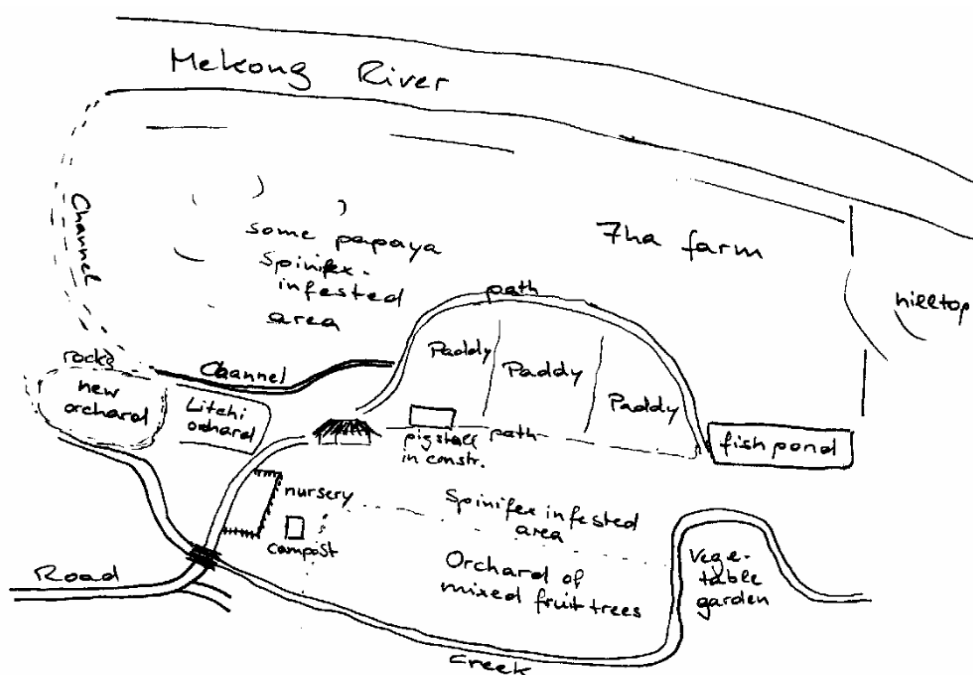


## Northern Lao PDR

*In the past few years he planted different species of fruit trees such as coconut, guava, jujube, custard apple and papaya, all mixed in one plot. The plot however is strongly infested with weeds, although pruned branches put around the trunk definitely help to suppress them. In another older plot he has planted jackfruit, lemon, star apple, tamarind, and pummelo. It is less infested due to the shade provided by these older trees' bigger canopies. In the past pruning was done by using only a machete. Now Mr. Thongvanh uses a saw, cutter, and knife, which work better.*

The soil near to the trunks is piled up slightly, with a drainage depression at the bottom. From time to time chicken or buffalo manure as well as straw ash is applied to the soil. In the raised vegetable seedbeds *Servin* is applied to prevent damage caused by ants, and also ash from burnt straw. The seeds are covered, because in his experience uncovered seeds need longer to germinate and are strongly affected by the sun. Fruit tree seedlings are propagated and many are grafted. Some are to be planted on the farm but most will be sold (namely for cooperation projects).

The potting mixture used in the fruit tree nursery is made of garden soil, compost (mixed with *Furadan* in case of attack by ants and termites), rice husks and bran, buffalo and chicken manure. This is placed into plastic bags which are placed below coconut trees, in order to provide shade and protect the seedlings from the rain. The nursery is fenced in by bamboo stakes.



## Northern Lao PDR

**Ban Thine** is famous for its lemons. The soil of the river bank of Nam Seung River is very fertile and farmers' plots are protected from the wind because the narrow valley is covered with forest.

**Mrs. Phouny** has been living there her whole life and has practiced horticulture since her grandmother taught her how more than 40 years ago. She farms a plot of around 0,5 ha by the river. It consists of three levels:

*On the upper level she carries out intensive mixed cropping, using every space available. Sapota, lemon, lime, chilli, papaya, eggplant, star apple, lemon grass, ginger, turmeric, galangal, sugar pea, common bean taro (in the small depressions on one side), mangosteen, banana, coffee, sunn hemp, sour apple, tamarind, pineapple on the highest edge, bamboo, leucaena and pigeon pea are grown side by side, giving each plant enough space and light to grow. All these benefit from having their root systems at different levels, species of higher and lower growth share the light, water and nutrients available. Grass and weeds are continuously cut or pulled out before they flower. Thus a thin mulch layer is formed to prevent weed growth and to keep the soil moist and cool. Pruned branches and twigs are collected and cut into pieces for „composting“ on the ground. Harvest residues as well are left on the plot, to improve and stabilize the soil structure. Nitrogen fixing legumes are grown for to be used for pulses and fodder and especially to supply the soil with nutrients.*

The medium level is just 2 m deeper and also almost flat. It is planted with mostly lemon as well as some lime and orange trees at approximately 4-5 m x 3-4 m. These are local varieties, grafted on rootstock of the same variety, that produce fruit quickly: Fruit setting starts on two-year old seedlings. Symptoms of Citrus canker (*Xanthomonas campestris* var. *citri*) are visible, but do not really affect the vigor of the plants. In 1996 this level was inundated, and afterwards replanted - now these trees are in full production. Mulberry stalks have been placed under the trees to support the branches and protect them from cracking (in earlier times silk worms had been raised for home production).

There is no irrigation and neither fertilizer nor pesticides applied to the trees. When available, wood and household ashes are applied to eggplants and trees, and that makes them „look nicer and happy“.

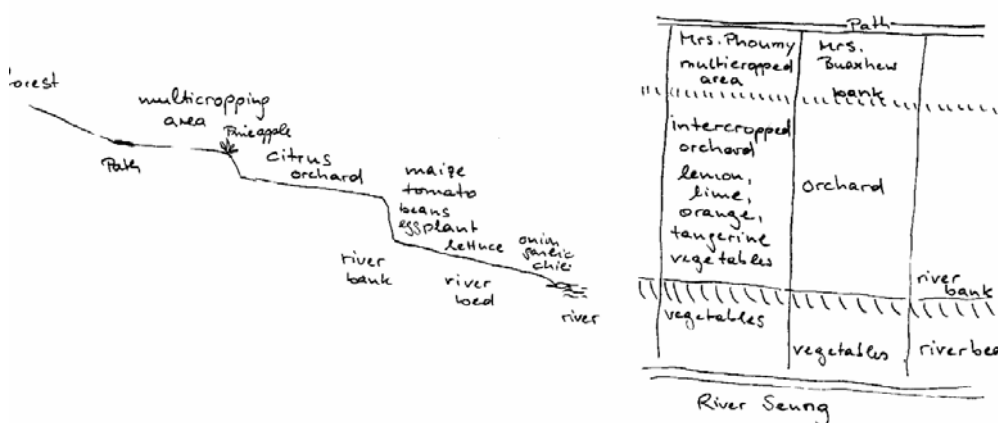
Vegetables and legumes are grown in the silt of the falling river. The steeper higher parts are planted with yardlong beans and common beans along the fence, and provided with one stake each. In between are eggplants, tomatoes, and chilies. These produce until August of the next year and are progressively supplemented, as the water level sinks.

Vegetables were sown in seedbeds in the upper part still during the rainy season. The seeds were treated with *Servin 85%* to protect them from ants. (In case of later attack *Folidol* will be applied to destroy ants' nests).

**Mrs. Phouny** also used to raise her own seedlings in boxes at home. These are put onto elevated stands made of bamboo, thereby out of reach of chicken and pigs. They are covered with fertilizer bags to protect the seedlings from strong rains, wind and sun. Fishing nets may be put up in order to keep chicken and other birds away. Broadcast sowing has always been done for further transplanting.

Everyday she sends home the products by thukthuk, sometimes she sells lemons directly at the orchard to merchants, in baskets for 15000 kip each (1 kg= 1500 kip). At home she fills sugar bags with fruit and plastic bags with light fruit for transport to the market at Luang Prabang, some 30 km from the village.

Mrs. Phuni earns 7 to 8 Mill. kip every year from her crops, and as well provides her family with healthy grown vegetables from her own garden.



**Mrs. Buaxhew** works the neighboring field. Her husband was the first farmer to plant lemon in the area, 17 years ago. She sows chili and pakchoy on the ground level on the river bed, and she plants onion and garlic bulbs in rows on the same plot. Then she covers the seedbed with fairly densely packed rice straw. This helps to control weed growth and keeps the soil moist and cool. While onion and garlic are kept on site, pakchoy will be transplanted, some for self consumption, most for sale.

The steep slope below the river bank is planted with yardlong beans and common beans, which have been staked with single bamboo sticks. Below that, where it is flat again, two rows of sweet corn have been sown: where the water is more concentrated and holds better.

**Northern Lao PDR**

Like **Mrs. Phoumy's** garden this one is also fenced in with bamboo sticks on the lower level and with mulberry poles in the upper level. In the citrus garden the soil around the trunks is piled up and clean, and covered with grass mulch between the rows. No pest problems have been mentioned, no nutrient deficiencies are visible.

On the road to **Ban Pak Ou Mr. Siphanch Chantaket** manages a 1,7 ha **hillside** farm: Upland rice has recently been harvested. One year ago the rice was intercropped with banana, mainly in order to reduce weed growth by their shade. For this reason the yield was less than in former years. However the banana trees are about to bear fruit.

In narrow depressions teak has been planted and in some open flat spots there is paddy rice grown. One hilltop is covered with cassava and another with job's tear. Near to the road and the houses many other species, mainly for self consumption, are intercropped. These include pumpkin, gourd, lemongrass, sugarcane, mangosteen, pigeon pea and cowpea, and sweet potato, planted in small furrows.

**Mr. Thongchanch** is teacher at the Northern Agricultural School. On his private plot he grows numerous different fruit trees, including include jackfruit, star apple, citrus, kapok, plus others. These are partly intercropped with banana for shading. All these species are mixed. The rocky steep slope is well maintained, the weeds cut down and left on the surface. When planting **Mr. Thongchanch** digs a deep hole and refills it only with topsoil, leaving all subsoil beside. Neither irrigation nor manuring is done.

*On another slope is pineapple planted in vertical rows, distance between plants in the row 20-30 cm and between rows 100cm. This technique is very common all around Luang Prabang, as it makes weeding easier, but increases soil erosion. This results in severe losses of topsoil and fertility, and thus complete degradation of steeper slopes.*

*Why not try to plant pineapple in dense rows (20-30 cm) along the contour line as it is practiced, for example, near to Nam Ngum dam on the road No.10? Weeding might be done also from top to bottom, but advancing from left to right and vice versa. By the time the slope shall be stabilized and gradually terraced as well, as pineapple is perennial. During rainy season a low growing legume could be sown between the rows, and incorporated or mulched later.*

## Central Lao PDR

**Mr. Somvangh** and his wife in **Ban Taothan** has been running a 5 ha integrated farm for 2 years now. Prior to 1997 they had only paddy rice and cattle. As their income was poor, they looked for alternatives, and participated in the training courses offered by **Phone Soung Rural Development Project**. He and his wife also had the opportunity to join study tours to Savannakhet, Champhasak and Thailand, to visit **integrated farm systems** and get inspiration how to convert their own farm.

They decided to sell some of their 30 cows and rice to be able to pay the machines to dig out 4 fishponds and to buy a pump. The farmland is undulating and sandy, the house built on the top, behind that edge there is a slope of silty soil turning over into paddy. While the upper sandy part is grazing land and sparsely covered with timber wood, the slope is now densely planted with banana, mango, tamarind, lychee, custard apple, papaya, lemon and jujube (improved variety from Vietnam). The rows have been planted from top to bottom and intercropped with lemon grass, the soil is covered with small growing weeds. Until now soil erosion is not a problem, but in the future Mr. Somvangh and his wife will plant in horizontal rows to avoid damage from the beginning. The species are well mixed and in very good condition. During dry season they mulch with rice straw around the trunks to keep the soil moisture.

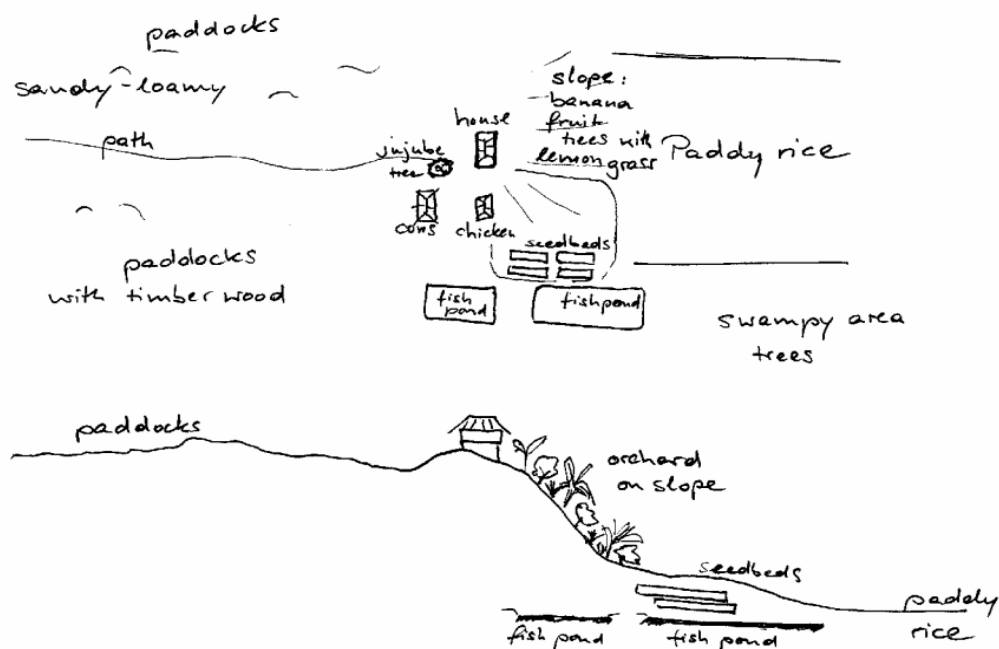
At the lowest part of the farm fishponds are producing an income of 1.5 Mill. kip per year with silver carp, Indian carp, “roho” and other species. Recently they have built a shed above the water for one white landrace pig, which fertilizes the water and makes the fish grow faster. They are planning to build another 4 sheds and to make a loan agreement with the project to get another 4 pure race pigs, which they must pay back in two years at a low interest rate.

On the margin between fruit trees and fish pond they are growing vegetables on 4 raised seedbeds, 1 m x 30 m each. They prepare the beds by hand tractor, ploughing once and after 10 days again. This time they mix the soil with burnt rice straw and husks, level the ground afterwards, sow the seed and cover it with a thin layer of rice husks. One seedbed was sown broadcast with Chinese cabbage alone 2 weeks ago, the second seedbed with Chinese cabbage on the edge, but with coriander on a quarter of the remaining bed: The rest was left open for further sowing (and possibly transplanting). Morning glory had been sown 15 days ago in 4 rows in the third seedbed, had reached on average a height of 10-15 cm and would be ready to harvest in 4 weeks. On the fourth bed they had started to transplant Chinese cabbage that had been thinned out of the first seedbed. When the seedlings were about 5cm of height, they spread cattle manure onto the surface soil. (To avoid losses of nitrogen it should be incorporated into the soil, but this is difficult in a growing plant cover).

## Central Lao PDR

There are also 150 local race and Vietnamese race chickens plus 10 ducks roaming around the house, that are gathered for the night in a raised chicken house. The concentrated manure is applied to vegetables (and fruit trees?) as well. The 13 cows and 5 calves spend the night in an enclosure near to the house. An old local jujube trunk was grafted successfully two years ago with an improved variety introduced from Vietnam and propagated in Haddokkeo Horticulture Research Center.

To run an integrated farm means to commit oneself to hard labor and perseverance. The effort however can pay off as it is possible to significantly improve the living conditions for the family within a short time. Mr. Somvangh and his wife share the work to be done, with from time to time help from their four young children, and for harvesting rice they need waged labor, too. Before changing the system they had an yearly income of 3 Mill. kip. This is now 8 Mill. kip: The fruit trees are just starting to produce, with bananas already generating 1.2 Mill. kip annually. The merchants come to buy directly from the farm, so that transport problems are avoided.



**Mr. Somvangh** and his wife belong to a group of 7 families, trained and supported by the Rural Development Project. They meet once a month and discuss their problems, planning and promising activities, about how to obtain equipment most reasonably and how to manage their household water supply (gathering from the roof and storing in a water tank, pump, tubes, etc.), among other topics. They also get a basic knowledge of calculation and book

## Central Lao PDR

keeping, and the project helps to administrate a fund that is used for innovations. Each family contributes with 10,000 kip monthly and may apply for money in case of need - the actual budget is 3 Mill. kip.

**Mr. Somvangh** and his wife would like to expand their fruit tree production - at the moment 4 rai are planted - and to raise 40 chickens above a fishpond through another loan from the project.

**Mr. Chom** inherited 1.5 ha of non cultivated land plus 2 rai of paddy from his parents a couple of years ago. Before he moved there with his family, he lived in the south. The piece of land was too poor to provide his family with enough food, so that he had to look for work outside of farming. Then he and his wife joined the training courses of the Rural Development Project and got ideas on how to convert their plot into an integrated farming system, that they are working on now in the third year.

The farmland is fenced with barbed wire. The three cows belonging to them are grazing outside during the day and will be enclosed below the old house over night. Just beside there is the stall for the local race pig and 10 hybrid piglets (of a value of 250,000 kip each). In a depression of clayey soil a fishpond was dug out and a chicken stable constructed upon it. Fifty „Tam Huang“ race chicken are raised here, fertilizing the pond, and in this way fattening the fish. The lower bank is planted mainly with banana. There are two other fishponds, all together 2 rai. Near to the fishpond and the stable are fruit trees, including lychee, lemon, custard apple, jujube, jackfruit and mango intercropped with ginger and lemongrass.

The other half of the plot is a poor sandy slope. At the bottom there is a well for drinking water, 2.5 m deep. On the top is scaffolding made for a still missing water tank, which shall supply water to the vegetables to be grown among the fruit trees on the slope. Formerly it was covered with grass (for roof making), that is still growing well along the border. The fruit trees on that spot are showing symptoms of nutrient deficiency and disease, in case of lemon bacterial canker caused by *Xanthomonas campestris* var. *citri*, and in the case of mango „burnt“ black leaf tips and curled minor leaves.

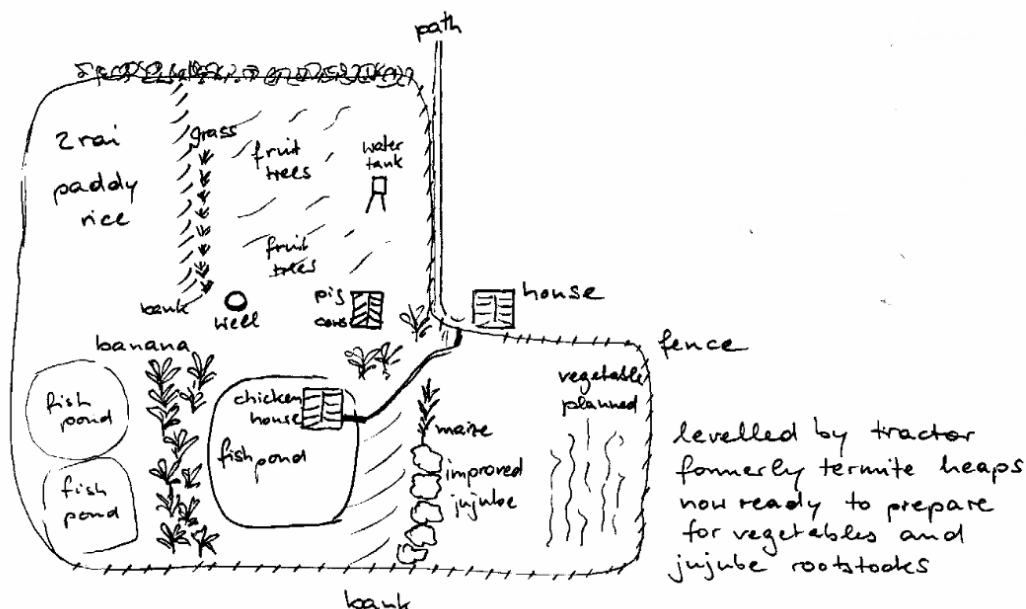
*Mr. Chom uses a preparation of a mixture of lemongrass, ginger, neem, garlic and makabuhay or boraphet (Tinospora rumphii or T. crispa) that he gathers in the forest to protect against insect pests in paddy rice and on his chickens: The ingredients (no exact amounts given) are put into 5 l of water and left for 3-5 days. The mixture is then filtered and diluted; 1 l of mix diluted in 50 l of water, and is thus ready to apply with a watering can or to the drinking water of the chicken, respectively.*

## Central Lao PDR

He is going to prepare the space between the fruit trees with dung of his own cows and additional chicken manure from other group members (see above!), to improve the growing conditions for vegetables and fruit trees. Actually the soil is covered naturally with local weeds that provide at least some protection from sun and rain. He is going to cultivate Chinese cabbage and eggplant in the dry season.

Above the slope is a flat area that used to be covered with termite hills, which have been destroyed and leveled with a tractor. The originally clayey soil shall be mixed with the fertile hill material and prepared to grow vegetables as soon as the rains stop. On the edge of this more or less flat part are some bud-grafted, improved jujube trees which are now bearing fruit. As this species does very well, Mr. Chom is going to grow local variety rootstocks among the vegetables and to bud-graft them with the improved variety in order to extend the orchard. One kg of jujube sells for 5000 kip, so it is far more promising than any other of the fruits grown there.

Mr. Chom also wishes to raise more chickens to be combined with fish production, so he can benefit from the chicken manure for fish feeding, but he will still have to buy chicken concentrated feed.



The family with 4 children has a sufficient and balanced diet nowadays and 3 Mill. kip of income per year. Their living conditions improved significantly as can be seen from their beautiful newly built Lao style house. His wife supports him through her labor and is also skilled in weaving.



## Central Lao PDR

The **Phone Soung Rural Development Project** includes a training center and facilities for up to 25 people per course, and has 10 staff members, trained in Thailand, Russia, Vietnam and Laos, mostly in Dongdok. There are six sections, including sustainable agriculture, livestock production, forestry, irrigation, health care and administration. The participants of the training courses are mostly villagers from each of the central provinces, chosen by the headmen, after the contact made by the staff. The center is financed by the Lao Government and sponsored by NGO's and has over 7 years experience in promoting improved rice and chicken production, as well as in the other fields. The centre produces 500 chickens per month; after 21 days in the incubator these are sold for 3000 kip each. The relation of cocks to hens (Vietnamese two-purpose yellow race) is 1:8, the project also aims to produce 100 eggs per day. There is a vaccination and training in chicken production. After 3-years the old hens are sorted out and slaughtered.

There is also a nursery for fruit trees and ornamentals, which allows for practice in different plant propagation methods and techniques. A total of 2000-5000 plants per year are provided for practical and demonstration purposes.

Training courses in bookkeeping, calculation and planning are offered and administrative services and credits as well.

The training courses are held for one to five days, depending on the topic, for 10 to 25 people.

Two years ago **Mr. Khamphanh** started to grow tomatoes in the wet season. He benefited together with other farmers of the area from training about a new technique adopted from Thailand. He does not own land but he leases up to 6 rai each year in Ban Haddokkeo.

**Mr. Khamphanh** starts in March to prepare the seedbed next to his house: The soil mixture is 1 part good soil from the Mekong river, 1 part cattle or buffalo manure, and 1 part sand, filled into a frame 1m x 1m, 10 cm high. He uses only hybrid seed from Thailand: „Season Red“ (= No. 382), a plentiful bearing variety with small to medium-sized fruit, and „Madonna“ (= No. 091), a less plentiful bearing variety with big rounded fruit. The seed is treated with Apron 35 SD. 10 g of seed are used for 1 m<sup>2</sup>, which is sown in rows 5.0 cm apart and 0.5 cm deep. They are lightly covered and sprinkled with a watering can 1-2 times per day, depending on rainfall and humidity. After sowing Mr. Khamphanh stretches a fisher net around the frame and covers it with a transparent plastic sheet, to protect the seedbed from chickens and the rain.

Fifteen days later he transplants only the best, strongest seedlings into plastic bags. This represents 80 % of the total or 3.500 seedlings, which get the same soil mixture and protection as mentioned above.

**Central Lao PDR**

Then he starts to prepare the beds in the field. One rai at a time is ploughed and harrowed and left for one week to settle/recover soil-structure/life. Raised beds (80 cm broad and 50 cm high) are constructed with hoes and rakes, using hired labor. Fifty kg of fertilizer 15:15:15 are incorporated into the beds. The ready prepared bed is covered by a black perforated plastic sheet and secured by placing soil along the edges. This procedure completely eliminates any weeds.

The seedlings are transplanted 15 days after the first transplanting. Spacing is approximately 1.0 m x 0.70 m in two rows. A seedling is planted in every second hole within a row, beginning with the first hole in one row and the second hole in the other. Between the beds is a 1 m path that also serves to help drain the beds. Once again after 15 days the plants are pruned, the lower leaves pricked off in order to provide better ventilation and save nutrients, leaving just 1-2 pairs of leaves.

A triangular stand made of bamboo and tied with plastic string in four levels is placed on the bed. The tomato plants are not be fixed with strings but climb the bamboo stalks on their own. Fertilizer is applied twice, 10 kg each time, diluted within irrigation water in order to suffice for one rai. Tin cans are used for this purpose. Watering is carried out just above the ground to allow the leaves to remain dry. First application is made one week after transplanting into the bed, the second close to harvesting.

To prevent pests and fungal diseases Mr. Khamphanh mixes the highly hazardous insecticide Lannate and the fungicides Benlate and Benomyl, plus the insect growth hormone Bifuron and sprays this diluted mixture 4 times onto the leaves. First application is done 15 days after transplanting, and the last one 10 days before starting harvesting. Mr. Khamphanh uses a mask, rubber gloves and boots while spraying (and for seed treatment), and stores the chemicals in a closed shed under his house.

Harvesting starts around 45 days after transplanting and goes on for up to 2 months. Neighboring merchants come to his plot to buy his tomatoes, and bring these packed into 12 kg- plastic bags by car to the Vientiane markets.

Up to 6 rai are planted with tomatoes during the wet season, one rai after the other on different plots. During dry season yardlong bean, luffa sponge gourd and cabbage are grown, but not tomato again: Mr. Khamphanh knows that fungal diseases could affect heavily a further crop.

## Central Lao PDR

Mr. Khamphanh has an input of 1.5 Mill. kip per rai, and an output of min. 5 Mill. kip and max. 15 Mill. kip per rai. The inputs include:

Inputs / rai	KIP
hired labor for ploughing, harrowing, making beds	90.000
hybrid seeds (also for other vegetables used 10 g @ 460 Baht)	1.000.000
fertilizer insecticides, fungicides, hormone plastic bags for first transplanting plastic strings for tying of bamboo plastic sheets for seedbed covering and perforated black plastic sheet (1m x 400m @1.200 Baht)	410.000
<b>Total</b>	<b>1.500.000</b>

### Southern Lao PDR

59 years old **Mr. Sentjanh in Ban Psakheng**, Padxiang District, owns a 4 ha of hilly land, and cultivates many different crops together with his wife, son and daughter-in-law. Two years ago he participated in a training course about botanical pesticides, and since then he is practicing this method on the farm.

The main crops are coffee, soy bean, black mottled bean, kapok, custard apple and pea nut. About 1 ha of rocky (volcanic) hillside is planted with coffee (Katimor), guava, pineapple, tamarind, longan, orange trees, papaya, banana and kapok, and furthermore local trees for providing shade to the coffee trees. Many of these are leguminous trees that supply with nitrogen fixation, too. Every little spot is covered with ginger, chili, lemon grass, tobacco and pigeon pea to keep the soil covered permanently, and to have the raw material for making botanical pesticides “by the hand”.

Most of the coffee and fruit trees are mulched with soybean straw (from recently harvested soybean plants) to keep the soil around moist, as there is no irrigation available.

At the foot of the hill there is a field planted with Robusta coffee for 10 years, and cut back to the stump every 4 to 5 years. The coffee plants are intercropped with rice during rainy season, and mulched with rice straw afterwards. There are also new planting holes done 50 cm deep and 30 x 30 cm wide which are going to be filled with 2 kg of ripe cattle manure from the farm each, to plant more Robusta coffee. Banana, papaya and kapok are growing in between, where moisture is gathered in small holes and trenches.

At the end of the field there is still a small plot covered with forest. The ground is damp and kardamom has been growing naturally for about 50 years, as long, as Mr. Sentjanh can remember. Some plants that had been planted 14 years ago, started bearing fruits after 3 years and can be sold now at 20 000 kip per kilo.

At the end of the slope on the other, drier side of the hill is soybean grown, followed by black mottled bean in dry season among custard apple trees, and the straw serves for mulching around their trunks. In a depression behind the hill is soybean grown below papaya trees, making use of the soil moisture gathered during rainy season, and followed by peanut that is going to be harvested after 3 months in June to July (around 2.5 tons per ha). In some of the low parts sweet potato is grown. The steeper hillside is planted with teak on an area of about 1 ha, and the soil is covered with weeds, in order to prevent erosion.

**Southern Lao PDR**

**Mrs. Ghaikhey in Ban Hanhatsaykhun** at the Mekong River manages a small plot of approximately 300 m just on the river bank. The planting beds are 2 to 3 m long and 80 cm broad, and arranged in small terraces like stairs steps. The pathways in between are very narrow to avoid the waste of fertile of soil.

The beds are not deepened, as seen at some of the neighbors, but flat and mulched with rice husks. The edges are stabilized by different herbs, but mainly dill and coriander. The beds are planted at the same time with 1 to 2 cucumber or melon plants, salad, onions, mustard and kale, phak hom chin and phak khaothong. There are other beds planted with salad in mono-culture, and Mrs. Ghaikhey seems to be very successful in selecting and multiplying her own seed material. Proudly she tells to have 100 % of germination of selected seeds from strong and healthy mother plants.

The beds are carefully prepared, using manure and rice husks, and moistened by watering equally. The crops have obviously been sown earlier than at most of the other plots in the area. By early growing and use of botanical pesticides Mrs. Ghaihkey succeeds in preventing damages related to diseases and pests. On the actual river bank slope tomato, yardlong bean and cabbages are grown in mixed cropping.

**The school farm of Pakse Southern Agriculture College** may also serve as an example for integrated farming. It benefits to a considerable extent from a creek bordering the school farm area on one side. A special pumping system depending on a strong water flow, called “hydraulic ram” was installed to pump water about 100 m up the hill into an elevated tank. With the pressure obtained from that reservoir it is possible to water the whole school farm by gravitation. A channel leads the water to the lower situated ornamentals section and the soy-bean field, which is irrigated by furrow system. Furthermore it passes three bio-garden sections and supplies with water for the fish breeding tanks, pig stall frog and algae tank, and two fish ponds before it vanishes in the rice fields.

There is another extension planned and partly constructed, to make use of the water for irrigation of the upper “representative area” near to the entrance and along the main road.

In the bio-garden there are fruit trees, vegetables, staple crops and herbs combined by multiple cropping. All parts are fenced with living fences to keep chicken and roaming cattle out. The vegetable “wastes” serve partly to feed the pigs and to a bigger part for making compost, that helps to improve the originally poor soil. The pig dung shall be led into a biogas plant to produce gas for the school kitchen. The fermented material fertilizes the algae tank and fur-

**Southern Lao PDR**

ther down two fish ponds. EM Bokashi has successfully been used for fertilizing and soil improving purposes.

Ten houses built by the students themselves are distributed all over the compound in a “strategic” way to make sure that the different production areas are watched and maintained. Three or four students of the 3<sup>rd</sup> grade live in the houses made of local materials, and grow vegetables in the surrounding garden for self-consumption and for sale. One plot is reserved especially for botanical pesticides providing plants, and another one for growing fodder grasses and legumes.

Along the water pipe between water tank and hydraulic ram there are several fish ponds, fed by water from the bordering creek. Above one of these there has been constructed a pig stall to fertilize the water and fatten the fish. Another one has been built for chicken. The terrain is slightly sloping, so that the ponds are situated at different levels. In the vegetable garden a portable chicken pen is used to apply manure directly in the place where needed.

Mound beds which have been put with twigs, branches, grass, leaves, etc. including tins in the low layer provide with mineral nutrients and humus.

Finally, it can be assumed that responsibility and reliability of the students and teachers involved in the farm work make the integrated farm system happen successfully.

<b>Institution/Project</b>	<b>Address</b>	<b>Tel.Fax</b>
Asian Regional Office- Asian Vegetable Research and Development Center	P.O. Box 1010 KU Bangkok 10903 Thailand	+ 66 – (02) - 9428686
Asia-Urbs Program, ADG - Aide au Development Gembloux	Saphantong Road (T.E.S.T Office) P.O. Box 8487 Vientiane Laos	21 - 414842
CIDSE - Cooperation Internationale Pour le Developement et la Solidarité	P.O. Box 2795 19/3 Chao Anou Road Vientiane Lao PDR	021 - 214862
DTAS - Dongkhamsang Technical Agriculture School		020 - 533245
FAO Inter-Country Programme for IPM in Vegetables in South and Southeast Asia Plant Protection Center Salakam	P.O. Box 811 Vientiane Lao PDR	021 - 812130
GTZ Lao German BAFIS Programme, Occupation Oriented Training for the Informal Sector	Thadeua Rd. km 8 P.O. Box 6505 Vientiane Laos	21 - 315719
GTZ PROFEP - Promotion of Forestry Education Project, PROFEP-GTZ, Faculty of Forestry, NUOL	PROFEP-GTZ P.O. Box 5653 Vientiane Laos	21- 732097
HHRC - Haddokeo Horticulture Research Center	P.O. Box 811 Vientiane Lao PDR	021 - 219377
NAC - Nabong Agriculture College		20 - 512910
NAFS - Northern Agriculture and Forestry School Luang Phrabang	P.O. Box 929 Luang Phrabang Lao PDR	071 - 212019
NAFES - National Agriculture and Forestry Extension Service	P.O. Box 811 Vientiane Lao PDR	021 - 732072
NAFRI - National Agriculture and Forestry Research Institute	P.O. Box 811 Vientiane Lao PDR	021 - 732074
PADETC - Participatory Development Training Center	P.O Box 2147 Vientiane Lao PDR	012 - 215909

PSAC - Pakse Southern Agriculture College	P.O. Box 333 Pakse Lao PDR	031 - 212258
SAF - Sustainable Agriculture Forum	P.O. Box 4881 Vientiane Lao PDR	021 - 313042



- A Primer on Vegetable Gardening**, R.L. Villareal et.al., AVRDC, Taiwan, 1993
- Agroforestry Species, A crop sheets manual**, P. K. R. Nair, ICRAF, Nairobi, Kenya, 1980
- Agroforestry Technology Information Kit**, DENR/FF/IIRR, Silang, Cavite, 1989
- Bio-Extract**, PADETC, Vientiane, 1999
- Contour Farming with Living Barriers**, Practical Guide Dry Land Farming, APAN (Lao / Engl.), 1998
- Control of Soil Erosion, Sedimentation and Flash Flood Hazards**, G.A. Oughton, Vientiane, 1993
- Controlling Crop Pests and Diseases**, R. Rappaport, CTA / The Macmillan Press Ltd, London/Basingstoke, 1992
- Erosion Control in the Tropics**, Hil Kuypers et al, Agrodok Series No.11, Wageningen, Netherlands, 1996
- Establishment Guide**, B. Macklin et al, Nitrogen Fixing Tree Association, Waimanalo, Hawaii, USA, 1989
- Farmer Field School on Integrated Soil Management**, Facilitator's Manual, FAO / UNDP, Thailand, 1998
- Farmer to Farmer**, E. Kruger et al., University of Natal, 1995
- Green manuring and other forms of soil improvement**, Agrodok-series No.28, Wageningen, 1989
- Hedges for Resource-poor Land Users in developing Countries**, Dr. Guido Kuchelmeister, GTZ, Eschborn 1989
- Home Composting**, AVRDC, Taiwan, 1991
- Improving nutrition through home gardening**, FAO, Rome, 1995
- Integrated Soil Management: A Philippine Experience**, FAO, Philippines, 1999
- Integrating Biological Control into IPM Programs**, M. J. Whitten, Iguazu Falls, Brazil, 1996
- Planning Soil Conservation Projects through Participation, A Guide (TDR Project R 65070)**, M. Douglas, P. Laurence, Report OD 139, HR Wallingford, DFID, Oct.1997
- Manual of Reforestation and Erosion Control for the Philippines**, H.J. Weidelt et al, GTZ, Eschborn, 1976
- Nutzgarten in den Tropen**, Dienste in Übersee, 1985
- Obstbaumschnitt Kernobst, Steinobst, Beerenobst**, H. Schmid, Ulmer Verlag Stuttgart, 1995
- Participatory Learning and Action**, J. N. Pretty et al., Sustainable Agriculture Programme, London, 1995
- Participatory Monitoring and Evaluation**, FAO-RAPA, Bangkok, 1988
- Permanent Compost Beds**, AVRDC, Taiwan, 1991
- Pflanzenernährung**, A. Amberger, Ulmer Verlag, 1983
- Planning Soil Conservation Projects through Participation, A Guide (TDR Project R6570)**,
- Plant Resources of South-East Asia**, No. 11, Auxiliary Plants, I. F. Hanum et al, Bogor Indonesia, 1997

- Plant Resources of South-East Asia**, No. 8, Vegetables, J. S. Siemonsma et al, Bogor Indonesia, 1994
- Planting Tree Crops, Practical Guide to Dryland farming**, APAN (lao/Engl.), 1998
- Preparation and Use of Botanical Pesticides at Southern Agriculture School Pakse**, Workshop paper, Ph. Sumption et al, Dec. 1997
- Preparing a Compost Pile**, LAO - IRRI project, 1992
- Provision of Techn. Support to WFP Project 4304, Training Module 3, Nursery Technique**, Hanoi 1995 FAO/NZODA/UNDP
- Raising Fruit Nursery**, S. S. Gill et al., New Delhi, 1985
- Regenerative Agricultural Technologies**, IIRR Cavite / Unicef Manila
- Resource Book on Sustainable Agriculture for the Lowlands**, SEASAN, 1992
- Resource management for upland areas in Southeast Asia**, An information kit, FAO Thailand/ IIRR, Philippines, 1995
- Shifting Cultivation Systems and Rural Development in the Lao PDR**, Nabong Agriculture College, Vientiane, 1994.
- Slash / Mulch Systems - Sustainable Methods for Tropical Agriculture**, H.D. Thorsten, Westview Press, USA, 1997
- Storage of tropical agricultural products**, AGROMISA, Agrok-series No.31, Wageningen, 1990
- Storing Fertilizer Materials**, LAO - IRRI Project, 1992
- Teaching Tools, Ausbildung in der „Dritten Welt“**, IPZ Consult Halle, 1997
- Testing Seed Germination**, LAO - IRRI Project, 1993
- The Bio-Intensive Approach To Small-Scale Household Food Production**, IIRR, Cavite, 1987
- The Cultivated Plants of the Tropics and Subtropics**, S. Rehm and G. Espig, CTA / Verlag Josef Margraf, Scientific books, Weikersheim, 1991
- The vegetable garden in the tropics with special reference to Africa**, AGROMISA, Agrodok-series No.9, Wageningen, 1996
- Tomato Pruning**, AVRDC, Taiwan, 1991
- Trees commonly cultivated in Southeast Asia**, an illustrated field guide, M. Jensen, FAO/RAP, Bangkok, Thailand, 1995
- Tropical Crops Dicotyledons**, J. W. Pursglove, Longman Group Ltd., New York, 1987
- Tropical Crops Monocotyledons**, J. W. Pursglove, Longman Group Ltd., New York, 1985
- Tropical Fruits, Trainer's Manual No.10**, S.K. Thapa et.al., Dep. of Agriculture, Kathmandu, 1990
- Using Indigenous Knowledge in Agricultural Development**; Int. Course on Regen. Agric., IIRR Silang, Cavite, 1993
- Vegetable Production in the Tropics**, C. N. Williams / J. O. Uzo, W.T.H. Peregrine Intermediate Agricultural Series, Longman, England, 1991
- Vegetable Production Training Manual**, Asian Vegetable Research and Development Center (AVRDC), Taiwan, 1990
- Additional drawings by:**  
Ecole sans Frontieres, Vientiane, 1999 and Dorothea Dietrich, Vientiane, 2001