# Where There is No Farm Advisor

**By Robin Denney**

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By Robin Denney, Illustrations by Robin Denney

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## Introduction

In the present global climate of food shortages and out of control price increases in food and fuel, helping communities improve local, sustainable food production is more important than ever. This booklet is a preliminary resource to introduce you to methods and concepts in Tropical Agriculture, and to assist you in conducting further research. Feel free to contact me (Robin Denney) with any questions at: redenney@gmail.com. And be sure to look through the Resources section of this booklet for further research and assistance.

## Using this Handbook

- Look at this handbook before you go overseas, and use the **Resources** section to assist you in conducting further research specific to the concerns of your region.
- Take this handbook with you as a resource.
- Take Moringa seed with you (see Moringa page 35) (to order see ECHO page 6).
- Start a small garden by your house as soon as you arrive overseas, so that you can try some of these techniques (see **Demonstration/Teaching Garden** below).
- Use **Plant Biology for Beginners** to get a basic knowledge of the science behind caring for plants or animals.
- Use **Working in Local Communities** for suggestions and cautions in beginning and conducting your work in agriculture with local people (cultural context and possible impacts of your work, are vital things to consider).
- Then, with the help of local farmers, learn as much as you can about the situation, problems, and farming practices (use **Assessing Agriculture in Rural Communities** to get techniques).
- When you understand the problems, use **Addressing Problems** for suggestions.
- The symbol : , indicates the best ideas that can improve agriculture everywhere.
- Also use **Resources** for tips on finding more suggestions, getting expert advice, downloading handbooks on various topics available for free, and visiting online libraries of tropical agriculture.

## Resources

The information for the writing of this booklet came from my personal experiences doing agriculture work, in Liberia and El Salvador, studying at the ECHO demonstration farm, and from my research of ECHO and Agromisa publications (cited where appropriate).

**Books:**

This booklet focuses on crop production in the tropics. If you are going to a place where **livestock** are an important part of local food production, I highly recommend you purchase either of the following books:

- Where there is no Vet by Bill Forse, Published by MacMillian, available from Amazon.com
- Where there is no Animal Doctor Published by Hesparian foundation, available online at: http://www.hesperian.org (use the site search function, enter this title as an exact quote, or search Google with this title as an exact quote to get the order page).

**This booklet** takes a basic, hands-on approach. If you are looking for a more scientific approach, (i.e. texts for educating college students), I highly recommend:

- The Tropical Agriculturalist series – By MacMillan Press, approximately 30 topical volumes in print. You can find some titles on Amazon.com, but not reliably. I recommend the ECHO Bookstore (see ECHO directly below)
- Other great books available from ECHO Bookstore online (info below)
- Intermediate Tropical Agriculture Series– Difficult to find, high level scientific texts (search Google).

## *Featured Resources:*

**ECHO- Educational Concerns for Hunger Organization-**

ECHO has a demonstration farm in Florida, and an excellent library and bookstore. They have the best selection of tropical agriculture books available (books even Amazon doesn't have). Their bookstore is available online. They also have many free publications online, including their book Amaranth to Zai Holes. They have a seed bank of excellent crops for development, and ship free samples to development workers. They have a staff of expert agriculturalists available by email or phone to discuss problems and options.
Note: ECHO does significant work with Moringa (see page 35) and can provide you with information and with seed (see Technical Notes on their website).

- **Before you go overseas**: Download Amaranth to Zai Holes and Technical notes on topics you are interested in. If you are planning on doing agriculture development work, plan a study trip to ECHO in Ft. Myers Florida for at least a week. Their work/study program is very affordable. Also register with ECHO to receive free Moringa seeds and other benefits!

**Website**: www.echotech.org
**Email**: echo@echonet.org
**Phone**: (239) 543-3246

### Agromisa

This is a group that produces handbooks on tropical agriculture, written with practical application in mind, for the subsistence farmer. You can get handbooks mailed to you for free if you are a development worker with an address overseas. You can also download the handbooks at the website below under the heading "Publications".

Titles available for **FREE** download on the internet:

**Crops and Forestry**
16 Agroforestry
19 Propagating and Planting Trees
8 Fruit growing in the tropics
40 Small Scale Mushroom Cultivation
41 Small Scale Mushroom Cultivation- 2
37 Small Scale Seed Production
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**Posters:** Nutrition, natural pesticide recipe, plant tea fertilizer recipe, how to make an efficient stove.

**Agromisa (continued)**
**Question and Answer Service:** You can submit in-depth questions about issues you are facing in the field, and volunteer experts will research and find answers for you (allow 2 months for answers). Submit a question at their website under the "Question and Answer" heading.

- **Before you go overseas:** download all applicable titles to your computer, they are not large, and then you will be sure to have them.
- **Once you are overseas:** email Agromisa with your address, and ask to become a member. You can request free copies of publications to be sent to your overseas address.

**Website**: www.agromisa.org
**Email**: agromisa@agromisa.org

## Food and Agriculture Organization of the United Nations (FAO)

The FAO is a critically important website. It has in depth agriculture and environmental statistics available for most countries. It also has important news, technical articles, and program information.

- **Before you go overseas:** look up statistics for your country to see what crops are grown, and what some of the issues are. This will guide your research.

**Website**: http://www.fao.org

## Hesperian Foundation

Hesperian has several full books, available for free download:

Where There Is No Doctor
Where Women Have No Doctor
A Book for Midwives
A Health Handbook for Women with Disabilities
HIV Health and Your Community
Helping Children Who Are Deaf
Helping Children Who Are Blind
A Worker's Guide to Health and Safety
A community guide to environmental health
Women's Health Exchange
Global Health Watch
Where There Is No Dentist
The Story of Stuff with Annie Leonard
Donde no hay doctor
Donde no hay doctor para mujeres
Un libro para parteras
Ayudar a los niños ciegos
Donde no hay dentista
Salud labora en la maquila: Una guía para los trabajadores

**Website**: http://www.hesperian.org/publications_download.php

## Appropedia

An online user-edited encyclopedia on development and appropriate technology. The contents of this booklet will be uploaded to the site soon (by individual topic).
**Website**: http://www.appropedia.org/

## *All other Resources:*
## ONLINE LIBRARIES AND INSTITUTIONS

**International Institute of Tropical Agriculture (IITA)** is an Africa-based international research for development organization.
Topics of Research: Agriculture and health, Agro-biodiversity, Banana and plantain systems, Cereal and legume systems, High-Value Products, Opportunities and threats, Root and tuber systems
Library - Excellent online library of Research journals on all topics
**Website**: http://www.iita.org

**CGIAR Consultative Group on International Agriculture Research** – major tropical agriculture research organization, with 15 centers around the world.
**Website**: http://www.cgiar.org
CIAT – International Center for Tropical Agriculture
**Website**: http://www.ciat.cgiar.org
Library- http://www.ciat.cgiar.org/biblioteca/index.htm
Sustainable Tree Crops Program, http://www.treecrops.org/
Publications: http://www.ciat.cgiar.org/downloads/onlinepublications.htm

**Royal Tropical Institute (KIT)** (The Netherlands): The aims of KIT are to contribute to sustainable development, poverty alleviation, and cultural preservation and exchange.
Issues for the Tropics (especially health and economic issues for the developing world)
Library- Online Library with broad search topics
**Website**: http://www.kit.nl

**Food & Fertilizer Technology Center** (Taiwan): Information center for farmers in Pacific Asia region. Library- tropical agriculture publications (mostly Asian agriculture)
**Website**: http://www.fftc.agnet.org/library

**University of Hawaii Manoa Science & Technology Department**: Tropical Agriculture Internet Resources:
Library- information on agriculture in the tropics, crops, animals, and forestry
**Website**: http://www.hawaii.edu/sciref/tropag.html

**International Rice Research Institute** (Philippines):
Publications, research, scholarship opportunities related to rice production
**Website**: http://www.irri.org/

**Belize Development Library on Tropical Agriculture**: Electronic Resource Library
**Website**: http://ambergriscaye.com/BzLibrary/ag.html

## SUSTAINABLE AGRICULTURE
**Sustainable Agriculture in Hawaii**:
Sustainable Agriculture (crops, forestry, and animal production), books and articles available for free download.
**Website**: http://www.ctahr.hawaii.edu/sustainag/newFarmer/links.asp

**Center for Agroecology and Sustainable Food Systems**
-Exploring Sustainability in Agriculture: An Online Sustainable Agriculture Instructional Resource (Santa Cruz, California)
**Website**: http://socialsciences.ucsc.edu/casfs/-old_site_files/instruction/esa/
-Publication on organic farming and gardening skills and practices, applied soil science, and social and environmental issues in agriculture.
**Website**: http://repositories.cdlib.org/casfs/tofg/

**International Federation of Organic Agriculture Movements**- Training manual on tropical organic production methods (available for download or purchase). Topics include organizing training courses, principles of organic agriculture, soil fertility, plant nutrition, pest disease and weed management, animal husbandry, and farm economy.
**Website**: http://www.fibl.org/english/publications/training-manual/content.php

**United Nations Conference on Trade and Development** - Organic Fruits and Vegetables from the Tropics: publication on how developing countries can enhance their production and export capacities in organic agriculture.
**Website**: http://www.unctad.org/en/docs/ditccom20032_en.pdf

## SOIL HEALTH

**Soil Food Web Australia**:
Information on improving soil health, Composts, etc
Website: http://www.soilfoodweb.com.au/

**World Wide Portal to Information on Soil Health:** Library on Soil Health information
Website: http://mulch.mannlib.cornell.edu/browse.html

## PEST CONTROL

Recipes for Homemade Natural Pesticides:
**Website:** http://www.ghorganics.com/page14.html

See Also: Under *Featured Resources:* (page 6) Publications available from the Agromisa website: Agrodok 29 “Non Chemical Crop Protection” and 30 “Pesticides: Compounds and hazards” and Agromisa Poster: “How to make a Natural Pesticide”

## FUNDING / GRANTS

**Sources of Funding** - a selection of websites for foundations, donors and other sources of funding from the CGIAR: http://www.ciat.cgiar.org/biblioteca/donors.htm

**The Foundation Center**, a good primer on seeking funds from foundations: Proposal Writing Short Course: http://foundationcenter.org/getstarted/tutorials/shortcourse/index.html
Website: http://foundationcenter.org/

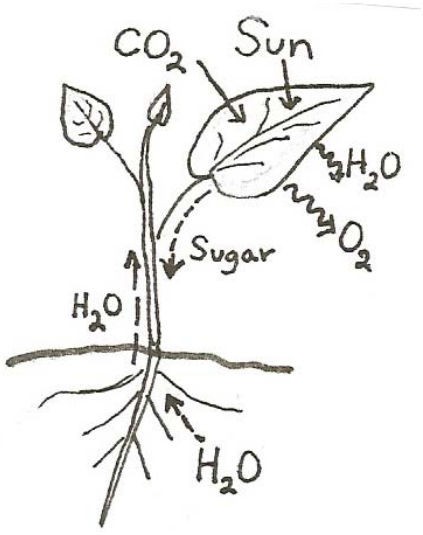
# Plant Biology for Beginners

**What Do Plants Need?** Sunlight, water, minerals, carbon dioxide, and something to grow in or on, usually soil or another plant.

**How does Photosynthesis work?** Photosynthesis is a metabolic pathway that takes water, air and sun energy and produces carbohydrates ($H_2O$ + $CO_2$+sun energy=CHO(sugar)+ $O_2$) Plants' leaves and green stems contain chlorophyll, a pigment which absorbs energy from sunlight. The plant stores this energy chemically, like a battery. A compound called ATP carries this chemical energy around the cell, and gives it up to be used in different processes that need energy. In the second phase of Photosynthesis, this ATP is used in a reaction which takes carbon dioxide and water and makes sugar. If you look at the chemical formula, you can see how this is possible. Sugar is then sent throughout the plant. It is stored for later use in stems and roots (sugars stacked and bound together form carbohydrates, and cellulose, which is called fiber in the human diet). It is also put into fruit, and used to build new cells (grow).

**What can farmers learn from this?**
Plants need maximum access to sunlight to grow best. Shaded plants will soak up less sun energy, and therefore not grow as well. (Exception: some plants, especially trees, need shade while they are seedlings. Other plants like coffee grow better in shade.)

**What do leaves do**? Leaves are where photosynthesis occurs. They also sweat (in plants it is called transpire). The leaves give off water, and as it evaporates it keeps the plant cool. Leaves have tiny holes on the underside, which allow oxygen and water to escape, and carbon dioxide to enter. These holes are called stomata, and can open and close. When they open, water evaporates from the interior of the leaf. If the plant is under water stress during the heat of the day, the stomata will remain closed because the plant knows it cannot afford to loose more water. When the stomata stay closed, photosynthesis stops, because the oxygen cannot escape, and carbon dioxide cannot enter the leaf.




**What can farmers learn from this?**
When a plant is under heat stress, it's leaves and growing stem tips will begin to droop. If this is happening, then photosynthesis and plant growth have stopped. The plant needs water to correct the situation and continue growing. Water stress can become severe enough to kill the plant. This will begin with the oldest leaves falling off, and the growing stem tips will dry up and die back.

**What do roots do**? Roots collect water and send it to the leaves for photosynthesis, and transpiration. They also take up nutrients, which are critical to both photosynthesis and

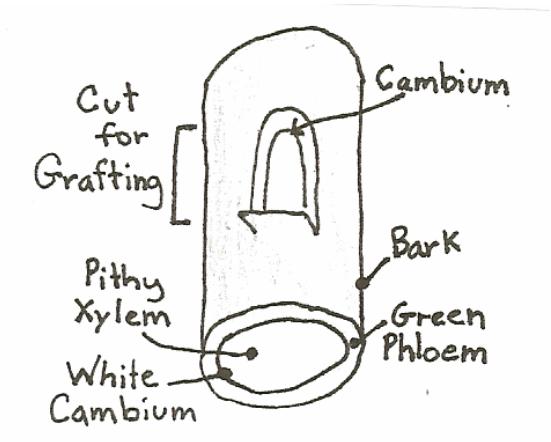
growth. The most important of these are Nitrogen (N) Phosphorous (P) and Potassium (K). Nitrogen is critically important, because both chlorophyll and amino acids (amino acids make up proteins) require Nitrogen. Symptoms that show NPK is lacking includes the yellowing of leaves, reduced growth, and lower yield. There are many other minor nutrients that are necessary in small amounts, symptoms that nutrients are lacking include deformity in growth, spots on leaves, die back (and others). (note: these can also be symptoms of disease or pests)

**What can farmers learn from this?**
It is critical that farmers care about the health of the soil. With each crop, nutrients are being removed from the field at harvest. If no new nutrients are added (through fertilizer, mulch, manure, etc), the next harvest will be smaller.

**How do branches form?** A growing shoot tip (end of a stem) produces a hormone called Auxin which moves down the plant and stops the buds on the stem from growing. The further it has to travel the less effective it is at this, so branches begin to form. If you pinch off the shoot tip of a plant, you remove the hormones, and branches will begin to grow. Once Auxin gets down to the roots it acts as a root growth hormone. The roots produce and opposite hormone called Cytokinin (CK). As CK travels up the roots it suppresses root growth. When it gets to the branches, it encourages new shoots to grow. In this way, the plant is able to keep its root growth and shoot growth in perfect balance. If many shoots are trimmed or eaten, then the plant has more CK than Auxin, so it produces more shoots. If roots are broken off during transplanting, there is more Auxin, and so more roots grow.

**What can farmers learn from this?**
Pruning encourages branching. This is especially effective when plants are younger. On trees that are used to produce food, this is important. More branches lower down, means more access to fruits, nuts, and leaves. Also when transplanting, trimming back the shoots will help remove some of the stress from the plant, since roots will be broken during transplanting.

**What are Xylem and Phloem?**
Xylem is the plant tissue that carries water up the plant. It is made up of specialized plant cells that die after they are formed, so as to form an empty tube, which acts like a drinking straw. As water is used for photosynthesis and transpiration in the leaves, more water is drawn up by suction through the xylem to the leaves. Xylem is located at the center of stems. In trees, xylem becomes wood once it is no longer in use.




Phloem are living cells on the outer rim of a stem that move the sugars formed in photosynthesis, down the plant to be used for growth or stored in the roots, stems, or fruits. As phloem dies it becomes bark, and falls off. Phloem is the green layer just under the bark. The cambium layer, is a layer of cells between the xylem and phloem. The cambium layer

produces new xylem cells on one side, and new phloem on the other. It is white and smooth, and can be seen if you slice into a stem with a knife (the xylem is usually white and pithy on the other side). If the cambium layer is damaged, it takes a long time to repair. (Think about a large tree branch that is pruned, with time, what appears to be the bark, swells up around the wound, until after many years the bark touches again, and the cambium layer re-connects.)

**What can farmers learn from this?**

Girdling (cutting around the outside of a stem, with something sharp, or slowly with a string or vine) will kill a plant.

If you want to graft a plant, the cambium layer of your improved variety, MUST touch the cambium layer of your original plant. If the wound is sealed, then the two cambiums will knit together, and the bud or stem that was added will grow.

When tapping a tree (as for rubber production), you have to be careful not to cut too deep and damage the cambium layer, or the tree will drop in production.

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# Working in Local Communities

**Subsistence and Commercial Agriculture**

Subsistence Agriculture is the backbone of most developing agricultural economies. This is critical, because being able to produce your own food supply gives subsistence farmers a level of stability: protection against job loss and fluctuations in the economy. Development workers need to remember this. Higher producing commercial agriculture, and subsistence agriculture can exist side by side. One is important for improving economic gains, and the other protects against famine. Small improvements in efficiency and yield can help subsistence farmers increase their production, and have excess crop to sell in the market. With extra income, farmers can continue to improve their agriculture practices, and their quality of life.

**Sustainability**

The concept of sustainability, is that farmers use a system of farming that will be able to sustain itself perpetually. When trying to develop sustainable systems, it is important to think local, and long term. How can farmers produce the inputs they need locally (fertilizer, seed, tools)? How can farmers change their practices in order to increase the health of their soil, environment, and crop? What low cost options are available?

*Example Non-Sustainable:* A system that encourages farmers to plant higher performing genetically modified, or hybrid seeds, is an example of short term thinking. This may solve the problem of low yields here and now, but it creates a dependency on foreign produced expensive seeds which require fossil fuels to transport and distribute. This system also replaces the locally produced seed, and means that if something goes wrong with the imported varieties (bad taste, pest susceptibility, supply, nutritional value) the community will not be able to revert quickly to their old seed (as supplies will be diminished or eradicated).

*Example Sustainable:* A sustainable system encourages local production of seed; low cost fertilizing methods such as mulch, compost, and planting of legumes; and non-chemical pest management or natural pesticide recipes.

This booklet highlights potentially sustainable methods only. Using the local knowledge of your community and region, you can determine which methods are truly sustainable in your region.

**Respect**
When working in local communities, it is important to show culturally appropriate respect to the people and elders of the community. It is also important that you go beyond the outward display of respect, and come to a place of feeling respect.
*Showing Respect*- You should know after living in a culture the proper ways of showing respect. This can include: how you dress; who you address first when asking a question; how long you wait in silence; how you greet a person; your tone of voice when speaking; whether to bring a gift; how to receive a gift; whether it is appropriate for you to speak directly to someone of the opposite sex; and any other considerations the local culture may have.
*Feeling Respect*- Truly feeling respect for the ways of another culture means that you must let go of some attitudes you may not even know you have. Paternalism is one of these fatal attitudes. This is where you feel you are coming from the "haves" to give to the "have-nots". It is an outcome oriented, charity minded approach. The problem with this attitude is that it blinds you from being able to see the wisdom and value of the local ways, and it sets up an unhealthy one-sided relationship. It is important that you let go of paternalism as well as any prejudices or stereotypes you may hold. Approach a new culture with true respect, realizing your way is only "a way" not "the way". Open yourself to learn from the hundreds or thousands of years of wisdom and agricultural experience of your hosts. Help them to articulate and implement their own vision, rather than imposing a vision of your own.

**Patience**
Don't be hasty! Western/Northern culture is fast paced, and in entering the cultures of the South, we must slow down. A slower pace of life is not backward, it is just different. You may even find that you prefer the slower pace, and see its value, if you take the time and the patience to live it. You may be frustrated by what you perceive as a waste of time, and as inefficient use of labor and resources, but you will not change the pace by being angry about it. Try to see what is good about this cultural difference.

**Caution**
Proceed CAUTIOUSLY with any change. Never make or encourage changes in farming systems that are irreversible.
*For Example:* large scale or free range cross breeding of local livestock with foreign livestock (this can weaken the natural resistance to disease that local livestock have, and effectively wipe out local livestock production); large scale replacement of local crops with higher producing foreign crops (this can wipe out seed stores, and prove disastrous if the higher producing seed must be purchased year after year, or if there is some problem related to its growth or use).
Try new techniques on a small portion of a plot and compare the growth of the specially treated plants with the traditionally grown plants. Encourage farmers to experiment, but always to start with only a small portion of their crop.

# Assessing Agriculture in Rural Communities

## History Taking

Begin by asking questions of Farmers.

Is the community able to produce enough food to feed the population?

Is malnourishment a problem in the community?

If so, research more about malnutrition in health books, like Where there Is No Doctor (Resources page 7). And see "Nutritional Problems" page 35.

Is the community mainly producing food for their own consumption?

This is subsistence agriculture. Problems often include low yield, storage and preservation of food, pests, flood, drought, erosion, physical damage to crop (from a storm or during harvest), availability of seed, not enough labor, cost of tools, and land availability

*Or* Is the community mainly producing crops to sell?

Crops that are grown to be sold are called "cash crops". Problems with cash crop production often include: low yield, pests, flood, drought, erosion, labor availability and cost, land availability, credit or money for crop inputs (fertilizer, chemicals, seed, tools, etc), transportation of crop to buyer, location or lack of processing facilities, fluctuating market prices, markets controlled by monopoly corporations.

What do the farmers say are problems in crop production? Are these recent problems, or have they been going on for a long time? How do they address the problems?

## Assessing plant health

Look at the stems, leaves, and flowers or fruit if present. Ask the farmer how the growth and current health of the plants compare to past crops, and crops in other regions. Look for any of the following symptoms:

**Low yield**: Yield is the weight of crop harvested per area of land. Yield decreasing from year to year is a common problem, and can be caused by all of the factors below.

**Water stress**: dry soil and-

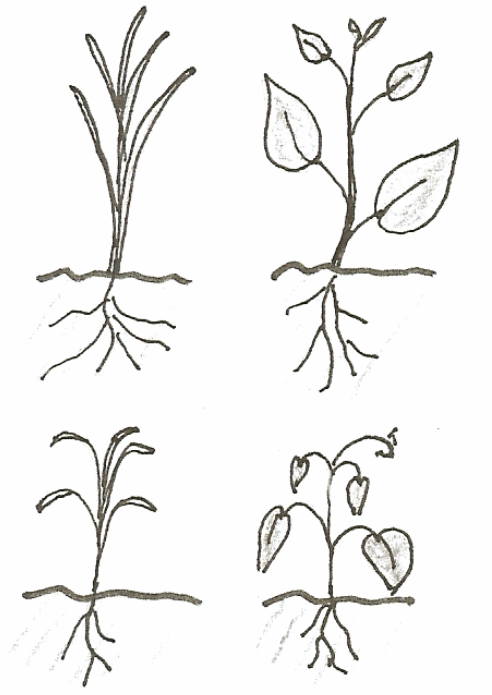
Recent stress: limp and drooping leaves and stem tips

Prolonged stress: Larger and older leaves fall off, stem tips dry up, yellowing of leaves, new leaves stay small

**Flooded**: wet soil, puddles on soil. Most plant roots, in prolonged flooding condition will begin to rot- this will give the same symptoms as water stress, because the plant is not able to get enough water when it's roots rot. (rice, and other swamp plants are the exception to this rule).

**Lack of nutrients**: Yellowing of leaves (indicates lack of Nitrogen), slow growth, small leaves, flowers set little or no fruit, deform-

Normal Plants and
Water Stressed Plants



ity of stems or leaves, discolored spots or dry spots on leaves.

**Pests**: Can you find any insects or eggs on the plant? Are there signs that insects are damaging the plant?

Common Insect Pests:

Grasshopper/locust/katydid: Can cause major damage, usually you can see where they are eating leaves, or fruit.

Caterpillars: Eat leaves and fruit, sometimes curl leaves to form nests/cocoons

Mites: insects almost invisible to the naked eye, they cause tiny spots to form on the leaf where they feed.

Aphids: Small insects that feed off of the phloem, usually found on soft new stems.

Mealy Bugs: Also phloem feeders. They are white, and exude a sticky goo. Ants farm mealy bugs, because they eat the sugary goo exuded by the mealy bugs. Ants will care for the mealy bugs, and move them to new feeding locations.

Beetles: some beetles eat plants, and some beetles hunt harmful insects, observe the beetle in question to see which kind it is.

Nematodes: microscopic worms in the soil that feed on roots.

Some wasps and flies harm plants or fruits, and some are hunters of harmful insects.

Animals, Birds, Rodents: livestock and wildlife can cause significant damage.

**Disease**:

Fungus: Fungus is a parasite that attacks the plant for food. Fungus can take the form of mildew, which often looks like powder and black spots on plants, or something as large as a plant like parasite growing on the bark of a tree. A fungus growing on the tip of a growing shoot can contort it. If only part of the plant is affected, prune that part and destroy it. If the whole plant is affected see viruses.

Viruses: Viruses often cause plants to mutate: leaves curl strangely, or get strange stripes, shoot tips contort and curl. Viruses are spread by propagating infected plant material (propagating means growing new plants from cuttings), or they are spread from plant to plant by certain insects, and nematodes. Plants cannot be cured of a virus, the plant must be destroyed, to stop the virus from spreading. Viruses usually spread very slowly, and most often occur from propagation. Be sure you know the cuttings you are using came from healthy plants.

Bacteria: Bacteria can take the form of rot on stems, roots, or leaves.

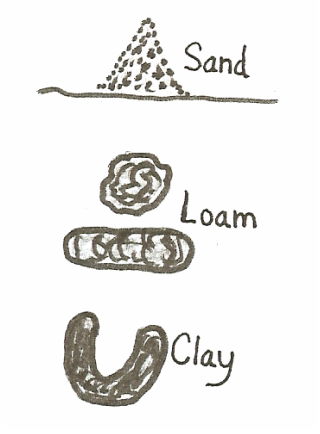
## Assessing Soil Health

**Slope**: Does the land have a shallow or steep slope? Erosion may be a problem on slopes. Is the land flat, low, near a river, and thus subject to flooding?

**Soil profile**: Dig a hole - The top layer of soil should be darker, and looser, this is the top soil, where most of the nutrients are found. The sub-soil should be lighter in color, and harder. How deep is the top soil? The deeper it is, the better the plants will grow. If the top soil is thin, see if there is soil erosion (see erosion on page 30).

**Soil Color**: Dark soils are rich in decaying organic material, which is full of soil nutrients. Light colored soils can be lacking in nutrients. Red soil has a high content of iron. Iron does not harm the plants directly, but red soils are dense, form crusts, and thus are difficult for roots to penetrate. (Gibbon, 12)

**Soil Texture:** Soil Texture affects the water holding capacity of soil. Soil is classified by it's content of each of the 3 sizes of soil particles which are: Sand, Silt, and Clay. A soil




that is a mixture of all three particle sizes is called a Loam soil. Loam soils are ideal because they combine good water holding capacity with good drainage. Clay soils have excellent water holding capacity and poor drainage. Sandy soils have excellent drainage, but poor water holding capacity.

**Soil Texture Test:** Take a lump of soil in your hand, and wet it. Sand cannot be formed, even into a ball. Loam soil can be formed into a ball, or rolled into a cylinder shape. Clay can be rolled into a thin cylinder and bent into a U without cracking.

**Soil Structure**: For ideal soil structure, soils require decaying plant material. This is called organic material, and provides not only nutrients to the soil, but a loose and spongy structure to the soil, which allows roots to penetrate easily, and tubers (i.e. potatoes, cassava) to grow. Organic material also improves the water holding capacity of sandier soils. (See Addressing Agricultural Problems: Yield, directly below for soil improving techniques).

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# Addressing Problems

## *Agricultural Problems*

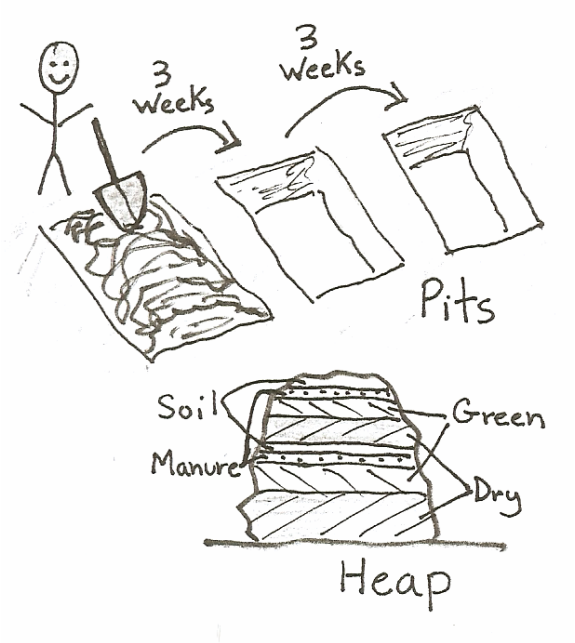
**Yield** Low yield occurs because the plant is not getting what it needs to grow. All of the plant and soil health problems listed on page 14-15 can cause a decline in yield. Look for suggestions below regarding the specific problems you find. However, your primary concern should be improving the quality of your soil, which increases the nutrient and water holding capacity, and will almost always translate to better yield.

- **Burning**: "Slash and burn" Many farming systems use a process where land is cleared, the green material burned, and then the crop is planted. The ash is a good source of P, K and minor nutrients, but burning vaporizes all of the Nitrogen (which is the most important for growth). The plants are able to get N from the rotting roots of the plants that were burned for approx 2 years, but after that, a sharp decline in yield requires the farmer to move to a new site. This system is only sustainable if the farmer has enough land where each site is revisited every 10 to 20 years. Returning too soon to a site means the ability of the land to support growth steadily declines over time. This contributes to deforestation. If done throughout a region, the climate and rainfall can be affected.
- **Mulch:** "Slash and mulch" This alternative to burning, has many beneficial results.
    - **How to:**
      Clear plant material from farmland, and lay it evenly across the ground, or pile it around the individual crop plants. Mulch should not touch the stem of the crop plants, or it may cause rot. Mulch should be at least 6 inches (15cm) deep,

but thicker than that is good. The layer of mulch closest to the soil will decay first. As it decays the mulch will get thinner, continue to add more mulch on top.

- **Benefits:**
  Fertilize- As the plant material decays it releases nutrients into the soil.
  Top Soil thickness- As it decays the mulch creates a nutrient rich organic layer to the top soil, which thickens it.
  Soil Structure- Mulch adds organic material to the soil, which improves aeration and water holding capacity. Mulch also absorbs the impact of rainfall, which prevents the formation of a thick crust on top of the soil.
  Soil moisture- The top-most layer of mulch absorbs the heat from sunlight, and shades the soil below, which helps keep moisture from evaporating.
  Erosion prevention- Rain hits the mulch and then slowly trickles down to the soil, giving it time to soak in. When the soil is saturated, the mesh of decaying plant material slows down run-off and helps prevent erosion.
  Weed suppression- A thick layer of mulch will block sunlight from reaching the soil surface, and keep weeds from sprouting.

- **Compost**: Decomposed plant material and kitchen waste makes nutrient rich compost, which can be added to the soil to improve nutrient content, and soil structure.
  - **How**: It is good to use different types and textures of materials in a compost heap. Having both coarse dry material, and green material is important. Manure adds nutrients and top soil provides the right micro-organisms.
    Compost Heap- Make a heap, with coarse difficult to decompose material at the bottom, and then layers of green material, manure, and a thin layer of top soil. After 2-3 weeks, the pile is mixed up. The coarse and dry material is then wetted, and put in the center of the heap as it is re-formed. Three weeks later the pile is mixed again. Mixing may need to be repeated a third time.




    Compost Pit- Dig three pits, approximately 50cm deep (18 inches). Follow the same layering technique from the heap technique. The top layer should be soil or banana leaves to keep water from evaporating. After 3 weeks, mix the compost, by putting it into the next pit (you can then put new composting

materials in the first pit). 3 weeks later, mix it and put it in the third pit. 3 weeks later, the compost should be ready to use.
Application- Apply compost around each plant, or dig a hole where each seed will be planted, and fill it with compost. This will make your compost go further than just spreading it evenly across the soil.
(Information from Agrodok 8 "Preparation and Use of Compost")

- **Benefits:**
  Fertilize- Compost is rich in soil nutrients.
  Top Soil thickness- Compost will thicken the top soil.
  Soil Structure- Compost adds decomposing organic material to the soil, which improves aeration and water holding capacity.

- **Manure**: Animal manure is full of plant nutrients, and can improve the health of the soil.
  - **Caution:** Adding raw manure directly to a plant can burn the plant. Also, manure should be handled and used with caution because it contains E. coli bacteria and other diseases. Do not use human feces, because it can spread deadly diseases.
  - **How**: The best way to avoid the negative effects of manure is to compost it first. The heat of the composting process will kill bacteria. If you choose not to compost it, you should mix it with some dry material like straw, rice hulls, dry leaves and stems, or saw dust, which will make it less potent, and less likely to burn the plants. Spread this mixture of manure and dry material around the plants, or dig a hole and place it in the hole with top soil before you plant your seeds.
  - **Benefits:**
    Fertilize- Manure is rich in soil nutrients.
    Top Soil thickness- Manure will add to the thickness of the top soil.
    Soil Structure- Manure adds decomposing organic material to the soil, which improves aeration and water holding capacity.

- **Green Manure**: Green manure is a term for the use of nitrogen rich plant material as a fertilizer, like manure.
  - **How**: Green manure is usually mixed into the soil. You can plant a cover crop of legumes (any bean plant) and then when it is time to prepare the field for planting, the cover crop can be tilled into the soil. You can do this with wild plants that are growing in the field (if these are weeds, be cautious, as tilling them under may cause them to spread), and you can also do it with crop residue. Everything that is green has nitrogen in it, and you can capture that nitrogen in your soil by letting that green material decompose.
  - **How is this different from Mulching**? Green Manure is buried in the soil, similar to animal manure. Mulch is placed on top of the soil. Green Manure puts nutrients into the soil more quickly than mulching. But those nutrients are also used up quickly as the decomposers in the soil break them down. Mulching has a longer lasting effect. These two techniques can be used simultaneously so that you get the best of both!
  - **Benefits**:
    Fertilize- Green Manure adds soil nutrients.

Top Soil thickness- Green Manure will add to the thickness of the top soil.
Soil Structure- Green Manure adds decomposing organic material to the soil, which improves aeration and water holding capacity.

- **Legumes, Cover Crop, and Crop Rotation**: Legumes are plants that can take Nitrogen from the air, and put it into the soil. All beans are legumes. There are also plants like Kudzu and clover which are legumes, and legume trees like acacia, gliricidia, and leucaena.
    - **How**:
      Crop Rotation- You can rotate crops. This means you don't continue to plant the same crop on the same land, you switch crops each planting season, following crops that use a lot of nutrients (like corn and cassava) with legume crops (like beans or cowpea). This way the soil can regenerate some nutrients from the beans. However, most of the nutrients are still leaving the field since you harvest the crop, so you need to combine this technique with others.
      *Example:* In El Salvador they plant corn at the beginning of the season, after harvest they leave the corn stalks standing, and plant beans, which climb on the stalks like a trellis.
      Cover Crop- You can plant a legume which is not used for human food between your rows of food producing plants. This is called a cover crop. It will cover the soil, and act like a living mulch, having many of the same effects of mulch. If the cover crop starts to compete for light and water with your crop, you can slash it down, and use it as a mulch. Or you can grow your cover crop seasonally and till it under as a green manure.
      *Caution:* In dry climates, cover crop can compete with crop plants for scarce soil moisture.
      Multiple Crops- You can plant many crops together, a row of beans next to a row of corn for example. In this way the beans are helping to nourish the corn.
    - **Benefits**:
      Fertilize- Legumes add nitrogen to the soil
      Erosion Prevention- cover crops help hold the soil in place and prevent erosion
      Weed Suppression- cover crops shade the soil and compete with weeds, effectively suppressing weed growth once the cover crop is fully established

- **Fallow**: This is what farmers call it when they leave a field to rest for a time. Fallow allows the land to regenerate some of its soil nutrients because wild plants grow and die, and all of the nutrients remain on the farmland (nothing is harvested). Fallow is also good when disease and pest pressure is high. Many pests and diseases of crops require those crops to be present for the pest and disease to thrive. If the land is left fallow for a time, many pests and diseases die off.
    - **How**: Leave the land alone for at least a year.
      Fallow with Cover Crop- If you plan to be coming back to the land in a short time (one or two years), you do not want wild weeds to take over and leave their seeds behind. You can discourage this from happening by planting a

cover crop of a legume plant. Do not mix it into the soil like you would with green manure. Just leave the cover crop, and let it take over for a year or two. When you come back to farm the land again, use the cover crop as a green manure or as a mulch, or as the bulk of a compost heap. Do not let all that good plant material go to waste!

Long term Fallow- If the land has been farmed for many years, and you are having difficulty getting yield to improve, even with other techniques, you may need to leave the land alone for 7-10 years. In that period of time, the forest will begin to re-grow, and the land will recover. For a long term fallow, you don't need to worry about weeds, just allow nature to do what it will.

- **Benefits**:

  Soil Nutrients- the process of fallow increases the quantity of nutrients in the soil.

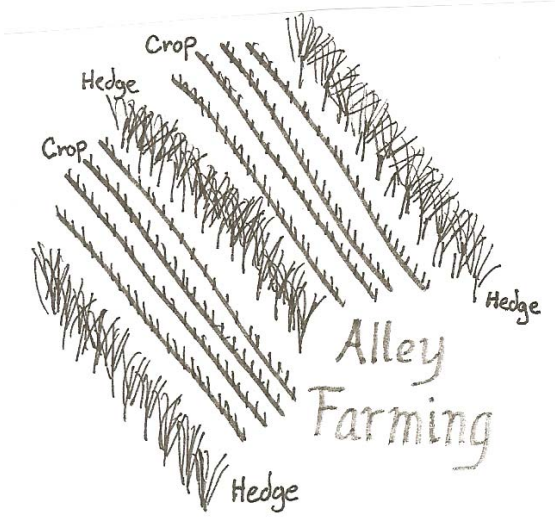
  Top Soil thickness- The top soil will thicken over a long fallow period

  Pests and Diseases- Fallow periods will cause pests and diseases of crop plants to die or leave the area. This is especially true of Nematodes (microscopic worms that feed on crop roots), because they are crop specific. Fallow is the best way to deal with nematodes.

- **Alley Farming**: This is a system of farming where crops are planted in swaths (alleys) between hedgerows. The hedges are generally a multi-purpose tree or shrub that is a legume. When the hedges get tall enough that they are interfering with the crop for light, they are slashed down, and the prunings used for mulch (or livestock feed). The roots of the hedges grow deep into the soil, and have access to nutrients that the crop plants cannot reach. These nutrients are put into the stems and leaves, which are then used to nourish the crop (as mulch), or livestock.

  - **How**:

    Hedge row plant selection- You want to choose a hedge row that meets your specific needs. Look for a plant that is readily available locally. Good hedge plant traits include: deep rooted, legume, fast growing, edible to livestock, firewood, medicine, human food.

    Here are some common choices:

    *Leucaena* is a legume tree and is probably the most popular hedgerow tree in alley farming. It is fast growing, can be used to feed livestock, and can be used for firewood.

    *Gliricidia* is also a legume tree and can be used for livestock and firewood.

    *Pigeon Pea* is a legume shrub. The beans can be harvested for human or pig feed, and the leaves can be fed to livestock or used as a mulch

*Moringa* is not a legume, but is very fast growing, and its leaves have exceptional qualities as human and livestock food and medicine, as well as making a highly nutritious mulch. (see Moringa on page 35)

Plant Spacing: Hedge rows should be planted at least 5 meters apart, and parallel to each other. The spacing may have to be adjusted for your specific location. Plant hedge rows east-west so that the crops planted between the hedges will have maximum sun exposure.

Contour Planting: If you are putting alleys in on sloping land, you should plant them along the contour of the hill to prevent erosion (See Contour Planting on page 30 for more detail). If planting on the contour, your rows will not be straight, and the distance between the rows will vary.

Pruning: The hedges should be pruned back severely as soon as they are competing with the crop plants for water or light. They may need to be pruned more than once in the growing season. The prunings should be laid down as a thick mulch. You can also use the prunings to feed livestock, but if you do this remember that you are taking Nitrogen and other nutrients out of the field, and you need some plan to replace that lost nitrogen (legumes, manure, mulch, compost, etc).

Alleys for Livestock: You can establish an alley system for livestock exclusively, or rotate grazing and crop growing. The hedges act as edible fencing. Between the hedges you have grazing space. The end of the alleys can be blocked off, and you can practice rotational grazing to reduce parasites, and improve pasture growth. The hedges can be cut for feed during the dry season when the grazing land is dry.

- **Benefits**:

  Mulching- hedges provide a nutrient rich mulch (see mulch benefits page 16)

  Soil nutrients- deep rooted legume hedges access nutrients deep in the soil and put nitrogen in the soil.

  Slow the spread of pests- hedges form wind breaks that slow down the spread of pests on the wind

- **Mixed Cropping**: Mixed cropping is where you plant different types of crops together. You can choose crops that are beneficial to each other: like legumes alongside crops that use a lot of nutrients. You can also combine tree crops with row crops. In this way you produce different types of food for your household, and the different types of plants are beneficial to each other.
  - **How**:

    Tree orchards and row crops – When a tree crop is planted, it is generally spaced so that the trees form a solid canopy. In mixed cropping, you leave a little more space between the trees so that light can penetrate to the "understory". Choose crops that tolerate shade. Collards and cabbage grow well in partial shade, which protects them from wilting. Ask local farmers what else grows well in shade. Rotating legume crops or cover crops in the understory will help replenish nutrients, and suppress weeds.

    Legumes and row crops – planting legumes alongside row crops (like corn or cassava which strip nutrients from the soil), will produce higher yields in the row crop, and protect your soil from severe depletion of nutrients during the growing season.

Gardening **–** Many small subsistence farms are grown in a garden style, with different crops together in the same plot, planted at different times to stagger harvest dates.

- **Benefits**:
  Soil nutrients- combing legumes or tree crops with row crops increases the amount of nutrients available to the crops.
  Pests and diseases – having different crops next to each other reduces the incidence and spread of pests and diseases.

- **Permaculture**: Permaculture means permanent agriculture. The idea is to create a system that is self-sustaining, and so can continue to be farmed permanently.
  - **How**: Permaculture requires very in-depth design, which often comes about only after many years of farming.
    Layout- the fields are laid out according to the amount of labor required. Livestock that are handled often, are kept close to the house, next vegetables and tree crops, next staple crops, next pasture, and last trees for timber production. Wells are dug near the location where the water will be needed.
    Systems- Systems are planned for composting, mulching, and utilization of manure. Also plants, crops, and pastures are planned to be able to feed livestock throughout the year. Crop rotations are planned to replenish the soil, and also to provide the right variety and enough quantity of food for the family. Crops are also chosen for their suitability for the time of year (wet season and dry season crops), and seed and plant material is saved so that future crops can be planted.
  - **Benefits**:
    Sustainability- if planned and implemented appropriately permaculture is able to be sustained for very long periods of time.
  - **Caution:** intensive design planning does not fit into every culture. Also, because each year is different, and the climate is always changing, agriculture does not function well in rigid systems.

- **Fish Pond with Farming**: In areas with pronounced wet and dry seasons, fish ponds can be used during the wet season, and when they are empty in the dry season, vegetable gardens or crops can be planted in them. Fish ponds can also be used in conjunction with swamp rice farming, where nutrient rich water from the fish ponds is drained into the rice paddies to fertilize the rice.
  - **How**:
    Fish pond construction- (see Agrodok 15 “Small Scale Freshwater Fish Farming”, Resources page 6) Build fish ponds in low locations, clay soil works best for making the walls and bottom of the pond. The pond should be naturally filled by a stream or ditch, and also be able to be drained.
    Fish pond gardening- In the wet season, crops can be planted around the fish pond. When the dry season comes, the pond is harvested, and the water is drained or dried up, then vegetables or row crops can be planted in the bottom of the pond, where the soil will be rich in nutrients, and will have moisture in the soil longer into the dry season.
    Fish pond and rice- fish ponds can be built just above (or before) rice paddies. This takes planning, you will need a channel that by-passes the fish pond to

feed the rice paddies, and the ability to block this channel to fill the fish ponds. Expensive dykes are not necessary, you can divert water by filling up the channel with sand bags. When the fish ponds are harvested the nutrient rich water can be drained into the rice paddies. Or some water from the ponds can be drained, and the ponds refilled regularly during the fish production cycle.

- **Benefits**:
  Nutrients- These systems take advantage of the nutrient rich water which is a by-product of fish farming.
  Prevent Pollution- nutrient rich water that is dumped directly into streams can have an adverse affect on the water supply and ecosystem by increasing algae and bacteria blooms. Using rice to "harvest" the nutrients out of the water is good for the ecosystem and the rice!
  Water Conservation- In the dry season you make use of the soil moisture that exists at the bottom of the recently drained fish pond.

## Pests

**Chemical Pest Control:** Chemical pesticides are dangerous to handle, and expensive. They usually kill beneficial predator insects, as well as the pests. When handled, mixed, or applied improperly they can cause serious illness and pollute the environment. (See Agrodok 29 Pesticides Compounds Use and Hazards, Resources page 6).

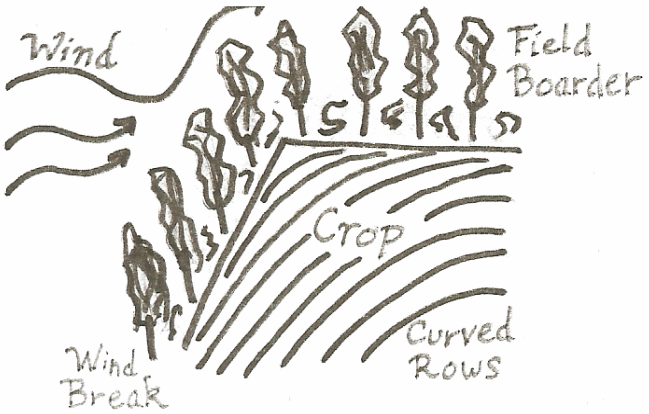
**Non-Chemical Pest Control:** See Agrodok 30 "Non-Chemical Crop Protection" for more information (Resources page 6). The remainder of this section on Pests, deals only with non-chemical pest control.

**Observation:** Pest control often requires critical thinking and observation. Observe the pest in question. How are the pests attacking the crop? Where do the pests live? How do the pests reproduce? Observing the pests will help you to determine what they are, how they hurt the plant, and maybe how to stop them! You may observe predator insects that attack the pest, and learn about how to encourage their growth.

**Biodiversity:** This means that you have many different species of plants, insects, birds, and animals on your farmland. This diversity of living things helps to maintain the natural balance in pest pressures. Different plants provide habitat for different types of insects, and increases the number of predator insects (which feed on the pest insects).

**Farming Techniques**

- **Curved Rows**: This confuses the pests, slows down the spread of pests, and maximizes the use of space.
  - **How**: Rather than drawing out rows in perfect lines, lay out rows in a curved pattern that follows the shape of the field.



- **Windbreaks**: Many pests travel on the wind, which carries them to your field.
    - **How**: Plant windbreaks around your field, and in the field, to slow the spread of pests. You can grow leguminous trees as windbreaks, and also get the benefit of improving the soil. (See "Alley Farming" page 20)
- **Field Borders**: Field boarders can be chosen that attract pests away from the field, "trap boarders" or you can choose borders that repel pests. (Agrodok 30 Non Chemical Crop Protection).

    **How**: Plant repellant plants around the field as a boarder, or in rows through the field. You can also alternate between repellant plants and trap plants as a cover crop. This creates the "push-pull" effect where insects are pushed away from the crop, and attracted toward the trap plant at the same time. (Agrodok 30 Non Chemical Crop Protection).

    Repellant Boarders – Here are some plants that repel pests:
    - **Lemon Grass**- planted in the field, it repels some insects
    - **Desmodium**- planted in the field, it repels some species of moth caterpillars
    - **Corriander**- Planted in the field, it repels whitefly

    Trap Boarders – Here is a plant that traps pests:
    - **Napier Grass**- Planted at the border of the field, it attracts moths to lay eggs, then traps caterpillars when they begin to feed.
- **Predator Habitat**: Field boarders can serve as habitat for predator insects. Observe the populations of insects in your field. If there are few or no predators, you may not have enough biodiversity in your field. You can try mixed cropping, strip planting, or more diverse crop boarders.
- **Crop Rotation**: Pests are often crop-specific. By switching crops, you interrupt the life cycle of the pest. (See "Crop Rotation" on page 19).
- **Strip Planting:** Crops are planted in strips, alternating between strips of different crops, and a regenerative grass/legume mix or cover crop. (See "Strip Planting" page 32). This increases biodiversity.
- **Multiple Cropping/Mixed cropping**: By planting crops mixed up together, or in rows side by side, you are increasing the biodiversity of the field, which makes it more difficult for pests to spread, and increases habitat for predators.
- **Increase Soil Nutrients:** Healthy plants can better withstand pest damage. See yield increasing techniques beginning on page 16.

**Local Remedies:** Always ask local farmers what they use to kill pests. They may have local plants and recipes for making them into pesticides.

**Pesticide Recipes:** Homemade pesticides kill beneficial predator insects as well as pests, and should therefore be used sparingly. Effective, safe to use pesticides, can be made from a number of common plants. Soap is often an main ingredient of such pesticides. CAUTION: farmers should take great care when formulating homemade pesticides from substances that are toxic to humans like: tobacco or castor oil (information from Agrodok 30). Many natural pesticide recipes can be found online. The following are some of the many plants/products can be used to make pesticides:

- **Neem**- the leaf and seed of the Neem tree have a powerful compound which interferes with pest reproduction, but does not harm humans. (See

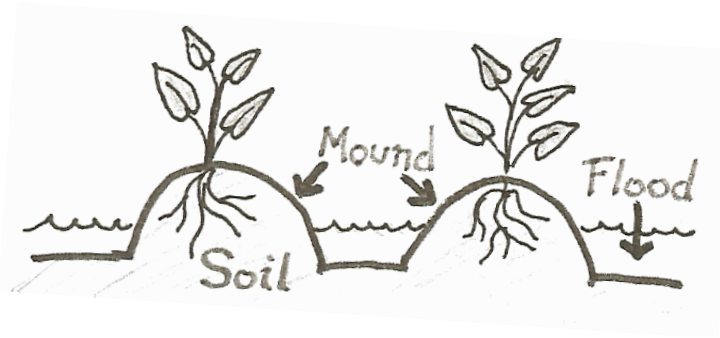
ECHO Technical Note on Neem, and Agromisa 30 “non-chemical crop protection” for more info). The leaf can be buried to kill nematodes, or made into homemade pesticide. As a development worker, you can obtain Neem seeds from ECHO free of charge (See Resources page 6).

- **Hot Peppers**
- **Papaya leaf**
- **Cinnamon oil**- Can be used as an insecticide. It kills many insects, including mosquito larva. Cinnamon oil comes from the bark of the Cinnamomum cassia tree, which grows in the tropics.
- **Onions**
- **Garlic**
- **Marigold**- leaves and flowers are used to repel pests
- **Wood Ash**- repels some pests
- **Milk**- can be used to make a fungicide
- **Chalk dust**- can be found naturally. When dusted on plants repels some small insects.

## Flood

- **Drainage Ditches**: Channel the flood water away from your crops.
  - **How**: Dig ditches (pick ax is the best hand tool for this). Keep in mind your ditch must lead to lower ground, and the bottom of the ditch must at all times be lower than the lowest point of the flooded ground. If flooding comes seasonally from a river, you may consider a levy building project.
  - **Benefits**:
    Flood prevention- Having a good drainage system prevents flooding, or shortens the duration of the flood.

- **Planting in Mounds or Raised Beds**: This technique raises the roots, or part of the root zone out of the flooded area.
  - **How**:
    Mounds- Till or hoe the dirt, and pile it into mounds: at least 30cm high, and wide, or whatever suits you. Plant one plant, or a cluster of plants in each mound (depending on your desired planting distance).
    Raised Beds- Till or hoe the ground, and form it into a long raised bed of soil. You can vary the height and width depending on the depth of flooding you expect, and the plant distance required.




  - **Benefits**:
    Protection from Rot- raising the root zone, can protect your plants from some flooding, which can cause rot.

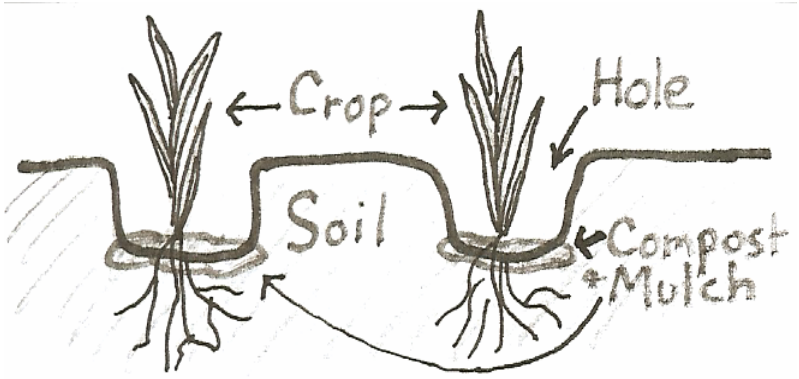
Protection from damage – planting in mounds also makes it easier to harvest tuber crops without damaging the tuber (because the soil is loose).

- **Crop Choice**: Choose a crop that does well in your area under flooded conditions.
  - **How**: Do not choose tuber crops, as tubers often rot in flooded conditions. Ask local people what crops can survive flooded conditions. Rice is the most common crop which tolerates flooded conditions. Some fruit crops, like Guava and Coconut also tolerate flooding well.

## Drought

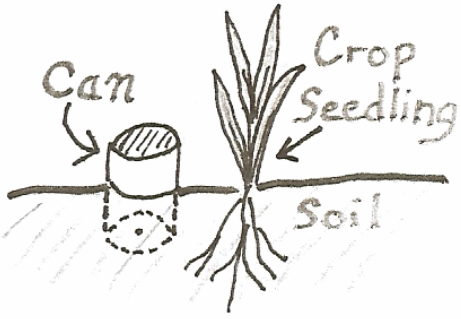
- **Early Planting**: By preparing seedbeds and planting before the first rain, you take advantage of the early rains, and get more growth. (Gibbon, 18-19)
  - **How**:
    Prepare the soil- At the beginning of the dry season, prepare your seedbeds. There is still some residual moisture in the soil at the beginning of the dry season, which makes the soil easier to till/hoe, and form into beds. (CAUTION: if wind erosion is a problem during the dry season, do not use this technique, because tilled soil will blow away more quickly)
    Plant the seed- Just before the first rain, plant your seed. This timing is important. Because the soil is very dry, the seed will not germinate, but leaving the seed in the soil for too long could lead to losses from scavenging birds, animals, and insects.
  - **Benefits**:
    Maximize Rainwater Use- Most farmers wait until the first rain to till the soil, because after the dry season it is hard. By the time the seed is planted, much of the water from the first rain has soaked past the seed zone or evaporated. This technique makes use of that first rain, by staying ahead of the normal schedule. (as with every technique, test this on a small portion of the crop before implementing it across the whole crop).

- **Planting in Holes or Furrows**: Holes and furrows collect rainwater, and move the root zone deeper where there may be better water holding capacity. By adding decaying plant matter and compost to the holes, you concentrate the nutrients at the plant root zone, and encourage worm and termite activity, which increases water penetration into the soil (info from Amaranth to Zai Holes see Resources, ECHO page 6)



- **How**: Furrows:
  Dig furrows that follow the contour of the hill (see contour planting), so that water does not run off. Dig channels that direct run off to your planting area. Dig/form basins which collect rainwater, and plant trees or groups of plant in the bottom of the furrows.
- **How**: Zai Holes: (info from Amaranth to Zai Holes Chapter 7)
  Dig a hole- Dig a hole for each plant at the beginning of the dry season. You can vary the size of the hole, but the recommendation is 20cm in diameter, and 10cm deep. If the top soil is very thin, you may want to dig the hole a little deeper, and then put the top soil back into the hole.
  Mulch - Fill the freshly dug hole with mulch (crop residue works), and some manure if available. The mulch adds nutrients, and encourages termite activity, which will increase rainwater penetration.
  Plant- Plant your seeds in the hole after the first rain, or irrigate.
- **Benefits**:
  Maximize Rainwater use- holes and furrows collect water, delivering it to the root zone, and termite activity increases penetration of the water.
  Wind break- If wind damage is a problem, the hole helps protect the seedling from the wind.

- **Tin Can drip irrigation**: If water is precious, drip irrigation makes better use of limited water resources, by concentrating the wet zone, and not allowing any run off. When drip hose is not available, you can use a tin can.
  - **How**:
    Collect materials- Choose a small container that can be readily found. Also collect something that can be laid across the top of the container as a lid (this could just be a rock). You can experiment with sizes of containers. A tin can, or soda can size container works. Poke a hole in the bottom of the container. The larger the hole (or more numerous the holes) the quicker the water will drain out. Or you could poke a hole on the side near the bottom, and point the hole toward the plant.

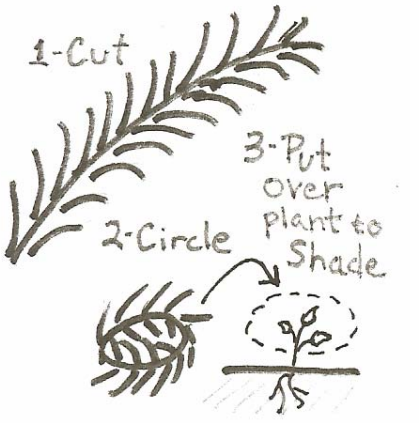
    Half bury the container- You can plant the container next to your seedling, or plant. Bury it at least half way up the container, so that the water leaks directly into the root zone.
    Water the plant- to water your plants, just fill the can with water, and place a rock/lid over the top to prevent evaporation. The surface of the soil will remain dry.
    When? This technique can be used to establish trees and plants during the dry season, and can be used for supplemental irrigation during the growing season.
  - **Benefits**:
    Water Conservation- water is delivered directly to the root zone of the plant,

and only there, so that it is efficiently used.
Reduced labor- after the initial labor of installation, the time it takes to water your plants, and the amount of water you have to haul is significantly reduced.
Weed prevention- because the surface remains dry, not as many weed seeds will germinate.

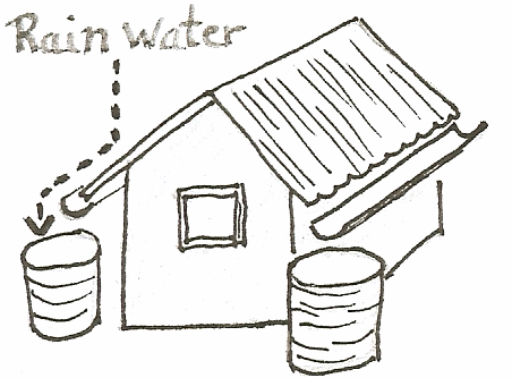
- **Erosion Control**: Erosion is a complete waste of valuable rainwater in dry climates. See Erosion page 30 for more ideas, including Contour Planting.

- **Mulch**: Mulch covers the soil and protects the soil surface from the strong rays of the sun. It also prevents erosion, so more rainwater penetrates the soil.
    - **How to:**
      Clear plant material from farmland, and lay it evenly across the ground, or pile it around the individual crop plants. Mulch should not touch the crop plant stems as it may cause rot. Mulch should be at least 6 inches (15cm) deep, but thicker than that is good. The layer of mulch closest to the soil will decay first. As it decays the mulch will get thinner, continue to add more mulch on top.
    - **Benefits**:
      Soil moisture retention- protects the soil surface from drying out
      Rainwater penetration- prevents erosion, so more rain soaks in
      See Mulch Benefits- page 16

- **Shade**: Shading the soil surface and plant from the sun reduces evaporation of soil moisture and reduces sun burn and withering of the plant..
    - **How**: There are many ways to make shade. Look for what materials are most readily available in your area.
      Braches- Branches of trees (leaf trees or palm trees) can be used to make shade. Stick the branch in the soil next to the plant so that the leaves provide shade. Individual shade huts can be formed by cutting up palm branches, and then bending the pieces into a circle and placing it around the plant (See Diagram).
      Shade structure- a thatched shade structure can be built over the plants (this is more labor and material intensive).
      Mulch- see mulch above.
      Alley Farming- see alley farming page 20.
      Trees- Combining tree crops with row crops, provides some shade to the row crop. The trees can be pruned back some during the rainy season so that they don't shade the crop too much. See "mixed cropping" page 21.

      
      
    - **Benefits**:
      Water Conservation- Keep rainwater from evaporating.
      Yield- Protect plants from sunburn, wilt, and die-back, which will reduce yield.

- **Rooftop Rain Catchments**: Every roof has the potential to collect rain in dry climates, but the supplies can be expensive.
    - **How**:
      Build a Gutter- construct a simple gutter and attach it to the edge of the roof. This can be made out of any sturdy surface that can be bent into a U, or is U shaped: large bamboo cut in half, strips of metal roofing, pipe cut in half, hollowed out wooden poles, etc. Slope the gutters downward toward to a common location.
      Obtain a tank or barrel- (tanks and barrels can be difficult to come by or expensive). Place the tank or barrel at the place where water runs out of the gutter. The tank, barrel should have a lid to protect from evaporation when it is not raining.

      
      
    - **Benefits**:
      Water conservation- Collect precious rainwater, make use of existing structures

- **Crop Selection**: Choosing the right plant is critical. Some plants are more drought tolerant than other plants.
    - **How**:
      Trees- Established trees have deep roots, and are more drought tolerant than crop plants. Some drought tolerant tree crops: Date Palm, Moringa, Cashew, Pomegranate, Dove plum, Karanda (Amaranth to Zai Holes Chapter 7).
      Crops- Millet and Cassava are both drought tolerant food crops.
      More- For more crops, read chapter 7 of Amaranth to Zai Holes available for free online. See Resources, (page 6) for website information.
    - **Benefits**:
      Increased success- By choosing a plant that does well in your conditions, you increase the success of your crop production.

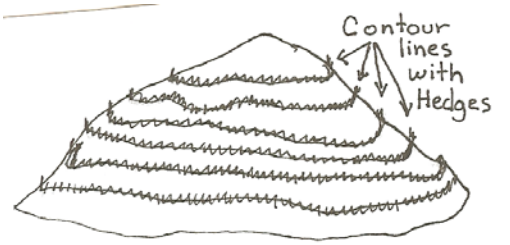
- **Household Water Conservation**: Save the water you use in your household.
    - **How**: Collect water you have used for dish washing, laundry, or bathing and use it for watering the garden.
    - **Benefits**:
      Water Conservation- Make use of existing water.

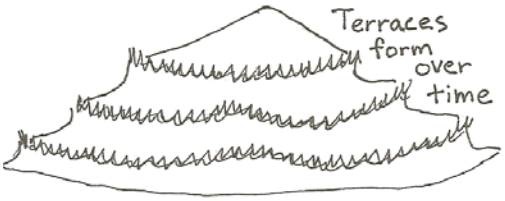
- **New Water Sources**: If water conservation isn't enough, you need access to new water sources. Wells, and reservoirs can be constructed, but usually at a great cost.

- **Fish Pond with Farming**: See "Fish Pond with Farming" (page 22).

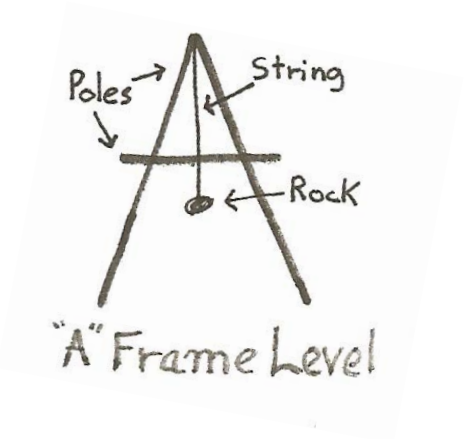
## Erosion

- **Mulch:** Mulch covers the soil and protects it from erosion and has many other benefits.
    - **How to:**
      Clear plant material from farmland, and lay it evenly across the ground, or pile it around the individual crop plants. Mulch should be at least 6 inches (15cm) deep, but thicker than that is good. The layer of mulch closest to the soil will decay first. As it decays the mulch will get thinner, continue to add more mulch on top.
    - **Benefits:**
      Erosion prevention- Rain hits the mulch and then slowly trickles down to the soil, giving it time to soak in. When the soil is saturated, the mesh of decaying plant material slows down run-off and helps prevent erosion.
      See other Benefits – Page 16

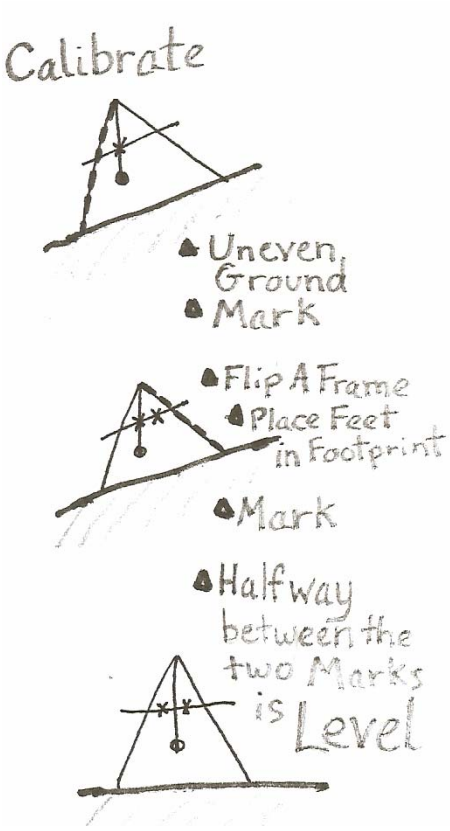



- **Contour Planting**: By planting along the contour of a hill or slope, you can control run off, capture more rainwater, and prevent serious erosion. Over time, natural terraces will form.
    - **What is a contour?** A contour line is essentially a level line that goes in and out according to the shape of a hill. The contour of the hill is always perpendicular to the flow of the run-off water. Every point along the contour line is at the same elevation. So if you plant along the contour, the plants and their roots act as a barrier to run off. When the run off water encounters the barrier, it would usually flow left or right along the row toward the lowest point, but because every point is the same height, the water slows down. When the water slows down, it drops the soil it is carrying, and more of the run-off water soaks into the soil.
    - **How**:
      Mark the Contour- It is important that the contour be actually level, and not just a guess at level.
      Construct an A Frame Level: You can construct a simple tool, called an A frame level. Collect three long straight strong sticks/poles (at least 1 meter long), a rock, a string, and a few nails. Nail the three poles in the shape of an “A”. The width of the bottom of the “A” should be the same as your planting distance,



or a multiple of your planting distance (example, for trees on a 3 meter spacing, make your frame 1.5 meters wide, and only mark every other time, or plants spaced 10cm apart, make your frame 1 meter wide, and know that you are marking every 10th plant). When the frame is nailed together, tie the string to the top point of the "A". The string should hang past the cross bar of the A. Tie a rock to the bottom of the string. (see diagram). If the A frame is not stable, cut and nail an additional crossbar lower down.




Calibrate the A Frame: Place the A Frame on slightly uneven ground. Mark the places on the ground where the two feet of the frame sit. Then mark on the crossbar the exact place where the string touches it. Carefully lift the A frame, turn it around, and place the first foot in the place where the second foot was before, and the second foot where the first foot was. Now mark where the string touches the crossbar. Measure between the two marks on the cross bar you just made, and make a larger mark half way between the two marks. This larger mark is your level indicator. When the two feet of the A Frame are at the exact same level, the string will hang down and touch this center mark on your cross bar.

Use the A Frame: Mark where you want your first plant to go on the contour line you intent to mark. (Sticks with a sharpened end work well for marking.) Place one foot of the A Frame next to your first marker. Move the second foot of the A Frame around until the string rests exactly where your calibrated center mark is on the A frame. Mark where the second foot is with another stick. Continue until you reach the end of your row. The row will look messy, in a zigzagging pattern. But you will notice as you walk the line you have marked, you never take a step up or a step down, you have marked a perfectly level line.

Plant along the contour: Prepare your raised seed bed along the contour line, and plant along the row you have marked, according to the plant spacing requirements.

Walls/barriers: You could also build a short rock wall along the contours leaving space between the contours for planting. Or you could dig ditches along the contours, and pile the dirt along the contour to make a barrier. These walls or barriers will interrupt the flow of water down the hillside, and slowly with time (if you repair and build up the barriers after the rains) erosion between the barriers will cause natural terracing.

Alley Farming: Combine contour marking with Alley Farming (page 20). Plant hedges (closely planted shrubs or trees) along contour lines. Leave space between hedge rows to plant your crop rows. The roots of the hedge provide greater stability to your slope, and the leaves can be used as mulch (or as a crop or livestock forage when appropriate plants are selected). With time

(depending on rainfall) the hillside will erode between the hedge rows, to form natural terraces on the hillside.

- **Benefits**:
  Erosion Prevention- Without erosion, the top soil with thicken, more nutrients will remain on the hillside, and yield will improve
  Rainwater Capture- Without prevention, approximately 90% of rainwater that falls on a slope, runs off, leaving only 10% of the rainwater that soaks into the soil profile. With hedges planted along contours, this statistic is reversed, approximately 90% of rainwater is retained on the hillside. (info from Alley Farming of the Tropical Agriculturalist Series)

- **Strip Planting**: A modification of "Contour Planting" above. (Agrodok 11, Erosion)
  - **How**: Plant in strips across a hillside following the contour approximately. Strips can vary in width, starting around 5 meters. Alternate between strips of crops, and strips of grass/legume mix. The grass legume mix fixes nitrogen, and reduces erosion. This method can then become "Crop Rotation" or "Fallow" (see page 19), if every couple years, you switch the strips: cultivating the grass strip, and leaving the previously cultivated strip to be "cover-crop" (page 19).
  - **Benefits**:
    Prevent Erosion- The strips of grass hold the soil in place, and slow down the flow of water down the hillside.
    Soil Fertility- The legumes, and the method of crop rotation improves the fertility of the soil, and reduce soil pests.

- **Reduce tillage**: Tilled, loose topsoil is easily carried away by erosion.
  - **How**: Reduce tilling as much as possible. Leave the stubble in place from the last crop, and till just where you intend to plant.
    Caution- Weeds may become a problem in this method. Slashing down the weeds, and using them as a mulch may work effectively to suppress weed growth.
  - **Benefits**:
    Reduce erosion

## Urban Agriculture

Where there is very little or no arable land for agriculture, people can still grow their own food. Plants can be grown in containers on roofs and in courtyards, in small raised beds, or even on discarded carpets. See Agrodok 24 "Urban Agriculture" available to download for free, for more specific information (Resources, page 6).

- **Safety**: There are major dangers involved in Urban Agriculture. Pollution like heavy metals, harmful chemicals, and dangerous bacteria and other disease pathogens can be found in the soil and the water in an urban setting. ALWAYS use soil you know is safe i.e. soil you have composted yourself, and use water you know is clean.
  - **Read**: Read Agrodok 24 "Urban Agriculture" (Resources, page 6), for more safety tips.

- **Compost**: See composting on page 17. Compost is critical in urban agriculture, because you can make your own soil, and be sure that it is free from dangerous pollutants and disease pathogens. After you have used the compost/soil once (harvested the crop), discard the soil. The used soil will be exhausted of nutrients, and possibly be infected with plant pathogens or pests.
    - Start fresh with new compost each planting cycle.

- **Containers**: Growing crops in containers is a great way to produce food in an urban area.
    - **How**: Many different things can be used as containers: plastic or metal containers of many sizes, tires, plastic bags, sacks, canvas, wood, or anything else you can find.
      Fill the container with compost/soil, and make sure that there is a hole in the bottom for drainage.

- **Carpet**: If soil is not available, or if you want to make your crop mobile (ie, an herb garden you can take to the market). It is possible to grow plants on a discarded carpet.
    - **How**: A carpet with longer fibers (i.e. shag carpet) works best. Germinate your seeds, and start your plants in compost/soil, then transfer them to the carpet. The roots grow into the carpet, which you will need to water often, and include fertilizer in the water (or use compost tea, or some other homemade liquid fertilizer). You will need to cover the carpet with something to help keep the moisture in and to give support to the plant stem: this could be a mulch of plant material, or even something like ground up tires, or empty soda cans. Plants will not grow as well using this system as they would in a container of soil/compost. (Technique seen at ECHO's demonstration garden, see Resources).

## Storage and Preservation of Food

Common spoilage of stored food is caused by mold/decay, physical loss, rodents, or insects. It follows that dry, well ventilated, well contained storage, with rodent and insect prevention would be ideal.

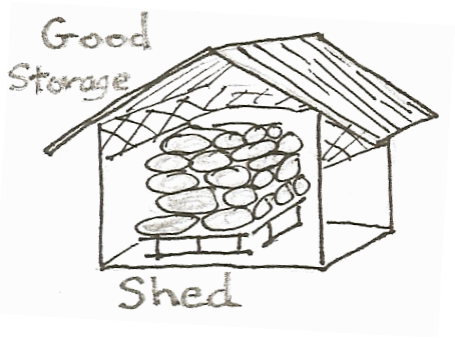
**Preservation Techniques**: Food can be preserved in many ways: drying, smoking, salting. There are usually preparation steps like: milling, chopping, skinning, removal of seeds from fruit. See Resources page 5-9, for more sources on preservation techniques.

**Common Storage Locations**:

- **Sack**: Grains, seeds, and other dried food for storage are commonly kept in rice sacks (large woven plastic sacks). The weave in the sack allows some ventilation, and also some water resistance.
  Benefit: It reduces physical loss by containing the food in a bag.
  It deters rodents and insects by containing the food (no spillage to attract pests).
- **Attic**: Food can be stored in stacks in an attic storage place. The ideal roof design would allow for some ventilation through the walls and floor of the attic, and provide protection from the rain.
  Benefit: Good ventilation and protection from moisture reduces mold.

- **Storehouse or shed**: A storehouse is a separate building where food is kept. Sometimes food is kept in heaps (which attracts rodents and insects, and can cause spoilage from mold). The best way to prevent physical loss (through trampling and wind), and to deter pests and prevent mold, is to store food in sacks, stacked on pallets (or some rack which allows some ventilation under the sacks). The pallets should be kept away from the walls, and away from areas where rainwater comes into the building. The storehouse should always have a good roof, and good cross ventilation.
  Benefit- Keeping food in a separate house allows the subsistence farmer to have a better control over the environment where they are keeping the food.
- **Tank**: Tanks are prohibitively expensive in most places. However, where available, they prevent rodent damage, and keep the stored food water tight. Caution: ventilation does not exist in a tank, so if there is any residual moisture in the food that you are attempting to store, it can mold
  Benefit: Prevents rodent damage, and damage from rain.

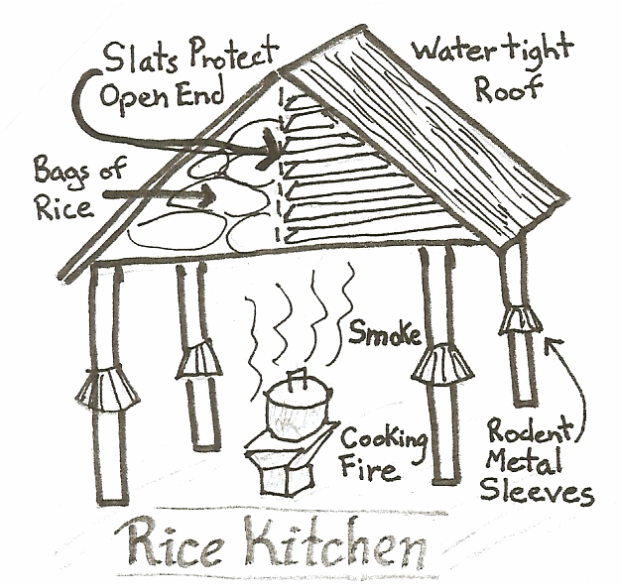
**Pest Prevention Techniques:**




- **Rodent Prevention**:
  - **Cleanliness and Containment**: Contain food items, so that they are difficult or impossible for rodents to penetrate. Keep the store area clean, with open areas around where the food is kept. Spilled food attracts rodents. Rodents like to stay hidden, so keeping food in the middle of the store room, with space around it will deter them (but only slightly).
  - **Elevated storage with metal sleeves**: Rodents cannot climb metal surfaces. You can build a store shed on stilts, and surround each leg of the shed with a narrow sheet of metal (this metal sleeve must be wide enough that the rodent cannot jump past it. You can also fashion the metal sleeve in the shape of a cone with the larger end pointed down.
- **Rodent Extermination**:
  - **Predators**: Keep cats, or other domestic animals that will hunt rodents
  - **Mechanical Traps, glue traps, poison**: These and other local rodent extermination techniques are often available in a local market.
- **Insect Prevention**:
  - **Smoke**: Smoke from a wood burning fire is a deterrent for many insects. Smoking can be done by building a fire under an elevated storage shed, or by wafting smoke into a storehouse or attic.
  - **Neem leaf**: The leaf of the neem tree is a natural insecticide, but is not harmful to humans. You can dry neem leaves, crumble them, and mix them into your sacks of dry food to deter insects. (see Neem page 24)
  - **Local Plants and Remedies**: Ask local people what plants or methods they use to keep insects away from their food.

**Example Storage System:**

- **Rice Kitchen**: This is the local way of storing rice in Liberia.
    - **How**: An open sided shelter structure is constructed on four poles. The roof will be the shelter both for the food storage attic, and for the kitchen area which will be set up under it. A water-tight tin roof, or a thick thatch roof is constructed, and a support for the ceiling is built under the roof out of poles, and a woven grass/reed mat. The sides of the roof face the prevailing wind direction. The roof has a good overhang. The open ends of the roof provide ventilation, and can be protected from rain by erecting slats of tin roofing, or a grass/reed mat. Finally, metal sleeves can be put on the four poles of the structure to deter rodents. The act of cooking on a fire every day, keeps the rice storage attic dried out, and makes smoke, which seeps into the attic, and deters insects.




    - **Benefits**: Combination mold, rodent, and insect prevention. Makes use of fire and smoke which must be made daily for a different purpose (cooking).

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## *Nutritional Problems*

It is not within the scope of this booklet to fully address nutritional problems. I advise you to see Where there is no Doctor available for free download (see Resources page 7). However, I will make two important suggestions.

**Vegetables-** Vegetables are higher in nutrients than cereal/staple crops. Vegetables generally require less labor than cereal/staple crops to grow, and can be grown in gardens by children, mothers, and the infirmed (all of whom need extra nutrition).

**Moringa-** The Moringa tree can be effectively used to treat malnutrition. Moringa leaves are highly nutritious with up to 30% protein by dry weight. They are also high in vitamins and minerals. Mixing the leaf powder into already cooked meals does not change the taste, but greatly increases the nutritional content. Moringa is attributed with many medical properties including killing internal parasites, curing skin infections (even staph infections), and regulating blood sugar in diabetics. Moringa can also be used as a very nutritious green manure to fertilize plants, or as the main constituent in pig feed.

For more information, go to ECHO's website (see Resources page 6). Look up Amaranth to Zai Holes Chapter 4, or ECHO Technical Note on Moringa. Be sure to register with ECHO and order free samples of Moringa seeds (many other seeds are also available).

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## *Infrastructure Problems*

These problems affect the distribution, availability and cost of crop inputs and tools, as well as the feasibility of selling a crop. Infrastructure problems affect the ability of a country to develop commercial agriculture, or small-scale cash crop production.

**Transportation of Crop:** Crops grown in rural areas far from urban zones, cannot expand their agricultural production without a transportation system to get their goods to town. This requires investment by governments, and aid organizations in development of roads. Communities can engage in basic road improvement by maintenance of roads (filling potholes, clearing brush), and by widening footpaths by clearing vegetation.

**Processing Facilities:** Facilities that process crops (grain mills, dehydrating/drying, chopping, canning, or any other process) add value to a crop, increase its shelf life, and improve its marketability. Processing facilities require large investments for start up costs. Basic processing can be done in communities. Small portable milling or chopping machines could be purchased by a farming group with small business loans or grants.

## *Economic Problems*

**Labor:** The cost of labor is generally very low in a developing economy. But subsistence farmers that are trying to move into cash crop production can still not afford labor. Forming agriculture work groups, or cooperatives is an answer to this problem. Such groups exist in many rural communities, where a work group rotates from farm to farm. Since each person's farm benefits from the work group, the members do not compensate each other with money.

**Cost of tools/inputs:** The cost of tools and inputs is often very high, because anything that is not made locally must be transported in. Fertilizer, unless subsidized, is often prohibitively expensive. In place of fertilizer, yield improving techniques can be used, like mulching (see page 16). Encouraging local seed and tool production will lower the cost of inputs and allow subsistence farmers to increase their production.

**Credit/Loans:** Unavailability of loans is a major problem in most developing nations. Credit institutions can be unstable, prejudiced, or simply non-existent. Loans allow farmers to purchase livestock and needed inputs like tools and seed, which allows them to increase their production. With loans, farming groups can also purchase processing equipment, to add value to their product. Many NGOs and development organizations offer small loans for business and agriculture projects.

**Fluctuating Market Prices, Monopolies:** The uncertainty of fluctuating market prices makes it difficult for farmers to make a profit if selling their crop. If the market is volatile, farmers may decide not to plant cash crops, because of the fear or reality of not being able to sell the crop for what they have invested in it. Large monopolies in supplies, processing, importing, or exporting, can control and manipulate the market to their personal advantage. Such problems require national/political action.

## *Political/National Problems*

**Land availability:** (see Urban Agriculture page 32) Access to land for farming, in many ways is access to survival. Land issues are different in every region. In some places land is taken up by large businesses or private landowners, and little is available for subsistence farmers. In some places, large populations mean there is not enough land available for farming. In some places, land is held communally and the village elders assign land to people who wish to farm. Conflicts, wars, and genocide can be the result of unresolved land disputes.

**Political Instability:** When nations are going through conflict and instability, agriculture production drops. Farmers are afraid to invest in crops that might be looted or destroyed, or they are unable to plant crops because they must flee. Food aid is critical during times of conflict. After prolonged conflicts, seed, and livestock must be brought in to restore agriculture production.

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## Demonstration/Teaching Garden

See Agrodok 9: "The Vegetable Garden in the Tropics" available to download for free (see Resources page 6)

Before you start, keep in mind:

- All your techniques should be able to be applied by the average farmer
- Consider what is locally available and culturally appropriate in terms of supplies and crops.
- New techniques should be demonstrated alongside traditional techniques
- Be sure there is a source of organic material and manure for composting
- Make sure you will have labor to tend the garden (even on school holidays)

Choose a site:

- Near a water source
- Look for good quality soil, (see assessing soil health on page 15)
- In full sun
- Not too steep, not where it will be flooded

Size of the Garden:

- Consider your available labor, available land, and desired yield.
- Yield Approximation (Agrodok 9 Vegetable Garden in the Tropics)
    - leaf vegetables: 8kg/$m^2$/year
    - fruit vegetables: 10kg/$m^2$/year
    - fruit (fruit trees): 2kg/$m^2$/year

**Set up your Garden**

- Fence: You will want to fence your garden to discourage casual thieves, destructive livestock, and wild animals. Use local materials (or commonly used materials) instead of expensive fencing materials. This shows that expensive inputs are not required to make a garden.
- Clear the ground: slash down the weeds and brush, and set it aside for compost or mulch.
- Compost: use the materials you just cleared, as well as nutrient rich additions like crop residue, legume leaves, and manure, to make compost for your garden (see "Compost" on page 17)
- Till: Till your garden using a hoe, pick ax, and shovel, according to what breaks up the soil easiest.
- Beds/furrows: When the soil is loosened, it can be formed into your planting beds or furrows. If it is the dry season you will want to plant at the bottom of furrows or in

holes (see section on “Drought” page 26). If it is the rainy season and flooding is a possibility, use raised beds or mounds. (See Flood page 25)
- Lay-out your planting pattern so that there is room to demonstrate different techniques next to each other. (i.e. mulching of eggplant next to traditional farming of eggplant).
- Plant your seed directly in the field, or start them in a shaded place and transfer them to the field. Plant seeds at a depth approximately the same as the width of the seed. If the seedlings are wilting in the sun, they may need to be shaded by sticking a small branch with leaves into the soil next to the plant as a shade.
- Stagger your planting times so that your harvest lasts longer.
- Water the plants as needed. Try the water saving techniques listed in the “Drought” section (page 26)

**Maintenance**
- Watering as needed
- Weeding: remove weeds and their roots before they set seed. Weeds can be composted, or used as mulch.
- Pest control (see section on pest control page 23)

**Techniques to Demonstrate**
- Mulching (page 16)
- Compost (page 17)
- Cover crop or mixed cropping with Legumes (page 19)
- Plant a boarder of pest repellant/trapping plants, and leguminous trees for mulch production and to encourage biodiversity of insects (see “alley farming” page 20 and Pest Control page 23)
- Plant a variety of locally acceptable vegetables, and trees. (mixed cropping)
- If dry: (See drought page 26)
    - Zai holes
    - Planting in furrows
    - Tin can drip irrigation
    - Mulch
- If flood potential (See flood page 25)
    - Drainage ditches
    - Planting in mounds, raised beds
- If on a slope
    - Contour planting with hedges (page 30)
    - Mulch
- If infested with pests
    - Test different natural pesticide recipes

**Use your Garden**
- Use your garden as a teaching site
- The harvest:
    - Use the harvest to feed children at the school/orphanage/community
    - Have the participants split up the harvest
    - Sell the harvest and divide the money among the laborers
    - Be sure to save some of the seed from the harvest to plant the next crop.

## References

Gibbon, D. and Pain, Adam. Crops of the drier regions of the Tropics. Intermediate Agriculture Series. Logman, London. Pp12, 18-19.

All references referred to in this booklet are detailed in the Resources Section, page 5-9.

## About the Author

Robin Denney received a BS degree from the University of California, Davis, College of Agriculture and Environmental Sciences, with a major in Viticulture and Enology, and a minor in Political Science. She also took courses in the Applied Biological Systems Technology department. Robin has worked professionally in commercial agriculture in California and Australia. She studied tropical agriculture for a week at ECHO's demonstration farm and library in Florida. As a member of the Episcopal Young Adult Service Corps, she served for a year at Cuttington University, Liberia. At Cuttington she was an assistant on the university farm and a lecturer. While there, she developed a goat project and a sustainable vegetable/orchard project, and developed curriculum and taught lecture and lab classes in Introduction to Agriculture, Animal Husbandry, Introduction to Forestry, and Livestock Production Systems. She also worked with her students to develop a Moringa community health project through the development of 10 pilot community orchards, and worked with a local community on clean water, skills training, and sanitation projects.