Agrodok-series No. 9

The home garden in the tropics

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Agrodok 9

The home garden in the tropics

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First edition: 2008

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Printed by: Digigrafi, Wageningen, the Netherlands

ISBN Agromisa: 978-90-8573-087-3
ISBN CTA: 978-92-9081-380-4

Foreword

This Agrodok replaces ‘The vegetable garden in the tropics’, which treated the garden as a series of plots for the production of vegetable crops. In this edition, features such as hedges and trees and shrubs that give a garden its permanent character, come to the fore. Moreover, the emphasis is on ensuring that some vegetables (and other products) are available throughout the year, even where the gardener faces water shortage. In this way, the garden can contribute substantially to an improved diet for the family. Hence the focus is on hardy perennials; the more demanding annual vegetables take second place.

Acknowledgements
Lanre Denton in Nigeria, and Gerard Grubben and Rudy Schippers in the Netherlands reviewed the manuscript; their suggestions for improvements are greatly appreciated. Piet Scheepens gave welcome comments on crop protection aspects. The Royal Tropical Institute in Amsterdam kindly permitted reproduction of photographs in its Communication 69: Tropical leaf vegetables in human nutrition, by H.A.P.C. Oomen and G.J.H. Grubben, published in 1977.

Contents

1 Introduction

1.1 Outline

The main concern in agriculture in many countries has long been - and still is - food security: increasing the production of the major food crops, in particular the staples, mainly cereals. Most of these staples are energy foods: they still our hunger and provide the energy for our daily activities. In addition we need protective food - proteins, vitamins and minerals - which enable us to grow healthily. These protective nutrients are mainly found in meat, eggs, dairy products, fish, pulses, fruit and vegetables. For a balanced diet both energy food and protective food are essential, as explained in Section 1.2 below.

Unfortunately protective food is expensive. To buy ample quantities of protective food a family has to be fairly well off. But if you cannot buy it, perhaps you can produce it yourself. Protective food is vitally important for the health of you and your children, so it is worth the effort! AGROMISA and its partners try to help you: many Agrodoks deal with home production of protective food (see list on back cover).

Vegetables are an attractive source of protective food, as they yield relatively good crops, in a short period of time, on a small plot of land, without much investment. Which other source of protective food has these advantages?

This Agrodok is meant to help you manage a home garden so that you can gather some vegetables and fruits throughout the year without spending a lot of time gardening. General aspects are presented in Chapter 2. First garden crops are compared with field crops. This is followed by a comparison of home gardens and market gardens. There is considerable overlap between the two, but they also differ in important aspects. Traditionally home gardens flourish in wet climates, but in the last Section of Chapter 2 it is argued that there is great scope for home gardening in drier climates too.

The topic of Chapter 3 is setting up a home garden, using trees and shrubs to give the garden a permanent character. Chapter 4 deals with choosing trees and shrubs as well as annual vegetables to be grown. A great variety of crops is grown in home gardens, including fruits, spices, medicinal plants, forage, ornamentals. This Agrodok focuses on food crops in the garden, in particular vegetables. The emphasis is on ways and means to ensure that the garden does not collapse during the off-season. Without demanding undue effort there should be some produce to make the meals more tasty and nutritious throughout the year. Chapter 5 discusses soil management, including use of manure and fertilizers. In Chapters 6, 7 and 8 growing techniques are presented, from sowing to harvesting.

1.2 Fruit and vegetables in the diet

The food we eat can be broadly divided in energy-providing food and protective food. Our meals consist largely of energy foods supplied by the principal food crops: cereals, tuber crops such as cassava and tannia, cooking banana. These major crops are rich in carbohydrates (nutrients based on starch and sugars), which are burnt (with the oxygen we inhale by breathing) to provide energy. The energy is used both for our daily activities and for life processes in our body cells. Surplus carbohydrate is converted into fat, stored in the body as an energy source for lean periods. Fat or oil used in preparing meals reduces the amount of carbohydrate required.

Protective food is needed - in smaller quantities - for the maintenance of living cells and the growth of new ones. Meat, fish, dairy products and eggs contain most of the protective nutrients we need: proteins, vitamins and minerals. However, animal products are expensive (and vegetarians object to eating all or most animal products). This is where fruits and vegetables come in. The wide range of fruits and particularly vegetables (including pulses) provides all the protective food needed to supplement the energy foods we eat. They also add variety and taste to the meals, and are rich in fibre that aids digestion.

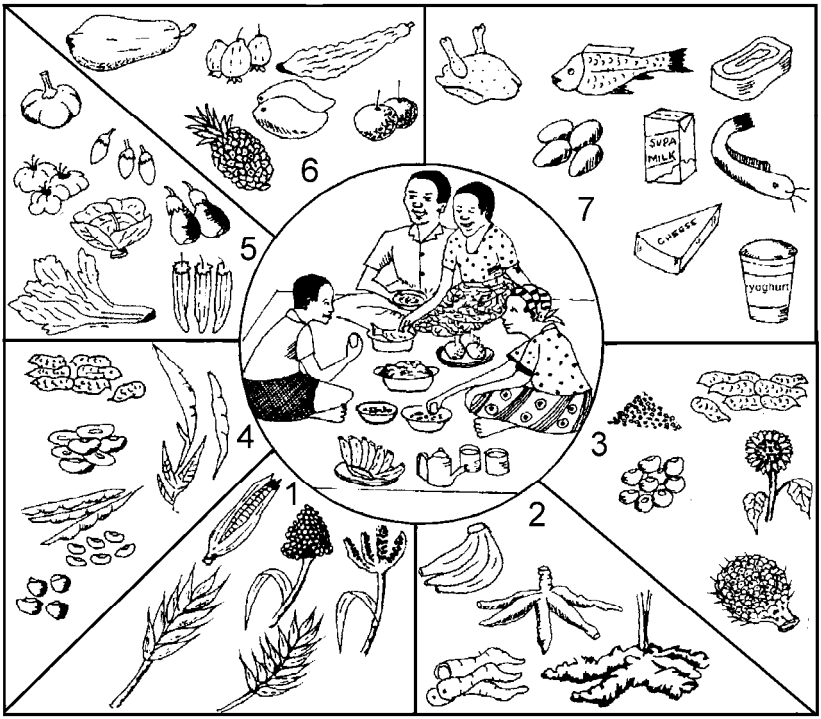

Figure 1: Food categories for a healthy diet: 1: cereals, 2: tubers, plantain, 3: oil crops, 4: pulses, 5: vegetables, 6: fruits, 7: animal products

The body requires only minute quantities of vitamins and minerals, but protein - together with carbohydrate and fat - belongs to the 'big three' when it comes to recommended quantities. Virtually all activities in living cells involve proteins (and the brain contains about 20% of all the protein in our body)! Because of their fast growth children need almost as much protein as adults, and they often suffer protein malnutrition (kwashiorkor). Protein deficiency also undermines the resistance against other diseases.

Among the energy foods cereals are relatively good sources of protein, but protein-content of tubers is quite low. Pulses are excellent sources

of protein, as good as or better than animal products. Note that protein can only play its protective role if the body is not short of energy. Eggs eaten by an undernourished person are burnt up to provide energy rather than being used for growth! Thus protective food can only play its proper role when hunger has been overcome.

Unfortunately consumption of protective foods is far too low in most tropical countries. In several African countries the average intake is less than half of the minimum quantities, 150 g vegetables and 50 g fruit per day, recommended by nutritionists. Even people who can afford to buy them often consume not nearly enough fruit and vegetables. Therefore diseases caused by what people eat - or rather by what they do not eat - are rampant, even where hunger is no longer a problem. Children suffer most from these shortages, and they are affected for life.

Deficiencies with respect to vitamins (A and C in particular) and minerals (especially iron) are widespread and debilitating. Vitamin A protects the skin, also the inner lining of nose, mouth and eyes; blindness in children is most often caused by lack of vitamin A.

Figure 2: Green leaves for bright eyes

Vitamin C functions in different ways. Little is stored in the body, so a regular supply of (fresh) fruit and vegetables is needed. Deficiency causes bleeding of the gums and affects the skin; children become irritable. Vitamin C improves the uptake of iron. Iron is needed for healthy blood; deficiency leads to excessive tiredness and poor resistance against infection.

Figure 3: Picking bitterleaf shoots for the next meal; monthly yield per 10 m hedge in Benin: 5 kg and 2 kg during wet and dry season respectively

Milk and eggs are good sources of vitamin A, but in the presence of fat the body can also make vitamin A out of carotene. Leaf vegetables (especially those with dark green leaves), and orange or yellow fruits and vegetables (papaya, orange; pumpkins, chillies, carrots) are rich

sources of carotene. The same vegetables and fruits provide vitamin C, especially when eaten fresh (prolonged cooking breaks down vitamin C). The dark green vegetable leaves contain much iron and so do pulses, cereals, meat and eggs.

There are many kinds of vegetables, especially leaf vegetables. The young shoots of many trees and shrubs can be eaten. Moreover, young leafy shoots are commonly gathered from certain field crops (cowpea, bean, cassava, sweet potato, pumpkins) and from the weeds growing between them (e.g. purslane, amaranth, African nightshades). However, this source is largely limited to the main growing season. The home garden is the proper place to produce vegetables (and fruits, spices, etc.) throughout the year.

2 General aspects of gardening

2.1 Garden crops and field crops

The original meaning of ‘garden’ (and of ‘hortus’) is ‘enclosure’ - an enclosed area, surrounded by a fence, hedge or wall - to grow crops. Within the enclosure, which would normally include the house, ‘garden crops’ are grown, while the ‘field crops’ are grown in the open. Within a village all farmers grow very much the same field crops during the same season(s), so they have a common interest in keeping animals out of these fields till after harvest. The main field crops are staple foods, such as cereals, pulses and tuber crops. The produce can be stored long enough to bridge the period from one crop till the next. In addition a few cash crops may be grown, such as cotton, or coffee. In the gardens, on the other hand, all sorts of plants are grown, including plants with medicinal uses, shade trees, ornamental plants, etc. Food comes from a wide variety of fruit, vegetables and spices. These foodstuffs should be available to supplement the staple food diet throughout the year.

Thus originally the garden was in fact a *HOME GARDEN*:

- near the house
- surrounded by a fence or hedge
- comprising a wide variety of crops
- grown on a small scale
- producing throughout the year.

Because of the year-round production of small quantities, a few goats or chickens can cause a lot of damage; hence the need to enclose the garden crops.

Garden crops are generally more delicate than field crops. Having the garden plants in an enclosed compound around the house makes intensive care possible; you pass through the garden every day and notice things to be done before it is too late. Many special techniques mentioned in textbooks such as watering by hand, mulching, composting,

and a variety of crop protection measures are hardly practiced on a field scale, but very relevant in the garden. In fact in the majority of garden crops each plant is handled individually, during transplanting, staking, pruning, and selective harvesting. By contrast, the field crops are generally treated as a crop, not as a collection of individual plants.

A final difference is that garden products are mostly perishable, in contrast with the staple products of field crops. That is why the home gardener aims at continuity of production, in order to always have some fresh produce.

A farmer is often best advised 'to do as thy neighbour does' in growing field crops. Best practices are very much the same for all farmers in the village. But if all gardeners come at the same time with the same tomatoes to the same market, the price will plummet! The perishable nature of garden produce puts a premium on out-of-season production. That is why a successful market gardener is an innovator; even home gardeners take pride in growing a special variety of crop or in harvesting before the neighbours. Therefore, gardens are a fertile ground for innovations. New crops or varieties, new materials and growing techniques (such as plastic materials for potting, covering, mulching, irrigation, packing) are quickly adopted.

Urban gardening

In the past gardening contributed substantially to food security within townships, also for low-income groups. Modern town planning disregarded the scope for gardening, but a revival of urban gardening is under way worldwide.

The renewed interest is all the more important because of the rapid expansion of cities. To be successful the small spaces inside or around the house have to be exploited, as well as roadsides, building sites and even public places. Where there is little horizontal space, going vertical may be the solution, using climbing plants. If vegetables are grown, high-yielding crops such as basella or amaranth (green leaves) and tomatoes or marrow (fruit) are preferred. See Agrodok 24: Urban agriculture.

Scarcity and high cost of water may limit urban gardening. A possible solution is collection and storage of rain water, further explained in Agrodok 13: Water harvesting and soil moisture retention.

2.2 Home gardening and market gardening

Increased consumption of vegetables is the most promising way towards a healthy diet in many countries. Hence, vegetable growing should be vigorously promoted. Both home gardening and market gardening need to be stimulated. The two overlap, but a clear distinction is desirable when it comes to development programmes. This is shown by the comparison of key features in Table 1.

Table 1: Keynotes for the development of home and market gardening

Keynotes	Home gardening	Market gardening
Motivation:	to eat better	to earn money
Type of crop:	hardy, requiring little attention	delicate, requiring intensive care
Production:	low input, low output	high input, high output
Produce:	traditional; what the family likes	fashionable: what higher income groups buy
Main benefit:	improved nutrition: - produce year-round - of high nutritive value	economic development: - income for more growers - increased employment - lower consumer prices
Development approach:	long-term nation-wide programmes, involving Ministries of Health, Education, Agriculture	specific projects in suitable areas, including infrastructural improvements

The crucial difference between home gardening and market gardening lies in motivation. The market gardener wants to make money. The home gardener on the other hand wants to eat better, making the meals more tasty and nutritious. Unfortunately, the desire to eat better is not very strong; if it was, home gardens would be much more common. So why not tempt people to establish a home garden with the prospect of selling some of the vegetables? Let the housewife earn some ‘pin money’ from selling produce!

There is nothing wrong with this approach; after all, market gardening has evolved out of home gardening because keen gardeners saw the possibility of earning a living. However, it is not the answer to malnutrition: if home gardening becomes so common that it has a worth-

while impact on malnutrition in the community, most gardeners are unlikely to find customers to sell their produce to.

Figure 4: A home garden in Benin that developed into a market garden

Vegetables and fruits are not as pricy as animal products, but because of their delicate, perishable nature they are still expensive in comparison with staple foods. The harsh truth is that many people can get enough protective food only if they grow their own. This leaves only two ways to stimulate home gardening:

- Strengthen the desire to eat better;
- Make gardening easier and more rewarding.

Most people will do their best to eat better if they are aware of the impact of malnutrition on health, their own health and that of their chil-

dren. In other words: nutrition education is essential. Food habits cannot be changed overnight; a substantial impact can at best be expected on the next generation. Thus nutrition education requires a long-term concerted effort, involving schools, health services, horticultural extension workers and the media. Schools can play a crucial role, especially where school lunches are combined with a school garden (see Box).

School gardens

A school garden, especially in combination with school lunches, is an ideal instrument for both health education (nutrition and hygiene) and horticultural training, including such typical gardening skills and insights as:

- nursery work
- the use of compost
- the effects of the seasons on plant growth
- in general: the response of plants to care

Work on their own plots in small groups (see figure 5) will also help the pupils to visualize and calculate areas, spacing, quantities, etc. The pupils can take some seeds, seedlings or cuttings home. In this way school gardens can foster awareness of the importance of protective food in the village and have a substantial impact on home gardening without unduly burdening agricultural extension staff.

Requirements:
- A school with some land - a few hundred to a few thousand m² - and at least enough water to keep a few plots going through a dry season.
- An enthusiastic teacher, for instance one who took an option course in gardening during training at the Teacher Training College.
- An incentive for the teacher, for instance paid tutoring in short courses in the district or prospect of promotion as agricultural tutor in a Teacher Training College or Secondary School with agricultural bias.
- A clear-cut policy for nutrition education and appropriate instruments within the Ministries of Education and Agriculture for successful implementation.

Making gardening easier and more rewarding is the subject of this Agrodok. Asked why they maintain a garden most people answer that they enjoy gardening. Most gardeners enjoy the work as well as relaxing in the shade of a tree planted years ago; the edible products are not the only benefit. Where the nutritionist thinks of a few vegetable plots producing protective food, the gardener thinks in terms of a hedge,

trees for shade, shelter or fruit, live stakes to support vines; in other words: a garden where woody plants create a congenial environment both for more demanding crops and for the family (see Chapter 3).

Figure 5: Children's plots in a school garden

Vegetable plots are seasonal, gardens are permanent. In a garden with the right plants some leaves, young shoots, bulbs or tubers, pods or berries, etc. can be harvested throughout the year, not just during the wet season. The quantities may be small but every bit is valuable, especially during the off-season. Therefore, to make gardening easy, projects should start by making available more and better hedging plants, perennial vegetables, fruit trees, live stakes, etc. (see Chapter 4). If not, nutrition education may fall on barren ground.

A household's first concern is for its livelihood; if the home garden requires too much effort it is bound to fail. The Agricultural Extension Service focuses on field crops; extension workers cannot possibly help every home gardener with advice and planting material. However, regional or district nurseries can propagate trees, shrubs and perennial herbs that thrive in the area. People are generally prepared to pay for fruit trees, especially if they are convinced that superior varieties are

available. Other perennials can be propagated by simple means and may be supplied free of charge, for instance to school gardens or other community gardens (see Box). If the extension worker helps the school to make a success of its garden, plants and gardening ideas will find their way through the entire village.

Since development of home gardening is based on concern for health, long-term projects are needed, backed by nutrition education. Malnutrition being widespread, the projects should be designed in such a way that they can be expanded to cover ever-widening areas.

On the other hand strengthening market gardening is based on concern for economic development: increased production and employment, lower consumer prices. Improvements have to come mainly from greatly increased out-of-season production and a better infrastructure: roads, transport, growers' organisations, market information. Instead of a set-up that can be expanded nationwide, specific projects are needed, based on scope and limitations of each production centre.

2.3 Home gardens in different ecological zones

The tradition of home gardening is strongest in the humid tropics. The famous home gardens in South-East Asia and those of the Aztecs in Mexico are examples. In such wet conditions people depend by and large on crops. Animal husbandry is limited to fowl, pigs and fish; if larger animals are kept they are usually stable-fed. Garden plants tend to merge with the field crops; there is often no clear distinction. Farms are generally small and this - together with the absence of herded animals - reduces the need to enclose the garden crops. Small farm size means high population density and relatively good infrastructure, conditions that favour market gardening.

In drier areas the role of arable crops gradually diminishes in favour of animal husbandry. Where the rains last long enough, a second crop follows the main field crop. In case of a shorter wet season there is only moisture for a single crop. If rainfall decreases still further only

short-duration crops, such as millets, can be grown. In the driest conditions crops disappear and nomadic herdsmen depend almost entirely on animal products and gathered leaves and fruits. This is shown schematically in figure 6.

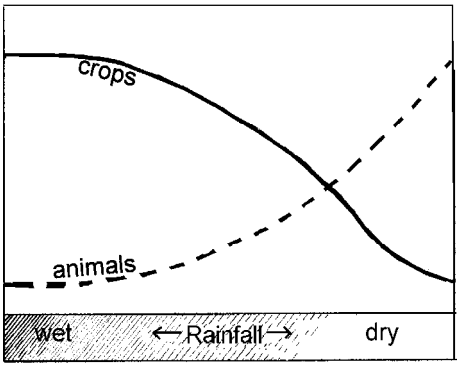

Figure 6: Going from wet to dry zones the role of crops declines in favour of animal husbandry

Since the land is cropped less intensively and animals require large areas to graze, the average farm size increases towards drier regions, the population density drops and consequently the infrastructure is usually less well developed. Market gardening is hampered by a feeble local demand.

Promotion of home gardening should certainly not be limited to humid regions, where these gardens already play an important role, as in South-East Asia. On the contrary: the scope for improved nutrition through more widespread and intensive home gardening may be greatest in the monsoon climates. In parts of Africa home gardens in fact come to the fore in such regions, and for good reasons. The wet and dry seasons favour distinct crops, the incidence of pests and diseases is less than in the humid tropics and infestations follow more predictable seasonal patterns. If the garden can be watered, even if only with household waste water, there is the potential for a wide range of crops and high yields.

In such regions the distinction between field and garden crops is quite clear: goats and cattle are herded and graze the stubble of field crops after harvesting, so garden crops need the protection of a hedge or fence. Only in the driest areas, where pastoralists move about with their cattle, the contribution of home gardens to a healthy diet will remain quite small.

3 Setting up your home garden

3.1 Planning the lay-out

As the name indicates home gardens are situated close to people's houses. Advantages, such as

- easy supervision,
- use of spare time to work in the garden and
- having the products readily at hand,

are so big that there must be compelling reasons to set up a garden further from the house. Such reasons are: lack of space around the house, completely unsuitable soils, or - the most common reason in a dry climate - another site may be preferred because of proximity of a water source.

Small or large garden?

There is often little space available to set up a garden. However, the smaller the area, the more intensive it can be utilised. Therefore the size of a garden is not all that important, even less if water is in short supply. Fifty m² is already very worthwhile; it can for instance produce all the leafy vegetables needed by a family of five, provided water is available. An area of a few hundred m² leaves more room for trees. Maintaining a much larger garden, say 1000 m², may be too ambitious, also because general activities, such as upkeep of hedges, paths, conduits for water, take much time.

Trees, shrubs, hedges: the permanent garden structure

A true gardener wants to give the garden a permanent character. Growing a few seasonal vegetables during the wet season is very commendable, but will not provide fresh produce during the dry season and forces the grower to start from scratch next year. Trees, shrubs and hedges are the permanent features of a garden. So, think twice before cutting trees already present, for instance a tree whose shade is enjoyed, trees and shrubs that break the wind, or a tree that supports a vine like the fluted gourd or eru. Try to include them in the garden plan.

Setting up a garden requires planning. First you should allocate an area for gardening and decide on the best way to enclose it. A fence can be set up quickly, while a hedge needs time to grow before it will provide proper protection. If there is sufficient space to plant trees and shrubs, do include them in your plan at an early stage. Planting material, especially of improved varieties, may be hard to obtain and trees take time to come into bearing. There may only be room for a few trees, which makes choosing the right trees even more important (see Chapter 4).

Trees and shrubs are generally planted near the edges of the garden, the hardy ones on the windward side, the more delicate ones on the lee side. This leaves the central area open for herbs, in particular vegetables. If the garden is exposed to strong winds (for instance desiccating winds during the dry season), a windbreak of hardy local trees and shrubs will greatly improve growing conditions in the garden.

Figure 7: Trees and shrubs give the garden permanence

Does all this sound like hard work and headaches? Yes, getting the permanent structure of the garden - enclosure and perennial plants -

into place does require keen planning and planting. But look at the result: you now have a garden that will serve you well as long as you live in that homestead.

3.2 Different types of home gardens

1. The take-it-easy garden (figures 8 and 9)

The motto here is gardening with a minimum of effort. The plants are rain-fed (but the young trees may need some additional watering during the first year or two to ensure vigorous growth and well-spaced sturdy branches). Starting with the woody plants as a permanent structure, the remaining space in the garden is planted with herbaceous vegetables, particularly hardy perennials. Maintenance of such a garden is indeed easy.

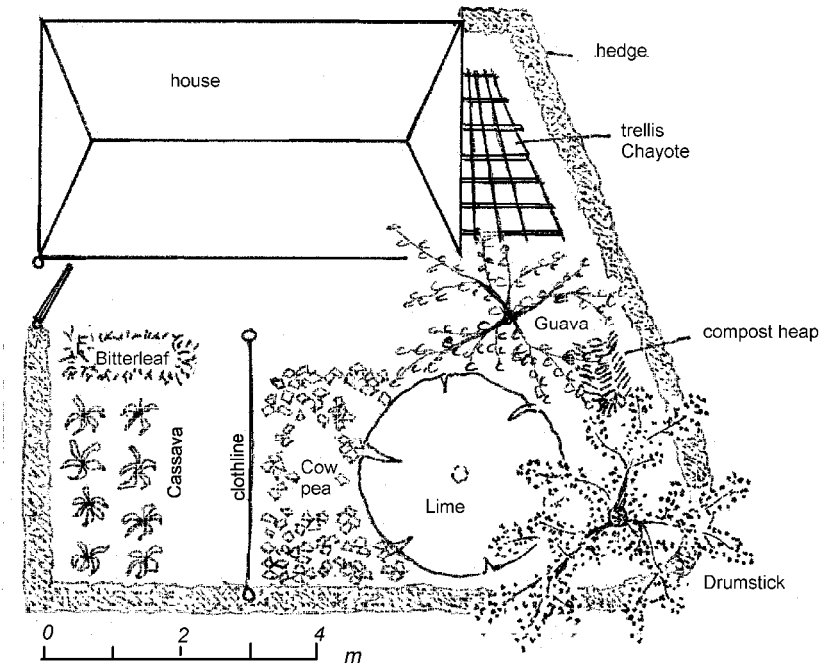

Figure 8: Plan of take-it-easy garden (50 m²)

To widen the choice (and to include more high-yielding vegetables) include one or two plots of vegetables that give good ground cover and have a long supply season (sweet potato, cowpea, pumpkins). Moreover, besides harvesting the main product, you can pick some shoots or leaves. The ground cover protects the soil against sun and rain and suppresses weed growth.

A cover crop such as cowpea, may also be the best intercrop between young trees. During the dry season the remains of the cover crop can be spread around the trees as mulch. You cannot expect high yields from such a garden, but if the dry season is not severe some produce will be available throughout the year to enrich your meals.

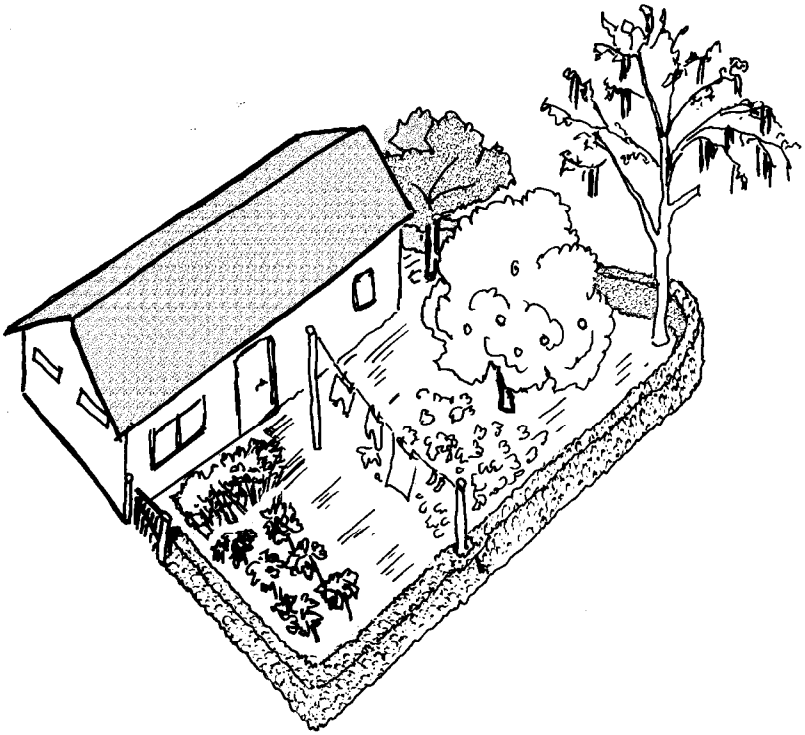

Figure 9: Bird's eye view of the garden of figure 8

2. Combining gardening with animal husbandry (figure 10,11)
The combination of animals and a garden is very attractive, provided the animals do not roam about freely. If chickens or pigs are not confined to a pen, growing herbs and greens is virtually impossible and gardens will be limited to hardy perennial plants.

If animals are kept in a pen or stable, the manure can be used to improve the garden soil. Equally welcome - if the garden is big enough - is the possibility to grow fodder in rotation with vegetables. If a plot has been under a fodder crop for a year or two, the soil will be in a much better condition for the following vegetables; moreover the risk of soil-borne diseases is reduced. If the garden can be watered a small fodder plot can contribute a lot to feed requirements during the dry season.

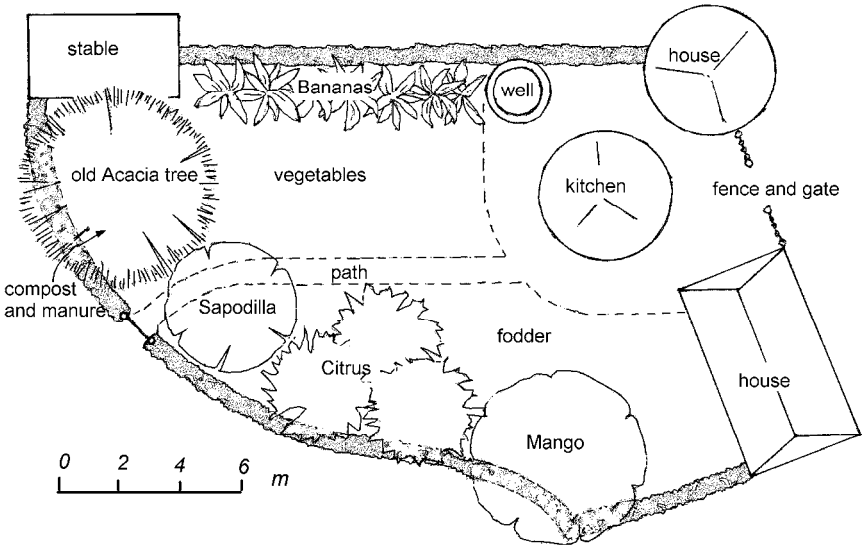

Figure 10: Plan of garden combining garden crops and animal husbandry (225 m²)

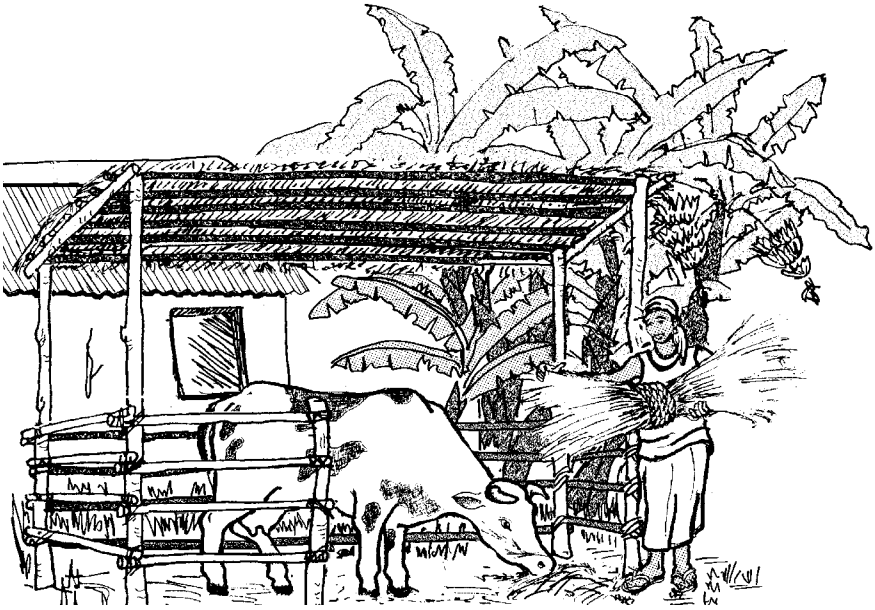

Figure 11: Feeding fodder grown in the garden

Common forage crops include tall grasses: elephant grass (*Pennisetum purpureum*), Guinea grass (*Panicum maximum*) and Guatemala grass (*Tripsacum andersonii*) as well as food legumes: lablab (*Lablab purpureus*), cowpea (*Vigna unguiculata*) and pigeon pea (*Cajanus cajan*). Lopped branches from live stakes and suitable shrubs can also be used as fodder.

3. The green-fingers garden (figures 12 and 13)

If you are a keen gardener or want to produce as much protective food as possible, you will go beyond the range of plants found in the take-it-easy garden. You will no doubt consider growing short-duration fruits (such as papaya, banana, pineapple), and annual vegetables. Of course, you will also be spending much more time gardening.

If water is not limited, papaya and banana may be planted as intercrops between the young trees. If water has to be carried, you may still grow a few of these plants, because of their high and early yield. Passion fruit may be grown on a trellis near the house, so that you can sit in the shade.

There is a rich choice of annual vegetables, both indigenous and introduced. Some greens, such as amaranth and Jew's mallow, can be harvested in a matter of weeks. They are productive and highly nutritious. Ground-covering crops (cowpea, sweet potato, gourds) deserve a place as well.

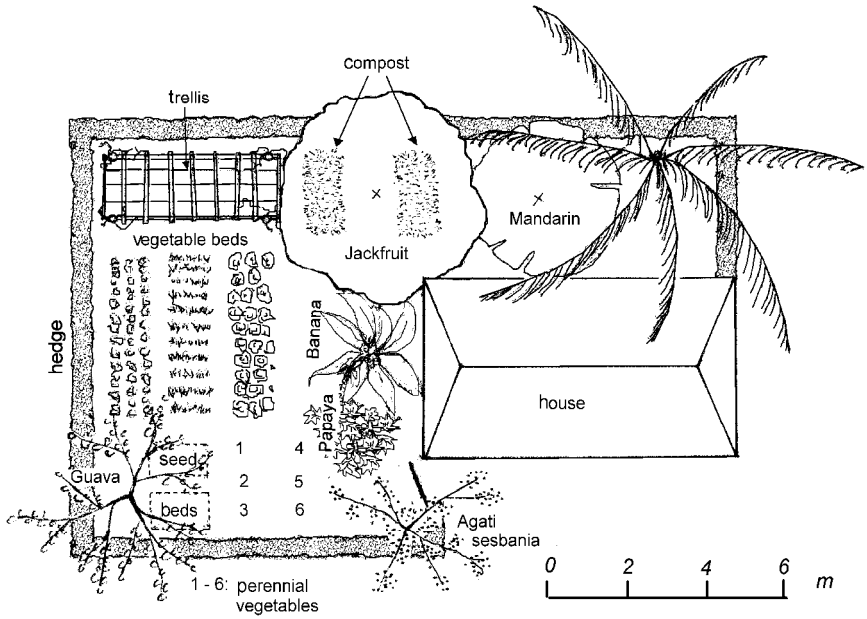

Figure 12: Plan of green fingers garden (130 m²)

If you have green fingers, a nursery to raise seedlings of vegetables that are normally transplanted, such as eggplant, tomato, cabbage, is a must. In the nursery you can also propagate other garden plants, such as a broader selection of fruit trees, spices, medicinal plants and ornamentals.

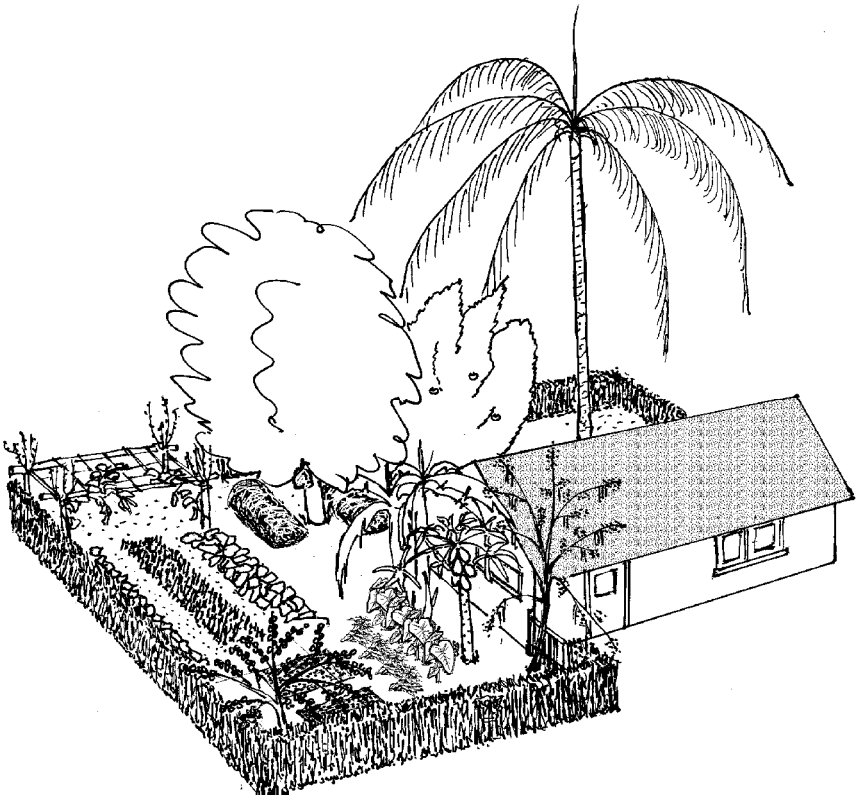

Figure 13: Bird's eye view of garden in figure 12

What does your garden look like?

The above three garden types are all based on the same permanent features: fence or hedge and a few trees and shrubs. Because of their permanent character all three types produce at least small quantities of protective food throughout the year. They differ mainly in the scope of the garden and in the time required to maintain the garden. The amount of protective food that can be produced also differs and depends to a large extent on the water supply. Well-distributed rainfall or adequate irrigation facilities greatly boost yield; a long dry season and hand watering, from a well or tap, limit potential yield.

> Do feel free to combine elements and ideas from all three types: there are as many different gardens as there are gardeners.

4 Choosing plants for your garden

4.1 Long-lived (perennial) plants

Let us look more closely at the plants that form the lasting frame-work of the garden: hedges, live stakes, fruit trees and perennial vegetables. Characteristics of plants in each category are given in Appendix 1. Agrodok 16: Agroforestry, gives information about a lot of trees and shrubs used for various purposes on the farm. But it is easiest - and often best - to start with trees and shrubs that thrive in the area where you live. Using plants you are familiar with greatly reduces the risk of setbacks and failures.

Hedges

Fences or hedges keep animals (and other intruders) out of the garden. A hedge is generally best for long-term protection, but it takes a few years to grow to full size. So you might start with a temporary enclosure of thorny branches or set up a fence with (live) posts linked by bamboo slats (figure 14). It is a good idea to plant a hedge inside the fence straight away, in order to provide protection in due course.

Figure 14: Fence: lattice supported by trees (Dupriez & de Leener, 1993)

There are many plants that can be shaped into hedges. Sometimes woody vegetables, like the cassava in figure 15, form the hedge. Fodder plants such as gliricidia and coral trees (*Erythrina* species) are also popular; the cuttings may be fed to animals, or can be used as green manure or mulch.

Figure 15: Hedge made with gliricidia poles and cassava cuttings

Where animal husbandry comes to the fore hedges have to be 'goat-proof' (figure 16). In these conditions mainly thorny or - in the driest climates - poisonous plants are used. Examples of thorny hedges: guayamochil (*Pithecellobium dulce*), Jerusalem thorn *(Parkinsonia*

aculeata), carissa (*Carissa carandas*), kei apple (*Dovyalis caffra*). Physic nut (*Jatropha curcas*) is a fast-growing poisonous shrub, in the limelight because the seeds are a source of bio-diesel oil. *Euphorbia tirucalli* is known by its English name as milk-hedge for its poisonous sap. In dry regions other *Euphorbia* species, cacti, agave and *Yucca* species are also used as hedging plants.

Planting and maintenance

When a hedge is sown or planted you want it to grow fast, but when it reaches the desired size fast growth means that the hedge needs to be cut 3 - 4 times each year. Trimming hedges is a lot of work. This is all right if the cuttings are used as fodder; if not, weigh the one-time advantage of fast establishment against the recurring advantage of easy maintenance! A slow-growing hedge requires little pruning during the first year or two. Just top the plants to induce leafing out of side shoots, making the hedge sufficiently dense right from the ground. Regular pruning suppresses flowering; so if hedges of carissa or kei apple bear a lot of fruit this indicates inadequate trimming!

Figure 16: Goat-proof hedge made by closely planted live stakes (Dupriez & de Leener, 1993)

It always pays to prepare properly for planting. Dig up a sufficiently wide strip (50 cm), incorporate manure and - if available - some phosphate fertilizer. Plant or sow timely - early in the rainy season - and protect the young plants as much as possible, e.g. by a fence. Collect seeds during the fruiting season and store the seeds properly. When seed is sown on the spot it is usually dibbled in double rows. If seedlings have to be raised for planting out, start the nursery in time and

make sure that there is water (even if it is only waste water from the kitchen), to raise the plants. Attention to field preparation and planting helps a great deal to speed up growth during the first year, shortening the establishment period.

A hedge is no stronger than its weakest spot. So do pay special attention to parts that lag behind in the first years in order to ensure uniform growth of the hedge.

Live stakes

Some woody plants can be propagated by very large stem cuttings. If poles the size of fencing posts are cut and planted they strike root and leaf out. Different kinds of coral trees (*Erythrina* spp.), for instance, are planted as stakes about 2 m long, with a diameter of 5 to 10 cm. They can support barbed wire or a lattice made from local materials to form a fence. In West Africa the boundary tree (*Newbouldia laevis*) is commonly used in this way. For a cattle pen the stakes may be set so close that they form a stockade without any further material (similar to the hedge in figure 16). In the highlands of East Africa *Commiphora* species (e.g. African bdellium, *C. africana*) are used in this way.

Figure 17: Snake gourd on a trellis

Live stakes are also used to support climbing plants such as black pepper, betel, vanilla and yams. The stakes may also be linked by bamboo cross bars and wires to form a trellis, e.g. for snake gourds (see figure 17), chayote, passion fruit, grapes or ornamental climbers

in the garden. In South East Asia *Lannea coromandelica* is preferred for trellising, because its trunk is perfectly straight.

Desirable qualities for live stakes are:
- easy propagation from large cuttings
- able to survive regular lopping of new branches ('pollarding')
- not attractive to termites and other pests
- shoots eaten by livestock (but not the bark: goats!)

If left unpruned, live stakes will grow into trees. To prevent heavy shading of the supported vine, the branches should be lopped before they have grown too much. This also reduces moisture consumption and helps the stakes through the dry season. The branches of most live stakes are used as fodder or green manure.

Suitable coral trees exist for lowlands as well as highlands; most species are adapted to a wide range of altitudes, but water requirements are generally 1000 mm per year or more. Gliricidia thrives in the same environment and the stakes are thinner. *Commiphora* species are suited to dry, some even to arid, conditions; they are leafless for about 9 months. Many *Euphorbia* species propagate easily through stakes and these may be suitable as live stakes under fairly dry conditions. Both stakes and hedges of physic nut (*Jatropha curcas*) are suited to hot and dry conditions.

Fruit trees

Because of the limited area of most home gardens, tree size is an important consideration. Starting with a small tree it is quite common to underestimate its final size! This is in fact true for all kinds of trees. Short-duration fruits – banana, papaya, pineapple – are most popular in home gardens, because their size is restricted and with proper care they yield good crops within a short period of time.

Examples of small to medium-sized fruit trees are: citrus species, guava, sugarapple, soursop, carambola, acerola, sapodilla, Indian jujube. In the highlands this list can be extended by cherimoya, casimi-

roa, oriental persimmon, loquat and fruits from the temperate zone (plum, peach, apple, pear). The actual size of these trees depends a great deal on how much fruit they produce. The trees remain small if they come into bearing quickly and produce good crops in the early years. The simple reason is that much energy is used for fruit growth, leaving no energy for vigorous shoot growth.

Early bearing, resulting in smaller tree size, is a feature of vegetatively propagated trees (e.g. through cuttings, layers, budding or grafting). Trees raised from seed go through a juvenile phase, during which they are not able to flower. The juvenile phase ranges from 4 to more than 10 years for different fruit crops (papaya - with a juvenile phase of less than one year - is an exception). So seedling trees already reach a substantial size before they flower for the first time, all the juvenile energy having been used for vigorous shoot growth. Agrodok 5: Fruit growing in the tropics, explains how you can control the growth of your trees in favour of more predictable flowering and better fruit loads.

Vegetative propagation has resulted in different varieties within fruit crops. These varieties not only differ in fruit traits, but also with regard to tree vigour, yield, adaptation to lowland or highland, wetter or drier climates, etc.

Perennial vegetables

The borderline between annual and perennial vegetables - a lifespan of one year - is not very practical for the gardener. Many herbs that in the natural state may live longer than one year, generally have a much shorter life as crop plants in gardens. The issue is complicated because crop duration depends on the cropping system as well as the variety and growing conditions:

- cassava grown as a leaf vegetable may occupy the garden for several years, grown for the tubers it may be cleared after 9 months (or later);
- basella may last only 3 months if large leaves are preferred; if not, it may last more than one year.

These examples show that arbitrary decisions are inevitable. Woody vegetable crops have all been included under perennial vegetables in Appendix 1, including pigeon pea and cassava, both often grown as annual crops. Conversely, herbaceous perennials that are usually grown as annual crops, such as basella, leaf cabbage, African eggplant and winged bean, have been listed under the annual vegetables in Appendix 2.

With minimal effort the perennials contribute to the permanent character of the garden and yield produce also during the off-season.

Most often the leaves or young shoots are the parts used as vegetable. This applies to 'vegetable trees' (drumstick tree, chaya, melinjo), but the leaves of many fruit trees and forage trees or shrubs are edible too. A row of shrubs quite naturally forms a hedge if the shoots are gathered frequently (for instance bitterleaf in figure 3 - page 10, cassava in figure 15 - page 30). Eru is a woody vine grown for its shoots. Other plant parts used as vegetables in woody perennials include: tubers (cassava), flowers (agati sesbania), young pods (drumstick tree, pigeon pea), seeds (pigeon pea, drumstick tree, giant yellow mulberry).

Most perennial herbaceous vegetables are also grown for their leaves (fluted gourd, yanrin, tropical primrose). The main exceptions are taro and tannia (both stem tubers and leaves are eaten), chayote (the fruit is most important) and leguminous vegetables: sword bean, African winged bean (the young pods and seeds are eaten).

Other woody plants

Numerous other woody plants may be found in home gardens, either because they were already there or because the gardener planted them; for instance: bamboos for light construction materials (and perhaps vegetable shoots!), trees such as agati sesbania to give a light dappled shade in the nursery area (or because of its ornamental value), trees yielding spices, medicines, insecticides (e.g. neem), etc. It all depends on what you like, on what will grow and what is available.

4.2 Short-lived (annual) vegetables

The PROTA Handbook about the plant resources of Tropical Africa lists nearly 100 annual vegetables and a somewhat smaller number of perennial vegetable herbs. Here we can only give a few suggestions for choosing annual vegetable crops for the home garden. Appendix 2 lists the climate preferences for some annual vegetables and some information about how to grow them.

Leaf vegetables, cover crops and legumes are three outstanding categories of vegetables. Leaf vegetables contribute most to your health, while the other two groups also contribute to the health of the garden.

Leaf vegetables, particularly the dark-green ones, are excellent sources of protective food, rich in protein, vitamins and iron. Examples: amaranth, celosia, Jew's mallow, waterleaf. If water is available they can be sown and picked throughout the year. Moreover, you can cut the young plants within a few weeks from sowing, after which they will sprout again, or just pick shoot tips from the plants as they grow.

Vegetables that provide good ground cover, such as sweet potato, cowpea and gourds, act as a live mulch, protecting the soil against the impact of sun and rain and suppressing weed growth. This effect is worthwhile because these crops generally cover the ground for a long time. Moreover, most vegetables in this group have edible leaves; some leaves can be picked in the course of the growing season without seriously affecting the yield levels of the main product.

Leguminous vegetables include all kinds of beans and peas; they are rich sources of protein. You can either consume the young tender pods or prepare dishes from the (dry) seeds. The garden benefits from legumes through their nitrogen fixation, part of which becomes available to companion crops.

Several gourds (cucurbits: cucumbers, pumpkins and other squashes, luffas, melons, watermelons) are good cover crops, but they are pri-

marily grown for their fruit or seed, as are the beans and peas. Among other fruit vegetables, the indigenous ones, such as aromatic pepper, African eggplant, gboma, okra, are generally best suited to home gardens, because they are more hardy and the taste is preferred.

Perennial tuber crops such as taro and tannia and also cassava are more common in home gardens than the annual carrot or radish. But sweet potato is an important annual tuber crop. Onions contrast starkly with sweet potato: their poor ground cover and susceptibility to diseases and pests moves the gardener as well as the cook to tears.

5 Soil management

5.1 Root growth and soil types

What roots do in the soil

To sustain plant growth the roots must find air and water with mineral nutrients, as well as the necessary support. The air is needed for the roots (and for other organisms living in the soil) to breathe. Nearly all the water taken up by the roots is transpired to cool the leaves during the daytime. Roots can only take up nutrients dissolved in water. The major part of some nutrients may be present in insoluble form; that part is useless for the plant!

Water and mineral nutrients are taken up almost exclusively by young roots. Hence roots must grow; if not, there soon will be no young roots. So garden soil should be able to support root growth as long as there are plants growing. Some woody plants shed their leaves when root growth is minimal.

Soil types

Soils range from light (mainly consisting of coarse sand grains) to heavy (mainly consisting of fine silt and very fine clay particles). Light soils generally have much space between the sand grains to provide air, but water drains away quickly and hardly any nutrients hold on to the surface of these grains. That is why sandy soils are easy to cultivate, but prone to drought and infertile.

Heavy soils have only tiny pores between the tightly packed particles. Soils that contain much clay swell when wet and shrink when drying, the soil cracks letting in air. The soil holds water tightly, releasing it slowly. On the surface of clay particles nutrients are held in a soluble form. The more nutrients are held, the higher the concentration of nutrients in soil moisture. Thus heavy soils are hard to work, short of air in wet conditions, but less susceptible to drought; moreover they tend to be fertile.

Loam refers to mixtures of sand, silt and clay. Loamy soils therefore have a range of characteristics depending on the mixture. Farmers know the soils in the area quite well and can explain the strong and weak points of different soil types in much greater detail.

5.2 Organic matter

The time-honoured method to improve soils, garden soil in particular, is generous application of organic matter year after year. Manure, compost, green manure and crop residue or litter are common sources of organic matter. The effect of organic matter is twofold:

1 Decaying organic matter and the resulting humus improve soil structure by glueing soil particles together. Sand grains form larger crumbs and clay clods become more friable. The result is that light soils can hold more water and heavy soils more air, thus facilitating root growth.
2 As the organic matter decays in the soil, nutrients are brought back in circulation. Before the introduction of mineral fertilizers adding organic matter was the only way to maintain or increase soil fertility. Since sand grains cannot hold nutrients, organic matter and humus are practically the only 'store' of nutrients in a sandy soil.

Soil organic matter

Soil organic matter includes all dead and decomposing organisms in the soil. It ranges from the remains of bacteria, moulds, earthworms, insects, mites, etc. that live in and on the soil to plant and animal matter, gradually decomposing until a black, rather stable end product is formed: humus.

In fact there are more life forms in a good topsoil than in the air above it. Together these organisms digest and decompose organic matter. Moreover, the great variety of life forms hampers rapid multiplication of bacteria, fungi and nematodes which attack plant roots. A diverse, thriving community of soil organisms checks soil-borne diseases!

Applying as much organic matter as possible during the first year or two is the way to quickly convert a soil into 'garden soil'. Thereafter, generous annual dressings of organic matter will keep the soil in good

condition. A garden soil has a good structure and fertility, is easy for you to work and for the roots to explore. You may be able to get a large quantity of waste material from agro-industries, such as filter press waste or bagasse from a sugar factory, groundnut or coffee hulls, coir fibre, bone meal or fish meal. Water plants that have to be removed anyway, such as water hyacinth, are another good source of organic matter. Bulky materials can be applied at the rate of about 1 m^3 per 100 m^2 per year.

Sources and use of organic matter

Manure: animal dung, pure or mixed with litter

Manure is the most effective organic matter, as it is rich in nutrients, particularly if stored dry. If you can obtain dung from a boma or corral (enclosures where cattle is kept during the night) before the start of the wet season, the dry dung is rich in nutrients (as these will not have been washed out by rain) and weighs little, making transport easy. Better still, if you keep animals, large or small, in a pen or stable near the house, the mixture of litter and dung ensures a steady supply of manure.

Compost

Compost can be made from any kind of organic matter: remnants of garden crops after harvesting, prunings from hedges, etc. if not too woody, household waste, sweepings from the yard and fireplace, litter and dung from a stable, and so on. Composting is the first stage of decomposition of organic matter in a heap or pit. During this process the concentration of mineral nutrients is increased. The bacteria and moulds that cause the decomposition should grow so fast that their respiration heats up the compost, killing germs and seeds of weeds. This only happens if composting is done properly, which is not easy: the material should be moist and contain sufficient air and nitrogen (for instance from legumes) to spur on the microbes, the material should be turned a few times, and so on (see Agrodok 8: Preparation and use of compost).

Mulch

Mulching is covering the soil around plants with litter. This is common practice for fruit crops. When you cut a banana stem after harvesting the bunch, you probably cut it up and leave the litter around the stool. The mulch protects the soil against heavy rain and the baking sun; it also conserves soil moisture and greatly moderates daily fluctuations in soil temperature, as shown in figure 18. A thick mulch layer suppresses weed growth. As the mulch decays the nutrients are gradually returned to the soil. After a few years of continued mulching you can find a lot of fine roots growing in the topsoil, just under the mulch layer.

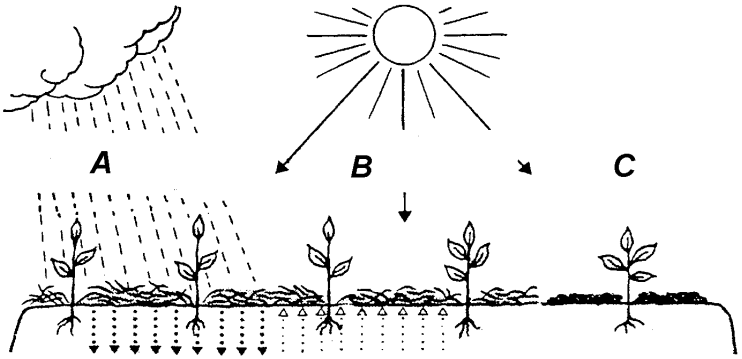

Figure 18: The benefits of a mulch – A: rain water does not compact the soil surface, but penetrates more easily, B: the soil is insulated; does not get very hot or cold and does not dry out quickly, C: weeds are suffocated, the mulch turns into humus

Mulch is so beneficial that extra mulching material, for instance slashed weeds and straw or other crop residues are spread in the garden, especially under fruit trees. The only drawbacks of mulching are the increased risk of fire during the dry season and the danger of attracting termites. Mulching of annual vegetables is less common. Seed beds on the other hand are often mulched, but only until the seedlings emerge.

Green manure

Green manure consists of plants that are worked under to enrich the soil. For this purpose a cover crop is sometimes grown between trees. The crop may be slashed to mulch the trees or ploughed in as green manure. Legumes are the preferred green manure crops as their organic matter is rich in nitrogen. Legumes - a very large family of trees, shrubs and herbs, including all beans and peas - are able to fix nitrogen with the help of bacteria in nodules on their roots. In the home garden it usually does not pay to grow a special green manure crop. However, many kinds of beans and peas are important garden crops; grown in crop mixtures including a legume, the other crops benefit from the nitrogen leaked by legume roots. When the remains of the legume are turned in, they benefit the next crop. In this way legumes supply part of the nitrogen needed by other crops.

Legumes

Legumes provide protein-rich food for the family, fodder for the animals and nitrogen for companion crops!

Apply fresh or make compost ?

Fresh organic matter, such as leaf litter, prunings or crop remains, may be applied directly or after composting. Conversion into compost by microbes reduces the amount of organic matter (you see the compost heap getting smaller all the time). However, composting often proceeds far from perfect, with the result that nutrients are lost, weed seeds are not killed and the end product is not the homogenous crumbly material expected.

Thus much is to be said for fresh application of organic matter, either on top of the soil (as mulch) or worked into the soil. This provides soil life with the maximum amount of digestible matter and it is easier for the gardener. However, be careful with large quantities of coarse fibrous or woody organic matter which contains little nitrogen, such as bagasse or maize stubble and stalks. Extra nitrogen is needed for the early stages of decomposition; it is extracted from soil moisture, so that initially there is less nitrogen available for the crop! This problem

can be prevented by applying nitrogen-rich material at the same time, for instance manure or bone meal. The problem is largely avoided if the material is applied as mulch.

A tidy gardener will still make compost, the compost heap or pit being the place where household and garden debris is put to good use when it cannot be applied fresh. Compost (and manure) is always worked into the soil; left on top there will be further losses of nutrients.

5.3 Plant nutrients, mineral fertilizers

Organic matter contains all the nutrients plants need. But if the soil is deficient in a certain nutrient, the organic matter will contain too little of that nutrient, leading to poor plants growth. And if the animal feed comes from the same soil, the manure will be an insufficient source of that nutrient too. That is one reason why farmers use mineral fertilizers, and the main reason for the gardener to apply such fertilizers occasionally.

Plant nutrients

The mineral nutrients needed by plants are usually divided in three groups:

1 **Major nutrients**: nitrogen (N), phosphorus (P) and potassium (K)
2 **Secondary nutrients**: sulphur (S), calcium (Ca) and magnesium (Mg)
3 **Minor or trace nutrients**: these include iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B) and molybdenum (Mo)

The letters between brackets are the abbreviations used for each nutrient in chemistry. Plants show certain symptoms if a nutrient is in short supply, but by the time the symptoms are clear, crop failure is near. That is why in commercial crops mineral analysis of soils or leaves is used to discover deficiencies early.

Only minute quantities of the minor nutrients are needed. Deficiencies are not common, but if such a deficiency occurs in your area, the agri-

cultural extension service should be aware and able to advise you how to correct it.

With respect to the secondary nutrients, soils generally contain more sulphur and calcium than necessary for good crops. These secondary nutrients are in fact more important in regulating soil acidity (see Box). Soils hold far less magnesium than calcium, but this proportion should be maintained when the soil is limed, for instance by using magnesium-rich lime. Magnesium is deficient in some sandy soils.

Correcting soil acidity

If the soil is acid, lime can be applied to reduce its acidity. Most crops prefer slightly acidic to neutral soil moisture, also because problems with fixation of nutrients in the soil are minimal under these conditions. Fixation is the conversion of an applied nutrient into insoluble substances, making it inaccessible for plant roots. In that situation applying the nutrient as a mineral fertilizer is throwing away money. Where acidic soils occur, information can usually be obtained locally about which liming material to be used and in what quantities.

The opposite problem, lime-rich soils, is sometimes encountered in dry climates. There is no instant remedy, but the adverse effects can be lessened by application of generous amounts of organic matter and - in case fertilizers are used - apply fertilizers that leave an acidic residue in the soil, such as sulphates.

The major nutrients - nitrogen (N), phosphate (P) and potassium (K) are quite often in short supply. So below we look at these nutrients and the fertilizers that supply them. More information is given in Agrodok 2: Soil fertility management.

Mineral fertilizers

Mineral fertilizers, also called chemical or artificial fertilizers, are salts containing one or several plant nutrients. They are expensive, even though only small quantities are supplied (in the form of powder or granules). Straight fertilizers contain one of the three major nutrients. Compound fertilizers contain two or all three: N, P and K.

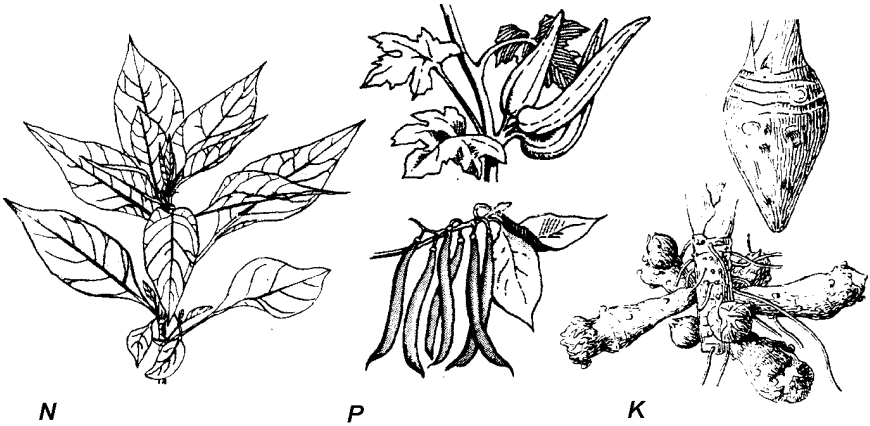

Figure 19: The main nutrients needed by crops –Nitrogen (N): promotes vigourous shoot growth, Phosphorus (P): stimulates root growth and flowering, fruit/seed production, Potassium (K): improves yield of root/tuber crops

Nitrogen

Nitrogen (N) is perhaps the most important nutrient for plant growth; it is an ingredient of all proteins. Nitrogen levels in the soil fluctuate sharply, because nitrogen in the form of ammonia is volatile and in the form of nitrate it is easily leached by rain to depths where it cannot be reached by the roots of annual crops (in the garden tree roots may still be able to find this nitrate). The main indication of shortage of nitrogen is pale-green young leaves and reduced or even stunted growth.

The common ways to prevent N-deficiency are the use of legumes, such as cowpea, pigeon pea or groundnut, in crop mixtures or in rotation with other vegetables, and generous applications of organic matter. Urea is a N-fertilizer that acts slowly, similar to decomposing organic matter. That is why urea and organic matter are applied as a basal dressing, worked into the soil before a crop is planted. Fertilizing a standing crop is called top dressing.

Fertilizers that contain ammonia or nitrate act immediately in moist soil, so they are useful as top dressing on poorly growing plants. However, watering the plants with cow dung (diluted till it has the colour of weak tea) gives good results too. Growers in different parts of the world brew their own 'plant tea' (see Box: Foliar fertilizers).

Phosphorus

Phosphorus (P) is particularly beneficial for better root growth, flowering and seed production. Legumes can fix far more nitrogen if the roots find enough phosphate. The phosphate levels in the soil are stable, but usually rather low, particularly in most African soils. Moreover, P levels drop gradually with crop removals year after year and this is aggravated by erosion of the topsoil.

Rock phosphate is mined in several places in Africa; this fertilizer only dissolves well if soil moisture is slightly acid. Superphosphate is soluble in water but more expensive. Mexican sunflower or tree marigold (*Tithonia diversifolia*, a tall, attractively flowering perennial plant, widespread in upland areas above about 500 m, see figure 20) is able to extract a lot of phosphorus from the soil. Tree marigold is also rich in nitrogen. It is now grown increasingly along field borders, the cuttings supplying P- and N-rich organic matter to the field. It may be an ideal plant to nourish your garden! And if it is fed to livestock you get rich manure.

Potassium

Potassium (K) facilitates life processes in plants and makes them more resistant to drought and diseases. Most clay soils are rich in potassium, but in sandy soils organic matter is practically the only source of this nutrient and in such soils K is easily lost through leaching. Once N- and P-deficiencies have been overcome, crops grow so much better that they will need much more K too. Moreover, certain crops - in particular banana and tuber vegetables (cassava, sweet potato) - show high K-requirements. This results in low K-levels after the harvest of these crops, especially in light soils. Potassium sulphate is the most common K fertilizer. Ashes are a rich local source of potassium.

Figure 20: Mexican sunflower extracts much P and N from the soil

Foliar fertilizers

Foliar fertilizers act quickly as they are (partly) absorbed by the leaves. Moreover, this avoids problems with immobilisation of nutrients in soils with certain defects (for instance: high lime content, phosphate-fixation). The main limitation is that the quantity of nutrients applied is very small, because the concentration should be so low that the leaves are not scorched. Foliar fertilizers are expensive, but useful when plants suffer from deficiencies in micronutrients.

There is a trend to prepare one's own foliar fertilizer or 'plant tea'. Fresh manure and water are mixed in 200 l drums. Molasses may be added for extra energy, yeast or forest topsoil for micro-organisms, a chopped-up legume for more nitrogen and wood ash to add mineral nutrients. After fermentation the liquid is strained and diluted to the desired strength. The quality of plant tea depends on the recipe. In general nitrogen is the main ingredient, but gardeners also ascribe benefits to plant hormones, vitamins, etc. in the tea.

5.4 Soil tillage

Tillage before planting

The soil is tilled to loosen the topsoil and to incorporate weeds and the remains of the previous crop along with added organic matter. Light soils can be tilled at any time. Heavy clay soils should be neither dry nor very wet. Hoeing dry soil is very hard work and results in a field of clods; wet clay sticks to the hoe and smears, sealing the cut surfaces and spoiling soil structure.

Correcting heavy and light soils

If the soil is heavy, sand may be mixed in, for instance from a nearby river. This is a lot of work, but can be worthwhile for seedbeds. Roots branch more in a light soil and it becomes easier to lift seedlings without rupturing the roots. Light and infertile soils can be improved by mixing in soil from termite hills, again starting with nursery beds. Similar improvements in the structure of both heavy and light soils also result from repeated application of organic matter.

Tilling to a depth of 15 - 20 cm is usually enough, also to get enough loose soil to make raised beds, ridges or mounds. The soil loosened by hoeing should keep an open structure through the activities of soil organisms, from plant roots to earthworms. And when the garden plants thrive, they - perhaps with the help of a mulch – will protect soil structure against the hot sun and beating rain. If ample organic matter is applied tilling becomes easier as the years go by.

Apart from preparing level plots, a hoe can be used to make basins around trees, raised beds (for instance in the nursery) or sunk beds (to take maximum advantage of water in a semi-arid climate), and ridges and furrows (for surface irrigation). Beds should not be more than 1.20 m wide, so that you can easily reach the centre without having to walk on the bed; the path between beds should be 40 cm or more. Raised beds are about 15 cm high, usually with a slightly higher edge to prevent water from flowing off the sides. Sunk beds are only about 5 cm deep. Beds should be well levelled to prevent water from collecting in low corners.

For surface irrigation ridges should run along the contour or at a slight slope. They should be at least 70 cm apart; if the spacing is less, the ridges may not be sufficiently sturdy to prevent irrigation water from breaking through. Crops are also grown on ridges to improve drainage.

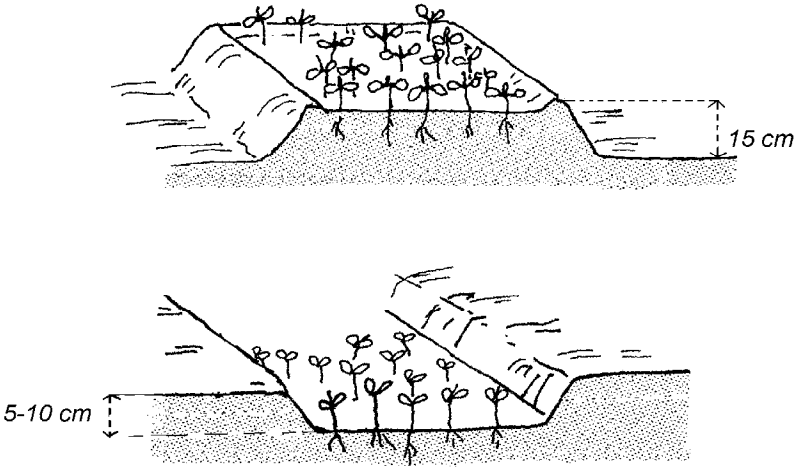

Figure 21: Raised bed (top) and sunk bed with seedlings

Tillage after planting

Superficial hoeing after planting is meant to break the crust on the soil surface, often formed due to the impact of rain or watering before the crop covers the ground. At the same time it serves as a weeding round. The loosened top layer of a few centimetres insulates the soil below, reducing evaporation and heating; it also limits germination of weeds.

A common practice for some crops, called earthing up, is to build ridges or mounds after planting. Soil is heaped around the base of plants with a hoe. This gives the plants more resistance against wind (maize), stimulates the growth of new roots (maize, beans, banana – old roots are often infested by nematodes by the time the bunch appears) or provides more loose soil for tubers to grow in (sweet potato). Earthing up after top dressing reduces losses of applied nutrients.

6 Plant propagation

This chapter focuses on annual vegetables, as propagation is a recurring routine for these crops. Techniques suitable for woody plants in the garden are described in Agrodok 19: Propagating and planting trees.

Most crops are propagated from seed (generative or sexual propagation), but for some crops other plant parts are preferred, such as tubers, suckers or cuttings of roots, stems or leaves (vegetative or asexual propagation).

6.1 Propagation by seed

Seed collection and storage

The simplest procedure is to collect seed from your own crops. This works well for the following vegetables, most of which have large seeds: pulses (beans and peas) cucurbits (watermelon, pumpkin), okra, roselle, jew's mallow, tomato, eggplants, peppers, African nightshades, amaranth, celosia and maize. Choose the healthiest plants and fruits. In crops grown for their fruit or seed choose plants that flower early. In that way you select for early fruiting. In crops of leaf vegetables choose late-flowering plants. That means you select for prolonged leaf production before flowering.

1 **Dry fruits** (legumes, okra, maize, bottle gourd, most leaf vegetables) must be harvested when the fruits are well ripened. The pods, cobs, ears, etc. should be further dried in the sun. Remove the seeds by hand or by threshing and winnowing.
2 **Firm fleshy fruits** (peppers, eggplants, gourds) should be harvested when the fruits are overripe. Cut the fruit in half, wash the seeds in water and gently rub them with a dry cloth or newspaper. Dry them well in the sun.
3 **Vegetables with fleshy, watery fruits** (tomato, cucumber): Mash the fruits and let them ferment in water for a few hours. The pulp

will float to the surface and the seeds will sink to the bottom. Put these in a cloth or newspaper and let them dry well in the sun.

Do not dry seeds on a surface that gets very hot (rock, concrete floor). The best way to dry them is on a cloth suspended above the ground. Well-dried seed can be stored in a cool and dry place. In a humid climate the seeds should be stored in an airtight container, adding a hygroscopic substance, such as finely powdered dry ash, charcoal or dried rice grains, to absorb moisture (figure 22). Ashes also repel insects.

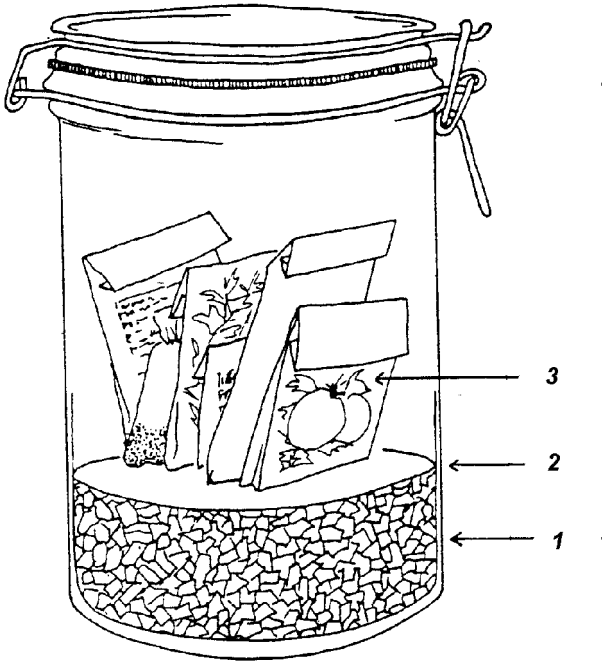

Figure 22: Air-tight glass jar to store seeds – 1: hygroscopic material, 2: paper cover, 3: seed packets

Store and sow only seeds that look healthy, discard infected or malformed seeds. Generally, the biggest and heaviest seeds are best.

These may be selected by hand, winnowing or submersion in water (see figure 23).

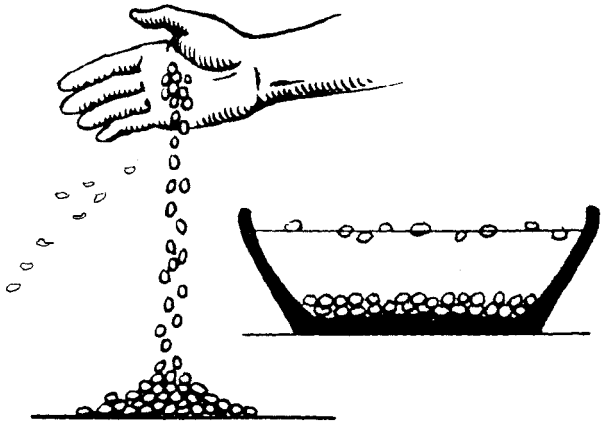

Figure 23: Grading the seed

A frequently made error is that seeds are sown too close together. That is a waste of seed and leads to extra work: the seedlings must be thinned as soon as they have germinated. Crowded seedlings grow spindly, are more vulnerable to diseases such as damping off and - in case of transplanting - survival will be poor. The table in Appendix 2 indicates the amount of seed to be used.

Some vegetables introduced from colder parts of the world do not produce seed in the tropics, because they need a cold period before they can flower (celery, cabbage, carrot). To grow these crops you will have to buy imported seed.

Direct sowing

Direct sowing means that the seed is sown where the crop is to be grown and harvested. This method is used for

- vegetables with big seeds (legumes, cucurbits, maize, okra);
- root vegetables that do not tolerate transplanting (carrot, radish);
- most leaf vegetables, especially if they are harvested within one or two months (amaranth, spiderplant)

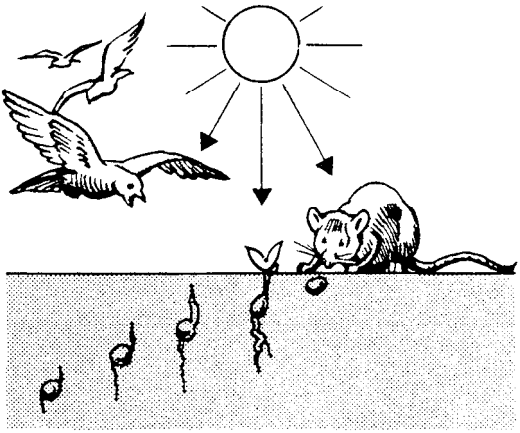

Figure 24: Sow seed at the right depth

Generally the correct sowing depth is 2 - 3 times the diameter of the seed. If the seeds are sown too deep, they are exhausted before the seedlings reach the surface. If sown too close to the surface the seeds may not find enough moisture to germinate or birds and rodents may carry them off.

There are three common ways to sow seed (figure 25).

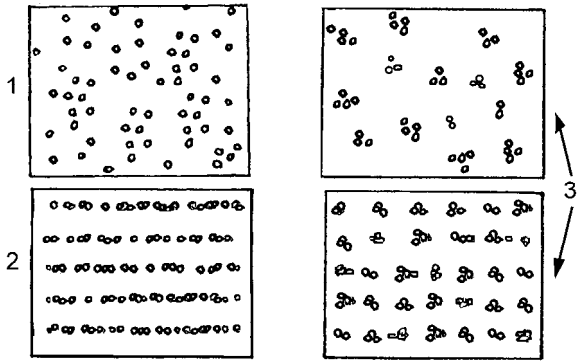

Figure 25: Different sowing patterns

1 Broadcasting: small seeds (amaranth, jew's mallow, etc.) can be broadcast, that is scattered over the area. To get a more even distribution and to avoid overcrowding the seed can be mixed with dry sand. After sowing the seed is lightly raked in. Then the soil is firmed somewhat to ensure close contact between seed and soil. This is important because the seed must imbibe soil moisture in order to germinate. Because of uneven plant spacing weeding has to be done by hand.
2 Drilling or row seeding: the seeds are put in little furrows, made with a pointed stick or by pressing a slat into the loose soil (see figure 26). After sowing, the furrows are closed by raking in soil that is lightly tamped. Ample row spacing should result in a more uniform crop stand, provided the seedlings are thinned if necessary. A hoe can be used for weeding. Row seeding is the logical answer if the plot is ridged.
3 Pocket drilling or sowing in seed holes: a method used for all vegetables that have large seeds and form big plants (maize, okra, legumes, cucurbits). Holes are made with a hoe and 2 to 5 seeds are dropped in each planting hole.

The recommended spacing of various crops is given in Appendix 2.

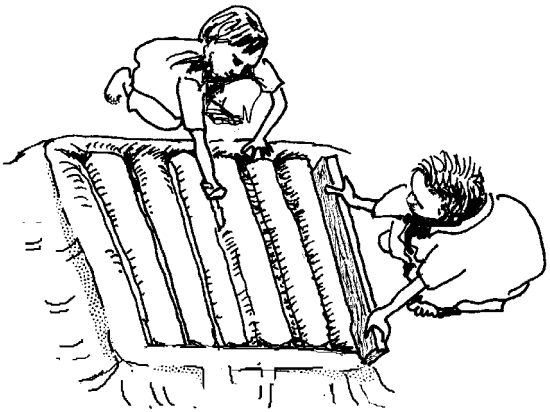

Figure 26: With a slat furrows are made in the seedbed

Raising plants in a nursery

Most small-seeded vegetables are sown in a nursery and later transplanted. In the nursery maximum care can be given to the young plants: shade, shelter against drying wind, regular watering (see figure 27). Because of the care and protection in the nursery a higher percentage of the seeds germinates and produces a seedling. Raising plants in a nursery saves space, water and seed; this should make up for the extra work (transplanting!). The nursery period lasts 3 - 6 week, depending on crop and season: about 1 week from sowing till germination and 2 to 5 more weeks till transplanting.

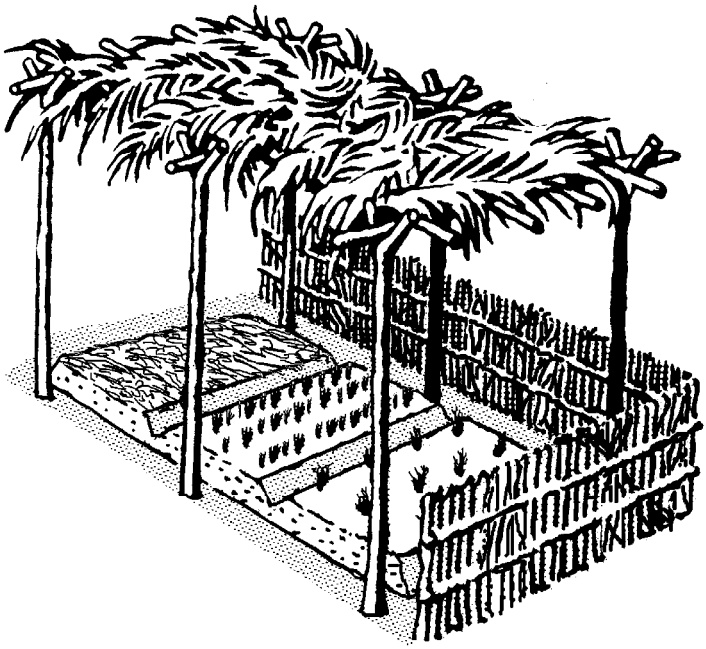

Figure 27: The seedlings should be sheltered

Seedbeds

The soil of nursery beds should be well drained and aerated. Roots and stones should be removed. The soil is worked to a fine tilth with-

out any clods. Fine manure or compost is worked in to ensure that the soil stays in good condition and can feed the roots until the seedlings are transplanted. Stick labels in the seed bed(s) so that you know what has been sown and when.

The beds should be kept moist, preferably by watering in the morning, to avoid high humidity during the night leading to damping off. Covering the seedbed with mulch conserves moisture; it also prevents a crust being formed on the soil, and seeds from being washed out by heavy showers or injudicious (splashing) watering. Remove the mulch as soon as the seedlings begin to emerge. Delayed removal will result in spindly seedlings, which are vulnerable to attacks by soil-borne diseases, such as damping off.

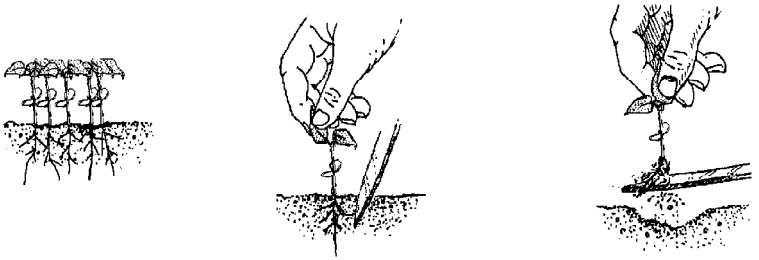

Figure 28: Pricking out: lifting the seedlings

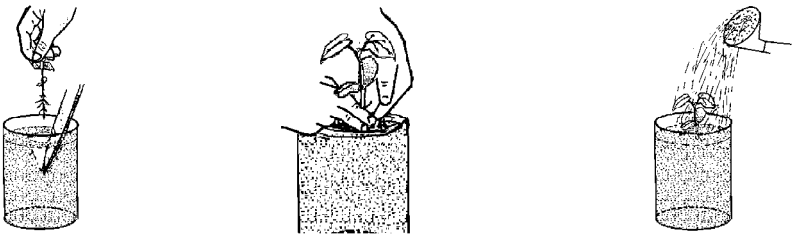

Figure 29: Pricking out: transplanting the seedlings

Pricking out

Transplanting young seedlings (as soon as the first two leaves unfold) within the nursery, at a spacing allowing unrestricted growth until field planting, is called pricking out. Seeds germinate with a dominant taproot that grows quickly at the expense of the growth of side roots. Figures 28 and 29 show pricking out step by step. In pricking out the tender tip of the taproot is lost; this leads to much better growth of the side roots at the expense of the growth of stem and leaves. As a result pricked out plants have well-branched roots and the plant is less tall but more sturdy by the time it is to be transplanted (figure 30).

This is a great advantage for planting out under harsh conditions, for instance during the dry season. The traditional practice is often to transplant two plants in a hole, in the hope that one will survive. In that case the extra work of pricking out is worthwhile, because with half the number of plants you get a better crop stand.

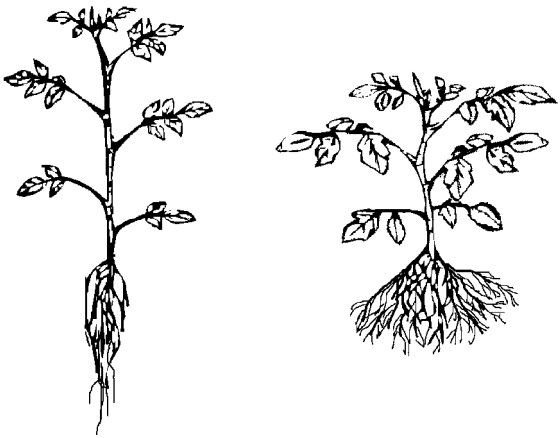

Figure 30: Pricked out tomato plant (right) has better root system and is more sturdy

One or two weeks before transplanting the seedlings are hardened off, that is gradually exposed to conditions similar to those after planting out. Shade is gradually removed and watering reduced.

Seed boxes

To avoid bending down for every job in the seedbeds, you can also raise seedlings in seed boxes or trays, placed on a work bench. Wooden boxes, baskets or containers about 10 - 15 cm deep can be used. The bottom of the boxes should be freely draining, so you may have to pierce holes.

Seed boxes are especially handy if you wish to prick out. Because the seedlings are removed within about a week from emerging there is no need for fertile soil; the boxes can be filled with clean sand. Early removal also allows a large number of seedlings to be raised in a box. You can prick the seedlings out directly from the box into a nursery bed.

Transplanting

The seedlings in the nursery are transplanted when they are big enough, normally 2 to 4 weeks after germination, when the plants have 4 to 6 leaves. Transplant in the late afternoon to avoid the heat of the day, if possible in overcast weather. Transplanting is done in several stages, that are similar to those shown in figures 28 and 29 for pricking out.

Lifting the seedlings

Soften the soil by watering, allowing the hardened seedlings to take up as much water as they like, a few hours before the seedlings are lifted. Lift the plants with the soil they are growing in with a fork and gently pull up the seedlings, placing them in a box or basket. Discard plants that do not look healthy or have poorly developed roots. Cover the lifted plants with a moist cloth or paper.

Planting

Make holes in the prepared garden plot that are deep enough to hold the plant without bending the roots. Generally the seedlings should be planted at the same depth as in the nursery; do not cover the lowest leaves with soil.

Hold the seedling against one side of the hole and fill by pressing soil with your foot or free hand from the other side of the hole. Press firmly (the roots should be in close contact with soil moisture), leaving a depression close to the roots that can hold some water.

Trimming
If the seedlings are top-heavy (well-developed leaves, poorly branched roots), nip off 1 or 2 leaves as soon as a seedling is planted. This reduces the risk of plants wilting.

Watering, shading
Water immediately after transplanting. If water is scarce you can just ladle some water in the depression alongside the plant described above. If conditions are really harsh it may be necessary to shade the plants during the first few days with twigs, pieces of palm leaf or the like.

6.2 Vegetative propagation

Quite a few vegetable crops - especially the perennial ones - are not normally propagated by seed but using other plant parts, for instance: off-shoots of taro, yam tubers (whole or cut in pieces), stem cuttings of kangkong and cassava. This is called vegetative propagation or cloning. Whereas the seed is the result of sexual fusion of pollen cell and egg cell, leading to reshuffling the genes and seedling variation, cloned plants have the same genetic make-up as the mother plant; altogether they form a clone.

Another important difference between using seed and other plant parts is that most diseases of the mother plant are not transmitted through the seed. On the other hand, when a diseased mother plant is cloned, it is likely that the off-shoots, tubers or cuttings are diseased as well. Therefore take care to select healthy plants for cloning.

Cuttings are usually taken during the wet season, and planted in the plot prepared to grow the crop. Examples of propagation through cuttings (see figure 31):

1 Cut woody cassava stems without leaves into pieces about 30 cm long and plant them out. Under wet conditions the cutting is planted upright, about one third of the stem in the soil. In dry conditions more than half of the cutting should be covered and the cutting may be set at an angle so that it does not go too deep into the soil.
2 Sweet potato cuttings are taken about 30 cm from the tip of the vine; the middle portion of the vine is sometimes used too. Remove the leaves from the lower half of the cutting and plant more or less horizontally on ridges, the lower 3 - 4 nodes covered by soil. If there is no standing crop to supply cuttings, you can also sprout some tubers and use the sprouts as cuttings.
3 To propagate taro you can use small corms, or larger corms cut into pieces, but suckers and headsets (the tip of a corm with 15 - 30 cm leaf stalk attached) are preferred in most countries.

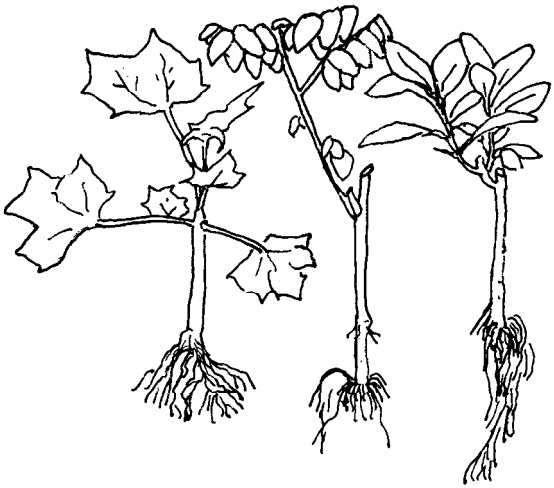

Figure 31: Two-week-old cuttings of (left to right): chaya, star gooseberry, bitterleaf

7 Crop protection

Loss of plants and spoilage of home garden produce due to pests and diseases are bound to occur occasionally. However, there are ways and means to keep these setbacks within acceptable limits.

7.1 Non-chemical control measures

Grow hardy plants

The main defense against pests and diseases in the home garden is to grow hardy plants, plants that are not susceptible to a host of pests and diseases. That is one more reason to give perennials a prominent place in your garden, because they are generally less affected than annual vegetables.

Practice mixed cropping

Rapid spread of diseases and pests is hampered because in the home garden the crop plants are mixed, trees, shrubs and herbs of various kinds growing together. In fact the risk of an entire crop failing due to a pest or disease is greatest in a plot with a single annual vegetable. Mixed cropping of annuals (for instance maize and beans with here and there a pumpkin) is common practice, for good reasons. Together, the tall, slender maize plants, the climbing beans and the spreading pumpkins fill the space more efficiently than each of these crops on their own. Moreover, maize and pumpkin benefit from nitrogen fixed by the beans. But crop mixtures may also lead to better protection against pests and diseases. Examples:

1 Vegetables with a strong smell, such as garlic, coriander, spiderplant (*Cleome gynandra*), may repel insects that attack companion crops. Growers in Sudan repel white flies in tomato by interplanting with coriander. The flies suck sap from the leaves, but in so doing they also transmit the Tomato Yellow Leaf Curl Virus, which affects young plants so badly that they do not produce fruit. Spiderplants

protect cabbages grown in the same plot to some extent against diamond back moth and french beans against flower thrips.

2 Amaranth checks nematode infestations in tomato. Slenderleaf (*Crotalaria brevidens*) also reduces nematode damage in companion crops, but it is best known for inducing germination of Striga seeds; in the absence of a vulnerable cereal the Striga seedlings die.

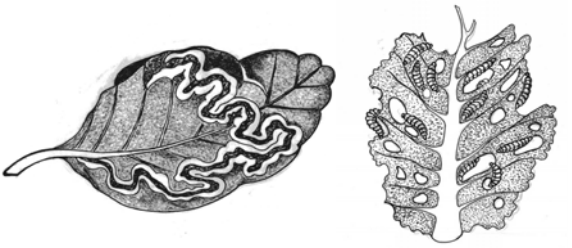

Figure 32: Insect pests: leaf miner (left) and caterpillars in cabbage

Maintain favourable growing conditions

Growing conditions range from shaded by trees to exposed to the sun and - depending on the climate - from wet to dry. Plant your crops where and when conditions are most suitable. Waterleaf and fluted gourd are shade-tolerant. Annual vegetables tolerate only light shade, but during the dry season they survive a few weeks longer in light shade than in full sun.

Plant spacing is important too. Wide spacing lets the air circulate, the plants drying quickly after rain. Between closely spaced plants the humidity remains high, facilitating the spread of diseases. Tomato growers go even further. During the wet season the crop is planted on ridges to improve drainage. Moreover, the plants are pruned to a single stem and tied to a stake, instead of letting the plants lie down and branch freely as in the dry season. Training to a single stem not only ensures rapid drying of the plants after rain, it also keeps the fruit off the ground where it would get soiled and be more easily infected.

There are quite a few soil-borne pests and diseases and the damage they do depends on soil conditions. As explained in Section 5.2 ample applications of organic matter ensure that the soil harbours a great variety of life forms. They keep each other in check, so that bacteria, fungi, nematodes (eelworms) and grubs which invade plant roots cannot easily get the upper hand. In addition proper drainage is important, because periods of water stagnation weaken the roots, making them much more vulnerable.

Damping off is an important soil-borne disease in the nursery. The stem of the seedling just above the ground rots and the plant topples. Inadequate drainage, sometimes coupled with a dense stand of spindly seedlings (for instance because germination was better than expected) gives the fungus the upper hand.

Practice crop rotation

Crop rotation - growing a succession of different crops in each plot - is important for the annual vegetables. Replanting the same crop, or a closely related crop, in a plot leads to 'replant problems': soil-borne pests and diseases of that crop build up, and nutrients preferred by that crop become deficient. For instance, rotate susceptible and resistant crops in order to reduce losses due to nematodes.

To prevent replant problems vegetables can be divided into a few distinct groups:

1 **legumes**: all kinds of beans and peas;
2 **root/tuber/bulb crops**: carrot, radish, sweet potato, onion, garlic;
3 **leaf vegetables**: dark green leaves and salad crops (amaranth, black nightshade; lettuce); cole crops (cabbages, kale, caisim, pak choi, cauliflower)
4 **fruit vegetables**: nightshades (tomato, eggplant, red pepper), okra, cucurbits (gourds, cucumber, melons).

Crop rotation means that in each plot a crop from one group should be followed by a crop from another group. Keen gardeners treat the underlined names as separate groups and follow a stricter rotation: re-

planting a crop from the same group should be preceded by two crops from other groups. Even if you practice mixed cropping it is worthwhile to choose crops from different groups when replanting.

It becomes much easier to prevent replant problems if both vegetables and fodder are grown in the garden. In that case the vegetable area can be rotated with the fodder area, as explained in Chapter 3.

Use physical protection

On the trunks of fruit trees one often sees collars made of metal sheeting or thorny branches to prevent rodents from climbing the trees. Sticky paper collars around the trunk stop ants (and other wingless insects) from climbing the tree. Ants may carry immobile insects around (scales, aphids, some leaf hoppers) to young shoots, in order to milk them for the honeydew they secrete. So controlling ants is important.

Large fruit, such as jackfruit may be bagged to protect it against insects, birds and bats. Smaller fruit (e.g. guava, mango), as well as fruit of susceptible cuccurbits (e.g. bitter gourd), is sometimes bagged too, in particular to prevent fruit flies from laying their eggs.

Wood ash is traditionally used, especially on seedbeds, to repel insect pests, such as ants, termites and caterpillars. If birds pick at emerging vegetable seedlings, you can ward them off by stretching black thread criss-cross over the bed, about 10 cm above the ground. Birds see the thread too late and bump into it. Growers in South-East Asia use fine-mesh nylon nets to protect their vegetable plots against butterflies and other flying insects laying their eggs. These nets are cheap and effective, so they may be a good choice if you have any money to spend on protection. The net can be removed as soon as the plants have grown beyond the vulnerable stage.

Practice hygiene

If you buy citrus trees infested with mealy bugs or scales, you fight a losing battle against these pests. Start clean, stay clean; this applies in

particular to perennial plants in your garden. Make sure you select healthy plants when collecting seed and especially when taking cuttings, for instance of cassava.

Many diseases become rampant during the wet season, so it is important to clean up before the rains start. Pink disease (*Corticia salmonicolor*) is a canker found in many tree crops throughout the year. By cutting out and burning affected branches before the end of the dry season, there are few sources of infection left to spread the disease during the wet season. Similarly, remove a diseased vegetable crop that is nearly finished anyway, before planting another plot of the same vegetable. If crop remains are properly composted, the risk of carrying over pests and diseases with the compost is greatly reduced.
Hygiene is also the most important weapon in fighting rats and mice: do not spill seed and remove garbage. These animals can also be controlled using traps.

Snails, slugs, caterpillars, crickets and other large insects can be removed by hand. This may sound primitive, but - as explained below - pesticides are not really effective against the larger insects.

Figure 33: Typical symptoms of disease caused by fungus (left) and virus

7.2 Commercial pesticides and plant extracts

Recipes for spraying or dusting commercial insecticides and fungicides are not given, because use of these products in home gardens is

rarely advisable. As a rule these pesticides are too expensive to warrant their use in home gardens. Moreover, in the complex plant community of a home garden, where produce is harvested almost every day, the benefits of a pesticide are small and the risk of harmful effects (to the grower, the consumer and the environment) large, in comparison with treatment of a field with a commercial crop. Use of commercial pesticides in poisoned baits is not harmful, provided the baits are placed out of reach of children and domestic animals.

As an alternative to spraying or dusting commercial pesticides you may use homemade concoctions, made from plants with insecticidal properties, such as the neem tree (*Azadirachta indica*) and bitterleaf. These 'plant teas' are inexpensive and can be made fresh when needed, doing away with the need to store poison. That an extract comes from a natural source does not mean it is safe. A striking example is nicotine, the plant extract from tobacco. It became a commercial pesticide, but is now banned in most countries because it is very toxic, also to humans. Prepare and handle plant teas with care, avoiding spray drifting onto plants that are to be harvested during the next few days. Plant teas are mainly used against pests; claims of effective control of diseases (caused by fungi and bacteria) have not been verified.

Traditional uses of different parts of the neem tree, in particular the seeds, to control insects are very effective. The hardy neem tree is also valued in agroforestry and an asset for larger home gardens. Domestic uses of neem as an insecticide are outlined in the Box.

For a plant tea to be effective it should be applied in the right way and at the right time, just like commercial pesticides. You should know which pest is damaging your crop and against which stage in its life the plant tea should be used. Often your target is a larva, for instance a caterpillar or a maggot. Larvae should be hit as soon as possible after hatching from the eggs. As they grow they eat ever less in relation to their body weight, so it becomes more difficult to poison them. Hence, early detection and assessment of the damage (is treatment warranted?) determines to a large extent the success of treatment. A delay of a few days may make all the difference.

Neem

Leaves, bark, wood and fruit of the neem tree are traditionally used in soil preparation, grain storage and animal husbandry practices, taking advantage of the insecticidal properties of azadirachtin, the main active compound. Farmers in India use neem cake - by-product of oil extraction from the seed - to dress the soil. They claim that this checks soil-borne problems caused by nematodes, grubs and fungi. Also, a mulch of neem leaves is said to reduce pest problems in crops. Stored cereals are protected for several months against insect pests when mixed with neem leaves or neem oil. Skin disorders in livestock are treated with neem oil.

Many leaf-eating or sucking insects and mites are repelled by neem compounds. If insects do eat or suck treated leaves, azadirachtin disrupts their life cycle, because it is very similar to a natural insect hormone. As a result the larvae do not pupate and egg production of the adult insect or hatching are impaired. Some beneficial insects are also affected, but not pollinating insects, including honey bees. Neem compounds have toxic effects on fish, but are relatively non-toxic to mammals.

To protect home garden crops against pests, extract neem leaves or - better - crushed seed to prepare 'neem tea'. For example: collect ripe fruit, wash the pulp off the seed and dry the seed in the shade for a few days. About 500 g of dried seed are crushed in a mortar and mixed with 10 litre of water. The mixture is left overnight and filtered the next day through fine cloth. The neem tea is now ready to be sprayed.

The active ingredients in both commercial pesticides and plant teas are broken down by sunlight; neem tea loses its toxicity completely within about a week after application. Hence the immediate effect - the 'knock-down effect' - is generally best if crops are treated in the evening. This applies in particular where the adult insects become active (e.g. beetles eating leaves, bollworms laying eggs) during the night.

It is a great help if you are familiar with the habits and life cycle of pests. A home gardener cannot be expected to know all the ins and outs of pests and diseases in the garden. But an observant gardener soon learns which pests and diseases are most troublesome. Agrodok 28: Identification of crop damage, explains how to find the cause of problems. Agrodok 30: Non-chemical crop protection, gives much more information on the subject in the title.

8 Crop care from sowing to harvest

8.1 Watering

If it rains regularly, the home garden does not need watering, except during sowing and transplanting. In the dry season you may grow vegetables that need little water, such as roselle and perennial vegetables.

Watering is usually measured in millimetres (mm): 1 mm = 1 litre per square metre = 1 watering can (about 10 litre) per 10 square metres. How much water is needed depends on the climate and the soil. In the dry season, if it does not rain, leaf vegetables need at least 6 mm a day and the other vegetables at least 4 mm a day, that is to say 6 and 4 watering cans respectively per bed of 10 square metres. Sandy soil must be watered more frequently than loam or clay, because sand can store far less moisture. Heavy soil should be watered slowly to allow time for the water to sink in. Do not apply too much water; it drives the air out of the soil so that the roots suffocate if the soil stays wet.

After transplanting crops may require light watering every day. Established crops should be watered about once a week on heavy soil and two times a week – or three times under hot and dry conditions - on light soils.

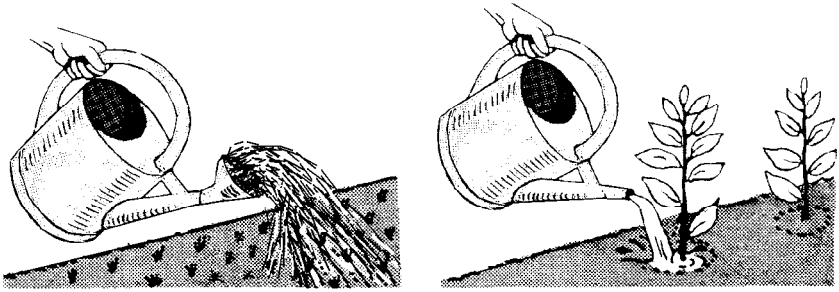

Figure 34: Watering with and without the rose

It is best to water in the late afternoon. Avoid watering in bright sunshine because more water is lost by evaporation. Use a watering can with a fine rose in the nursery. This has the effect of soft rain and does not wash away the soil. You can also use a broom and a bucket or a calabash filled with water for this purpose (see figure 35).

Figure 35: Watering seedlings with a broom and a bucket

For plants that are spaced well apart – such as tomato, eggplant, cabbage, pepper and cucumber – water close to the plant, for instance using the watering can without the rose (figure 34). Keeping the leaves dry helps to reduce the spread of diseases.

A simple method of drip irrigation is shown in figure 36. This method saves labour if the drum can easily be filled, for instance from a tap. It also saves water, because losses due to uneven distribution, evaporation and run-off are minimal. If surface irrigation is possible, follow the local methods for flooding of sunk beds, or watering the furrows in ridged plots.

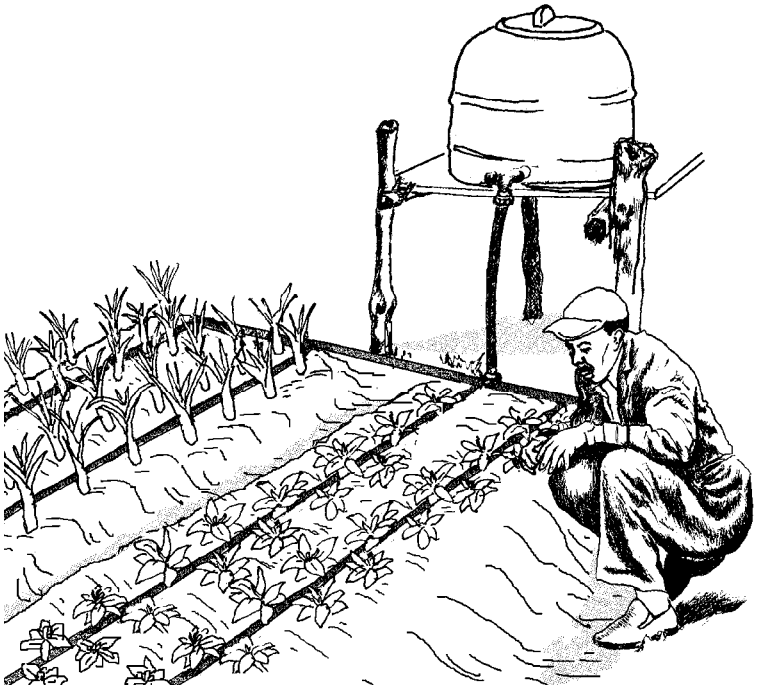

Figure 36: Drip irrigation using a drum and two drip lines per bed

8.2 Other forms of crop care

Shelter

A shelter protects seedlings and freshly transplanted plants from fierce sunshine or heavy rainfall. The most common shelters are a cover of leaves or plaited straw, supported by stakes, above the nursery (see figure 27 in Section 6.1). Loosely woven leaves that filter sunlight mainly provide shade, for instance over seedbeds. Densely woven leaves, slightly hanging over, protect against rain. A shelter of this kind should be about one metre high, or two metres if you do not want to bend down while tending the plants. If too low, there will be insufficient ventilation and light for proper plant growth.

A cover of transparent polythene is sometimes used to keep the plants dry, for instance to minimize the spread of diseases in tomatoes during the wet season. You can shelter single plants with palm leaves, as in the example shown in figure 37.

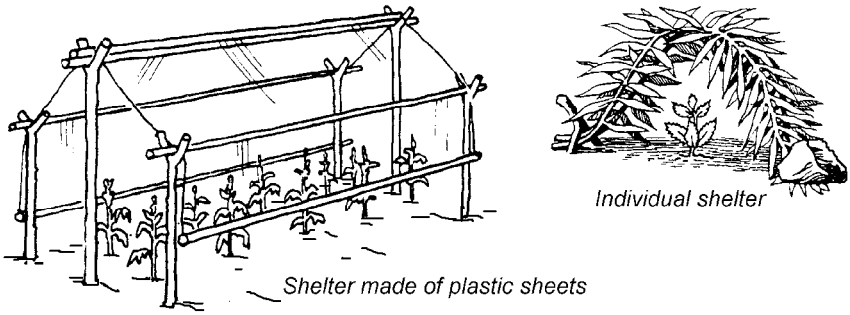

Figure 37: Shelters: polythene rain cover and palm frond for shade

Weeding

Weeds compete with the crop for light, water and nutrients. Most common weeds grow fast and can easily smother young plants. Climbing weeds or green manure crops, such as kudzu or desmodium, can quickly overgrow young trees; if a shade cover has been set over the trees you may not even notice the problem in time. Hand weeding and hoeing are the common methods.

A sharp push hoe (see Appendix 3) is pushed just below the soil surface. It is an ideal tool to cut weeds soon after they have germinated, provided the topsoil is dry. Larger weeds are pulled up by hand or struck with the common hoe, making sure you strike deep enough to prevent regrowth (see figure 38).

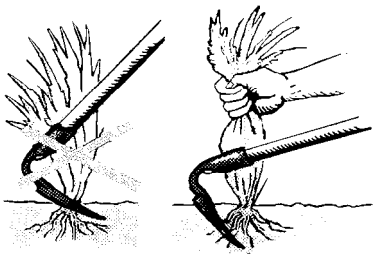

Figure 38: Weeding with a hoe

If the weather is dry and sunny, weeds can be left to dry on the spot. They can also be gathered and put on the compost heap, or under trees as a mulch.

Weeds that spread through underground stolons (for instance some grasses, including the noxious satin tail - *Imperata*) or tubers (nutgrass - *Cyperus*) are hardest to control. You may need a fork to lift these underground parts, but several forking or hoeing rounds will be needed to exhaust and kill these weeds. Mulching does not help much to control weeds with underground stolons or tubers. Herbicides are too expensive and risky (damage to the crops, toxic to humans) to be used in home gardens.

Staking and pruning

Plants that are not sufficiently sturdy (tomato, eggplant) can be loosely tied to a stake to support the weight of their fruit (see figure 39). Climbers (several beans, basella, bitter gourd) seek any support that is available, from dead branches stuck in the ground or (live) stakes to trellises (chayote, passion fruit).

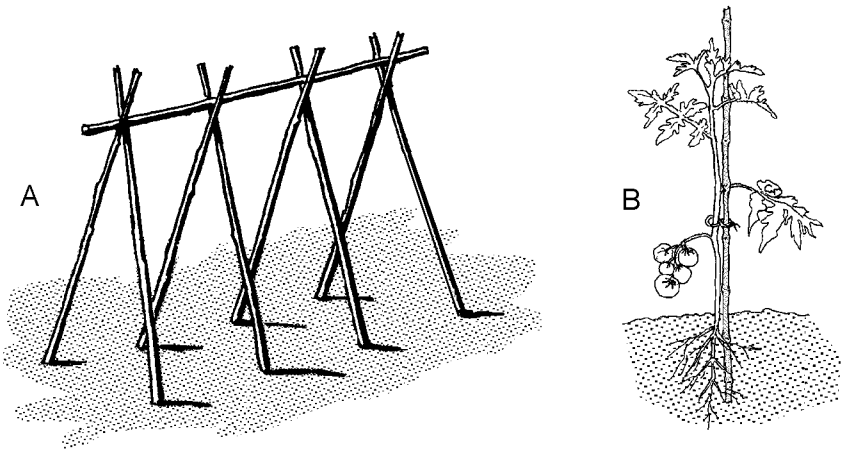

Figure 39: Staking – A: stakes for pole beans, B: staking of egg-plant or tomato; the plant is loosely tied to the stake

Picking young shoots of herbs, shrubs or trees for the next meal is a form of pruning. Usually new shoots leaf out from buds below each cut, so that before long you can again pick shoots. Tomato plants may be trained to a single stem by pinching out side shoots soon after they appear. In that case the complete shoot is removed, leaving no buds that can sprout again, resulting in a single stem.

Harvesting

Ideally you should be able to gather some leaves, young shoots, or other produce every day and throughout the year. Harvest leaves and young shoots early in the morning. Keep an eye on the weather: fruits and vegetables harvested dry keep better than wet products. Wash fruit of eggplant, tomato and cucumber shortly before consumption, because once washed these fruits deteriorate quickly. Fruits and vegetables are best kept in a dry, cool, ventilated and dark place. See Agrodok 3: Preservation of fruit and vegetables, for methods of long-term conservation.

Appendix 1 Perennial garden plants

Explanatory notes

The table is split into three sections:

- live stakes and hedging plants
- perennial vegetables: trees and shrubs
- perennial vegetables: herbs.

Sometimes the information is incomplete; in a few instances the information from various sources is contradictory. AGROMISA welcomes suggestions for corrections, supplementary information about species and additional species that deserve being listed.

Botanical name: The species are listed alphabetically by their botanical name. If the botanical name has changed in recent years and the species is still better known by its former name, that name is given between brackets. An asterisk (*) behind the botanical name indicates that the species is able to convert inert nitrogen from the air into a form that can be taken up by the plant.

Common names: Common names are not unique; they may differ in different parts of the world. That is why for some species several common names are given.

Uses: The use as a perennial garden plant is listed first, starting with the main part used as food in the case of vegetables. The limited space does not permit listing uses extensively.

Where grown: The continent where the plant is thought to have its origin is listed first, followed by other continents where the plant is now common.

Habit: The general appearance of the plant. The habit of plants occurring over a wide range of ecological conditions may differ substantially at the extremes of the range.

Propagation: Propagation methods that have found practical application are given. If several propagation methods are used, the most common method is mentioned first.

Ecology: Information about the growing conditions required by a plant is often fragmentary, and presented in very different terms in the various sources. Moreover, within many species several types are distinguished which differ in their ecological requirements, e.g. one type being much better adapted to dry conditions than the other type.

Information starts with the range of altitudes at which the plant is found within the tropics. The symbol < indicates 'lower than'; > indicates 'higher than'; a plus sign (+) behind a figure means that the plant is generally found up to the altitude given, but in some instances in even higher locations.

Rainfall requirements are given in similar terms. However, if plants have access to ground water, e.g. along riverbanks or in depressions, they may thrive with less rainwater than indicated. Information about soil requirements is available for only very few species.

Remarks: Information that does not fit under other headings.

Nr	Botanical name	Common names	Uses	Where grown
Live stakes and hedge plants				
1	Caesalpinia decapetala	Mauritius thorn	hedge, medicine, tannin	Asia
2	Carissa macrocarpa (Carissa grandiflora)	carissa, Natal plum	hedge, fruit, medicine	S.Africa pantropical
3	Commiphora africana	African bdelllium	live stakes, hedge, fodder, resin/gum, food	Africa
4	Dovyalis caffra	kei apple	hedge, fruit	Africa
5	Erythrina fusca*	purple coral tree	live stakes, forage, shade tree, ornamental	pantropical
6	Erythrina poeppigiana*	mountain immortelle, coral tree	live stakes/support/shade, fodder, green manure	S.America pantropical
7	Erythrina subumbrans*	December tree	live stakes, fodder, medicin, shade tree	Asia pantropical
8	Euphorbia balsamifera	balsam spurge	hedge, fodder (camels, goats), medicine	Africa
9	Euphorbia tirucalli	finger tree, rubber euphorbia	hedge, latex, fish poison, woodcraft, medicine	Africa, pantropical
10	Flemingia macrophylla*	-.-	hedge, alley crop, forage, cover crop, mulch, fallow	Asia, Africa, America
11	Gliricidia sepium*	gliricidia, mother of cocoa	live stake/support, shade, hedge, fodder, green manure	C.America, pantropical
12	Hibiscus rosa-sinensis	China rose	hedge, ornamental, forage	Asia, pantropical
13	Inga edulis*	guamo	live stakes, food (pods), shade, green manure, fuelwood	S.America
14	Jatropha curcas	physic nut, purging nut	hedge, live stakes, seed oil, latex, medicine	C.America, pantropical
15	Lannea coromandelica (Lannea grandis)	-.-	live stakes, fodder, ornamental	S-E. Asia
16	Lantana camara	lantana, wild sage	hedge, ornamental, medicine	America, pantropical

Nr	Habit	Propagation	Ecology	Remarks
Live stakes and hedge plants				
1	straggling spiny shrub	seed	lowland, <1000 m monsoon climate	requires much training
2	climbing shrub with strong spines	(air) layering	full sun, seasonal climate	strong hedge, tolerates salt, frost
3	small deciduous tree	stake cuttings	dry areas, such as sahel, savanna woodland	most of the year leafless
4	small tree with strong spines	seed	highland monsoon climate	slow-growing, excellent hedge
5	spreading tree, spiny branches	stake cuttings, seed	0-2000 m; 1200-3000+ mm rain	most widespread coral tree
6	deciduous spreading tree	stake cuttings	500-1500+ m; >1200 mm rain; fire resistant	fast growth, coppices very well
7	deciduous spreading tree	stake cuttings, seed	0-1500 m; <4 months with <100 mm rain	excellent support for climbing crops
8	erect shrub	cuttings	southern edge of Sahara (<900 mm rain); deep sandy soil	best protective hedge in dry areas
9	succulent shrub or small tree	cuttings	up to 2000 m; drought-tolerant	good hedge for dry regions
10	deep-rooted, semi-woody shrub	seed	0-2000 m; >1100 mm rain; stands long dry season	coppices very well
11	small tree	cuttings, seed	0-1500 m; >900 mm rain; tolerates fire	multi-purpose agroforestry tree
12	shrub	cuttings, layers	0-1500+ m, no prolonged drought, permeable soil	many ornamental hybrids
13	tree	seed	0-1600 m; >1200 mm rain, short dry season; tolerates acid soil	leave some foliage when pollarding
14	tall shrub	cuttings, seed	0-1700 m; drought-tolerant; likes permeable soil	common hedge in semi-arid areas
15	tree	stake cuttings	fairly humid lowlands	sturdy straight trunk
16	low shrub	cuttings, seed	0-1500 m; open, not too moist habitats	may become noxious weed

Nr	Botanical name	Common names	Uses	Where grown
17	Leucaena leucocephala*	leucaena	live stakes, fodder, food (shoots and pods, seed), medicinal gum, shade	pantropical
18	Newbouldia laevis	boundary tree	live stake/fencing, medicine	W.Africa
19	Parkinsonia aculeata*	Jerusalem thorn	hedge, charcoal, fibre, reforestation, ornamental	America pantropical
20	Pithecellobium dulce*	guayamochil, sweet inga, manila tamarind	hedge, fodder, food (pods), medicine	America, pantropical
21	Prosopis juliflora*	mesquite	hedge, land reclamation, food/forage (pods), honey, wood, gum	S.America, pantropical
22	Spondias mombin	yellow mombin, hog plum	live stake/fencing, shade, food (fruit, leaves), wood	America, pantropical
23	Tephrosia candida*	white tephrosia, white hoary pea	hedge, land reclamation, green manure, shade, fuelwood	Asia, Pacific, S.America
24	Ziziphus mauritiana	ber, Indian jujube	hedge, fruit, fodder, timber, shellac	pantropical
Perennial vegetables: trees and shrubs				
1	Adansonia digitata	baobab	leaves and other parts eaten; many other uses	Africa scattered
2	Cnidoscolus aconitifolius	chaya, tree spinach	leaves; forage, medicine	C.America
3	Gnetum africanum	eru	leaves, seed; medicine, rope (stem)	W. Africa
4	Gnetum gnemon	melinjo, Spanish joint fir	leaves, inflorescences, nuts; strong fibre	S.E.Asia
5	Moringa oleifera	drumstick tree	leaves, flowers, fruit, seed; forage, medicine, dye, essential oil (seed)	pantropical
6	Myrianthus arboreus	giant yellow mulberry	leaves, fruit, seed; medicine, mulch (fallen leaves)	Africa
7	Sauropus androgynus	star gooseberry	leaves, flowers, fruit; medicine, dye for pastry	Asia

Nr	Habit	Propagation	Ecology	Remarks
17	small tree	seed	0-1000+ m; 650-1500+ mm rain	popular agroforestry tree
18	small tree	stake cuttings	humid lowlands	commonly marks field boundaries
19	small deciduous thorny tree	seed	from wet to dry areas	danger: may spread like a weed
20	small thorny tree	seed, air layering	lowland up to 1500+ m; 400-1650 mm rain; tolerates drought, salinity	easily shaped into a hardy hedge
21	spiny shrub or small tree	seed, root cuttings	0-1500 m; tolerates drought (50+ mm rain) and saline soils	rampant growth requires strict pruning
22	tall deciduous tree	stake cuttings	0-1000 m; semi-arid to humid climates	popular fence/shade tree in W. Africa
23	herb, shrub or small tree	seed	0-1600 m; >700 mm rain; acid soil	replaces leucaena on acid soils
24	tree or bushy shrub	seed, grafting	0-1000 m; >200 mm rain	hardy: tolerates extreme temp., drought, soil defects
Perennial vegetables: trees and shrubs				
1	massive deciduous tree	seed, cuttings, grafts	0-1200+ m; 200-800 mm rain; prefers sandy topsoil	seedlings vary; selection desirable
2	shrub or small tree	stem cuttings	0-1300 m; hardy: thrives in wet and dry conditions and on shallow soils	good hedge; stinging hairs no problem in garden var.
3	dioecious liana	seed, cuttings	0-1200 m; rainforest (3000 mm rain); needs support and shade	wild stands overexploited; domesticate in home gardens
4	slender tree	seed, air layers	0-1200 m; rainforest tree, in garden dry period preferred, but roots need water	leaves picked mainly from male trees (no nuts)
5	semi-evergreen small tree	seed, stake cuttings	0-1500 m; drought-tolerant (>500 mm rain)	popular home garden tree
6	deciduous shrub or tree	seed, stem cuttings	0-1200 m; needs moist conditions	both leaves and fruit much liked
7	erect shrub	stem cuttings, seed	0-1300 m; prefers shade, tolerates heavy rain and soil	usually grown as a hedge

Nr	Botanical name	Common names	Uses	Where grown
8	Sesbania grandiflora	agati sesbania	flowers,tender pods, leaves; forage, shade, support, fuel, medicine	S.E. Asia pan-tropical
9	Vernonia amygdalina	bitterleaf	leaves; forage, medicine, fungicide (wood ash), honey	Africa
10	Vernonia hymenole-pis	sweet bitterleaf	leaves; as V. amygdalina; ornamental	Africa
Perennial vegetables: herbs				
1	Asystasia gangetica	tropical primrose	leaves; fodder, medicine, ornamental	Africa, pan-tropical
2	Cajanus cajan	pigeon pea	seed, pods; hedge, shade, cover crop, feeds silk-worms/ lac insects; medicine	India, E.Africa, pantropical
3	Canavalia gladiata	sword bean	young pods/seed; forage and cover crop	pantropical
4	Colocasia esculenta	taro, dasheen, eddoe, cocoyam	corms, leaves; forage (after fermentation or cooking)	pantropical
5	Dioscorea bulbifera	aerial yam, potato yam	bulbils, tubers	Asia, Africa
6	Launea taraxacifolia	yanrin, African lettuce	leaves; forage	Africa
7	Psophocarpus scan-dens	African winged bean	leaves, fruit, seed; forage, fibre	Africa, Indian Ocean, C.America
8	Sechium edule	chayote	fruit, leaves, root, seed; forage, fibre	C.America pantropical
9	Telfairia occidentalis	fluted pumpkin, fluted gourd	leaves, seed; oil (seed), medicine, fibre	W.Africa

Nr	Habit	Propagation	Ecology	Remarks
8	short-lived tree	seed	0-800 m; >800 up to 4000 mm rain; tolerates flooding, salinity	rapid early growth (4-5 m in 1 year)
9	shrub or small tree	seed, cuttings	0-2000 m; prefers humid conditions, but fairly drought-tolerant	easily shaped in hedge; branches serve as live stakes
10	herb, shrub or small tree	seed, cuttings	1400-2500+ m; >850 mm rain	may replace bitterleaf
Perennial vegetables: herbs				
1	upright herb, <2 m tall	seed, cuttings	0-2500 m; < 4 dry month; all soils, also acid peat	cover crop; tolerates shade
2	short-lived tall herb	seed	0-2000 m (no frost); 600-1000 mm rain best; well-drained soil	multi-purpose legume, esp. in semi-arid regions
3	trailing/climbing herb	seed	0-1000 m; 900-1500 mm rain; hardy: tolerates shade, drought, salinity, acid soil	often grown as annual; cooking ripe seed laborious
4	large-leaved herb with corms	corms	lowland -medium elevation; wetland crop, but some cvs tolerate drought and salt	wide range of cvs for different conditions
5	twining herb, dioecious	bulbils, tubers	0-1200+ m; >1000 mm rain, <4 dry months; fertile soil	labour-intensive crop, famine food
6	rosette-forming herb	seed, cuttings	600-1700 m; grows in open savanna, drought-tolerant	known as the dry season vegetable
7	climbing or twining herb	seed	0-1000 m; 1000-1800+ mm rain; prefers swamps	more hardy than common winged bean
8	sprawling or climbing herb	seed	350-2500 m; 1500-2000 mm rain; prefers moist air	multi-purpose, high-yielding, easy-to-grow vegetable
9	dioecious climbing herb	seed (germinates in fruit)	humid lowlands; grown as rain-fed crop, but responds well to watering	leaves picked for 6-10 month when rain-fed

Appendix 2 Annual vegetables

			(1)	(2)
nr	**Common name**	**Botanical name**	**propagation**	**plants/10 m²**
1	Common bean	Phaseolus vulgaris	d	40*
2	Lima bean	Phaseolus lunatus	d	30*
3	Yard-long bean	Vigna unguiculata	d	30*
4	Winged bean	Psophocarpus tetragonolobus	d	30*
5	Sweet potato	Ipomoea batatas	v	120
6	Carrot	Daucus carota	d	400-800
7	Onion	Allium cepa	n	250
8	Shallot	Allium cepa	v	250
9	Welsh onion	Allium fistulosum	v	
10	Amaranth	Amaranthus species	d, n	250-500
11	Celosia	Celosia argentea	d,n	
12	African nightshade	Solanum scabrum	n	250-500
13	Jew's mallow	Corchorus olitorius	d, n	250
14	Kangkong	Ipomoea aquatica	v, d	120
15	Lettuce	Lactuca sativa	n	200
16	Waterleaf	Talinum triangulare	n, v	150-300
17	Chinese cabbage	Brassica rapa	n	40
18	Pakchoi, Caisin	Brassica rapa	d,n	200
19	Headed cabbage	Brassica oleracea	n	30
20	Leaf cabbage	Brassica oleracea	n	40
21	Ethiopian kale	Brassica carinata	n	100
22	Eggplant	Solanum melongena	n	10-30
23	African eggplant	Solanum aethiopicum	n	20-60
24	Gboma	Solanum macrocarpon	n	
25	Hot pepper	Capsicum annuum	n	10-30
26	Sweet pepper	Capsicum annuum	n	30-50
27	Tomato	Lycopersicon esculentum	n	20-30
28	Bitter gourd	Momordica charantia	d	40*
29	Pumpkin	Cucumis sativus	d	
30	Cucumber	Cucumis maxima	d	10-25*
31	Melon	Cucumis melo	d	15*
32	Okra	Abelmoschus esculentus	d	20-50*
33	Roselle	Hibiscus sabdariffa	d	20

Explanatory notes:
(1) d = direct sowing, n = sowing in nursery bed, v = vegetative propagation
(2) per 10 square metres of cultivated area
* = the figure indicates the number of seed holes with 2-4 seeds each

		(3)			
nr	**duration in days**	**humid lowland 28-30°**	**savanna climate**		**highland 15-30°**
			hot 30-40°	**cool 20-30°**	
1	90	+	+	++	++
2		++	++	+	+
3	100-150	++	++	+	+
4	270	++	++	+	-
5	90-180	++	++	+	+
6		-	-	+	++
7		-	-	++	++
8		+	+	++	++
9		-	-	+	++
10	20-90	++	++	+	+
11		++	++	+	+
12	40-120	++	++	++	+
13	45-80	++	++	++	+
14	60-30	++	++	++	+
15		+	+	++	++
16	100-180	++	++	+	+
17		+	+	++	++
18	50-80	++	++	++	++
19	60-100	+	+	++	++
20		+	+	++	++
21	50-100	++	++	++	++
22	80-200	++	++	++	+
23	60-300	++	++	+	+
24		++	++	+	+
25	90-270	++	++	++	+
26	50-130	-	+	++	++
27	60-160	+	+	++	++
28	70-110	++	++	++	+
29		++	++	++	++
30	60-150	+	+	++	++
31	70-120	–	+	++	++
32	60-360	++	++	++	+
33	120-180	+	+	++	+

(3) ++ = very suitable climate
+ = less suitable climate
– = non-suitable climate

Appendix 3 Garden tools

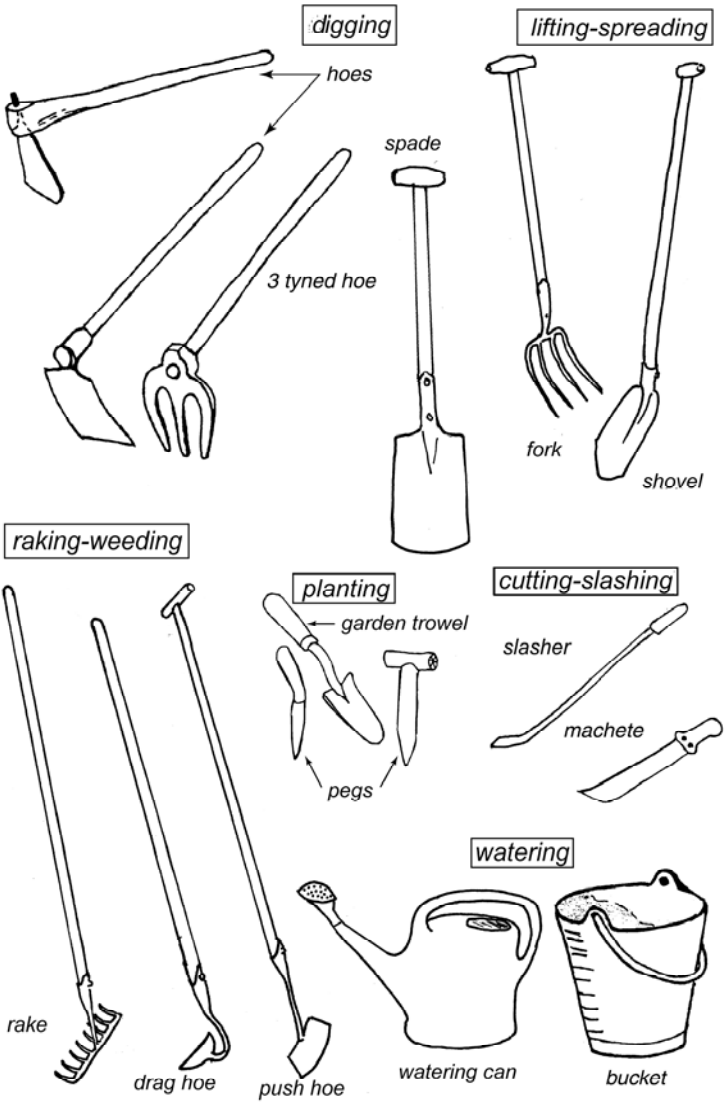

Figure 40: Garden tools

Further reading

Bailey, J.M., 1992: **The leaves we eat.** CTA/South Pacific Commission Handbook 31, Noumea, New Caledonia: 97 pp. ISBN: 982-203-245-5

Chigumira Ngwerume, F., 1999: **Vegetables, Book 1: Principles of planning vegetable production, with drought in mind.** (First of 4 self-study booklets). SADC Centre, Harare, Zimbabwe: 32 pp.

Dupriez,H. & de Leener, Ph., 1988: **Agriculture in African rural communities.** MacMillan Publ., London, UK: 294 pp. ISBN: 0-333-44595-3

Rice, R.P.; Rice, L.W.; Tindall, H.D, 1992. **Fruit and vegetable production in warm climates.** MacMillan Publ., London, UK: 486 pp. ISBN: 0-333-46850-3

Nutrition Programme Service, 2001: **Improving nutrition through home gardening: a training package for field workers in Africa.** FAO, Rome: 275 pp. ISBN: 92-5-104388-4

Grubben, G.J.H. & Denton, O.A., Editors, 2004: **Plant resources of tropical Africa 2. Vegetables.** PROTA Foundation/ Bakhuys Publ., Leiden/CTA, Wageningen, Netherlands: 668 pp. ISBN: 90-5782-147-8

Schippers, R.R., 2000: **African indigenous vegetables, an overview of the cultivated species.** Natural Resources Institute, Chatham, UK: 214 pp. ISBN: 0-85954-515-6

Siemonsma, J.S. & Kasem Piluek, Editors, 1993: **Plant resources of South-East Asia 8: Vegetables.** PUDOC, Wageningen, Netherlands: 412 pp. ISBN: 90-220-1058-9

Youdeowei, A., 2002: **Integrated pest management for production of vegetables.** IPM Extension Guide 4, Min. of Agriculture, Ghana and GTZ, Germany: 49 pp. ISBN: 9988-01088-5

See also the periodicals:

***Spore* magazine**
Bi-monthly journal of the Technical Centre for Agricultural and Rural Cooperation (CTA) – ACP-EU. ISSN: 1011-0054
Adress: CTA – Spore,
PO Box 380, 6700 AJ Wageningen, the NETHERLANDS
E: spore@cta.int
Spore on the web: www.spore.cta.int

CORAF Action
Quarterly Newsletter of the West and Central African Council for Agricultural Research and Development.
Adress: CORAF/WECARD,
BP BP 48 Dakar RP CP 18623, SENEGAL
E: coraf.action@coraf.org , pdf-version of the journal: www.coraf.org

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T: (62) 222786245
E director: imhidayat@yahoo.com

HDRA, the Organic Association
The International Development Programme of HDRA promotes and facilitates organic agriculture in Africa, Asia and Latin America. It offers a range of booklets and leaflets on various techniques related to natural crop protection (free downloadable):
Contact: Ryton Organic Gardens
Coventry, Warwickshire CV* 3LG, United Kingdom
T: +44 [0] 24 7630 3517, F: +44 [0] 24 7663 9229
E: enquiry@hdra.org.uk, W: www.gardenorganic.org.uk

ILEIA
Centre for Information on Low External Input and Sustainable Agriculture. Promotes exchange of information for small scale farmers in the South through identifying promising technologies. Information about these technologies is exchanged mainly through the LEISA Magazine. All articles accessible on-line.
Contact: ILEIA, Zuidsingel 16, 3811 HA Amersfoort, The Netherlands
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E: ileia@ileia.nl, W: www.leisa.info

Glossary

annual plant	plant that completes its life cycle from seed to seed within one year (but see also section 4.2: Annual vegetables)
bulb	an underground, rounded storage organ with a much shortened stem bearing swollen leaf-bases enclosing a bud (e.g. onion)
carbohydrates	foodstuffs based on sugars and starch, providing energy
carotene	foodstuff that is converted in vitamin A in the body
clone	a group of plants originating by vegetative propagation from a single plant and therefore genetically the same
corm	a solid, short, swollen underground stem
cultivar	a variety that had its origin in selection and/or breeding and known under its own name in the trade
energy food	foodstuffs, particularly carbohydrates, that provide the energy needed for life processes
hypocotyl	the young stem below the cotyledons (seed-leaves)
indigenous	native to a particular area or region
pantropical	distributed throughout the tropics

perennial plant	plant with a life cycle longer than one/two (annuals/bi-annuals) years
pod	a longish fruit that opens spontaneously when ripe and dry
pulses	dry edible seeds of legumes
protective food	foodstuffs needed - in addition to energy food - for healthy growth: protein, vitamins, minerals, fibre
root-nodules	small swellings on roots of legumes containing nitrogen-fixing bacteria (rhizobia)
staple food	foodstuffs that can be stored for prolonged periods of time: cereals, pulses, tubers
stolon	a trailing stem, usually above-ground, producing roots and shoots at the nodes
tillage	cultivation of the soil, for instance by hoeing or ploughing
tuber	an underground storage organ, formed by a swollen portion of a stem or root (e.g. sweet potato)
variety	a distinct type within a species with a natural origin