Agrodok 9

The vegetable garden in the tropics

Henk Waaijenberg

First English edition: 1989
Third revised edition: 1994
Fourth edition: 2003

Author: Henk Waaijenberg
Translation: I. Veerman
Printed by: Stoas Digigrafi, Wageningen, the Netherlands

ISBN: 90-77073-50-7

NUGI: 835

Foreword

This Agrodok does not pretend to be an original work. In fact it is an anthology of the literature mentioned in the bibliography.
The main objective of this Agrodok is to serve as a general manual for those who practise or teach gardening in developing countries, in order to improve the living conditions of the inhabitants of these countries.
I would like to thank Mr. G.J.H Grubben of the Royal Institute for the Tropics, Amsterdam, and several others who have corrected the text and given important advice.

Henk Waaijenberg

Contents

1	**Why gardening?**	**6**
2	**Fruit and vegetables in the diet**	**7**
3	**Which type of garden?**	**11**
3.1	Gathering wild fruits and vegetables	11
3.2	Vegetables in mixed cultivation with field crops	11
3.3	The homesite farm	12
3.4	Intensive cultivation for family use	12
3.5	Commercial vegetable growing	13
3.6	Other gardens: communal, school and demonstration gardens	13
4	**Garden tools**	**15**
5	**Preparing the site**	**18**
5.1	The best site for a garden	18
5.2	Size and design of the garden	19
5.3	Clearing the site	20
5.4	Cultivating the soil	21
5.5	Preparing the beds	23
5.6	Fences	24
6	**Soil improvement**	**26**
6.1	Soil conditioning	26
6.2	Plant nutrients	26
6.3	Organic manure	28
6.4	Chemical fertilizers	32
6.5	Crop rotation	33
7	**Sowing and propagation by cuttings**	**35**
7.1	Seeds	35
7.2	Direct Sowing	38

7.3 Sowing in a nursery 41
7.4 Transplanting 43
7.5 Taking cuttings 45

8 From sowing to harvest: techniques of cultivation 46
8.1 Watering 46
8.2 Control of diseases, insects and other parasites 47
8.3 Other techniques of cultivation 53

9 Choosing the right crops 57

Further reading 59

Useful addresses 60

Appendix 1: Some important vegetables 62

Appendix 2: Data about important vegetables 64

Appendix 3: List of technical terms 66

Appendix 4: Pictures of common vegetables in the tropics 69

1 Why gardening?

Throughout the tropics people grow fruit and vegetables in their own vegetable gardens. Why do they keep a garden?

- It assures them good food at low cost. Fruit and vegetables are necessary for the good health of children and adults. They make their diet more balanced and tastier. By keeping a garden people are less dependent on shops and markets, where supplies are often irregular and prices are high.
- It is a source of revenue. By selling produce not needed for personal use, the gardener can earn extra money.
- It is a pleasant and instructive pastime.

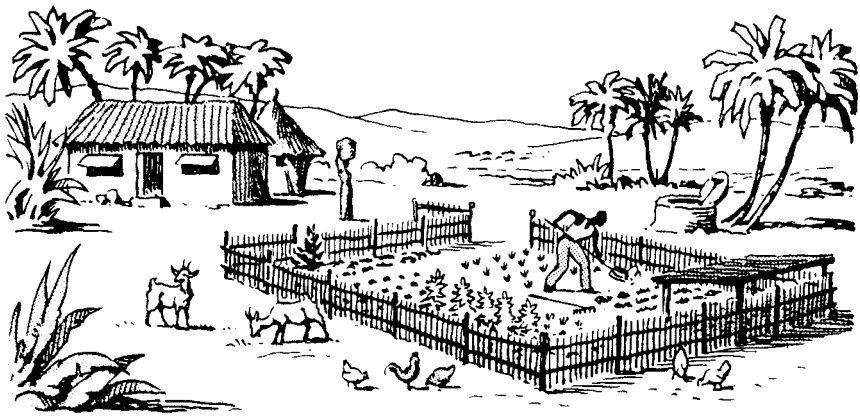


Figure 1: A garden requires little space. A surface of 50 to 100 square metres, when efficiently used, can provide all the vegetables needed to feed a family of six.

2 Fruit and vegetables in the diet

In a garden you will find vegetables, fruit trees, herbs, spices and sometimes flowers. In this Agrodok we will deal mainly with the cultivation of vegeta-bles, as they form the most important part of the garden and the garden produce. Because of their size most gardens contain only a limited number of fruit trees. Spices such as ginger and hot pepper are consumed only in small quantities, and therefore hardly contribute to human nutrition. Several other cultivated plants can be used as vegetables, such as the leaves of cassava, sweet potato, cocoyam and taro, but generally these plants are cultivated in large fields.

We can divide vegetables into the following types:
1 **Leaf vegetables**, grown for their green leaves, such as Ceylon spinach, amaranth, lettuce, cabbage.
2 **Fruit vegetables**, grown for their fleshy fruits, such as tomatoes, eggplant and string beans.
3 **Seed vegetables**, grown for their dried seeds, such as groundnuts, beans pigeon peas and some Cucurbita species (the West African "goussi").
4 **Root vegetables**, grown for their fleshy roots or lower stems, such as carrots, turnips, radish.
5 **Miscellaneous vegetables**, such as cauliflower, asparagus, onions.

The nutritive value of root vegetables is comparable to that of tubers like sweet potato and cocoyam, or may be even higher; carrots contain a lot of carotene, rich in vitamin A.
Table 1 gives an impression of the composition of these types of vegetables and allows us to compare their nutritive value with that of some other food-stuffs. Men, women and children need a balanced diet to stay in good health and to be able to work and grow. Proper nutrition provides the body with the following substances:

1 **Carbohydrates**, which provide energy to the body. One gram gives 4 kilocalories or 16.7 kilojoules of energy. Sources: flour, starch, sugar,

cereals, tubers, bananas, legumes. Those foodstuffs that are eaten daily in large quantities are called staple foods.

2 **Fats**, which provide energy and make carotene more digestible for the human body. One gram gives 9 kilocalories or 38 kilojoules. Sources: coconut, oilpalm, peanut and maize oil, avocado, animal products.

3 **Proteins**, the material of which our bodies are made. Proteins are necessary for growth and development of the body and are very important for children and for women during pregnancy and when they are breastfeeding. Sources: cereals, seed vegetables, animal products.

4 **Minerals**, substances like iron and calcium which are taken up by plants from the soil. The most important minerals are:
calcium, the mineral of which bones and teeth are composed.
Sources: leaf vegetables, seed vegetables, milk.
iron, the mineral necessary for healthy blood.
Sources: leaf vegetables, seed vegetables, cereals, meat, eggs.

5 **Vitamins**, nutrients needed only in small quantities to preserve good health. Below are listed the most important vitamins.
vitamin A, or retinol, protects the mucus membranes (nose, mouth) and the skin and plays an important role in vision. The body produces this vitamin out of beta-carotene. Sources of vitamin A: milk, eggs.
Sources of carotene: leaf vegetables (especially those with dark green leaves), fruit vegetables (chillies), fruits (papaya), carrots.
vitamin B_1, or thiamin, is necessary for the functioning of the nervous system. Lack of vitamin B_1 causes "beri-beri". Sources: fruit-vegetables, germ and bran of cereals, eggs, milk.
vitamin B_2, or riboflavin, prevents lesions of the skin, eyes and lips.
Sources: leaf vegetables, seed vegetables, meat, eggs, milk.
vitamin C, or ascorbic acid. Deficiency of this vitamin causes scurvy and bleeding of the gums and skin. Sources: leaf vegetables, fruit vegetables, fruits, tubers (if eaten fresh).
niacin prevents pellagra, other skin and intestinal diseases, and malfunctioning of the nervous system. Sources: leaf vegetables, seed vegetables (peanut), meat, fish. Fresh maize contains a very small amount of this vitamin, but the flour can be enriched by treatment in an alkaline medium.

Table 1: Composition of different types of vegetables and of some other types of food (all values per 100 grams of foodstuff)

Foodstuff[1]	water g	carbo-bohydrates g	fats g	proteins g	calcium mg	iron mg	vita. A / carotene mg	vit. B_1 mg	vit. B2 mg	vit. C mg	Niacin mg
Leaf vegetables	84	8	0.5	4.3	176	2.6	/5.00	0.10	0.20	78	1.2
Fruit vegetables	92	5	0	1.5	26	0.9	/0.60	0.07	0.06	51	0.9
Seed vegetables	9	39	16.6[3]	26.0	110	4.9	/0.04	0.85	0.19	0	5.8
Fruits	82	16	0	0.7	17	0.5	/0.26	0.05	0.04	34	0.4
Cereals	12	72	3.7	9.9	20	3.0	0	0.35	0.13	0	2.4
Tubers	68	28	0.2	1.6	21	1.1	/0.02	0.09	0.03	19	0.7
Meat (lean)	66	0	14.0	19.0	10	3.0	0	0.10	0.20	0	5.0
Fish (lean)	79	0	1.5	17.5	50	1.0	0	0.04	0.08	0	2.0
Eggs (chicken)	74	0.5	11.5	13.0	55	2.8	0.18/0.06	0.12	0.35	0	0.1
Milk (cow)	88	4.7	3.6	3.3	120	0.1	0.04/0.02	0.04	0.15	1	0.1
Minimum daily requiremnt for adults[2]				46.0	500	9.0	0.45/2.40	1.0	1.5	30	17.0

(1) All figures are approximate averages
Leaf vegetables: amaranth, cassava, kangkong, taro
Fruit vegetables: eggplant, okra, sweet pepper, tomato
Seed vegetables: peanut, cowpea, pigeon pea, soy bean
(2) The required daily energy (2,500 kilocalories) can be taken as carbohydrates or fat.
(3) Only peanuts and soy beans contain fat.

We see that fruits and vegetables can contribute considerably to good nutrition. When people cultivate their own garden they enrich their diet with several nutrients. The addition of vitamins and minerals is very important, as other foodstuffs are often short of these nutrients. Fruit and vegetables also make the basic diet more appetizing, and they improve digestion.
Table 1 shows that the nutritive value of animal products is also high. For example they contain a high proportion of high quality proteins. Unfortunately these products are often very expensive. A mixture of several vegetables (e.g. leaf vegetables and seed vegetables) can provide a diet of a quality comparable to that of the best animal products. It should be mentioned that, contrary to common opinion, European vegetables (lettuce, cabbage) are not more nourishing than tropical vegetables.
The daily needs of vegetables are normally about 150 to 250 grams per person, of which at least 50 grams (a handful) should be leaf vegetables. This means a consumption of 55 to 90 kg per person per year. It is particularly important that growing children and breastfeeding mothers consume sufficient quantities of vegetables (especially leaf vegetables) and fruit.

3 Which type of garden?

There are several types of vegetable gardens and ways of growing vegetables. Each gardener must choose according to his or her circumstances. In the countryside the gathering of wild vegetables and mixed cultivation with field crops offer a good opportunity to practise gardening. A fence around the house helps to make a small garden with fruit trees and vegetables randomly mixed. When space is scarce, as in the city, intensive cultivation is better. A nearby city offers the possibility of commercial vegetable growing as a way of earning a living.

3.1 Gathering wild fruits and vegetables

Thousands of wild plants have edible parts. Some examples are: the leaves of the monkey bread tree (fresh or powdered), the pulp in tamarind pods, the fruit of the wild mango tree, young bamboo shoots, young leaves of many ferns, the nuts of the shea butter tree, the weed Portulaca (purslane). Several weeds are cultivated for their leaves: amaranth, Black nightshade, kangkong, Bidens pilosa (Spanish needle).
On fallow land we can find plants that have become wild again: banana, plantain, cassava and sweet potato (leaves and tubers), and several others. There are no general rules to distinguish the toxic species : each region has its own edible species. Generally it is best to avoid plants with milky juice, cook unknown plants very well before eating and throw away the liquid, and to avoid unknown plants that are bitter after being cooked. Above all, take good notice of the local knowledge.

3.2 Vegetables in mixed cultivation with field crops

Vegetables for personal use and for the market are often planted together with field crops (e.g. rice, maize). In the rice fields of Asia you can find kang-kong. Banana, cocoyam or taro are often planted between coffee and cocoa shrubs. The banana trees help by giving shade to the

young shrubs. In regions with shifting cultivation we are likely to find many vegetables in mixed cultivation with field crops. Gourds, cucumbers and pole beans are sown
against the stems and branches of Solanaceae (tomato, eggplant, chillies, sweet pepper, Black nightshade, tobacco). Leaf vegetables (e.g. jews mallow, roselle), pigeon pea, banana, cocoyam, taro and okra are also found. Vegetables are often planted in places that are not used for field crops, such as the edges of the fields, old termite mounds and close to roads and houses. Because the vegetables are grown in relatively small quantities, they don't affect the main crop.

3.3 The homesite farm

A homesite farm is one where a variety of vegetables and fruit trees are planted randomly around the house. This type of garden often gives good yields with little effort. Besides fruits and vegetables, such a garden can provide firewood, building materials, herbs, spices and medicines. Although found all over the tropics, the homesite farm is most common in Asia. Even with very little work (e.g. 2 hours per week), a home plot with a surface of less than 400 m^2 can produce enough fruit and vegetables to provide all vitamins and minerals, most of the proteins and an important part of the carbohydrates needed by a family of six. A homesite farm requires little attention. Organic waste can be used instead of manure, a few square metres are tilled at a time for sowing or planting, and weeding is minimal. You can grow a variety of crops such as fruit vegetables, seed vegetables, leaf vegetables, herbs, spices, staple crops and fruits. Generally European vegetables (e.g. lettuce, cabbage) are less suitable as they require more tending.

3.4 Intensive cultivation for family use

This kind of gardening is characterized by the extra work needed for the crops: seedbeds, soil cover, tying up, weeding and watering. This extra work, however, usually results in higher yields than those for a traditional homesite farm. Leaf vegetables such as amaranth can yield up to 18kg per m^2 per year: 50g per day! Growing plants in well weeded and

watered plant beds makes it possible to grow European vegetables. Intensive cultivation is very suitable for small kitchen gardens in cities.

3.5 Commercial vegetable growing

Commercial vegetable growing is practised in urban areas, often on swampy soil and is of great importance for the food supply of the urban population. Transport of perishable goods can be a problem. In several areas, market gardening has partly switched from European vegetables to tropical vegetables, such as amaranth, which are easier to grow and therefore cheaper. Cultivation
is generally intensive, using plant beds and improved seeds, paying special attention to watering, manuring (frequent use of chemical fertilizer) and disease control (often with chemical products). For successful commercial vegetable growing you should have a thorough technical knowledge of the subject and it is recommended that you consult an agricultural instructor beforebeginning.

3.6 Other gardens: communal, school and demonstration gardens

Communal gardening is practised by groups of several families. Problems with the organization of work and rights to the land frequently arise, and it is generally better when each family has its own garden and only seed, tools and fertilizer are bought at joint expense.
A school garden can produce vegetables for the pupils and teach them agricultural techniques and working discipline. Frequent errors are:

- the garden is too large to be worked properly
- the water supply is too far away
- too much emphasis is placed on European vegetables
- expensive materials are used (e.g. wire netting for fences)
- there is not enough organic manure
- not enough tending during the school holidays

A larger garden offers the possibility to do small experiments. Try, for example, dividing a bed of $10m^2$ into several parts, give each part a dif-

ferent type of manuring (e.g. manure, compost, street sweepings, chemical fertilizer, control plot without manuring). Plant the same vegetable (e.g. amaranth) on all plots and wait for the results. It is also a good idea to plant small plots of the local staple crop and to plant a small orchard. These points also apply to demonstration gardens. These must have a simple design so that everyone can easily understand what is demonstrated.

From here on we will pay attention to gardening for family use, be it in the form of a "homesite farm" or intensive cultivation in plant beds. However, many of the techniques mentioned are also applicable to other kinds of gardening. In the following chapters we will describe a wide variety of techniques; you will have to make a choice according to the characteristics of your own garden. It is not necessary to apply every technique in each garden.

4 Garden tools

A family garden requires very few tools. You can usually manage with a hoe and a machete, and a bucket or water container where the climate is dry. Figure 2 shows the most practical tools:

- **Hoe**: used to loosen the soil and build up hills or ridges. Small hoes are also used for weeding.
- **Machete**: used for clearing the land and harvesting produce.
- **Bucket**: (can, gourd) used for transporting water.
- **Spade**: (or shovel) used for turning the soil, digging irrigation and drainage ditches.
- **Dung fork**: used to transport and spread manure and compost and to collect plant waste. A fork with flat solid prongs can replace a shovel when working in wet and sticky clay soil. (Use shoes!)
- **Swan-neck hoe**: used to crumble the hard crust formed on the soil surface, to make seed drills and to weed. There are two types: bow hoes and push hoes (Dutch hoe). The angle between the shaft and the blade is about 60 and 120 degrees respectively.
- **Rake**: used for breaking clods, levelling seed beds, covering up seeds and removing pebbles and waste.
- **Planting peg**: (dibble stick) used to make holes in the ground to plant out seedlings. The seedlings are dug out with a **garden trowel** or a machete.

Other useful tools are a pick, a mallet (to firm the earth), stakes, string (to draw straight lines), a saw and a wheelbarrow (the axle of which must be oiled frequently). By piercing the bottom of a gourd or can with tiny holes one can make an adequate watering can. Be sure to make small holes - if the drops are too big they can damage the seedlings and cause erosion.

A balance is useful to weigh chemical fertilizers or harvested produce. In a family garden it is better to control plant diseases and insects without using chemical products (see Chapter 8). Therefore you are unlikely to need any kind of sprayer.

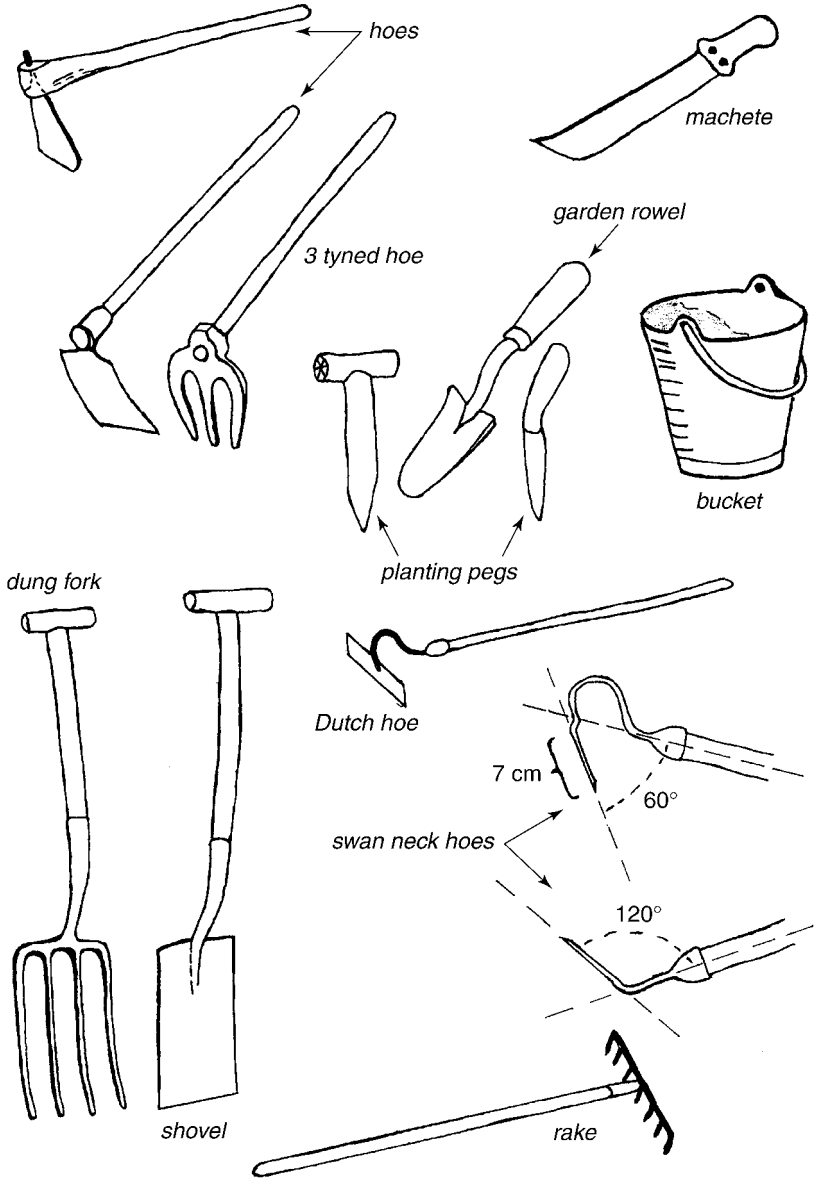


Figure 2: Some garden tools

For a family garden only absolutely indispensable tools should be bought. The garden must be profitable! You could buy the more expensive tools together with neighbours or friends.

The successful gardener looks after his or her tools carefully, cleans them properly after the work is done, sharpens them when necessary and keeps them in a dry place when not in use. Tools that you are not going to use for a while should be rubbed with an oil-soaked cloth to prevent them from rusting.

In the case of a low-protein basic diet (where tubers form the staple food), vegetables can improve the diet considerably. Seed vegetables and, fortunately, the leaves of several tuberous plants (cassava, cocoyam, taro, sweet potato) are high in proteins. Cassava leaves, sliced into small pieces, must always be very well cooked to eliminate the toxic hydrocyanic acid.

Each region has its own traditional methods of preparing vegetables. Still, a short description could be useful here. Many vegetables are eaten raw (lettuce, cress, cucumber, tomato), but there is a risk of infection if these are not well washed in clean water. Do not eat raw leaves of Poinsettia or leaves and shoots of cassava. In some regions vegetables are wrapped in banana leaves and grilled in hot ashes or between hot stones. One can also boil the vegetables in water, stew them or fry them with fat or oil. Vegetables are often mixed with staple foods and cooked together: stockpot, rice stew. Vegetable soups and sauces are also frequent, as a separate dish or with the main dish. Generally speaking, the cooking time should not be too long, otherwise too much of the nutritive value of the vegetables will be lost (especially vitamins B and C).

5 Preparing the site

5.1 The best site for a garden

The best sites for a garden are located:

1 Near a water supply (well, stream, pool). In the dry season the crop needs watering. Sometimes you may have to have two gardens, one for the dry season, located near a well or by the side of a lake or pool, and one for the rainy season on a flat site that does not flood.

2 On flat or only slightly sloping ground. On steep slopes terraces have to be made to prevent erosion. If you have a terraced garden take care that the top layer, which is the most fertile, stays on the surface.

3 Near the house, so carrying supplies and guarding the garden are easier.

4 On a loose and permeable soil that is rich in organic matter. Avoid stony or very clayish soils, which crack deeply when they dry out, and very sandy soils. Sites with poor (sandy) soil can be suitable if improved with manure or compost (see Chapter 6).

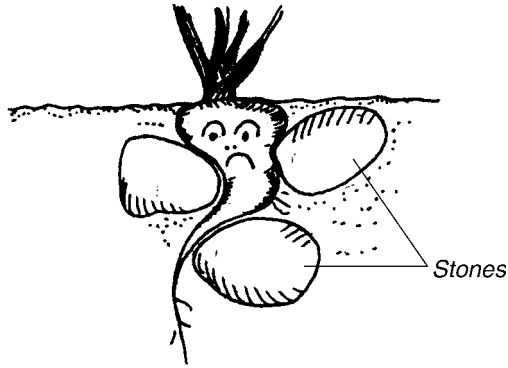


Figure 3: Avoid stoney soils!

5 In a sunny place, well sheltered from the prevailing winds.

6 On ground with few weeds that have underground stems, such as Imperata (satin tail), or small tubers like Cyperus. Ground covered with these weeds is difficult to clear and keep weed-free.

Generally, newly cleared forest soil, rich in humus, light non-flooded soil in valleys and soil where humus and eroded matter have accumulated, are suitable.

If you have no choice, you will probably have to improve less suitable ground.

5.2 Size and design of the garden

Regarding the size, you must remember that a small, well tended garden gives better results than a larger but poorly maintained one.
The size of the garden should be calculated according to:

- the amount of vegetables needed for family use and for the market.
- time, water and fertilizer available.

In a family garden, approximate yields to be expected are:

- leaf vegetables: 8kg/m^2/year
- fruit vegetables: 10kg/m^2/year
- fruit (fruit trees): 2kg/m^2/year

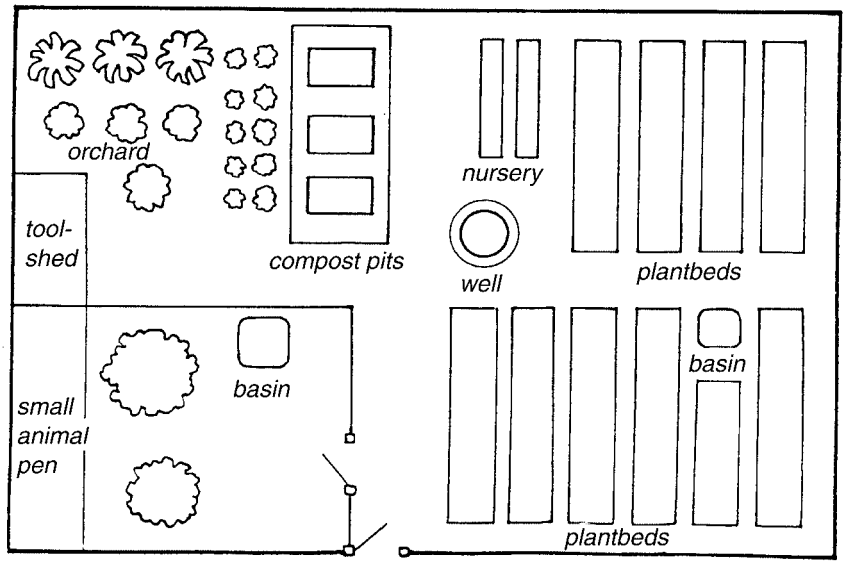


Figure 4: The lay-out of a garden

Therefore, for a family of six people, where each member consumes 50g leaf vegetables, 100g fruit vegetables and 50g fruit a day, a surface of 100 m^2 would be sufficient. If you also want dried beans (0.4kg/m^2/year) and tubers (8kg/m^2/year) from your garden, you will

need a much larger site. You will have to add surface for the paths and for a compost heap. It is good to make a drawing of the layout of the garden on which you can also indicate crop rotation (see Chapters 6 and 8). Figure 4 is an example of such a plan, although it is not necessary for every garden to be so "orderly". Most important is that you place the nursery beds near the water supply and the compost heap far away from the water supply, so the water does not become polluted by infiltration, especially if you use the water supply for drinking water.

5.3 Clearing the site

You will have to start by clearing the covering vegetation from the site of your future garden. Clearing is necessary because:

1 Trees, shrubs and weeds draw water and minerals from the soil that are needed for the vegetables.
2 The shade caused by their leaves hinders crop development.
3 They shelter insects.

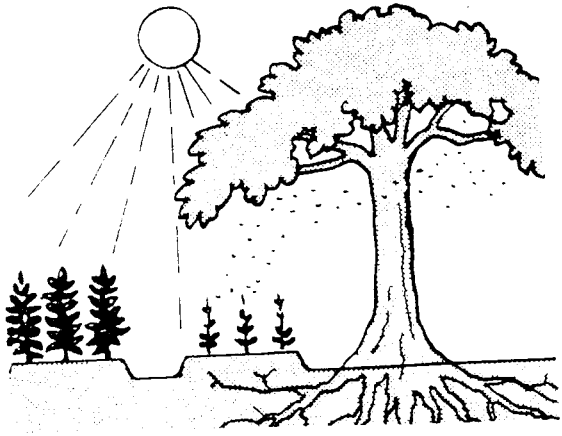


Figure 5: This tree hinders crop development. Why?

Shrubs and trees must be completely removed. If it is not too difficult, tree roots should also be removed. Cut trees and shrubs provide sticks of all sizes that are always useful (e.g. for fences, stakes), wood for con-

struction and firewood. Waste wood should be burned and the ashes thrown on the compost heap. Other waste material can be put directly into the compost heap. Dead and dry material can be used for soil cover (see Chapter 8). Remove stones and larger pebbles. It is worth keeping a few trees to provide shade for a small cattle pen, the compost heap and the nursery.

5.4 Cultivating the soil

Why cultivate the soil?

- Newly cleared soil is often hard and compact, especially when it is clayey. Air and rain water can not penetrate and it is covered with weeds. These are some of the reasons for tilling the soil:
- loosening the soil aids root penetration and growth.
- aerating the soil and making it permeable for water.
- working in organic matter and weeds, that form fertile humus.

When should you cultivate the soil?

- A light (sandy) soil can be cultivated at any time. A heavy (clayish) soil should be neither too dry nor too wet.
- A soil that is too dry can be too hard for the tools to penetrate and you get big clods, which are difficult to break up.
- A soil that is too wet sticks to the tools and you risk destroying the structure of the soil.

How deep should you till?

- For a successful tillage it is necessary to know something about the vertical build-up of the soil. In general, a soil profile has three layers:
- a surface horizon (**topsoil**), containing some humus (remains from plant debris, see Chapter 6). This layer is usually slightly darker coloured and is the most fertile part of the soil.
- a subsurface horizon (**subsoil**), containing less or no humus, sometimes heavier than the overlying and underlying layers.
- the more or less unweathered **parent material** from which the overlying layers have developed. This layer is much less fertile and usually lighter than the topsoil.

Most of the roots of vegetables concentrate in the topsoil and, to a lesser extent, in the subsoil, but there are differences between vegetables. Pigeon pea roots, for example, grow much deeper than those of lettuce.
Soil tillage should not change the relative position of the soil layers: the fertile top layer should stay on top and each layer should stay in place as much as possible.
The first tillage of the soil, especially if the soil is compact after clearing, should be done two spits deep, to at least 30cm. Work with an open furrow. At the bottom you turn the spadeful, and on top of that you throw the first spadeful from the next furrow etc. When working with a hoe you also work with an open furrow. Remove the earth from a narrow strip, loosen the bottom layer and cover it up again with the earth of the top layer from the next strip, and so on.

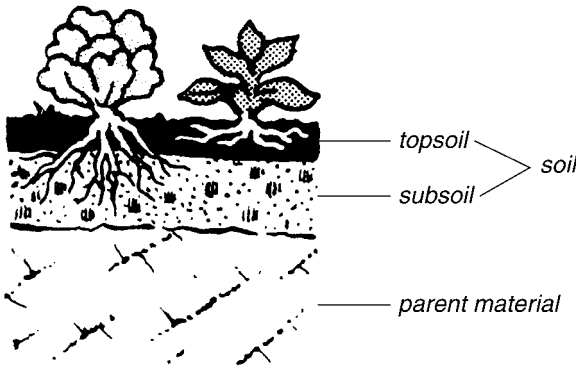
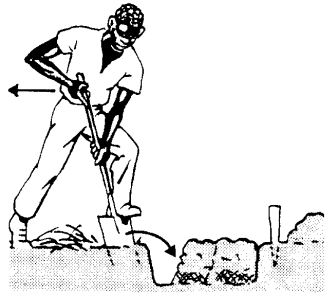


Figure 6: A soil profile

Deep tillage is especially recommended for soils that are compact and less permeable (often clayish soils). For normal maintenance, a depth of one spit will do (see fig. 7). After several tillages (while working under manure) the layer of topsoil, suitable for cultivation will become thicker and looser.



Spading is done while working backwards. Cut of clods of about 15 cms and throw them in the furrow in such a way that manure weeds are in the bottom.

Hoeing is done while working forewards. You walk on the worked part. Hoeing is suitable for a shallow tillage, for hard soils and making ridges.

Figure 7: Hoeing and spading

5.5 Preparing the beds

The beds are the parts of the garden where the crops themselves are grown. The division of the garden into beds makes crop rotation possible.

Erosion prevention

On steep sloping ground the beds should be made across the slope, so that they are horizontal. By digging trenches around each bed, you prevent the earth from being washed away by rainwater.

Size

The beds should not be more than 1.2m wide, so that the gardener can easily reach the middle without having to walk on the plants. Main paths should be at least 60cm wide (to enable a wheelbarrow to pass), and footpaths should be 30-40cm wide (the size of a foot).

Level

In the dry season or on sandy soil you make flat beds with raised edges of 5-10cm, so that the water does not flow off to the sides. In the rainy season, or on clayish soils you should make beds with a level of up to

20cm, with a slightly rounded form: enough to let the surplus water flow away, but not enough to let the earth be washed away. In the rainy season it is sometimes useful to put stones, bamboo sticks or plaited palm leaves around the edge of the beds to prevent erosion.

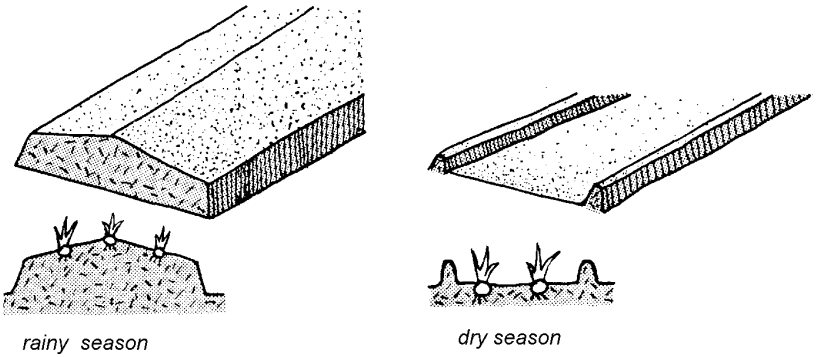


Figure 8: Different beds

It should be noted here that in several countries vegetables are grown on ridges. This is especially suitable for the cultivation of big plants such as maize, eggplant and melon, and on soils with poor drainage.

5.6 Fences

It is worth making fences to protect your crops against animals and the wind. You can make a fence from solid sticks, live stakes (see below), thorny branches, palm leaf-stalks, bamboo or barbed wire (expensive!). It might be a good idea to enclose the garden with branches to keep the vegetables out of sight of hungry animals.
If you want to plant a live hedge, use some of the following plants spaced close together:

- **shrubs** and **trees**, such as the drumstick tree, which has edible leaves and of which you plant 1m high cuttings.
- **sisal**, which gives very good protection and is suitable for the savanna; plant bulbils in double zigzag rows, about 50cm apart.

- a **cassava** hedge provides edible leaves. Cuttings must be planted 5-10cm apart or in double zigzag rows, 20cm apart. For a dense hedge, the plants must be trimmed and strengthened with sticks or bamboo. This kind of hedge gives good protection.
- **pigeon pea**, a leguminous perennial shrub, gives poor protection, but provides edible beans and fodder for small stock.
- a **hedge** consisting of stakes or live trees (drumstick tree, mimosa) in combination with climbing vegetables (passion flower, Ceylon spinach, beans, gourds, chayote) gives poor protection.
- **ornamental plants**, such as croton, bixa and bougainvillea give fairly good protection after a few years of growth.

6 Soil improvement

Plants must receive sufficient nutrients in order to grow properly.

- The leaves absorb oxygen and carbon dioxide from the air. They produce the constituents of the plant: carbohydrates, proteins etc.
- The roots draw up water and other vital elements from the soil. Nitrogen, phosphate and potassium are the most important of these. They are found in the soil as mineral salts and in humus.

The gardener must improve the soil in his or her garden by adding nutrient elements to replace the elements lost by harvesting the vegetables or erosion, and to enrich the soil. There are 4 ways of doing this: soil conditioning, organic manuring (dung), chemical fertilizer and crop rotation.

6.1 Soil conditioning

Conditioning a soil means modifying its physical state by changing its texture, permeability and humidity. The soil is composed of clay (very small particles), sand (coarser particles) and humus (partially decomposed organic matter). The best proportions of these components for farmland are approximately: 20-30% clay, 65-75% sand and 5% humus. A soil that contains too much clay is heavy and compact, impermeable to water and air, very hard when dry and sticky when wet. Such a soil is difficult to cultivate. Adding sand or humus makes it lighter. On the other hand, a soil that is too sandy is light and easy to cultivate, but dries out quickly and does not retain nutrients. Adding organic matter is the most important improvement you can make. By applying organic manure you improve the physical state of the soil by increasing the amount of humus and by adding nutrients which your crops need.

6.2 Plant nutrients

Plants need nutrient elements for their growth. We distinguish principle elements (nitrogen, phosphorus, potassium) which are needed most of-

ten, and in the largest quantities, and secondary elements (calcium, magnesium, sulphur) which are needed in small or very small quantities. Besides these there are minor elements (iron, copper, zinc, manganese, boron, chlorine, molybdenum) which are needed only in minimal amounts. These elements are present in the soil in the form of mineral salts. They are absorbed by the roots. A soil is fertile when it has a high content of nutrient elements and when it has a high retention capacity, that is to say that it retains many of these elements in a form which plants can easily take up. Generally, clay soils are more fertile than sandy soils. A soil rich in humus has a high retention capacity for nutrient elements. The amount of nutrient elements in a soil is increased by adding fertilizer. The added elements remain available to the plants for a long time if the retention capacity of the soil is high; if not, they are quickly lost.

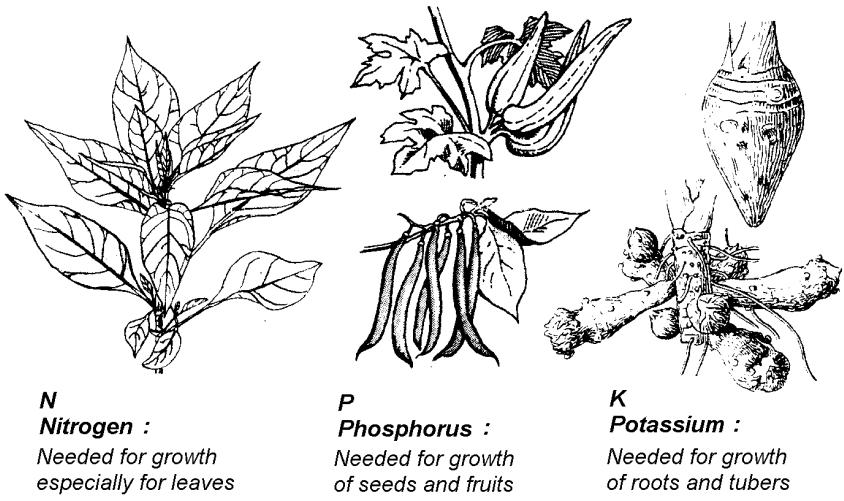


Figure 9: The main elements necessary for the crops in a vegetable garden

1 Nitrogen, represented by the symbol N, is needed for plant growth, especially of the stems and leaves. It gives the leaves a dark green colour. Vegetables grown especially for their leaves (amaranth, let-

tuce)need large amounts of nitrogen. Beds on which you want to grow tomato, eggplant or carrots shouldn't get too much N because this would favourgrowth of the leaves, instead of the roots and fruits. Signs of deficiencyare: small and deformed plants, particularly small, light or yellowish green leaves and premature browning of the bottom leaves, while the top of the plant stays green.

2 Phosphorus, (phosphate), represented by the symbol P, is necessary to formseeds and flowers, and to increase disease resistance. It is needed especially for seed and fruit vegetables (tomatoes, pepper, okra, beans) and for root vegetables (carrots). Signs of deficiency are: stunted growth, light green leaves often purple or brown at the tips and edges, slow and often etiolated development, and few fruits and seeds.

3 Potassium, represented by the symbol K, stimulates development of rootvegetables (carrots, radish, cassava) and tubers (sweet potato, potato) and is also important for onions and tomatoes. Potassium helps the plant to resist drought and diseases. Signs of deficiency are: white yellowish or reddish spots on the leaves, starting at the leaf edges (especially of the lower leaves), which turn yellow, red or brown and finally dry out and die, and stunted growth.

6.3 Organic manure

Organic manure provides the soil with humus and all the nutrient elements necessary for plant growth. The humus makes the soil easier to cultivate and increases its permeability and its retention capacity for water and nutrients. Organic manures are: dung, compost, litter and green manure. The necessary amount of green manure is at least 1kg per kg harvested vegetables or 2.5kg anure per square metre, to be worked in before each sowing.

Dung

Dung is obtained by fermentation of faeces and litter of animals. It makes the soil very fertile. Some animals give better dung than others (in decreasing order: poultry, horses, sheep and goats, cattle, pigs). To get good dung, the bedding of the animals must be abundant and re-

newed often enough to be able to absorb the droppings and to keep the manure heap humid. The earth under the heap should be well tamped or even cemented to avoid losses by leaching. Before cultivating a plant bed, spread the dung evenly over the surface and then begin to work it under. Ideally, the soil should be prepared like this and tilled one or two weeks before sowing or planting, so the dung has had time to decompose a little. You can also use a solution of liquid manure or dung in water: mix a few litres of liquid manure or a few handfuls of dung for a bucket of water of about 10 litres. Sprinkle the soil with this solution, not the plants.

Compost

Compost is obtained by decomposition of a mixture of vegetable waste matter, household waste or street sweepings from the city (anything that cannot decompose should be removed: cans, plastics etc.), cooled ashes, sweepings, weeds, leaves, straw, groundnut or cotton cake etc. Composting is done in pits (in a dry climate) or heaps (in a humid climate). Compost heaps require less work than pits. Fig. 10 explains the classic process of preparing compost as it is done in temperate climates. The process is the same, whether it is for a "pit" or a "heap".

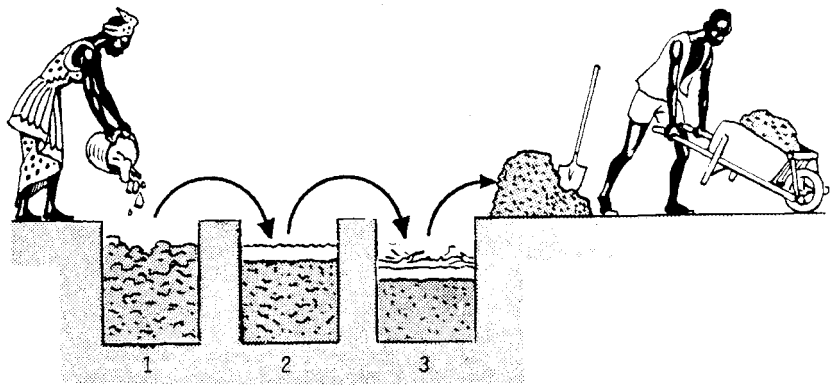


Figure 10: How to make good compost

1 Dig three pits of about 1.5 x 1.5m, side by side (or make three heaps and so on).
2 In the first pit you put a mixture of the above mentioned waste, on top of which you put earth and/or dung to stimulate decomposition. Cut big objects (such as banana tree trunks, maize stalks) into smaller pieces.
   Burn woody wastes which do not decompose and diseased or insect infested plants, and put the ashes on the compost heap. The contents of the pit should be humid but not too wet, to decompose well. Water or shelter the pit as necessary.
3 After a month fill pit number 2 with the contents of pit number 1. Mix in water and pack the pit well. Cover it with a layer of earth, which you stamp down and water from time to time. When pit number 1 is empty, you can fill it up again with new waste.
4 After another month fill pit number 3 with the contents of pit number 2 and air it well. Cover it with a little earth and branches to protect it from evaporation and rain, but do not pack it. Fill pit number 2 with the contents of pit number 1 and refill pit number 1 with new waste.
5 At the end of the third month you can empty pit number 3 and use the compost. Continue in the same way, emptying and refilling the pits. Work the compost into the soil in the same way as manure. Composting has the advantage that plant and human diseases are killed by the high temperatures during the composting. Agrodok 8 describes in detail how to make and use compost.

City street sweepings and fresh household waste

These and all other materials that decompose easily can also be worked in directly without composting. In a tropical climate organic matter decomposes quickly and therefore it is not always necessary to compost. Sometimes it is too much work and the chances of loss of nutrient elements are higher. Our advice is to work in directly all material that is easily broken down (fine, not woody, leaves etc.) and to compost only those materials that take longer to decompose. If there is danger of contagious disease simply compress the waste or the sweepings for one or two weeks before working them in. This should be enough to kill most

microbes. A simple way to use household waste is to fill up a hole with it and plant a banana shoot in it. (Remove cans, plastics etc.)

Mulching

This is done by covering the seed and planting beds and the soil around the plants with a layer of straw, long straw manure, maize stalks etc. After a certain amount of time the straw rots and becomes humus. Fig. 11 shows also the other effects of covering the soil.

NB The cover should never touch the plant stems as this can cause rot. In some cases the cover can attract termites. You should never cover with material that is infected by disease or contains insects.

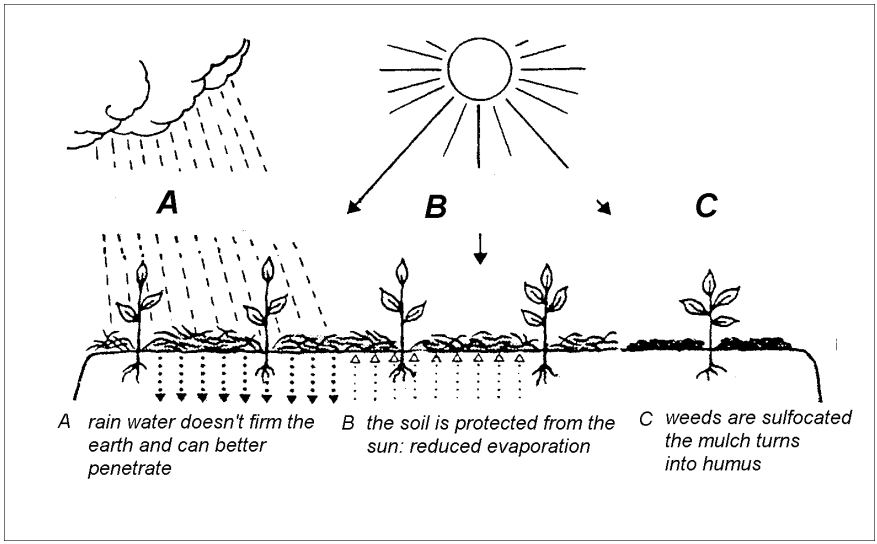


Figure 11: The effects of soil covering

Green manure

This consists of plants that are worked in to enrich the soil. The leaves and stems of legumes such as beans and peanuts are excellent, as they are rich in nitrogen. The roots of legumes can fix the free nitrogen present in the soil.

6.4 Chemical fertilizers

Chemical (or mineral) fertilizers are powders or granules that contain nutrient elements. They do not provide humus. When sufficient organic manure is available, a family garden generally does not need any chemical fertilizers. These fertilizers are expensive and it is better to consult an agricultural adviser before using them. Below are a few important points about fertilizers.

1 **Straight fertilizers** contain only one nutrient element, for example N, P or K. The most important ones are the nitrogenous fertilizers (nitrates, ammonium sulphate); phosphates and superphosphate; potassium chloride and potassium sulphate. The sulphate fertilizers also contain sulphur.
2 **Compound fertilizers** contain at least two fertilizing agents. One such fertilizer, much used in commercial vegetable growing, is the so-called 10-20-20 (fig. 12), a fertilizer containing 10kg nitrogen (N), 10kg phosphate (P) and 20kg potassium (K) per 100kg. The order of notation N-P-K is always the same. A bag of 50kg of fertilizer contains 5kg nitrogen, 5kg phosphate and 10kg potassium. A normal dosage of this fertilizer - for a not very intensive cultivation - is 20-50g per m^2 per crop.

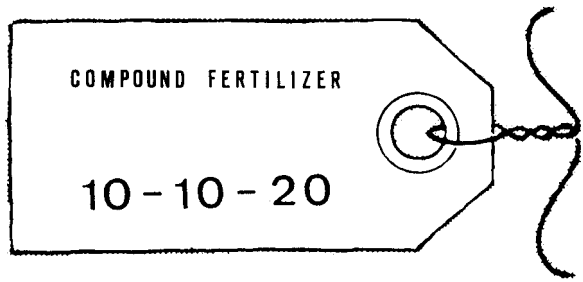


Figure 12: Label for a fertilizer bag

3 Secondary elements can be provided by ashes, rich in calcium, magnesium and potassium. Calcium (lime, limestone) makes the soil less

acid. N and K fertilizers in the form of sulphates contain sufficient sulphur. **Thomas slag** contains all trace elements, as well as phosphoric acid.

4 In a tropical climate it is better to apply small quantities of fertilizer often, rather than to add a large quantity in one treatment. This makes the fertilizers more profitable and prevents too rapid growth. Normally, fertilizers are applied shortly before sowing or transplanting. Nitrogen fertilizers can be partially applied while the crop is growing.
5 Most often the fertilizer is spread by hand and then worked under by superficial cultivation with a hoe. Sometimes the fertilizer is applied in lines or strips next to the plants, or next to or under the seeds. The fertilizer should not come in contact with leaves or buds as it will burn them.
6 Chemical fertilizers are expensive and should be kept in a dry place to avoid hardening or loss.

6.5 Crop rotation

Crop rotation is the practice of growing a sequence of different vegetables on the same bed. If you grow the same vegetable several consecutive times on the same bed you get lower and lower yields. By alternating the crops the beds continue to give high yields. Crop rotation is necessary for three reasons.

1 Different vegetables have different insect pests, diseases and nematodes.

   If you grow the same vegetables, or vegetables from the same family (see Chapters 8 and 9) several times in succession, you encourage the multiplication of insects, nematodes and diseases common to this vegetable or group of vegetables. If you vary the vegetables, you lessen this problem.
2 Vegetables differ in their nutrient requirements. As mentioned above, leaf vegetables have high nitrogen requirements, while seed and fruit vegetables need more phosphate. Plants grown for their tubers or roots need more potassium. If, for example, you grow beans several times after each other on the same bed, phosphate reserves run out and yields get lower. But if you plant cassava after the beans, which

needs the nitrogen with which the beans (legumes!) have enriched the soil, the cassava grows well and the soil can build up new phosphate reserves.

3 Different vegetables take up nutrients from different depths. Some plants, such as lettuce, have very shallow roots and take up nutrients from near the soil surface. Others, such as okra, tomato and beans, have deeper roots and obtain their nutrients from deeper layers of the soil.

If sufficient organic manure is available only the first point is important, but that is, however, the most important reason for crop rotation. You should therefore grow **consecutively** in the same beds vegetables that have different parasites and insects. You should grow **simultaneously** but in different beds a variety of vegetables. This is better for your diet and the market as well. For crop rotation see also Chapters 8 and 9.

7 Sowing and propagation by cuttings

There are two ways to multiply plants: by seed (generative propagation) and by leaf, stem or root cuttings (vegetative propagation).

7.1 Seeds

It is best if the family garden can produce its own seeds. This is a simple procedure for the following vegetables: legumes (beans, peanuts, cowpea, soy bean, pigeon pea), Cucurbitaceae (cucumber, bitter gourd, marrow, melon), Malvaceae (okra, roselle), jews mallow, Solanaceae (tomato, eggplant, sweet pepper, pimento, Black nightshade), amaranth, cockscomb, Ceylon spinach and maize.
It is best to choose the healthiest plants and fruits. From fruit and seed vegetables you should choose early plants, and from leaf vegetables you should choose late plants. (Leaf vegetables here mean plants that produce a lot of leaves before flowering.)

1 Vegetables with dry fruits (legumes, okra, maize, calabash, most leaf vegetables) must be harvested when the fruits are well ripened. The pods, siliquas or ears should be further dried in the sun. Remove the grains by hand or by threshing with a stick onto a jute sack.
2 Vegetables with fleshy fruits, not very rich in water (chillies, sweet pepper, melon, gourd, eggplant) should be harvested when the fruits are very ripe. Cut these 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) should be treated as follows: let the mashed fruits rot in water for a few hours. The pulp will float to the surface and the seeds will sink to the bottom. Put thesein a cloth or newspaper and let them dry well in the sun.

The seeds must be well dried before they can be stored in a cool and dry place. Never let them get too hot during the drying process. In a wet

climate, the seeds must be kept in an airtight container with a hygroscopic substance added to absorb moisture (see fig. 13). It is also possible to keep the seeds mixed with fresh, finely powdered ashes or charcoal. The ashes absorb the moisture and prevent insects from eating the seeds. Before sowing, the seeds should be selected with great care, because diseased or malformed seeds will give poor results. Generally, the biggest and heaviest seeds are best.

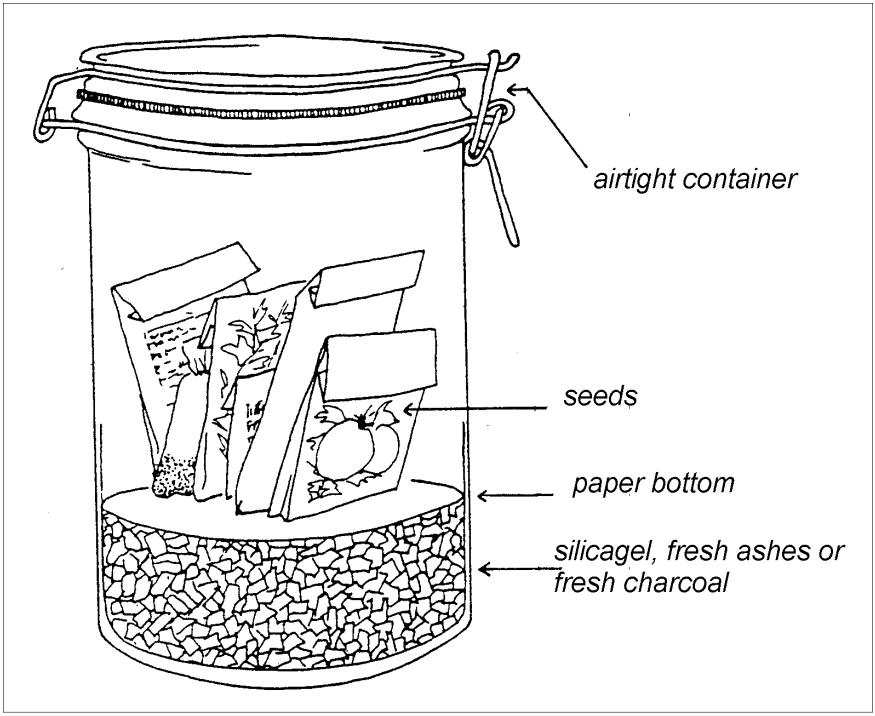


Figure 13: Stocking small quantities of seeds

The seeds can be graded as follows:

- by hand (big seeds)
- by winnowing: empty or broken seeds that are too light (and thus worthless) are blown away by the wind (fig. 14)
- by putting them into water: seeds that float are too light and should be rejected (fig. 14)

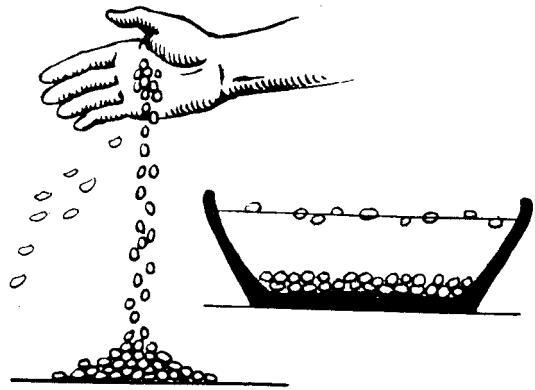


Figure 14: Grading the seeds

It can be useful to determine the germinative capacity of the seeds before sowing them. For example, put 20 seeds in a wet cloth or newspaper and keep them moist and warm for a few days. Then count how many seeds have germinated. Some gardeners soak certain seeds in water for some time to pregerminate the seeds before sowing them (e.g. maize). These methods are unnecessary. They accelerate emergence of the seedlings, but increase the risk of the seeds rotting, or damaging the germinating root tip. A frequently made error is that too many (expensive) seeds are sown per square metre. The table in appendix 2 gives general recommendations for the right amount of seed to be used. Some European vegetables do not produce any seeds in the tropics, either because the length of daylight is too short for them to flower (e.g. lettuce), or because they need a cold period before they can flower (celery, cabbage, carrot, several onion varieties). If you want to grow these varieties you will have to find a local seed sales outlet. If you do not succeed, see Table 2. The same applies if you cannot produce good seeds yourself because your plants are diseased, or if you are just beginning your garden.

7.2 Direct Sowing

Sowing in situ, or direct sowing, means that the seed is placed directly in the ground where the cultivation of the crop is planned. This method is used for vegetables with big seeds (legumes, Cucurbitaceae, maize) and for root vegetables that do not tolerate transplanting (carrot, radish). You can also sow several vegetables with small seeds in situ (e.g. amaranth, cockscomb, jews mallow).

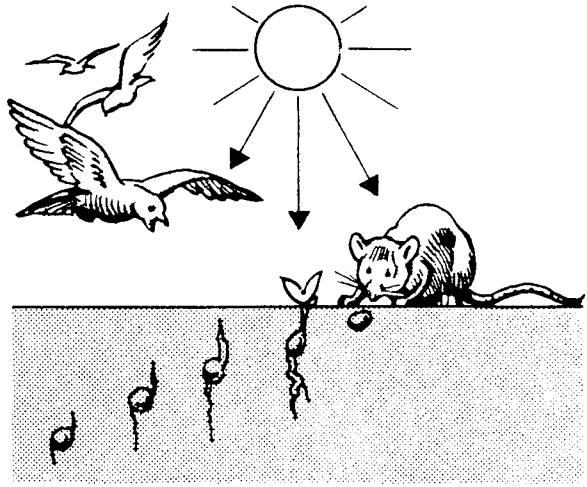


Figure 15: Seeds should be sown at the right depth

The bigger the seeds, the deeper they are sown. Generally, you cover the seed with a layer of earth three times its size. If the seeds are sown too deep, they have difficulty emerging from the ground and may rot. If the seeds are sown too close to the surface the risk is greater that they will be dried out by the sun or eaten by birds or rodents (see Chapter 8).

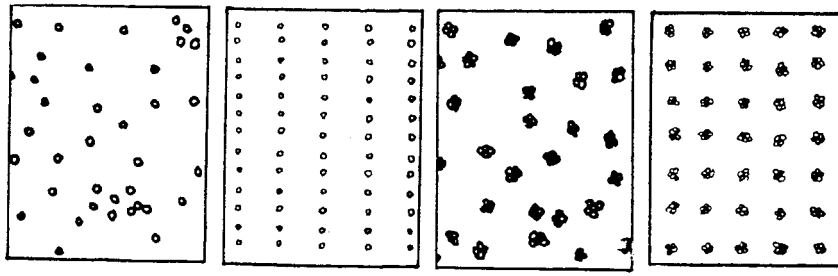


Figure 16: Sowing methods

The sowing can be done in three different ways.

1 **Broadcast sowing**: small seeds (amaranth, jews mallow etc.) can be sown by broadcasting, which means they are scattered by hand over the entire surface of the plot. To get a more regular dispersal the seeds can be mixed with dry sand. After scattering the seeds, a rake is used to cover them superficially and the ground is lightly firmed. Broadcast sowing gives an irregular plant spacing. In some places the plants will be too close together, while in others there will be empty spaces. Hoeing is impossible and weeding has to be done by hand.
2 **Drilling** or **row seeding**: the seeds are put in drills, made with a pointed stick or with a hoe. After sowing, the edges of the drill are turned over with a rake so the seeds are covered. To make straight drills, use a string stretched between two stakes as a guideline. By using a marker you can quickly make several parallel drills at once (fig. 17). On sloping ground, the drills should be made across the slope, to prevent the earth from being washed away by rain. Row seeding ensures that each plant has the same surface area available and makes weeding easier. Watering is also easier if ditches are made between the rows of plants.

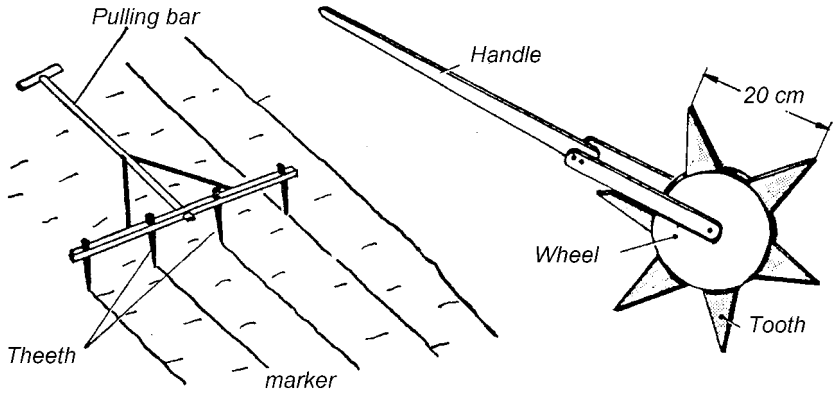


Figure 17: Marker and spacing wheel

3 **Pocket drilling** or sowing in seed holes: a method used for all vegetables that have big seeds and form big plants (maize, okra, legumes,Cucurbitaceae). Holes are made and 2 to 5 (sometimes only one) seeds are dropped in each planting hole. A spacing wheel makes it easy to make rows of holes (figs. 16 and 17). The spacing and the size of the holes must be adapted for each crop. If you are afraid that birds will eat the seeds, you must sow deeper so the seeds are more difficult to reach.
For example: place beans 10cm deep and cover them with only 3cm of earth (see fig. 18).

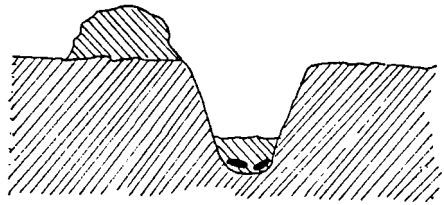


Figure 18: Deep sowing of beans

If, after coming up, the plants are too close together, some must be pulled out (thinned out), or transplanted to places where extra plants can be used. If you have a surplus of seedlings of leaf vegetables, these plants can also be eaten. For the correct spacing of various crops see Chapter 9.

7.3 Sowing in a nursery

Some vegetables must first be sown in a nursery and then later transplanted to the main garden, when they have sprouted. These are generally plants with small seeds (tomato, eggplant, pepper, cabbage, lettuce, onion etc.). Some gardeners also transplant "spinach": amaranth, cockscomb etc. This method makes it possible to give maximum care to weak seedlings (watering, shade, protection against diseases and insects), and saves seeds, space and water. The soil must be of very high quality: rich in humus, light and well drained.

Nursery in open ground

The soil of the nursery should be carefully tilled and enriched with fine manure or compost. Roots and stones should be removed and clods should be crumbled. Depending on the size of the seeds, sowing should be done by broadcasting or in rows (generally 10-15cm apart). The seeds are covered and the earth is lightly firmed. The nursery should be regularly watered when dry, preferably in the morning, but never in the sun, and kept well hoed and weeded. The seedlings should be protected from direct sun, heavy rainfall and strong wind by a shelter (fig. 19).

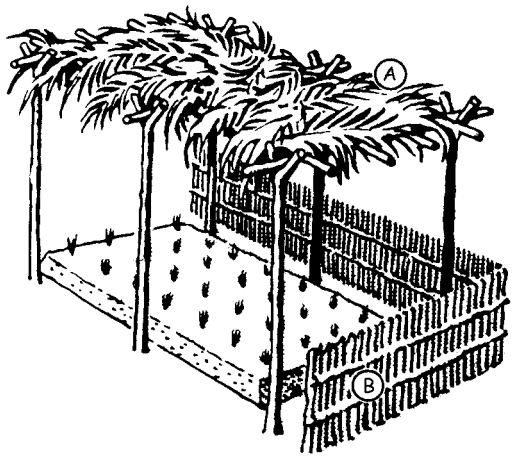


Figure 19: The seedlings should be sheltered

One or two weeks before transplanting the shelter must be removed so the plants can adjust to an open-ground situation. If ants are damaging the seeds, the earth can be sprinkled with sand mixed with petroleum. If the soil is heavily infected with disease it can be sterilized (Chapter 8).

Seed boxes

Wooden boxes about 10-15cm deep can be used. Pierce the bottom with holes, to allow excess water to drain after rain or watering. Baskets or other containers can also be used. The bottom should be covered with a layer of pebbles and then with a layer of dry weeds, to prevent the earth from clogging the holes. After this, the box can be filled with good, finely sieved earth, mixed with an equal amount of good compost. If the soil contains a lot of clay, sand should be added (1 part of sand to 5 parts of the mixture of earth and compost).

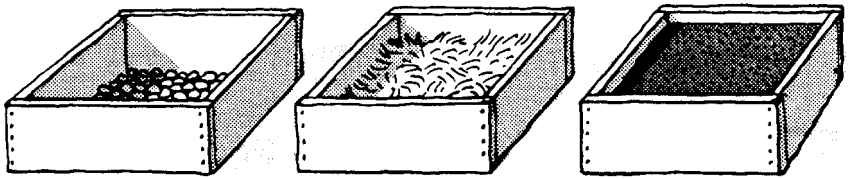


Figure 20: Preparing the seed box

Make 0.5-1cm deep drills, spaced 5-15cm apart in the firmed surface, depending on the size of the seeds. After sowing the seeds are covered with earth which is lightly pressed down. The boxes should be sheltered from strong sun and rain and preferably kept in a humid environment. They can be protected from insects (ants) by placing them on some kind of table, the legs of which are put in jars filled with water or kerosene covered with a layer of oil. They can be protected from rats by putting a smooth metal collar around the legs of the table. See Agrodoks 31:Storage of tropical agricultural products.

NB: It is helpful and easy to mark the parts of the nursery or boxes where each vegetable has been sown.

7.4 Transplanting

The plants sown in the nursery must be transplanted when they are big enough; this is called "planting out". Normally this is done 2 to 4 weeks after germination, when the plants have 4 to 6 leaves. To reduce the risk of drying out, do the transplanting in the late afternoon, if possible in cloudy or rainy weather. Planting out is done in several stages.

1 **Digging up the seedlings**
Start by softening the soil by watering the nursery some hours before the transplanting is to be done. You can either pull out the plant with bare roots, that is to say with no earth around the roots, or you can dig it out with a ball of earth. While digging out the plant, lightly press the root ball so it does not crumble. Digging out the plant with a ball of earth around the roots causes less damage to the plants but takes longer. Where possible, choose strong and healthy seedlings, well developed and with healthy roots.

2 **Keeping the seedlings in a trench**
The plants can be kept for a while by putting them in a small trench in the shade and covering them with moist earth. It is, however, always better to transplant them immediately after digging.

3 **Puddling**
Bare rooted plants are put in a container filled with mud made of loam or earth from a termite mound in such a way that they are submerged up to the rootneck (the base of the stem just above the roots). Chemicals are sometimes added to kill parasites. Puddling is mostly practised in the cultivation of cabbage.

4 **Trimming**
About one third of the roots and leaves can be cut to stimulate rooting and reduce drying out of the plants. Fleshy roots should not be trimmed as they will rot. Trimming is not always necessary.

5 **Planting**
Transplanting should be done with great care. Make a hole that is big enough to contain the roots without forcing them upwards. Generally the plant should be planted at the same depth as in the nursery. However, whenthe soil is light and the climate dry, some vegetables, such as leeks, onions and tomato, can be placed deeper to encourage extra

root growth. The earth around the roots must be firmed to prevent the roots from dryingout (fig. 22). Firming the earth should be done by pressing firmly but not too hard with the fingers

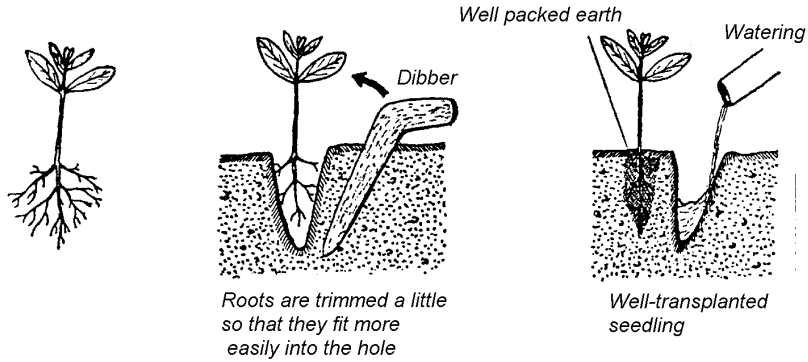


Figure 21: Transplanting the correct way

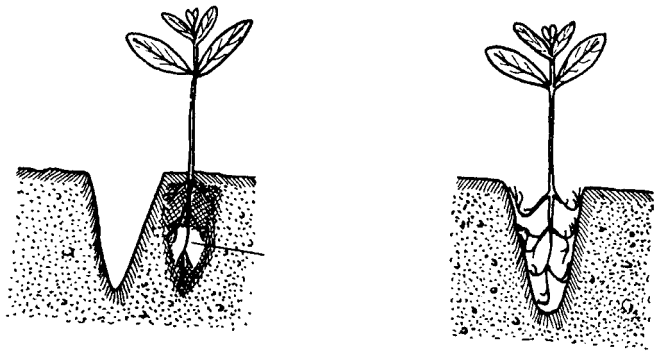


Figure 22: Transplanting the wrong way

6 **Watering and other tending**

Watering should be done immediately after transplanting. Do not sprinkle plants that are in the sun! To encourage growth to start

quickly, sprinkle them after a few days with the solution of manure in water mentioned in Chapter 6, to which a handful of wood ashes has been added. If necessary, the newly transplanted plants can be sheltered with folded banana leaves or other small cup-like objects.

7.5 Taking cuttings

Some plants can be propagated by taking cuttings. Cut off a part of the mother plant, put it in the ground, and a new plant will grow, once it has rooted. Cut big cassava stems without leaves into pieces about 40cm long. Plant these with about one third of the stem covered, in ridges, normally two cuttings per ridge. The same thing can be done with sweet potato stems. Remove the leaves from the lower half, and plant the stem in the earth. Yam and sweet potato can be multiplied by planting a tuber or part of a tuber. Cocoyam and taro can also be multiplied by planting young shoots. In this case it is called propagation by division. Several other vegetables can also be propagated from cuttings. Ideally you should do this during the rainy season, in soil which should be moist, but not soaked with water. When making cuttings, you must disinfect the tools you use (e.g. a knife) in boiling water **before each cut**, to prevent spreading infectious diseases.

8 From sowing to harvest: techniques of cultivation

8.1 Watering

If it rains regularly, the family garden does not need watering, except during sowing and transplanting. In the dry season it is better to grow only those vegetables that need little water, such as roselle and perennial vegetables (see Chapter 9). If water is very scarce (where the water supply is far away or the well is very deep), it is better not to use any water for a garden. Usually, water quantities are measured in millimetres (mm): 1 mm = 1 litre per square metre = 1 watering can (about 10 litres) per 10 square metres. The amount of water needed depends on the climate and the kind of soil. The hotter and sunnier the weather, the more water is needed for the vegetables. In the dry season, if it does not rain, leaf vegetables need at least 6mm a day and the other vegetables at least 4mm 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 and more heavily than a clayey soil. Recently sown or transplanted plants require light daily watering; for stronger plants once a week is enough. You must take care not to overwater - if the soil stays wet for a long time the roots might rot.

It is best to water in the late afternoon, and not during hours of fierce sunshine. This way you will avoid burning the leaves and loss of water by evaporation. On young seedlings and on beds where the plants are close together (like beds of amaranth or jews mallow), use the watering can with a shower head, so that the wa-

Figure 23: Watering seedlings with a broom and a bucket

ter is sprinkled over the plants. You can also use a broom and a bucket or a calabash filled with water for this purpose.
For spaced plants such as tomato, eggplant, cabbage, pepper and cucumber, water next to the plant using the watering can without the head, or using a bucket. If water is abundant, it can be led directly to the plants by small ditches (bed irrigation).

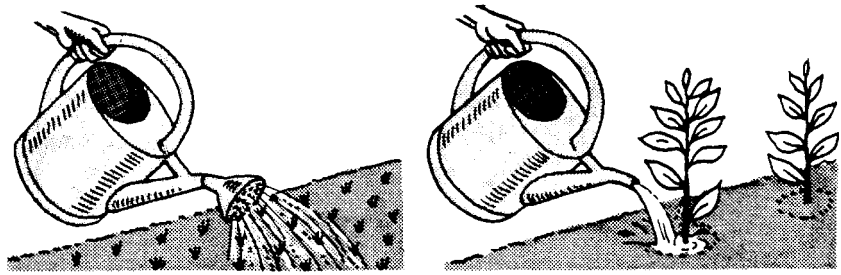


Figure 24: Watering

8.2 Control of diseases, insects and other parasites

In a family garden, parasites are generally of little importance, because there is usually a wide variety of more or less hardy plants being grown at one time. In single crop farming (commercial vegetable growing) a large area is planted with one type of vegetable and damage caused by disease and insects can become more serious. The most common diseases and parasites are mentioned here briefly, arranged according to their method of control. The groups are arranged in diminishing order of importance. We strongly advise against the use of chemicals (pesticides) in fighting plant pests in the family garden. They are expensive in comparison to the damage caused by diseases and parasites. Moreover they are very poisonous (dangerous) for human beings and often have only a slight effect on diseases and parasites. If you still want to use them anyway, you must take the following precautions:

- Keep them locked away, out of reach from children.
- Read and follow the instructions printed on the package before using them.
- Do not use them too shortly before the harvest.
- Avoid all contact with pesticides (hands, eyes) and don't breathe them in.
- Wash thoroughly with soap after use.

Take care not to pollute river or well water by throwing in extra chemicals or empty packets, but bury these in a hole that will be filled up again later. In case of poisoning, go **immediately** to a dispensary. The best precaution is not to use chemicals at all!

Insects, snails, mice, rats and birds

Those insects that eat or suck leaves and fruit generally cause the greatest damage in the family garden. Caterpillars in particular are very damaging. Other insect pests are locusts, aphids (plant lice), bugs and mites. Insects and snails not only cause loss of production, they also make the products less appetizing and less marketable. Snails, caterpillars and other large insects can be removed by hand. Heavily infected plants should be burned. Spreading powdered wood ashes is effective, especially against caterpillars, but it makes the leaves dirty and may cause them to rot. Some less toxic insecticides that are used in commercial vegetable growing are: Lindan, Carbaryl (Sevin), Fenitrothion (Sumithion), Malathion, Bromophos (Nexion), Dimethoate (Perfekthion), Diflubenzoron (Dimilin). The names in parentheses are brand names. The insecticides Thuricide (also known as Dipel or Bactospeine), Rotenone and Pyrethrin are effective and not toxic, but are expensive. We must strongly advise against the use of DDT, Parathion, Dieldrin, Aldrin, Endrin and Endosulfan, which are very toxic and remain for a long time in plants and the soil.

The most important weapon in fighting rats and mice is hygiene: remove waste and garbage, cover the compost heap with earth etc. Traps, poisoned bait in a bamboo tube (to protect it against rain and prevent children from getting it) can also be used to control these animals. To

chase away birds you can make noise or stretch threads a few centimetres above the ground.

Diseases and parasites attacking from the soil

There are several diseases and parasites that attack the plants from the soil and which stay behind in the soil after the vegetables are harvested. They cause, together with mineral deficiency, soil exhaustion. This results in lower yields, especially after several years of cultivation. The most common soil-borne diseases are:

- **Damping off of seedlings**, caused by Pythium fungi. The young plants die shortly after germination. Rotting seeds, roots and stems, especially at the base, are noticeable.

- **Wilt**, caused by bacteria and Fusarium fungi. This is sudden wilting and death of the entire plant; in Solanaceae the sheaths turn brown.

- **Rot (necrosis) of the stem base**, caused by Rhizoctonium and Sclerotium fungi. Plants rot, starting from the stem base, and then wilt. It affects Solanaceae, lettuce, cabbage, beans etc.

- **Eelworms or nematodes** (tiny round worms, not visible with the naked eye), of which especially the Meloidogyne types (root knot nematodes) are very harmful. The plant shows little development, wilting is often seen and very characteristic nodular swellings develop on the roots (root knots). **NB:** Do not confuse these root knots with the root nodules of legumes that are used for nitrogen fixation!!

By taking good care of plants you stimulate their growth and make them more resistant and more productive. Good soil drainage is most important. Bad drainage (too much water in the soil) weakens the roots and stimulates plant diseases and parasites. Infected plants should be removed and burned. After harvest, plant remains should be buried or put on the compost heap. Besides these general methods there are specific methods of controlling soil-borne diseases and parasites, some of which are mentioned here.

- **Applying organic manure** helps protect the plants, especially against root knot nematodes.

- **Disinfection of the soil with steam.** In general it is not possible to disinfect the entire garden, but it is worth disinfecting the soil in the nursery. The simplest method is to pour boiling water over the freshly cultivated soil in a quantity of about 10 litres per square metre. Cover the soil immediately with plastic. It is also possible to pile up jute sacks filled with earth in an oil drum with a double bottom. Water is boiled between the two bottoms for about one hour (fig. 25A). Another method is to cover a heated metal sheet with a layer of about 5cm earth, and sprinkle water over it (fig. 25B). Fig. 26 shows how to use solar heat for soil disinfection.

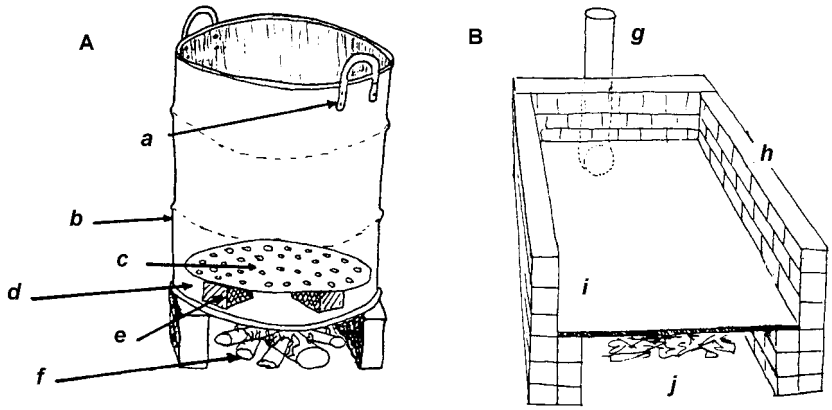


Figure 25: *Methods for soil disinfection; a: handles, riveted or welded to drum (or strong wire passed through holes), b: metal oil drum, c: plate with holes pierced, d: water, e: plate support (bricks), f: wood fire, g: chimney, h: bricks, i: metal sheet, j: wood fire.*

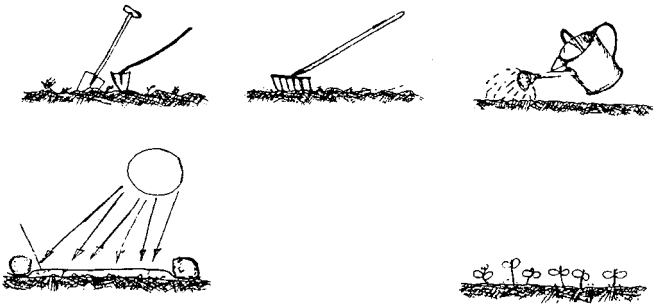


Figure 26: Soil disinfection using solar heat (only possible in a very sunny climate)

Crop rotation

With the help of the table in appendix 1 you can arrange the vegetables into six groups: Nightshade family or Solanaceae (tomato, eggplant, red pepper), Gourd family or Cucurbitaceae (cucumber, melon), Legumes (beans, peanut), Cabbage family or Cruciferae (cabbage), leaf vegetables (amaranth, Ceylon spinach), and plants with edible tubers, bulbs or roots (onion, cocoyam). A crop rotation scheme consists of choosing a plant from a different group for each new cultivation. Never grow a plant from the same group again on the same bed before having grown at least two crops with plants from different groups. This is a rough guide to the rules. It is better to alternate plants susceptible to specific diseases with plants that are resistant to these pests. See Table 2. You should not plant papaya trees in vegetable beds as they are very susceptible to root nematodes. Beds heavily infected by eelworms can be rid of them by planting a cover crop of African marigolds (plants of the Tagetes genus), which strongly suppress eelworms. Leaving the bed fallow or growing gramineous plants for a season also suppresses eelworms, but tends to encourage weeds. Therefore, a cover crop of legumes, such as Stylosanthes in savanna regions and kudzu bean (Pueraria) and Centrosema in the forest is preferable, as is a dense stand of pigeon pea, or a similar crop.

Table 2: Susceptibility to wilt and root knot nematodes

wilt		**root knot nematodes**	
susceptible	**resistant**	**susceptible**	**resistant**
eggplant	amaranth	eggplant	amaranth
African eggplant	Ceylon spinach	Ceylon spinach	African eggplant kangkong
cucumber	okra	cucumber	hot pepper (slightly susc.)
yardlong bean	jews mallow	okra	
common bean	onion	jews mallow	
lettuce	kangkong	lettuce	
melon		melon	
tomato		tomato	

Other diseases

Other common diseases are caused by a wide variety of fungi, bacteria and viruses. Some examples are:

- Mildew and powdery mildew on the leaves, especially of Cucurbitaceae; the first causes brown spots on the under side of the leaf (cucumber), the second is visible as white dust on the upper side (local gourds). Both diseases flourish in high humidity.

- The fungi Cladosporium and Cercospora can cause brown spots, especially on older leaves.

- Viruses (often transmitted by insects) cause mottled colouring, deformed leaves and poor development in many different plants.

The only effective way of controlling these diseases is to remove and burn infected plants and use seeds and cuttings from healthy plants. Preventive treatment with fungicides (substances that kill fungi) are expensive and often have little effect. Some fungicides that are less toxic and frequently used in commercial vegetable growing are: Maneb, Zineb, Benlate and Karathane. They are often applied to tomato plants and Cucurbitaceae.

When diseases and parasites cause serious problems, an agricultural adviser should be consulted. Physiological diseases (mineral deficiency, excess water, acidity of the soil) should not be found in a well manured and well drained garden.

8.3 Other techniques of cultivation

Shelter

A shelter serves to protect seeds and freshly transplanted plants from fierce sunshine or heavy rainfall. The most common shelters are made from a roof of leaves or plaited straw, supported by stakes above the plant beds (see fig. 19 on page 32). Loosely woven leaves that filter sunlight serve mainly as a protection from the sun. Densely woven leaves, slightly hanging over, protect from the rain. Such a shelter should be about one metre high. If it is too low, there will be insufficient ventilation and light for proper plant growth. You can make shelter for single plants out of palm leaves, as in the example shown in fig. 27. Sometimes (in commercial vegetable growing) a shelter made of transparent plastic is used. This serves mainly to increase the air humidity, especially in arid regions.

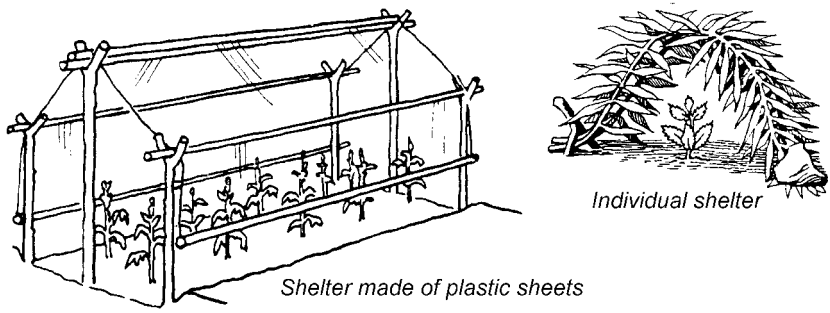


Figure 27: Shelters

Weeding

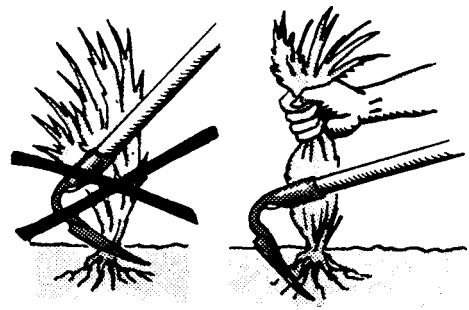


Figure 28: Weeding

Weeding means removing weeds that grow between the vegetables. Weeds hinder the development of the vegetables, especially of young plants. Therefore early weeding is necessary. Do weeding by hand, with a hoe or with a Dutch hoe (scuffle hoe). It is important that the roots and the tubers of the weeds are also removed, so they cannot grow again. If the weather is dry and sunny, the weeds can be left to dry in place. They can also be gathered and put on the compost heap. Weeds that carry seed should be burned. The use of herbicides (chemical substances that kill weeds) is generally not recommended for the family garden. These substances are expensive and toxic to humans and you risk killing the vegetables too. In commercial growing Paraquat (Gramoxone) is sometimes used, which kills only the parts of the plants it touches (leaves, stems), and glyphosate (Roundup), which also kills the parts of the weeds that are in the soil, for example the tubers of nutgrass (Cyperus) or the roots of satin tail (Imperata). Most weeds can be suppressed by mulching.

Hoeing

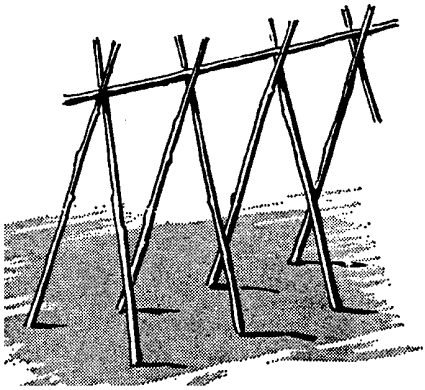
Hoeing is done with a hoe. Hoeing breaks the hard crust on the surface of the soil and crumbles the earth a few centimetres below. By hoeing deeper you risk damaging the roots of the vegetables. By hoeing the soil that has been packed down by rain and watering is aerated and is kept humid. A layer of loose earth is formed on top of the soil, which prevents evaporation. Hoeing also helps to control weeds.

Earthing up

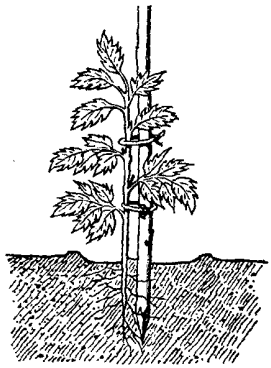
This is heaping earth around the base of plants, which gives them more resistance against wind (maize) and stimulates the growth of new roots and, in turn, extra plant growth. Plants that are often grown in hills are: maize, potato and beans. Make the hills with a hoe.

Staking

If the plants are fragile (tomato, eggplant) or if they are climbers (several beans, Ceylon spinach, bitter gourd), stakes can be placed in the ground to support them. Shape and size of the stake vary according to the plants cultivated (figure 29). For some Cucurbitaceae and for Ceylon spinach a firm construction can be made, about 1-1.5m high, resembling a table. The simplest method is to let the plants climb along dead branches. Some plants must be tied to the stake, but loosely, to allow room for the stem to grow thicker. Most climbing plants attach themselves to the stakes and do not have to be tied.



Stakes for pole beans



Staking of eggplant or tomato. The plant is loosing tied to the stakes with raffia.

Figure 29: Staking

Harvesting

You should harvest leaf vegetables early in the morning. For other vegetables the time of the day is less important. It is better not to harvest when they are wet, since they keep better when they are dry. The fruits of eggplant, tomato and cucumber should only be washed shortly before consumption, since once washed they rot quickly. Fruits and vegetables are best kept in a dry, cool, ventilated and dark place. See Agrodok 3 (in Dutch) for methods of long-term conservation.

9 Choosing the right crops

You should take the following factors into consideration when choosing which plants to cultivate in the family garden.

1 **Climate.** The abundant rains and high daytime temperatures of the tropical forest are very suitable for the cultivation of tropical leaf vegetables. The climate of grassland regions is less wet and has two distinct seasons, which allows the cultivation of a large variety of annual plants. In mountain regions with a lower daytime temperature, the cultivation of vegetables from more temperate climates ("European" vegetables) is possible. Some of these vegetables, cultivated for their leaves (cabbage, lettuce) or their bulbs (onion), do not normally set seed in the tropics, for reasons already mentioned in Chapter 7.
2 **Crop rotation.** When choosing your plants it is important to preserve the fertility of the soil, control diseases and plant parasites and guaran-tee a regular supply of vegetables by rotating crops (see Chapters 6 and 8).
3 **Objectives and possibilities.** When planning your garden you should consider whether you are growing the vegetables to feed members of the family or for the market, and how much land, water and labour are available.

Among the suitable plants for the family garden we mention:

- Annual vegetables such as amaranth, African eggplant, okra, jews mallow, tomato, roselle, hot pepper. Leaf vegetables give particularly high yields where the size of garden is limited.
- Perennial plants such as pigeon pea, cassava, banana, papaya, fruit-trees, ginger, drumstick tree. The shade of these plants is good for taro and cocoyam. Perennial plants keep producing for several years and they often produce in the dry season, when the cultivation of annuals is difficult if not enough water is available.

- Climbing plants (along fences), such as Ceylon spinach, bitter gourd and yardlong bean.

In this manual it is impossible to discuss each vegetable in detail. Some characteristics of 30 important vegetables are shown in the table in appendix 1. For more information about gardening or vegetables try consulting some of the books listed in the bibliography.

Further reading

Bunnik J. (1990) **Fresh fruits and vegetables: A survey of the methods and other major markets in the European community.** CBI-Rotterdam., The Netherlands. pp 38.

CTA (1991) **Production of fresh ACP fruits and vegetables for export**. CTA, Macmillan, Wageningen, The Netherlands, pp.297, ISBN 09290810955

Chweya JA . & Zaguirre, E.Y.(1999) **The biodiversity of traditional leafy vegetables.** IPGR., pp 181, ISBN 92-9043-404-x

FAO (2003) Handling **and preservation of fruits and vegetables by combined methods for rural areas.** TECHNICAL Manual FAO agricultural service bulletin, ISBN 92-5-104861-4

Hall, D. (1995) **A garden of plenty growing vegetables.** David Philip. ISBN 0864860870

Kasem, P. (1993) **Vegetables.** Pudoc Wageningen, The Netherlands. pp.412, ISBN 90-220-1058-9

Shippers, R.R. (2000) **African indigenous vegetables.** Natural Resource institute. pp 214. ISBN 085954515-6

Van der Maesen, L.J.G & Somaatmadja, S. (1992) **Plant resources of South –East Asia; NO 1: Pulses.** PROSEA, Bogor, Indonesia, pp.106, ISBN 979-8316-00-2

Youdeowe, A., Mofa. (2002**) Integrated pest management for production of vegetables.** PPRSD GTZ, Germany, pp 48. ISBN 9988010885

Useful addresses

PTC+ is an international training institute which focuses on all the links in the production chain on plant and animal commodities, (agricultural) technology, (food) technology and natural areas.
Training programmes are practice-oriented and mix theory with practical classes. **PTC+** offers "open entry" programmes, "tailor-made" programmes and consultancy. Programmes are offered in the Netherlands and/or at location.
It is the policy of **PTC+** to search for partnerships and co-operation programmes with national and international institutions abroad.
For more information: visit our web-site: www.ptcplus.com and/or write to:
PTC+ Head Office
P.O. Box 160, 6710 BD Ede, The Netherlands
Tel.: +31 318 645700
Fax: +31 318 595869
e-mail: info@ptcplus.com

Plant Research of Tropical Africa (PROTA)
P.O. Box 341 AH Wageningen, The Netherlands
Tel. +31 (0)317 484587
Fax +31 (0)317 482206
E-mail: prota@wur.nl
Website: www.prota.org.nl.

Henry Doubleday Research Association
HDRA is dedicated to researching and promoting organic gardening, farming and food.
Ryton Organic Gardens, Coventry CV8 3LG, Inited Kingdom
Tel: +44 (0)24 7630 3517
Fax: +44 (0)24 7663 9229

E-mail: ove-enquiry@hdra.org.uk,
Website: www.hdra.org.uk.

Asian Vegetable Research and Development Center
P.O,Box 42 Shanhua, Tainan 741, Taiwan
E-mail: avrdcbox@netra.avrdc.org.TW
Website: www.avrdc.org

AVRDC-ARC
PO Box 9-1010 (Kasetsart), Bangkok 10903, Thailand
Tel: +66-02-942-8686 / 942-8687
Fax: +66-02-942-8688

AVRDC Regional Center for Africa
P.O. Box 10, Duluti, Arusha, Tanzania
Tel: +255-27-2553093 / 2553102
Fax: +255-27-255-3125

Appendix 1: Some important vegetables

English name	Scientific name	Family	Products
African cabbage	Brassica carinata	Cruciferae	leaves
African eggplant	Solanum macrocar-pon	Solanaceae	leaves
Amaranth, Chinese spinach, African spinach	Amaranthus spp.	Amaranthaceae	leaves
Bitter cucumber, bitter gourd, bitter melon, Balsam pear, sopropo	Momordica charantia	Cucurbitaceae	leaves, young tops fleshy fruits
Black nightshade, wonderberry	Solanum nigrum	Solanaceae	leaves
Carrot	Daucus carota	Umbelliferae	roots, leaves
Cassava, manioc tapioca	Manihot esculenta	Euphorbiaceae	root tubers, young tops and leaves
Ceylon spinach, Indian spinach, vine spinach, country spinach, Malabar nightshade	Basella rubra and Basella alba	Basellaceae	leaves
Chinese cabbage: Pak-Choi Petsai	Brassica campestris var. chinensis var. pekinensis	Cruciferae	leaves
Cockscomb	Celosia spp.	Amaranthaceae	leaves
Cocoyam, taro tania	Xanthosoma spp.	Araceae	tubers, stolons, leaf stalks, leaves
Cocoyam, taro eddo, dasheen	Colocasi esculenta	Araceae	tubers, leaves leaf stalks
Common bean, French bean, Kidney bean, pole bean	Phaseolus vulgaris	Leguminosae	ripe seeds, young pods, sometimes young leaves
Cowpea, catjang bean	Vigna unguiculata spp. unguiculata	Leguminosae	young leaves and pods, ripe seeds
Cucumber (gherkin)	Cucumis sativus	Cucurbitaceae	fleshy fruits
Eggplant, garden egg, aubergine, brinjal, melongene	Solanum melongena	Solanaceae	fleshy fruits, leaves
Garlic	Allium sativum	Liliaceae	bulbs
Groundnut, peanut, goober	Arachis hypogeae	Leguminosae	ripe seeds

English name	Scientific name	Family	Products
Jews mallow, jute, krin-krin, bush okra, West African sorrel, long fruited jute, Oyo, Eyo, ewedu, jute mallow	Corcorus olitorius	Tiliaceae	young leaves and stem tops
Kangkong, swamp cabbage, water spinach	Ipomoea aquatica	Convulvulaceae	leaves
Lettuce	Lactuca sativa	Compositae	leaves
Lima bean, Sieva bean	Phaseolus lunatus	Leguminosae	young seeds and leaves, young pods; ripe seeds sometimes poisonous
Maize, corn	Zea mays	Gramineae	cobs, seeds, young leaves
Melon, cantaloupe	Cucumis melo	Cucurbitaceae	ripe fruits, seeds
Okra, lady's fingers	Hibiscus esculenta	Malvaceae	young fruits, leaves, shoots, flowers
Onion	Allium cepa	Liliaceae	bulbs, young plants
Pigeon pea, Angola pea, Congo pea, gram, no-eye pea	Cajanus cajan	Leguminosae	young leaves, shoots and pods, red young and ripe seeds
Potato	Solanum tuberosum	Solanaceae	tubers
Pumpkin, gourd, squash, vegetable marrow	Cucurbita moschata C.maxima C. pepo	Cucurbitaceae	ripe or half-ripe fruits, ripe seeds
Roselle	Hibiscus sabdariffa	Malvaceae	leaves, young tops, calix
Sweet pepper, paprika	Capsicum spp.	Solanaceae	fruits
Hot pepper	Capsicum spp.	Solanaceae	fruits
Sweet potato, kumara	Ipomoea batatas	Convulvulaceae	tubers, young leaves and stem tops
Tomato, kamako, love-apple	Lycopersicon esculentum	Solanaceae	fruits
Watermelon	Citrullus vulgaris	Cucurbitaceae	ripe fruits, seeds, very young leaves
White cabbage, drum/head cabbage	Brassica oleracea var. capitata	Cruciferae	leaves
Winged bean, Goa bean, four angled bean	Psophocarpus tetragonolobus	Leguminosae	leaves, seeds thickened roots
Yardlong bean, asparagus bean	Vigna unguiculata spp.sesquipedalis	Leguminosae	ripe seeds, young pods and leaves

Appendix 2: Data about important vegetables

Name	humid forest 28-30 °C	savanna hot 30-40 °C	climate cold 20-30 °C	mountains 15-30 °C	propagation (2)	seeds g/m^2 (3)	plants 10 m^2 (3)	duration in days (4)	seed production (5)
African cabbage	++	++	++	++	n	1	100	50-100	+
African eggplant	++	++	+	+	n	2-6	20-60	60-300	+
Amaranth	++	++	+	+	d, n	1-2	250-500	20-90	+
Bitter cucumber	++	++	++	+	d	5	40*	70-110	+
Black nightshade	++	++	++	+	d	1	250-500	40-120	+
Cassava	++	++	+	+	v	-	100	60-270	–
Ceylon spinach	++	++	+	+	d, v	10	50	60-180	+
Chinese cabbage:									
Paksoi	+	++	++	++	d	2	200	50-80	+
Petsai	–	+	++	++	n	1	60	40-110	–
Cocoyam, taro	++	+	+	+	v	-	20	60-270	–
Common bean	–	–	+	++	d	50	40*	90	+
Cowpea	++	++	+	+	d	40	55*	100-150	+
Cucumber	+	+	++	++	d	2-5	10-25*	60-150	+
Eggplant	++	++	++	+	n	8	10-30	80-200	+
Groundnut	++	++	+	–	d	40-80	100-200*	120	+
Jews mallow	++	++	++	+	d, n	5	250	45-80	+
Kangkong	++	++	++	+	v, d	5	120	60-30	+
Lettuce	–	–	+	++	n	5	200	30-60	–
Maize	++	++	++	++	d	10-20	40	90-180	+
Melon	–	+	++	++	d	2	15*	70-120	+
Okra	++	++	++	+	d	6	20-50*	60-360	+
Pigeon pea	++	++	+	+	d	15*	10	270	+
Red pepper	++	++	++	+	n	5	10-30	90-270	+
Roselle	+	+	++	+	d	6	20	120-180	+
Sweet pepper	+	++	++	++	n	4	30-50	50-130	+
Sweet potato	++	++	+	+	v	-	120	90-180	–
Tomato	+	+	++	++	n	4-6	20-30	60-160	+
White cabbage	+	+	++	++	n	1	30	60-100	–
Yardlong bean	++	++	+	+	d	20	25*	100-150	+

(1) ++ = very suitable climate
+ = less suitable climate
– = non suitable climate

(2) d = direct sowing
n = sowing in nursery bed
v = vegetative propagation

(3) per 10 square metres of cultivated surface
* = the figure indicates the number of seed holes with 2-4 seeds

(4) perennial plants continue to produce in the following years

(5) + = possible
– = extremely difficult

Appendix 3: List of technical terms

English	Francais	Nederlands	Espanol
annual	annuel	eenjarig	anual
aphid/plant louse	puceron	bladluis	piojo/afido
broadcast sowing	semis a la volee	breedwerpige zaai	siembra a voleo
bucket	seau	emmer	cubo
carbohydrates	hydrates de carbon	koolhydraten	carbohidratos
clayish soil	sol argileux	kleigrond	suelo arcilloso
climber/runner	plante grimpante	klimplant	planta trepadora/planta sarmentosa
compost	compost	compost	compost de basura
compost heap	compostiere	composthoop	monton de basura
compound fertilizer	engrais compose	mengmeststof	abono compuesto
crop rotation	rotation de cultures/assolement	vruchtwisseling	alternativas de cosecha
cutting	bouture	stek	estaca/esqueje
dibbling/pocket drilling	semis en poquets	pocket zaai	siembra a golpes
disease control	lutte contre les maladiesen	gewasbescherming	lucha contra fermedades de plantas
ditch	fosse	greppel	zanja, cuneta
drainage	drainage	afwatering	drenaje
dung/manure	fumier/engrais	mest	estiercol/abono
Dutch hoe	ratissoire	schoffel	escardillo/almocafre
eelworms/nematodes	nematodes/anguillules	nematoden/aaltjes	anguilulas
erosion	erosion	erosie	erosion
fallow	jachere	braak	baldio/barbecha
fats	lipides	vetten	grasa
fence	cloture	heining	valla
fertilizer	engrais chimique	kunstmest	abono quimico
fruit vegetables	legumes□fruits	vruchtgroenten	hortalizas de fruta
garden trowel	transplantoir	plantschepje	trasplantador
grading	tri	sorteren	clasificacion
green manuring	engrais vert	groenbemesting	abono verde
harvest	recolte	oogst	cosecha
hoe	houe/binette	hak	azada/binadora
homesite farm	jardin de case	tuin op eigen erf	huerta de solar
humus	humus	humus	humus/mantillo
irrigation	irrigation	bevloeiing	riego/irriga□cion
kitchen garden/vegetable garden	jardin potager	moestuin	huerta
leaf vegetables	legume□feuilles	bladgroenten	verduras de hojas

English	Francais	Nederlands	Espanol
litter	paillis	strooisel	cama de paja/litera
marker	rayoneur	rijentrekker	marcador
minerals	mineraux	mineralen	substancias minerales
mulching	paillage	bodembedekking	cobertura del suelo
nursery bed	pepiniere	kweekbed	semillero
perennial	perenne/vivace	vast/overblijvend	perenne/vivaz
pesticide	pesticide	bestrijdingsmiddel	pesticide
plant, to	planter	planten/poten	plantar
plant bed	planche	bed	almacigo
planting peg/dibble stick	plantoir	plantstok	plantador
plant out, to	repiquer	uitplanten/verspenen	plantacion de asiento
pod	gousse	peul	vaina
proteins	proteines	eiwitten	proteinas
rake	rateau	hark	rastrillo
ridge	billon	rug	caballon/lomo
ridge up, to/earth up	butter	aanaarden	aporcar
root vegetables	legumes racines	wortelgroenten	verduras de raiz
row seeding/drilling	semis en lignes	rijenzaai	siembra en lineas
sandy soil	terre sablonneuse	zandgrond	tierra arenosa
scuffle, to	biner	schoffelen	ascardar
seed	semence, graine	zaad	semilla/semiente
seed vegetables	legumes graines	zaadgroenten	hortalizas de grano
soil disinfection	desinfection du sol	grondontsmetting	desinfeccion del suelo
soil improvement	amelioration du sol	bodemverbetering	mejoramiento del suelo
sow, to	semer	zaaien	sembrar
sowing in situ/direct sowing	semis sur place	directe zaai	siembra de asiento
spade/shovel	beche	spade/schop	azada
straight fertilizer	engrais simple	enkelvoudige meststof	abono simple
subsoil	sous-sol	ondergrond	subsuelo
thin, to	eclaircir	uitdunnen	aclarar/ralear
tie, to	tuteurer	opbinden	atar
tillage	labour du sol	grondbewerking	labranza/laborero
tools	outils	gereedschap	utiles
topsoil	couche arable	teellaag	capa arable
transplant, to	transplanter	verpoten	trasplantar
vegetable growing	culture maraichere	groenteteelt	cultivo de hortalizas
water, to	arroser	begieten	regar
watering can	arrosoir	gieter	regadera/aspersor

English	Francais	Nederlands	Espanol
weed, to	sarcler	wieden	escardar/desmalecar
weeds	mauvaises herbes	onkruid	malas hierbas
wheelbarrow	brouette	kruiwagen	carretilla
wilt, to	fletrir	verwelken	marchitarse
winnow, to	vanner	schonen	aventar/abalear
wire netting	grillage	gaas	tela metalica

Appendix 4: Pictures of common vegetables in the tropics

Figure 30: Roselle

Figure 31: Jews mallow

Figure 32: African eggplant

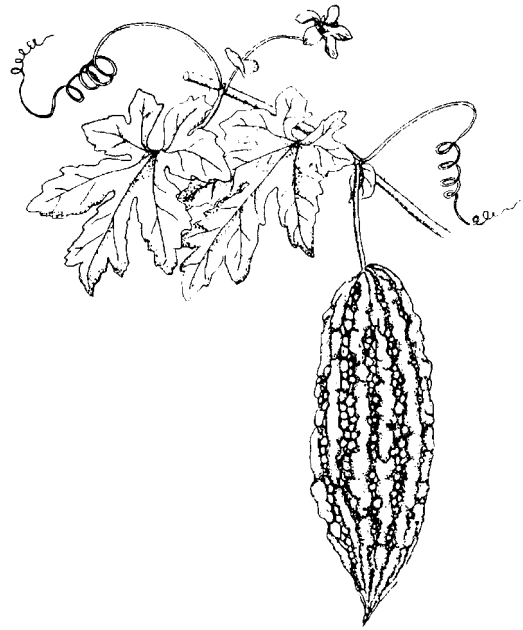


Figure 33: Bitter cucumber

Figure 34: Black nightshade

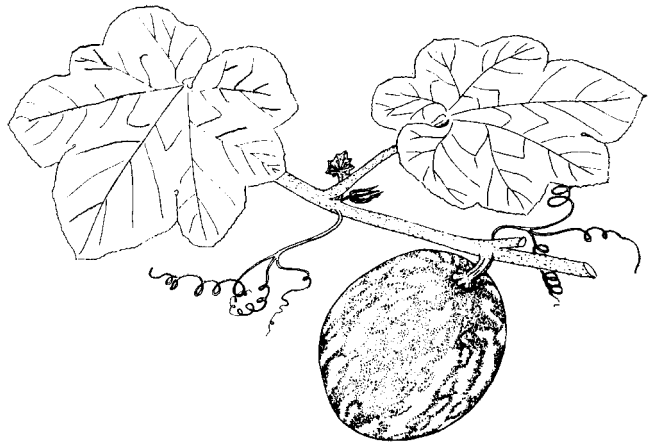


Figure 35: Pumpkin

Figure 36: Amaranth