
Agrodok 17

**How to grow
tomato and peppers**

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Foreword

This Agrodok on the growing of tomatoes and peppers is meant for fieldworkers in developing countries. It is intended to serve as a practical manual, also for those who have little knowledge of agricultural matters. The methods described are suitable for small-scale cultivation and require little external input.

In order to compile a handy manual, the authors had extensive discussions focusing on the practical aspects of cultivation. In our opinion being practical contributes more towards healthy tomatoes and peppers and a reasonably steady yield than giving lengthy theoretical explanations.

We would like to express our thanks to Leo van den Berkmortel for his technical advice.

Agromisa welcomes your comment or suggestions concerning the contents of this book, in order to improve future editions.

The authors.

Wageningen, December 1989.

Contents

Foreword	3
1 Introduction	6
A brief description	6
Tomato	6
Spanish pepper and sweet pepper	8
Chilli pepper or tree-pepper	10
2 Conditions for succesfull cultivation	12
Climate and soil	12
Choosing cultivars	13
Varietal resistance	14
Cultivars	16
3 Preparation	22
Raising seedlings	22
Field preparation	24
Transplantation	25
4 Crop husbandry	26
Manures and fertilizers	26
Water requirements	28
Pruning	29
Nipping	29
Supporting stems	30
Weed control	33
Crop rotation	34
Cropping systems	35

5	Pests and diseases	37
	Eelworms (nematodes)	37
	Insects	39
	Fungi	48
	Control of diseases and plagues	52
6	Harvest	56
7	Seed production	58
	Seed selection criteria	58
	Seed cultivation	59
	Open pollinated and F1-hybrid cultivars	59
	Hygienic precautions	63
	Drying and storing sowing seed	63
	Seed quality	66
	Appendix 1	66
	Recommended for further reading	68
	Used literature	69

1 Introduction

A brief description

Tomato, sweet pepper, Spanish pepper and chilli pepper all belong to the Solanaceae family. This family also includes other well-known species, such as nightshade, potato, aubergine (egg-plant) and tobacco. As growing tomato is very similar to growing pepper and sweet pepper (paprika), this booklet will describe how to grow all three species.

Sweet pepper and Spanish pepper are both cultivar groups of the species *Capsicum annuum*. Spanish pepper contains a substance known as capsine, which gives it its characteristic hot flavour. This substance is virtually not produced in sweet pepper (and California pepper). These are large, sweet kinds of Spanish pepper. Chilli pepper is a cultivar group of the species *Capsicum frutescens*. This species grows as a shrub and is less commonly grown than the *Capsicum annuum* species. Besides these two species, there are others of regional importance. *Capsicum chinense* is common in the Antilles, while *Capsicum pendulum* (Caji) and *Capsicum pubescens* are grown in the Andes.

The following sections describe the three species tomato, pepper and sweet pepper in more detail.

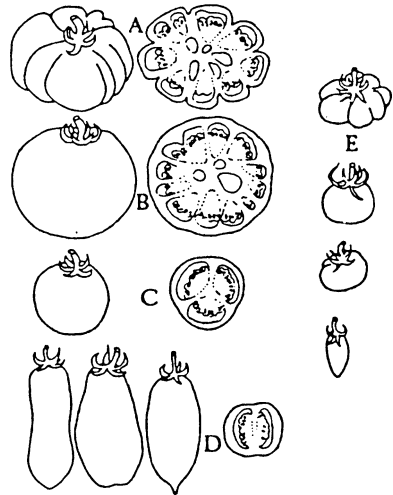
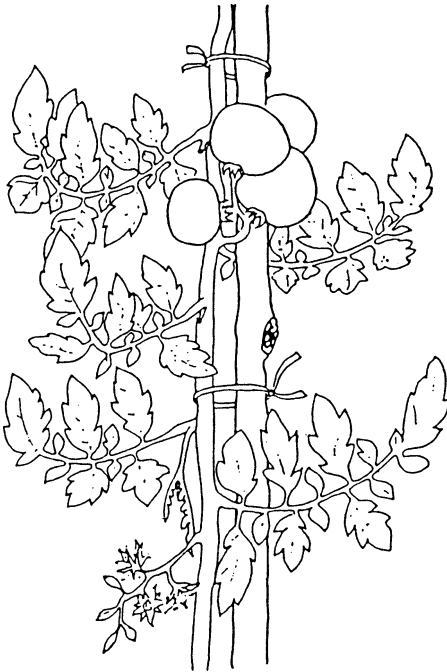
Tomato

The Latin name of the species is *Lycopersicon esculentum* Mill. Common names for the tomato are: love apple, tomate (Spain, France), tomatar, vilayti, baingan (Indonesia), rangam, tomat (Malaysia), faan ke'e (China), tomati (West Africa), tomatl (Mexico), jitomate (the Caribbean), pomodoro (Italy).

The tomato (see Figure 1) is an herbaceous plant which can reach a height of more than two metres. It is usually grown as an annual crop.

In South America, however, the tomato is often grown as a perennial crop. The same plants are harvested for several years in succession. Three different types of tomato plants can be distinguished:

- the bush type,
- the tall type,
- the semi-bush type.



Tied up along the stem

Different shapes of the fruit

- A: *quick cultivar with flat, ribbed fruit*
- B: *late cultivar with large fruit*
- C: *Anglo-Dutch cultivar*
- D: *cultivar with oblong fruit*
- E: *various cultivars of cherry tomato*

Figure 1: Tomato

Blossoms and fruit grow in clusters along the stems. Self-pollination takes place when the flowers bloom. Both the stem and the leaf of the tomato are covered in fine hair. Some of the hair is glandular hair. These contain an oily substance which gives tomato its characteristic fragrance and which stains hands green.

The first harvest is possible 45-55 days after flowering, or 90-120 days after sowing. The shape of the fruit differs per cultivar. The colour ranges from yellow to red. Tomato contains much vitamin B and C. Yellow tomatoes have a higher vitamin A content than red tomatoes.

Spanish pepper and sweet pepper

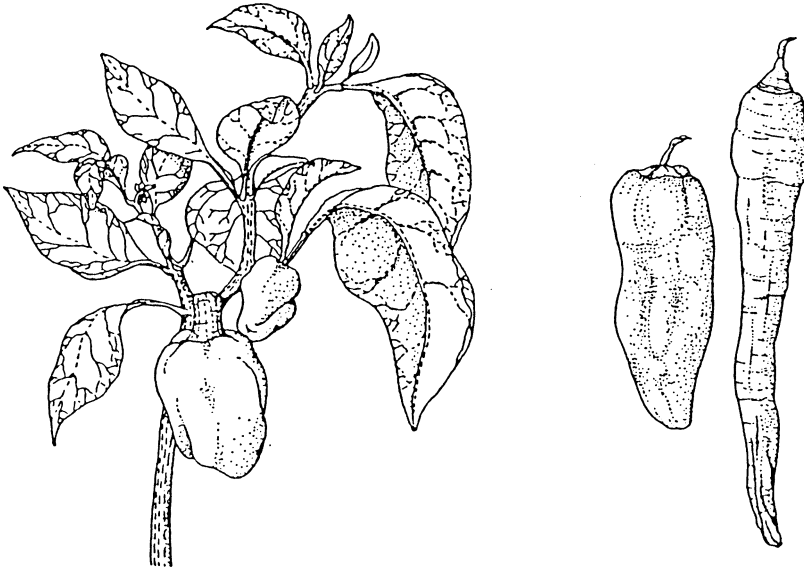
The Latin name of the species is *Capsicum annuum* L. Common names for Spanish pepper and sweet pepper are: capsicum, bell pepper, red pepper, chili, chilli, cherry pepper, paprika, pimenta, long pepper, cayenne pepper, piment, poivron (France), aji, pimiento (Spain), paprika (Germany), mireh, lombok (Indonesia), t'im tsui (China).

Spanish pepper and sweet pepper (see Figures 2: A and B) are annual herbaceous species. Some cultivars are bushy, with woody stems. Each plant has many branches. The height of a full-grown plant ranges between 0.5 and 1.5 m.

The stems are sturdy so pepper plants do not have to be tied up. The leaves are smooth, with an entire edge. Blossoms are white to greenish and appear in the leaf axil. They appear singly, not in clusters as on the tomato plant. Self-pollination is most common, but bees and ants also help in pollination. Approximately 16% crosspollination takes place, which means that 16% of the flowers are fertilized by pollen from other flowers. Under good growing conditions about half of the flowers bear fruit.

The first harvest can be expected 50-80 days after transplantation, assuming that transplanting occurs when the first flowers bloom. The plants reach an age of 8 months. The fruit has high vitamin A and C

contents. The shape and taste can differ considerably. Young fruit is always green.



A: Sweet pepper: plant with fruit

B: Spanish pepper and the variation in the shape.

Figure 2: Pepper plants

During ripening, the colour of the fruit changes from yellow or faded brown to red. Some cultivars turn yellow or green when ripe. The cultivar determines the final colour, shape and flavour of the fruit.

It is possible to distinguish between five groups of pepper cultivars according to the shape of the fruit:

1. wrinkled peppers: oval-shaped fruit with wrinkled skin, shorter than 5 cm.
2. chillies: oblong fruit, longer than 9 cm, with a pointed tip and hot taste,

common in India.

3. cherry pepper: round red, yellow or purplish fruit with sturdy pulp, 1.2-2.5 cm diameter, hot taste.
4. sweet peppers and paprika: large red or yellow fruit, dented at the base, mild taste.
5. long pepper: red, yellow or ivory-coloured, hanging fruit, narrows down to a pointed tip, 23-30 cm long, usually mild taste.

Chilli pepper or tree-pepper

The Latin name of the species is: *Capsicum frutescens* L. Common names for chilli pepper or tree-pepper are: hot pepper, bird chilli, birds-eye pepper, red pepper, goat pepper, tabasco pepper, spur pepper, tjabe rawit, tjabe setan (Malaysia), tse tin tsiu (China), chile de arbol (Mexico).

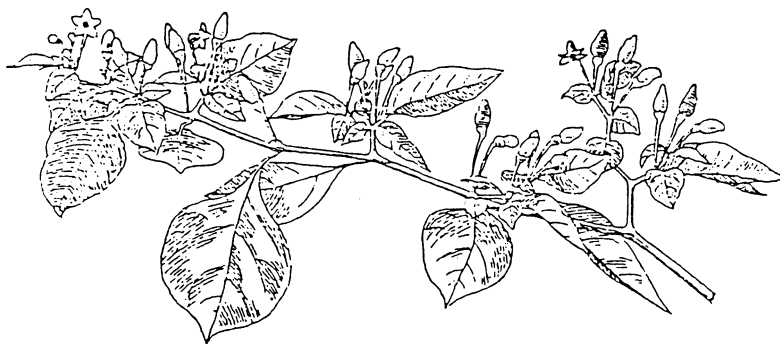


Figure 3: Tree-pepper

The chilli bears a strong resemblance to the Spanish pepper and sweet pepper but it is a perennial bush species rather than an annual species. The plant can reach a height of 1.5 m. The most important difference with the Spanish pepper and sweet pepper is that the green-white flowers appear in clusters of 2-3 rather than singly. They are usually self-pollinated, but bees and ants contribute to some cross-pollination. The first fruit can be picked 80-100 days after transplantation. The plants can produce for 2-3 years if grown under good conditions. The fruit is usually cone-shaped or round, and small. It is 2-3 cm long. Chilli pepper has a much hotter taste than Spanish pepper. Compared to the Spanish pepper, the vitamin C content of the chilli pepper is much lower, but the vitamin A content is 2-16 times higher.

2 Conditions for successful cultivation

Climate and soil

To help determine whether or not tomato and (sweet)pepper can be grown in a certain area, the following needs to be known:

- what are the temperatures?
- how much water is available?
- what is the soil like (clay, sand, etc.)?

Temperature

The plants can survive a range of temperatures but growing stops below 10°C. If cool weather spells persist, pollen production can also suffer. This will influence fruit formation. Frost kills the plants. To avoid frost, it is good to wait until the winter is definitely over before sowing. It is possible to sow indoors earlier (in pots or trays) to avoid damage by frost. Hot pepper stops growing if the average temperature is less than 16°C, and is more suited to hot temperatures than sweet pepper and tomato (see Table 1).

Table 1: Average temperatures (°C) for growing tomato, pepper and sweet pepper

Crop	Temperature (°C)			Minimum temperature difference (day/night)
	optimum	minimum	maximum	
Tomato	20-27	10	30	5
Sweet pepper	20-25	10	30	5
Pepper	20-30	16	35	5

Water and humidity

A simple rule of thumb can be used to determine whether local water supplies are sufficient for growing tomato and (sweet)pepper. If there are herbaceous plants (plants with many thin leaves) growing in the natural environment, growing tomato and (sweet)pepper will be possible. You should be able to count on at least three months of rain. Inadequate rainfall will cause buds and flowers to drop off. However, if rains are too heavy and humidity is too high, the growth of mould and the rotting of fruit will increase.

In humid areas, flowering and fruit formation is lower than normal. Tomato is especially sensitive to moisture. Cloudiness will slow down the ripening of tomatoes. (Sweet) pepper, however, will grow better in shady areas and with cloudy weather. It is preferable to plant (sweet)pepper under taller crops (young bananas, coconut, fruit trees/bushes, intercropping with e.g. runner beans).

In the humid tropics (e.g. rain forests), it is advisable to consider planting tomato and capsicum in the 'dry' season.

Soil

The soil needs to be permeable. After a heavy rainstorm, no puddles should remain on the ground. Pepper and sweet pepper cannot endure more than a couple of hours of saturated soils. The leaves will fall off if the roots are waterlogged for longer. The type of soil is not very important. Loamy soils are best and will give highest yields. The soil should not contain too much calcium (so white soils are not very suitable).

Too many plant remains or turf in the soil makes the soil acidic. Acidic soils can be made suitable by adding calcium. It is always possible to improve the soil by adding manure or compost.

Choosing cultivars

Due to centuries of endeavour by farmers and plant breeders, there are now many different types of tomato, pepper and sweet pepper. These

different types are called cultivars. They are a result of the continual process of selection of plants on characteristics such as type of fruit, shape of plant, hair growth, vitality and resistance to diseases.

An important characteristic to take in account when choosing a cultivar is the resistance to harmful agents as diseases (fungi, viruses), eel-worms (nematodes) or plagues (insects).

Varietal resistance

Tomato and (sweet)pepper are susceptible to diseases and plagues. There are various ways to protect plants from these diseases and plagues or to cure them. One of the ways to protect a plant is by making it resistant.

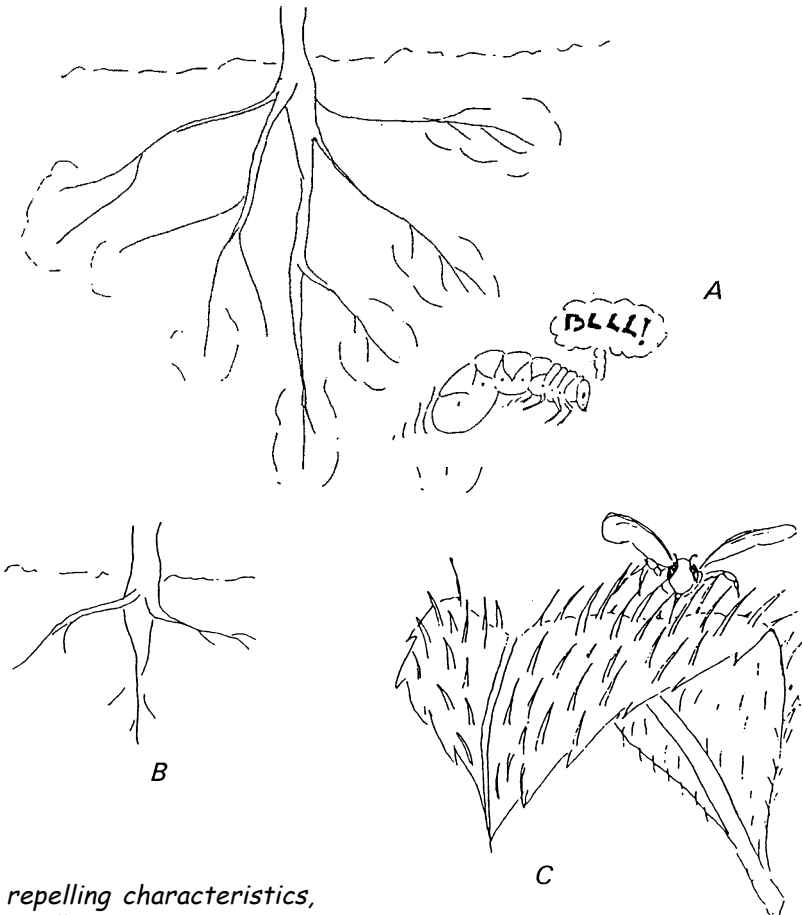
Resistant cultivars have an in-built immunity or resistance which is carried in the seed. Resistance to a specific disease means that it is very difficult or impossible for a plant which has this resistant characteristic to get that disease. It is possible to buy cultivars that are resistant to certain diseases. Resistance can be a result of various plant characteristics. Leaves can be densely covered in hairs so that certain insects do not like sitting on them. Some colours can be unattractive to certain insects. Such characteristics are visible. Sometimes, however, characteristics that contribute to resistance cannot be seen.

For example, the sap of a plant can taste horrible to insects or does not allow harmful agents to grow (see figure 4). Unfortunately, there are no cultivars on the market which are resistant to all existing diseases and plagues.

It is possible to buy seed from plants which are resistant to one or several diseases. In the next section an indication will be given as to the kind of resistance which certain cultivars have.

It is also possible to breed your own resistant cultivars. This is almost automatically a result of selecting the best, least damaged plants with the best fruit, for seed cultivation (see Chapter 7). Those plants have

been harmed the least by diseases and plagues. Do remember, though, not to accidentally select unwanted characteristics! If, for example, there is a beetle larvae that eats plant roots, it is possible to select plants with nasty tasting roots. Then you will get healthy plants with a healthy root system. However, maybe a small root system is also accidentally selected. Then the larvae have less chance of finding the roots and it seems as if the problem has been solved. But at a certain point the



- A: repelling characteristics,
- B: small root system,
- C: hairs protect the leaf from insects

Figure 4: Three forms of resistance

harvest will decrease because plants with a small root system have been bred (see Figure 4B). You have to be careful with resistant cultivars. There are always a few pathogens which are immune to resistant characteristics. These strong pathogens slowly replace all other pathogens which are unable to grow in the resistant cultivar. Slowly but surely, after a few seasons, the in-bred resistance of a cultivar is no longer effective and that particular cultivar is no longer useful. Therefore it is important to stay one step ahead of strong pathogens by continuing to select for resistance.

Cultivars

Tomato

In Chapter 1 it was mentioned that tomato plants grow in three different shapes: i.e. the bush type, the tall type, and the semi-bush type.

The bush type is the least labour-intensive to grow. Growth of the stem ends with a cluster of flowers, after the formation of a limited number of flower clusters along the stem. This type of tomato is a small bush-shaped plant which usually does not need any support. There is a less dense leaf-coverage than with the two other types. In a humid climate, therefore, a tomato plant of the bush type is less likely to be bothered by mould. However, in a dry climate with bright sunshine, there is more chance of the fruit splitting due to variations in temperature.

The stem of the tall type keeps growing despite the formation of an unlimited number of flower clusters.

Looking at the semi-bush type the stem growth ends with a cluster of flowers. This is the same as for the bush type but the semi-bush type grows taller. Besides this, there are more leaves and flower clusters than with the bush type.

The tall type and the semi-bush type therefore have a denser leaf-coverage, reducing the chance of sunburn in a dry and sunny climate. However, these two types run a higher risk of mould growth in humid

Cultivar	Resistance (1)	Maturity	Fruit		Use (2)	
			Weight(g)	Shape (3)	Fresh	Processing
Ace 55	VF	mid-late	170	B	+	+
Cal j	VF	mid-early	90	F		+
Campbell 33	VF	mid-early	130	B		+
Campbell 35	VF	mid-early	110	D		+
Campbell 37	VF	mid-early	90	K		+
Chico iii	F	mid-early	60	L		+
Chico grande	FS	mid-late	110	M		+
Coeur de boeuf	-	mid-late	160	N	+	+
Floradel	CFS	mid-late	180	C	+	
Heinz 1350	VF	mid early	160	B	+	
Heinz 1370	F	mid-late	120	D	+	
Lima	VF	early	60	G		+
Manalucie	CFS	mid-late	230	C	+	+
Manapal	CFS	mid-late	150	C	+	+
Marglobe	-	mid-early	150	C	+	
Marmande	-	very early	150	A(r)	+	
Marmande	F or VFN	early	170	A(r)	+	
Moneymaker	-	early to mid-early	70	C	+	+
Monprecos	-	early to mid-early	70	C	+	+
Napoli	VF	mid-early	55	M		+
Pakmor	VFS	mid-early	180	C	+	+
Pearson improved	VF	late	180	C	+	+
Red cloud	VF	early	100	C	+	+
Roma	VF	mid-late	50	L		+
Rio grande	VF1,2	mid-late	100	H		+
Santa cruz kada	-	mid-late	90	H	+	
St. Pierre	-	late	170	C	+	
Supermarmande	-	very early	180	A(r)	+	
T2 improved	VF2	mid-late	100	F		
Tropic	VFS	mid-late	190	C	+	+
UC 82	VF	early	60	G		+
UC 134	VF2	mid-early	80	F		+
Ventura	F	early to mid-early	60	M		+
VFN 8	VFN	mid-early	140	G	++	

(1) C: Cladosporium, F: Fusarium wilt, N: Nematodes, S: Stemphylium, V: Verticilium wilt.

(2) Use + : Recommended

(3) Fruit shape:

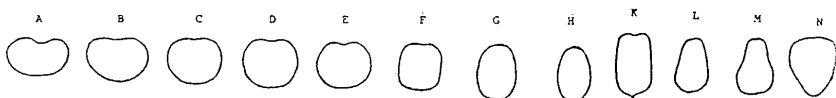


Table 2: Tomato cultivars - Open pollinated

areas. Furthermore, to prevent plants of these types from falling, it is necessary to tie them to a stick for support. The most common cultivars are mentioned in Table 2. This table also gives an idea of the kind of resistance, length of time to mature, shapes of the fruit and the way to use the product.

Pepper and sweet pepper

Pepper and sweet pepper are hot-tasting and sweet-tasting cultivar groups, respectively. Figure 5 shows different groups of pepper cultivars. Most commercial breeding has been done with sweet cultivars because these are grown commercially world-wide on a larger scale than hot peppers. Almost every region has its own hot pepper cultivars. Table 3 at the end of this chapter gives a few examples of more commercially-used cultivars. In Mexico alone, where hot peppers were probably first grown on a larger scale, there are hundreds of local cultivars. It is usually true that a specific cultivar is mostly suited to climate and to the wishes of the inhabitants of the region where it was first grown. If you want a low-risk crop it is probably better to choose a local cultivar. If you want to introduce different cultivars or cultivars with resistance to certain diseases consult Table 3.

Table 3 mentions some commonly used cultivars. The table shows the resistance to diseases, the time when maturity occurs and some characteristics of plants and fruit. You can also write for information to one of the seed distributors listed in Appendix 1.

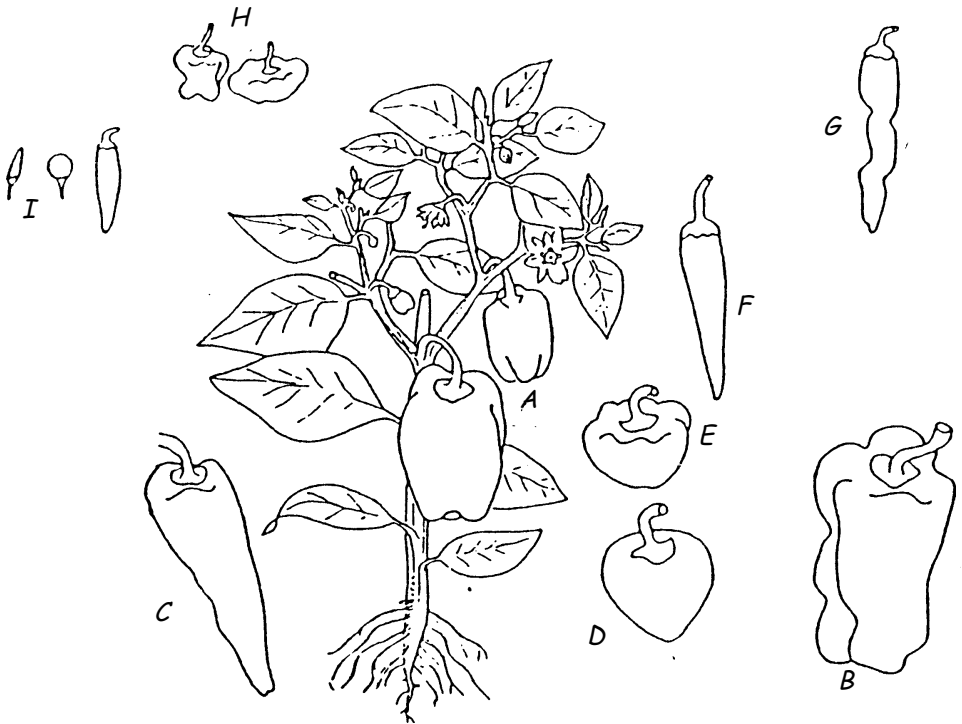


Figure 5: Different (groups of) pepper cultivars

- | | |
|--------------------------|---------------------------------------|
| A: 'Yolo Wonder' | F: 'Chupete' |
| B: 'Largo Valenciano' | G: 'Dulce largo de las Landas' |
| C: 'Cubanelle' | H: <i>Capsicum chinense</i> species |
| D: 'Pimiento Perfection' | I: <i>Capsicum frutescens</i> species |
| E: 'Antibois' | |

Table 3: (Sweet) pepper cultivars

Cultivar	Resis- tance (1)	Maturity	Plant	
			height (cm)	type
<u>SWEET PEPPER</u>				
Golden Cal. wonder	-	mid-early	50-60	rather compact
California wonder	-	mid-early	60-70	rather compact
Yolo wonder B (tmr)	TmV	mid-early	50-60	rather compact
Hungarian yellow sweet wax	-	early	50-60	compact
Marconi	-	mid-early	70-90	vigorous, leafy
Resistant giant	TmV	mid-late	65-75	compact, sturdy
California wonder 300 (tmr)	TmV	mid-late	60-70	rather compact
<u>HOT PEPPER</u>				
Cayenne long slim	-	mid-early	65-70	vigorous, leafy
Anaheim chili (tmr)	TmV	mid-late	70-85	vigorous, leafy
Anaheim chili	-	mid-late	70-85	vigorous, leafy
Hungarian yellow wax hot	-	mid-early	65-70	upright

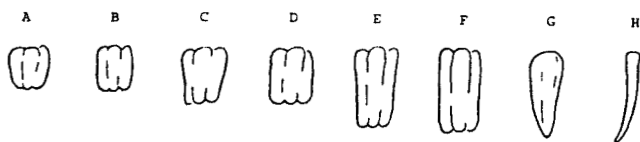
(1) Resistance TmV: Tomato mosaic virus

Fruit characteristics

length (cm)	Ø (cm)	shape (2)	nr. of cells	wall (mm)	colour
9	9	A	3-4	5-6	green-yellow
10	9	A	3-4	5-6	green-red
10	8	A	3-4	5-6	green-red
14	4	G	-	4-5	light-yellow- orange red
20-22	4-5	G	-	4	green red
8	10	B	3-4	5-6	green red
11	9	A	3-4	5-6	green red

12-15	2	H	-	2-3	green-red
17-20	4	H	2	2-3	green-red
17-20	4	H	2	2-3	green-red
13-15	4	G	-	2-3	light-yellow- orange red

(2) Fruit shape:



3 Preparation

Raising seedlings

There are three ways to raise seedlings:

- on seedbeds
- in seed trays
- in seed pots

Seedbeds

Theoretically a seedbed can be any size you want. Usually seedbeds are 1.2 m wide and 8 m long. A path of 15 to 18 cm is left open for walking in between the beds.

To plant tomatoes, you need 3 grams of seed per m², which is about 30 grams of seed per seedbed. For (sweet)pepper you need 10 grams/m², or 100 grams of seed per seedbed of the dimensions mentioned above.

All three species are sown in rows, leaving 5 cm between the rows. For tomato, place the seeds 5 cm apart in the rows, pressing them about 1.5-2 cm in the soil. (Sweet)pepper seeds can be placed shallowly in the ground (0.5-1.0 cm), at 1 cm distance.

For all three species, the soil should be pressed slightly and moistened after sowing.

The seedbeds should be protected from bright sunshine, heavy rains and excessive drying by covering them (e.g. with palm leaves). If the top centimetre of soil feels dry, it is necessary to moisten the seedbed. It is best to water the beds once or twice a day, preferably in the morning. The leaves and the top layer of soil should be dry before night. Do not give too much water at one time because this can cause moulding (especially in shaded areas).

Tomato seedlings must be hardened off for 7 to 10 days before being transplanted: Gradually the seedlings should be given less water and be exposed to sunlight. This same procedure is necessary for (sweet)pepper seedlings when they are about 10 cm tall (about 1 week before transplanting).

Seed-trays

An easier way to nurse healthy seedlings is in seed-trays. Seed-trays are easy to transport and to water. Besides this, it is also possible to use a better soil mixture for the seed-trays than for the seedbeds.

A few holes are made in the bottom of the trays to allow excess water to drain away. A layer of large pebbles is spread on the bottom of the tray, on top of which a layer of grass is placed to hold water. On top of this a layer of soil mixture is spread. To get soil with a good structure, mix equal parts of compost, sand and garden mould (rich, black soil). Rice husks or bagasse (sugar-cane pulp) can also be added to the mixture. Be careful not to use garden mould from a field where any of the following crops were planted in previous seasons: tomato, (sweet) pepper, potato, aubergine, tobacco or any other plant of the Solanaceae family. If animal manure is available, you can add that to the soil mixture before sowing. However, do not use fresh manure for this purpose.

A well-mixed soil should be free from eelworms and other pathogens. It might help to disinfect the soil mixture before it is used. One way to do this is by steaming the soil. Place the mixture on a flat sheet of aluminium (or corrugated iron). Wet the mixture and heat it by placing the sheet over a fire. Keep heating the soil for about half an hour, until it is almost dry. Sowing tomato and (sweet)pepper in trays is done in the same way as sowing in seedbeds.

Seed pots

Seed pots can be made from cardboard, compacted peat, banana leaves or plastic. If plastic pots are used, you need to take the seedlings out of the pot when transplanting them. This is not necessary if pots of organic

(degradable) material are used. This kind of material falls apart in the soil. The advantage of using organic pots is that roots are damaged less during transplantation. Roots will be less likely to dry up and the plants less likely to get sick.

Field preparation

A field can be prepared by ploughing it or digging it up so that organic fertilizers are mixed into the soil. (Sweet)pepper needs soils that have been ploughed to a depth of 25-30 cm. For tomato this preparation is less important.

Level or sunken beds are suitable in dry seasons or dry areas, and on sandy soils. The uptake of water by the plants is increased and the soil is prevented from being washed away. In humid areas or in the rainy season, and on loamy or clayey soils, it is better to plant on raised beds to prevent waterlogging. The height of the bed can vary from 20 to 50 cm, and depends on rainfall, the type of soil, and the slope of the land. The distance between the beds varies from 30 to 50 cm. A bed can be 1-1.5 m wide.

Distances between rows and plants are largely determined by the type of crop.

Tomatoes

Table 4: Planting distances for the three types of tomatoe plants

Type of plant	Distance between rows and plant
Bush type	1.0 x 0.3 m
Semi-bush type	1.2 x 0.5 m
Tall type	1.4 x 0.5 m

If the tomatoes are to be supported by sticks, then the distances between rows can be decreased by 20-40 cm.

(Sweet)pepper

(Sweet)pepper is planted at wider distances than tomatoes, and is consequently not planted close together in rows. The distance between plants is about 50-75 cm. The width of the beds should be between 75 and 90 cm.

Transplantation

Transplantation of tomatoes to beds in the field takes place 3 to 6 weeks after sowing. The seedlings should be about 20 cm tall. It is better to transplant (sweet)pepper later, when the first flowers appear (after 6 to 8 weeks). It is best to transplant the seedlings in the evening or in humid weather. This prevents the roots from drying out. Moisten the soil a couple of hours before transplanting them. When removing the seedlings, keep a large clump of soil attached to the roots to prevent them from being damaged. Make the holes for the plants large enough so that the lowest leaves are at ground level. After transplanting, place mulch on the ground around the plant. Mulch is composed of plant remains (e.g. rice-straw or sorghum-straw) which cover the soil to control weed growth and prevents erosion. Moisten each plant immediately after transplanting. But be careful not to wet the lowest leaves, as this can stimulate the growth of mould.

The newly transplanted plants should be protected from heat during the first 5 days, e.g. by covering them with large leaves.

4 Crop husbandry

Manures and fertilizers

To get a very high yield, tomatoes need to be fertilized. There are two groups of fertilizers: organic fertilizers and chemical fertilizers

Organic fertilizers

Farmyard manure, poultry manure and compost are three types of organic fertilizers, they are described in this paragraph.

The three most common kinds of farmyard manure are horse, cow and pig manure. Of these three kinds of manure, horse manure has the best balance of nutrients. Cow manure has relatively little phosphate. Pig manure is usually rich in mineral salts but has relatively little potassium.

It is better to use farmyard manure on sandy soils than on clayey soils, because it is quite sticky. Sandy soils will not fall apart as easily if manure is added, and will therefore be able to hold more water.

If only farmyard manure is used, then 3 to 5 kg/m² is a reasonable amount to apply. Lower applications of manure can also be enough if growing conditions are not so good or if chemical fertilizer is also applied.

Poultry manure is usually 3 to 4 times as strong as farmyard manure. It is a very valuable kind of manure as plants can easily absorb the nutrients from it. Be careful not to use too much though, not more than 1.5 kg/m². A good way to apply poultry manure is by first mixing it with an equal amount of crumbly soil or sand. You can sprinkle this mixture between rows, after which it is good to rake or hoe it lightly. Poultry manure, unlike farmyard manure can be used on clayey soils because it is not too sticky. It is also suitable for acid soils because this kind of manure contains a lot of calcium.

It is not advisable to plough fresh manure into the ground as it is too strong and can damage the sprouting plant.

Compost is easy to make of all kinds of organic materials. Examples of materials that can be used are: crop residues, uncooked kitchen wastes, garden cuttings and manure. Compost has less nutrients than manure. It is especially useful to improve the soil structure (See Agrodok no. 8: 'Preparation and use of compost').

It is important to have organic fertilizer that has decomposed well, and which is not too sticky or too wet. It must not be too dry, as moistening organic fertilizer again can be difficult. You can get good fertilizer by covering fresh fertilizer (against the rain) and storing it for about one month before using it. Advantages of using organic fertilizer are that it provides a large variety of nutrients and that it improves the structure of the soil.

Chemical fertilizer

Chemical fertilizer does not improve the soil structure but enriches the soil by adding nutrients. One disadvantage of chemical fertilizer is that it is expensive. It does not pay to use a lot of chemical fertilizer in small-scale cultivation, and in situations of fluctuating prices and low yields (resulting from diseases, unfavourable weather or poor soils). Chemical fertilizers can be divided into two groups: compound fertilizers and simple fertilizers.

➤ Compound chemical fertilizers.

This kind of fertilizer is a mixture of nitrogen (=N), phosphate (=P₂O₅) and potash (=K₂O). The compound fertilizer 12-24-12 contains 12% nitrogen, 24% phosphate and 12% potash.

➤ Simple chemical fertilizers.

In this kind of fertilizer there is only one nutrient. It is used when a crop has a specific deficiency (e.g. sodium nitrate, urea or super-phosphate). Tomato especially needs phosphate after transplantation. It is better to spread nitrogen and potash applications during the

growing season. (Sweet) pepper needs less fertilizer than tomato. Usually equal amounts of nitrogen, phosphate and potash are applied.

In the tropics the application of chemical fertilizer ranges between 40-120 kg/ha of nitrogen, 30-90 kg/ha phosphate and 30-90 kg/ha potash. Never spread chemical fertilizer on young or wet plants because this will cause burns.

Combination of organic and chemical fertilizers.

Tomato is usually given a combination of organic and chemical fertilizers. It is not necessary to apply this mixture at one time. For example, you can apply half when preparing the beds or mixed with the soil in the holes for the seedlings. The remainder can be applied when the plants flower or when the fruit is being formed. It is best to rake this into the soil about 15 cm from the rows. A second application, to replenish nutrients in the soil, is especially advisable on sandy soils, where nutrients are leached more quickly.

Water requirements

Tomato and (sweet)pepper are not resistant to drought. Yields decrease considerably after short periods of water deficiency. It is important to water the plants regularly, especially during flowering and fruit formation. The amount of water that is needed depends on the type of soil and on the weather (amount of rain, humidity and temperature). It is especially important to water regularly (e.g. 3 times a week) on sandy soils. Under good circumstances once a week should be enough. It is better to give small amounts regularly than a lot of water at one time. To prevent diseases, it is advisable to keep the leaves dry by applying surface irrigation. To allow leaves and the top layer of soil to dry during the day, it is better to water in the morning. In this way mould growth can be controlled.

Pruning

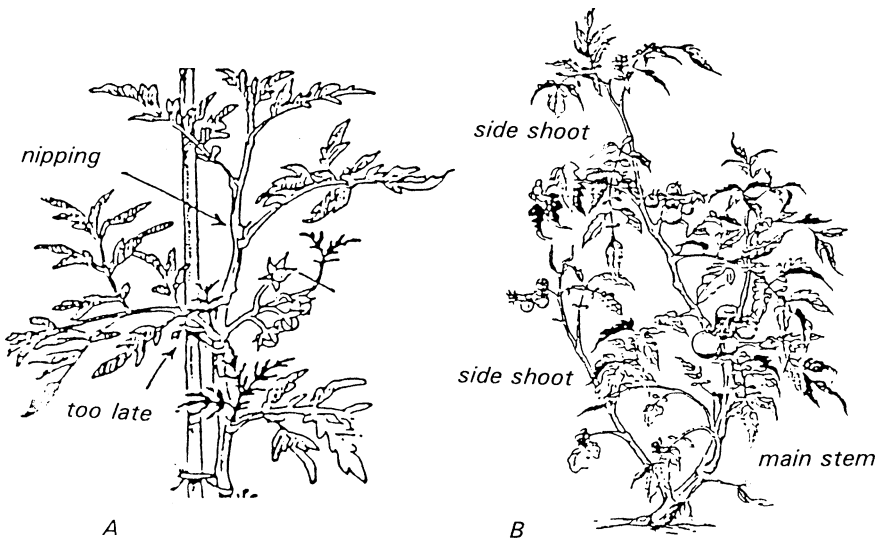
For tomatoes pruning is important. Pruning the side-branches is called nipping. Pruning the tops of the stem is called heading.

Need of pruning depends on:

- the type of plant, certain types, notably the bush type, are not pruned;
- climate, in humid areas or during the rainy season, the chance of infection as a result of pruning wounds is large. Therefore plants are often not pruned;
- size and quality of fruit, if plants are not pruned, they will grow at random and fruit will be smaller. It is better to guide the growth of the plants by pruning.

Nipping

It is important to pinch out side-shoots of tomato plants. When plants are nipped, the small side-shoots are removed and only one main stem remains (see Figure 6). The fruit clusters grow along this main stem.



A: *Nipping: this must be done when the side-shoot is still small.*

B: *A badly pruned tomato plant. Two side-shoots (at left) have continued to grow. The main stem (at right) suffers from this.*

Figure 6: Nipping

Heading

The tip of the main stem of the tall type of tomato plant is pinched off when 3 to 5 leaves are fully grown. The shoots that grow out of the top 2 to 4 eyes are left to grow. In this way 2 to 4 side-shoots will grow as main stems, supported by sticks (see Figure 7). When these stems are 1 - 1.25 m long, the tops should also be pinched off. New side-shoots should be removed regularly by nipping them. Usually 3 to 4 fruit clusters grow along each stem.

Trimming leaves

Old, yellow or sick leaves should be removed from tomato and (sweet)pepper plants. This controls the development and spreading of diseases. Be careful when pruning the plants. It is very easy to spread disease via your hands or any tools that are used, so avoid sick plants. Clean tools regularly. It is best to prune in the morning on a sunny day so that the wounds can dry quickly.

Sweet pepper plants are pruned like tall type tomato plants. Sometimes 10 day-old sweet pepper seedlings are headed before transplanting to encourage branching of the plants. Hot pepper and self-topping tomato plants are not pruned. It is not necessary to nip side-shoots (on bush type) because these stop growing after some time.

Supporting stems

Tying up

Tomato (tall type) can be tied to sticks to support the stems while they are growing.

Tie them loosely to the sticks and retie them regularly as they grow. In order not to damage the roots of the plants, support sticks should be put in place before transplanting. The sticks should be at least 1.5 m long, as they will be pushed 40-50 cm into the ground. Sticks that are to be used again should be washed with a disinfectant beforehand, to kill any germs that might still cling to them.

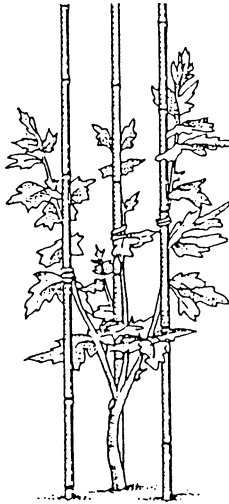


Figure 7: A tomato plant of which the top three side-shoots are supported.

Although it is not common to support hot pepper plants, sweet pepper plants are usually tied up.

Fencing

It is useful to make fencing of sticks and rope to support tomato (tall type) and sweet pepper for several reasons:

- plants get better support
- there is better ventilation, so less chance of spreading diseases and plagues, especially in humid areas or seasons
- it is possible to plant more plants per hectare
- weeding and harvesting is easier

Fencing can also be handy for bush type tomatoes, to prevent heavy clusters of fruit from touching the ground. Leaves and fruit that lie on

the ground rot easily, increasing the chance that plants will be damaged by diseases and insects. This can be prevented by:

- placing a fence of two parallel strings on either side of the plant (see Figure 9);
- planting on ridges or mounds, if you plant on level beds, it will be necessary to earth up around the plants;
- place straw or mulch under the plants.

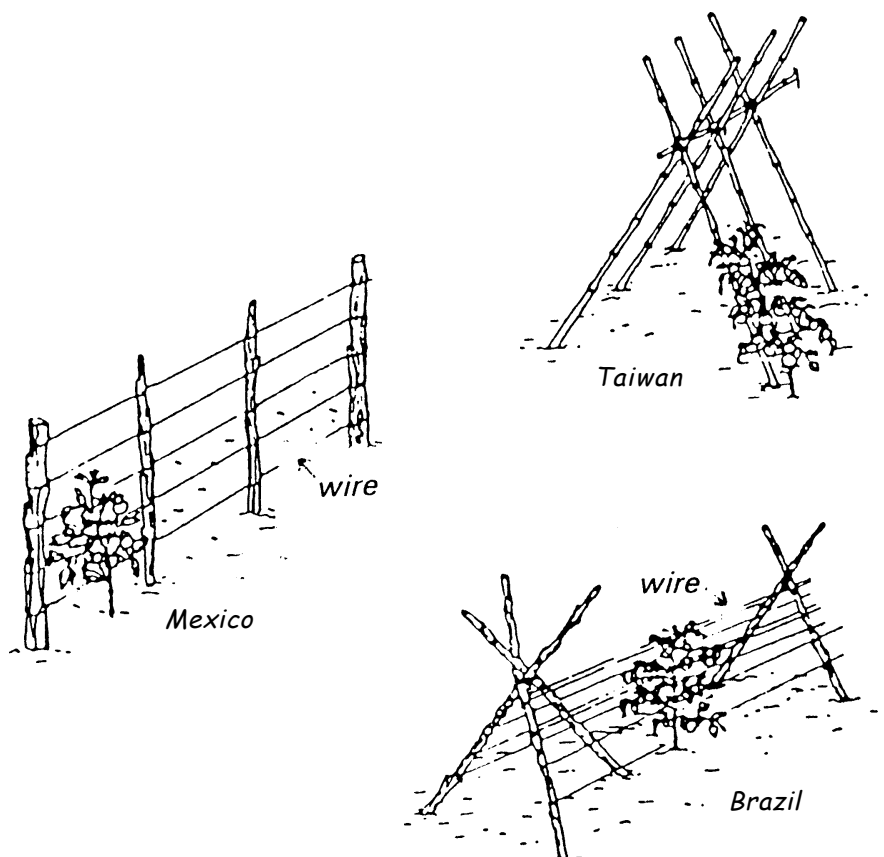


Figure 8: Different types of fencing used.



Figure 9: Bush type tomato supported by two parallel strings

Weed control

Weeds present problems either because they compete for light, water and nutrients, or because they transmit diseases and plagues. Therefore, controlling weed growth is very important.

It is best to remove weeds before they produce seed. They can be removed by pulling them out by hand or by hoeing just under the surface of the soil. To avoid damaging the roots, do not weed by hoe too often or too deep. Weed growth can be suppressed or slowed down by covering the ground with mulch. Mulch consists of plant remains such as rice-straw, sugar-cane pulp (bagasse), grass and/or leaves. Mulching has several advantages:

- reducing weed growth, reducing the necessity for weeding

- preventing the soil from drying out
- protecting the soil from the eroding effect of heavy rains
- reducing large fluctuations in temperature and humidity, thereby preventing fruit from splitting
- enriching the soil as it decomposes and improves soil structure (see Agrodok 2: 'Soil fertility')

Be careful not to use weeds with seeds in the mulch. Also be careful not to use plant remains from the Solanaceae family, as these can transmit pests and diseases (see Chapter 5).

Crop rotation

If tomato and (sweet)pepper are planted in monoculture, crop rotation is important. Crop rotation means planting a different crop on the field each season and only returning the same crop after at least three growing seasons. By doing this the life cycle of pathogens is interrupted and chances to get damage by diseases or pests are reduced.

Do not rotate tomato and (sweet)pepper with potato, tobacco and aubergine because these plants are all from the same family (Solanaceae) and have the same types of pests and diseases.

Some examples of crop rotation with tomato and (sweet)pepper are:

- tomato or (sweet)pepper followed by maize and beans
- tomato followed by upland or irrigated rice. It is best to plant tomato two weeks before the second upland rice harvest
- (sweet)pepper followed by beans, onion and cabbage

Remember to grow two other consecutive crops before planting tomato and (sweet)pepper again on the same field (i.e. once every 3 cropping seasons).

Cropping systems

Tomato and (sweet)pepper can be grown in monoculture or in a mixed-

cropping system. Mixed-cropping has advantages because this:

- reduces the chance of diseases and plagues
- reduces problems caused by weed growth, and
- makes it possible to grow two or more crops at the same time (which reduces risks when one of the crops fails).

Smallholders will gain the most from the advantages of mixed cropping.

Some examples of mixed cropping are:

- Tomato or pepper intercropped with sugar-cane (see Figure 10). The dwarf cultivars of tomato or pepper are planted on a raised bed about 1.2 m wide, with sugar-cane grown in the furrows between the beds.

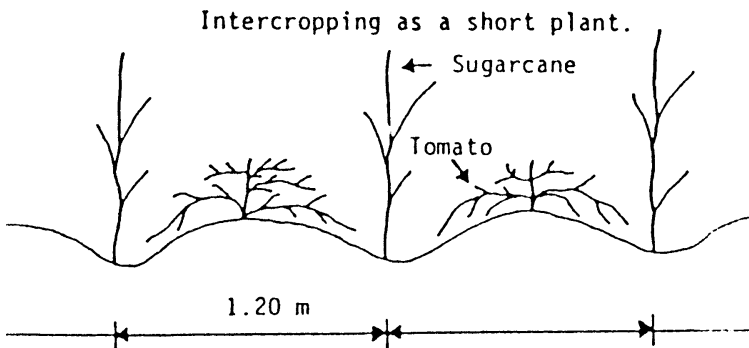


Figure 10: Bush type tomato intercropped with sugar-cane.

- Tall type tomatoes are grown along stalks covering 0.6 m of the bed (see Figure 11). Next to the bed, about 0.6 m higher, pepper and cauliflower are grown. The furrows are 0.3 m wide and serve as a path.

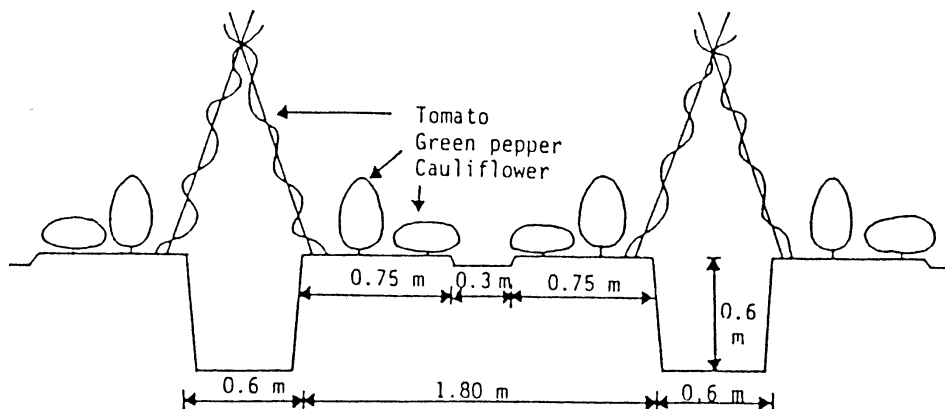


Figure 11: Tall type tomato intercropped with pepper and cauliflower

- Intercropping of tomato or (sweet) pepper with cabbage. Combining these crops will reduce the damage done by the diamond-back moth.
- Alternate climbers, such as runner beans and peas, with tomato. Two weeks before tomato is harvested, the beans and peas can be planted in between the tomatoes. The sticks supporting the tomato can be used for the new crop.
- Intercropping of (sweet)pepper with lettuce, radish, spinach and various kinds of beans with a short growing season.

5 Pests and diseases

Prevention of pests and diseases is extremely important. This chapter discusses the most important pests and diseases and gives advice on their prevention and cure. This is followed by some information on different types of pesticides and fungicides.

Eelworms (nematodes)

Eelworms are very small worms living in the soil and feeding on plant roots. Plants can be damaged severely by an attack of eelworms. Due to their small size (only a few mm long), it is not possible to see them.

In the cultivation of tomato and (sweet)pepper the root-knot nematodes are of importance, they cause gall-nuts (cancerous swells) on plant roots (see Figure 12). Three common types of root-knot nematodes are: *Meloidogyne incognita*, *M. javanica* and *M. arenaria*. Affected plants remain small, and are susceptible to all kinds of other soil diseases, such as fungus and bacteria. About 30% of the tomato harvest in the tropics is lost due to nematodes.

The nematodes can be transmitted via infected plants, tools, rainwater and irrigation water, strong winds (which blow soil away), and animals. Nematodes will survive in soil as long as it stays moist.

The use of chemical pesticides and fungicides or soil disinfectants is, for a number of reasons, not very effective. Instead of that, the following effective measures can be taken:

- Crop hygiene measures.
Immediately remove weeds and plant remains (old rotten leaves and fruit). This will also stimulate the effectiveness of crop rotation and other measures.

- Mixed cropping with crops that emit substances via their roots which nematodes do not like or which kill them, like sesame or tagetes (a kind of African marigold: a weed resembling this can be found in many countries).
- Rotation of tomato and (sweet)pepper with other crops such as cereals, cabbage, onion, ground nut, cassava, sesame, etc. (no Solanaceae !, see Chapter 3). Rotating with crops of the Cucurbitaceae family (e.g. cucumber or pumpkin) and papaya can also encourage the transmission of diseases.
- Exposing the soil to sun and wind. Plough the soil several times. The eelworms will be ploughed up to the surface of the soil and will be exposed to the sun and high temperatures which kills them. The disadvantage of ploughing is that organic matter in the soil will break down quickly, making the soil less rich and increasing the danger of erosion.
- Spray the soil with a neem solution

It is possible to graft tomato and (sweet)pepper onto rootstock of resistant plants. However, for this you need rootstock and more technical knowledge.

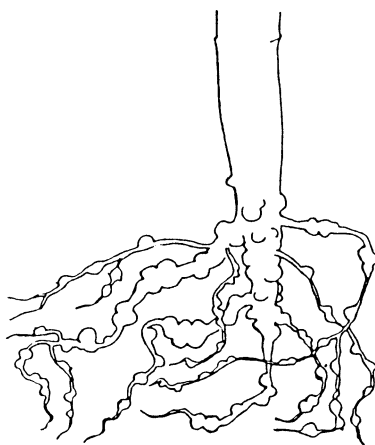


Figure 12: Roots of a tomato plant with gall-nuts caused by nematodes.

Insects

Usually tomatoe and (sweet) pepper are not affected directly by harmful insects. However, indirectly insects can reduce yields considerably because they transmit diseases such as viruses and fungi. Leaves damaged by insects become more susceptible to diseases.

All pricking and sucking insects, such as the white fly, thrips, aphids, mites and nematodes, transmit viruses and fungi. If such insects are present, one sick plant can infect an entire crop. Use of healthy sowing-seed can help reduce the damage caused by insects. In a crop that is healthy as a start, insects will be less disastrous.

White fly and melon fly (Bemisia tabaci, Dacus cucurbitae)

The white fly lays its eggs on the underside of leaves. The eggs hatch after about 1 week. The larvae feed on the sap from the leaf for 2 to 4 weeks and then form a cocoon. They remain in the cocoon for about one week. The adult fly is about 1 mm long and feeds, just like the larvae, on the leaf sap.



Figure 13: A colony of white fly on the underside of a leaf

White fly is especially a problem in the dry season. Once the wet season has started it will disappear. Some measures to combat the fly are:

- encourage the presence of natural predators of the white fly, by intercropping or growing near roadsides, shrubs or other varied vegetation forms
- use resistant cultivars (hairy leaves hinder the white fly in laying its eggs)
- spray a solution of kerosine and soap

Aphids (Aphidae)

Aphids are soft, oblong insects about 4 mm in length (see Figure 14). There are aphids without wings and some kinds have a wingless and a winged form. They prefer young leaves and stems. Direct damage occurs when they appear in great numbers in the crop.

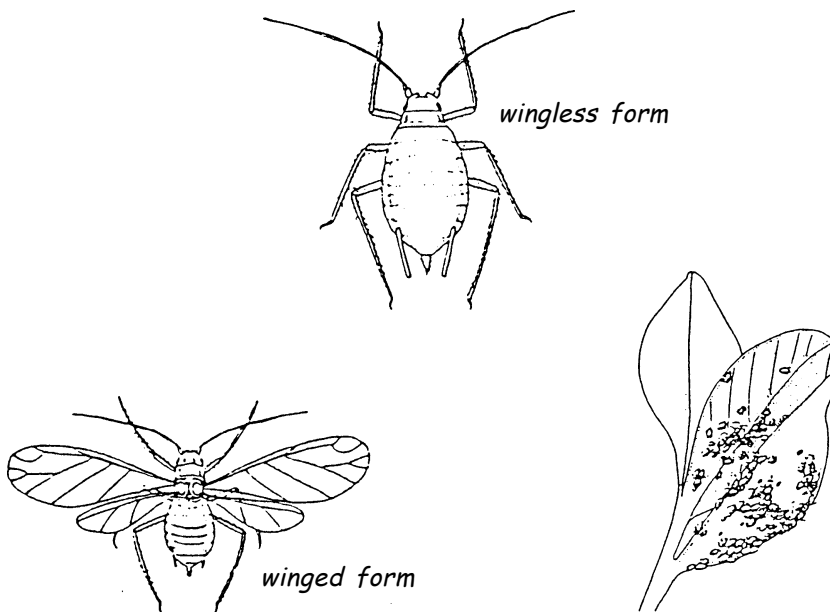


Figure 14: A winged and a wingless aphid and aphids on the underside of a leaf

Some measures to control aphids are:

- intercropping tomato and (sweet)pepper
- moderate use of nitrogen fertilizer, good fertilization with organic fertilizers
- plan to plant when aphids are least likely to be expected
- spray with a solution of soap, cow urine or neem
- cover the ground with grey plastic foil (this colour scares away aphids)

Thrips (Thrips spp.)

Thrips are very small insects, only 1 mm in length (see Figure 15). You have to look carefully to spot them.

Thrips lay their eggs in the leaf, near the surface of the leaf. The larvae appear after about 10 days. The larvae and adult thrips suck the leaf cells, causing silvery spots on the leaf surface.

The adult thrips also leaves its excreta on the leaf, which can be seen as small black dots. The cocoon stage takes place in the soil.

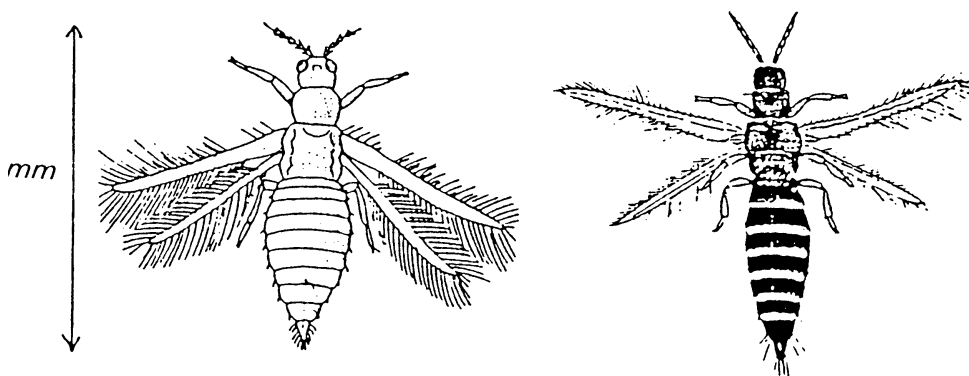


Figure 15: Two different kinds of thrips

Some measures to control thrips are:

- cover the ground with plastic foil. This is important to interrupt the cocoon stage of thrips
- plough well, so that cocoons are brought to the surface causing them to dry up
- remove crop remains
- spray with a soap or neem solution. Repeated spraying is necessary because this does not affect the cocoons in the soil. The thrips that appear out of these cocoons will then be affected by a repeated spraying.

Mites (Tetranychus spp.)

Mites are spider-like insects. They are smaller than 1 mm, often yellow, red or orange. They lay their eggs on the underside of the leaf. The larvae and adult insects suck sap from the leaves. Leaves and stems become yellow and dry up. Mites make a kind of web (fluff), similar to that of the spider. Most damage is done in the dry season.

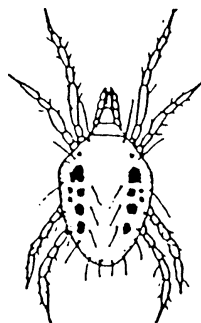


Figure 16: A mite

Some measures to control mites are:

- if possible, plant in the wet season
- stimulate the presence of natural predators by intercropping or growing near roadside, shrubs and other varied vegetation
- spray with a soap or a kerosine-soap solution

Butterflies and moths

(*Heliothis* spp., *Plutella* spp., *Trichoplusia* spp., *Agrotis* spp.)

Butterflies and moths are a common plague in tomato and (sweet)-pepper crops. Green or brown eggs are laid on young leaves, flowers

and fruit. The larvae (caterpillars, see Figure 17)) eat the leaves, flowers, fruit and even the roots. After feeding, the caterpillars enter the ground to form cocoons.

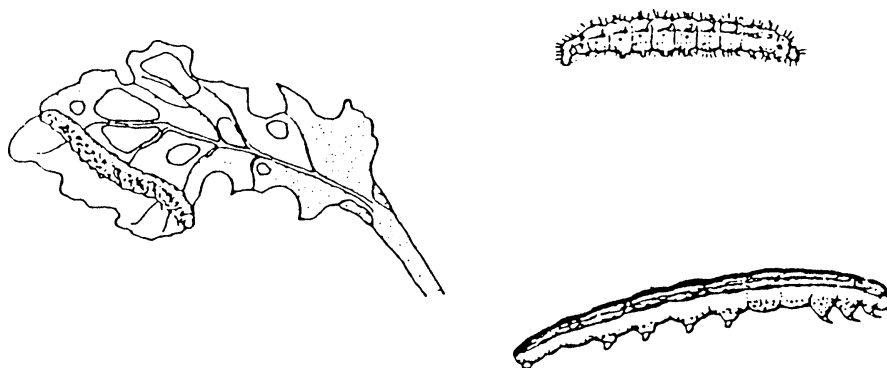


Figure 17: Caterpillars of different kinds of butterflies or moths

Some measures to control caterpillars are:

- remove weeds regularly
- plough one month before sowing or transplanting
- plant early
- adopt crop rotation
- check regularly for the presence of eggs and then take measures to control them
- use light traps that will attract moths at night, preventing them from laying their eggs on the plants
- apply wood ash, wood and/or calcium to seedbeds
- intercropping with cabbage
- spray with a neem solution or other locally used natural pesticides

Jassids and potato jassid (Cicadellidae: Empoasca fabae)

The most common jassid that occurs as a plague in tomato and

(sweet)pepper crops is the potato jassid. They jump away sideways if they are disturbed. They lay green banana-shaped eggs on the under-side of the leaf.

The potato jassid is only found in North, Central and South America. They feed on plant juice. Where they have sucked, the leaf becomes lighter in colour. If damage is severe, the entire leaf becomes light-coloured.

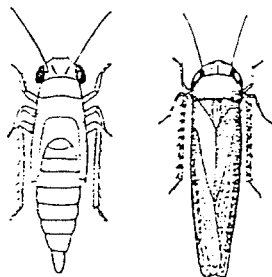


Figure 18: Jassids (nymph and adult jassid)

Some measures to control jassids are:

- if possible, plant during the rainy season
- use resistant cultivars (e.g. hairy leaves hinder the laying of eggs)
- mulch well (this prevents jassids from forming cocoons in the soil)
- spray with a neem solution or other locally used pesticides (e.g. pyrethrum, derris, sabadilla). The best time to spray is in the first month, when the plants are about 10 cm tall. Around this time the female jassids lay their eggs.

Bacteria

Most bacterial diseases are transmitted when humidity and temperatures are high. Some bacterial diseases which are commonly found in

tomatoes and (sweet) pepper are discussed below.

Bacterial wilt (*Pseudomonas solanacearum*)

This bacteria is especially common in humid tropical lowlands, where temperatures are relatively high. It is a soil disease which usually occurs together with nematodes. Symptoms vary considerably, but it is generally accompanied by a sudden yellowing or wilting of the leaves, especially in young plants. When the stem or roots are cut, a dark slimy sap appears. The root is dark on the inside. Sometimes there will be excessive growth of prop roots or side roots above the soil.

The following measures will help to control bacterial wilt:

- do not grow on fields where a crop of the Solanaceae family was grown in the past three to five years; once the soil has been infected, do not grow Solanaceae for at least 7 years; rotate with cereal crops;
- try not to injure roots or leaves, so be careful during transplantation and prune as little as possible;
- make sure the field is well drained;
- if necessary, sterilize the soil (see Agrodok 9: Vegetable gardening in the tropics);
- planting resistant cultivars can help; however, such cultivars rarely have the desired taste or shape.

Bacterial spot, bacterial scab (*Xanthomonas campestris*)

This bacteria is found in all parts of the world and is spread via seed, insects, raindrops, infected plant remains and Solanaceae weeds. Heavy rains and high humidity increase the rate with which it spreads. The bacteria enters the plant through the stoma and damages the fruit. Small spots containing fluid appear on the leaves and on the fruit of infected plants. These spots turn grey-brown and dry up. On fruit these then appear as cork-like spots, while on the leaves they leave a cream-coloured layer. Flowers and young fruit fall off. If the roots or stem are cut, a dark sap will appear. The root is dark on the inside. Sometimes there is an unusually large number of prop roots or side roots above the ground. The symptoms vary per climatological situation.

The following measures can help in controlling bacterial spot/scab.

- use germ-free seed. Hot water treatment of seed: soak for 25 minutes in water of 50(C;
- adopt crop rotation;
- weed thoroughly, being especially careful to remove members of the Solanaceae family;
- clear away crop remains;
- plant in rows parallel to the direction from which winds are most common;
- use the chemicals 'tribasic copper sulphate' or 'copper acid';
- plant resistant cultivars.

Bacterial cancer (Corynebacterium michiganense)

This disease is most common in the highlands of South and Central America. It occurs especially when temperatures are high. The disease is spread via seed or the soil. The bacteria can survive for two years in plant remains and on support sticks! Plants are infected via injured stems or roots. Damage may be severe when root-knot nematodes are present. The leaves of infected plants become yellow, wilt and dry up. Long, brown stripes, which can split open, appear on the stem. 'Bird's eyes' appear on the fruit; round slightly raised spots with a red dot surrounded by a white ring.

Some measures to control bacterial cancer are listed below:

- use germ-free seed. Hot water treatment: 30 minutes in water of 56(C, or 5 hours in a 5% solution of hydrochloric acid;
- do not sow on infected soil;
- do not keep using the same sticks;
- be careful when pruning. You can raise the standard of hygiene by not pruning sick plants and by regularly disinfecting the pruning knife;
- ensure adoption of crop rotation (if possible a rotation of 5 years);
- remove and burn crop remains;

Viruses

The most serious diseases in (sweet)pepper in the tropics are caused by viruses. The tomato is also very sensitive to viruses. Some common viruses are:

- tobacco mosaic virus or tomato mosaic virus (TMV)
- tobacco etch virus (TEV)
- potato virus-Y (PVY)
- pepper mottle virus (PeMV)
- cucumber mosaic virus (CMV)
- pepper veinal mottle virus (PVMV)
- chilli veinal mottle virus (CVMV)

As the names show, these diseases are also common in other Solanaceae plants. The viruses can cause a large variety of diseases, singly or in combination with other viruses, such as acuba mosaic (TMV), double stripe disease (TMV + PVX) and dwarf disease (TMV + TAV). All of these viruses can be spread simply by touch (e.g. via contact with hands). Pricking and sucking insects are common transmitters of viruses, the only exception being TMV.

TMV causes by far the most damage, especially in areas of intensive cultivation where plants are touched more often. This virus can be found in the tobacco of cigarettes (!).

The symptoms of TMV are: yellow-green spotted leaves, rolled-up leaves, stunted growth and few fruit.

General signs of a virus infection in tomato and (sweet)pepper are spots or dots (mottling) on leaves, disfiguration and discolouration of leaves, smaller and shorter leaves, and often stunted growth.

Measures to control viruses include those listed below.

- Adopt crop hygiene measures: use healthy seed and destroy infected

plants Avoid contact with infected plants and with tobacco: never smoke near the plants - even cigarette ash can transmit infection!! - and wash your hands with soap and water after touching plants.

- Avoid the presence of other Solanaceae in the vicinity. Some members of the Cucurbitaceae (cucumber, etc.) are also prone to viruses.
- Young plants, in particular, should be kept free of pricking and sucking insects.

Fungi

Most fungi grow well on plant remains and seeds under humid conditions. Therefore it is important to adopt crop hygiene measures to prevent fungi from growing and spreading. Use clean (disinfected) sowing-seed and remove crop remains as soon and as much as possible. It is advisable to remove the older leaves, those lower down on the plant. These leaves should preferably be removed in the morning, so that the wounds can dry in the sun and will not be infected. Sunlight can help kill fungi, in this way hindering them from spreading.

Early blight (Alternaria solani, A. alternata)

Spanish: Candelilla temprana)

This fungus can be found everywhere, especially in the rainy season, with cooler temperatures. It is spread via seed, wind, rain and infected plant remains. Plants that have been damaged are more susceptible to this fungus. Round, brown spots (with concentric rings like on a target) appear on the leaves, reaching a diameter of 1.5 cm. Sometimes small lumps can be found on the stem or on leaves, causing leaves to turn yellow and wilt. Flowers and small fruit fall off.

Measures that can be considered to control early blight are:

- removal and burning of damaged plant parts
- regular and thorough weeding
- use of clean seed
- crop rotation

- avoiding water deficiency
- no planting of young plants near older plants

Late blight (Phytophthora infestans)

Spanish: candelilla tardia)

This fungus can be found in all regions of the world, but is more common in highlands or in cool humid conditions in lowlands. The fungus is usually spread via crop remains. Dark, watery marks with a yellow spot on the inside are visible on the leaves. Sometimes the marks start at the edge of the leaf and spread inward, sometimes the spots spread from the centre of the leaf outward. On the underside of the leaves, the spots are white. The stems and fruit can be affected also. Fruit gets brown spots and the leaves wilt. The signs of late blight become visible early in the growing season.

Measures that can prevent late blight include:

- thorough and regular weeding
- removal and burning of affected plants and plant remains
- no mixed planting of young and old plants
- applying mulch on seedbeds, so that watering can be decreased
- no planting of tomato near potato

Fusarium wilt (F. oxysporum)

Spanish: la marchitez fungosa.

This disease is only found on tomato plants. Nematodes help spread this disease, especially in sandy soils. From the bottom up, leaves wilt, turn yellow and curl at the edges. A brown stain can be seen if the stem or roots are cut. The plant can wilt on only one side or on a leaf, while the other half or rest of the plant can remain healthy for a long time. Pink fungus fluff is an indication that part of the plant has already died off.

Some measures to help control fusarium wilt include the following.

- Adopt crop rotation
- Remove and burn affected plants
- Try to minimize moistening the crop by watering less often, to help prevent drying of the soil, apply mulch on the seedbed
- Raise the acidity of the soil by applying calcium or marl
- Resistant cultivars can help (e.g. the cultivars Pan-American, Southland, Jefferson, Manalucie, Homestead, Indian River, Manapal, Urbana, Roma, Dombo, Dombito, Dukado)

Verticillium wilt (V. albo-atrum, V. dahliae)

This disease is most common in cooler areas (e.g. highlands). Crop remains spread the fungus, especially in slightly acidic soils, with a low pH. Signs of infection are similar to those of fusarium, but they appear more slowly. This disease also affects other Solanaceae plants. It is possible that many side roots are formed at the base of the plant. The plant wilts, and leaves become orange-yellow.

Measures to control this wilting disease are:

- thorough weeding
- ploughing and clearing of crop remains
- use of healthy seed
- rotation with plants other than Solanaceae
- application of calcium or marl in the soil

Powdery mildew (leveillula taurica)

This mildew appears as yellow spots on the leaves and powder from spores on the underside of these spots. Unlike with other forms of mildew, the hyphal threads are completely inside the plant. The plant is infected via the stoma and leaf surface. The disease spreads quickly in dry conditions.

Leaf spots (Cercospora spp.)

Depending on the kind of fungus, brown or black spots appear on the leaves, and sometimes also on the fruit. This disease spreads quickest under humid conditions, via wind, rain, plant remains and neighbouring

plants. Transmission via seeds hardly occurs.

Anthracnose (Colletotrichum capsici)

Signs of infection by this disease are grey-brown spots (dents) on the fruit and, in humid weather, salmon(pink) spores. The disease spreads quickly in humid weather, and with high temperatures and humidity. Transmission is most common via infected plant material (especially the fruit). Therefore, measures relating to crop hygiene are very important.

Physiological diseases

Physiological diseases are not diseases caused by pathogens, but which occur due to nutrient deficiencies, or conditions of drought or extreme temperatures.

Fruit splitting

Due to large fluctuations in the moisture content of the soil, little ribs appear in the (usually ripe) tomato or (sweet)pepper fruit. Sensitivity to these fluctuations depends on the cultivar. The ribs help in transmitting other diseases and plagues, making it advisable to avoid splitting as much as possible. Two ways to do so are by covering the ground with a layer of mulch and watering it twice a week, or by picking fruit just before it is ripe and letting it ripen indoors in a dry spot (e.g. on straw).

Sunburn

Brown or grey indentations appear on the fruit. The part of the fruit that is most exposed to the sun rots first. This can be prevented by planting trees to provide shade or by intercropping with a crop that provides shade as the fruit ripens.

Blossom-end rot

This disease is caused by a calcium deficiency, which is usually a result of too many mineral salts in the soil. The concentration of salt on the soil can be lowered by extra irrigation (with sweet or distilled water), under conditions of good drainage. If drainage is inadequate, extra irrigation can have the opposite effect: soils may become even more salty! Always do this in consultation with your neighbours.

Control of diseases and plagues

Diseases and plagues can be controlled by using chemical and natural pesticides and fungicides, and by biological control. These three types of measures will be discussed in further detail below.

Chemical pesticides and fungicides

Chemical pesticides and fungicides are substances produced by the chemical industry on a large scale. Most of these chemicals need to be imported and are relatively expensive or otherwise hard to obtain. If they are available, information on how they are best applied is minimal and incomprehensible for laymen. The application of chemical pesticides and fungicides is risky for the health of human beings and animals. Besides these disadvantages, they are also only effective on the long term if they are alternated regularly. If this is not done, diseases and plagues will build up resistance to the chemical being used.

If tomato and (sweet)pepper are grown in home-gardens on a small scale, the application of chemicals is not necessary. In commercial cultivation, chemicals are often applied. However, even under those conditions it is advisable to compare the disadvantages due to damage (of humans and of the environment which harbours natural enemies of diseases and plagues) and costs, with the expected extra yield.

For detailed information on applicability and availability, it is best to consult local sources. In any case, remember to read the directions before using any chemicals. Remember the dangers that they can present for children, cattle, food and drinking water, and when stolen. Wash your hands well after use.

Natural pesticides and fungicides

Although natural pesticides and fungicides for tomato and (sweet)pepper can also be poisonous, they do have certain advantages over chemicals. These are:

- more security about availability as they are made from locally available ingredients (plants, soap, diesel, ash, etc. are usually easier

- to obtain than imported chemicals)
- low costs, and
- usually no negative side-effects for the environment.

It is worthwhile to look into local crop protection measures, as these are often made from local plants (pyrethrum, neem).

Some remedies that are in widespread use are mentioned below (from ‘Natural Crop Protection’ by Gaby Stoll).

➤ Kerosine-soap solution

This solution helps to get rid of aphids, mites, thrips and leafborers. Application: Dissolve 500 gr soap in 4 litres of boiling water. Then add 8 litres of kerosine while making the emulsion. This can be done by beating the mixture well, or by spraying the solution into the mixture (use a powerful pump, e.g. a plant spray). You should end with a creamy mixture, and no oily layer on top. Once it has cooled down it will congeal into a smooth, thick paste. Dilute the emulsion 10 to 15 times before using it.

➤ Soap solution

This is a good remedy against aphids and thrips. Application: Dissolve 30 cc liquid soap in 5 litres of water by shaking it. Before spraying it on the crop, test the solution on a single plant. If the concentration of the solution is too high, burns (spots) will appear on the plant. The solution should then be diluted more.

➤ Cow urine

This has proven to be effective in controlling aphids, mites, thrips and other insects, and also against mosaic-virus and fungi. Application: Store urine in the sun for two weeks. The urine should be diluted 6 times before spraying it. Test it first on the leaves and fruit of the plants, and dilute more if necessary. If a second spraying follows after 1 or 2 weeks, it will have more effect. This can be used as a preventive measure.

➤ Cow manure

The applicability of cow manure as a pesticide and fungicide for plagues and diseases in tomato and (sweet)pepper is similar to that of

cow urine.

Application: Put 3 cow pats in a bucket of water. Store it for two weeks, stirring every day. If the smell becomes too strong, stones and cloth can be added. This solution should be diluted 3 to 5 times before spraying it. Other animal manure can be similarly used, but test it on a single plant first!

► **Neem - *Azadirachta indica* (melicaceae)**

Neem is a fast growing tree, widespread in South-east Asia, Africa and Central America. The tree grows in various climates and soil types. It bears fruit after 4 or 5 years (average of 30 to 50 kg/tree). The seeds contain 35% to 45% oil. Neem is effective against all the plagues that have been mentioned here, and against nematodes.



Figure 19: Leaf with fruit from the neem tree

Application:

1. A watery extract from the neem seed is used as a spray. As the product is broken down by sunlight, it is best to prepare it in the evening. Collect the fallen fruit, remove the pulp and wash them. Dry the seed well and store it in a well-ventilated space (e.g. baskets or

bags). The seeds you need should then be peeled and ground. The ground seeds (about 5 kg) are wrapped in a piece of cloth and soaked in 10 litres of water overnight. The next day the water is sieved and diluted 10-20 times with water (totalling 100 to 200 litres). You will need about 500 litres to spray 1 ha (i.e. 13-25 kg ground seed). As a preventive measure, use a weaker dilution. It might be necessary to spray a second time.

2. The pressed neem fruit cake (not only the seeds) can be used to control nematodes in tomato. Plough 1 to 2 tons/ha of the cake into the soil.

Biological control

Controlling an insect pest by using its natural enemies is called biological control. Natural enemies can be birds, spiders, other insects and even fungi or bacteria. You can enhance this natural system by stimulating the presence of the natural enemies that are around anyway. You do need to know the insect and their enemies to do so. Important is the condition that few or no chemical pesticides and fungicides are used, because then the natural enemies are killed as well. Explaining in detail about biological control goes beyond the scope of this book.

6 Harvest

Harvesting on time and proper post-harvest treatment of the fruit is at least as important as all the aspects of cultivation and crop protection that have been discussed above. The high water content of tomatoes makes these fruits especially prone to post-harvest losses. (Over) mature fruit gets easily damaged or starts rotting. This causes weight losses which can be as high as 50% of the total production. The first measure to help limit the extent of post-harvest damage is harvesting at the right moment.

It will be necessary to harvest several times as the fruit of tomato and (sweet)pepper plants do not all ripen at the same time.

Tomato

The first tomato harvest is possible 3 to 4 months after sowing. Harvesting will continue for about one month, depending on climate, diseases, plagues and the cultivar planted. The number of times that harvesting will be necessary during one season varies from 4 to 15.

If the tomatoes are to be used for the production of, for example, ketchup, chutney, purée or juice, the fruit must be picked when it is red and completely ripe.

If the tomatoes are to be sold as vegetables on the market, they can be harvested while still green. Green tomatoes can be ripened after picking, until they are red. One disadvantage of early picking is that the nutritional value of the tomatoes decreases. One advantage is that green tomatoes are less likely to get damaged or to rot. If harvest is during the rainy season, it is advisable to pick tomatoes early. Add a few red, ripe tomatoes to each crate of green tomatoes, as red tomatoes will speed up the ripening process.

(Sweet) pepper

Harvesting (sweet)pepper does not differ essentially from that of tomato. Seventy to 140 days after the crop has sprouted, a weekly round of the fields is needed to pick ripe fruit. Just like that of tomatoes, the harvest of (sweet)pepper takes a lot of time and is hard work. An extra disadvantage of hot pepper harvest is that the hands can get irritated.

The moment at which to harvest (sweet)pepper depends largely on the cultivar and on the purpose for which the fruit will be used. Sweet pepper is usually picked early in the maturity stage, when it is still green. If (sweet)pepper is to be processed in industries, both red and green fruit can be picked. Hot cultivars are usually left to ripen completely (until the colour is red).

Harvesting the green fruit has the following advantages:

- lower chance of rotting
- early harvest disturbs flowering less, allowing for more fruit to form if other growing conditions are also met

In some areas such as India, Mexico and Hungary, fruit is hung up to dry. In such cases it is handier to pick the fruit with the stem still attached.

7 Seed production

Seed selection criteria

When collecting seed it is important to pick fruit only from healthy plants which also have other desirable characteristics. Such characteristics could include:

- good taste and easy to prepare (hot or sweet, skin not too hard)
- resistance to diseases or plagues. Sometimes the shape of the plant can be an indication for its susceptibility to diseases and plagues. A plant with lots of space between the leaves is better ventilated and will be less likely to get fungus, hairy or thick-leathery leaves will make life hard for insects.
- plants that produce a lot of fruit which is easy to store. This is an important characteristic if you are interested in selling more tomato, and (sweet)pepper

You need a lot of patience for the selection process. However, if you continue to select the best plants every year, you will soon notice that fruit production is of a higher quality and quantity.

Seed cultivation

Cultivating tomato and (sweet)pepper solely for seed production requires quite a bit more care than only for fruit production. If you can choose between a dry season and a wet season crop, the dry season is to be preferred.

Disease control and fertilization are of great importance. Only healthy plants can be expected to produce good seed. To produce good seed it will be necessary to apply more phosphate and potassium than for fruit cultivation (see Chapter 4). You will need to check the plants more frequently. Therefore, it is best to limit seed cultivation to those fields

that are within easy reach of the house.

This can be accomplished in two ways:

- 1) select a few fruits or plants from among the standing crop for seed production. This is handiest if you have little time, or if you want to be able to compare the plants for a better selection.
- 2) prepare and plant a separate plot for seed production. This will make such aspects as fertilization or disease control easier.

Only use good, ripe fruit from healthy plants for collecting seed. This is important as some diseases (such as tobacco mosaic virus and early blight in tomatoes, and *Phytophthora* blight in (sweet)pepper) can be transmitted through the seeds.

Open pollinated and F1-hybrid cultivars

Choosing the most suitable cultivar is very important. The tomato and (sweet)pepper cultivars that are commercially available are either open pollinated or hybrid (see below). The difference between these two kinds is the way in which pollination occurs. You can recognize hybrid seed by the indication on the packaging: a large 'F1'. Seed from hybrid cultivars is usually more expensive.

Seed that is collected from hybrid plants cannot be trusted to give reliable yields in following seasons. The yield will usually be lower.

If you want to continue using hybrid strains, you will have need to make a trip to the seed merchant every season.

In contrast to hybrids, open pollinated tomato and (sweet)pepper cultivars are very suitable for seed production by cultivators themselves. The seed from fruit can be selected as sowing-seed for the next crop.

F1-Hybrid

Hybrids are plants that are a result of an artificial way of cross-pollination. The first crop from hybrid seeds will produce well, but it is not

advisable to use second generation seed for planting. The chance that you will get plants with inferior characteristics is high. New seed must be bought and used for each crop.

Open pollinated

These plants grow as a result of self-pollination or cross-pollination. Cross-pollination takes place when one cultivar is pollinated by another cultivar due to wind or insects, or human beings. The seed from these plants can be selected and planted without any difficulty. One can be sure that offspring of only one cultivar will bear strong resemblances to the parent plant because, within a cultivar, tomato and (sweet) pepper can pollinate themselves.

However, this is not the case if there are other cultivars (also wild cultivars) within a 500 meter range: then cross pollination is also possible.

Seed gathering

To ensure that seed has fully ripened, only pick entirely ripe fruit. A rule of the thumb concerning seed production is that the best seed comes from freshly picked, ripe fruit. If it is not possible to let the fruit mature on the plant, let the picked fruit ripen further in a dry, cool place (14-15(C) before removing the seeds. However, this should be seen as a last measure and you should only do this if the weather is bad, e.g. rains at harvest time.

Tomato

Before tomato seed is ready for use, it is necessary to remove a thin gelatine-like layer. To determine whether there is such a layer, bite a seed: fresh seeds are smooth and difficult to bite, while seeds without the gelatine-layer are easy to chew. It is possible to remove this layer by treating seeds with an acid. However, it is much easier to treat them by a fermentation process.

- 1) Wash the fruit, preferably with a bit of soap to decrease the chance of infection by diseases or plagues. Cut the fruit in four pieces and

remove the seed with a spoon. You can also squeeze the pieces above a plastic, glass, or ceramic bowl, but not above a metal bowl (this is bad for seed quality), until only the seed-jelly and fruit sap is left. If necessary add more sap or water, so that all seeds are moistened.

- 2) Cover the bowl with cloth or paper to keep away flies and dirt, but do not make it airtight.
- 3) Let the seeds stand for 1 to 5 days (usually 2 to 3 days in warm areas) at 14-15°C. The fermentation will break down the gelatine-like layer. Stir the seeds daily to ensure uniform fermentation and to prevent discolouration of the seed.

After the gathering of the seeds, wash the fermented tomato seeds preferably in a sieve so that only the seeds remain and any other parts of the plant are removed. Any seeds that float can be thrown away as these are either not ripe or have not filled properly and therefore are weaker. One kilogram of tomatoes will produce between 1 and 4 grams of seed.

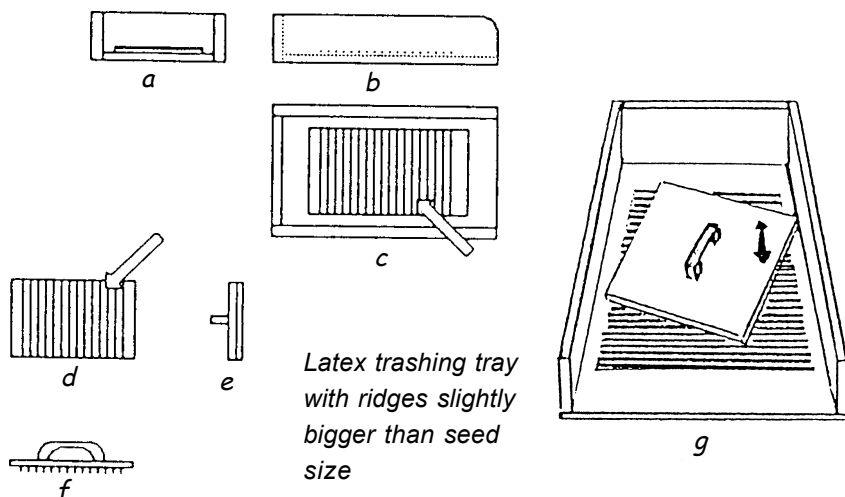
(Sweet) pepper

(Sweet)pepper seeds do not have a gelatine-like layer like the tomato has. Therefore the fermentation process unnecessary. Wash the fruit, preferably with some soap, cut them open and remove the seed. This is only possible with large fruit, such as sweet pepper and Spanish pepper.

Chilli peppers are very small, and cutting them to remove seeds is only advisable if you have a small amount of fruit. If you have a lot of fruit, let them dry and remove the seed from the dried fruit. On a small scale, seeds are best removed in a so-called ribbed tray (see Figure 20). A handy format for the tray is: 40 cm x 25 cm x 10 cm (Length x Width x Height). The paddle should be smaller than: 25 cm x 18 cm x 10 cm

After the gathering of the seeds, wash them, preferably in a sieve so that only the seeds remain and any other parts of the plant are removed. Any seeds that float can be thrown away as these are either not ripe or have not filled properly and therefore are weaker.

1 Kilogram of chilli pepper will produce between 25 and 100 grams of seed, and for Spanish pepper and sweet pepper this is 5 to 50 grams.



a: front view tray; b: side view tray; c: top view tray; d: bottom view paddle; e: front view paddle; f: side view paddle; g: By filling the tray with a handful of peppers and moving the paddle at an angle in the tray, you will soon loosen the seeds.

Figure 20: Threshing tray for threshing pepper.

Hygienic precautions

In many cases, seed carries diseases or pests which can have a large effect on the next crop. Therefore it is important to take precautions to limit the effect of diseases and pests. Some of these measures include dry storing of the seed, keeping away insects and minimizing humidity in the storage place. The only remedy for fungus in storage places is by drying them thoroughly. If the incidence of insects reaches plague proportions, a last resort is pesticide which should be evenly spread among the seed.

A cheap method to combat insects is warm water treatment of seeds. Submerge the seeds for 25 minutes in water with a constant temperature of 50(C. Let the water and the seeds cool. The seeds must be dried within 24 hours.

Drying and storing sowing seed

Drying

Seed to be used for the next crop must be dried thoroughly and quickly. If seeds keep to have a high humidity content their quality decreases quickly.

Seed should only be dried in indirect light and in well-ventilated places (e.g. where wind can reach it). In bright sunlight seeds will get damaged because temperatures are too high (higher than 35(C). Quickest drying will be on a sunny day between 13:00 and 15:00 hours.

To separate any seeds that are still stuck together after they have dried, rub them gently in a piece of cloth.

To avoid getting small splits in pepper seeds, these should be dried more slowly. The layer of seed that is being dried should therefore be stirred several times a day.

It is best to select half the seeds: select the largest, most filled and least damaged. These will be easiest to store.

Storing

Tomato and (sweet)pepper seed that cannot be sown immediately needs to be stored for some time. The biggest danger in the humid tropics is that the seed will start to mould. In the dry tropics, insects are the biggest danger.

A very good way to store seeds is as follows:

- Make sure that the seeds are completely dry because they will be

stored in a waterproof container. Take a clean jar or bottle of clear non-coloured glass, and place a clean piece of cloth with warm ashes in the bottom. You should be able to touch the ashes without burning yourself. Close the pot or bottle well and let the ashes cool.

- By adding ashes, any water that manages to get in the bottle or pot will first be absorbed by the ashes and will prevent seed from losing quality.
- After an hour or so, the ashes should be cool and you can then place the seeds, loose or wrapped in a transparent plastic bag, in the pot or bottle. Close the bottle with a real cork or a piece of plastic. Spread a 2 mm layer of grease or vaseline over the cork or plastic so that the edges are covered.
- Store the bottle or pot in a cool place, as dry as possible and never in water. That would be much too damp to store seed well.
- During the first ten days, check daily if mould has formed on the seed. If the seed has been dried well, the chance that this will happen is very small. However, should you see mould, dry the seed again.

In this way you can store seed for at least 3 months. If the seed has been dried extremely well, it can keep up to 2 years. Drying seed should not be a problem in the dry tropics, savannas and in deserts.

There are, of course, other methods than the one described above to store seeds. It is a good idea to find out how seed is usually stored in your area. Ask how seed is dried, where it is laid, and how long it is stored before being used.

If at least one third to half the seed in the seedbed or on the field germinates, the storage method being used presents no problems. It is very likely that the method being applied locally will be cheaper and easier. The advantages of the method described here is that insects cannot reach the seed and the seed cannot get moist easily. Should seed get mouldy, it will be easy to see. The clear glass allows sunlight in which further reduces the growth of mould.

Seed quality

The quality of seed is crucial. If you have healthy seed, then your crop will be stronger than that from bad seed. It is better to have little seed of good quality than a lot of seed of bad quality.

It is possible to recognize good quality seed. Unfortunately this is only possible after the seeds sprout. However, it is easy to spot bad quality seed without sprouting them. Bad quality seed will smell dusty, they will be damaged, wrinkled or empty, mould can be seen, insects will be present, and the size of the seeds will not be the same. You will usually just have to trust the quality of seed. There are ways to determine seed quality but this will require some precision work and some time. Make 4 groups of 50 seeds each. Sow the seeds in 4 trays or in 4 marked plots. At least a third of the seeds should produce healthy plants.

APPENDIX 1: LIST OF SEED DISTRIBUTORS

ROYAL SLUIS – *For specific varieties for your region.*

Contact your local seed supplier or:

Royal Sluis

P.O. Box 22

1600 AA Enkhuizen, the Netherlands

Tel: +31 228 310444, Fax: +31 228 313969

PANNAR SEED , *specialized in seeds for Africa*

Pannar Seed P/L

P.O. Box 19

Greytown 3250

South Africa

Tel: +27 33 4131131, Fax: +27 33 4131261

E-mail: info@pannarseed.co.za Website: www.pannarseed.com

BEJO Zaden B.V. – *Top quality vegetable hybrid seeds also for the tropics*

Bejo Zaden B.V.

P.O. Box 50

1749 ZH Warmenhuizen

the Netherlands

Tel: +31 226 396162, Fax: +31 226 393504

ECHO Seed Company (*samples of seeds for free*)

Recommended: World list of Seed sources, published by the FAO.

Copies may be purchased from CTA's bookseller:

Those in ACP countries who have registered with CTA's Publications Distribution Service (Service de distribution des publications) may also obtain these publications using their credit points and their CTA publicaitons order forms.

When you apply for seed, do provide the following information:

1 main use of the product (dried, fresh, for direct use or sale)

2 months in which sowing and planting takes place

3 annual rainfall in mm

4. the dry months

5. minimum and maximum temperatures

6. information about the soil, such as pH and fertility

7. altitude of fields which will be planted

8. seed import regulations

RECOMMENDED FOR FURTHER READING

Agrodok 2: Soil fertility. Agromisa, Wageningen

Agrodok 8: Preparation and use of compost. Agromisa, Wageningen

Agrodok 9: Vegetable gardening in the tropics. Agromisa, Wageningen

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