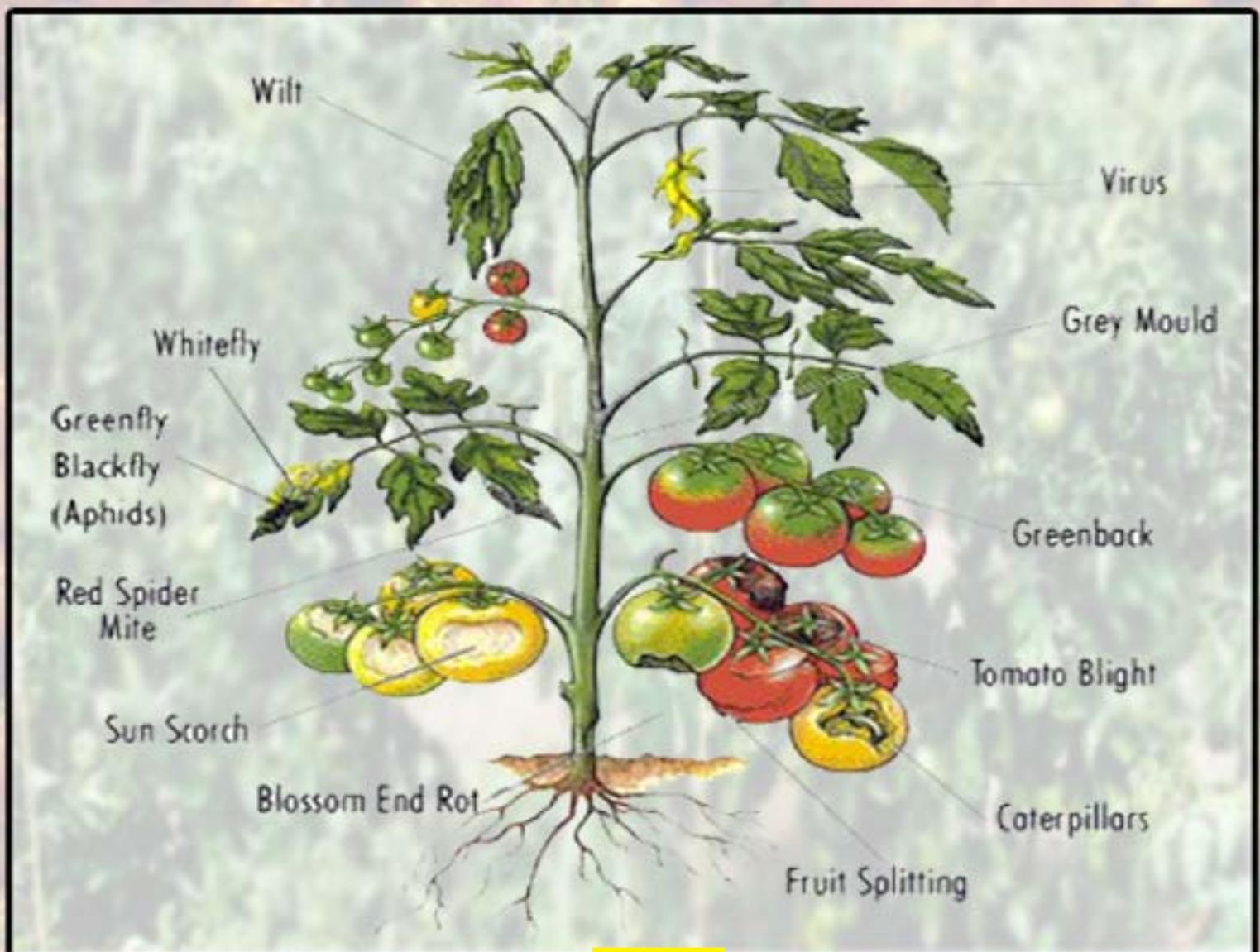


# TOMATO PRODUCTION



## **INTRODUCTION**

This tomato is believed to have its origin in the Peru-Ecuador areas from where it spread as a weed throughout

many parts of tropical America and then domesticated in Mexico. It was introduced into Europe early in the sixteen-century and the United States of America two centuries later. Tomato belongs to the family Solanaceae and its scientific name is *Lycopersicon esculentum*. Tomatoes can be considered one of the most important vegetables. The fruits can be cooked or eaten raw. Additionally, this vegetable is used extensively in the

canning industry in the production juices, sauces, ketchup and paste

### **Varieties**

In Guyana, the varieties are described as “Creole” and “English”. Within the Creole there are the small rounded cherry types and the large flat types. “English” are those varieties that are imported and include Heat Master, Heatwave, Capitan, Alafua Winner, TA, TB, and TC etc.

## **CULTIVATION**

### **Propagation**

Plants are propagated from seeds that should be sown either in seed boxes or in seedbeds from where they are transplanted into the field.

### **Seed Treatment**

As a precaution against seed-borne disease, seeds should be treated with fungicides e.g. Captan, Mancocide at 2-3 g/kg seed. Seeds can also be treated with 0.8% acetic acid overnight or in hot water (50°C) for 30 minutes.

### **Soil Treatment**

Sterilize seed-box or nursery bed with Formaldehyde 1:3 (1 part in 3 parts water), Captan or Phosal 80 Wp at 2g/ liter of water. The use of Rhilolex to treat the soil has also been shown to be effective. Cover soil with a polyethylene bag for one day. Seeds should not be sown until 5-6 days after.

### **Sowing**

Moisten soil before sowing seeds. Use a mixture of four parts pen manure or compost, three parts burnt rice husk and one part black sand. Scatter thinly over the area. Barely cover seeds with soaked jute bag, which should be kept, damp and removed immediately after germination commences. Germination should take place 3-4 days after sowing.

### **Shading**

Shading is necessary to protect young seedlings from being burnt by the sun or beaten down by rain. Overhead shades about 30cm above the seedbed should be provided. Saran netting or coconut branches can be used to provide shade.

### Hardening

As seedlings grow and produce 4-5 leaves, progressively remove shade thus allowing them to be exposed daily to more and more hours of sunshine until they receive the total day's sunlight. During this period of hardening the amount of water applied to seedlings should be reduced.

**Transplanting:** It is advisable that the following guidelines be followed when transplanting:

- (i) About 6-9 days before transplanting, harden seedlings by slightly withholding water and exposing them to strong sunlight by removing the shading. Thoroughly water plants 12 to 14 hours before transplanting to the field;
- (ii) The ideal transplant is a seedling with 3 to 5 true leaves, disease-free and well grown for variety, stocky and succulent, and not yet having flower buds or flowers;
- (iii) Dig a hole for each plant deep enough to bury it so that the first true leaf is just about the soil surface;
- (iv) Leggy plants, which have grown past the ideal size for transplanting, should be buried deeper. Pull off a few older leaves and, to make planting easier, bend the stem and lay it sideways;
- (v) Press the soil firmly around the root, then top irrigate lightly to settle the soil;
- (vi) Furrow irrigate the field as soon as possible;
- (vii) Transplanting should be done in the late afternoon to minimize shock under high temperatures; and
- (viii) About 7 days after transplanting replant any missing plants.

### Fertilization

A soil test should be done to determine the fertilizer requirement. As a guide the following recommendation should be followed:

Urea	-	180 kg/ha	-	30% at transplanting (1.5g/plant)
				40% at flowering (2.0g/plant)
				30% at Fruit set (1.5g/plant)
TSP	-	80 kg/ha	-	All at transplanting (2.2g/plant)
MOP	-	120 kg/ha	-	50% at transplanting (1.6g/plant)
				50% at flowering (1.6g/plant)

If organic manure is being applied, then synthetic fertilizer rate should be lowered.

### Soil and Crop Management

Proper soil and crop management entails the following:

- (i) If the land is dry, irrigate before land preparation;
- (ii) Plough with a rotavator (or fork and chip);
- (iii) Form the bed 100-cm wide and 20-25 cm high and leave furrow between beds 50cm wide;
- (iv) Dig one row to a depth of 15-25 cm in the middle of bed. The recommended spacing should be 60cm between the rows and 45cm along the rows (approximately 37,000 plants/ha);
- (v) Place basal fertilizer into the row and cover with soil prior to spraying with pre-emergent herbicide and transplanting;

- (vi) Spray lasso into the bed before transplanting;
- (vii) Keep the space between hills at 40cm;
- (viii) Stake a 150-180 cm bamboo pole beside each plant 3-4 weeks after transplanting;
- (ix) Mulch the bed with rice straw or dry grass the during dry season; and
- (x) Tie the vine to the bamboo stake and pinch off the sprouted auxiliary bud in order to maintain a single stem per plant.

### Weed Control

It is recommended that weed control be done manually. If herbicides are to be used, the following are recommended:

- Spray Lasso with sprayer at rate 9ml/litre of water on the top of bed before transplanting. Lasso is more effective when the soil is relatively moist; or
- Spray Gramaxone or Amaxone with a nozzle shield at the rate of 6ml/litre of water. Avoid contacting tomato plant with these chemicals.

### Irrigation

It is desirable to have the soil well supplied with water before ripening begins so that subsequent irrigations may be kept to a minimum. However, don't keep the air spaces in the soil filled with water.

## INSECT PEST MANAGEMENT

### MITES

The tomato russet mite, *Aculops lycopersici* is smaller and more elongate than spider mites, with the body tapering toward the rear end. This mite is pale in colour and, like spider mites, has eight legs (Figure 1).

#### Symptoms:

- Mites Attack the undersides of lower leaves, causing them to become silvery and chlorotic and then necrotic;
- As the attack spreads, stems and leaf petioles appear bronzed, and lower foliage desiccates; and / or
- Plants may be killed in only a few days in hot dry weather.



**Fig 1. Mite**

**Control:** The control measures recommended are:

- Chemical control; spray with Hostathion, Abamectin (10ml/5 liter of water) etc.; and or
- Effective weed management.

### APHIDS

There are two main species of aphids (Figure 2) that attack tomato. The potato aphid, *Macrosiphum euphorbiae*, is a large aphid, which may be either green or pink. The green peach aphid, *Myzus persicae* is smaller and light

to dark green in colour. Aphids invade tomato fields as winged adults but produce unwinged offspring *parthenogenetically*. They have piercing-sucking mouthparts and disseminate important viral diseases in tomatoes.

**Symptoms:** The Symptoms of Aphids are:

- Sooty mold can be seen growing on heavy honeydew secretions from the insects;
- Chlorotic spotting;
- General chlorosis and distortion of leaves; and / or
- Stunting and wilting of plants.

**Control:** The Control Measures recommended for Whiteflies are:

- Chemical control using chemicals such as Fastac, Vydate L, Karate etc;
- Crop rotation; and or
- Weed control

**WHITEFLIES**

The sweetpotato whitefly, *Bemisia tabaci*, (Figure 3) is common in the field and a vector of several important viral diseases around the world. Whiteflies life stages occur on the undersides of tomato leaves. Whitefly adults are always winged and have a white, powdery wax on their wings and bodied.

**Symptoms:** The Symptoms of Whiteflies are:

- Production of honey dew ( and the growing of sooty mold on it);
- Chlorotic spotting and chlorosis of leaves; and /or
- The spotting of fruit, and the stunting and wilting of plants.

**Control:** The Control Measures recommended for Whiteflies are:

- Planting of trap crop to attract whitefly away from the economic crop;
- Good weed management ;
- Good soil management; and /or
- Spray with chemicals such as Admire, Basudin, Abamectin (10ml/S liter of water), extract from neem leaves or seed etc.

**THRIPS**

Thrips palmi are small elongate insects, They primarily attack tomato flowers and the adults are usually yellow or brown and have slender, featherllke wings fringed with long hairs (Figure 4). The eggs are inserted into succulent plant tissue, including leaves, stems, pistils, or small fruit.

**Symptoms:** The Symptoms of Thrips are:

- Damaged tissue which initially appears silvery but may turn necrotic or black;
- Increasing flower drop; and /or
- Discolored fruits

**Control:** The Control Measures recommended for Thrips are:

- Weed control;
- Crop rotation; and /or
- Chemical control, with chemicals such as Abamectin (10ml/5 liter of water), Vydate L, Fastac, Karate etc.



**Fig 2. Aphids on tomato leaf**



**Fig 3. Whiteflies**



**Fig 4. Thrips**

**LEAF MINER**

These are tiny yellow maggots that tunnel between the leaf surface.

**Symptoms:** The Symptoms of leafminer are:

- Damage done by their feeding habits, which leave irregular trails on the leaves (Figure 5);
- Yellowing and drooping of leaves; and /or
- Loss in yield.

**Control:** The Control Measures recommended for leafminer are:

- Crop rotation;
- Spray with Abamectin, Trigard, Vydate L etc.; and /or
- Weed control



**Fig 5. Symptoms of leafminer attack**

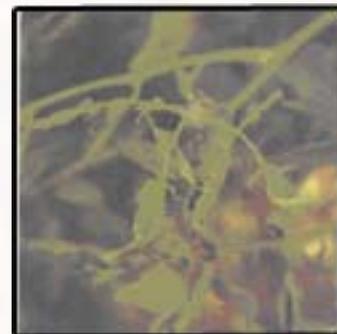
**DISEASE MANAGEMENT**

**CUCUMBER MOSAIC VIRUS (CMV)**

This disease is widely distributed in the tropics.

**Symptoms:** The symptoms of CMV are:

- Crinkled leaves;
- Necrosis on the stem and leaves (Figure 6);
- Sun scald on fruits; and/or
- Reduction of number of flower and fruits produced.



**Fig 6. Symptoms of CMV**

**Disease Cycle**

Mosaic virus is transmitted by seeds, by soil through the debris of infected plants and mechanically from the infected plants by farm practices, namely, transplanting, disbudding etc. Continuous cropping enhances the disease incidence.

**Control**

In order to manage the CMV infected plants should be rouged. Alternatively seeds should be treated with hot water at 50°C for 30 minutes before planting .

**SPOTTED WILT (SW)**

Tomato spotted wilt virus is common and important in the tropics.

**Symptoms:** The Symptoms fo SW are:

- Yellowing of leaves;
- Wilt of leaf tips;
- Appearance of brown necrotic lesions on leaves (Figure 7).;
- Necrotic streaks on stem and petioles.; and/or
- Distorted fruits.



**Fig 7. Symptoms of spotted wilt**

# T O M A T O

## Disease Cycle

The virus is transmitted by thrips in a persistent manner. The virus is not transmitted through seeds or soil.

**Control:** The control measures recommended for SW are:

- Rouge infected plants;
- Use good management practices; and /or
- Control insect pests.

## LEAF CURL

Tomato yellow leaf curl virus (TYLCV) belongs to the Geminivirus group.

**Symptoms:** The typical symptoms of TYLCV are:

- Dwarfism and curling in newly developed leaves (Figure 8);
- Curling, twisting and interveinal yellowing in lower leaves;
- Young plants are stunted and apical leaves proliferate; and/or
- A small number of flowering buds are produced.



**Fig 8. Symptoms of TYLCV**

## Disease Cycle

TYLCV has a narrow host range and tomato is the only crop damaged. Tobacco white fly transmits the virus in a persistent manner.

**Control:** The control measure of TYLCV include:

- Good crop management practices;
- Rouge infected plants; and/or
- Spray insecticides to control vector (Admire, Abamectin (10ml/S liter of water), Basudin, Regent etc).

## BACTERIAL WILT (BW)

The causal agent is *Pseudomonas solanacearum*

**Symptoms:** Typical symptoms of BW are:

- Wilt on leaves and shoot apex with no color change; and/or
- Browning on the vascular strands of the basal part of the stem in the wilted plant (Figure 9). When a section of infected stem with browning of the vascular stem is placed in water, a milky white bacterial exudate oozes out from the cut surface in a few minutes.



**Fig 9. Symptoms of bacterial wilt**

## Disease Cycle

Wilting occurs mainly in the wet season and is easily spread by running water or splashing from raindrops.

**Control:** Types of control measures are as follow:

- Provide adequate drainage to remove excess water;
- Pull out and destroy infected plants to reduce spread of disease;
- Apply limestone to achieve a pH of 5.8 - 6.8. This pH level will render conditions unfavorable for the wilt infection;
- Spray soil with Phyton 27 (fungicide) at transplanting during the wet season; and /or
- Plant resistant varieties.

**BLOSSOM END ROT**

**Symptoms:** The symptoms of blossom end rot are:

Small water-soaked spots at the bottom end of the fruit which enlarge overtime into large blackish -brown sunken water - soaked areas (Figure 10).



**Fig 10. Symptoms of blossom end rot**

**Disease Cycle**

This is caused by a physiological disorder as a result of uneven levels for water application combined with a lack of calcium in the soil.

**Control:** The recommended measures of control are as follow:

- Apply limestone one month before planting to achieve a pH of 5.8 - 6.8.
- Maintain watering at a constant level. Too much or too little water at irregular intervals can create conditions for blossom end rot; and or
- Spray calcium base liquid fertilizer at flowering and fruiting.

**BACTERIAL SOFT ROT (BFR)**

The causal agent is *Erwinia carotovora*

**Symptoms:** The symptoms for Bacterial Soft Rot are:

- Leaf margins become dehydrated, and leaf blades wilt with yellowing and drying up (Figure 11);
- In main stem, dark to blackish brown water-soaked lesions are formed;
- Discolored parts surround the stem and spread to the pith; and /or
- When stem is pressed with fingers a juice with rotten smell is obtained.



**Fig 11. Symptoms for bacterial soft rot**

**Disease cycle**

The pathogen enters the host through feeding traces of insects and at sites of mechanical injury due to disbudding or rain. High temperature and high humidity conditions enhance the severity of the disease.

**Control:** The recommended measures of control are as follows:

- Avoid continuous cropping;
- Good soil drainage; and/or
- Spray copper compound (fungicide) for effective control. e.g. Benlate, Trimiltox, Kocide DF etc.

**PITH NECROSIS**

The causal agent is *Pseudomonas corrugata*

**Symptoms:** The symptoms of Pith Necrosis are:

- Pith of stem and petiole show browning and necrosis (Figure 12);
- Browning of vascular bundles and ooze of bacterial exudate are observed; and /or
- Upper leaves show slight yellowing and wilt.

**Disease cycle**

Bacteria which survive in irrigation water or in soil may enter through foliage wounds at transplanting or thereafter. Pith necrosis occurs mainly in plants that become weak when grown under low temperature and high humidity conditions.

**Control:** The recommended measures of control are as follows:

- Use healthy soil for raising seedlings;
- Remove infected plants as soon as they appear;
- Provide adequate drainage during the rainy season; and /or
- Spray Phyton 27 at transplanting.



**Fig 12. Symptoms of pith necrosis**

**LATE BLIGHT**

The causal agent is *Phytophthora infestans*

**Symptoms:** The symptoms of Late Blight are:

- Lesions on leaves which initially appear as small water soaked irregular spots with grayish green colour later becoming dark gray (Figure 13);
- On stems and petioles, dark gray water soaked lesions are formed which later become slightly sunken and dark black; and /or
- Slightly sunken, dark gray irregular lesions are formed on fruits that eventually rot.



**Fig 13. Symptoms of late blight**

**Disease cycle**

The disease spreads under cool and rainy conditions but the development is limited under low humidity conditions. The disease is prevalent in the rainy season. In the rainy the disease spreads rapidly and destroys the plants in a few days after initial occurrence.

**Control:** The Control Measures recommended for Late Blight are:

- Fungicides such as Ridomil, Phosal 80 WP will effectively control the disease;
- Straw or grass mulch is effective for the decrease of the disease incidence; and /or
- Disbudding and defoliation of tomato plants should be avoided when it rains.

**FUSARIUM WILT (F.W.)**

The causal agent is *Fusarium oxysporum*

**Symptoms:** The symptoms of F.W. are:

- Initially, lower leaves show wilting and yellowing and droop slightly;
- Later, yellowing develops on upper leaves and the plants are almost dead;
- Browning appears up to the higher part of the stem vessel (Figure 14);
- Root rot wilt occurs under cool conditions.; and /or
- Browning of stem vessels is restricted to the stems near the soil surface but roots show severe browning and decay.

**Disease Cycle**

The casual fungus survives in soil within debris of infected leaves and roots. It produces spores, which can survive under adverse environments for a long period of time in soil.

**Control:** The control measures recommended for F.W are:

- Continuous cropping should be avoided;
- Plant resistant varieties;
- Graft seedlings on resistant rootstocks;
- Soil fumigation - Treat planted area with Rhizolex; and /or
- Plant on ridges.



**Fig 14. Symptoms of fusarium wilt**

**SOUTHERN BLIGHT (S.B)**

The causal agent is *Sclerotium rolfsii*

**Symptoms:** The symptoms for S.B are:

- White silky and thread-like mycelia appear on the stems near the soil surface and around the stem (Figure 15);
- Brown and black rot of the stem, which develops near the stem line; and /or
- The infected plants show poor growth, wilt and eventually die (Figure 16).

**Disease Cycle**

The fungus can survive for years as sclerotia in soil and host debris. The movement of soil or infested plant material can disseminate sclerotia. The optimum temperatures for disease development are in the range of 25 - 35°C.



**Fig 15. Infected stem due to southern blight**

# T O M A T O

**Control:** The control measures recommended for S.B are:

- Crop rotation with nonsusceptible grass crops such as com reduces disease incidence;
- Plowing to replace the surface soil with subsoil is effective for reducing disease occurrence;
- Use wider plant spacing;
- Provide adequate drainage; and /or
- Spray with fungicide (Earthicide at 15g/5 liter of water).

## DAMPING OFF

The causal agents are *Phythium vexans*, *Rhizoctonia so/ani* and *Phytophthora spp.*

**Symptoms:** The symptoms of Damping Off are:

- Reduced germination;
- Dark brown or black water soaked lesions develop rapidly and involve the entire seedlings (Figure 17); and /or
- A dark colored and soft lesion develops around roots.

## Disease cycle

The casual fungi can survive in infected plant debris in soil. Moist soil conditions are conducive to the disease.

**Control:** The control measures recommended for Damping off are:

- Treat soil with fungicide such as Captan (15g/5liter water), Earthicide (20g/litre of water) and Phosal 80 WP at 20g/5 liter water;
- Avoid over irrigating seedlings; and /or
- Use free draining soil for seedling mixture.

## ANTHRACNOSE

The causal agent is *Colletotrichum coccodes*

**Symptoms:** The symptoms of Anthracnose are:

- Small, slightly depressed circular lesions first appearing on fruits;
- Later, lesions become more sunken, with concentric ring markings (Figure 18);
- The center of the lesion is usually tan and as lesions mature the fruit becomes dotted with small black specks (Figure 18).

## Disease cycle

The Anthracnose fungi may infect fruit resting on the soil surface. Ripe or overripe fruit are highly susceptible, and symptoms progress rapidly on them.



**Fig 16. Symptoms for southern blight**



**Fig 17. Symtoms of damping off**



**Fig 18. Symptoms of anthracnose**

**Control:** The control measures recommended for Anthracnose are:

- Crop rotation with a non-solanaceous crop;
- Good weed control practices; and /or
- Spray effective fungicide such as Benlate, Trimiltox, Maximo etc.

## NUTRITIONAL DISORDERS

### Nitrogen

- Restriction in growth rate and uniform chlorosis of older leaves;
- Later, chlorosis appears on progressively younger leaves; and /or
- Oldest leaves become yellow and finally drop (Figure 19).

### Phosphorus

- Restriction in growth rate is followed by dull or light green coloration.
- Purple coloration appears on the leaf undersides, beginning at the veins and proceeding to interveinal areas.
- Plant is dwarfed with stiff often-upright leaves that are light green to yellow on the upper side and purple on the underside.

### Potassium

- Marginal necrosis of older leaves (Figure 20);
- Necrosis is preceded by scattered small, chlorotic spots;
- Yield and fruit quality is impaired; and /or
- Defects in fruit quality includes puffiness, ripening quality, softness, irregular shape etc.

### Harvest Maturity Indices

The average time from transplanting to harvest of large-fruited cultivars ranges from 60 to 70 days for early cultivars, 70 to 80 days for mid-season cultivars, and more than 80 days for late cultivars. There are several reliable external and internal indices of tomato fruit maturity. The external fruit maturity index is based on skin colour, while the internal indices are based on seed development and locular gel formation. Also, location of the fruit on the plant and fruit size may be used as rough guides in determining where to look for mature fruit. However, by themselves they are not reliable indicators of maturity. The most widely used index of tomato maturity is skin colour. Distinct changes in external colour occur in tomato fruit which can be used to determine harvest maturity. Skin colour remains green during fruit development on the plant. As the fruit becomes mature, the blossom end changes to a light green or whitish colour. One or more distinct white streaks usually form at the blossom end, typically in the shape of a star. At this stage, the fruit is mature and ready for harvest and is referred to as being 'mature-green'. The fruit will continue to change colour, regardless if it is attached or detached from the plant. Tomato fruit colouration follows a typical sequence with ripening. With red-skinned cultivars, after the mature-green stage the tip of the blossom end will change to a pinkish-yellow colour, which is commonly referred to as the 'breaker stage'. The breaker stage usually occurs within a day after the mature-green stage. The entire fruit then turns colour to pink, followed by light red, and finally deep red. The ripening stages of mature tomato fruit are categorized as green, breaker, turning, pink, light red, and red (Figure 21) and are described in Table 1. For maximal market life, tomatoes should be picked at the mature-green stage.



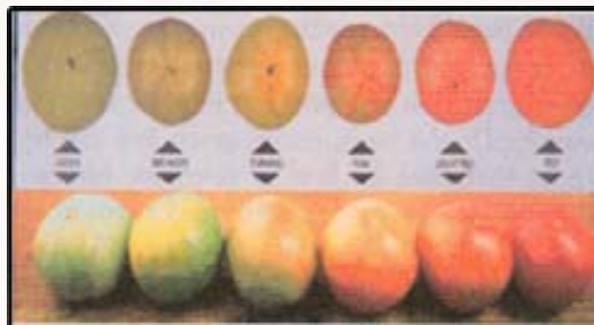
**Fig 19. Symptoms of nitrogen deficiency**



**Fig 20. Symptoms of potassium deficiency**

# T O M A T O

They will be able to tolerate the stresses of handling and transport much better at this stage. Properly handled mature-green tomatoes develop flavor to the same extent as fruit left on the vine another day, until the 'breaker' stage. However, if immature green stage fruit are inadvertently picked, eating quality is reduced. Immature green tomatoes will ripen poorly and be of low quality. The problem is when pickers are unable to determine the difference between immature green and mature-green fruit in the field. A tomato picked at the breaker stage will be indistinguishable in quality from one that has ripened to a full red colour on the vine. However, fruit allowed to ripen to a full red colour before picking will have a significantly shorter market life. Red fruit will be much more susceptible to bruising and injury during harvest and postharvest handling. This will result in more deterioration and postharvest decay.



**Fig 21. Ripening stages of mature tomato fruit; from left to right: green, breaker, turning, pink, light red, red.**

Table 1. Terminology used to describe tomato colour as an indication of ripeness stage.

<u>Colour</u>	<u>Description</u>
Green	The surface of the tomato is completely green. The shade of green may vary from light to dark.
Breaker	There is a definite break in the colour from green to yellow, with pink or red skin covering not more than 10 percent of the surface.
Turning	More than 10 percent but not more than 30 percent of the surface, shows a definite change in colour from green to yellow, pink, red, or a combination of these colours.
Pink	More than 30 percent but not more than 60 percent of the surface shows pinkish red or red colour.
Light Red	More than 60 percent but not more than 90 percent of the fruit surface shows pinkish red or red colour.
Red	More than 90 percent of the surface shows red colour.

The two internal fruit characteristics commonly used to determine harvest maturity of green fruit are seed development and locular jelly formation. Mature-green fruit have fully developed tan-colored seeds which will not be cut when the fruit is sliced with a sharp knife. The seeds in immature green fruit are white and not sufficiently formed, and are cut through when the fruit is sliced open with a knife. The fruit cavity of mature-green fruit is completely filled with jelly in each of the locules. Immature green fruit have one or more locules without jelly. Internal characteristics are used for determining harvest maturity of randomly selected green fruit of different sizes. It is then assumed that all green fruit of similar size from the same location on the plant will be of the same maturity.

On this basis, mature-green fruit can be harvested according to size. Pickers should be trained on how to determine harvest maturity in order to avoid picking immature green fruit. The quality and flavor of immature green harvested fruit will be inferior and picking these fruit should be avoided.

The harvest maturity stage depends on the intended market destination and the time needed to market the fruit. Tomatoes for local markets can be harvested at the mature green stage if they will be held for a week or more, or they can be allowed to develop more colour before picking, according to buyer preferences. Tomatoes intended for export should be harvested at the mature-green stage, or the breaker stage if they will be marketed as 'vine-ripe'. Fruits harvested at the breaker stage can be handled and shipped with less damage than those with more colour. The fruit from new 'long-shelf life' tomato cultivars stay firm for several weeks, even when picked at the breaker stage.

Vine-ripe tomatoes must be harvested every other day to avoid having too many red fruit. Mature-green tomatoes are normally harvested only four or five times during the season.

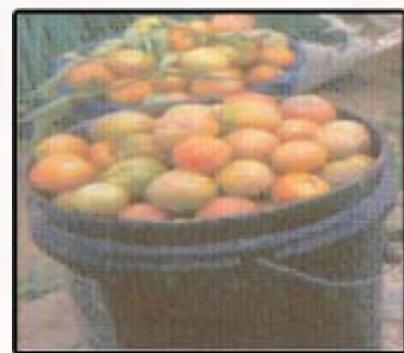
### Harvest Methods

Tomatoes should be removed from the plant by gently twisting or rotating them in order to cleanly remove the stem from the fruit. The stems in most field-type tomato cultivars release at the point of attachment to the fruit (termed 'jointless'). However in some cultivars, a natural abscission layer or break point forms at the junction of the stem and the stalk when the fruit is mature (termed 'jointed'). With these cultivars, pickers should grasp the fruit firmly but gently and pull upward with the thumb and forefinger pressed against the stem (Figure 22). The stem should then be carefully removed prior to putting the fruit in the harvest container to prevent puncture wounds of adjacent fruit.



**Fig 22. Harvest procedure for removing 'jointed' tomato fruit from the plant.**

Workers should wear cotton gloves during picking to minimize harvest damage of the fingers. If gloves are not worn, all fingernails should be trimmed short to avoid puncturing the skin. Jewelry such as rings and bracelets should also be removed to reduce mechanical damage to the fruit during harvest. Harvested fruits should not be thrown or dropped into the picking container, as they are very susceptible to bruise damage. The picking container should have smooth inner walls to prevent abrasion of the fruit (Figure 23). Ideally, picking containers should be wide, shallow, and stackable to avoid excessive weight and bruising of



**Fig 23. A smooth-lined plastic pail is an appropriate tomato harvest container.**

tomatoes at the bottom of the container. A well-ventilated plastic crate is ideal. It is recommended not to fill the container with more than 10 kg of fruit. Tomatoes may suffer compression injury if piled too high in the picking container. This is especially problematic if the fruit are picked in the afternoon with a high pulp temperature.

Tomatoes should be picked during the coolest part of the day, such as early morning or late afternoon. If they are picked in the morning, harvest should be delayed until the moisture has dried off the fruit surface. Tomatoes should never be picked in the rain or when they are wet. Harvesting wet fruit encourages the spread of decay.

It is also important to avoid picking the fruit when it has a pulp temperature over 25°C (77°F). Fruit with higher pulp temperatures is very susceptible to pressure bruising when squeezed too hard during the picking process.

Fruit should never be allowed to remain in the sun for extended periods. Tomatoes held in the sun for an hour on a hot, sunny day can be 10°C (50°F) hotter than fruit kept in the shade.

Fruit which are injured, diseased, or unmarketable should be removed from the plant and not mixed in the same harvest container as the marketable fruit. The culled fruit should be removed from the field to avoid the buildup of insect pests and diseases.

### **Preparation for Market**

The harvested tomatoes should be taken to the packing area soon after picking to begin the process of cleaning, grading, and packing. During all operations, from harvest through packing, the fruit should be handled

carefully to avoid bruising and injury to the tissue. Bruises can affect ripening and cuts or injuries to the skin and predispose the fruit to invasion of decay-causing organisms. The fruit should be kept in a well-ventilated shaded area during market preparation.

#### *Cleaning*

The initial step in preparing tomatoes for market is to clean the surface of the fruit and remove any dirt, surface stains, or adhering leaf tissue. Depending on the volume of fruit to be cleaned, the process can be done manually or automatically. Small scale operations usually choose to clean the individual fruit by wiping them with a damp cloth just prior to grading. Larger volume operations may choose to use a water dump tank or overhead spray wash system to clean the fruit. In order to avoid the spread of disease, the wash water should be clean and regularly sanitized by maintaining a 150 ppm sodium hypochlorite concentration (2.4 pints of 5.25% household chlorine bleach to 100 gallons of water) and a water pH of 6.5. The chlorine level and pH of the wash water should be checked at least hourly during the day with paper test strips or portable meters. If a conductivity meter is used to check the sanitizing potential of the water, the oxidation-reduction potential (ORP) should be at least 650 millivolts mV to kill the soft rot and sour rot bacteria freely suspended in the water. However, water chlorination may not eliminate the more tolerant fungal pathogens such as *Rhizopus* and *Botrytis*.

The sanitizing effect of chlorine is greater at higher water temperatures and the wash tank water temperature should range between 16°C to 27°C (60°F to 80°F) for effective sanitation. The temperature of municipal or well water in Guyana should fall within this range. Use of cool water relative to the tomato fruit temperature can be a problem. When tomatoes are submerged in water of a lower temperature, the air inside the fruit contracts and water is drawn in through the stem scar or any openings in the skin. If the water is contaminated with microorganisms they will also enter the fruit through the stem scar, growth cracks, or damaged areas of the cuticle. Water will not be drawn into the fruit if the water temperature is higher than the tomato temperature.

Ideally, it is recommended to heat the wash water temperature about 5°C (10°F) higher than the fruit temperature. At the least, the water temperature should not be less than the pulp temperature of the tomato. Therefore, it is very important to check both the water and fruit temperatures prior to cleaning and maintain a slightly warmer wash water temperature. The tomato fruit temperature at the time of harvest generally ranges from 22°C to 32°C, depending on the time of day and whether it was exposed to full sun or shaded. Keeping harvested tomatoes in the shade is highly recommended to minimize an increase in pulp temperature and avoid the necessity and cost of heating water.

The immersion depth of the tomato fruit in the water tank should not exceed 60 cm (2 feet). Pressure from deeper submersion forces pathogen-containing water through the stem scar into the fruit. In addition, the length of submergence time should not exceed 2 minutes. At the recommended 150 ppm concentration of hypochlorous acid and water pH of 6.5, the fruit should be sufficiently sanitized after about 30 seconds (Figure 24).

The other method to clean the fruit prior to grading is to move the tomatoes under a series of high pressure (> 60 psi) spray nozzles as they move over a set of soft brush rolls (Figure 25). The water remaining on the fruit surface should be removed by air drying, fans, or sponge-rollers prior to packing the fruit.



**Fig 24. A properly sanitized wash tank is essential to minimize postharvest decay.**



**Fig 25. Over-head spray of high pressure water for cleaning mature green tomato fruit.**

### **Waxing**

A thin water-wax emulsion spray coating can also be applied to the fruit as the final step in the cleaning process.

Waxing the fruit will enhance its appearance and make it more glossy. Waxing can reduce fruit shriveling and increase market life. Waxing also provides lubrication to the fruit surface which reduces rubbing injury during transit. Care should be taken to prevent heavy waxing of the stem scar because ripening will be adversely affected. Tomato waxes must be food-grade and are often made from plant extracts (i.e. candellila) or insect extracts (i.e. shellac, beeswax).

### **Grading**

All tomatoes must be sorted and graded before packing for market. The main fruit characteristics used to grade tomatoes are size, colour, shape, appearance, and firmness.

Tomatoes should be separated into small, medium, and large sizes. If it is a round-type cultivar, this is typically based on fruit diameter. Size generally does not influence flavor, but does affect market demand and price. This holds true whether the fruit are sold domestically or exported. An example of the size classification used for tomatoes exported to North America is shown below in Table 2.

# T O M A T O

Table 2. Size classification of tomatoes intended for export to North America.

<u>Size</u>	<u>Minimum Diameter</u>	<u>Maximum Diameter</u>
Small	5.40 em (2.13 in)	5.72 em (2.25 in)
Medium	5.79 em (2.23 in)	6.35 em (2.5 in)
Large	6.43 em (2.5 in)	7.30 em (2.87 in)
Extra Large	7.30 em (2.87 in)	

In small-scale operations, tomatoes are usually sized manually by one or more workers. Fruit is hand placed into the different market containers based on the acceptable pre-established size categories for the market. Larger-scale operations use various types of packinghouse equipment to speed up the grading and sizing process. Tomatoes may be sized by passing the fruit over a series of perforated belts with holes corresponding to the maximum allowable diameter for the particular size/class (Figure 26).

A rotating bar-sizer may also be used, constructed out of a series of PVC tubes of gradually increasing opening width (Figure 27). It is very important that the drop height be minimized and all impact surfaces be well padded. A layer of 1.5 cm (.6 inches) closed-cell foam with a smooth, washable outer surface should be adequate. A daily cleaning with a strong chlorine solution (112 pint or .24 liters of 5.25% hypochlorous acid (bleach) per gallon or 3.79 liters of water) followed by a clean water rinse will help prevent the buildup of decay organisms on packing equipment.



**Fig 26. Semi-automated tomato washing and sizing equipment.**



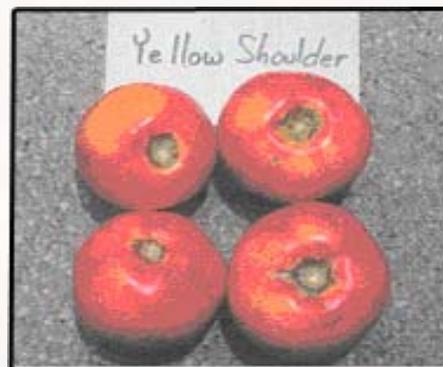
**Fig 27. Rotating bar-sizer for categorizing tomato fruit.**

Tomatoes of uniform colour should be packed into each container. Buyers do not like a mixture of ripeness stages and fruit colours within the same container (Figure 28).



**Fig 28. Fruit of mixed ripeness stages should be separated and packed into different cartons.**

When marketing ripe fruit in the domestic market, the fruit should be as free of yellow shoulder as possible. This is a quality defect characteristic of certain cultivars and accentuated by low potassium fertility that negatively affects external appearance as well as internal eating quality (Figure 29).



**Fig 29. Yellow shoulder is a common ripening disorder of certain cultivars.**

The fruit should also have a well-formed uniform shape typical of the cultivar. Deformed or catfaced fruit should be culled out and not be packed for market, particularly if the fruit are intended for export (Figure 30). The fruit should have a smooth, shiny external appearance, with small blossom-end and stem-end scars. The fruit should be void of cracks, bruises, open wounds, sunscald, insect injury, and decay. Finally, the fruit should be firm enough to withstand transport and distribution to market. Soft and over-ripe fruits should not be packed for market, as they will bruise easily and not tolerate transport and handling without suffering high amounts of postharvest losses. High quality fruit are firm, shiny, uniformly coloured, and free of mechanical injury, shriveling, and decay.



**Fig 30. Irregular shaped catfaced fruit sold in Parika market, below export quality.**

**Packing**

The fruit surface must be free of moisture before packing in order to reduce storage rots. The type of container used for packing tomatoes depends on the market destination. Tomatoes sold in the domestic market are packed in a diversity of container types. However, they should be well-ventilated, strong, and capable of being stacked without damaging the fruit. They should not be over-stuffed. Improper packaging can be a major source of postharvest loss (Figure 31).



**Fig 31. Over-filled, inadequately ventilated wooden crates.**

Sized and graded mature-green tomatoes destined for export are typically packed loose in strong well-ventilated fiberboard cartons containing a net weight of 11 kg (25 lb). Carton dimensions are usually 30 x 40 x 24 em (12 x 16 x 9.5 in) (W x L x H) The cartons should have a minimum test strength of 275



**Fig 32. Well-ventilated fiberboard cartons used for exporting mature-green tomatoes.**

# T O M A T O

## Temperature Control

The optimal storage temperature for tomatoes depends on the stage of ripeness. Fruit harvested at the mature-green stage should be held between 13°C to 20°C (56°F to 68°F), depending how long the fruit need to be stored. Holding the fruit at the lower end of the temperature range will maximize the storage life, which is up to 4 weeks with mature-green fruit. Holding mature-green tomatoes above 25°C (77°F) will result in soft fruit with a lighter red colour upon ripening. At temperatures above 35°C (95°F), mature-green fruit will not turn red (Figure 35).

Fully red fruit can be stored at 10°C (50°F) for maximizing market life, which is about 7 to 10 days. However, tomatoes should never be held at temperatures below 10°C, as chilling injury will result and the fruit will not ripen properly.

Tomatoes destined for distant markets or tomatoes in the pink or light red stage should be cooled as soon as possible after harvest to avoid becoming overripe before reaching the consumer. Proper temperature control is critical to product quality and shelf life.



**Fig 35. Red colouration is inhibited in mature-green fruit held at 35°C or higher**