BDN TECHNICAL GUIDE FOR EXTENSION OFFICERS NO. 1

GOOD PRACTICES FOR TOMATO CULTIVATION

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Introduction

The tomato (*Lycopersicon esculentum)* is a popular vegetable crop belonging to the family Solanaceae and can be grown in almost all agroclimatic zones in Sri Lanka, except the up-country wet zone. The annual extent of tomato cultivation is approximately 6008 ha, with an average production of 14.1 Mt/ha. It is an important cash crop with a good export potential. Tomatoes are mainly grown in open fields; however, greenhouse tomato production is popular. Tomatoes are typically cultivated for their edible fruit. It is used as a cooked vegetable or salad, or processed into tomato paste, jam, sauce, and juice. Tomatoes are present in different shapes, sizes, and colors with different sugar levels. Some plants have a self-pruning gene that is responsible for deciding the determinate growth habit.

Types of tomatoes

The following are some different types of tomatoes.
1. Determinate type – primarily cultivated in the open fields.
2. Semi-determinate - cultivated in open fields and protected conditions.
3. Indeterminate type – mainly cultivated under protected conditions.

Recommended varieties

HORDI Tomato hybrid 03; Thilina; KWR; T245; Ravi; Lanka Sour (Goraka Takkali); Maheshi; Tharindu; Rajitha; Rashmi; Bhathiya; KC 1; and Lanka Cherry, Padma, Platinum 701F1.

Popular varieties cultivated under protected conditions

Big beef, Sensation, Volvo, Valouro RZ F1.

Choose tested varieties that are resistant to the most important diseases and pests and are suitable for cultivation in particular agro-climatic zones. These varieties should also possess desirable qualities for consumers and markets.

Nutritional importance

Tomatoes contain high levels of lycopene, which has several health benefits. They are also rich in vitamins A and C, and minerals.

Climatic requirements

Tomatoes can be cultivated up to 2,000 m above sea level and perform well in areas with over 600 mm of annual rainfall. Rainfall should be well distributed throughout the growing season. High rainfall and humidity lead to fungal infections. The tomatoes performed well in warm climatic conditions. The optimal day and night temperature range is 20 – 25 °C and 15 – 17 °C, respectively.

Soil

The quality and quantity of tomatoes are greatly influenced by the soil fertility and nutrient levels. Tomatoes grow moderately well over a wide range of soil types. Although tomatoes are moderately tolerant to a wide range of pH, they grow well in soils with a pH of 5.5-7.5. The addition of organic matter is favorable for better growth.

Seed requirement

The seed rate is 200-250 g/ha. Disease-free seeds with high germination rates should be used to avoid seed-borne diseases and low germination rates. If the seeds are not pre-treated, seed treatment with recommended chemicals (Captan 50% WP or Thiram 80% WP at 1.25 g/250 g of seeds) is needed to produce healthy seedlings.

Nursery management

Typically, tomatoes are raised in nurseries before transplanting. Two types of nurseries are commonly used in tomato cultivation.

1. Raised bed nurseries – mostly used in open-field cultivation.
2. Nursery trays – these are used in both open-field and protected cultivation.

The nursery should be in a plot that has not been planted with a member of the Solanaceae family for the last three years. Select a site with good drainage. Prepare a 1 m wide and 15 cm high seedbed with a convenient length. Mark lines on the nursery bed, each 12 -15 cm apart and 0.5 cm deep, perpendicular to the long side of the nursery bed. Clean the nursery space to be weed-free. Sow the seed in a thin layer on the lines. Cover the seeds with a fine soil layer. Mulch the nursery bed using clean paddy straw and water the nursery bed daily and sufficiently. Remove the mulch when the seeds are germinating. Harden the seedlings 1 week before transplanting by reducing the frequency of watering and gradually exposing the seedlings to direct sunlight. Insects such as whiteflies can transmit viruses to young tomato plants, which can be controlled using pesticides.

If the nursery uses seedling trays (protrays), it should be new or properly cleaned. Check trays for the presence of holes at the bottom of plugs to ensure proper drainage. The protrays of 98 cells are ideal for tomato seedling production. Around 255 protrays are required to produce seedlings for one-hectare cultivation. The use of a good and sterilized substrate mix is essential. The nursery requires optimized and regular irrigation with no overwatering. Trichoderma and beneficial microbes can be applied to seedlings if not used in seeds. Keep the nursery protected by an insect-proof net of 40 mesh size to reduce pest damage and protect them from rain. Harden the seedlings for one or two days before transplanting into field conditions and transplant during cooler and cloudy weather (better in the evening).

Land preparation

Harrow the field deeper and break it into a fine texture. Mark planting holes according to the given spacing and fill the holes with decomposed manure or organic matter (10 Mt/ha). Drains must be prepared to prevent water retention. Apply basal inorganic fertilizer one day before transplanting. Weeds should be eliminated regularly. A thicker layer of organic mulch (such as rice straw) or plastic mulch helps to reduce nutrient leaching, conserve moisture, and reduce weeds.

Planting

Transplant the seedlings to the field 14-18 days after the sowing. Healthy seedlings with 3-5 true leaves are most suitable for transplanting. Transplanting should be performed in the evening to minimize the risk of transplant shock. After transplanting, shade should be provided for the new transplants.
The recommended planting space was 80 × 50 cm.

Seedlings can also be planted in raised beds to facilitate furrow irrigation and drainage. One recommendation for raised beds is 1 m wide with furrows 50 cm wide. Bed height varies with season: 20 cm in the dry season and 35 cm in the wet season.

Tomatoes grow well in crop rotations, such as after paddy, and there will be fewer nematodes and diseases. Growing after the Solanaceae family crop needs to be avoided.

Fertilizer

If specific information is unavailable, calculate the fertilizer requirements based on the crop nutrient requirements and soil test results or follow the Department of Agriculture fertilizer recommendations described below.

Apply chemical fertilizer as per the recommendation below. Apply basal fertilizers 2-3 days before planting. Chemical fertilizer recommendations for all districts except Badulla district.

Time of application	Urea (kg/ha)	TSP (kg/ha)	MOP (kg/ha)
Basal fertilizer – 1-2 days before planting	65	325	65
1st Top dressing (03 weeks after planting)	65	–	–
2nd Top dressing (06 weeks after planting)	65	–	65

Apply the above-recommended urea and MOP quantities and reduce TSP to 215 kg/ha for the Badulla district.

Remove weeds around the plants manually 3 and 6 weeks before top dressings. Do not over-fertilize, as crops such as tomatoes will grow much foliage but fewer fruits.

Water supply

Tomatoes are sensitive to water deficits immediately after transplanting, during flowering, and fruit development. Plants should be provided with adequate water, and overwatering should be avoided, especially in the dry seasons. This may have caused the fruit to crack. Irrigate in the morning and not in the evening. In the dry season, irrigation is required to maintain soil moisture near the field capacity.

Weed control

Always keep the cultivated land free of weeds. This will reduce the risk of pest attack and disease infection. When plants are young, especially 3-6 weeks after transplant, remove weeds by hand around them. In addition, weeding should be performed before applying fertilizers.

Training and staking

Tomatoes cultivated in open fields need staking. Therefore, staking should be done 2-3 weeks after planting (before top-dressing). Stalking materials, wooden stakes, bamboo (Apala), or any other sturdy material can be used. Strings, plastic strips, and other materials can be used to train plants in protected cultivation. Pruning is necessary for indeterminate varieties. It involves removing side shoots, extra flowers, fruits, and diseased leaves, leading to early fruit maturity and encouraging an increase in fruit size and uniformity. It is recommended to prune one stem by removing all lateral branches.

Pests and diseases of tomatoes

The fields should be scouted regularly, and any possible pests and diseases must be identified and controlled. In general, start with preventive methods, then biological controls. If you use a pesticide, ensure it is the right one for correctly identified disease or pest problems. Follow crop rotation to break pest and disease cycles. To prevent the spread of pests and diseases, remove sick plants and surrounding weeds.

Use yellow sticky traps to manage thrips, whiteflies, other pest flies, and leaf miners. Blue sticky traps can better control thrips. A minimum of 40 traps/ha should be placed after transplanting. Replace sticky traps once a month.

Major pests

Pest damage reduces the quality and quantity of produce. The major pests of tomatoes are as follows.

i. Tomato fruit borer – *Helicoverpa armigera*

Female moths lay eggs near or on flowers or small fruits. Caterpillars feed on flowers and green fruits, causing flower abortions and sunken necrotic spots (Figure 1). The feeding holes created by the caterpillar serve as entry points for bacteria and fungi, which may lead to fruit rot.

Figure 1. Tomato fruit borer damage.
Photo: Regional Agricultural Research and Development Centre (RARDC), Bandarawela | Shutterstock.com

Management
- Practice recommended spacing.
- Destroy crop residues immediately after harvesting.
- Regular field inspection.
- Practice crop rotation with a non-legume crop.
- Set up pheromone traps at the rate of 12 traps/ha.
- Collect and destroy damaged fruits and grown-up caterpillars.

Chemical control
The first spraying may be performed at the time of flowering and fruit formation, and it may be repeated, if necessary, at 10-14-day intervals without repeating the same insecticide.

- Novaluron 100 g/l EC – rate of application 16 ml / 16l of water.
- Chlorfluazuron 50 g/l EC – rate of application 24 ml / 16l of water.
- Chlorantraniliprole 200 g/l SC – rate of application 4 ml / 16l of water.
- Fubendiamide 24% WG – rate of application 5 g / 16l of water.
- Fubendiamide 20% WG – rate of application 6 g / 16l of water.

ii. Tomato fruit and leaf miner -*Tuta absoluta*

Pests can spread through seedlings, containers, fruits, and soil. The damaging stage is the larval (caterpillar) stage. The damage is characterized by squiggly trails that appear just beneath the leaf surface (Figure 2). It also burrows on stems, causing breakage. Severe *T. absoluta* infestation can lead to 100% crop loss.

Management
- Early control is essential before pest pressure increases.
- Carry out cultural practices, such as field hygiene and crop rotation.
- Remove and destroy infected fruits as well as leaves.
- Carry out regular scouting/monitoring of the pest population.
- Use of pheromone traps to attract male insects for both monitoring/surveillance and pest control.
- Use light and sticky traps, especially in polytunnel cultivation.

Figure 2. Tomato fruit and leaf miner damage.
Photo: RARDC, Bandarawela.

Apply recommended insecticides
- Emamectin benzoate 5% SG – rate of application 6 g/16 l of water.
- Abamectin 18 g/l EC – rate of application 10 ml /16 l of water.
- Indoxacarb 150 g/l EC – rate of application 6 ml /16l of water.
- Spinetoram 25% WG – rate of application 4 g /16 l of water.

iii. Cutworms (*Agrotis* spp.)

The stems of young seedlings may be cut off at the soil line or the collar region of the plant. Larvae causing damage are usually active at night and hide during the day in the soil at the base of the plants or in the plant debris of toppled plants. Larvae may exhibit various patterns and coloration, mainly black, but usually curl up into a C-shape when disturbed (Figure 3).

Management
- Plough the soil deeply to bring the larvae and pupae to the soil surface.
- Regular-field monitoring.
- Hand collecting and destroying the caterpillars.
- Proper field sanitation.
- Encouraging predatory birds to prey on worms during tillage operations.

Chemical control
1. Profenophos 500 g/l EC - rate of application 32 ml per 16 l of water.
2. Etofenprox 100g/l EC - rate of application 24 ml per 16 l of water.

Figure 3. Adult moth and larvae of the cutworm.
Photo: RARDC, Bandarawela.

iv. Leaf miner-*Liriomyza huidobrensis*

Leaf miner adults are tiny flies, about 2.5 mm long, and black. The parts of the thorax, legs, and abdomen are yellow.

Damage symptoms
Adult punchers leave for feeding and oviposition, which may result in a spotted appearance on the foliage. Larvae make irregular mines, which results in the drying and withering of leaves (Figure 4). Damaged plants succumb to secondary fungal infections.

Figure 4. Leaf miner damage.
Photo: RARDC, Bandarawela.

Management
- Regular field Inspections.
- Establish yellow color sticky traps.
- Remove other host plants surrounding the crop field.
- Removal and destruction of the infected plant material.
- Augment ecto-parasitoid *Diglyphus isaea*.
- Encourage naturally found parasitoids, *Hemiptarsenus semibiclavas* and *Opius* spp.

Chemical control
1. Azadiractin 1% EC - rate of application 16ml/16 l of water.
2. Abamectin 18g/l EC - rate of application 9.6 ml/16 l of water.
3. Neem seed water extract - rate of application 640g/16 l of water.

v. Whiteflies (*Bemisia tabaci*)

Whiteflies are tiny white-flying insects that congregate on the undersides of tomato leaves (Figure 5). Both nymphs and adults aggregate, feeding together on leaf undersides by piercing and sucking out the sap from the foliage, leaving spots, and sometimes causing yellowing and distortion.

Management
- Destroy crop residues immediately after harvesting.
- Regular field inspection.
- Establish yellow color sticky traps (15-20 traps/ha).
- Removal of other host plants surrounds the crop field.
- Removal and destruction of infected plant material.

Figure 5. Whitefly infestation in tomatoes.
Photo: RARDC, Bandarawela.

Chemical control

- Neem seed water extract - rate of application 640g/16 l of water.
- Thiocyclam 50% SP - rate of application 40g/16 l of water.
- Buprofezin 250 g/l SC - rate of application 30ml/16 l of water.
- Sulfloxaflor 50% WG - rate of application 5g/16 l of water.
- Pymetrozine 50% WG - rate of application 8g/16 l of water.

vi. Thrips (*Thrips spp*.)

Adult thrips are tiny (0.5 – 2.0 mm), slender, and winged (Figure 6). The wings are long, narrow, and fringed with long hair. The nymphs are either white or yellow. Both adults and nymphs feed on the lower leaf surfaces, buds, flowers, and fruits. It transmits the tomato-spotted wilt virus. An attack on leaves causes speckling and small necrotic patches. Heavy infestation causes premature wilting, delayed leaf development, and distortion of young shoots. Attacks on buds and flowers can lead to abortions.

Figure 6. Trips infestation.
Photo: Shutterstock.com

Management

- Ploughing and harrowing before transplanting to kill pupae in the soil.

Chemical control

1. Neem seed water extract - rate of application 640g/16 l of water.
2. Thiamethoxam 25% WG - rate of application 5g /16 l of water.
3. Imidacloprid 70%WG - rate of application 2g /16 l of water.
4. Chlorantraniliprole 20% + Thiamethoxam 20% WG - rate of application 5g /16 l of water.
5. Buprofezin 250 g/l SC - rate of application 30ml/16 l of water.
6. Sulfloxaflor 50% WG - rate of application 5g/16 l of water.
7. Pymetrozine 50% WG - rate of application 8g/16 l of water.

vii. Aphids (*Aphis* spp.)

Small, soft-bodied insects are usually green, brown, red, or black, depending on the species and the host plant. They feed on the underside of the leaves and apical part of the plant. Heavy aphid infestation may cause leaves to turn yellow and distorted, with necrotic spots on leaves and stunted shoots (Figure 7). Aphids secrete a sticky, sugary substance called honeydew, which encourages the growth of sooty mold on plants.

Figure 7. Aphid infestation.
Photo: Shutterstock.com

Management

- Destroy crop residues immediately after harvesting.
- Regular field inspection.
- Establish yellow color sticky traps (15-20/ha).
- Removal of other host plants surrounds the crop field.
- Removal and destruction of infected plant material.

Chemical control

- Neem seed water extract - rate of application 640g/16 l of water.
- Thiamethoxam 25% WG - rate of application 5g /16 l of water.
- Imidacloprid 70% WG - rate of application 2g /16 l of water.
- Chlorantraniliprole 20% + Thiamethoxam 20% WG - rate of application 5g /16 l of water.
- Buprofezin 250 g/l SC - rate of application 30ml/16 l of water.
- Sulfloxaflor 50% WG - rate of application 5g/16 l of water.
- Pymetrozine 50% WG - rate of application 8g/16 l of water.

Disease management

i. Early blight

Early blight is a common tomato disease caused by the fungus *Alternaria solani*. It appears as significant, irregular spots with yellow halos on the leaves that eventually turn yellow (Figure 8).

The dark lesions on the stems start small and are slightly sunken. As they become larger, they elongate and begin to see concentric markings, such as spots on the leaves. If early blight occurs on the fruits, spots will begin at the stem end, forming a dark, leathery, sunken area with concentric rings. Both green and ripe tomatoes can be affected. Affected seedlings will have dark spots on their leaves and stems. They may even develop the disease in their cotyledon leaves.

Figure 8. Early blight symptoms on tomato leaves.
Photo: Shutterstock.com

Management
Use of recommended fungicides at the initial stage of disease development. If needed, repeat the spray with different fungicides every 15 days, but do not spray the crop more than three times in a season.

1. Mancozeb 80% WP – rate of application 32 g / 16 l of water.
2. Chlorothalonil 500 g/l SC – rate of application 48 ml / 16 l of water.
3. Chlorothalonil 75% – rate of application 32 g / 16 l of water.
4. Maneb 80% WP – rate of application 32 g / 16 l of water.
5. Propineb 70% WP – rate of application 32 g / 16 l of water.
6. Mancozeb 64% + Metalaxyl 8% WP – rate of application 40 g / 16 l of water.
7. Mancozeb 60% + Dimethomorph 9% WP – rate of application 80 g / 16 l of water.
8. Metiram 55% + Pyraclostrobin 5% WG – rate of application 32 g / 16 l of water.
9. Azoxystrobin 120 g/l + Tebuconazole 200 g/l SC – rate of application 5.6 ml / 16 l of water.

ii. Late blight

The fungus *Phytophthora infestans* causes late blight. The main symptoms are brown spots, primarily on the stem and leaves of the plant (Figure 9 & Figure 10), which then spread rapidly to the fruits to rot (Figure 11).

Leaves: The first symptoms of late blight on tomato leaves are irregularly shaped, and water-soaked lesions are usually found on younger leaves. Spots also appeared on both sides of the leaves. As the blight continues to take hold, the leaves become brown, shrivel, and die.
Fruits: Late blight can also take hold of tomato fruit at any plant development stage. Rotten fruits have greasy brown spots that will eventually look and feel like leather.

Figure 9.
Late blight symptoms on leaves.
Photo: RARDC, Bandarawela.

Figure 10.
Late blight symptoms on stems.
Photo: RARDC, Bandarawela.

Figure 11.
Late blight symptoms on fruits.
Photo: RARDC, Bandarawela.

Management
Use recommended fungicides at the initial stage of disease development.
1. Mancozeb 75% WG – rate of application 32 g / 16 l of water.
2. Mancozeb 80% WP – rate of application 32 g / 16 l of water.
3. Chlorothalonil 500 g/l SC – rate of application 48 ml / 16 l of water.
4. Chlorothalonil 75% – rate of application 32 g / 16 l of water.
5. Maneb 80% WP – rate of application 32 g / 16 l of water.
6. Propineb 70% WP – rate of application 32 g / 16 l of water.
7. Mancozeb 64% + Metalaxyl 8% WP – rate of application 40 g / 16 l of water.
8. Mancozeb 60% + Dimethomorph 9% WP – rate of application 80 g / 16 l of water.
9. Metiram 55% + Pyraclostrobin 5% WG – rate of application 32 g / 16 l of water.
10. Azoxystrobin 120 g/l + Tebuconazole 200 g/l SC – rate of application 5.6 ml / 16 l of water.
11. Fluazinam 500 g/l SC – rate of application 16 ml / 16 l of water.
12. Azoxystrobin 250 g/l SC – rate of application 16 ml / 16 l of water.

iii. Powdery mildew

The fungus *Oidium lycopersicum* causes this disease.

Symptoms
- Light green to bright yellow lesions on the upper surface of the leaf (Figure 12).
- The lower surface develops white powdery patches when the fungus sporulates.
- Severe infection results in leaf defoliation.

Management
Use recommended fungicides at the initial stage of disease development.
1. Apply sulfur 80% WG a rate of application 80 g/16 l of water.
2. Chlorothalonil 500g/l SC - rate of application 48 ml/16 l of water.
3. Thiophanate-methyl 70% WP - rate of application 16 g/16 l of water.

Figure 12. Powdery mildew infestation in tomato.
Photo: RARDC, Bandarawela.

iv. Collar rot/Root rot

Collar rot is caused by the fungus *Fusarium* spp., *Rhizoctonia* spp., and *Sclerotium* spp.

Symptoms
The pathogen attacks the collar portion of the plant. The infection leads to the drying of lower leaves, and eventually the whole plant dries, giving a typical symptom of wilting, ultimately leading to death.

Management
Drenching soil using the following fungicide. Recommended only as a spot application.

1. Pencycuron 25% WP – rate of application 100 g/50 l/10 m^2.
2. Thiram 80% WP – rate of application 70 g/50 l/10 m^2.
3. Thiophanate-methyl 50% + Thiram 30% WP – rate of application 50 g/50 l/10 m^2.
4. Carbendazim 50% WP – rate of application 70 g/50 l/10 m^2.
5. Carbendazim 500 g/l SC – rate of application 70 ml/50 l/10 m^2.

Bacterial diseases

i. Bacterial wilt

The causal organism of bacterial wilt is *Ralstonia solanacearum*.

Disease symptoms

- Permanent wilting of the plant even during the optimum water level in the soil (Figure 13).
- Viscous ooze exudes at the cut end when immersed in water (Figure 14).

Figure 13. Bacterial wilt symptoms.
Photo: RARDC, Bandarawela.

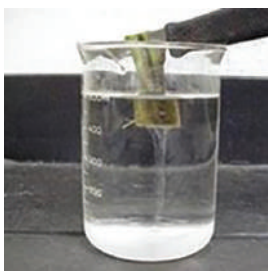

Figure 14. Bacterial ooze.
Photo: RARDC, Bandarawela.

Management
- Use wilt-resistant varieties.
- Use wilt-resistant rootstock grafted tomato seedlings.
- Crop rotation using legumes, cereals, etc.
- Maintain field sanitization.

Viral diseases

Several viral diseases can affect tomato plants. The incidence of viral diseases can be reduced to a greater extent by adopting the following practices.
- Use authentic disease-free seeds.
- Observe strict field sanitation and freedom from weeds.
- Control vector populations (whiteflies, aphids, and thrips) as described above for the management of insect pests.

i. Tomato Yellow Leaf Curl Virus (TYLCV)

The virus is transmitted by whiteflies.

Symptoms
- Upward curling of leaves.
- Yellow (chlorotic) leaf margins (Figure 15).
- Smaller leaves than normal.
- Plant stunting and flower drop.
- If tomato plants are infected early in their growth, there may be no fruit formed.
- Infected plants may appear randomly throughout the field.

Figure 15. Yellow Leaf Curl Virus infestation in tomato cultivation.
Photo: Shutterstock.com

ii. Curly Top Virus (CTV)

The virus is transmitted by leafhoppers.

Symptoms (Figure 16).
- Inward rolling of leaflets along the midrib.
- Petiole and midrib frequently curve downwards, giving the leaf a drooping but not wilting appearance.
- Leaves are thick, crisp, brittle, and dull green with purple veins.

Figure 16. Curly Top Virus.
Photo: RARDC, Bandarawela.

iii. Tomato Spotted Wilt Virus (TSWV)

The virus is transmitted by thrips.

Symptoms
- Plants show bronzing, curling, necrotic streaks, and spots on the leaves.
- Dark-brown streaks also appear on leaf petioles, stems, and growing tips (Figure 17).
- Plants are small and stunted.
- The ripe fruit shows paler red or yellow areas on the skin.
- Plants are killed by severe necrosis.

Figure 17. Tomato Spotted Wilt Virus.
Photo: RARDC, Bandarawela.

iv. Cucumber Mosaic Virus (CMV)

CMV virus is transmitted by aphids.

Symptoms

- The early stages are yellow, bushy, and considerably stunted. Later, filiform or shoestring-like leaf blades (Figure 18).
- Shoe string like leaf blades.
- Leaf mottling.

Figure 18. Cucumber Mosaic Virus.

Photo: RARDC, Bandarawela.

Harvesting

Harvesting is done when the fruits turn green or yellow. The fruits should be sorted according to size and quality and stored in a well-aerated place. Yield is typically approximately 20-30 tons per hectare, but it varies with season, variety, and climate.

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