Tomato Growth and Development

The tomato is an annual that requires about 100-150 days to complete a seed to seed life cycle.

Seed germination

Seed of most varieties germinate at an optimum temperature range of 26-32\degree C. Under optimal conditions seedlings break through the soil surface about four days after sowing. Seed sowing depth should be about 1-2 cm.

Shoot Development

After emergence, the cotyledons expand rapidly and the first true leaves develop at the growing point. Leaves grow alternately (2/5 phyllotaxy). Most varieties develop 7-11 leaves below the first inflorescence. After the first cluster, indeterminate varieties typically develop three leaves between flower clusters and six or more flower cluster on a single branch. Determinate types usually show two leaves between flower clusters and up to 5 clusters per branch. Side shoots arise from each leaf axil that lead to new branches, leaves, and flower clusters.

Flowering

Tomato is a day neutral plant, meaning that day length does not affect the number of days to flowering. The first flower of the first cluster starts to open about 55-60 days after sowing. The second cluster flowers about one week after the first and soon for determinate varieties; duration from first flowering to completion of flowering is about 45-60 days for determinates. Time length between flowering of sequential flower clusters for indeterminates is 10-14 days.
Fruit Development

- Fruit require 40-60 days from flowering to full ripening. Full fruit size will be achieved in 20-30 days after flowering.

Tomato fruit anatomy

Plant Characters

- **Growth habit**
  - tomato plants can be classified into two major types
  - **Indeterminate**: The terminal bud or the stem remains vegetative and will continue to produce leaves and stem from the growing tip. Flower clusters are formed after every three leaves. Plants can grow almost indefinitely and consequently indeterminates tend to be much taller than determinates.
  - **Determinate**: The growing point in the axil of the last-formed leaf transforms into a flower cluster, after which vegetative growth on that stem ceases. Flower clusters are formed about every two leaves. **Semi-determinates** have six or more clusters with two leaves between clusters. Strong determinates tend to be bushy and short compared to indeterminates. The height of semi-determinates is intermediate between determinates and indeterminates.

Determinate

Indeterminate
Tomato Market Types

- **Fresh market**
  - Fresh market tomato is used for cooking or eating raw. Most consumers prefer dark red tomatoes, globe or deep-globe shape, and 50-125 g size. However fresh market tomatoes can vary greatly in color, shape, and size.
- **Cherry tomato**
  - Cherry tomato fruit is small-sized (< 30g), and borne on long clusters (> 10 fruit/cluster). Cherry tomato is often sold in the fruit market rather than the vegetable market and good taste is particularly important.
- **Processing tomato**
  - Processing tomato is produced for processing into paste, catsup, sauce, diced or-whole-peel tomato. Particular fruit quality such as dark red color, high solids (brix) content and pH <4.5. In addition to the fruit characters, processing varieties are usually of determinate growth type and some have compact vine and joint less pedicel to facilitate machine harvest.

<table>
<thead>
<tr>
<th></th>
<th>Indeterminate</th>
<th>Determinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pruning</td>
<td>1/2 steins/plant</td>
<td>Some in dry season</td>
</tr>
<tr>
<td></td>
<td>Wet season-pruning to 1 or 5 steams recommended</td>
<td></td>
</tr>
<tr>
<td>Plant Density*</td>
<td>33,000 plants/ha</td>
<td>&gt; 15,000 plants/ha</td>
</tr>
<tr>
<td>Staking</td>
<td>Yes</td>
<td>Wet season-yes</td>
</tr>
<tr>
<td></td>
<td>Dry season-usually no</td>
<td></td>
</tr>
<tr>
<td>Harvest Period</td>
<td>&gt;5 weeks</td>
<td>4-5 weeks</td>
</tr>
<tr>
<td>Mechanical Harvest</td>
<td>No</td>
<td>Yes with some varieties</td>
</tr>
</tbody>
</table>

Fruit Qualities

- **Color:** The red colored fruit of most tomato varieties is due to a carotenoid called lycopene. Lycopene synthesis is temperature sensitive and little is produced at temperatures >28 C. Tomato fruit ripened under high temperatures often develop a condition called "blotchy ripening" where lycopene does not form properly. Varieties grown in the off-season should develop adequate leaves (canopy or vine cover) to shade the fruit from the sun.

Size

- Depending upon the variety, average fruit range can range in size from 5->300 grams. Fruit borne on lower clusters tend to be larger than those on the upper clusters; on a given cluster, proximal fruit (those closest to the stein) tend to be larger than distal fruit. Production of large-fruited varieties is difficult under high temperatures and heat tolerant varieties tend to be small-fruiting. At the AVRDC researcher have found that fruit size of heat tolerant varieties is reduced by 30% or more when grown in the summer compared to the dry season.

Shape

- Fruit shape ranges from almost flat to elongated types. In most countries consumers prefer globe, deep globe, oblong, or pear shapes

Different shape of tomato fruit
Firmness

- Fruit firmness can be defined as the resistance of the fruit pericarp to pressure and thick walls are often associated with firmness.

Solids (°brix)

- Tomato fruit is about 95% water, and 4-5% organic compounds called solids. The solids portion consists of about 50% sugar (glucose and fructose) found mostly in the fruit wall; 25% is alcohol insoluble solids which include pectins, cellulose, proteins, polysaccharides; and organic acids, mostly citrate and malate. The remainder of the solids consists of carotenoids, volatile compounds, amino acids, and inorganic compounds.
- A high solids content is important for processed tomato, especially paste. However, yield and solids content are negatively correlated (the higher the yield the lower the solids). In general, indeterminate varieties tend to have higher fruit solids contents compared to determinate types.

Acidity ((Xi citrate)

- Most acid in the fruit is contained in the locules and acidity ranges in pH from 4-5 in tomato. A pH <4.5 is required for processed tomato because microbial growth is inhibited. A high acid content imparts a sour taste that is desirable in some countries.

Cultural Practices

- **Seedling Production**
  - About 250 g of seed is required to produce enough seedlings to plant one hectare. Seed germination should be greater than 80%. Seedlings grown in individual containers produce healthier and more vigorous seedlings compared to seedlings grown in flats or seedling beds. Seedlings grown in beds or flats suffer root damage when the plants are pulled for transplanting.

Seedling container method

- Fill a 10-cm diameter pot or seedling tray with holes for individual plants with a well-drained medium such as 2:5:1 (sand, compost, burnt rice hull).
- Maintain the pots/trays off the ground in sheltered area such as a plastic covered rain shelter.
- Plant 2-3 seeds/pot and thin to one plant 2-3 days after emergence of the first true leaves.

Seedbed method

- Choose a well-drained area not recently cropped with tomato. A site where air circulation is good will be advantageous.
- In soils where soil borne pathogens are a problem, burning rice straw on the seedbed or soil fumigation may be needed.
- Broadcast and incorporate fertilizers at the rate of 40 g ammonium sulfate, 50 g calcium super-phosphate, 30 g potassium chloride, and 2 kg of compost for each 1 m² of bed area.
- Prepare raised seedbeds at a width of 0.8 m and a height of 15 cm or higher to allow good drainage. Plant the seeds in rows 6 cm apart at a depth of 0.5 - 1.0 cm. Cover the bed surface with a thin layer of compost or ash before thinly mulching with rice straw and covering with mesh screen at 30 cm high. About 60 g of seeds are required per 250 m² seedbed.
- Care must be taken to prevent the soil from drying out and forming a crust on the soil surface. This crust often prevents seedling emergence, resulting in poor stand. Sprinkler irrigation of the seedbed is preferable to surface irrigation.
**Land Preparation**

- **Soil types.** Tomato can be grown on soil textures ranging from sand to heavy clay but silty clay loam soils are preferable. Soil pH should range from 6.0-7.0. Tomato production after paddy rice is advantageous because of lower incidence of bacterial wilt and nematodes.

**Beds**

- Shaping the land into beds and growing tomato on top of the bed facilitates furrow irrigation of the crop and drainage after rainstorms. Beds can be prepared in many ways. At the AVRDC, beds are made with a mechanical bed shaper and the beds are about 1 in wide and furrows (ditches) are 50 cm wide. Bed height varies, depending upon the season. In the dry season the bed height is 20 cm and increased to 35 cm in the wet season.

---

**Mulches**

- Mulching is the use of inorganic materials such as thin plastic sheets, or organic materials such as rice straw to cover the soil surface. Mulches can modify soil temperatures, reduce fertilizer leaching, decrease moisture evaporation, and improve weed control. The plastic mulch is covered with rice straw in the hot summer to lower the temperature of the plastic.

**Hardening**

- Harden the seedlings by slightly reducing water and exposing them directly to sunlight about 6-9 days before transplanting.
- A good seedling should be about 3-4 weeks old (4 or 5-leaf stage) and vigorous, not thin and etiolated.
- Transplant in the late afternoon or on cloudy days to minimize transplant shock.
- For transplanting, insert the seedling in a hole so the cotyledons appear above the soil surface. Older or etiolated seedling should be buried deeper. Press soil firmly around the root. Top irrigate lightly to settle the soil. After transplanting is completed, irrigate the field as soon as possible.

---

**Trellising/Staking**

- Staking or trellising is the use of bamboo, wood, metal poles, or other materials to support the plant and keep the fruit and foliage off the ground. Staking can increase fruit yield and size, reduces the proportion of unmarketable fruit, and facilitates chemical spraying, and harvesting. Indeterminate varieties should be staked in the dry and summer seasons to facilitate pruning, pinching, and other cultural practices. Determinate tomato varieties should be staked in the summer season in order to avoid fruit contact with wet soil which will cause fruit rots. Many staking arrangements are possible.

**Pruning**

- Pruning is the selective removal of side shoots to limit plant growth. Indeterminate varieties should always be pruned. Pruning may force early fruit maturity, increase average fruit size and uniformity, improve fruit flavor and increase content of vitamins A and 'C' content. Pruning improves air circulation in the canopy which may hinder development of foliar diseases, facilitates chemical spray applications and eases harvest. Without pruning, indeterminates will set fruit poorly in the wet season because too much photosynthate is diverted into vegetative growth instead of the fruit. The degree of pruning varies according to the season.
**Pinching**

- Pinching is the removal of extra flowers on the cluster and farmers may do this in order to increase fruit size. This is an advantage if markets pay a premium for larger fruit.

**Hormone application**

- High temperatures may drastically reduce tomato fruit-set and consequently, fruit yield. Application of tomatotone (4-Chlorophenoxyacetic acid or CPA) may increase tomato fruit-set under high temperatures.

<table>
<thead>
<tr>
<th>Fruit Ripening and Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The process of fruit ripening regulated by plant hormones and modified by genetic and environmental factors. Changes include:</td>
</tr>
<tr>
<td>• Starch degradation and glucose/fructose formation</td>
</tr>
<tr>
<td>• Loss of fruit chlorophyll</td>
</tr>
<tr>
<td>• Increase in citrate and malate</td>
</tr>
<tr>
<td>• Lycopene and Beta-carotene synthesis</td>
</tr>
<tr>
<td>• Fruit softening due to increase in polygalacturonase &amp; soluble pectins</td>
</tr>
<tr>
<td>• Production of flavor and aromatic compounds</td>
</tr>
<tr>
<td>• Breakdown of toxic alkaloid á-tomatine</td>
</tr>
<tr>
<td>• Tomato is a climacteric fruit, The height of the climacteric happens at the pink-stage.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stages of Fruit Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Immature Green: no jelly in locules</td>
</tr>
<tr>
<td>• Green-mature: jelly in locules; seeds not cut when fruit cut by shape knife. Fruit will mature normally if picked at this stage</td>
</tr>
<tr>
<td>• Breaker: not more than 10% of the surface is tannish-yellow, pink, or red; Color first appears on the blossom end</td>
</tr>
<tr>
<td>• Turning: color change has occurred over 10-30% of the fruit</td>
</tr>
<tr>
<td>• Pink: 30-60% of the fruit surface has shown pink/red</td>
</tr>
<tr>
<td>• Light red: &gt;60% but &lt;90% fruit surface is red/pink</td>
</tr>
<tr>
<td>• Red: &gt;90 fruit surface is red (no pink)</td>
</tr>
</tbody>
</table>

**Harvest**

- Tomato can be harvested at a number of ripeness stages, depending upon distance to the market and intended purpose for the fruit. For long distance transport, fruit should be harvested at the green-mature stage, whereas fruit destined for local sale can be harvested at the pink or breaker stage. Tomato for processing is harvested at the full ripe stage.