TOMATO CULTIVATION IN OPEN FIELDS AND GREENHOUSES
INTRODUCTION

Tomato is one of the most popular vegetables in the world. With the help of modern irrigation technology, this crop can grow all year round.

Top tomato-producing countries in 2008 (million tons) were:
China 33.8; USA 12.5; Turkey 11.0; India 10.3; Italy 6.0

Tomato production is sensitive to temperature—the optimal temperature is 23-27°C. Temperatures lower than 15°C or higher than 35°C (and night temperatures above 21°C) are detrimental to fruit setting.

Tomatoes grow best in warm temperatures with a lot of light. Low levels of light (less than 15% of summer light levels) will greatly reduce fruit yield in fall or winter crops in greenhouses.

Tomato crops can be classified as either determinate or indeterminate: Determinate tomato crops will ripe and harvest at one time, whereas indeterminate tomato crops will grow as a vine that never tops off and can produce fruit throughout the season.

PROCESSING TOMATO AND FRESH TOMATO

There are two main groups:
1. Processing tomato—cultivated in open fields
2. Table tomato—cultivated in open fields or in greenhouses

Open field cultivation can produce 100-120 ton/ha. Table tomato cultivation in greenhouses can yield up to 500 ton/ha.

Different qualities are demanded by the market from each tomato type:
• Processing tomato—the brix (measure of the carbohydrate level in the fruit juices) is counted
• Table tomato—the consumer test and shelf life are dominant

Besides the tomato variety, other factors affect the quality of the tomato fruit. Irrigation and fertigation are the most influential of these factors.

Crop cycle
Processing tomato in open fields: 120-135 days, according to variety
Table tomato in greenhouses: 6-10 months

PROCESSING TOMATO

For tomato farmers, the main criteria for crop management is deciding whether to grow for quantity or quality (with maximum tonnage). Highly soluble solids (brix) are accompanied by lower yield.

The limited wetted volume under the drip system gives maximum flexibility of control, providing the right amount of moisture for each growing stage up until the harvest.

Soil and Water
Most soils are suitable for growing tomato, as long as there is good drainage.
Optimal soil pH is 6-7.5.

The tomato plant is capable of developing a deep and well-spread root system. It’s important to allow the roots to utilize the soil profile—up to 1.2 m in heavy soil, and 40-60 cm in light sandy soil. It’s important to fill up the soil profile accordingly, before planting.

The tomato plant is relatively more tolerant to salinity. However, above 3.0 m/mho/cm you can expect a reduction in yield, but an increase in quality. The fruit is smaller and sweeter.

As tomato is sensitive to soil diseases, disinfecting treatment should be applied every year.
Temperature Requirements (Celsius) vs. Growing Stage (Processing Tomato in Israel)

<table>
<thead>
<tr>
<th>Growth stages</th>
<th>Minimum</th>
<th>Optimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination</td>
<td>11</td>
<td>16-29</td>
<td>34</td>
</tr>
<tr>
<td>Growth development</td>
<td>18</td>
<td>21-24</td>
<td>32</td>
</tr>
<tr>
<td>Fruit set—night</td>
<td>10</td>
<td>14-17</td>
<td>20</td>
</tr>
<tr>
<td>Fruit set—day</td>
<td>18</td>
<td>23-26</td>
<td>30</td>
</tr>
<tr>
<td>Turning red</td>
<td>10</td>
<td>20-24</td>
<td>30</td>
</tr>
<tr>
<td>Turning yellow</td>
<td>10</td>
<td>21-23</td>
<td>40</td>
</tr>
</tbody>
</table>

IRRIGATION (Processing Tomato)

Watering Guideline and Crop Factors—Drip Irrigation

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Pre-planting Irrigation to 120 cm depth with sprinklers/rain</th>
<th>Germination and Establishment Seeds or seedlings, 45-60 days</th>
<th>Flowering &amp; Fruit Set Till the oldest fruit change color 20-30 days</th>
<th>Ripening 20-30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop factor and tips</td>
<td>100-250 mm</td>
<td></td>
<td>0.4-0.6</td>
<td>0.7-0.9</td>
</tr>
</tbody>
</table>

  First dose: 30-50 mm Second dose: (after 7 days) 20-30 mm
  Intensive irrigation starts 2 weeks after flowering starts. Filling up with technical irrigation of 50 mm. Intervals of 1-3 days
  Last irrigation 10-20 days before harvest (50-80% red fruits). Plant utilizes the deep water storage.

Moderate stress management for higher brix

<table>
<thead>
<tr>
<th>Tensiometer reading (in cbar) at 30-60 cm depth</th>
<th>10-30 cb, depending on soil type</th>
<th>40-60 cb for high brix, depending on soil type</th>
</tr>
</thead>
</table>
Nutrient Uptake Rates for Tomatoes

### Irrigation Guide Lines for Table Tomato in Open Fields

From planting to establishment, apply light irrigation of 5-10 m³/day/ha.

For sandy soil, irrigate daily.

For medium to heavy soil, irrigate every 2-3 days.

After establishment, apply irrigation in wider intervals of 3-5 days, depending on the soil type.

In winter, irrigate every 5-7 days.

Irrigation quantity will be calculated according to ET and tensiometers (tensiometer station of 30 & 60 cm depth).

Total amount of water per crop cycle: 630-750 mm

### Planting

Open fields

Double row on 1.5-2.0 m bed, with 30-50 cm between rows

25,000-30,000 plants/ha (5-6 plants /meter/ bed)

### Irrigation Management

Using a tensiometer is recommended in order to better gauge the moisture availability at each profile depth and according to the plant’s needs. This helps in deciding when to irrigate and how much (quantity) to irrigate.

Each station includes 2 units at a depth of 30 and 60 cm, or 20 and 40 cm, in light soil.

**Water Stress and Soluble Solids Control (brix)**

Deficit irrigation should be applied to put the tomato plant in a state of moderate controlled stress. This technique enables the grower to get higher soluble solids at minimal yield reduction.

The ideal time to apply deficit irrigation is when the first fruits show color.

### Fertilization

In general, the fertilizer program should be based on a soil test, conducted before planting.

Minimum levels for Phosphorus and Potash in the soil:

- **Phosphorus (P):** 25-30 mg/kg (for each 1.0 mg/kg missing, broadcast 20 kg/ha P₂O₅ or 12-14 kg/ha P₂O₅ via the drip system)

- **Add the required Phosphorus till the end of establishment stage (about 25-30 days after planting).**

- **Potash (K):** 14 mg/liter (CaCl₂ extraction method), or ΔF = (-)3,300 cal/mol.

  For 10-12 mg/l, add 200 kg/ha K₂O. If less than 9 mg/l, add 400 kg/ha

### Nutrient Uptake Rates for Tomatoes

![Graph showing nutrient uptake rates for tomatoes over time](image)

- **Nutrient uptake rates (g/plant)**

  - K: 12
  - N: 10
  - Ca: 8
  - P: 6
  - Mg: 4

  **Time (weeks)**

  - Transplant
  - Flowering and fructifying
  - Harvest

  *source-Huett 1985*
The phosphorus and potash can be applied as a base or partly through the irrigation water.

**Fertilizers Quantity Guide for Expected Crop of 100-120 t/ha, Absorbed by Plant**

<table>
<thead>
<tr>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>60</td>
<td>500</td>
</tr>
</tbody>
</table>

The phosphorus and potash can be applied as a base or partly through the irrigation water.

**NPK Ratio—Table Tomato**

<table>
<thead>
<tr>
<th>Crop Stages</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination and establishment</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Flowering and fruit set</td>
<td>1</td>
<td>0.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Till end of harvesting</td>
<td>1</td>
<td>0.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Additional Micro- & Macro- Elements for Table Tomato**

From picking time, the addition of Iron (Fe) and Manganese (Mn) is recommended. Magnesium (Mg) is also recommended for light soil.

**SDI**

The SDI (Sub-surface Drip System) is a recommended solution for processing tomato crops.

The heavy machinery used during harvesting can damage the drip line. This problem can be overcome with shallow installation, around 10 cm, which protects the drip lateral. After harvesting, the drip laterals are extracted and can be reused. The selection of suitable wall thickness should be considered for this operation.

Deep installation (30-40 cm) is practical for permanent installation and cultivation methods follow the same track.

The application of fertilizer directly to the root system at 30-40 cm contributes to improved efficiency and higher yields.

During the germination stage, wetting the seeds or young plants sufficiently can prove challenging when the dripline installation is deep. An efficient solution to this problem is using a portable sprinkler system.

AmnonDrip AS (Anti-Siphon) and TopDrip AS are most suitable for SDI application. Anti-siphon is a built-in characteristic of the dripper. It prevents sand from being sucked into the dripper during drainage.
GREENHOUSE (GH) CULTIVATION

Tomato crops in greenhouses are grown on local soil or on substrate (soilless culture).
In GH, tomato can be grown 10 months a year, producing 300-500 ton/ha (or even more, depending on the variety).
This protected high-yield crop requires a professional drip system and fertigation system. A heating system is necessary in cold countries, and a cooling system or ventilated GH is required in hot places (tropical and sub-tropical climates).

Tomato in Soilless Culture

Growing tomato on substrate allows better control of moisture and oxygen levels, pH and nutrient availability; factors which all contribute to earlier production and high-quality yields.

The growing substrate is shallow—15-20 cm in height. At this shallow depth and high drainage rate, the water spread is limited.
Dense dripper spacing at low flow rate (1.0-1.6 l/hr) is required to achieve uniform, complete coverage of the growing substrate, avoid salinity buildup and facilitate maximal growing volume for the roots.

Drainage System

In soilless culture, the surplus irrigation and the nature of the substrate create substantial drainage.
The design of an irrigation system and the growing beds or gutters must include the solution for the drainage recycle.
(NDJ design office can advise and design a complete system to suit your needs.)

Irrigation and Fertigation

The characteristics of the substrate and limited growing volume require intensive irrigation and fertilizer application:
1. Small water doses a few times a day, combined with continuous fertigation (4-8, with more pulses in some cases)
2. Increase of water quantity by 30-50% (depending on water quality) to allow leaching of salt buildup and fertilizer residue.
CNL (Compensated Non-Leakage) drip system is recommended for pulse irrigation.

<table>
<thead>
<tr>
<th>Lateral Spacing</th>
<th>Bed width/Lateral spacing (m)</th>
<th>Dripper spacing (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing tomato</td>
<td>1.8-2.0; 1.0 lateral for two rows</td>
<td>50-75</td>
</tr>
<tr>
<td>Table tomato open field</td>
<td>1.6; 1.8; 1.0 lateral per row</td>
<td>40-50 (sandy soil 20/25 )</td>
</tr>
<tr>
<td>Greenhouse/ net house on soil (21,000-24,000 plants/ha)</td>
<td>1.2; 1.0 lateral 1.6-2.0; 2 rows /beds, 50-60 cm between the rows, 2 laterals</td>
<td>40-50</td>
</tr>
<tr>
<td>Greenhouse soilless culture - Continuous bed - Rockwool block/bag system (average 23,000 plants/ha)</td>
<td>2 laterals per bed One dripper per plant</td>
<td>20-30 5-6 plants /meter</td>
</tr>
</tbody>
</table>

Laterals & Dripper Spacing

The density of the plants depends on light conditions and variety.
GREENHOUSE CLIMATE CONTROL
The GH structure and conditions cause an increase of temperature that affects the tomato plant development (flower pollination and fruit sets). The NDJ Fogger system is very effective in helping to cool the greenhouse, while increasing humidity. Humidity helps the plant to better withstand high temperatures. Bee pollination is very successful in tomato greenhouses. The bees become less productive in high temperatures, and the cooling system with the fogger will increase pollination percentage success.

SPRAY SYSTEM WITH NDJ FOGGER SYSTEM
Pesticide and insecticide practice in GH with the same cooling system is highly effective and has numerous advantages:
• On-time operation with no delay
• One man operation
• Environmentally safe
It is most useful as a preventative treatment method, with minimal dose of 500 liters/ha. The system can work with a wide range of pesticides

IRRIGATION & FERTIGATION CONTROL UNITS
A compact head control unit, which controls irrigation and fertigation (climate control is optional), is available for greenhouse tomato crops. The system monitors water requirements and scheduling, allowing pH and EC control of both the irrigated water and the drainage water (for soilless culture GH).
NaanDanJain is committed to finding the ideal solution for your tomato crop, tailored to your local climatic conditions, soil, water properties, and budget. Contact our office or your local dealer for further information.

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All information should be used only as a guideline. For specific recommendations contact your local agronomist.