Diseases

Tomatoes grown in soil culture are subject to nematodes, Fusarium and verticillium wilt botrytis, leaf mold, early and late blight, foliar and fruit bacterial problems and viruses. These can occur as a single problem or a combination of two or more at a time. Total or marketable yields can be reduced by 10 to 80 percent, depending on the severity of one or a combination of these diseases.

Disease	symptoms
Bacterial spots	Small, raised spots on fruit. They are usually brown to black. Bacterial canker is a white spot on the fruit.
Early blight	A problem in soil houses. It is identified by the presence of small, brown-to-black spots which develop into target-like spots. The spots appear on the lower leaves first. They appear as a dark, leathery spot on the stem end of the fruit.
Fusarium wilt	Not likely to be a problem in soilless houses. Typical symptoms include a yellowing and wilting of the foliage. Stem tissue near the ground line is likely to show brown streaks.
Gray mold	Very common in both soil and soilless houses. It is usually recognized by a fuzzy, gray growth on the stems or flower pedicels. The leaves turn brown beginning at the tip and progress backward. It becomes a major problem when the house is not ventilated and the humidity is continuously kept at high levels.
Leaf mold	Different than gray mold. Symptoms include yellow, circular like spots on the upper surface of leaves. Spots are olive to gray on the underside of leaves. Occur in both systems when the humidity is kept constantly at a high level.
Nematode injury (root knot)	Is likely to be found in soil houses where continuous production has occurred. Plants will wilt rapidly during periods of moisture stress. Leaves turn yellow and may appear to have a nutrient deficiency. Plants become stunted and the roots develop galls or knots
Tobacco mosaic virus	Leaf symptoms include mottling, with raised dark green areas and some distortion of younger leaves. Severe symptoms include leaves which may turn downward, become rough, crinkled or corrugated, and may curl downward at the margins. Plants may become stunted.
Southern blight	Is more of a problem in a soil house. Plants wilt and die very rapidly without a distinctive yellowing of the foliage. The stem at the ground line will usually be decayed and covered with a white mold and small light-brown fruiting bodies.
Verticillium wilt	Not likely to occur in soilless systems. The foliage will yellow and wilt. It forms v shaped lesions on the leaves. Internal tissue near the base of the plant will usually show brown discoloration.

Insects

Green house are subject to infestation by aphids, flea beetles, fruit worms, white flies, mites, leaf miners, pinworms and others. A description of these insects is provided in Table below.

Insect	Symptoms
Aphids	Small, soft-bodied, pear-shaped insects with a pair of cornicles (tailpipe-like projections) protruding from the rear end. They may be red, black or green. They may be winged or wingless and feed in colonies on terminals and leaves. Infested leaves often curl and become distorted. Aphids transmit virus diseases.
Fruit worms	Adult moths are yellowish-olive. Larvae vary in color from greenish-yellow, reddish brown or even black with paler stripes running lengthwise along the body. Fruit worms feed on the leaves and fruit and may bore into the stalk.
Leaf miners	The larvae are yellow and about 1/8 inch in length. They tunnel the leaves between the upper and lower surfaces. This damage results in long, white, winding tunnels on the leaves.
Tomato pinworms	The adult moth is gray with a wingspan of 1/2 inch. The mature larvae may be yellow, green or ash gray and covered with dark purple spots. Pinworms can cause whitish leaf streaks, folded and tied leaves, pinholes in stems and fruit and fruit blotches.
Spider mites	Small, yellowish to dark green spider like pests that are the size of pepper flakes. They may be detected by dislodging them from the plant onto a piece of white paper and viewing them with a 10X magnifying lens. Webbing may be seen over the infested plants. Mites suck the sap from foliage. Leaves take on either a yellowish or bronze cast.
White flies	There are several species of white flies. They may vary in certain aspects of body shape, such as wing shape. However, they are all small insects with broad wings covered with fine, snow-white waxy powder. Both adults and nymphs may feed on foliage by sucking juices from the underside of the leaf. They produce honey dew which may result in a blackening of the leaf. Some species are also capable of transmitting certain viruses, which greatly damage the plant.

Chemical name	Quantity	To control
Fungicides		
Acrobat	1.5gm/liter	Mildews and leaf spots
Amistar	0.5 ml /liter	Blight and Mildews
Bavistin	1 gm/ liter	Diseases like wilt, root rot and leaf spot.
Copper oxy chloride	2 gm/ liter	Damping off and root rot and collor rot
Dithane M-45	2 gm/ liter	Downey mildew , leaf spot and other diseases
Nativo	0.5 gm/liter	For the Early blight & leaf spot diseases.

Chemical name	Quantity	To control
Insecticides		
Actara	0.5/liter	to control the sucking pests like thrips, white flies, Aphids
confidor	1 ml/liter	to control the sucking pests like thrips, white flies, Aphids
Exodus	2ml/liter	To control the fruit borers and the mites.
Larvin	2 gm/ liter	To control the fruit borers.
Spinosad	0.5 ml/liter	For the Thrips and the caterpillars
Vertimac	0.5 ml/liter	leaf miner and red spider mites

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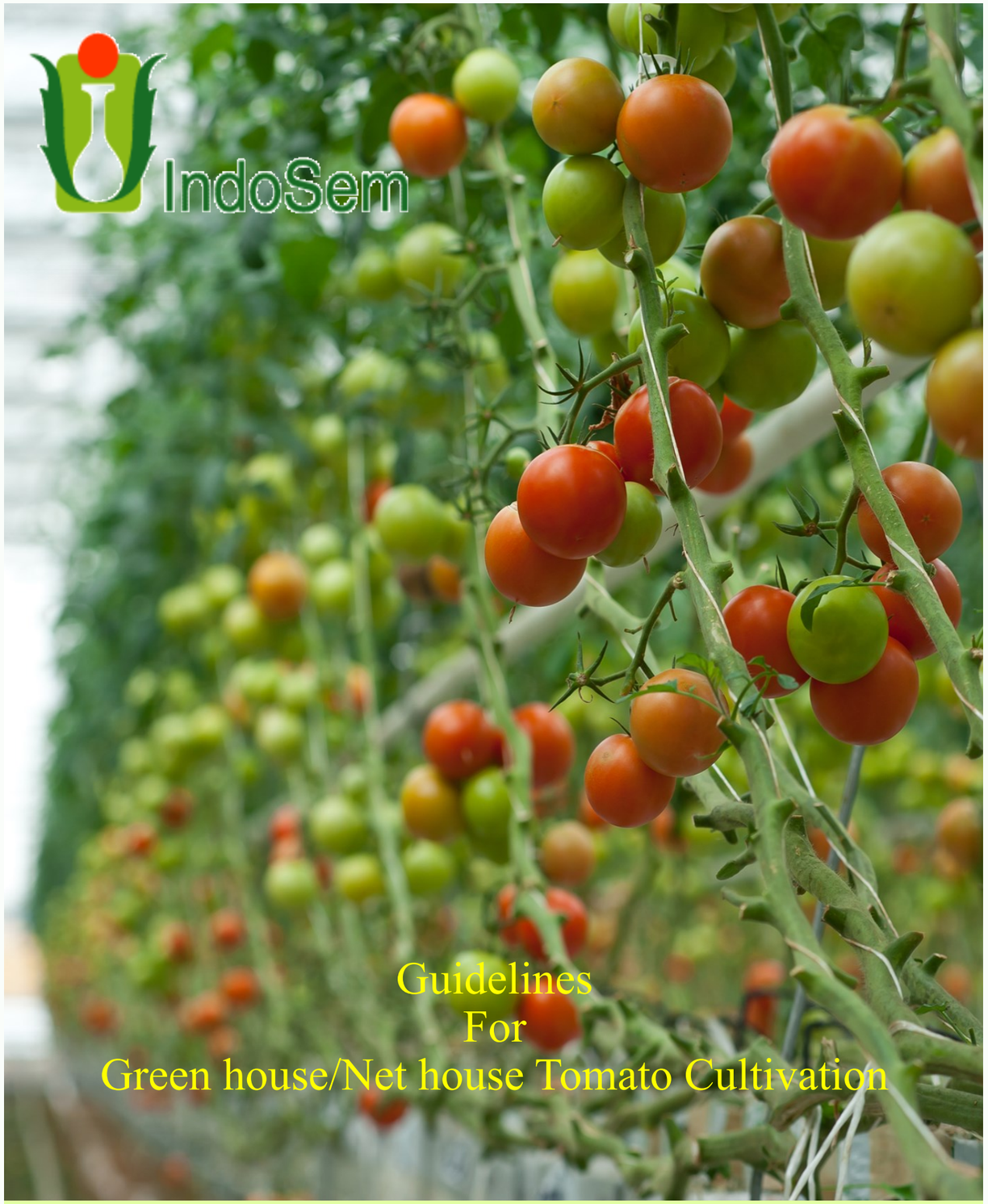


Guidelines For Green house/Net house Tomato Cultivation

Tropica Seeds pvt ltd,
54, South End Road 1st Floor, Nama Aurore Building,
Basavanagudi, Bangalore 560029, INDIA.
Website: www.tropicaseeds.com
Email: info@tropicaseeds.com

Introduction

Greenhouse tomato production offers interested growers an opportunity to produce a marketable product at times when supplies are low. It increases the length of time tomatoes are available and improves buyer interest in the area. The system offers profitable opportunities before field tomatoes are harvested, and when field tomatoes production have been depleted.

Optimal growing conditions for tomato

Optimum germination soil temperature	23-28^{0}C
Optimum growing temperature	20-30^{0}C
Limiting factors for sowing	Low temperatures and frosts
Seed to transplant	4 weeks
Vegetative to flowering	3-4 weeks
Flowering to harvest	6-8 weeks
Duration of harvest	Up to 5 months
Soil pH	5.5 to 6.8
Salinity tolerance	Moderate
Irrigation	Depending on method of irrigation, variety and seasonal conditions
Post harvest storage temperature	7-13^{0}C
Post harvest storage humidity	85-95%

Field Selection: Check the irrigation water quality. Optimum pH is 6.5 to 7.5 and EC should around 1mmho. Excess sodium and fluoride may affect proper plant growth. Ideally, the land should be gentle sloping to facilitate drainage.

Soil environment: Tomatoes can grow in a variety of soil types; they do best in well-drained, deep, uniform clay or silty loams. The soil should be loose, deep and of correct structure

Land preparation: During land preparation, 8 tons of farm yard manure per acre can be incorporated into the soil to improve its structure; this will in turn improve soil aeration and water percolation.

Seed requirement: The amount of seed will be determined by the spacing used. A plant density of 3 plants per sqmt is recommended for most regions.

Nursery management: Trays can be used for growing seedlings. Watering will be done lightly using a watering can and timed in the morning to avoid conditions conducive for the development of diseases. It will take about a month before the seedlings are ready for transplanting.

Transplanting: The seedlings need about a month of growth before they are ready for transplanting. Transplanting is best done in the evening when the weather is cool. Transplant directly into already prepared holes Spacing ranges from 60x45 cm, or 60x60 cm depending on soil condition and water availability.

Agronomic practices.

Agronomic practices include: nutrient management, irrigation, support, pruning, weeding, pest and disease management, harvesting.

Nutrient management

Fertilization of Soil Systems

When spring tomatoes are grown in greenhouses with soil, good calcium levels, above 200kg per acre, should be available to reduce blossom-end-rot. The pH should be 6.1 or above. Lime and fertilizer used in soil systems can be applied and worked into the soil before planting.

The general principle is to apply Phosphate fertilizer as basal dressing for root development; for this, DAP can be used at the rate of 150Kg/ ha. After transplanting, Calcium nitrate can be used for leaf establishment. Apply Calcium nitrate in the 5th week and are applied at the rate of 200Kg/ha at the onset of flowering, top dress with NPK at 200Kg/ha, a compound fertilizer is necessary for the supply of N, P and especially K that is needed for flowering. The NPK top dress can be repeated after the first harvest. To correct micro-nutrient deficiencies, foliar feeds can be applied alongside the regular pesticide applications. Avoid excessive Nitrogen, it leads to excess vegetative growth, poor fruit set, smaller fruits, hollow fruits and poor keeping quality.

Irrigation

The amount and frequency of irrigation depends on prevailing weather conditions and the stage of growth. Avoid irrigation in the evening to prevent disease development. For a standard greenhouse of 240 square meters install a 500 litre tank, this will serve the plants for a single day - i.e. half a litre per plant per day. Apply water regularly during dry spells to reduce physiological problems.

Recommended Fertigation per growth stage for tomatoes grown in soil

Phase	Kg/ha/phase					
	Days from planting	Ammonium nitrate 34-0-0	MAP 12-61-0	Potassium nitrate 13-0-46	Calcium nitrate 15.5-0-0+26 cao	Magnesium sulphate (16 % mgo)
Planting	1	3	0	2	0	0
Vegetative	2-15	24	3	28	4	0
Flowering	16-30	26	3	30	4	6
Fruit set	31-40	18	3	20	4	0
Fruit growth	41-60	71	10	83	8	6
1st harvest	61-65	18	3	20	4	0
Harvest	66-120	382	59	452	50	50
Harvest	121-170	262	39	309	35	31
Last harvest	171-210	209	31	248	27	25
Total		374	139	1080	119	113

Fertilization of Soilless Systems

When soilless systems are used, a plumbing system must be provided that allows frequent deliveries of water-soluble nutrients to the root zone. Soilless systems require that appropriate concentrations of each of 13 nutrients be supplied to the plants. The required concentration varies with each nutrient. In most cases, the best way to accomplish this is to purchase pre-mixed, water soluble nutrients and mix them into the appropriate water volume suggested by the manufacturer.

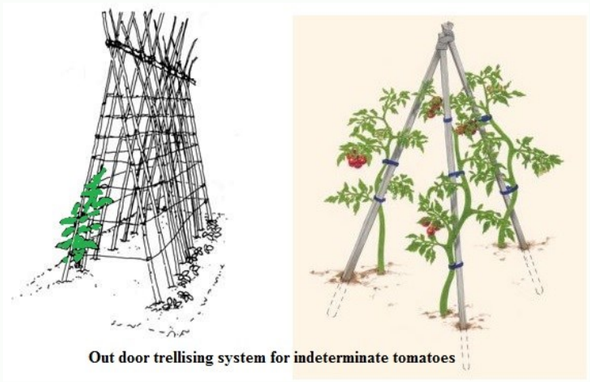
Fertilizer recommendation for hydroponic tomatoes

Nutrient	Growth stage				
	1	2	3	4	5
	Transplant to 1st cluster	1st cluster to 2nd cluster	2nd cluster to 3rd cluster	3rd cluster to 5th cluster	5th cluster to termination
	Final delivered nutrient solution concentration (ppm)				
N	70	80	100	120	150
P	50	50	50	50	50
K	120	120	150	150	200
Ca*	150	150	150	150	150
Mg*	40	40	40	50	50
S*	50	50	50	60	60

* Ca, Mg, and S concentrations may vary depending on Ca and Mg conc. in water and amount of sulfuric acid used for acidification.

Trellising or Providing Support

Tomato plants must be supported, regardless of the growing system. In soil systems, they can either be staked individually or the Florida system can be installed. With the Florida Weave System, two plants are spaced between stakes and supported by nylon string tightly connected to both sides of the stakes and running parallel to the soil surface, at about the 12-inch height. Strings are then repeated about every 8 inches until supporting is complete.



Out door trellising system for indeterminate tomatoes

Soilless systems use a different support system. These systems drop strings from overhead wire done, begin the process when the first suckers are about 2 inches long and continue thereafter as new suckers reach that length. If the suckers become much longer, they are difficult to remove without leaving a wound on the stem. Usually, a plant can be pruned to a two-stem system, although soilless systems are normally pruned to one stem. One-stem plants are desirable when close spacing's are used, but are less necessary with wider spacing's. To develop the two stems, allow the main stem to grow, and then allow the first sucker underneath the first flower cluster to grow. Keep all others removed. This will form a two-stem system and will increase the chances of higher yields.

Pruning

To avoid the spread of diseases from plant to plant, do not use secateurs or a knife, 'pinch out' instead using your thumb and forefinger.

Daily scouting is done for side shoots before they develop into big shoots.

Remove side shoots, laterals, old leaves, diseased leaves & branches and overshadowed lower leaves by hand.

After formation of the first fruit cluster of mature green tomatoes remove all the lower older leaves to allow for ventilation and disperse food to the fruits. (Defoliation) Flowers should be pruned to 5-6 per cluster for medium- large sized fruits.

Bunch Pruning

Bunch pruning is done as required during the twisting and pruning events. It involves the removal of young fruit from the bunch as a technique to maintain optimum plant balance. A good balance for tomato plants would be approximately 20 - 25 fruit to 20 leaves, generally the market requires clusters of 4 to 6 tomatoes with all tomatoes showing a touch of mature colour. The weight of the clusters should be between 454 to 680 grams. Beefsteak tomatoes have heavy fruit, to prevent the cluster stem from linking, an arched plastic support can be placed over the cluster stem.

Pollination

Pollen released without vibrating the flower will not be sufficient to produce high yield of good quality fruit. Natural wind is absent in the greenhouse, tomato growers must pollinate their crop by several means including battery operated vibrators, or blowers.

Fruit Physiological Disorders

There are several physiological disorders which can occur in greenhouse tomatoes. Descriptions of some of the more common disorders follow.

Blossom-end-rot (BER): This disorder appears on the blossom end of the fruit, usually after the fruit is three-fourths to full size. It appears as a light tan, brown or black sunken area. It is not a soft rot, but is a firm, somewhat leathery condition accompanied by a dry rot. BER is caused by a calcium deficiency. It can occur when adequate calcium is present, but conditions exist which reduce its uptake such as an insufficient amount of water in the root zone.

Fruit Cracking: This is one of the more serious problems with greenhouse tomatoes. Cracks radiating from the stem are the most prevalent, but some concentric cracking also occurs. Like blossom end- rot, cracking is associated with water stresses within the plant. Fluctuating water levels within the root system may increase the incidence of cracked fruit. Cracking has also been associated with genetics of the plant. As a result, some recent varieties have been evaluated for crack resistance.

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Rough or Cat faced Fruit:

This problem has been clearly shown to be associated with low temperatures during flower bud development. Greenhouses which have uneven temperatures due to cold spots or sloping elevation that favors colder temperatures at the lower levels will usually have a high percentage of cat faced fruit produced at the lower levels. The shoulders of large- fruited varieties usually are rougher than smaller-fruited varieties.

Blotchy Ripening:

This problem appears as a flattened, blotchy, brownish-gray area on green fruit. As the fruit ripens, these areas may remain gray or turn yellow. Dark brown vascular tissue can be seen in the fruit walls when the fruit is cut. Determining the cause of the problem can be difficult. It may be a result of the many environmental problems already mentioned. In addition, the development of red fruit color is inhibited when temperatures move above 86 degrees during fruit development.

Zipper or Anther Scar:

This vertical scar along the side of the fruit resembles a zipper, or perhaps the type of scar left by stitches. It is caused by the anther sticking to the edge of the ovary (immature fruit). The anther appears to adhere to a higher percentage of the fruit when the greenhouse humidity is excessive, increasing the stickiness of the anther to the fruit. As the fruit increases in size, the anther tears away from the fruit, leaving the scar

Weed Control

Weed control in a soil system is very much like cultivation in the field, because there are no herbicides labeled for greenhouse use. However, fumigation will reduce the requirement for weed control. Cultivation can begin when weeds and grasses are very small, and should be done as shallow as possible to reduce root damage. Cultivation is usually accomplished by running a rototiller between the rows. Soilless systems normally do not require weed control programs because the system itself usually prevents weed growth.

Harvesting

Harvest tomatoes for shipment when the star on the blossom end turns pink. Fruit harvested at this time is red internally and will turn red without treatment with ethylene. Green fruit are usually harvested less frequently than ripe fruit. Tomatoes that are to be sold locally and used immediately can be harvested when vine-ripe.

Sorting and Packing

Tomato fruit should be sorted by size and color to have a uniform pack suitable for various markets. Only one size and color should be placed in a box. This allows buyers to know what they are purchasing and improves a grower's reputation for packing a high-quality product.

Storage

Keep green tomatoes above 13^{0}C until they have ripened. If they are stored at temperatures below 13^{0}C while green, the low temperature deactivates the enzyme responsible for color development.

The salability of the product and reputation of the grower are then reduced. After ripening, tomatoes can be kept 5 to 10 degrees cooler than mentioned above, but the humidity must be high to keep the fruit from swiveling due to water loss.

General Management of pest and diseases

Pests and diseases remain the greatest challenge in Tomato production. Appropriate and timely management makes all the difference between good production, poor production or total crop failure. Proper identification of the pest and disease is critical in a control strategy.

The general principles in pests and disease management include;

- **Practicing crop rotation.** Observe minimum 2 year rotation program
- **Planting resistant varieties** - Use certified disease-free seed treated with an approved fungicide to control seed rots and post emergence damping off
- **Field hygiene**-old crop should be removed from the fields, control weeds and crop debris since these are source of pests and diseases. Staking and pruning are also key to disease incidence reduction
- **Using proper crop production practices** that provide the right growing conditions for plants (sufficient water and balanced fertilization), particularly when crops are young. Strong healthy plants are more likely to withstand pests and diseases.
- **Irrigation management**; poor irrigation timing and scheduling may lead to disease, overhead irrigation in the evenings can encourage early blight.
- **Ensure regular crop scouting** for pest and disease as well as weed and nutrient deficiencies. Proper pest and diseases identification is the first and critical step in their management. This helps to detect problems early and take control measures on time.

NOTE: Use registered products at the recommended rates observing the PHI; Refer to product label.