



Technical Services
TRAINING GUIDE



Tomato & Pepper Production Guide

Deficiencies, Toxicities & Diseases

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Best Production Practices

Germination Time

Germination time is influenced by soil temperature. The optimum temperature range will provide the best germination rates as well as the shortest germination time. Tomatoes and sweet peppers have roughly the same optimal temperature, which is 29 °C (85 °F). Some varieties can take more or less time to germinate.

Table 1. Soil temperature and germination time for tomatoes and peppers

Soil Temperature °C (°F)	10 (50)	15 (59)	20 (68)	Optimal Range		35 (95)
				25 (77)	30 (86)	
Days to emergence						
Sweet peppers	x	25	12	8	8	9
Tomatoes	43	14	8	6	6	9

Data from Oregon State University website.

Hardening

Hardening plants before transplanting in the field (less favorable conditions) is critical to make them more resistant to environmental extremes and maximize their survival.

- Process should be started several days before transplanting to slow plant growth;
- Reduce temperature;
 - » Open the sides of the greenhouse or move the plants outside in a protected, shaded location.
 - » Avoid drastic temperature changes which can induce catfacing of the fruit.
- Reduce watering;
 - » Reduce the amount of water used for irrigation without allowing plants to wilt.

Keep it Clean

Good hygiene practices are the best way to prevent pathogens.

- Weed and pest management;
 - » Some insects can be vectors for pathogens and viruses.
 - » Weeds can act as a reservoir for pathogens.
- All surfaces such as floors and benches should be clean and free of plant debris.
- Reused trays or containers should be emptied, cleaned and sterilized.
- Use an uncontaminated growing media from a reputable manufacturer and never reuse substrate.
- Keep your equipment clean and install hooks to keep your tools off the ground, including hoses.
- Don't bring infected plants into your greenhouse.

Simple and inexpensive steam sterilization technique:

- Items to sterilize are stacked on a bench or on a clean portion of the floor.
- Cover them with tarp.
- Release steam under it.
- Increase temperature to 80-85 °C (176-185 °F).
- Hold for about 30 min.
- Trays are ready to be used.

Hot Water to Manage Pathogens

Using fresh, high quality seeds from a reputable manufacturer is always recommended to avoid the presence of pathogens. If not, sterilizing seeds in hot water may be necessary to eliminate pathogens present on the surface or inside seeds.

- Use a precision water bath and an accurate thermometer;
- Heat must be uniformly distributed throughout the water in the bath (no cold or hot spots);
- Temperature and duration of the treatment varies depending on plant species and on type of pathogen.

Table 2. Guidelines for hot water treatment of seeds

	Water temperature	Duration
Sweet peppers	51.5 °C (125 °F)	30 minutes
Tomatoes	50 °C (122 °F)	25 minutes

Data from Cornell University website

Do not treat seeds that have already been primed (pre-soaked to promote earlier and uniform germination) or chemically-treated. Keep in mind that any treatment done to seeds after purchase may void guarantees from the seed company.

Discarding Infected Plants

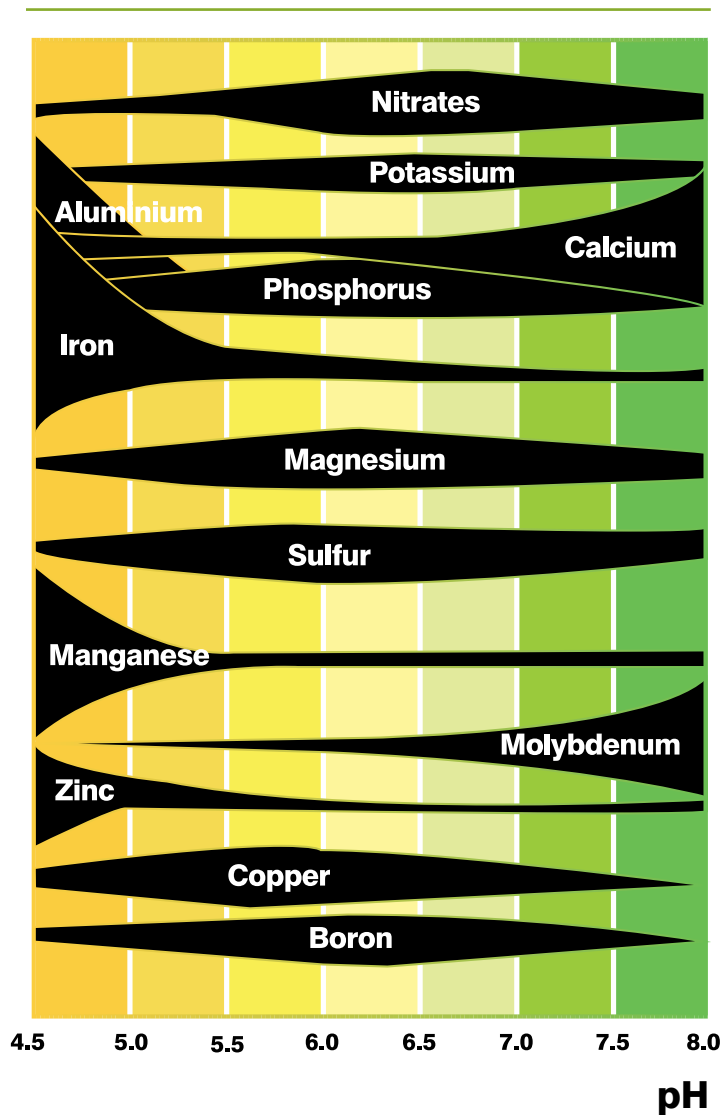
Pathogens can spread easily and can survive in plant debris for prolonged periods of time. If you suspect that a plant is contaminated, here are important precautions that need to be taken to prevent further dispersal of the disease:

- Wash your hands after touching contaminated plants;
- Safely remove a diseased plant;
 - » Cover it with a plastic bag and keep it in the bag while you pull it out.
 - » Avoid excessive manipulations.
 - » Seal the bag.
- Plant debris should not be left on the floor or under benches;
- Discard the plant material appropriately;
 - » Do not pile plant debris near your production.
 - » If needed, burn the infected plants debris (where permitted).

Soil pH and Available Nutrients

Managing soil pH is critical as it has a direct impact on nutrient availability. A nutrient may be present in the soil, but it is unavailable because it is tied up due to the pH. The following diagram gives an overview of the effect of the pH on nutrient availability.

Graphic 1. pH impact on nutrient availability



What can affect soil pH?

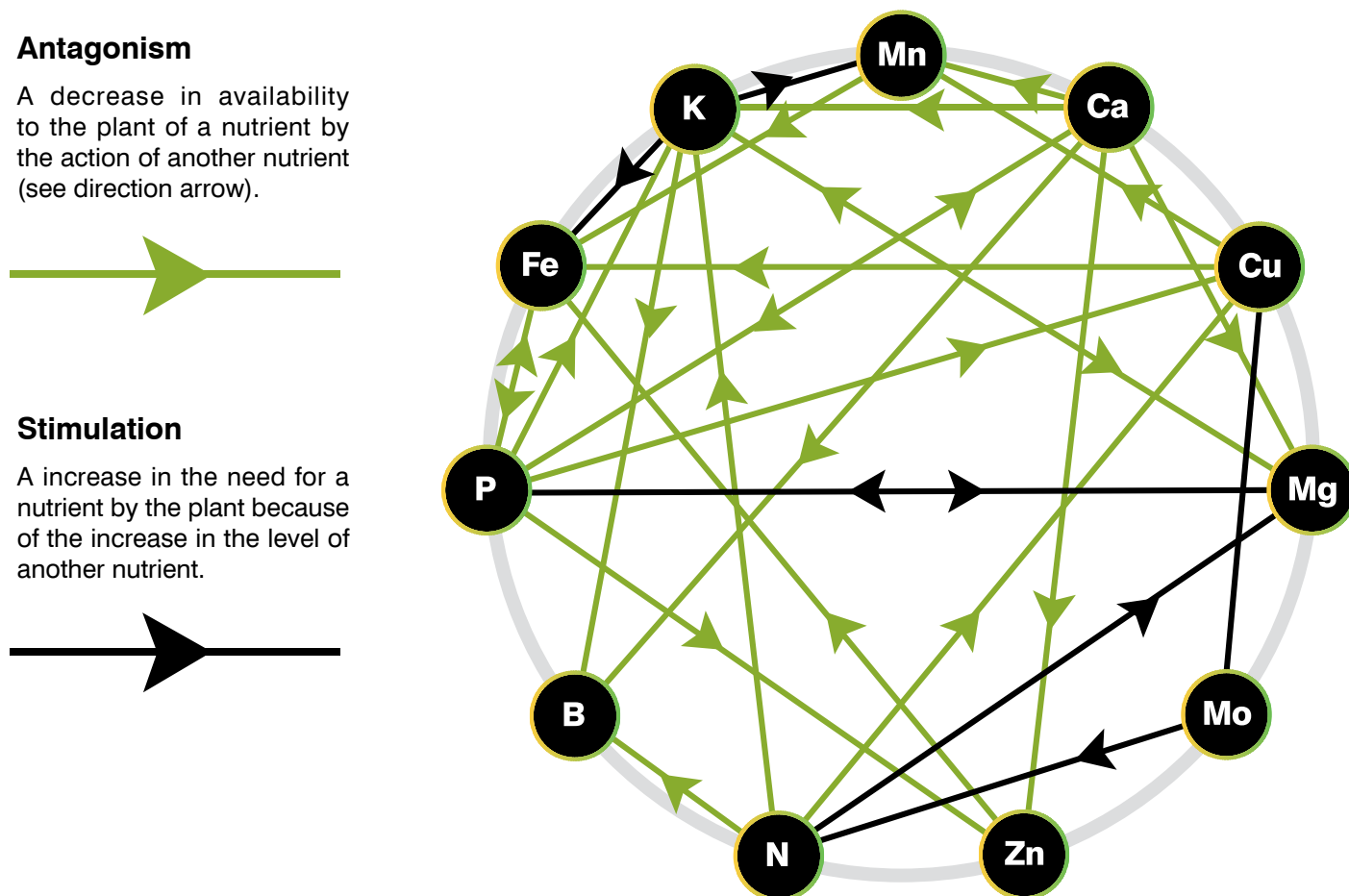
Berger offers high quality mixes with a buffered pH. However, it is the responsibility of the grower to manage the pH throughout the production and make sure it stays within the optimal range. Several factors can have an effect on soil pH:

- Water alkalinity;
 - » Alkalinity is a measure of the capacity of water to neutralize acids.
 - » Water alkalinity fluctuates depending on the water source and climatic events and should be monitored regularly.
 - » The higher the alkalinity, the more the media pH will drift upwards.
 - » Acid injection or acid fertilizers can be used to counteract this effect.
- Fertilizers;
 - » Fertilizers can increase or decrease the media pH.
 - » The potential to modify the pH is expressed in calcium carbonate equivalents (CCE) of acidity or basicity per unit weight of fertilizer.
 - Information can be found on the fertilizer packaging.
 - » Fertilizers should be chosen wisely in order to minimize pH drift in media.

Interactions between Nutrients

The pH of the soil is not the only thing that can affect nutrient availability: nutrients also interact with each other in the soil which can make them more or less available to plants. The Mulder Chart (see below) illustrates the interactions between nutrients.

Graphic 2. Nutrients interactions



Nutrient Deficiencies & Toxicities

K

Deficiency Symptoms



<http://www.yara.us/agriculture/crops/tomato/crop-nutrition/deficiencies/k/01-10018-potassium-deficiency---tomato/>

<http://www.tomatogrowing.co.uk/newsletter/tomato-leaves-and-nutrient-deficiencies/>

http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{9098AC88-7BA4-490A-9646-2CA80EFF5DA3}

Potassium Deficiency:

- Initially, leaves appear darker than usual.
- Eventually, margins of older (lower) leaves become yellow, progressing up the plant.
- Yellowing appears between the veins which remain green.
- Leaves will tend to curl and may develop necrotic spots.
- Young leaves will only show symptoms in case of severe deficiency.
- Yellowing is irreversible.
- May look like magnesium deficiency.

Potassium Toxicity:

- Young leaves wilt.
- Can induce Ca or Mg deficiencies and salts damage.

N

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{9FA58ABD-1330-401E-A26F-93596DA81BC6}

Nitrogen Deficiency:

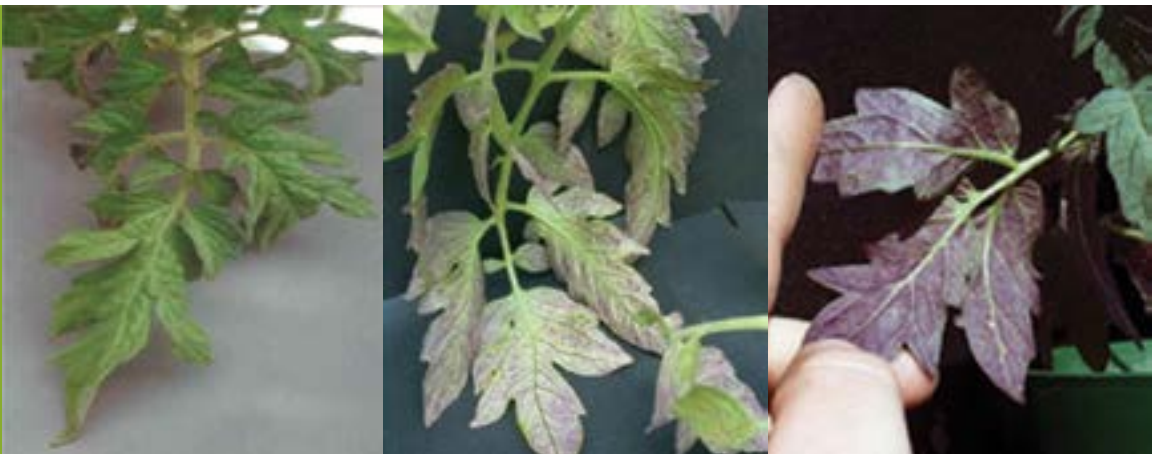
- Generalized, uniform yellowing over the entire leaves.
 - » Gradual effect that starts with the lower (older) leaves.
 - » Begins with a light green.
 - » Can reach a yellowish-white color in case of extreme deficiencies.
- Occasionally, a light red tint on the veins and petioles.
- Recovery is very quick when nitrogen is supplied.

Nitrogen Toxicity:

- Plants will grow big and leafy.
- Produce few if any fruits.
- Leaves edges may burn and crack.

P

Deficiency Symptoms



<http://people.umass.edu/psoil120/manual/lab7.html>

Phosphorus Deficiency:

- Difficult to identify.
- Plants appear stunted and much younger than they actually are.
- A distinct purple tint may appear on the stem, the petioles and the underside of the leaves.

Phosphorus Toxicity:

- Slow plant growth with several symptoms related to Zn deficiency.
- Leaves become yellow and may appear shorter but thicker.
- Plants can have a burned appearance, with large sections of the leaves turning light brown.

Ca

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{CD505A53-FF54-4723-AAA9-0A4102283BA9}

<http://gardening.stackexchange.com/questions/7877/why-are-my-chilli-pepper-leaves-curling-and-new-flowers-are-falling-off>

Calcium Deficiency:

- Stunted growth.
- Small internodes.
- Lack of turgor.
- Leaves misshapen and show necrosis around the base.
- Plants have an increased tendency to wilt.

Calcium Toxicity:

- No visual effects.
- Decreased magnesium and potassium absorption (Mg and K deficiencies).

Mg

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{A4E97D29-7746-4CCA-B67D-14A77A97A826}

http://vegetablemdonline.ppath.cornell.edu/PhotoPages/Impt_Diseases/Tomato/Tom_Magnesium.htm

<https://extension.tennessee.edu/Grainger/Pages/Tomato-Disease-and-Insect-ID-.aspx>

Magnesium Deficiency:

- Yellowing between the veins starting on older leaves first.
- Veins remain green.
- Raised puckered surface between veins, the top of which become progressively necrotic.
- May look like potassium deficiency.

Magnesium Toxicity:

- No visual effects.
- Decreased potassium and calcium absorption (K and Ca deficiencies).

S

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{62EFEBD2-0308-46D3-A77F-6A94EB008C78}

[http://psstaging3.psssoftware.com/portals/0/images/tom/Sulfur\(S\)_Deficiency-41.jpg](http://psstaging3.psssoftware.com/portals/0/images/tom/Sulfur(S)_Deficiency-41.jpg)

Sulfur Deficiency:

- Uniform yellowing of the plant beginning on the youngest leaves.
- Veins and petioles became a reddish color.
- Looks like nitrogen deficiency.

Sulfur Toxicity:

- Very rare.
- May occur if excessive sulfuric acid is injected to neutralize water alkalinity.
- No visual effects.
- Will reduce nitrogen availability (N deficiency).

Zn

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{2F8FBEB6-D2D1-42A1-A01A-956B741717D4}

<http://www.yara.co.nz/images/585-14902410521-zinc%20deficiency%20-%20tomato-main%20image.JPEG>

Zinc Deficiency:

- Acute stunting of seedlings.
- Initial symptoms.
 - » Thickening of the leaves.
 - » Yellowing of the margin and between the veins.
 - » Starts with the younger leaves.
 - » Veins remain green.
- Looks like phosphorus toxicity.

Zinc Toxicity:

- Plants are smaller.
- Roots are less developed.
- Leaves become yellow in between the veins and necrotic over time.

Fe

Deficiency Symptoms



<http://www.insectimages.org/browse/detail.cfm?imgnum=1572047>

[http://psstaging3.psssoftware.com/portals/0/images/tom/Iron\(Fe\)_Deficiency-27.jpg](http://psstaging3.psssoftware.com/portals/0/images/tom/Iron(Fe)_Deficiency-27.jpg)

Iron Deficiency:

- Earliest symptoms
 - » Yellowing between the veins of the youngest leaves.
 - » May end up looking bleached.
 - » Starts from the base of the leaves.
- Upon Fe fertilization, veins will quickly become green again but tissue between them will take longer to recover.
- May look like Roundup injury.

Iron Toxicity:

- Normally related to the pH (too low).
- Reduces availability of zinc (Zn deficiency).

Mn

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{D1921410-DEC0-413D-A9FA-E22ED3C064D1}

<https://www.agric.wa.gov.au/vegetables/manganese-deficiency-vegetables>

Manganese Deficiency:

- Early symptoms look like iron deficiency.
 - » Light yellowing between the veins of the younger leaves.
- Severe deficiencies.
 - » Gray metallic tint or a purplish luster on the leaves.
 - » Dark freckles along the veins.

Manganese Toxicity:

- Beginning on older foliage, leaf veins become darker.
- Leaves edges or tips may become necrotic.
- Reduces availability of calcium (Ca deficiency).

Cu

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{61CA1AB4-3394-44B0-B560-257A52296FA2}

[http://psstaging3.psssoftware.com/portals/0/images/tom/Copper\(Cu\)_Deficiency-19.jpg](http://psstaging3.psssoftware.com/portals/0/images/tom/Copper(Cu)_Deficiency-19.jpg)

Copper Deficiency:

- Leaves are curled and petioles are bent downward.
- Young leaves look slightly wilted.
- Some leaves may show bleached to whitish gray areas.

Copper Toxicity:

- Damage to the root system.
- Low shoot vigor.
- Reduces iron availability (Fe deficiency).

B

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{65F189CC-ABC7-45B2-950C-823C8C390FEA}

<http://psstaging3.psssoftware.com/MainPage/tabid/55/Page/Tomatoe-Photos/Default.aspx>

Boron Deficiency:

- Slight general yellowing.
- May look like nitrogen deficiency.
- Leaves and stems look brittle.

Boron Toxicity:

- Reduced vigor.
- Retarded development.
- Leaf burn (yellowing and necrotic patches on older leaves).

Mo

Deficiency Symptoms



http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/#{85431F47-75EF-4605-921A-C2690312B6E4}

[http://psstaging3.pssftware.com/portals/0/images/tom/Molybdenum\(Mo\)_Deficiency-33.jpg](http://psstaging3.pssftware.com/portals/0/images/tom/Molybdenum(Mo)_Deficiency-33.jpg)

Molybdenum Deficiency:

- Early symptoms look like nitrogen deficiency.
- Severe deficiencies cause some mottled spotting.

Molybdenum Toxicity:

- Characteristic orange coloration of leaves.
- Yellowing and browning of the leaves.

Insect Pests

Cutworms Noctuidae species



<https://news.uns.purdue.edu/images/2013/krupke-cutworm.jpg>

Symptoms

- Young plants are cut down just above the soil surface.
- Damage are usually worst in the wet areas or at the margins of the field.

Description of the worm

- Always smooth skinned.
- 1-2 inches long.
- Curl up when disturbed.
- Can have various colors and patterns.
- Hides in the ground during the day and feeds at night.

How to confirm the presence of this pest

- Look for the worms on the soil at night or early at dawn.

Control

- For fields with a history of cutworm problems, use a preventive insecticide.
- If more than 5% of the seedlings have been attacked, use directed sprays for cutworm control.
 - » Sprays should always be applied at the end of the day, when the worms become active.

Fungus gnats *Orfelia* and *Bradysia* species



<http://www.viette.com/v.php?pg=978>

http://www.thestar.com/life/2014/11/08/the_little_worms_that_promise_to_rid_your_home_of_fungus_gnats.html

Symptoms

- Small dark insects flying around the plants and near the substrate.
- Stunted plant growth.
- Death of seedlings.
- Adults carry pathogens such as the fungus *pythium* sp.

Description of the insect

- Dark and delicate.
- Characteristic “Y” shaped vein on the wing.
- Adults are about 2.5 mm in length.
- Weak flyer (erratic flight).
- Larvae: clear and measure 3-4 mm.
 - » Feed on fungus and roots in the upper portion of the soil.

How to confirm the presence of this pest

- Use yellow sticky cards.
- Place a piece of potato on the surface of the soil.

Control

- Numerous sticky cards.
- Biological control for larvae: soil bacterium *Bacillus thuringiensis* subspecies *israelensis* (*Bti*).
- Top dressing with diatomaceous earth.
- Pesticides: can be used to kill the adults, but they may not kill the larvae.
- Prevention: allow the top layer of the substrate to dry between irrigations.

Leaf borer *Liriomyza sativae* and *Liriomyza trifolii*



http://210.69.150.201/insectsite/_Data/OriginalPicture/20060127130916/20060127131251/200602151534082.jpg

<http://ephytia.inra.fr/fr/I/6086/Tomate-mineuse-tomate-DB-294>

Symptoms

- Flies lay their eggs inside the leaves.
- Larvae feed in between the two surfaces of the leaf and produce long tunnels.
- Leave thin white serpentine trails on the leaves, with increased width toward the end.
- The larvae and their fecal deposits can be seen through the leaf.
- Small leaves have large, whitish blotches.
- Injured leaves may fall.

Description of the insect

- Small black and yellow flies.
- Adults are 1.5 to 2 mm in length.
- Larvae: yellowish and measure around 2 mm.

How to confirm the presence of this pest

- Look for mines on the leaves.
- Use sticky card to detect the presence of adult flies.
- In mature plants, plastic trays under the foliage during a couple of days will catch the falling pupate.

Control

- Take off infected leaves.
- Biological control: parasitic wasps like *Chrysocharis parksi* and *Diglyphus begini*.
- Insecticides: can be successful, but this pest has acquired resistance to several chemicals.
- Prevention: tomato varieties with curled leaves are less susceptible to this pest.

Nematodes *Meloidogyne incognita*



https://upload.wikimedia.org/wikipedia/commons/b/b2/CSIRO_ScienceImage_2818_Group_of_Nematodes.jpg

https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/images/pepper_root_knot.jpg

Symptoms

- Root damage, with galls or knots along the roots.
- Galls become infected by fungus and/or bacteria.
- Non-specific poor growth appearance.
- Plants do not respond to fertilizer applications.

Description of the pest

- Microscopic roundworms.
- Eggs are laid on the surface of the galls.

How to confirm the presence of this pest

- Look for galls on the roots.

Control

- Chemical: Non-Fumigant and fumigant nematicides can be used in certain areas.
- Biological: Currently, there aren't any effective commercial biological control agents.
- Prevention: some sweet pepper varieties are resistant to this pest.
- Prevention: Avoid contaminated water, soil, machinery, shoes, etc.

Red Spider mite *Tetranychus urticae* & *Tetranychus cinnabarinus*



[https://commons.wikimedia.org/wiki/File:Tetranychus_urticae_on_sweet_pepper,_Bonenspintmijt_op_paprika_\(2\).jpg](https://commons.wikimedia.org/wiki/File:Tetranychus_urticae_on_sweet_pepper,_Bonenspintmijt_op_paprika_(2).jpg)
<http://www.maine.gov/dacf/php/gotpests/bugs/images/spider-mites/spider-mites-big.jpg>

Symptoms

- Numerous tiny pale dots on leaves.
- Affected leaves eventually become gray or yellow and die.
- Webs around the stem or other parts of the plant.
- Plants can die quite rapidly.

Description of the insect

- Very small (0.3-0.5 mm).
- Yellow or green with two darker spots on its back.
- Thrive in hot and dry weather.
- Become orange-red as winter approaches (hence their name).

How to confirm the presence of this pest

- Put a white sheet of paper under a branch or a leaf and shake the plant to see if mites fall on it.
- To differentiate plant-feeding and predatory mites: crush them under a finger in a streaking motion. Plant-feeding mites produce a green streak on a white paper while predatory mites produce a yellow or orange streak.

Control

- Biological controls: lacewings, ladybeetles and predatory mites (be sure to select a species that is appropriate for your culture).
- Insecticidal soaps and oils: can be effective.
- Chemical miticides: effective if you select a product labelled as “miticide”. Spider mites are usually resistant to normal chemical insecticides.
- Mites population eventually become resistant to most chemicals after a couple of years.
- Prevention: Some varieties are more resistant to this pest (ex: Beaufort tomato).

Broad mite *Polyphagotarsonemus latus*



<http://www.forestryimages.org/browse/detail.cfm?imgnum=1576076>

Courtesy, Erbe, Pooley: USDA, ARS, EMU. «All of the micrographs on the web site are in the public domain and can be freely used.» --Christopher Pooley.

Symptoms

- Has a toxic saliva that causes a lot of damages to several plant species.
- Twisted, hardened and distorted growth of the newest leaves.
- Leaves turn downward and may become copper or slightly purple.
- Stunted growth.
- Symptoms look like damages caused by herbicides.

Description of the pest

- Microscopic mite (0.1-0.2 mm) with light yellow, green or amber oval bodies.
- Extremely short life cycle (4-10 days depending on the temperature).
- Can use other insects such as whiteflies to “hitchhike” from plant to plant.

How to confirm the presence of this pest

- Look for symptoms first.
- With a magnifying glass, look for mites on the underside of the leaves.

Control

- Numerous chemical products available.
- Insecticidal oils or soaps are often as effective as chemicals.
- Biological controls: predatory mites.
- To kill the mites on one plant: lower the plant into a hot water bath (110-120 °F or 43-49 °C) for 15 minutes.

Potato psyllid *Bactericera cockerelli* (or *Paratrioza cockerelli*)



<http://entoweb.okstate.edu/ddd/insects/potatopsyllid.htm>

Symptoms

- Both adult and nymph feed on leaves, piercing and sucking their surface.
- Release a toxin while feeding.
- Leaves become curled and yellow (sometimes purple).
- Reduced yield or plant death.
- Transmit the bacteria *Candidatus Liberibacter solanacearum*.
- If infected by bacteria transmitted by this pest: stunted growth and their yield can be decreased up to 60%.

Description of the insect

- Very small (about 2 mm).
- Transparent wings and golden or darker bodies with clear patterns.
- Look similar to aphids, but lack the cornicles.
- Nymphs: very small, green, flattened and look like little scales.

How to confirm the presence of this pest

- Monitor the adults with traps.
- Look under the leaves for nymphs.

Control

- Different chemical pesticide options are possible.
- Biological controls: green lacewings, ladybird and others.

Aphids *Aphis gossypii*, *Aulacorthum solani*, *Macrosiphum euphorbiae*, *Myzus persicae*



<http://gipcitricos.ivia.es/wp-content/uploads/2010/07/Foto-23.jpg>

<http://www.omafra.gov.on.ca/english/crops/facts/06-081.htm>

Symptoms

- Leaves curl downward, wilt and become yellow.
- Distorted young shoots and leaves.
- Leaves become shiny and sticky because of a substance secreted by aphids, called honeydew.
- Honeydew attract ants and other pests and may cause fungus development.
- Rarely lethal for the plant, but induce stunted growth and decrease quality and number of fruits.
- Can transmit several viruses to plants.

Description of the insect

- Very small (1-3 mm long).
- Pear-shaped insects with long legs and antennae.
- Usually green but some species can be brown, black or red.
- Have two tube-like structures called cornicles at the end of their abdomen.
- When populations become very dense, winged individuals can develop.

How to confirm the presence of this pest

- Visual observation of the plants.
- Look closely at the underside of the leaves.
- Sticky card can be used to monitor winged aphids, but they are less frequent than wingless ones.

Control

- Biological controls: the most common are parasitic wasps, predatory midges and ladybeetles.
- Chemicals.

Whiteflies *Bemisia tabaci* and *Trialeurodes vaporariorum*



<https://news.uns.purdue.edu/images/+2007/egel-whitefly.jpg>

<http://www.ediblearoids.org/portals/0/taropest/lucidkey/taropest/media/Html/Arthropods/Btabaci/Btabaci6.htm>

Symptoms

- Both the adult and the larva feed on plant sap and excrete honeydew.
- Honeydew increases fungus infections.
- Stunting, yellowing and seedling death.
- Leaves may become shiny and sticky because of honeydew.
- Can transmit several viruses to plants.

Description of the insect

- Two species are called whiteflies and are really similar.
- Both have four white wings and a yellowish body.
- Measure around 1.5 mm in length.
- Larvae: thin, flat, elliptical, yellow or green and mostly found under the leaves.

How to confirm the presence of this pest

- Look under the leaves for flies and larvae.
- Use sticky card to monitor adults.

Control

- Biological controls: parasitoids like *Encarsia* and *Eretmocerus*, lacewings (*Chrysoperla*), minute pirate bugs (*Orius* sp.), bigeyed bugs (*Geocoris* sp.) and some coccinelids (*Delphastus catalinae*).
- Insecticides: effective, but several application are needed and results may be deceiving.
- Has developed resistance to several chemicals.

Diseases (Fungal, Bacterial & viral)

Fungal Diseases

Fungal disease can be caused by various pathogens. Although they have different effects on crops, they are propagated in a similar manner. Moreover, the prevention and treatment solutions are also comparable.

Propagation

- Infected seeds.
- Infected crop debris.
- Contaminated water.
- Contaminated equipment (tools, machinery, racks, hoses, trays, stakes, etc.).
- Dirty hands or clothing .
- Splashing water (i.e. rain or overhead irrigation).
- In some cases by wind or insects.

Prevention

- Use sterile containers and tools.
- Use clean water and high quality growing media.
- Avoid compacting soil and very damp conditions (overwatering).
- Increase air circulation.
- Apply preventive fungicide treatments.

Treatment

- Remove infected plants, in some cases adjacent plants, and destroy them.
- Do not put infected plants debris in compost.
- Do not reuse substrate.
- Wash your hands and tools before touching healthy plants.

Bacterial Infections

Bacterial infections occur less often than fungal infections, but their effects are more devastating. Although symptoms are different from one bacterial pathogen to the other, they are propagated in a similar manner. Moreover, preventive measures and treatment strategies are similar.

Propagation

- Comes from infected seeds, infected plant debris, contaminated equipment (tools, machinery, racks, hoses, trays, stakes, etc.) and/or contaminated water.
- Propagates via wounds and splashing water (i.e. rain or overhead irrigation).

Prevention

- Remove all plant debris from the previous crop productions.
- Sanitize greenhouse between productions.
- Use seeds that are pathogen-free.
- Use sterile containers and tools.
- Use clean water.
- Use high quality growing media.
- Limit manipulations when plants are wet.
- Apply preventive copper treatments.

Treatment

- Immediately remove all infected and adjacent plants including the growing media.
- Be careful not to break or damage infected plants inside the greenhouse.
- Sanitize tools and machinery.
- Wash hands and change clothes before handling healthy plants.
- Disinfect the area surrounding infected plants.
- Use a copper treatment or products like AgriPhage.

Viral Infections

Viruses are less frequent at the seedling stage, but can still be a problem. They are mostly transmitted by insects, so a good pest management is the first step towards preventing viral infections. Once some plants are infected, it can spread via contaminated equipment (tools, machinery, racks, hoses, trays, stakes, etc.), therefore infected plant material should be discarded immediately. Some viruses can be seed borne, so using seeds that are certified pathogen-free will limit the risk of infection.

Damping off or seedling blight Fungus (several species)



<http://www.omafra.gov.on.ca/IPM/english/peppers/diseases-and-disorders/damping-off.html>

Symptoms

- Seedlings look like they have been pinched or cut at the base of the stem.
- Dark and shriveled portion at the soil line.
- Affected plants wilt, fall over and die.
- White mold can appear on the substrate and on dead plants.
- Before emergence: the seed or seedling rots in the soil.

Prevention

- Keep temperature steady.
- Keep the soil surface as dry as possible.
 - » Sub-irrigation.
 - » Top dress with a thin layer of perlite.
- Apply preventive fungicide treatments.

Root rot Fungus (several species)



http://msue.anr.msu.edu/news/how_to_spot_and_stop_diseases_on_greenhouse_tomato_seedlings

<http://www.growgardentomatoes.com/root-rot.html>

Symptoms

- Seedling are stunted and yellowing, and will wilt and die.
- Seedling lose their “seed leaves” (cotyledons) prematurely.
- Growth is uneven over a single tray.
- Roots will rot, looking brown-black.

Septoria leaf spot Fungus (*Septoria lycopersici*)



<http://www.ipm.iastate.edu/ipm/info/files/images/plantdisease/12/26.jpg>

<http://umaine.edu/ipm/ipddl/plant-disease-images/septoria-leaf-spot-images/>

Symptoms

- Numerous small circular spots which usually appear on the lowest leaves first.
- Spots have a tan or grey center with small raised structures visible upon close examination.
- If lesions are very numerous, the leaf will turn yellow or brown and wither.
- More frequent in mature plants.

Prevention

- Do not use overhead watering.
- Control weeds, as they can transmit the disease.
- Apply preventive fungicide treatments (chlorothalonil or mancozeb).

Treatment

- If the infection is caught early on mature plants, affected leaves can be removed and destroyed.
- Use fungicides sprays to prevent new infections.

Verticillium wilt Fungus (*Verticillium dahlia*)



http://www.uky.edu/Ag/kpn/kpn_09/Images/071409%20Hartman%20Catalpa%20Verticillium%20wilt%20on%20lvs.JPG

<http://www.omafr.gov.on.ca/IPM/french/tomatoes/test-your-knowledge/question-three.html>

Symptoms

- Characteristic V shaped lesions that begin on the margin of the leaves.
- Lesions start yellow and affect the lower leaves first.
- Infected leaves go from yellow to brown and eventually die.
- Seedlings will wilt and die quickly.

Prevention

- Use resistant varieties.
- Control weeds; they can be vectors of the disease.

Bacterial leaf spot (BLS) Bacteria *Xanthomonas* spp



<http://www.apsnet.org/edcenter/intropp/lessons/prokaryotes/Pages/Bacterialspot.aspx>

<https://negreenhouseupdate.info/photos/bacterial-leaf-spot-xanthomonas-campestris-pepper-0>

Symptoms

- Begins with small yellow-green lesion on young leaves, which appear deformed and twisted, or with dark, water soaked and grease looking lesions on older leaves.
- Lesions grow rapidly and become brownish.
- Margins of lesions follow the veins of the leaves, giving an angular shape to the spots.
- Spots tend to be more numerous at the tip and margin of the leaf.
- On seedlings, it is very hard to distinguish from bacterial speck.

Bacterial speck *Bacteria Pseudomonas syringae*



<http://www.uaex.edu/yard-garden/resource-library/diseases/tomato/>

<http://www.insectimages.org/browse/detail.cfm?imgnum=1440021>

Propagation

- Infection is favored by wet and cold weather.
- This pathogen can survive up to 20 years on tomato seeds.

Symptoms

- Brown-black leaf spots, which are often surrounded by a yellow or gold ring.
- The lesions occur on leaves, stems and branches, but are often concentrated on leaf margin which cause marginal necrosis.
- Lesions stop growing during hot weather.
- There is stunting and yield loss.
- On seedlings, it is very hard to distinguish from bacterial spot.

Treatment

- Apply copper treatment at first signs of infection.
- Stop using sprinkler irrigation.

Prevention

- Use speck resistant varieties.
- Avoid exposure to cold and wet conditions.
- Use sub-irrigation.

Bacterial canker *Bacteria Clavibacter michiganensis* spp *michiganensis*



<http://u.osu.edu/hightunneldiseasefacts/tomato-diseases/bacterial-canker/advanced/>

Symptoms

- Seedlings develop cream or white raised blisters or small pustules on leaves and stems, which resemble oedema.
- On older plants, these water-soaked areas will develop into yellow-brown to brown necrotic areas, which may look like sunburn.
- The leaf edges become brown-black, with minimal spotting in the middle of the leaf.
- Infected plants are stunted and may begin to wilt.
- As the incubation period is long, infected seedling may not show any symptoms until a couple of weeks after having been transplanted.

Treatment

- Copper can be used to reduce spreading but is ineffective for controlling this issue.

Prevention

- Using varieties that are resistant to bacterial canker.
- Seedlings should be examined often for symptoms.
- Apply preventive treatments of Cyclone or Kasumin.

Bacterial wilt *Bacteria Ralstonia solanacearum*



<http://www.plantmanagementnetwork.org/elements/view.aspx?ID=4418>

<http://bugwoodcloud.org/images/768x512/1234079.jpg>

Propagation

- Enters via the roots or via small wounds on the plants.

Symptoms

- Soilborne bacteria.
- Sudden wilting without yellowing.
- Seedlings die within a couple of weeks.

Prevention

- Avoid over watering and very humid conditions.
- Make sure seedlings get enough calcium (calcium deficiencies increase sensitivity to bacterial wilt).



Simple detection method for bacterial infections:



http://wiki.bugwood.org/Bacterial_streaming

<http://ncsupdicblog.blogspot.ca/2011/07/my-tomato-plants-are-wilting-and-then.html>

1

Cut the stem of a suspicious branch or leaf and place it in a glass of clear water.

2

If it is a bacterial infection, a milky white cloud will come out from the cut end.

Tomato spotted wilt virus (TSWV)



<https://www.ces.ncsu.edu/wp-content/uploads/2013/05/TSWVCU.jpg>
<http://www.forestryimages.org/browse/detail.cfm?imgnum=1573187>

Propagation

- Thrips (*Frankliniella occidentalis*).

Symptoms

- Tomato:
 - » Young leaves exhibit bronzing of the upper side, show small dark-brown spots or rings and will eventually die.
 - » Dark brown streaks may appear on stems and petioles.
 - » The plant may be stunted or exhibit only one-sided growth.
- Sweet pepper:
 - » The seedling may be stunted.
 - » The leaves are stunted with necrotic spots or rings.
 - » Young leaves suddenly become yellow, then brown and eventually necrotic.
 - » Long necrotic streaks appear on stems and extend up to the growing tips.
 - » Infected leaves will develop a bronze appearance.

Treatment

- Take actions to control thrips.

Prevention

- Manage thrips populations.
- Drench seedling with Actigard and/or an insecticide.

Tomato yellow leaf curl virus (TYLCV)



<http://colgateimmunology.blogspot.ca/2013/04/whos-reponsible.html>

<http://www.forestryimages.org/browse/detail.cfm?imgnum=5411489>

Transmitted by:

- Silverleaf whitefly (*Bemisia tabaci*).

Symptoms

- Yellow leaf edges with upward or inward leaf cupping.
- Plants will be stunted and have reduced leaf size.
- Symptoms may not show up in seedlings, as the incubation period is about 3 weeks.
- Can affect both tomato and pepper.

Treatment

- Take action to control silverleaf whitefly populations.

Prevention

- Apply a preventive insecticide treatment (imidacloprid).
- Monitor whitefly population.



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