

Managing Tomato Diseases Successfully

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There are several diseases affecting tomato caused by fungi, oomycetes, bacteria, viruses, and nematodes. Occurrence varies farm to farm because some pathogens are not ubiquitous, reflecting their inability to spread far, and environmental conditions are not uniformly favorable.

1. Know what diseases have and could occur on your farm. Understand important aspects of each of these pathogen's life cycle, including potential sources, how spreads and survives, and favorable conditions. See photographs and information in tomato factsheets.
2. Select resistant varieties.
3. Purchase seed that has been tested for pathogens that can be seed-borne. Tomato seed can be treated with hot water which is especially useful for bacterial pathogens which can be inside seed. Some seed companies treat seed with hot water or steam. Trisodium phosphate is common treatment for virus.
4. Control potential sources of pathogens and their spread in the greenhouse where transplants are grown, and avoid favorable conditions for disease development. Thoroughly clean and disinfect all surfaces. Do not reuse trays following outbreak of bacterial disease. Do not grow ornamental plants in the same greenhouse as tomato seedlings and manage weeds and thrips; these other plants can harbor viruses, notably tospoviruses, which thrips vector. Water during the day when foliage is dry and will quickly dry afterwards (morning is best); some pathogens are dispersed by splashing water and infect while the leaf surface is wet. Adjust amount of water based on conditions (cloudiness and temperature) and plant size (need for water can vary substantially from day to day); soil mix that stays wet for prolonged period promotes root rot and slows seedling growth. Use fans to reduce humidity. Minimize handling of plants. Brushing to obtain short plants with thick stems is a great way to spread pathogens, especially bacteria. Inspect plants at least once a week for disease symptoms; obtain diagnosis if not positive about the cause; and discard trays with seedlings confirmed to be diseased. When transplants will be grown by someone else, discuss their disease management plan in advance.
5. Apply fungicides in the greenhouse based on past occurrences of disease. Starting before symptoms develop is important to successful management of bacterial diseases. Diseases starting on seedlings are difficult to manage.
6. Power wash dirt off tomato stakes and then disinfect before re-using. This is especially important for bacterial pathogens. Power washing wooden stakes is not sufficient to remove bacteria because they can be in the small spaces of wood. Washing is important because soil interferes with disinfecting. Disinfect them with a quaternary ammonia product (best) or 10% bleach solution. Make sure stakes are completely submerged and not tightly bundled. Soak for at least 20 minutes. Where bacterial canker developed it is recommended that the stakes be disposed of because it is difficult to eliminate all the bacteria by disinfecting contaminated stakes, and canker is more difficult to manage than other bacterial diseases.
7. Select a field where tomatoes were not grown for at least 2 years (3 years when canker occurred), trees or buildings will not create shade, and water drainage and air flow are good.

8. Promote dry foliage by orienting rows parallel to the prevailing wind direction, trellising, and using drip rather than overhead irrigation. If drip is not an option, overhead irrigate when foliage is dry and there will be time for it to dry before night.
9. Inspect plants at least once a week for disease symptoms; obtain diagnosis if not sure of cause. Promptly report suspect occurrences of late blight to extension specialist.
10. Check the USABlight website weekly for information about late blight occurrences.
11. Apply fungicides in the field based on past occurrences of disease and observed symptoms. See additional information below.
12. Avoid moving pathogens on equipment and hands. Especially important with bacterial pathogens to work progressively from least to most affected plants. Workers should periodically wash hands or change gloves.
13. Destroy crop debris promptly after harvest. Chop debris well and incorporate into soil to hasten decomposition. Removing debris with canker from the field is worthwhile when feasible.

Using fungicides to manage tomato diseases. Accurate disease identification is important because the most effective fungicides, especially among conventional products, often have targeted activity, which may be limited to one disease. Also, some diseases (and not just those caused by viruses) plus disorders (which can be mistaken for a disease) are not affected by any fungicide.

Application timing can be at least as important as the products used. A program will be more effective when started as soon as first symptoms are seen or before. This is because very few fungicides (and only conventional ones) have curative (kickback) activity, and curative activity is effective only on very recent infections. It typically takes about a week from infection until symptoms are visible for most diseases caused by fungi and bacteria. At this point the pathogen is established and not only cannot be killed by the fungicide, but will continue producing more inoculum for additional infections. Most fungicides act on pathogens to prevent infection. Some diseases, in particular late blight and those caused by bacteria, are notoriously difficult to suppress on susceptible varieties without a preventive program. It is also important to start applications before disease onset with fungicides that activate the plant's defenses (systemic acquired resistance = SAR and induced systemic resistance = ISR), which include Actigard, LifeGard, phosphorous acids, Regalia, and most biopesticides with *Bacillus* spp. as the active ingredient.

Appropriate timing of successive applications in a fungicide program is also important. Calendar-based scheduling (e.g. 7-day spray interval) often is used. However, the impact of environmental conditions on fungicide and the pathogen that determines when another application is needed. Rain (and irrigation) can remove some residue from plant tissue, more so with contact products than those that are mobile and move into plant tissue. Two inches of water is considered the amount that will remove residue of most contact fungicides. Fungicide formulations often include spreaders and stickers to minimize wash-off, or penetrants to facilitate uptake of mobile products. Sometimes the manufacturer of a fungicide will recommend that an adjuvant be used to improve control. This will be stated in the use directions.

Environmental conditions also affect the pathogen's activity. Most fungal and bacterial pathogens need free moisture on leaves lasting a long enough period of time that they can complete the infection period. Some can infect when humidity is high (typically above 90%). The amount of time needed depends on the pathogen and on the temperature. The optimum temperature for development varies among pathogens. Powdery mildew fungi, including the one that is a pathogen on tomato, are exceptions and prefer dry conditions. Forecasting programs

have been developed for some diseases, including early blight, Septoria leaf spot, and anthracnose (TOM-CAST) and late blight (Cornell Decision Support System) of tomato. These programs can be run for a particular crop using data from a near-by weather station that is part of NEWA (Network for Environment and Weather Applications). They are accessible through <http://newa.cornell.edu/> under 'Crop Pages'. When a fungicide application is warranted is determined based on susceptibility of the variety and temperature plus moisture data since the last application (or since planting for the first application) and forecast conditions.

Environmental conditions during and after an application can also impact fungicide efficacy. If leaves are wet from dew or rain when an application is made, some product may run off leaves. Some product can also be lost if rain or dew occurs before the spray residue has completely dried, necessitating making another application soon to maintain control. Products differ in rainfastness, which is the time needed for a pesticide to dry sufficiently that rain or irrigation will not affect efficacy. The rainfastness of a product often is included on the label or in company information posted on the web.

The equipment used to make an application also can impact the program efficacy. Nozzles differ in their suitability for applying fungicides compared to other pesticides. Having drop nozzles directed at each side of the plant as well as a nozzle directed at the top to the plant will improve coverage with trellised tomatoes. Drop nozzles are especially important for maximizing disease control because many diseases start to develop on leaves that are low in the canopy and also inside the lower canopy. Mobile fungicides cannot move from where deposited on upper leaves to leaves low in the canopy. Sprayer pressure is also important. Large droplets are formed when pressure is low. These are more likely to run off leaves than small droplets, and large droplets provide less coverage than the same amount of fungicide solution in several small droplets. Recommended pressure to use is around 60 psi, varying a bit with the nozzle type. When very high pressure is used there will be more small droplets prone to drift. When spraying several plantings, start with the youngest or the one with least symptoms. Airblast sprayers are not recommended when bacterial pathogens are present because the force of the spray can move bacteria between rows and it can cause small wounds that serve as infection sites for bacteria.

Being prepared before the growing season gets underway is also important because it minimizes response time. This includes de-winterizing the sprayer, making sure it is fully functional, replacing old nozzles, and calibrating the sprayer. It also includes deciding what products will be used, calculating the amount needed for each application, and identifying a source. Purchasing products in advance also facilitates responding immediately to disease detection.

An important component of an effective fungicide program is resistance management. This is because most fungicides with targeted activity are prone to resistance development because they have single site mode of action. Additionally, resistance management needs to always be implemented, starting at first use of the fungicide, because the primary goal is to delay resistance development rather than to manage resistant pathogen strains after they have been detected. First determine what pathogens have already developed resistance and to which fungicides. Some types of fungicides labeled for a disease may no longer be recommended for use in the northeast, or recommended used on a limited basis, because of resistance. General recommendations for managing fungicide resistance are to use products at risk for resistance development in alternation based on FRAC Code and tank-mixed with a contact, protectant fungicide that has low risk.

To achieve the full potential of a fungicide program, it needs to be implemented as part of an integrated program with cultural practices listed above.

Key practices for important diseases:

Bacterial Canker. Pathogen-free seed. Greenhouse and field sanitation. New tomato stakes. At least 3-year rotation. Apply foliar pesticides when leaves are dry; don't use airblast sprayer. Few fungicide/bactericides labeled for bacterial speck and spot are also labeled for canker, including copper. Labeled products: AgriPhage-CMM, BacStop, Badge (X2 and SC), Nordox. Remove or destroy crop debris.

Early blight. Resistant varieties (new). At least 2-year rotation. Minimize leaf wetness. Apply fungicides weekly starting before or at first symptoms; alternate based on FRAC code and label restrictions, ex: Inspire Super (3+9) alt Miravis Prime (7+12) for 5 apps; Endura (7), Inspire Super, Endura, Inspire Super (5 apps low rate) or Mettle (3) or Rhyme (3).

Conventional and organic fungicides and bactericides for diseases affecting tomatoes in the northeastern USA. Products are listed by disease beginning with products applied before planting and those affecting seedlings during transplant production. Products approved for organic production (OMRI-listed) are designated. They could be used as the protectant fungicide in a conventional fungicide program. OLP = other labeled product. Several conventional fungicides are not permitted used in greenhouses primarily because of concerns of fungicide resistance development in a contained pathogen population. Under current regulation, a product can be used in a greenhouse if the label does not state that greenhouse use is prohibited.

Diseases affecting seedlings during transplant production (applications in greenhouse):

Bacterial speck and spot. Agri-mycin. Copper tank-mixed with mancozeb.

ORGANIC: copper, AgriPhage, Double Nickel, Organocide, OxiDate, Prevont, Regalia, Cease or Serenade Opti (Cease is a greenhouse product), Sporatec AG, Taegro 2

Damping-off. Conventional fungicides with targeted activity for *Pythium*: Previcur Flex - apply as a directed spray to lower stems and soil. Ranman – apply as a drench to seeding tray anytime from seeding to 1 week before transplanting.

ORGANIC: several biopesticides are labeled for applying to the seeding mix, including Actinovate, Bio-Tam, Double Nickel, Mycostop, Prestop, RootShield Granules, and Serenade ASO, Taegro 2

Gray mold (Botrytis). Decree (FRAC Code 17); labeled for use with another labeled fungicide. Scala (9) can be applied in a well-ventilated plastic tunnel or glass house; ventilate for at least 2 hours after application.

ORGANIC: copper, Actinovate, Aviv, Carb-O-Nator, Double Nickel, Howler, LALSTOP G46 WG, MilStop, Rango, Regalia, OSO, OxiDate 2, Prestop, Problad Verde, Romeo, Serifel, Serenade Opti, Sporan EC², Sporatec AG, Stargus, TerraNeem EC, Thyme Guard, Thymox Control, Timorex Act, Trilogy

Root rots in the field. Note that Previcur Flex and Ranman are labeled for use in the greenhouse but not in the field.

Ridomil Gold SL or OLP - apply to soil at planting, then inject into drip irrigation 4 to 6 weeks later. Targeted activity for *Pythium* and *Phytophthora*.

ORGANIC: biopesticides listed above for damping-off are also labeled for application to soil in field. Additional products: Pvent, Rango, Regalia, TerraClean 5.

Foliar and fruit diseases. When a preventive application schedule is used for a conventionally-produced crop, protectant fungicides are recommended until diseases are detected, then switch to a targeted fungicide for the specific disease(s) developing. Alternate among products in different FRAC Groups is needed for managing resistance and often is a label restriction, also tank-mix with protectant fungicides.

Protectant fungicides. chlorothalonil, mancozeb, ziram, copper, or an organic product.

Anthracnose. FRAC Group 11 fungicide [Flint Extra, Quadris, Quadris Opti (also M5), Quadris Top (3), Luna Sensation or Priaxor (3), or Tanos (27)], Inspire Super (3 + 9), Rhyme (3), Catamaran (33+M5). Revus Top (3 + 40) recommended only when late blight also present.

ORGANIC: copper, Actinovate, Carb-O-Nator, Howler, LALSTOP G46 WG, MilStop, OxiDate 2, PerCarb, Prestop, Rango, Serifel, Timorex Act, TerraNeem EC. Trilogy

Bacterial speck and spot. Actigard, copper tank-mixed with mancozeb. Tanos is labeled for suppression used with copper plus mancozeb. Resistance to copper is common.

ORGANIC: copper, AgriPhage, Aviv, BacStop, Cease, Double Nickel, LifeGard, PerCarb, Prevont, Organocide, OxiDate 2, Regalia, Serifel, Serenade Opti, Sporan EC² (spot), Sporatec AG, Stargus (spot), Taegro 2, Thymox Control, Timorex Act

Bacterial canker. Labeled copper fungicides: Badge (X2 and SC) and Nordox.

ORGANIC: AgriPhage-CMM (start applications soon after transplanting), BacStop

Buckeye (Phytophthora) fruit rot. Orondis Opti (49 + M5), Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus (40) or Revus Top (3 + 40), Tanos or Reason (11), Ridomil Gold Bravo or OLP (3), Ranman (21), Aliette (33), Gavel or Zoxium (22), Presidio (43). There are pathogen strains resistance to Ridomil.

ORGANIC: Cease, Serifel, Serenade Opti

Botrytis gray mold. Endura (7), Miravis Prime (7 + 12), Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Cabrio (11). Uncommon in field-grown crops.

ORGANIC: copper, Actinovate, Aviv, Carb-O-Nator, Double Nickel, Howler, LALSTOP G46 WG, MilStop, Regalia, OSO, OxiDate 2, Prestop, Problad Verde, Rango, Romeo, Serifel, Serenade Opti, Sporan EC², Sporatec AG, Stargus, TerraNeem EC, Thyme Guard, Thymox Control, Timorex Act, Trilogy

Early blight. Inspire Super (3 + 9), Miravis Prime (7 + 12), Endura (7), Mettle (3), Rhyme (3), Scala (9), Luna Tranquility (7 + 9), Switch (9 + 12), Previcur Flex (28), Catamaran (33+M5), FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Priaxor (7), Tanos (27), Cabrio, Flint, or Reason]. Pathogen strains resistant to QoI fungicides (11) and strains with reduced sensitivity to chlorothalonil have been detected in a few locations in the US where these products are used intensively. Revus Top (3 + 40) recommended only when late blight also present.

ORGANIC: copper, Actinovate, Aviv, Carb-O-Nator, Double Nickel, EcoSwing, LALSTOP G46 WG, OSO, OxiDate 2, PerCarb, Prestop, Rango, Regalia, Serifel, Serenade Opti, Sonata, Sporan EC², Sporatec AG, Taegro 2, TerraNeem EC, Timorex Act, Trilogy

Late blight. Orondis Opti (49 + M5), Curzate or Tanos or Cymbol Advance or Cymbol Balance (all have same active ingredient in FRAC Group 27), Presidio (43), Previcur Flex or Cymbol Balance (28), Ranman (21), Gavel or Zoxium (22), Reason (11), Zampro (40 + 45), Revus (40), and Forum (40). These need to be tank-mixed with a protectant fungicide, except for Gavel, which contains mancozeb. Note that applying chlorothalonil weekly starting before disease onset has provided good control in fungicide efficacy experiments. This disease is extremely difficult to control with fungicide applications started after detection. Curzate and Tanos have good curative activity but short residual activity, thus

another fungicide will be needed about 3-5 days after application. Previcur Flex has good systemic activity and thus protects stems and new growth. Ridomil Gold Bravo (or OLP) is very effective for sensitive pathogen strains like US-23, which has been the main one detected recently in the Northeastern USA. Strain identification can now be done in 1-2 days.

ORGANIC: copper, Actinovate, Aviv, Double Nickel, OSO, OxiDate 2, PerCarb, Rango, Regalia, Romeo, Serifel, Serenade Opti, Sonata, Sporan EC², Sporatec AG, Stargus, Taegro 2, TerraNeem EC, Timorex Act, Thyme Guard, Zonix

Leaf mold (some labels only have pathogen name, *Cladosporium* or *Fulvia*). Miravis Prime (7 + 12), Tanos, protectant fungicides. Uncommon in field-grown crops.

ORGANIC: copper, OSO, OxiDate 2

Powdery mildew. Luna Tranquility (7+9), Miravis Prime (7+12), Aprovia Top (3+7), Inspire Super (3+9); Rally, Rhyme, or Trionic (all 3), FRAC Group 11 fungicide [Cabrio, Flint, Reason, Quadris, Quadris Opti (also M5), Quadris Top (3), Topguard (3)], Vivando or Prolivo (50), Torino (U6).

ORGANIC: copper, sulfur, Actinovate, Aviv, Carb-O-Nator, EcoSwing, Kaligreen, LALSTOP G46 WG, MilStop, Organic JMS Stylet-oil, Organocide, OSO, OxiDate 2, Prestop, Prevont, Problad Verde, Rango, Regalia, Romeo, Serifel, Serenade Opti, Sonata, Sporan EC², Sporatec AG, TerraNeem EC, Timorex Act, Taegro 2, Thyme Guard, Thymox Control, Trilogy

Septoria leaf spot. FRAC Group 11 fungicide [Cabrio, Flint, Reason, Quadris, Quadris Opti (also M5), Quadris Top (3), Priaxor (7), or Tanos (27)], Aprovia Top (3+7), Luna Tranquility (7 + 9), Miravis Prime (7 + 12), Inspire Super (3 + 9), Scala (9), Switch (9+12). Mettle (3). Revus Top (3+40) recommended only when late blight also present.

ORGANIC: copper, MilStop

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

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