



Designing an Effective Fungicide Program (Organic and Conventional) to Manage Tomato Diseases

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While fungicide choice is important, there is a lot more to designing an effective fungicide program than selecting the most efficacious product!

The first step in designing an effective fungicide program is making a list of the diseases that have occurred in previous years. Try to identify any unknown diseases. This 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), which include Actigard, phosphorous acids, Regalia, and Companion.

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, it is 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 the 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. This information has been posted for several products at <http://edis.ifas.ufl.edu/pi238>

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. Information on this is at <http://www.teejet.com/media/40076/users%20guide%20final%28low%29.pdf>. 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. Fungicides should not be relied on as the sole management practice especially under severe disease pressure. Cultural practices for diseases of tomato include rotation, selecting resistant varieties, using seed tested and treated for seed-borne pathogens, disinfecting used trays, stakes, and other planting materials, mulching, trellising, and using drip irrigation. Also select planting site with good air movement and soil that drains well. Plant parallel to the prevailing wind direction. Destroy infested crop debris after harvest and incorporate into soil to hasten decomposition.

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 managed before planting:

White mold. Apply Contans (organic) to soil at planting or transplanting. Treatment in the fall and again in the spring may improve control.

Diseases affecting seedlings during transplant production:

Bacterial diseases. Agri-mycin. Copper tank-mixed with mancozeb.

ORGANIC: copper, DoubleNickel, Organocide, Regalia, Cease or Serenade Optimum* (Cease is a greenhouse product), Sporatec AG, OxiDate

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 (or Tenet), Double Nickel 55, Mycostop, Prestop, RootShield Granules, and Serenade Soil.

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, DoubleNickel, MilStop, Regalia, Serenade Optimum*, Sporatec AG, Trilogy, OxiDate

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: Regalia.

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

Anthraxnose. FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Flint, or Tanos (27)], Catamaran (33+M5), Inspire Super (3 + 9), Revus Top (3 + 40).

ORGANIC: copper, Actinovate, MilStop, Trilogy, OxiDate

Bacterial diseases (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, DoubleNickel, Organocide, Regalia, Serenade Optimum*, Sporatec AG, OxiDate

Bacterial canker. copper

- Buckeye (Phytophthora) fruit rot. 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 (22), Presidio (43). There are pathogen strains resistance to Ridomil.
ORGANIC: Serenade Optimum*
- Botrytis gray mold. Endura (7), Inspire Super (3 + 9), Scala (9), Switch (9 + 12) (note that these 3 are in the same FRAC group, Cabrio (11) (suppresses). Uncommon in field-grown crops.
ORGANIC: copper, Actinovate, DoubleNickel, MilStop, Regalia, Serenade Optimum*, Sporatec AG, Trilogy, OxiDate
- Early blight. Endura (7), Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus (40) or Revus Top (3 + 40), Previcur Flex (28), Catamaran (33+M5), FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), 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.
ORGANIC: copper, Actinovate, DoubleNickel, Regalia, Serenade Optimum*, Sonata, Sporatec AG, Trilogy, OxiDate
- Late blight. Curzate or Tanos (both have same active ingredient in FRAC Group 27), Presidio (43), Previcur Flex (28), Ranman (21), Reason (11), Revus (40), Gavel (22), 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, DoubleNickel, Regalia, Serenade Optimum*, Sonata, Sporatec AG, OxiDate
- Leaf mold (some labels only have pathogen name, *Cladosporium* or *Fulvia*). Tanos, protectant fungicides. Uncommon in field-grown crops.
ORGANIC: copper, OxiDate
- Powdery mildew. Rally (3), Quadris, Cabrio, or Flint (all 11).
ORGANIC: copper, sulfur, Actinovate, Kaligreen, MilStop, Organic JMS Stylet-oil, Organocide, Regalia, Serenade Optimum*, Sonata, Sporatec AG, Trilogy, OxiDate
- Septoria leaf spot. FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Tanos (27), Cabrio, Flint, or Reason], Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus Top (3 + 40), Previcur Flex (28), Tanos (27), Catamaran (33+M5)
ORGANIC: copper, Organocide
- * Serenade Optimum is a new formulation.

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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