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Fusarium Diseases in Tomato

By Ramón Arancibia, Dhruba Dhakal and Peng Tian

Fusarium spp. are soil-borne fungal pathogens that affect many crops. Fusarium infects plant roots and crown, infecting cortical tissue and when reaches the vascular system it interrupts sap flow inducing wilting. Symptoms are dry root rot, damping off, stem collapse, leaf yellowing, wilting, and death. Fusarium persists in the soil mainly in plant debris and can be seed-transmitted. *Fusarium* spp. produce typical microconidia, macroconidia and chlamydospores (inoculum) that can infect plant tissue. Chlamydospores can overwinter/survive in the soil as well as wooden and other surfaces. Many crops and weeds are susceptible to *Fusarium* spp. and are the source of inoculum for infection of tomato and other crops.

Fusarium crown and root rot (*Fusarium oxysporum* f. sp. *radicis-lycopersici*) is a problem in many solanaceous crops, including tomatoes, in greenhouse and field production. Infection and disease development is favored by cool temperatures (60-70°F). Fusarium crown and root rot infects the cortical tissue through wounds and natural openings inducing a dry lesion with a distinctive chocolate-brown discoloration. The internal discoloration of the cortex tissue and cambium can extend 2 to 4 inches up from the lesion at the base of the plant (Figure 1). In mature plants, the margin of lower leaves may turn yellow and develop into necrotic tissue (Figure 2). Plants may wilt, especially on hot days, and become stunted. Eventually, fungal structures such as white mycelium and spores appear in lesions, necrotic tissue and debris. Microconidia of *Fusarium oxysporum* f. sp. *radicis-lycopersici*, however, are airborne, which facilitates infection of surrounding healthy plants and reinfestation of steamed soil, especially in high tunnels and greenhouses.



Figure 1 Fusarium crown and root rot: internal discoloration of the cortex and cambium. (source: R.A. Arancibia)



Figure 2 Fusarium crown and root rot foliar symptoms: lower leaves with marginal necrosis. (source: R.A. Arancibia)

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Fusarium wilt (*Fusarium oxysporum* f. sp. *Lycopersici*) is another important soilborne disease of tomato, and other solanaceous crop that is favored by warm temperature (82°F). It also infects through wounds, but invades and clogs the vascular system (xylem) reducing or stopping the flow of sap, which induces wilt. There are three identified races (races 1, 2, and 3), all present in tomato production areas in the United States. Many tomato cultivars have been developed with resistance to races 1 and 2, but only a few with resistance to race 3. Fusarium wilt symptoms in high tunnels and greenhouses may start with bright yellowing of bottom leaves that may continue to the length of the plant (Figure 3). In mature plants, it induces yellowing and wilting usually after flowering (Figure 4). The initial symptoms of yellowing may appear on one side of the leaf and/or plant (Figures 3 and 4), then develop into chlorosis and wilting of the entire plant. Internally, the vascular system (xylem) turns reddish-brown (Figure 5) and can extend the length of the plant.

Fusarium foot rot (*Fusarium solani* f. sp. *eumartii*) in tomato is a minor disease, but it can kill the plant. It induces reddish-brown lesions in the cortex of taproot and large secondary roots and is associated with vascular discoloration. As the disease further develops, these lesions may encircle the root, and the entire plant may die. Meanwhile, leaves may show interveinal chlorosis and necrosis during the growing season. The optimum growth temperature of isolates from California is 77-86°F. There is no resistant cultivars, so the only control method is sanitary practices to avoid its introduction and limit its spread.



Figure 3 Fusarium wilt foliar symptoms: yellowing on leaves in one side of the plant. (source: R.A. Arancibia)



Figure 4 Fusarium wilt foliar symptoms: yellowing on one side of the leaves and wilting and stunting of the entire plant. (source: R.A. Arancibia)



Figure 5 Fusarium wilt: vascular tissue (xylem) discoloration. (source: R.A. Arancibia)

Management

The first and most effective practice to manage *Fusarium* spp. is the use of resistant cultivars, however, many growers and consumers prefer heirloom cultivars are not resistant to diseases. Even when using resistant cultivars, cultural practices to reduce inoculum (micro and macroconidia and chlamydospores) and Fusarium incidence should be considered to minimize the risk of developing Fusarium races that may overcome cultivar resistance. Sanitary practices include reducing inoculum by pulling and burning diseased plants and not reincorporate them into the soil or compost, preventing conditions for diseases to become established (soil drainage and raised planting beds or 10-15 inches ridged rows), and those that modify the environment to reduce infections and disease incidence (planting site, soil, tillage, crop rotation, wind breaks, and good irrigation practices to avoid soil saturation). Biological agents (microorganisms attacking pathogens) incorporated into the soil have been identified and their effectiveness in reducing Fusarium incidence have been evaluated by several research institutions. Commercial products containing these biological agents are available and registered in the OMRI list for organic production and for conventional production as well. A list of several commercial products, the active ingredient, and target disease can be found in Gauthier, N., et al. (*see Literature resources*)

LITERATURE RESOURCES

Davis, R.M. and A.O. Paulus. 2014. Fusarium crown and root rot. In: Compendium of tomato diseases 2nd Edition, J.B. Jones, T.A Zitter, T.M. Momol, and S.A. Miller. (Editors). The APS press, 3340 pilot Knob Rd. St. Paul, Minnesota.

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Timber Rot in Tomato and White Mold in Lettuce

By Justin Keay

The MU Extension Commercial Horticulture team hosted a high tunnel field day at a small farm in northeast Missouri a couple of weeks ago. The grower had a very well managed high tunnel with rows of tomatoes interplanted with lettuce. The tomatoes were in the row center, and the lettuce was planted on the shoulder of the beds. The tomatoes were growing vigorously and looked very healthy overall. The lettuce had sized up nicely and most was ready or nearly ready for harvest. Most of the lettuce looked healthy, but a portion of the heads had collapsed completely or were in the process of collapsing.



Photo c/o Justin Keay



Photo c/o Peng Tian

When plants are wilting or collapsing or wilting, whether greens or fruiting vegetables, it can be helpful to dig a plant out of the soil and inspect the roots. Are the roots thick, healthy, creamy white? Are the roots woody, corky, brown, rotting, or few and far between? It can also be helpful to cut the stem of the plant to look for signs of vascular discoloration in the xylem (tissue transporting water up the plant) or phloem tissue (tissue transporting sugars down the plant). When the vascular tissues of a plant are compromised or infected, plants can go downhill quickly.

We cut open several heads of lettuce that were in the middle stages of decline. The vascular tissue looked healthy everywhere except the base of the plants, where healthy tissue would abruptly transition into brown mush.

The lettuce heads had a fuzzy white mold at the base of the crown of the plants. This type of fuzzy mold is always indicative of a fungal pathogen.



Photo c/o Peng Tian



Photo c/o Peng Tian

Scraping off the moldy white material and soil from the top of the root crown revealed many small brown/blackish structures tucked around the base of the plants. The structures are known as sclerotia, an overwintering structure for fungi. This complex of symptoms are tell-tale signs of a disease called white mold, *Sclerotinia sclerotiorum*. In lettuce this disease is commonly called lettuce drop, the same disease is called timber rot in tomatoes.



Photo c/o Justin Keay

The sclerotia overwintering structures will reside in the soil until the following spring when they infect another round of plants. In fact, these structures can survive in the soil for up to 10 years. This disease is a problem during cool, moist growing conditions, present during spring lettuce production.

This disease has a very wide host range and over time can build up to damaging levels in high tunnels. The image below shows a tomato stem with signs of a timber rot infection. Sclerotia can also be found in bisected tomato stems of plants infected with timber rot.



Photo c/o Peng Tian



Photo c/o Z Mersha

The overwintering structures of this disease make it uniquely challenging because they can persist for so long in the soil. This disease is also problematic because it has an extremely broad host range, infecting virtually every vegetable crop besides sweet corn and crops in the allium family. Fungicide control options are extremely limited. *Contans** is an OMRI listed bio-fungicide that has proven to be very effective for control of white mold. However, it is costly, and while labeled for use on many vegetables, it is not labeled for tomatoes.

In high value growing areas such as high tunnels, it is critical to take steps to reduce the buildup of this disease. Sanitation is a foundational practice for long term control. Removing infected plant material and the accompanying sclerotia can slow the buildup of this disease. Deep plowing can help bury the sclerotia and reduce disease pressure, but this isn't a surefire solution and may be impractical in a high tunnel. Further tillage could bring buried sclerotia back to the surface. In addition to the overwintering structures, this disease can spread through aerial windborne spores, called ascospores. Weeds can serve as a host for this disease, so keeping a weed-free perimeter around the high tunnel can help prevent ascospores from infected weeds blowing into the tunnel.

With proper identification and sanitation practices, this disease can be managed. Without following these two principles, this disease can build up to devastating levels in high tunnels. The MU Plant Diagnostic Clinic is a valuable resource for Missouri growers and can help identify diseases through digital or physical sample submissions.

**Inclusion of a pesticide tradename does not represent an endorsement of a product.*

Potential Drift Damage in Produce Fields: How to Recognize It, Document It, and Decide What to Do Next

By Juan Cabrera-Garcia

You may have observed plants with twisted leaves, cupped foliage, distorted growth, or unexplained stunting. The immediate question is often, "*Did herbicide drift cause this?*"

Sometimes the answer is yes. Sometimes it is not.

Pest management programs in current corn and soybean production systems commonly use dicamba and 2,4-D for weed control. Their use raises concerns about potential off-target movement for produce and fruit growers, vineyard managers, and homeowners. Before concluding that a distorted plant was injured by herbicide drift, it is important to understand what drift symptoms actually look like, what they do not look like, and the steps growers should take when concerns arise.

Not every distorted plant is herbicide drift

One of the most common mistakes during the growing season is assuming that any unusual growth pattern must be caused by herbicides. Many other problems can resemble drift injury, including:

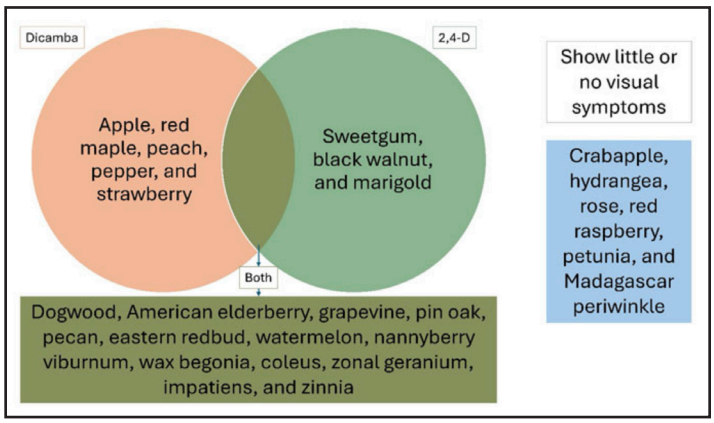
Heat stress
Broad mite damage
Contaminated compost
Environmental stress
Physiological leaf roll
Nutrient disorders
Insect feeding
Fasciation

For that reason, it is critical to rule out any other causes prior to assuming herbicide drift damage. Symptom diagnosis should always consider the entire field history, crop stage, weather conditions, neighboring farm(s) herbicide application history, and distribution of symptoms. You don't have to figure this out on your own, MU Extension specialists are there to help diagnose symptoms.

Some crops are more sensitive than others

Research at University of Missouri has shown that plant species differ tremendously in their sensitivity to synthetic auxin herbicides such as dicamba and 2,4-D. Among perennial species evaluated in Missouri, grapevine was consistently one of the most sensitive plants, while hydrangea was among the least sensitive. Among vegetable crops, tomato, watermelon, and cantaloupe were highly sensitive to driftable fractions of dicamba and 2,4-D. Two neighboring plant species exposed to the same drift event may show different responses.

The diagram below shows how different plant species respond to dicamba and 2,4-D. The diagram can help narrow down potential culprits. For example, dicamba is the more likely culprit if you see injuries on an apple tree. Sensitive plants may serve as indicators. A grower may notice injury on their tomato plants and check for symptoms in plants surrounding their farm to narrow down the potential culprits.



What to do if you suspect drift?

If herbicide drift is suspected, avoid making immediate assumptions or taking irreversible actions. Focus on narrowing down the issue, documenting evidence, and keeping records.

Write down the date you first noticed symptoms and flag affected plants. Take photographs (make sure to set the date when using point and shoot cameras) of the entire plants, individual leaves, field edges, patterns across the planting area, and adjacent vegetation. Take notes of crop growth stage, weather conditions, and other potential stress factors. Have conversations with neighbors to make them aware of issues and determine if they have made herbicide applications.

Growers can benefit from a second opinion from extension services. Many issues may initially appear to be herbicide related but can turn out to be related to diseases, insect pests, nutritional problems, environmental stress, or carryover in compost or hay.

Food safety considerations

There is confusion about the difference between plant injury, pesticide residue, food safety and marketability. A plant can show obvious herbicide injury while containing extremely low pesticide residues. Visible symptoms alone do not determine whether a crop is safe, legal, or marketable.

The U.S. Environmental Protection Agency establishes pesticide tolerances, which are maximum legal residue levels permitted on food commodities. The tolerances can be found in the Code of Federal Regulations 40 CFR Part 180 (§ 180.142 for 2,4-D and § 180.227 for dicamba). Each pesticide-crop combination has its own regulatory framework. If EPA has not set a tolerance or tolerance exception for a specific crop, then any detectable residue in that food is illegal and legally classified as adulterated (a zero-tolerance standard). Zero tolerance exists because safety thresholds for human consumption may not have been determined for that commodity.

When drift is suspected and harvest is approaching, growers should consult extension specialists, Missouri Department of Agriculture (MDA), and organic certifiers (if applicable) before making any marketing decisions. Extension specialists can direct you to laboratories that can test for residues.

Maintaining good relationships with neighbors

In many situations, a respectful conversation can resolve misunderstandings before they become disputes. Most neighboring farmers share similar goals: producing a quality crop, protecting their livelihoods, being good stewards, and maintaining community relationships.

Communication is often most effective when concerns are discussed early and professionally. A conversation may reveal what products were applied, when they were applied, weather conditions during application, or whether another explanation is more likely.

Maintaining positive relationships is particularly important in Missouri's diverse agricultural communities where crop producers, produce growers, orchards, vineyards, and livestock operations often work side by side.

When should you contact the Missouri Department of Agriculture?

If you believe pesticide misuse may have occurred and concerns cannot be resolved informally, the Missouri Department of Agriculture can investigate alleged pesticide misuse incidents. MDA administers pesticide licensing, inspections, and complaint investigations under Missouri pesticide regulations.

Growers should consider contacting MDA when significant injury is observed, evidence suggests a recent pesticide application may be involved, crop losses are likely, documentation has been collected, and questions remain unresolved. Prompt reporting is important because evidence becomes more difficult to collect as time passes.

Final thoughts

Herbicide drift is a real concern for specialty crop growers, but not every distorted plant has been injured by off-target herbicides. Good diagnosis starts with careful observation, documentation, and communication.

The goal should not be to immediately prove drift occurred. The goal should be to accurately determine what happened, protect the crop when possible, preserve relationships when practical, and ensure that decisions are based on evidence rather than assumptions. With a systemic approach, growers can make better decisions and avoid unnecessary conflicts while protecting both their crops and their businesses.

Suspected herbicide drift checklist

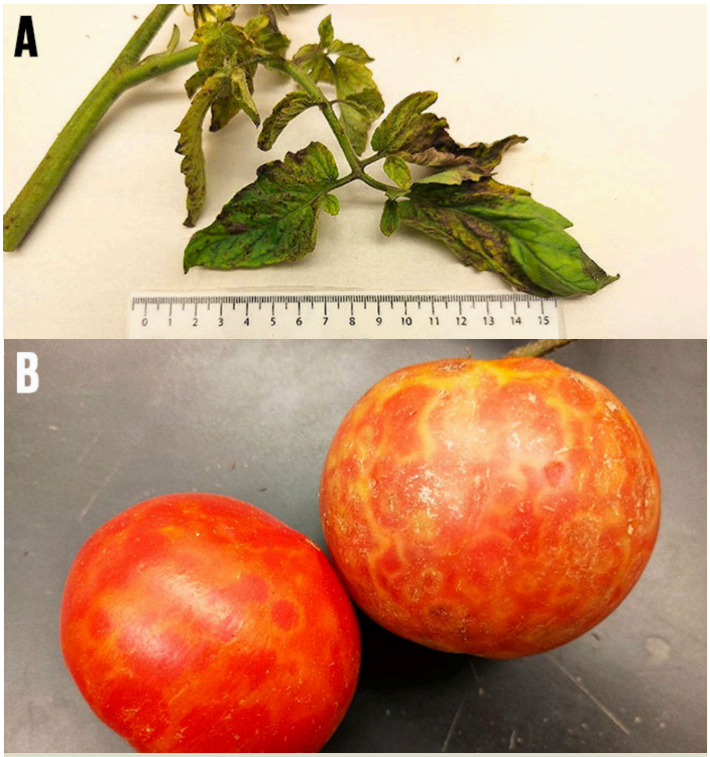
- ✔ Observe and document symptoms
- ✔ Take photographs immediately
- ✔ Flag affected plants
- ✔ Record dates, weather, and field observations
- ✔ Contact Extension for assistance with diagnosis
- ✔ Talk with neighboring landowners or applicators
- ✔ Evaluate food safety and marketing questions
- ✔ Contact the Missouri Department of Agriculture if necessary

Tomato Spotted Wilt Virus: Disease Facts and Tips for Control

By Riley France and Peng Tian

Originally discovered in Australia in 1915 and found on U.S. soil in the 1970's, tomato spotted wilt virus (TSWV) is a highly impactful plant disease that can result in both aesthetic damage and significant loss in crop revenue. This Tospovirus has one of the widest known host ranges, with over 1000 susceptible species in 85 families. As it is unable to move on its own, TSWV is primarily transmitted by thrips. Due to the easy spread, broad host range, and economical loss caused by TSWV, it is important to understand how to identify and manage infected crops.

The symptoms of TSWV may vary from different host species or different cultivars within a single host species. The plants frequently appear as stunted, wilting, bronzing with cupping of younger leaves, and chlorotic and necrotic spots with or without a bull's-eye pattern. Symptoms can also be manifest on fruit, frequently as ring-shaped chlorotic blotches.



Bronzed lesions on tomato leaves (A) and yellow ringspots on tomato fruits (B). (Photo: MU-PDC)

TSWV is transmitted by at least 10 species of thrips which allow the virus to replicate inside their bodies. The adult thrips move the virus from one plant to another while feeding. TSWV infection makes a plant more susceptible to thrips infestation, so the adult thrips will choose to lay their eggs on an infected host. When the eggs hatch and the nymph feeds on virus-infected plant, it becomes a vector for TSWV and will transmit it for the rest of its life.

The host range for TSWV is extremely broad. It includes specialty crops such as most Solanaceae family of plants, which include tomatoes, peppers, and eggplants. It can also cause significant damage to peanut and tobacco crops, and economic damage to ornamentals such as chrysanthemums and ornamental peppers.

How to manage TSWV:

TSWV is a viral disease and there is no known cure for infected plants. However, good cultural practices can help reduce the damage caused by this disease.

First, start with healthy plants. By selecting virus-free seedlings as well as inspecting all plant materials for TSWV symptoms and thrips infestation, the growers could avoid introducing TSWV by accident. There also are TSWV-resistant varieties to choose from, especially when the growers have this disease and are preparing for the next season.

Second, manage thrips. It is very challenging to control thrips. Using yellow sticky cards and to monitor them allows a rough estimation of the population and helps to informed management decisions. Choose an insecticide with ingredients such as azadirachtin, spinosad, and spirotetramat. Always read and follow label directions. Insecticide rotation is vital because continuous use of one single pesticide may cause the development of resistance.

Third, control weeds. Throughout the growing season, many species of weeds can host different kinds of pests, and some are reported to host TSWV and thrips. Therefore, maintain a vegetation-free border around the greenhouse or high tunnel and remove any weeds that might have overwintered inside. This will help to reduce the potential introduction of disease problems.

Finally, discard diseased plants. Any infected plants should be eradicated as they may serve as a source of infection to other plants. Plant debris such as fallen leaves and fruits should not be used for compost either.

El Niño Returns in 2026

By Zach Leasor

El Niño is a naturally occurring climate phenomena characterized by sea surface temperatures along the Equator in the Pacific Ocean. El Niño describes the warm phase of the El Niño-Southern Oscillation (ENSO), a recurring climate cycle where sea surface temperatures go through warm and cold cycles. The opposite phase, La Niña, occurs when sea surface temperatures in the region are cooler than average. ENSO is one of the most important drivers of global climate variability and can significantly influence weather in Missouri as well.

The first half of the 2020s was dominated by La Niña conditions. Aside from a moderate El Niño event that developed during late 2023 and persisted into spring 2024, Pacific Ocean temperatures were generally near or below average since 2020. During 2026, however, El Niño has re-emerged and strengthened rapidly. During 2026, El Niño has re-emerged and strengthened significantly this year. According to the U.S. National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC), El Niño conditions are currently present and are expected to intensify through the remainder of 2026.

One of the key indicators used to monitor ENSO is the Relative Oceanic Niño Index (RONI), which measures the sea surface temperatures in the Pacific Ocean. By July 2026, the RONI reached + 0.5 °C, meeting NOAA's threshold for the start of an El Niño event. Scientists are paying close attention to this event because forecasts indicate that it may become a one of the strongest El Niño events on record. Deeper waters in the Pacific are much warmer than normal and will fuel the continued warming of sea surface temperatures and forecasters expect this El Niño to strengthen during the coming months. Ocean forecast models predict El Niño to strengthen and peak during the late fall months. Most models predict sea surface temperatures will warm to greater than 2.0 °F above average, making it a very strong event. Many have referred to this event as a "Super El Niño" this summer. Recent strong events include 2015 (+ 2.4 °C), 1997 (+ 2.4 °C), 1992 (+ 2.3 °C), 1982-3 (+ 2.5 °C), 1972 (+ 2.3 °C), 1965 (+ 2.0 °C), and 1958 (+ 2.0 °C).

ENSO events have a global impact on weather patterns, including in Missouri (Figure 1). The Pacific Ocean is a significant source of global heat energy and small changes in temperature control pressure patterns with far-reaching impacts. Since ENSO evolves slowly over timescales ranging from seasons to years, it provides a climate signal that can help forecasters predict weather conditions months in advance. For producers, this information can be useful when planning for the growing season. The strongest relationships between ENSO and weather conditions are during the cooler months when large-scale weather systems moving across the country are steered by global pressure patterns. When summertime precipitation and weather are more local, there is less influence from El Niño or La Niña events (Figure 2).

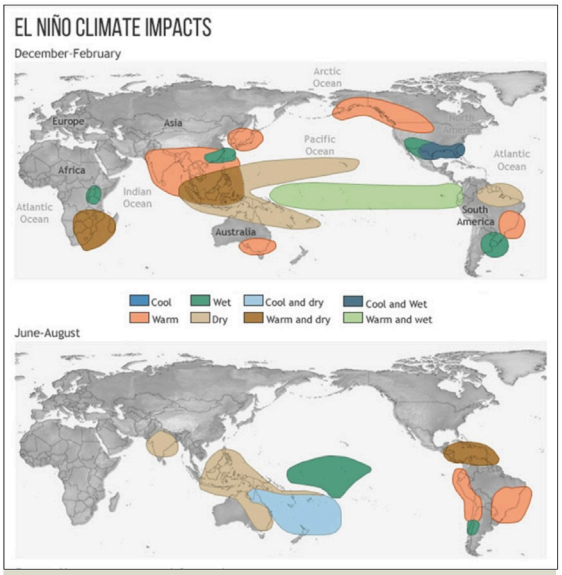


Figure 1 (Source: NOAA (https://www.noaa.gov/climate))

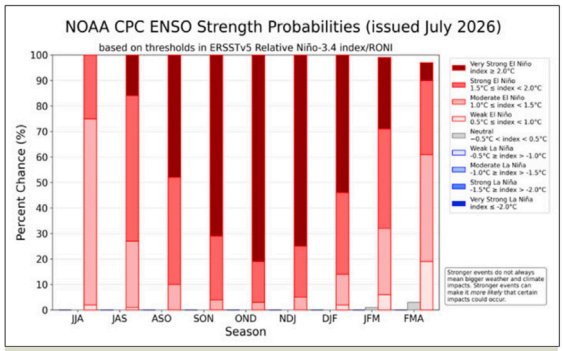


Figure 2 (Source: NOAA Climate Prediction Center (https://www.cpc.ncep.noaa.gov))

In Missouri, there is a link between El Niño events and cooler temperatures and wetter conditions during the late summer and fall months. However, it is important to note that not all El Niño events are the same and there can be other years with dry and warm conditions. During colder months impacts are more certain. Missouri typically sees wetter winters and can see two different temperature scenarios. Northern Missouri has observed a tendency for more warmer winters during El Niño while southern Missouri can observe more cooler winters. The most recent strong El Niño event occurred in 2015-16 bringing wet conditions, a warm fall, followed by a winter with temperatures close to average. NOAA and other groups will continue monitoring ENSO and Pacific Ocean sea surface temperatures closely through the remainder of 2026.

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