K-STATE Research and Extension

Twospotted Spider Mite

Management in Greenhouses and Nurseries

The twospotted spider mite, *Tetranychus urticae,* is one of the most destructive mite species. It feeds on a wide range of ornamental plants grown in greenhouses and nurseries, including more than 300 plant species. Twospotted spider mites are difficult to manage in greenhouses and nurseries for the following reasons:

- wide host-plant range
- multiple generations occur simultaneously
- high reproductive potential
- rapid population growth rate
- short life cycle
- resistance to pesticides (miticides)

This publication addresses a number of topics associated with twospotted spider mites including biology and damage, management, scouting, use of miticides, resistance and resistance mitigation, impact of pesticides on mite populations, and biological management.

Biology and Damage

Twospotted spider mite adults are small (0.3 to 0.45 mm long), oval-shaped, and may vary in color from green-yellow to red-orange (Figure 1), but this varies depending on the host plant. Adults possess distinct black spots on both sides of the body, and males usually are smaller than females and more elongated, with a pointed abdomen. The sex ratio is three females to one male. Adult females live about 30 days and can produce up to 200 small, spherical, transparent to pale-colored eggs during a two-week period. Eggs are deposited on leaf undersides along the mid-veins. The number and time to hatching vary depending on plant type and quality, based on nutritional status. Unfertilized females lay eggs that only develop into male offspring, whereas fertilized females produce both male and female offspring.

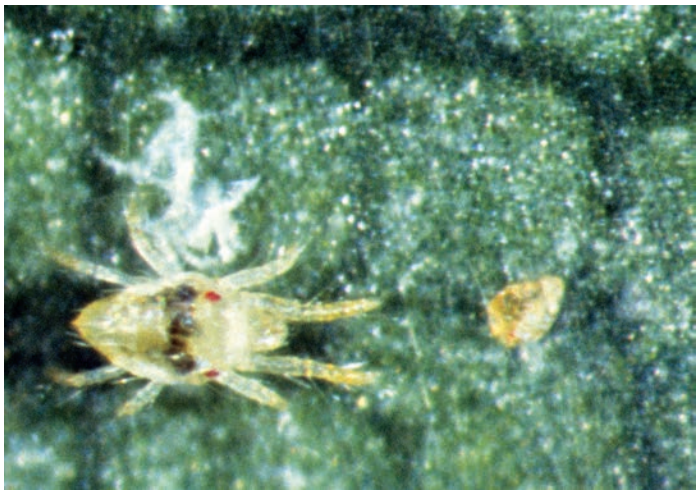

Figure 1. Twospotted spider mite adult.

Figure 2. Leaves damaged by twospotted spider mites.

Eggs hatch into yellow-green, six-legged larvae, which quickly mature into eight-legged nymphs, and then adults. Twospotted spider mites turn orange-red in late summer through fall and overwinter, primarily outdoors, as fertilized females. In greenhouses, absence of host plants may provoke dormancy, causing mites to reside in cracks and crevices until new plant material is present. The life cycle from egg to adult takes one to three weeks to complete, depending on ambient air temperature. For example, the life cycle takes 14 days at 70°F (21°C) and seven days at 84°F (29°C).

Twospotted spider mites prefer to feed on the undersides of leaves. They use stylet-like mouthparts to pierce and feed on individual plant cells, damaging the spongy mesophyll, palisade parenchyma, and chloroplasts. This reduces chlorophyll content and the plant's ability to photosynthesize. Damaged leaves appear bleached and stippled with small silvery-gray to yellowish speckles (Figure 2). In addition, there may be fine mottling on the upper leaf surface

Figure 3. Twospotted spider mite damage appears as mottling on upper leaf surfaces.

Figure 4. Heavily infested leaves may turn brown and eventually fall off of the plant.

(Figure 3). Heavily infested leaves may appear bronzed, turn brown, and fall off (Figure 4). Plants with extensive populations may exhibit premature defoliation. Symptoms associated with feeding injury may vary depending on the host plant. Feeding injury may lead to excessive water loss via transpiration. Heavy mite populations may result in the production of irregular webbing on leaf undersides or on plant stems where all life stages (e.g., egg, larva, nymph, and adult) are present. The webbing provides protection from rain, watering, and spray applications of miticides. The webbing also allows mites to move among plants, especially when plants are spaced close together and leaves touch each other.

Young females tend to migrate to newly emerging leaves. Twospotted spider mites may also be dispersed by wind currents or crop handling by workers. Dispersal depends on mite population density and plant nutritional quality. Twospotted spider mites prefer warm, dry environmental conditions to develop and reproduce with optimal temperatures between 68˚F and 86˚F (20˚C and 30˚C) and a relative humidity between 30 and 50 percent. Development from egg to adult may take just seven days at temperatures above 80˚F (26˚C), resulting in mite population outbreaks.

Management

Twospotted spider mite management involves combining pesticides with miticidal properties (miticides) and cultural practices. Practices that will reduce problems and avoid mite outbreaks include the following:

- Avoid overfertilizing plants, especially with nitrogen-based fertilizers, which results in the production of soft, succulent tissue that is easier for mites to penetrate with their mouthparts. Twospotted spider mites respond positively to increased fertility levels, particularly nitrogen, because amino acids are essential for development and reproduction. As such, well-fertilized plants tend to have higher mite populations.
- Remove old plant material that can serve as a source of twospotted spider mite populations when the next crop is started. Incorporate trap plants, or those highly susceptible to mites, into empty greenhouses to attract dormant mites, potentially reducing reinfestation when a new crop is introduced.
- Avoid allowing plants to become water stressed, which increases suceptibility to mites. Water-stressed plants tend to accumulate higher concentrations of soluble salts and amino acids, increasing their nutritional value to twospotted spider mites.

Figure 5. Nightshade weed shows twospotted spider mite damage.

- Remove weeds and heavily infested plants within and around greenhouses and nurseries because weeds, including the nightshades (Figure 5) and creeping woodsorrel (*Oxalis corniculata*), are secondary hosts.
- Irrigation practices, especially overhead watering, may reduce mite populations by increasing relative humidity. Watering also may wash mites off the tops of leaves.

Scouting

- Visually inspect plants regularly, using a 10x hand lens, by looking at leaf undersides for the presence of twospotted spider mite eggs, larvae, nymphs, or adults.
- Check hanging baskets routinely. Plants are located such that the ambient air temperature is warmer than the rest of the greenhouse, which is conducive to population development. As populations increase and plant quality declines, mites will fall onto plants located below hanging baskets.

Management Using Miticides

Due to the low tolerance for twospotted spider mites, which is associated with potential aesthetic injury to plants that can reduce quality and marketability, the primary means of dealing with mite populations is the use of pesticides that have miticidal activity (miticides). A number of miticides or insecticides/miticides are available to suppress twospotted spider mite populations. Most have contact activity, so thorough coverage of all plant parts, especially leaf undersides, is essential. Some pesticides have translaminar activity, which means that the material penetrates leaf tissues and forms a reservoir of active ingredient within the leaf. This provides residual activity even after spray residues have dried. Mites that feed on leaves may ingest a lethal dose of the active ingredient. Table 1 presents pesticides with mite activity registered for use in greenhouses and nurseries, and the susceptible life stages (egg, larva, nymphs, and adult) of twospotted spider mites. This table allows producers to determine life stage or stages for which these miticides are most effective.

The keys to managing or suppressing twospotted spider mite populations with miticides include the following:

- Complete coverage. Thorough coverage of all plant parts, especially leaf undersides, is essential.

Table 1. Miticides[a] (active ingredient and trade name) and twospotted spider mite, *Tetranychus urticae,* susceptible life stages and miticide mode of action.

Active Ingredient	Trade Name	Activity Type	Egg	Larva	Nymph	Adult	Mode of Action
Abamectin	Avid	C and T		X	X	X	GABA[1] chloride channel activator
Acequinocyl	Shuttle	C	X	X	X	X	Mitochondria electron transport inhibitor
Bifenazate	Floramite	C	X	X	X	X	Mitochondria electron transport inhibitor
Chlorfenapyr	Pylon	C and T	X	X	X	X	Oxidative phosphorylation uncoupler
Clofentezine	Ovation	C		X	X		Growth and embryogenesis inhibitor
Etoxazole	TetraSan	C and T	X	X	X		Chitin synthesis inhibitor
Fenazaquin	Magus	C	X	X	X	X	Mitochondria electron transport inhibitor
Fenbutatin-Oxide	ProMite	C	X	X	X	X	Oxidative phosphorylation inhibitor
Fenpyroximate	Akari	C	X	X	X	X	Mitochondria electron transport inhibitor
Hexythiazox	Hexygon	C	X	X	X		Growth and embryogenesis inhibitor
Milbemectin	Ultiflora	C	X	X	X	X	GABA chloride channel activator
Pyridaben	Sanmite	C	X	X	X	X	Mitochondria electron transport inhibitor
Spiromesifen	Judo/Forbid	C and T	X	X	X		Lipid biosynthesis inhibitor
Spirotetramat	Kontos	C, T, and S	X	X	X		Lipid biosynthesis inhibitor

Activity Type Codes:
C=Contact T=Translaminar S=Systemic

[a] Be sure to read the label, as some miticides in the table are not registered for use in both greenhouse and nursery.
[1]Gamma-aminobutyric acid.

- Frequency of application. Spray applications must be performed at intervals between 5 and 7 days to kill life stages that were not inhibited from previous applications.
- Application timing. Conduct spray applications when the susceptible life stages (e.g., larvae, nymphs, and adults) are predominantly present.
- Rate used. The appropriate label rate or rate designated for twospotted spider mite suppression is essential.
- Residual activity. Using miticides with long-residual, persistant activity (more than 30 days), may reduce the number of spray applications.
- Miticide rotation. Rotating miticides with different modes of action reduces the potential that twospotted spider mite populations will develop resistance. (Refer to Table 1 for the modes of action of miticides registered for use in greenhouses and/or nurseries.) In addition, use potassium salts of fatty acids (insecticidal soap), petroleum-based oils, and/or clarified hydrophobic extract of neem oil in rotation with other miticides helps to avoid resistance development in twospotted spider mite populations. These pesticides have activity on most life stages of the mite, including eggs, and are less prone to developing resistance.

Resistance and Resistance Mitigation

Twospotted spider mites possess the ability to develop resistance to miticides within a short time. In fact, numerous mite populations have already developed resistance to commonly used miticides. Resistance develops at the population level, not within an individual, and populations may differ widely in resistance potential. Genes for resistance may already be present in a population before a miticide is applied, although the genes usually occur at very low frequencies in the population. An individual does not become resistant to a miticide, but multiple applications of the same miticide across several generations results in the removal of susceptible individuals from the population, leading to a twospotted spider mite population that has a high proportion of resistant individuals, and consequently, is more difficult to suppress. The extent of resistance may vary depending on the geographical location of the mite population (and strain) and amount of selection pressure exerted on the mite population.

Continued reliance on miticides increases the probability of twospotted spider mite populations developing resistance. Rapid reproductive rate and dispersal behavior are factors that contribute to the ability of twospotted spider mite populations to develop resistance. Because mites cannot fly, greenhouses and nurseries tend to have isolated populations with limited movement of susceptible individuals into the mite population to dilute resistance levels. Some long-term crops, such as roses grown for cut-flower production, remain in place for years, along with twospotted spider mite populations that are continuously exposed to a variety of miticides, increasing the potential for resistance developing in the population. Twospotted spider mite, for example, reproduces by a combination of sexual and asexual means, resulting in offspring that develop from both fertilized and unfertilized eggs. In general, within a twospotted spider mite population, males only have one copy of a resistant gene (R), whereas females have two copies (RR). This often indicates that females are more tolerant to miticide applications or may develop resistance faster than males. The typical mechanism of resistance exhibited by most twospotted spider mite populations is metabolic detoxification.

The rate of resistance development may be faster in twospotted spider mite populations because resistant genes are exposed to selection for resistance almost immediately. As such, resistant genes can rapidly be expressed in a mite population within a short time. However, the rate of resistance development to a particular miticide will vary depending on the amount of selection pressure (frequency of applying miticides) placed on the mite population.

Many currently available miticides contain resistance management information on the label, which may include the number of applications per crop cycle, number of sequential applications and total amount of product that may be applied per crop cycle, or a combination of these statements. These directions are incorporated into labels to delay or reduce the onset of resistance.

It is important to rotate miticides or insecticides/miticides with different modes of action to reduce the possibility of twospotted spider mite populations developing resistance. In general, greenhouse and nursery producers should only use a miticide once or twice within a generation (depending on the time of year), then switch to a miticide with a different mode of action. This will extend the longevity and effectiveness of the currently available miticides. For more information on resistance and mode of action, refer to the K-State Research and Extension publication *Resistance Management: Resistance, Mode of Action, and Pesticide Rotation,* MF-2905.

Impact of Pesticides on Twospotted Spider Mite Populations

Certain insecticides (and some fungicides) have been implicated in directly and indirectly affecting population dynamics of the twospotted spider mite by influencing

development, behavior, and reproduction. Possible factors responsible for this phenomenon include the following:

- Elimination of natural enemies, which naturally regulate twospotted spider mite populations.
- Direct stimulation of mite reproduction. Certain insecticides, especially those in the chemical class organophosphate, may actually stimulate female reproduction and lead to potential mite outbreaks.
- Indirect stimulation through effects on plant biochemistry by improving the nutritional quality (by virtue of the quantity of essential amino acids) of host plants.
- Enhanced dispersion of mites due to irritation or agitation caused by an insecticide.

Twospotted spider mite responses to these factors may also be due to changes in plant nutrition or composition induced when pesticides are applied to the soil or growing medium. Soil- or growing medium-applied pesticides, which typically have systemic activity, may actually stimulate plant growth, potentially increasing problems with twospotted spider mites. However, this depends on the pesticide used, rate applied, formulation, soil or growing medium used, and binding ability of the active ingredient to soils or growing media.

Twospotted spider mite populations may respond positively to increased concentrations of sugars and nitrogen based on enhanced development. Repeat applications of pesticides may be required to create stimulatory effects. Knowing that pesticide applications may lead to potential outbreaks of twospotted spider mites should assist greenhouse and nursery producers in making better decisions in managing mite populations.

Biological Management

Biological control, or the use of natural enemies, is another viable strategy to manage twospotted spider mite populations. Biological control can be very effective, but in some cases (e.g., when mite populations reach damaging levels), natural enemies may not be able to suppress or regulate mite populations at sufficient levels to prevent aesthetic damage. Also, some natural enemies are sensitive to certain miticides.

Biological control may be more amenable for use on long-term crops (e.g., chrysanthemum, roses, transvaal daisy) or vegetables where aesthetics is of less concern than with short-term crops (e.g., bedding plants) that are grown and sold within four to six weeks. Biological control may be effective on short-term floricultural crops if a preventive (prophylactic) strategy is used. For some producers, higher costs or labor associated with biological control may be a deterrent. However, broadcast methods (e.g., using blowers to disperse predatory mites) may reduce these costs.

A number of predatory mites, a predatory midge, and a ladybird beetle are commercially available (Table 2). If used properly, these natural enemies can provide effective suppression and regulation of twospotted spider mite populations. The biological control agent that is most widely used against twospotted spider mite is the predatory mite, *Phytoseiulus persimilis*. This predator has good searching ability (very active) and completes development in three to five days, which is shorter than the prey mite. *Phytoseiulus persimilis* females also have a high reproductive potential and feed exclusively on all life stages (e.g., eggs, larvae, nymphs, and adults) of the twospotted spider mite. This predatory mite is such an efficient predator that

Table 2. Biological control agents (natural enemies) commercially available for regulation of twospotted spider mite, *Tetranychus urticae,* populations in greenhouses and nurseries.

Predatory Mites	*Phytoseiulus persimilis*	Only feeds on twospotted spider mite. Requires temperatures around 68°F (20°C) and a relative humidity above 60%.
	Galendromus occidentalis	Tolerates a wide range of temperatures and relative humidity.
	Neoseiulus californicus	Survives longer in the absence of prey than *P. persimilis* and feeds on other pests such as mites and thrips. Also tolerates higher temperatures and relative humidity than *P. persimilis*.
	Neoseiuls fallacis	Survives under lower temperatures and lower prey availability than *P. persimilis*. May regulate twospotted spider mite populations in outdoor situations.
Predatory Midge	*Feltiella acarisuga*	Larva is the only predaceous life stage. Feed on all life stages of twospotted spider mite including eggs, larvae, nymphs, and adults.
Predatory Ladybird Beetle	*Stethorus punctillum*	Both larva and adult are predaceous. Feed on all life stages of the twospotted spider mite including eggs, larvae, nymphs, and adults.

it can nearly eliminate twospotted spider mite populations, resulting in its own starvation. As such, *P. persimilis* needs to be reintroduced periodically. In addition, *P. persimilis* requires temperatures between 60˚F and 80˚F (15˚C to 26˚C) and a relative humidity above 50 percent.

Other predatory mites tolerate higher or lower temperatures and relative humidity than *P. persimilis* and feed on alternative food sources (Table 2). Biological control agents must be released before twospotted spider mite populations reach damaging levels. The population growth of predatory mites depends on the density and distribution of twospotted spider mite populations as well as temperature and relative humidity. Contact suppliers or distributors of biological control agents for information on release rates and other ways to maximize the effectiveness of natural enemies.

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