# Spider Mite Management in Strawberries

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## Spider Mite Biology

The two-spotted spider mite, *Tetranychus urticae*, is a very common pest of strawberries. This species overwinters in the soil as mated adult females, which are an orange color with two darker brown spots. All subsequent generations of spider mites during the growing season are a pale green with two dark spots, one on each side of the body. Upon emergence from the soil in the spring, overwintered females start to feed and lay eggs. The eggs hatch into 6-legged nymphs, which then go through two additional molts to 8-legged stages before attaining adulthood. These mobile stages of mites feed by puncturing ~20 individual plant cells at each place where they insert their mouthparts and suck out the cells' contents. Chlorophyll is removed from each feeding site, leaving tiny chlorotic spots. With sufficient mite feeding, the leaf takes on an overall chlorotic appearance and the plant can be stunted.

The development rate of spider mites is dependent on the ambient temperature. They are high-temperature adapted mites, and are able to complete a life cycle in as little as 7 days when temperatures are in the 80's (ºF). A special challenge for strawberry growers is spider mite reproduction under floating row covers. The temperatures are elevated under row covers, permitting both the plants and the spider mites to develop faster. Spraying is obviously impossible, though, with row covers in place. The nitrogen content of leaves also influences the mite reproduction rate. Excessive nitrogen conditions favors spider mite outbreaks.

Spider mites take their common name from their ability to produce silk. Colonies of mites feed on the underside of leaves, sometimes protecting themselves from predators under a layer of silk webbing. In severe circumstances, the entire plant can become encased in silk. The silk plays an important role in dispersal, too. When populations of mites on a leaf are too high, or the leaf becomes depleted as food for mites, some of the mites will crawl to the upper part of the plant and "balloon" by releasing themselves into the wind with a trailing strand of silk. Mites can become airborne and can travel long distances in this manner.

The genetic system in spider mites is arrhenotoky, which is found in many parasitic wasps and in honeybees. Unfertilized eggs are haploid and develop into males, while fertilized eggs develop into females. Therefore, males only have one set of chromosomes and every gene is expressed as a dominant trait (similar to the genes of the human "Y" chromosome). This type of system would be very efficient for exposing chance mutations that can confer resistance to miticides. This genetic system and the ability to complete several generations each growing season makes management and resistance management of twospotted spider mites formidable.

## Monitoring Methods

To assess whether you have spider mite problems that require spraying, check the undersides of leaflets with a 10_ hand lens. Spraying is justified when counts of spider mites exceed 5-25 mites per mid-tier leaflet, based on the stage of development of the plant. Within the first four months after transplanting, the threshold is lowest (5 mites per leaflet), whereas the threshold at the beginning of harvest should be 10 mites per leaflet. After harvest, the plants can

tolerate up to 25 mites per leaflet. Besides doing semi-quantitative counts of mites on leaves, be sure to walk your fields and be on the lookout for any chlorotic areas or signs of webbing.

While monitoring spider mite populations, keep track of the number of predatory mites you are observing. One predatory mite for every 10 spider mites is a high population for predators, and the spider mite population can be predicted to quickly diminish. The presence of predatory mites can dramatically change the outcome of spider mite infestations in strawberries. However, these predators do need food (spider mites) to maintain their populations. This is why having a few spider mites in fields can be beneficial – their presence allows you to "grow your own" biological control in the field. There's more on this subject under "Biological control."

## Control Strategies

**Biological control**. We are fortunate in New England in having an abundance of a very effective spider mite predator, *Neoseiulus fallacis*. This predatory mite will disperse into strawberry fields and, as long as disruptive pesticides are avoided, can keep spider mite populations low. On the west coast, growers often release beneficial predatory mites to help keep the balance between predators and prey. In fact, Oregon State University has published a guide that permits growers to calculate how many predators should be released to achieve biological control of spider mites within a user-defined length of time. To view this calculator, visit the web site (http://oregonstate.edu/Dept/entomology/ipm/mcalc.html#SAMP).

Because predatory mites are usually already found in New England strawberry fields, the more cost-effective way to use them is by implementing conservation strategies. As mentioned under "Monitoring methods," it can be beneficial to have some spider mites present in a field to provide food for predators. These act as food for predators, and as long as they remain below economical damage thresholds, you obtain benefit by "growing your own" predators. The most important component in conserving predators is avoiding pesticides that are highly toxic to predatory mites. The pesticides most toxic to predatory mites are pyrethroids (bifenthrin [Brigade], fenpropathin [Danitol], and permethrin [Pounce or Ambush]), carbaryl [Sevin], chlorpyrifos [Lorsban], and Benlate. For additional information on other pesticides and their toxicity to *N. fallacis*, see (http://www.ent.orst.edu/prattp/pesticides.html).

**Foliar sprays of miticides.** Several types of miticides are currently available for strawberry fields, and other new compounds may soon be labeled. The miticides can be categorized based on the stages of the mites that are killed. Horticultural oil kills by suffocation and is effective against all stages of mites, including eggs. Some miticides are only active against the mobile stages of mites. These would include dicofol (Kelthane), abamectin (Agri-Mek), bifenazate (Acramite) and Vendex (fenbutatin-oxide). Hexythiazox (Savey) and similar miticides not yet registered for use in strawberries kill the mite eggs, some the hexapod nymphs, and sterilize adult females. Notes on the characteristics for each miticide are listed below the table.

In the table on the next page, I have assumed that the normal labeled rate is being applied. Where a range in cost per acre is indicated, this reflects the range of rates on the label (in most cases), or where a lower rate is appropriate for integrated mite management (Agri-Mek). The costs are based on the per-acre quantity of material being applied. For soap and oil, which are mixed based on a dilute spray and quantity per 100 gallons of spray mix, I assume that a grower would apply 50 gallons of spray per acre.

| Trade name | Active ingredient | Cost per acre | Signal word | PHI[a] | Groups killed[b] |
|---|---|---|---|---|---|
| Acramite | bifenazate | $38 - 51 | Caution | 1 d | SM mobile |
| Agri-Mek | abamectin | 32 - 172 | Warning | 7 d | SM mobile |
| Kelthane | dicofol | 14 - 28 | Danger | 3 d | CM, SM, **PM** |
| oils | paraffinic oils | 3 - 6 | Caution | 0 d | all TSSM |
| M-Pede | soap | 18 | Caution | 0 d | SM mobile |
| Savey | hexythiazox | 96 | Caution | 3 d | SM eggs |
| Vendex | fenbutatin-oxide | 28 - 37 | Danger | 1 d | SM mobile |

[a]The minimum reentry interval without PPE may be 12 hours for soap and oil.
[b]CM, cyclamen mite; PM, predatory mite; SM, spider mite

**Acramite**, or bifenazate, has just obtained its registration for use on strawberries in Connecticut (October 23, 2003). Bifenazate is an extraordinarily active contact miticide, quickly killing mobile stages of spider mites. It reportedly also will kill some spider mite eggs. Probably more important is the fact that residues remain active long enough to kill mites when they finally hatch from eggs, so spraying when many eggs are present is not a problem. It is also essentially non-toxic to predatory mites, so it is compatible with integrated management of mites. The use rate is 0.75 – 1 lb. of product per acre.

**Agri-Mek**, or abamectin, is a trans-laminar systemic miticide and insecticide, meaning that it is absorbed into the leaf tissue but is not transported upward or downward in the plant. Absorption into the plant tissue is beneficial in several ways: it minimizes the contact of this product with beneficial predatory mites and insects, and it protects the active ingredient from being broken down too quickly by sunlight. It continues to be effective for ~2 weeks after application because feeding mites continue to ingest the active ingredient sequestered in the leaf. **The label rates of this product are greatly excessive.** Used at the rate suggested on the label (16 fl. oz. per acre for each spray, with two sprays), abamectin is highly toxic to predatory mites and is prohibitively expensive. A more practical application rate is 6 fluid ounces per acre, in one application (giving the $32/acre cost given above), followed by a second application only if predatory mite populations are not sufficient to finish "mopping up" the spider mite infestation. If possible, Agri-Mek should be combined with horticultural oil or DyneAmic (a miticidal adjuvant containing vegetable oil + organosilicone surfactant) for resistance management purposes and to maximize the movement of active ingredient into the leaves. The abamectin + oil combination has been my standard against which all other miticides have been compared for the last 10 years.

**Brigade**, or bifenthrin, is a pyrethroid insecticide that also has miticidal activity. It is extremely toxic to predatory mites and resistance to pyrethroids among twospotted spider mites is common. Therefore, outbreaks of spider mites are very common following application of this product and it should not be considered a miticide. Brigade is the mainstay for control of adult root weevils and sap beetles, so growers may have to resort to using this product. If bifenthrin application is necessary, a grower should plan to either combine it with oil or to use horticultural oil early in the growing season to avoid mite outbreaks.

**Danitol**, or fenpropathrin, is a pyrethroid insecticide that also has miticidal activity. It has shorter residual activity than Brigade and is not effective against root weevil adults, but it is

very toxic to predatory insects and mites. Therefore, I do not see any reason to use this product in a strawberry insect or mite management program.

**Kelthane**, or dicofol, is an old organochlorine miticide. Its mode of action is to disrupt nerve transmission in the spider mite. It has the unfortunate characteristic of being very toxic to predatory mites, but can have a place in strawberry pest management if cyclamen mites are a problem (Thiodan, or endosulfan, also controls cyclamen mites). Cyclamen mites feed within the crown of the plant and cause leaves to be dwarfed and cupped. Be aware that spider mites probably have a long history of ancestral exposure to dicofol, meaning that resistance genes may be very common in the population. This implies that resistance could crop up nearly immediately following a single spray of this miticide. It is applied at a rate of 1 – 2 pounds of Kelthane 50W product per acre (3 – 4 pounds per acre for control of cyclamen mites).

**Horticultural oils** available under a variety of trade names are registered for use on strawberries. Oils are the least expensive IPM-compatible product, and are probably organically acceptable. The remarkable feature of oil is that it is generally toxic to many pests, but surprisingly does not kill many predatory mites. The challenges in using oil are that (1) it requires good agitation in the spray tank, (2) very thorough spray coverage is necessary, because the mite has to be directly contacted with the spray emulsion, and (3) it is not compatible with some other pesticides (notably Captan, Morestan, and sulfur). Oil works by suffocation, which means that all stages of spider mites are susceptible. As the respiration of the pest increases with temperature, the amount of oil required to suffocate them decreases. Therefore, even a 0.5% suspension of oil can provide great benefit for control of mites under 75-85ºF temperatures. Genes conferring tolerance to suffocation are not known in spider mites, so oil is also resistance-proof. Including oil with another miticide (such as Agri-Mek or Savey) can be a good resistance management strategy.

A very successful strategy has been the use of oil soon after overwintering spider mites are found on the foliage. 50 gallons per acre of a 1% spray emulsion applied with a tractor-driven mist blower can provide season-long control of spider mites at this time. The very early spray timing is necessary to avoid the incompatibility of oil with Captan, and takes advantage of there being minimal foliage to cover. A similar strategy may work for spraying strawberries 1-2 days following renovation mowing. The chemical cost of this treatment is negligible (~$3-6 per acre), as only 2 quarts of oil per acre need to be used.

**M-Pede**, or insecticidal soap, will kill mobile stages of mites directly contacted by the spray solution. However, this material is more costly and less effective than horticultural oil. Insecticidal soap is probably organically acceptable. The use rate for M-Pede is a 2% solution, or 2 gallons mixed with 98 gallons of water.

**Savey**, or hexythiazox, is a growth regulator miticide that kills eggs, young nymphs, and sterilizes adult female mites. One of the challenges in using hexythiazox is its inability to kill older mobile stages of spider mites. Therefore, the full effect of a Savey application may not be seen for 2-3 weeks. If spider mite populations are high at the time of spraying, considerable damage can continue to take place. On the other hand, Savey can be combined with oil for a quick knock down and residual control, and it is not toxic to predatory mites. Savey can only be applied once per year, at a rate of 6 oz. of product per acre.

**Vendex**, or fenbutatin-oxide, blocks oxidative phosphorylation of ADP to form ATP, which is the common currency of energy in the cell. This molecule is surprisingly selectively toxic to spider mites, so it is compatible with integrated management of spider mites. Vendex is used at a rate of 1.5 – 2 lb. of product per acre.

A management program entirely dependent on foliar sprays to control spider mites is risky. The foliage can be too dense to allow thorough enough spray coverage of the undersides of the leaves, permitting some of the mite population to remain on untreated surfaces. The reproductive rate of these mites permits survivors to repopulate the leaves quickly to damaging levels. If insecticides, fungicides, and non-selective miticides have eliminated predatory mites from strawberry fields, then multiple miticide sprays may be necessary to obtain adequate control. Some miticide labels now only allow one spray per year (to avoid excessive selection for resistance), and growers may be forced to use very expensive miticides.

Repeated resurgence of spider mites is prevented when predatory mites are conserved and a selective miticide is used. Selective miticide use leads to a situation in which there is an overabundance of predatory mites relative to their prey. The predators left on leaves from which spider mites have been eliminated then actively search for food, and will find the regions on the plants where spray coverage was inadequate. This is ideal from a mite management and resistance management perspective: the mites that would be expected to have survived due to resistance then can be subjected to intensive predation and their chance to reproduce is cut off. Furthermore, the active searching of predators into mite refuges can essentially "mop up" the mite populations following the spray.

## Summary

Twospotted spider mites can be a challenge to control in strawberry plants if (1) the foliage is very dense, (2) predatory mites are not present, and (3) the plants are over-fertilized with nitrogen. Expenses can mount quickly if repeated applications of miticides (especially newer products) become necessary. Conserving predatory mites and appropriate use of selective miticides can transform mite management into an inexpensive procedure. Using horticultural oil early in the growing season is the least expensive option, and has been very successful for integrated management of spider mites.

Note: Always follow label directions. Use of a product name does not imply endorsement of the product to the exclusion of others that may also be suitable.