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Taifun Soy Info

Specialist information for soy producers and processors

Spider mites on soybeans

1. Overview

1.1 Spider mites at a glance

Spider mites (Tetranychidae) cause great damage in agriculture worldwide. The family comprises about 1200 species adapted to different host plants. The greatest damage is caused by the red or two-spotted spider mite (*Tetranychus urticae*). The species infests many different crops worldwide, including soy. The red spider mite feed on plant sap from leaf cells which they pierce and suck with their mouthparts. Infested leaves can be identified by these punctures on the underside of the leaves, recognizable as yellowish or whitish dots. The infestation leads to uncontrolled water loss and a reduced rate of photosynthesis. If the density of mites is high, the leaves discolor and fall off. In rare cases the plant dies. Spider mite infestation can reduce the soy yield by 40-60%, depending on time and intensity (Buyung et al., 2011; Knodel, 2010). **As the mites are, due to their small size, hardly visible, the symptoms of infestation can easily be confused with water stress, improper herbicide application or leaf diseases.** For visual identification of spider mites on the leaves you need a magnifying glass. The easiest way to detect an infestation is to tap a leaf over a sheet of white paper on which the mites are visible as dark, moving dots. Also, the eponymous webs on the leaf surface indicate an infestation. An infestation usually occurs at the edge of the field. Especially when the adjacent vegetation is mown the mites migrate into the field. Neighboring alfalfa fields pose a particular risk, as alfalfa is a preferred host plant of mites. The infestation first spreads from the lower to the upper leaves and then from the field edge towards the inside of the field. The mites use the wind and their nets for transport, flying like a balloon ("ballooning").

Spider mites are a problem especially in hot and dry periods. Then they find optimal development conditions and benefit from the fact that the plants are under water stress. Furthermore, the natural fungal enemy (*Neozygites floridana*) and various predators are largely absent under these weather conditions or cannot keep up with population growth of the spider mites.

1.2 Control strategies

Spider mites are naturally controlled by various enemies. These are mainly predatory mites (e.g. species of the *Phytoseidae*), lesser mite destroyer / spider mite destroyer *(Stethorus punctillum*), the common green lacewing (*Chrysoperla carnea*), brown lacewings (*Hemerobiidae*) and predatory bugs (*Orius sp*). To avoid mass reproduction of spider mites, these beneficial insects should be supported. In addition, all cultivation measures that reduce the plants' drought stress will help. Rain is the farmer's best friend in case of spider mites, because the spider mite population usually collapses at the end of the hot dry period.

For chemical control, there are only a few miticides available in the USA with the active ingredients chlorpyrifos, dimethoate or bifenthrin,

but they are often not able to effectively control an infestation. In Germany, no agents are approved for soy. In special crops there are several agents with active ingredients such as rapeseed oil, pyrethrins, abamectin, spirodiclofen or fenpyroximate. In most cases, repeated treatment with various miticides is necessary to control newly hatching mites.

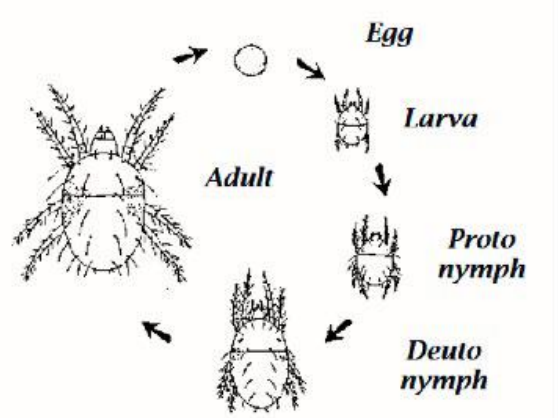

Fig. 2: Life cycle of the red spider mite (Ostlie K., 2012)

2. Further information

2.1 Biology

Red or two-spotted spider mites are arachnids. Like all mites, they consist of two segments, the oval idiosoma and the gnathosoma, which contains the mouthparts. Spider mites are very small: adult mites are less than half a millimeter in size, eggs are only 0.15 mm in size. The mites develop from an egg through a larval stage with three pairs of legs, over two nymph stages (4 pairs of legs) to an adult animal with the 4 pairs of legs typical for arachnids. Nymphs and adults are translucent yellowish green to dull orange and have a dark spot on both sides of the body caused by accumulated particles in the digestive tract. Nymphs and adults feed on plant sap, which they suck out of leaf cells with their mouthparts. Besides soy they infest various plants (250 species), including many other crop plants like corn, alfalfa and various vegetables, but also ornamental plants, cotton and fruit trees.

Fig. 1: Red spider mite (digitally coloured) (Fasulo and Denmark, 2009)

Spider mites are most common in hot climates. Female spider mites hibernate in protected vegetation in a survival stage in which they do not consume any food. In the agricultural landscape, hibernation takes place at field edges or permanently existing fields, especially in alfalfa fields. The name ‘Red Spider’ comes from the red orange color of the wintering females. They can survive low temperatures but need a relatively high air humidity to survive. In spring, the female mites resume their feed intake and egg production. To lay their eggs they spin webs on the underside of leaves and lay the eggs there. Depending on temperature, humidity and host plant, the larvae hatch after about 3-4 days (Buyung et al., 2011). The optimum temperature is 30-32°C, but development takes place in a temperature range of 12-40°C (ibid.). Spider mites live in overlapping generations, (generation time of about 4-14 days according to Cullen and Schramm, 2009) and hence all stages of development can be found simultaneously during the vegetation period. The warmer it is, the faster the generations follow each other. Females lay about 90-110 eggs during their 30-day life. Under optimal conditions up to 300 eggs are possible (Cullen & Schramm, 2009), indicating a high reproductive potential.

Fig. 3: Adult red spider mites with eggs (bugwood.org)

The ability to spin webs distinguishes spider mites from other mites. They not only use the nets for oviposition but also overcome greater distances by letting themselves be carried away by the wind blowing into the nets ('ballooning').

Fig. 4: Spider mite webs on the underside of a leaf (Fasulo and Danmark, 2009)

Spider mites occur in large numbers in soybean stands only in summers with hot dry periods. In years with normal precipitation and temperature patterns, mass reproduction is prevented by various factors. Spider mite populations are usually controlled by several antagonists. On the one hand, the pathogenic fungus *Neozygites floridana* attacks all stages of the spider mite. Yet, this fungus cannot produce infectious spores under hot dry conditions. On the other hand, spider mites are hunted by various predators, predatory mites and insects. However, if spider mites find optimal development conditions, they reproduce much faster than their predators. Hence, biological control is not possible during hot dry periods. In addition, soy is an attractive host plant, especially when it is under drought stress. In this case the plant juices are particularly rich in nutrients. For a mass infestation with spider mites, certain environmental conditions are therefore necessary.

2.2 Damages

For their food intake, spider mites pierce holes in leaf cells. Clusters of these punctures are visible as white to yellowish spots on the leaves. The activity of the mites leads to a reduction of the chlorophyll content in the leaves and thus a reduced rate of photosynthesis. The plant also uncontrollably loses water through the punctures. This increases the simultaneously occurring drought stress. In the case of heavy infestation, the leaves change color from yellow to bronze to brown and finally fall off. Occasionally whole plants die off. Spider mites can thus considerably reduce soybean yield. The amount of loss depends on the time and intensity of the infestation. Studies in the North Midwest USA showed yield losses of 40-60% with infestation during the end of the vegetative and early reproductive phase. In this phase, which is decisive for the yield, the mites delay the growth of new leaves and the development of the canopy. The plants grow fewer pods, produce fewer beans per pod and smaller beans. Pods from infested plants break more easily, which further increases crop losses. This occurs mainly during late infestation. Differences in the reproduction rate of mites between different soy varieties have been observed, but could not be explained so far. In Table 1 at the end of the text the harvest loss can be estimated by means of a damage scale.

Fig. 5 (l.): Soybeans with spots (Hammond et al., 2009) Fig. 6 (r.): Typical yellow discoloration of infested leaves (Hammond et al., 2009)

Fig. 7: Typical bronze discoloration of infected leaves (Hammond et al., 2009)

2.3 Infestation

Serious problems with spider mites are irregular and only occur if optimal conditions for the mites are present. Persistent dryness is the most important factor. Permanent high temperatures are also beneficial. Infestation is also possible at moderate temperatures, but the symptoms are less pronounced. Drought stress in the adjacent vegetation (e.g. alfalfa fields) can cause mass movements into the soy field, especially when the alfalfa is mowed. For transport, the mites crawl onto exposed plant tops and are carried by the wind into the adjacent fields. Spider mite infestations therefore typically start at the edge of the field and spread in the wind direction.

Fig.8: Soy field infested by red spider mites. It can be clearly seen that the infestation started at the edge of the field. (Krupke & Obermeyer, 2012)

It has been shown that many cases of mite infestation are a result of intensive use of insecticides, fungicides or herbicides. The application of pesticides weakens the soybean plants and many of the natural antagonists die, hampering biological control.

2.4 Proof

The symptoms of spider mite infestation are similar to the symptoms of drought stress, leaf diseases or improper herbicide use and are therefore easily confused, especially since spider mite damage occurs so irregularly. To determine infestation, one should start with an examination at the edges of the field, where the infestation usually begins, and symptoms appear first. With the help of a magnifying glass (at least 10x magnification) the leaves of individual plants are examined for mites. An easier observation is possible on a white sheet of paper over which the leaves are tapped. The adult mites can be seen as small dark moving dots on the paper. If predatory mites also appear on the leaves, they can be recognized by their faster movements and the lack of dark spots. With a magnifying glass the mites are easier to recognize on the paper and you can also distinguish nymphs. Also nets on the underside of the leaves, where the eggs are laid, indicate an infestation, but this infestation may already be in the past. Eggs are visible under a magnifying glass and look like pearls.

The colonization of plants usually starts in the lower and middle leaves. If the upper leaves are also affected, the mites have already started to migrate. If an infestation is found at the edge of the field, the whole field must be examined. Even green, healthy looking plants can be infested. For the examination you go about 30 meters into the field, where you make a first stop. From there you walk a large "U" with 20 random stops. At each stop, at least two plants are inspected for symptoms such as spotting and discoloration and the presence of mites. In the early stage of infestation, the typical spotting is discovered mainly on the underside of the leaves. Special attention should be paid to areas in the field which are susceptible to drought stress, e.g. on higher situated areas in the field, or in wind direction to the determined infestation.

2.5 Control

2.5.1 Biological

The most effective measures to prevent spider mite infestation are on the one hand the promotion of natural antagonists and on the other hand adapted cultivation measures to avoid drought stress. Alfalfa fields adjacent to the soybean field pose a risk, because spider mites can migrate from there to the soybean field. If possible, vegetation adjacent to the soybean field should not be mowed during dry periods, because this can cause mass movements. To prevent infestation, care should also be taken when applying pesticides to ensure that important beneficial organisms are not damaged. Predatory mites are the main predators of red spider mites (e.g. species of the *Phytoseidae*). Spider mites are also eaten by the lesser mite destroyer (*Stethorus punctillum*), the larvae of the common green lacewing (*Chrysoperla carnea*), brown lacewings (*Hemerobiidae*) and predatory bugs (*Orius sp*). However, an active release of these species makes no sense in soybean cultivation for financial reasons.

Fig. 9 (l.): Predatory mite (*Phytoseiulus persimilis*) (ökolandbau.de) Fig. 10 (r.): Lesser mite destroyer (*Stethorus punctillum*) (evergreengrowers.com)

Fig. 11: Predatory bug (*Orius ssp*.) (ökolandbau.de)

In hot dry phases, however, despite taking precautions, the spider mites may spread strongly. In horticulture and greenhouse cultures biological insecticides like neem extract and soft soap are used. However, it is questionable whether it is worthwhile using them on the scale of soybean fields.

With the end of the dry period, the spider mite population also collapses, among other reasons because the mites are then attacked by the fungal antagonist *Neozygites floridana*. The fungus requires 12-24 hours of weather conditions of less than 29°C in combination with 90% humidity to spread throughout the entire population. Infected mites can be recognized by their waxy and dull structure. They die after about 1-3 days. Rain also ends the drought stress of the plants, which then suffer less from mite damage. If the dry period continues after a rain or thunderstorm, the precipitation is not always sufficient to stop a strong infestation.

Fig. 12: Healthy spider mite and infested by *Neozygites floridana* (Washington State University)

2.5.2 Chemical

The chemical control of spider mites on soybeans holds several pitfalls. There are relatively few agents that are recommended for the use against spider mites. In soy stands in the USA, for example, the organophosphates chlorpyrifos and dimethoate and the pyrethroid bifenthrin are used. Few other pyrethroids are recommended for preventive suppression, but not for the control of an infestation. The use of pesticides not explicitly recommended for spider mites usually has undesirable effects on the mite population: the population grows because the natural enemies but not the mites are weakened. Miticides have no effect on the eggs of the mites, so multiple treatments are usually necessary. The same miticide should never be used twice because spider mites are able to quickly develop resistance. The miticides not only damage the spider mites, but also the natural antagonists. If the spider mites hatch out of the eggs, the population can recover within a very short time or even increase because the natural antagonist is lost. Treated fields should therefore be observed carefully in order to be able to intervene again if necessary. The second treatment should take place before the newly hatched mites lay their eggs. Nevertheless, miticides can often only reduce the reproduction rate of the spider mites but cannot control the infestation.

Exact damage thresholds are not known. However, there are indications, which are shown in Table 1. As far as permitted, treatment makes sense during the phases critical for yield formation (R4 and R5). Although infestation in later growth phases results in increased breakage of the pods, the negative effects on the yield are not as high.

Symptoms	**Evaluation**
Hardly any mites on the underside of the leaves on dry places in the field or field edges. Hardly any damage to plants visible.	1: no economic damage
Mites easily visible on the underside of leaves on dry places in the field or field edges, but hardly on leaves inside the field. Foliage green, but spotting on underside of leaves visible, but not on all plants.	2: no economic damage, further monitoring
Most plants are infested on close observation. Most plants in the field show spotting, even on green leaves. Discoloration of the lower leaves. Field edges and dry spots show damage.	3: **Treatment recommended**, especially if also eggs and nymphs are found
All plants are heavily infested when observed closely. Discolored and wilted leaves are easy to spot anywhere in the field. Severe damage obvious.	4: **Treatment may be recommended**; rescue treatment may obtain harvest
Extremely high mite infestation. Field discolored, leaves discolored bronze and fall off.	5: No preservation of the harvest possible.

Table 1: Treatment guidelines and damage assessment for spider mite infestation (from Cullen and Schramm, 2009)

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