SPIDER MITE BIOLOGY AND ECOLOGY

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Abstract

There are at least 33 species of mites in the family Tetranychidae are reported to be pests of cotton throughout the world, and 19 species in the United States (Leigh 1985). Of those mites affecting U.S. cotton, the most prevalent species are the twospotted spider mite, *Tetranychus urticae*, the carmine spider mite, *T. cinnabarinus*, the strawberry spider mite, *T. turkestani*, the Pacific spider mite, *T. pacificus*, and the desert spider mite, *T. desertorum*. The strawberry, Pacific and desert spider mites occur primarily in California, whereas the twospotted and carmine spider mites occur belt wide and are the most common spider mite pests affecting U.S. cotton. However, these two species are extremely difficult to distinguish from one another. The carmine spider mite females are red, while the twospotted spider mite is greenish in color. However, when nearing conditions suitable for initiating diapause, the female twospotted spider mite may also be red (Tuttle and Baker 1968). Thus, color is not always a good indicator of speciation. The primary character for distinguish these species is the shape of the striae on the mite's cuticle. Carmine spider mites are supposed to have striae that are pointed and tall as broad, while twospotted are supposed to be rounded (Tuttle and Baker 1968). However, more recent findings are that these characters are not reliable (Carbonnelle and Hance 2004). To date there is not a reliable means to distinguish carmine from twospotted spider mites. Additionally, the biology and ecology of these two species is very similar; thus the remainder of this discussion will focus on theses two species but will not differentiate between them.

Spider mites in cotton feed primarily on the underside of the leaves, but under high populations will infest the fruiting structures as well. These spider mites are well known for producing profuse webbing. This webbing is thought to serve a number of purposes (Gerson 1985). It aids in courtship and mate finding. Females will sometime cover themselves with light webbing as a means to aid the male in location. She will also deposit sex pheromone onto the webbing as a means of holding the pheromone for uniform dispersal. The webbing serves as a mean of locomotion between plants or plant parts, and may favorably affect microclimate within the webbed area. However, the primary benefit of webbing is protection. Webbing can hamper predators and will help in repelling precipitation or miticide applications.

The twospotted spider mite is extremely polyphagous with a cosmopolitan distribution. It is known to feed on over 900 host species including over 150 economically important ornamental and food crops, including grass and broad-leaved crops. Because of its wide distribution and wide host range, the twospotted spider mite is the most economically important phytophagous mite in the world.

The twospotted spider mite can reproduce year round as long as warm temperatures persist. Spider mite females can lay over a 200 eggs, but generally average about 70 (Martin 2000, Wilson and Sadras 1997). They will generally lay 3 to 14 eggs per day. These eggs appear as small pearl to pink colored spheres. Twospotted spider mites exhibit a type of parthenogenesis called arrhenotoky where unfertilized (haploid) eggs will produce males and fertilized (diploid) eggs will produce females and males, at an approximate ratio of 3 to 1 (Crooker 1985). Eggs will hatch in a few days into a 6 legged larval stage. The immature stages look like small adults in shape. The larval stage is extremely small and somewhat translucent in color. It will molt to two eight legged nymphal stages, protonymph and deutonymph; and finally to the adult which will measure about 0.65 mm in length. Growth and development is temperature dependent and is influenced by the host plant (Martin 2000). The entire life cycle will require 7 to 14 days to complete in summer months. Although the life cycle speeds up at higher temperatures (upper 80's and 90's ^{o}F), egg production is maximized in the 70's ^{o}F.

There are a number of factors that can influence spider mite population growth (Logan et al. 1976). Abiotic factors

such as temperature, humidity, precipitation and dust (Logan et al 1976, Demirel and Cabuk 2008, Martin 2000). Population growth will increase with increasing temperatures, but when given a preference, twospotted mites prefer moderate temperatures. Surprisingly, although spider mite outbreaks are often associated with dry conditions, they prefer more humid conditions. However, egg laying and survival tend to be higher at low humidity. Mite infestations are often associated with dusty conditions. Although not well understood, dust may impact the effectiveness of mite predators.

Biotic factors also influence population growth potential (Martin 2000, Wilson and Sadras 1997, Wermelinger et al. 1991, Agrawal 2000). Host condition plays a significant role. High levels of leaf nitrogen, phosphorus and carbohydrates tend to support mite population growth (Wermelinger et al. 1991), while water stressed plants tend to have lower mite reproduction (Martin 2003). Although mite outbreaks have been associated with potassium deficiency, this correlation has not been positively supported (Steinkraus et al. 2003). Previous generation's host, and current host's previous exposure to mites may influence mite reproduction. Sometimes it takes several generations for the mite to adapt to a new host, and cotton seedlings exposed to mites develop some slight resistance to subsequent infestations (Agrawal 2000, Karban and Carey 1984). As expected, natural enemies play a significant role in regulating mite populations (Sabelis 1985) and pesticides can reduce predator populations or the population of the mite pest. Additionally, some pesticides have been implicated in increasing the reproductive potential of spider mites. Imidacloprid has been shown to increase the fecundity of twospotted spider mite (James and Price 2002). Imidacloprid is commonly used for managements of thrips, aphids and plant bugs in cotton in the U.S.

There are a number of predators that prey on spider mites in cotton, including minute pirate-bugs, big-eyed bugs, lady beetles, thrips, predacious mites, lacewings and others. Spider mite eggs tend to be the most commonly preyed on stage of the spider mite (Wilson and Sadras 1997). In much of the U.S. cotton belt, the Western flower thrips, *Franklinella occidentalis* is the most important predator of spider mites. Although there are no know parasitoids of spider mites, diseases are often instrumental in mediating spider mite populations. In the U.S., the fungal pathogen *Neozygites floridana* commonly infects twospotted spider mite (Van der Geest 1985).

Spider mite infestations usually begin on field edges, often near dusty roads (Demirel and Cabuk 2008). The populations commonly move into cotton from weedy hosts such as morning glory or palmer amaranth (Steinkraus et al. 2003), or other crops such soybeans or corn. Thus, predicting a spider mite outbreak in cotton can often depend on the population in the immediate surrounding habitat. The twospotted spider mite overwinters as an adult female (Veerman 1985). They like to seek out dark, humid environments in leaf litter or similar habitat to overwinter. When temperatures are warm, diapause may be temporarily broken and reproduction may occur on winter weeds. As warm temperatures are sustained, mite populations will build on spring weeds, and as crowding occurs or with host deterioration, the mites will move into adjacent cotton.

Population dispersal from weeds into cotton may occur as mites crawling from one host to another. This type of dispersal may be most evident in situations where weedy areas are directly adjacent to cotton fields (Steinkraus et al. 2003). The most common mite stage to disperse by crawling is pre-reproductive females. Mites will also move via the wind (Kennedy and Smitley 1985). Mites may be carried short distances on the breezes directly, or by ballooning, where the mite spins a strand of silk to catch the wind. This type of dispersal may carry the mite for miles. Mites can also disperse by catching rides on animals or machinery. This type of dispersal is called phoresy.

Spider mite outbreaks tend to be more common in irrigated or well watered cotton than in dryland cotton (Martin 2000). The reasons for this are not certain but may relate to a lack of nearby weeds around dryland cotton, tougher leaves, decreased reproduction on water stressed plants, lower nitrogen inputs or reduced insecticide use in dryland cotton.

Spider mites feed by piercing clusters of plant cells with their chelicerae (Tomczyk and Kropcznska 1985). They then use their palpi to suck the contents from the palisade and mesophyll cells (Wilson and Sadras 1997). Thus damage usually occurs in clusters. Damaged clusters appear as a white spec on the leaf, termed stipules (Martin 2000). This damage is Phase I damage. As feeding increases and the mites persist, the damage spreads and the leaf takes on a reddened appearance (Phase II) and eventually necrosis (Wilson and Sadras 1997). Cotton photosynthesis has been correlated with this damage and appears to sharply decline when Phase II is reached; about 20 mites per leaf.

Many spider mites are known to inject toxic saliva into their hosts. The twospotted spider mite is known to inject substances into the plant that translocates to new growth, but the impact of these substances in not known (Tomczyk and Kropcznska 1985).

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