Integrated Pest Management
University of Missouri

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Whitefly Control in High Tunnel Tomatoes

by Justin Keay, *Horticulture Field Specialist*

Whiteflies are a common insect pest of concern for tomatoes grown in the field and in high tunnels. In protected environment structures like high tunnels and greenhouses whiteflies can complete their lifecycle in as little as three weeks. The three major whiteflies of concern in Missouri are the greenhouse whitefly, the sweet potato whitefly, and the silver leaf whitefly.

Whiteflies feed on the sugary sap of plants by inserting their piercing/sucking mouthparts into plant tissues. Their feeding causes an overall reduction in plant vigor, leaf yellowing, irregular ripening, and development of sooty mold which grows on the honeydew secreted by whiteflies. Whiteflies can also serve as vectors for viral diseases.

Within 2-3 generations, a complete infestation of a high tunnel can occur. Plant scouting and monitoring using yellow sticky cards are essential to prevent severe infestations and outbreaks from occurring. A minimum of four yellow sticky cards per 1,000 sq.ft. of high tunnel space is recommended. Yellow sticky cards should also be placed at plant canopy height and near doors and sidewalls where whiteflies are likely to enter the structure. Although no action thresholds have been developed for high tunnels, greenhouse action thresholds are .5 whiteflies per sticky card for young crops and 2 whiteflies per sticky card for mature crops.

As with management of any insect pest, an integrated pest management approach is recommended. Proper monitoring can assist in the timing of control measures. Prevention practices include but are not limited to growing and/or purchasing clean transplants, keeping the area around the high tunnel free of weeds, and sanitation of the growth space before transplants are set in. Although natural enemies like lacewing and ladybeetle larvae prey on whiteflies, their predation rarely offers effective control of this pest. Whiteflies cannot survive Missouri's winters, so rolling up the sides of a high tunnel and having no crops during the winter can prevent them from overwintering in protected structures.

The MidWest Vegetable Production guide offers a full list of pesticide options available for whitefly control. Some products such as imidacloprid (e.g., Admire Pro) can be used as a soil drench or a foliar spray. If used as a soil drench these products have a 21-day pre-harvest interval and would only be appropriate for initial stages of crop growth. When used as a foliar spray these products have a zero-day pre-harvest interval. Pyrethrins such as bifenthrin may also be used as a foliar spray but complete coverage of leaf surfaces is critical as whiteflies often are found on the underside of leaves. With any pesticide application be sure to rotate products so their IRAC codes do not overlap and read the label thoroughly for potential phytotoxic effects and application restrictions related to protecting pollinators.

Organic control options are also available for whitefly control in tomatoes. Products such as Pyganic, Azidirachtin and insecticidal soaps may be used to control whitefly, complete foliar coverage is also critical for effectiveness of these products. *Beauvaria bassiana* is an entomopathogenic fungi that has also shown strong effectiveness against whitefly populations, control takes several days from application to whitefly infection and death. Purchased biological control agents such as the parasitic wasp *Encarsia Formosa* have shown to offer effective control in greenhouses, but their effectiveness is less well understood in high tunnel production systems. Certified organic farms should always check with their certifier before using pesticides not currently listed in their annual Organic Systems Plan.

Also in this Issue:

Plastic Mulch Color and Soil Temperature

by Ramón Arancibia, *Horticulture Field Specialist*

Plastic mulch has been a feasible and useful technology for specialty crops including fresh vegetables and small fruit crops for over six decades, but proper selection and installation are critical to get the most out of it. High value vegetable crops well suited to production with plastic mulch are tomatoes, peppers, melons, squash, cucumbers. Strawberry is also a well-known crop that benefits from plastic mulch. This article discusses how plastic mulch color and proper installation influence energy flow and soil temperature.

Growers use plastic mulch because it provides benefits such as soil moisture retention and improved water use efficiency, weed and pest control, reduction of soil compaction, erosion and nutrient leaching, ability to absorb or reflect sunlight (solar radiation) to warm or cool the soil depending on mulch color, season extension, and improved yield and quality. In contrast, disadvantages of using plastic mulch are increased in inputs and costs from the use of specialized equipment, labor/time for installation, and removal and disposal of used plastic unless adopting biodegradable mulches.

Commonly used plastic mulches come in colors such as black, clear, silver reflective, white, and infra-red transmittance green (IRT-green). Black plastic mulch is widely used in spring and late fall to warm up the soil and is usually the least expensive. The black plastic warms up as it absorbs the energy from the sunlight (figure 1). Then the heat is transferred by conduction from the black plastic mulch to the soil when there is tight contact with the soil. Heat conduction is inefficient and soil warming is suboptimal when black mulch is not tightly in contact with the soil. Improper bed preparation and/or plastic installation may result in clumpy soil and/or loose plastic mulch. At night, the air temperature decreases, especially with cloudless sky and dry air, and the soil heat loss occurs by conduction through the plastic mulch back to the atmosphere. However, water condensation beneath the plastic acts as a barrier to heat conduction and soil cooling is slower than in bare ground (table 1).

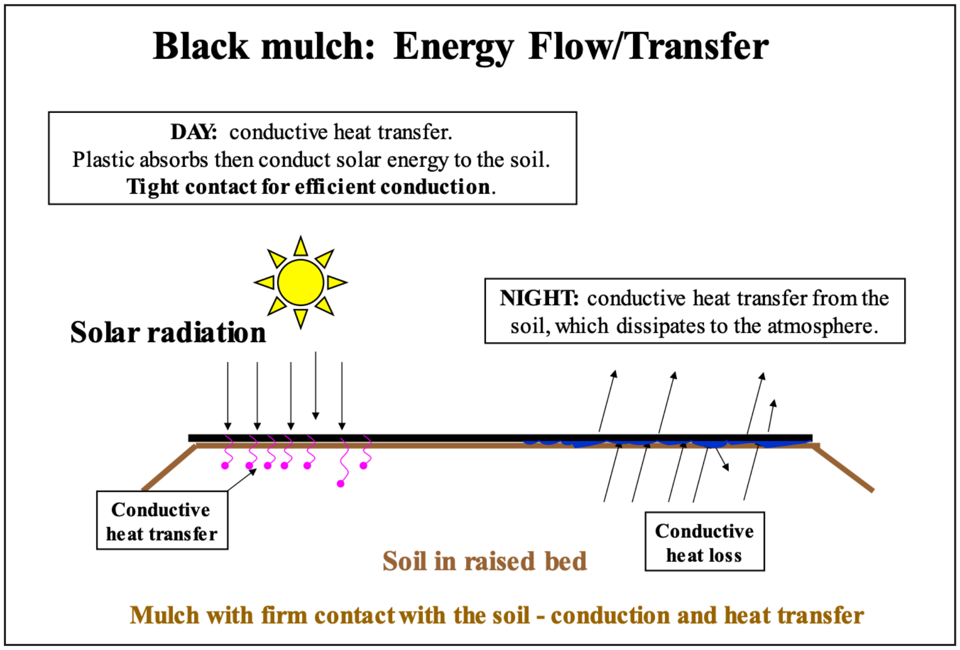

Figure 1 Energy flow in black plastic mulch. During the day, sunlight heats the black plastic and heat is transferred by conduction to the soil. At night, soil heat is lost by conduction through the plastic mulch, but water condensation reduces heat loss.

Mulch	Avg. T max (day)	Avg. T max (day)
Bare ground	76	100
Silver reflective	81	94
White	79	100
SRM-red	80	110
Black	80	109
IRT-green	80	113

Table 1 Soil temperature (degree Fahrenheit) [average minimum (Avg, T min) and average maximum (Avg. T max)] 2 inch deep under colored plastic mulch in comparison to bare ground.

There is a controversy as to whether black or clear plastic mulch heats the soil better and is due to the different mechanism of heating the soil. In contrast to black mulch, clear plastic mulch allows sunlight to pass through heating the soil directly. Tight contact with the soil is not as important but recommended to avoid flapping and transplant damage. However, herbicides may be needed to control weeds growing under clear plastic mulch since weeds can use the light passing through the mulch. Similarly, red plastic mulch, which is sometimes used in tomatoes, does not have good weed control and weeds push the plastic up and loosen it as they grow.

White and silver reflective mulches reflect most of the sunlight back to the atmosphere, so there is minimal energy

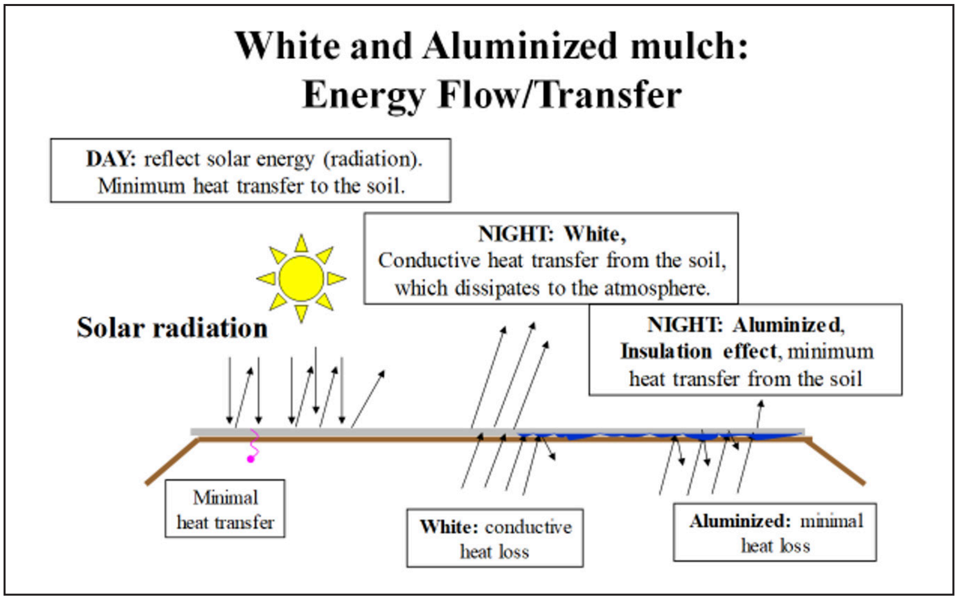

Figure 2 Energy flow in white and silver reflective plastic mulch. During the day, most of the sunlight is reflected to the atmosphere. At night, soil heat is lost by conduction through the plastic mulch. Silver reflective mulch as well as water condensation have insulating properties that reduce heat loss.

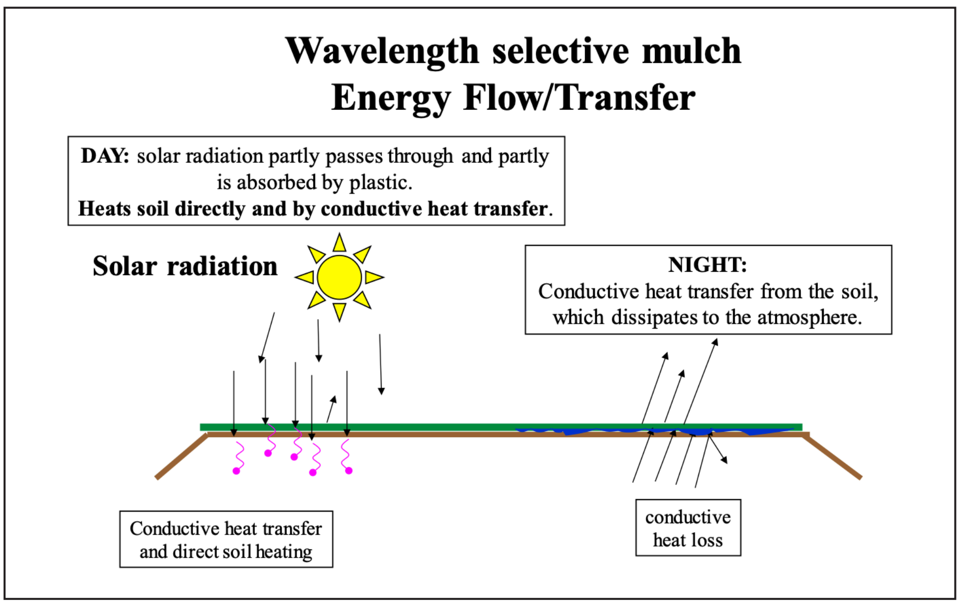

Figure 3 Energy flow in wavelength selective plastic mulches. During the day, sunlight heats the plastic and heat is conducted to the soil, and part of the solar radiation passes through the plastic to reach and heat the soil directly. At night, soil heat is lost by conduction through the plastic mulch, but water condensation reduces heat loss.

absorption and heat transfer to the soil (figure 2). Therefore, the soil usually stays cooler than bare ground or under clear, black, or any colored plastic mulch (table 1). At night, soil heat loss occurs by conduction through the plastic mulch back to the atmosphere. Silver reflective or aluminized plastic mulch, however, has been shown to have some insulating capacity since it reduces heat/energy loss at night keeping the soil warmer than other plastic mulches or bare ground (table 1).

Wavelength selective plastic mulches (IRT-green, PST-green, SLT-red, SRM-red, Al-Or brown) can absorb, reflect, and let through specific wavelengths of the solar radiation. These mulches absorb most of the visible light transferring the heat to the soil by conduction given a tight contact with the soil (figure 3). Absorption and exclusion of the photosynthetically active sunlight allows excellent weed control. In addition, these mulches allow part of the sunlight spectrum (e.g., IRT=infra-red transmitting) to pass through and heat the soil directly (figure 3). Therefore, both mechanisms (heat transfer from plastic and direct soil heating) play a role in the more efficient soil warming characteristic of wavelength selective plastic mulches (table 1), which is useful for early plantings.

Good heat transfer starts with proper soil preparation. All organic matter must be turned over and there should be no clumps on or near the surface. These clumps interfere with a smooth, sharp-edged bed and tight contact between the plastic mulch and the soil. Some growers use rotary tiller as the final step since they mix soil horizontally, not vertically. Another helpful practice is to pre-shape the bed. This is as simple as pre-shaping the row/bed with coulters/hipper to throw soil into the center of the ridged row/bed. Not enough soil in the center leaves pockets and plastic stays suspended above the soil. The air in that space will be heated, but heat transfer to the soil is inefficient. In addition, proper adjustment to the bed shaper and plastic layer itself is also important to getting enough soil into the bed.

There are two basic types of plastic mulch to choose: smooth or embossed plastic. Embossed plastics can stretch so they are less prone cracking due to expansion and contraction under fluctuating temperatures as smooth plastic are. They also maintain better contact with the soil for efficient energy transfer. Warming the plastic before laying helps with tight contact with soil. Plastic mulch is often laid cold after being in storage. Once it is laid in the field, sunlight warms it and it becomes loose on the bed due to expansion. Loose plastic not only is inefficient to transfer heat to the soil but can be caught by the wind and eventually pulled off. If possible, store the plastic in a heated area before use or let it sit exposed to sunlight before laying it on the field.

On-Farm Sweet potato Slip Production under Protected Systems in MO

by Ramón Arancibia, Juan Cabrera-Garcia, and Patrick Byers

Production of sweet potato by local produce growers is not enough to supply Missouri's local market demand. Most of the sweet potatoes consumed in the state are imported from southern states (Louisiana, Mississippi, and Arkansas). Missouri growers have an opportunity to increase local production and increase their market share. This article discusses the findings of a study focused on on-farm production of sweet potato slips under low and/or high tunnels to optimize quality and timing for field planting. Early field planting extends the growing period of sweet potato that may result in higher yield and access to better prices. This study was supported by a Specialty Crop Block Grant (Missouri Department of Agriculture and U.S. Department of Agriculture - Agricultural Marketing Service).

Sweet potato is a perennial tropical crop but cultivated as annual in the U.S. It is sensitive to chilling temperatures (temperatures between 32°F and 60°F) and will die with freezing temperatures. However, production of sweet potato slips begins early in the spring under protected systems to harvest slips for field planting as soon as the soil temperature in the field reaches 65°F and the risk of freezing has passed. Therefore, a trial was set in three Missouri locations (Henry Co. Greene Co. and Oregon Co.) in Early April 2021. Pre-sprouted 'Beauregard' sweet potato "seeds" G1 (storage roots of generation 1) from Louisiana State University were used. After spreading a single layer of "seeds" on the ground we covered them with soil/compost (2 inches above storage roots) and green plastic mulch (figure 1). Three protected systems and a control without protection (Op) were trialed. The protected systems consisted of a low tunnel (LT) covered with spunbonded row cover over wire hoops (2ft tall), high tunnel (HT), and low tunnel inside a high tunnel (LTHT) (figure 2). The plastic mulch was removed when slips were pushing from the ground and the row covers were put back on accordingly. When slips were 12-14 inches tall, they were topped/trimmed back to 10-12 inches (figure 3) and left uncovered for another 1 week or so to toughen up before planting them in the field.

Figure 1 Sweet potato bedding: spreading "seed" (storage roots) in one layer on the ground and covering with compost/soil (2 inches above roots) for on-farm slip production.

Figure 2 Two on-farm sweet potato slip production trials: low tunnel covered with spun-bonded row cover inside a high tunnel, high tunnel, low tunnel, and open without cover.

Figure 3 Growth differences of sweet potato sprouts grown under low tunnel inside the high tunnel (top picture, trimmed front plot), high tunnel (top picture, untrimmed plot), low tunnel (bottom picture, front plot with hoops), and open unprotected (bottom picture, back uncovered plot).

Differences in soil and air temperatures under different protected systems influenced the timing of sweet potato sprout emergence from the soil, plastic mulch removal, growth rate, date of sprouts/slips trimming, and slip harvest for field planting (figure 3). In general, slips grown under a low tunnel inside a high tunnel were harvested first and planted in the field the last week of May in the three locations. Slips grown in the high tunnel without low tunnel were harvested and planted in the field a week later. Then, slips grown under low tunnels outside were harvested and planted in the field 2 to 3 weeks after the first harvest depending on location. Growth of slips in the control plot without any protection (only plastic mulch before emergence) was slow and were the last ones planted in the field 3 to 4 weeks after the first planting. Consequently, on-farm production of sweet potato slips under high tunnels allows growers in Missouri to plant in the field much earlier than low tunnels and uncovered systems. Slip production ranged between 40 and 80 slips/square feet or around 400 to 800 slips/bushel (40lb) of sweet potato "seed". Additional advantages of on-farm production of sweet potato slips are: 1) the flexibility at the time of planting, that is, not having to wait for a shipment to arrive from elsewhere or slip deterioration/decay in arrived boxes when planting is delayed due to adverse weather conditions; and 2) reduced cost of planting by avoiding costly slip purchases that include shipping costs; and 3) increased resiliency in the local food production system.

In summary, on-farm sweet potato slip production under protected systems in Missouri allows farmers to field planting early in the season, so plants have a longer growing period, which increases yield. In addition, early planting with on-farm grown slips available at the appropriate planting time has the potential to reduce planting costs and increase gross income, which would improve the economic sustainability of the operation.

ADDITIONAL ARTICLES

- On-Farm Sweet Potato Slip Production for Field Planting *https://ipm.missouri.edu/MPG/2021/1/sweetpotatoSlipProduction-RA/* (01/06/21)
- Sweet Potato Harvest, Curing and Storage *https://ipm.missouri.edu/MPG/2020/9/sweetPotato-RA/* (09/04/20)

Plants get sick too, The University of Missouri Plant Diagnostic Clinic can help

by Peng Tian, *Lab Director & Plant Diagnostician*

Do you know like humans, plants get sick, too? There are two major factors that can cause plant diseases: biotic and abiotic factors. Biotic factors include all living organisms such as insects, mites, nematodes, fungi, bacteria and viruses. Abiotic factors are mostly related to environmental stress or human activities, such as drought stress, winter injury, chemical injury, mechanical injury and cultivating problems. In many cases, plant diseases occur due to a complication of both abiotic and biotic factors, therefore, the identification of primary cause and contributing factors associated with the disease problems is important to manage the issue and avoid it in the future.

As a plant diagnostician, I run the MU Plant Diagnostic Clinic. As a part of MU Extension, we operate all year around and offer services including plant disease diagnosis, insect identification and weed identification. Regarding disease diagnosis, we use conventional approaches such as microscopic observations and culturing to identify most of the fungal pathogen and apply molecular and serological assays for identification of bacterial and viral diseases. I work with a team composed of several extension specialists and scientists specialized in entomology, weed science, plant physiology and plant pathology in MU extension. We believe a fast and accurate diagnosis and proper recommendations are vital for solving plant health problems and limiting the pesticide applications.

If you need help with a plant problem, please send us samples that represent the problems together with detailed information of the host, disease symptom, field and chemical application history. MU extension field specialists working throughout the state provide strong support for the local communities. They are well trained in detecting and solving plant health problems. They also work closely with the clinic and will assist the clients in correctly submitting samples.

Again, The MU Plant Diagnostic Clinic is dedicated to help you to solve plant health problems and support your business.

Peng Tian, PhD, Lab Director & Plant Diagnostician

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Cucumber Beetle

by Katie Kammler, *Horticulture Field Specialist*

While the name implies that they are a pest of cucumbers, they also feed on many other plants. Cucurbit species are their favorite, including cucumber, cantaloupe, winter squash, pumpkin, gourds, summer squash, and watermelon. They will also feed on beans, corn, peanuts, potatoes, other crops, and weeds. Cucumber beetles are native to the US with a range that extends from Canada to Mexico. There are two types of cucumber beetles: striped and spotted.

They are one of the biggest concerns in cucurbit production because they cause four types of damage: seedling destruction, flower and foliage damage, root feeding, and transmission of bacterial wilt disease. They can be an early season pest, starting with adults feeding on seedlings. They will feed on newly emerged cotyledons and stems, even going below ground level to feed on plants as they emerge. Adults will lay eggs in the soil near the seedlings and larvae will hatch and feed on the roots. Typically, larvae damage to the roots is minor unless under dry conditions. The first generation of adults that feed on flowers and foliage emerge in early summer. The foliage damage is usually minor but heavy feeding on the flowers can lead to poor fruit set. Another generation emerges later in the growing season.

The fourth kind of damage is the most severe and is why the threshold for cucumber beetles is very low. They can carry and transmit bacterial wilt. Bacterial wilt can kill many plants in a field and drastically reduce yield. Both stripped and spotted cucumber beetles have similar life cycles, and both can carry the bacterial wilt. They are not equal, however, when it comes to their rating as a pest on cucurbits. The spotted cucumber beetle is a general feeder and a pest in other crops as well as cucurbits. It is not as serious of a pest as the striped cucumber beetle because the striped feeds almost exclusively on cucurbits. Bacterial wilt is transmitted through feeding on a single leaf, then spreads to the entire plant. Bacterial wilt is a serious disease of cucumber and muskmelon, and to a lesser extent, pumpkin and squash.

Control measures are usually needed to keep ahead of cucumber beetle damage. Row covers provide a barrier to keep out beetles. Just remember that bees are needed for pollination in most cucurbit crops so barriers can only be used for a short time unless bumblebees are introduced to low tunnel covers. Trap crops can give some degree of control. Trap crops are where an insect feeds on a crop that is not used for production and where they can be controlled by insecticides without spraying the desirable crop. Insecticides are often necessary to control this pest.

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