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Management Strategies for Tomato Spotted Wilt Virus in Utah Tomatoes

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MANAGEMENT STRATEGIES FOR TOMATO SPOTTED WILT VIRUS

IN UTAH TOMATOES

by

Benjamin Scow

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ABSTRACT

Management Strategies for Tomato Spotted Wilt Virus in Utah Tomatoes

by

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Utah State University, 2021

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Western flower thrips (WFT; *Frankliniella occidentalis*) is the vector of Tomato spotted wilt virus (TSWV; Bunyaviridae: Tospovirus) and is one of the top causes for crop damage and loss in tomato in the U.S. Damage because of thrips feeding on tomatoes can cause a substantial amount of loss and in the presence of TSWV lead to 100% yield loss.

This field study was conducted to determine if silver plastic mulch or floating row covers can be used to reduce WFT in tomato production. To monitor the presence of thrips, yellow sticky cards were inserted within tomato research plots and collected at different stages of the crop's growth. In this study tomatoes were planted in either reflective silver mulch, black plastic mulch, or black plastic mulch with a floating row cover installed over the top of the plot. Silver reflective mulch and floating row covers were compared to the standard control of black plastic mulch. Each plot was replicated four times and organized in a randomized complete block design. The trial was repeated twice over a period of 2 years.

Row covers had the greatest effect on significantly reducing the number of thrips present on tomato plants, while silver reflective mulch also reduced thrips numbers compared to black plastic mulch standard. Significant effects were greatest during the earlier parts of the growing season when tomato plants were small and lessened through the growing period until no significance was detected in the number of thrips at the end of the growing season. However, TSWV symptoms were most severe on plants infected early in the season and the results showed that both floating row covers and silver reflective mulch are effective in reducing thrip numbers. Plants exhibiting signs of infection were sampled and sent to the USU Pathology lab for testing to determine if they had contracted TSWV.

As part of this study, a TSWV resistant varieties called Mountain Glory was planted and compared to a variety that has not displayed resistant traits called Celebrity. Because of the lack of infection throughout the study plots, this portion of the study is inconclusive.

(42 pages)

PUBLIC ABSTRACT

Management Strategies for Tomato Spotted Wilt Virus in Utah Tomatoes

Benjamin Scow

Plant diseases are among the leading causes of tomato stand loss in the state of Utah. Viral plant diseases are often transferred from one plant to another by insect feeding. In Utah, one of the leading viruses that infects tomatoes is Tomato spotted wilt virus (TSWV) which is spread by thrips. The objectives of this study were as follows.

1. Determine the impact from reflective mulch and row covers on thrips population numbers.
2. Determine the effects of row covers on the TSWV infection rate.
3. Compare varietal response to thrip populations.

This 2-year study focused on the use of two different types of plastic mulch and the use of row covers to deter the number of virus-carrying insects on tomato plants. Silver reflective mulch and floating row covers were compared to black plastic mulch, which is the tomato industry standard. This study was set up in a randomized complete block design and repeated twice over 2 years. Two different tomato varieties, "Mountain Glory" and "Celebrity," were used in this study to determine if Mountain Glory was a viable option for tomato producers in the southern part of Utah. Plants that show signs of infection were sampled and tested for presence of the virus. Two-sided yellow sticky trap cards were deployed within the trial plots, collected three times each year, and analyzed for the number of thrips.

The results showed that silver reflective mulch, and the use of floating row covers significantly reduced the number of thrips in tomato production compared to the standard black plastic mulch. No significant difference was observed when comparing the number of thrips present on the sticky cards when analyzed by tomato variety

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Benjamin Scow

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Tomatoes (*Lycopersicon esculentum*) are an important crop in Utah with 179 acres of tomatoes grown in Utah on 273 farms as of 2017 (National Agriculture Statistics Service [NASS], 2017). Tomatoes are the most widely grown vegetable in the U.S. with over 400,000 acres being used for tomato production (Kelley & Boyhan, 2017). Tomatoes were introduced into the U.S. in 1710 but were widely thought to be poisonous until approximately 100 years ago and since have become commercialized and used primarily in the processing industry (Sims, 1980).

Virus diseases are a common limiting factor in tomato production, most virus diseases cause stunting, discoloration, distortions or sports on the foliage or fruit and result in an unmarketable product (Kelley & Boyhan, 2017). Tomato spotted wilt virus (TSWV) is a virus disease that can destroy an entire crop of tomatoes. Tomato yield loss to TSWV in the state of Georgia, between the years 1996 and 2006, is estimated to have been $9 million annually (Fonsah et al., 2010). In Utah TSWV is one of the most common virus diseases impacting tomato growers and has become a more prevalent problem for growers in recent years. Once tomato plants are infected with TSWV they will start showing symptoms 7-10 days later (Nischwitz et al., 2019). TSWV destroys fruit quality through scarring, spots, blemishes, and irregular ripening; it also severely wilts the plant which reduces fruit yield and size (Fonsah et al., 2010). TSWV is transmitted by western flower thrips (WFT) which moves the virus through its saliva during feeding on host plants (Nischwitz et al., 2019). Thrips feeding prevention, using floating row covers or reflective mulch has shown potential for mitigating the presence of thrips on tomato crops in different climates. It has been shown that reducing the number of thrips through different management tactics will also reduce the number of plants infected by TSWV (Awondo et al., 2012) The research for this project was carried out in southwestern Utah and focused on the use of row covers and reflective mulch as a viable option to reduce WFT numbers on plants and the presence of TSWV.

CHAPTER II

LITERATURE REVIEW

Biology and Behavior of Western Flower Thrips

TSWV is known to be transmitted by nine species of thrips, in the order Thysanopterae and family Thripidae (Zitter & Daughtrey, 1998). Of those, the most common vector in Utah is the WFT (*Frankliniella occidentalis [Pergande]*), but onion thrips (*Thrips tabaci[Lindeman]*) can also spread the virus (Nischwitz et al., 2013). Reitz, (2009) reported that WFT have become one of the most important pests on a global scale. Thrips are a group of tiny insects that are characterized by fringed wings and are commonly found in flowers and on the leaves of most plants. WFT feed on plant tissue, as well as pollen and feed with a rasping and sucking method, where they push their mouth cone into the tissue, and then suck out fluids through their straw-like stylets (Childers & Achor, 1995; Terry & Alston, 2011). In addition to feeding on plants, WFT are also known to be a predator to spider mites, another important pest in crops (Trichilo et al., 1986). WFT bodies are long and tubular in shape: females are about 1/25 of an inch (1 mm) long, and males are about one-third smaller. Females have many color forms varying from pale yellow to dark brown, whereas males are lighter yellow in color. Thrips wings are fringed on the margins and are clear to light yellow in color (Terry & Alston, 2011). Their life cycle consists of five stages: egg, larval, prepupal, pupal and adult. Female adult WFT live up to 30 days and lay 2-10 eggs per day. The WFT uses its mouthparts primarily to extract plant cell nutrients (Childers & Achor, 1995).

Originally reported in 1985 the WFT is a native insect of the western part of North America and was later reported in the 1970s and early 1980s to have spread throughout North America (Beshear, 1983). WFT lay their eggs in plant tissue, using aserrated blade-like ovipositor to insert eggs into leaves, buds, and petals. After egg hatch, there are two immature feeding life stages, these stages are followed by two immobile non-feeding stages (the propupa and pupa stages) both of which occur in the soil. Adults emerge from pupae with developed wings. The adult life cycle concludes with feeding, mating, and the female thrips laying eggs (Driefsche, 2021). A few species of thrips are now worldwide pests, and one of these is the WFT (Terry & Alston, 2011). WFT has become a common pest on numerous crops, including peanut, tomato, lettuce, celery, pepper, pea, onions, apples and grapes (Robb, 1989; Yudin et al. 1986).

Biology of Tomato Spotted Wilt Virus

Crop damage due to TSWV in tomato, pepper, eggplant, and other vegetables in Utah is on the rise. According to Nischwitz et al., (2019), this virus has become more prevalent in Utah in recent years. TSWV is an invasive and destructive virus for vegetable growers across much of the U.S. TSWV is a tospovirus which belongs to the genus Orthotospovirus, of the family Tospoviridae (order Bunyavirales) (Olaya et al., 2020). Characteristics of TSWV were first described in Australia in 1919 and later identified as a virus disease (Zitter & Daughtrey, 1998). In tomato and pepper stands losses are significant because the majority of available vegetable cultivars are susceptible to TSWV (Diaz-Perez et al., 2003). TSWV is transmitted by several insets, with the most prevalent vector being thrips. This virus is also one of only a few viruses transmitted by thrips, but it is by far the most important (Zitter & Daughtrey, 1998). It is estimated that worldwide TSWV causes losses, mainly in commercial vegetable crops, of around one billion dollars annually (Parrella et al., 2003). The TSWV hosts range includes horticultural and agronomic crops across temperate, subtropical, and tropical regions of the world (Adkins, 2000). TSWV has been found in many host plants. According to Parrella et al. (2003), there are over 1,090 species of plants that can serve as a host to TSWV.

Thrips acquire TSWV by feeding on infected plants as larvae, three to seven days after thrips feed on infected tissue WFT become a viable vector for TSWV and will remain infectious the remainder of their life cycle (Groves et al., 2002). Once infected with TSWV, plants can start to exhibit chlorotic or necrotic rings on the leaves of many infected hosts and may also appear on the fruits of some hosts. Necrosis may develop in the foliage of some host plants due to other environmental stresses and can make diagnosis based on symptoms alone difficult (Sherwood et al., 2003). Symptoms of tomato spotted wilt differ among hosts and can be variable in a single host species. Stunting is a common symptom of TSWV infection; this symptom is generally more noticeable and severe when younger plants are infected (Sherwood et al., 2003). The virus is mechanically transmissible as thrips physically transfer the virus among plants. TSWV is not transmitted by the propagation of seeds (Pappu, 2008).

Riley et al. (2000) noted that TSWV is vectored by the thrips which transfers the virus from a host plant to another plant that is susceptible to the TSWV. Feeding injury by thrips on leaves can have an adverse impact on leaf size and photosynthesis and can eventually result in significant yield loss under high populations (Ship et al., 2000). Another trait that compounds the spread of TSWV is that the tomato is a poor reproductive host for WFTs (Brodbeck et al., 2001; Reitz, 2005). According to Reitz (2005), epidemics of TSWV may be greater in less preferred hosts. This is due to the higher activity thrips will exhibit as they move from tomato plant to tomato plant in search of a more suitable or preferable host. The more mobile the vector the farther the virus can spread.

Management of Western Flower Thrips and Tomato Spotted Wilt Virus

Plants infected with TSWV cannot be cured. However, different preventive strategies can be effective for TSWV management. Research done by Parrella et al. (2003) found that TSWV-infected weed hosts in vegetable-growing regions play an important role in the epidemiology of the disease; thus, the elimination of weeds that host TSWV is a primary agronomic practice to control outbreaks of the virus. By reducing the weed hosts, growers can also potentially reduce the number of WFT infected with the virus and transmitting the virus to host crops.

Another common management method is monitoring for WFT. Perma et al. (2018) carried out a study in onions to monitor for both onion thrips and WFT. They used five different colors of sticky cards and found that yellow was the most effective in catching these two species of thrips. In tomato fields it is recommended that sticky cards are either yellow, blue, or white in color and can be secured to a post or stake and left in the field. Cards are then collected at 2-week intervals to count the number of thrips present on the cards.

Currently, the most common method to manage thrips is the use of insecticides to kill large numbers of thrips and reduce the feeding damage and potentially the number of thrips carrying TSWV. However, research has shown that the use of insecticides to control thrip populations has proven to be ineffective for management of TSWV (Brown & Brown 1992; Helyer & Brobyn, 1992). This is because of the rapid buildup of resistance to insecticides in thrips. Monitoring studies conducted in Australia soon after the discovery of WFT in 1993 indicated a high degree of tolerance by thrips to a range of carbamates, organophosphates and pyrethroids (Gao et al., 2012). It is advised that when spraying insecticides, several different chemicals with different modes of action are used in a rotation to prolong the effectiveness of insecticides classes against thrips.

Natural enemies that prey on thrips include predators, such as minute pirate bug (*Orius* spp.), banded wing thrips (*Aeolothrips fasciatus [Linn.])* and several species of predaceous mites which can be purchased and released in crops to kill thrips (Terry & Alston, 2011) Natural enemies are most effective against larval thrips, and are ineffective for preventing damage caused by the ovipositing female, which are a predatory thrips, and predaceous mites can be purchased and released in crops to kill thrips. In using these biocontrol's, it has been found that the predators will only attack larval thrips and are not effective for preventing the damage caused by the ovipositing female.

Cultural practices to mitigate thrips populations and their damage are the focus of this thesis. This study examines the use of silver reflective mulch (SRM), black plastic mulch (BPM), and floating row covers (FRC) to deter thrips from landing and feeding on tomato plants and spreading TSWV. A study done by Powell and Stoffella (1990) found that the use of SRM had an effect on the number of whiteflies and other insects present in different crops planted in SRM. Csizinszky et al. (1999) looked at controlling white flies with a mixture of black, white, silver, and silver with black and white strips down the center with very mixed results in infections over a three-year period. Hutton and Handley (2007) noted that mulches can also affect the environment of the plants in other ways by inhibiting weed growth, maintaining soil moisture, repelling insects, and reflecting select light wavelengths reflected back into the plant canopy. In a study done by Ren et al., (2020), it was determined that WFT preferred yellow and blue sticky cards over other colors in a free-choice tests.

CHAPTER III

MATERIALS AND METHODS

Research Objectives

Of the different viruses that growers in Utah experience TSWV is one of the most problematic. Vegetable growers use many different tools to combat the elements and insects to preserve and improve the quality of their crops. Modern crop production methods for growing crops have great potential for mitigating the amount of damage caused by insects. Of these methods the use of floating row covers, and different colors of plastic mulch have shown a reduction in the number of different insects present on crops. One of the benefits growers can receive from mitigating insect presence is to reduce the potential for insects to transmit disease among host plants. This thesis project addressed the following research questions.

1. What is the impact from reflective mulch and row covers on thrips population numbers?
2. What are the effects of row covers on the TSWV infection rate?
3. Are there different numbers in thrip populations when comparing different tomato varieties?

Materials

In accordance with current industry standards, the tomatoes were planted in raised beds, 1 meter wide and 0.15 meters tall. Each plot was 6 meters long. Plastic mulch was stretched over both the growing area and drip tape to reduce weeds and hold in moisture. The plants were planted in two rows, each row was next to a line of drip tape.

Two types of plastic mulch were used in this study. A black plastic mulch (Grower's Solutions, Tennessee) and a silver reflective mulch (Ken-Bar, New York). The black plastic mulch and the silver plastic mulch were 1.0 millimeter thick. All plastic mulch was stretch and buried by hand.

The drip tape used was 6 mil, 12" spaced emitters, with a flow of .22 gph (Rain-Flo, Pennsylvania). Two lengths of drip tape were buried under each plastic mulch covered row to provide adequate water. A 10psi pressure reducer (Dripworks, California) was also used to meet the recommended pressure for this irrigation system. Irrigation timers (Orbit, Utah) were used to automate the irrigation process, which watered plots three times/week for 3 hours, totaling 1.98 gallons a week per plant, once plants were established.

The floating row covers (Valible, California), had a thickness of 1.5 millimeters. Due to risk for high winds at this study site, the floating row covers were secured to hoops by greenhouse clamps (The Bootstrap Farmer, North Carolina) and anchored to the ground on each end using concrete stakes. The hoops were bent out of ½" electrical conduit and were 1.2 meters wide by 1.4 meters tall.

Two varieties were examined in this study. One TSWV resistant variety, 'Mountain Glory' (Developed by North Carolina University) and one susceptible variety, 'Celebrity' were planted to determine the resistant variety's suitability for production use in Utah.

Site Information

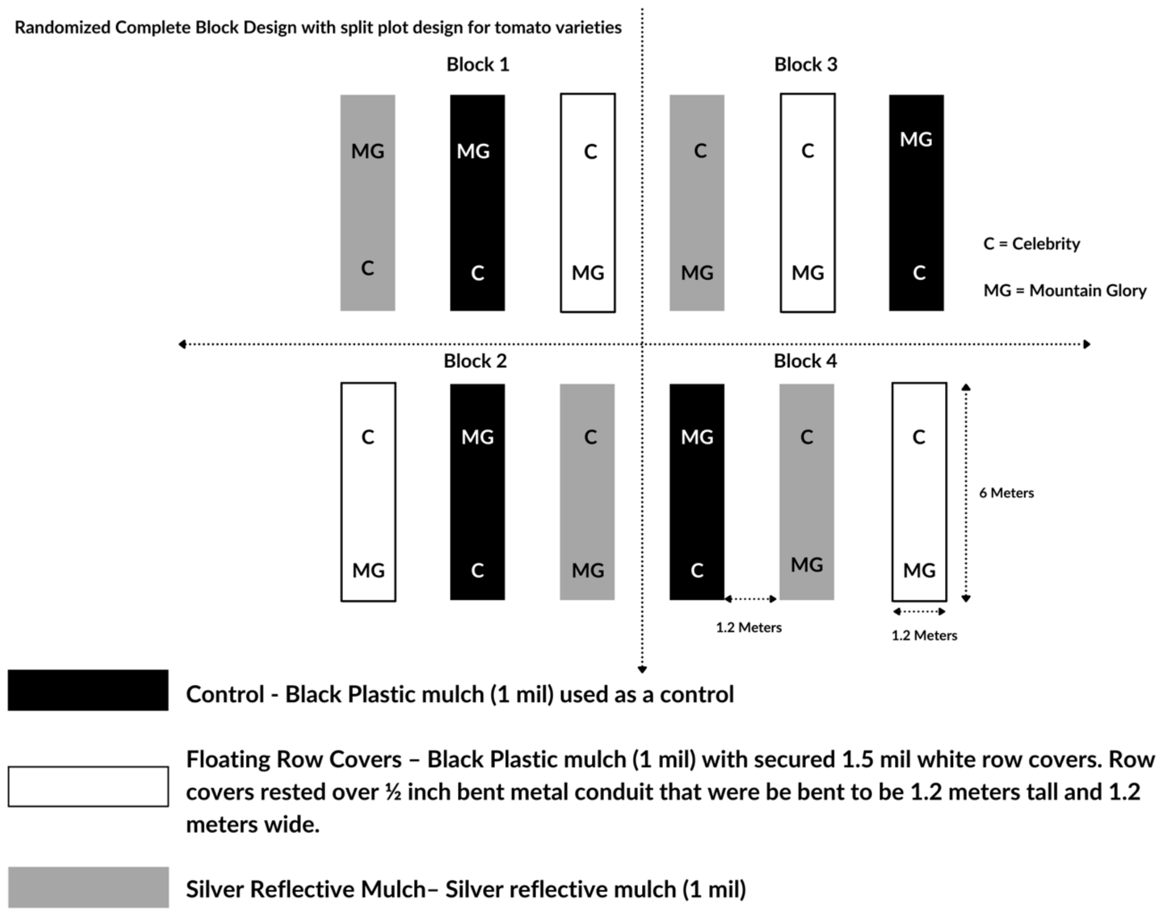
To evaluate the effects of silver reflective mulch and floating row covers on the presence of WFT on tomato plants, test plots were set up in Hurricane, Utah (3,248 feet elevation) at Hurricane Valley Fruit Farms at 37.169662 N, -113.320512 W. The soil used in this trial is classified as Harrisburg fine sandy loam. Soil samples were sent to Utah State University's Analytical Lab and tested for nutrient level which revealed a soil pH of 7.9, soil salinity ECe of 2.46, a phosphorous level of 79 mg/kg and a potassium level of 532 mg/kg. All nutrient levels were adequate or high, providing a suitable amount of nutrients to grow a tomato crop. The ECe level was slightly elevated, and the plot was flooded with approximately 3 inches of irrigation water to leach out salt and lower the salinity level and create a more favorable growing environment. This site was used for both years of the study.

Plot Establishment and Experimental Design

Three tomato production methods were used in this study with each method being replicated four times. A randomized complete block design was used to mitigate any potential bias in the layout of the research plots (Figure 1). The treatments were: (1) black plastic mulch (standard control), (2) silver reflective mulch, and (3) black plastic mulch with floating row cover. As black plastic mulch is the industry standard, this production method was used as a control. Once the plastic mulches were buried, each subplot was 7.62 meters long by .91 meters wide. Twenty tomato plants were planted into each plot in two rows and spaced 0.61 meters apart.

Figure 1

Plot Layout



Two varieties of tomatoes were planted in each subplot, with a total of ten plants of each variety. Each variety was planted in a block pattern in half of each subplot; the distribution for tomato varieties was determined using a random number generator (Figure 1).

Plots were established with consideration of the average last frost date for this site, which is April 14th. The first year's plot was established early on April 1, 2019, and the second year was established on April 15, 2020. Yellow sticky cards in both years were put out on April 15th. Floating row covers were also installed at the time of establishment. Drip irrigation and plastic were both installed during the month prior to planting. Plots were spaced 1 meter apart and blocks spaced 2 meters apart. Irrigation took place every day for the first week for 30 minutes, then was stretched to every other day for approximately 2 weeks and then spread out to three days between watering events. Floating row covers were secured to the hoops with the use of clips and fastened on the end with twine to keep them in place during high wind events. These covers were removed once fruit had set, and the current batch of yellow sticky cards were ready to be collected and new cards put out. This would allow analysis of the yellow sticky cards with only data collected while the covers were in place. Once the covers were removed, the new card was used to collect the data as an uncovered plot.

Detection of Tomato Spotted Wilt Virus Infection

Each plant was assigned a number that was used to track samples collected for TSWV detection. Plant numbers were three-digit codes that identified the block, subplot, and location of the plant within the subplot. For example, a plant assigned the code 1-2-6 was located in block 1, subplot 2, and the sixth plant from the top in that subplot (see Figure 1). Plants that showed symptoms of being diseased were sent to the USU Pathology Lab for testing for possible infections with TSWV. Enzyme-linked immunosorbent assay (ELISA) testing was used to determine if any samples were positive for TSWV. Plants were monitored biweekly, and samples collected when virus symptoms were suspected. All plants were observed after the floating row cover were removed and samples were also taken as needed for plants that displayed any symptoms of infection. Samples were only taken if plants were exhibiting symptoms associated with TSWV.

As the sampling of symptomatic tomato plants for TSWV occurred, this study also looked at the potential suitability of a resistant variety to be used for tomato production in Utah. The varieties that were grown were: (1) Celebrity and (2) Mountain Glory. The Mountain Glory variety of tomato has been advertised as being resistant to TSWV, while Celebrity is considered to be a standard variety that has no record of being resistant. The placement of each variety was random and selected with the use of a random number generator. Each variety was planted in groups of 10 plants and were grouped either at the top of the subplots or at the bottom (Figure 1).

Data Collection and Analysis

For data collection, two yellow sticky cards were placed in each plot to catch thrips, one card at each end of the plot. A date was placed on each card to determine the length of time that the cards had been left out. Cards were also be placed under the row covers to determine the number of thrips that were able to get through or around the cover. Cards were collected and sent in to the USU Pathology Lab twice during the growing season in 2019, the first set of cards covered 4/15/2019 to 6/15/2019 and the second set of cards covered 6/15/2019 to 8/5/2019. In 2020, sticky cards were collected three times, the first set of data covered 4/15/2020 to 5/25/2020, the second set covered 5/25/2020 to 7/1/2020, and the third set of data covered 7/1/2020 to 8/15/2020. The cards were analyzed at the Washington County Extension Office by the researcher. The data from each subplot was collected and combined to show the overall effectiveness of each production method. Each batch of data was analyzed separately first and then collectively. The thrips counts were taken by looking under a microscope at a minimum of 10X power magnification. Counts were taken of each side and then put into an excel spreadsheet and ran through SAS Software to determine if there was a statistical difference between the three production methods. Statistical analysis was conducted using the PROC GLIMMIX function in SAS 9.4 and analyzed as a split plot randomized complete block design.

Assumptions

1. It was assumed that lowering the number of thrips would also lower the level of virus transmission by thrips.
2. It was assumed that since plant viruses had been present at this study location in the past, and that study results would reflect typical thrips and virus severity.

CHAPTER IV

RESULTS

Effects of Silver Reflective Mulch on the Presence of Western Flower Thrips

In 2019, two sets of sticky cards were deployed. Data collected earlier in the year, mid-May to mid-June, from both 2019 and 2020 showed a significant difference in the number of thrips collected on plots covered with SRM when compared to the control plot with BPM (see Tables 1 and 2). Thrips numbers from mid-April to mid-June showed a 40% increase in thrips numbers in the BPM plot as compared to the SRM. Thrips numbers from mid-June to early August showed a 26% increase in thrip numbers in the BPM plots compared to the SRM plot; however, the differences observed in Collection Event 2 were not statistically significant at the $p = 0.05$ confidence (Table 1).

Table 1

Number of Thrips on Yellow Sticky Cards from April 15 to June 15, and June 15 to August 5, 2019

	Thrip density on sticky cards	
Production method	Collection event 1	Collection event 2
Black plastic	3279 A	46 A
Silver reflective plastic	1969 B	34 A
Black plastic with floating row cover	297 C	32 A

Note. Collection Event 1 – April 15, 2019, to June 15, 2019

Collection Event 2 – June 15, 2019, to August 5, 2019

Values followed by the same letter within columns are not significantly different at the $p = 0.05$ confidence level.

Table 2

Number of Thrips on Yellow Sticky Cards from April 15 to May 25, May 25 to July 1, and July 1 to August 15, 2020

	Thrip density on sticky cards		
Production method	Collection event 1	Collection event 2	Collection event 3
Black plastic	169 A	435 A	180 A
Silver reflective plastic	57 B	175 B	92 A
Black plastic with floating row cover	74 B	65 C	170 A

Note. Collection Event 1 – April 15, 2020, to May 25, 2020

Collection Event 2 – May 25, 2020, to July 1, 2020

Collection Event 3 – July 1, 2020, to August 15, 2020

Values followed by the same letter within columns are not significantly different at the p=0.05 confidence level.

Data collected in 2020 exhibited a similar trend to 2019 but with three sets of data instead of two. In the first collection event (Collection event 1, Table 2) the BPM had 66% more thrips compared to SRM. Collection Event 2 showed an increase in number of thrips caught in BPM plots of 60% when compared to SRM. Collection Event 3 indicated a 48% increase in the number of thrips caught in BPM numbers when compared to SRM.

Effect of Floating Row Covers on the Presence of Western Flower Thrips

In 2019 floating row covers (FRC) were removed from the plots on June 15th and left uncovered for the remainder of the growing season. The first collection event (Collection Event 1, see Table 1) showed a significant difference of a 91% increase in the number of thrips BPM plots compared to the FRC plots. The second collection event (Collection Event 2, see Table 1) showed a 30% increase in the number of thrips in BPM plots when compared to the FRC plots. This difference was not statistically significant (Table 1).

In 2020 three sets of data were collected. Collection event 1 (Table 2), exhibited a 56% increase in BPM mulch thrips counts, compared to plots with FRC. Collection event 2 (Table 2) exhibited a significant difference at the .05 level of probability with an 85% increase in the number of thrips caught in plots with BPM when compared to FRC. The third collection event (Table 2), taken after FRC were removed, exhibited a 6% increase in thrips caught in BPM plots compared to plots with FRC (Table 2) and was not considered to be significantly different.

Effect of Tomato Variety on the Presence of Western Flower Thrips

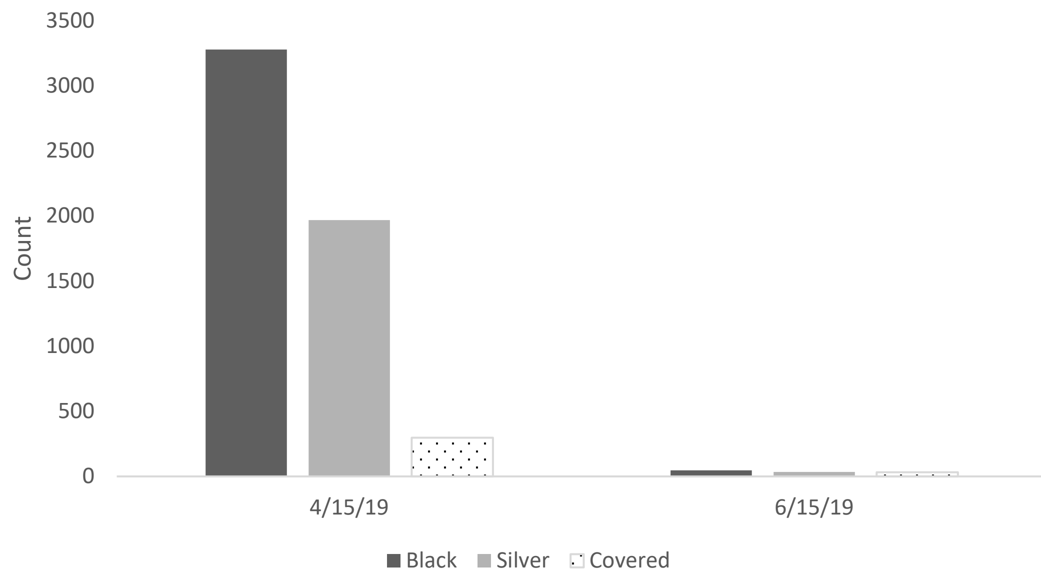
For both 2019 and 2020, thrips numbers from the two varieties were compared to each other. The analysis found that there was no significant difference in numbers of thrips between the two varieties at a 0.05 confidence level. The p value for the two collection events in 2019 were 0.4060 and 0.6443, with the three samples from 2020 being 0.1404, 0.2627, and 0.8149. The conclusion from this study is that thrips do not prefer one variety of tomato over another in this trial.

Comparison of Floating Row Covers and Silver Reflective Mulch

In 2019, a statistically significant difference at the .05 level of probability was observed between SRM and FRC plots in collection event 1 and no significant difference being observed in collection event 2 (Table 1, Figure 2) between production methods

Figure 2

Thrip Counts from Yellow Sticky Cards for Each Production Method for 2019

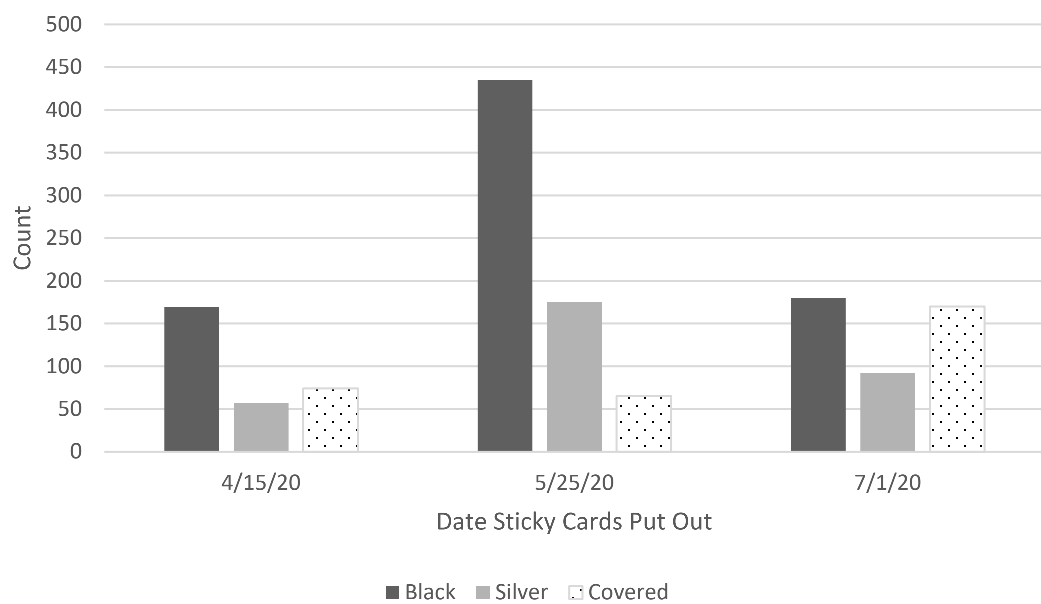


used. Collection event 1 (Table 1) exhibited an 85% increase in the number of thrips in SRM plots when compared to FRC plots. Collection Event 2 (Table 1, Figure 2) showed a 6% increase in thrips caught on yellow sticky cards in SRM plots when compared to FRC plots but did not meet the 0.05 confidence requirement for statistical significance. Collection Event 2 was collected after floating row covers were removed from plots.

In 2020, no significant differences were found between SRM and FRC in collection event 1 (Table 2, Figure 3), even though there was a 23% increase in thrips caught on sticky cards in the FRC plots. In collection event 1 (Table 2, Figure 3), SRM plots caught fewer thrips compared to plots with FRC. In collection event 2, a significant difference was found with SRF plots having 63% more thrips on sticky cards compared to plots with FRC. Collection event 3 (Table2, Figure 3) did not find a significant difference between SRM plots and plots with FRC. Collection event 3 was collected after floating row covers were removed for the season. This collection event exhibited a 45% difference between the FRC and SRM, with FRC catching more thrips than SRM plots.

Figure 3

Thrip Counts from Yellow Sticky Cards for Each Production Method for 2020



Note. Floating row covers were removed on July 1, 2020.

Tomato Spotted Wilt Virus Testing

Plant disease testing was incorporated into this project to evaluate any differences in diseased plants under each production method produced. As mentioned earlier, samples were sent to the Utah State University Pathology Lab where ELISA testing was carried out on the samples. In total, 10 weed samples and 47 tomato plant tissue samples were sent to the lab to be tested for potential infections for TSWV. Of those samples none of them tested positive for TSWV. In 2020 no tomato plants exhibited symptoms associated with TSWV and no samples were sent to the lab for analysis.

CHAPTER V

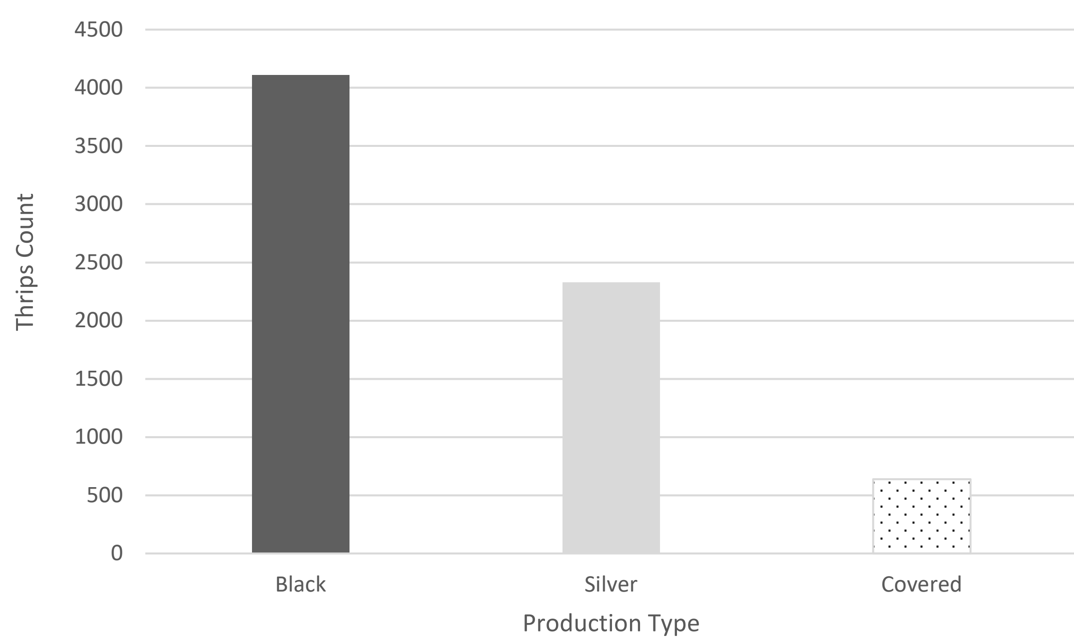
DISCUSSION

Summary of Findings

The results of this study found that there is a significantly lower number of thrips present on plots of tomatoes planted in SRM compared to planting tomatoes into BPM (Figure 4). Overall, SRM was 43% more effective than BPM in deterring thrips, with this difference totaling 1,782 fewer thrips overall during this 2-year study in a 16 by 23 meter research plot. This difference decreased as the growing season progressed. The decrease is most likely due to the growth of the plants and their ability to cover the SRM and

Figure 4

Combined Count of Thrips for Both 2019 and 2020 Up Until the Floating Row Covers Were Removed



greatly inhibit any reflective properties that may deter the number of thrips in these plots. However, plants are most vulnerable to TSWV when they are young, and the reduction of thrips at this stage of growth is the most important to prevent crop losses. Interestingly, during the first collection of data in 2020, SRM had lower numbers of thrips when compared to FRC, which had the lowest numbers of thrips overall. This would indicate that the potential for deterring thrips with SRM in the early development of a tomato stand without covering the actual plants has some potential. It is worth noting that thrip counts under SRM was lower than black plastic mulch (BPM) consistently throughout the study.

It was also determined that overall, FRC was the most impactful protection against thrips populations on tomatoes. Overall, with both years combined, plots with FRC had 80% fewer thrips compared to BPM (Control) and was 37% more effective in deterring thrips when compared to SRM. The largest gap between the number of thrips caught on yellow sticky cards was observed in 2019; FRC had 91% percent fewer thrips compared to BPM, a difference of 2,982 thrips. If FRC is used to its fullest potential, it can have a large impact on the number of thrips present on plants. FRC can be a great option for the health of a plant when it is left on for a large portion of the growing season and then taken off when the plats are mature and are better able to fight off viruses and diseases if they do become infected later in the growing season. Once the FRC is removed the number of thrips present in the plots rise to match the other two production methods.

Virus Testing

One of the original goals of this research was to determine if there was a significant difference in the number of plants infected with TSWV in the different production methods. As previously mentioned, this study also incorporated two varieties to see if the use of resistant varieties was a viable option for tomato production in Utah. The Utah State University Pathology Lab confirmed that the 47 samples of symptomatic plants from this site, taken in 2019, did not have any detectable trace of TSWV. In 2020, no samples exhibited any symptoms, and no samples were sent in during that growing season. Due to the lack of information of TSWV infection in this study, no conclusion could be made with regard to TSWV reduction with the respective production methods. The lack of infection can be attributed to the nature of viruses and the fact that disease incidence and severity is influenced by several factors which can vary greatly from year to year. Some of these factors include insect populations and densities (Brown et al., 1989), weather patterns, and reducing host plants (Campbell et al., 2017). Tomato plant resistance, and overall effectiveness of different production methods in reducing infection rates should be considered in future studies, perhaps including a larger sample size to have a higher probability of measuring impacts in these areas.

Implications

The findings from this study show that alternative production methods have a positive effect on populations of thrips found in these types of production methods. These findings can be used by growers who experience a lot of damage from TSWV or heavy thrips feeding in their current IPM plans. Damage from thrips on tomato fruit results in blemishes and can reduce the value of a crop. By reducing thrips populations growers can produce a higher quality product. This can result in premium price for their tomatoes and potentially increase the income the crop produces.

Organic and "pesticide free" operations can also take advantage of these findings, since producers can significantly reduce the presence of thrips, and the viruses they carry, without the use of pesticides. The use of floating row covers is a common practice in organic production in many crops. This research shows that incorporating FRC into tomato production can have an additional benefit of reducing thrips presence and reducing the spread of TSWV.

After staring this project, it became apparent that other production methods may have an impact on the presence of thrips and other insects in a stand of tomatoes. Shade cloth is a method used in areas that get more heat and direct sun and may influence thrips feeding. The use of white or red plastic that has properties to reflect light or different wavelengths of light to produce a higher yield may also influence deterring thrips. In organic production natural mulches like straw or hay are often used to reduce the number of weeds but may also influence thrips when compared to bare soil or other ground cover management systems.

Based on findings of this research, small scale tomato growers who experience high losses to TSWV should use silver reflective mulch or floating row covers for part of the season to deter thrips who are the main vector of this virus. The information gleaned from this research with SRM, may also be useful in other crops where it is practical to deter thrips and prevent the feeding damage they cause. If floating row covers are used, they should be secured with as few openings as possible to reduce the number of thrips that get under the covers

Limitations and Recommendations

One of the factors that this study did not look at is the effect that the use of SRM or FRC had on overall tomato yields. From visual observations in the two years of this study, no visual differences were observed. However, no yield data were taken for comparison. Yield data will be incorporated into this study in future years.

The use of SRM has also highlighted some barriers that growers may have when considering the use of this material. One concern highlighted by Decoteau (1989) is the effect that different colored mulch has on growth habits of tomatoes, citing the observation that the color of mulch and the type of light that is being reflected causes a change in the number of branches the plant will grow, the amount of foliage, and the overall yield of the plant. Yield and biomass were not measured in this study, but it should be noted that at the end of the season no visual difference was observed between BPM and SRM plots in plant size or yields. In future studies the number of fruits that have sunscald will be counted to identify any differences in quality between production methods. Weighing of the tomato plants with the soil removed will be used to determine any biomass differences SRM may cause.

It should also be noted that this study did not identify the different species of thrips caught on sticky cards. Sticky cards were collected, and thrips were counted but not identified. It is noted that WFT are the largest vector for, and the most common thrips species in southern Utah. Researchers did not identify the thrips species on the yellow sticky cards to see which thrips were present.

Looking at the future potential that SRM and FRC have in tomato fields, the FRC is difficult to work with and SRM can be hard to find in large quantities, which may make it less attractive for large commercial growers. SRM and FRC are more expensive production methods when compared to BPM and may not be cost effective for different operations. Csizinszky et al. (1999) also cited the added expense of using silver mulch as a production method, and other growers mentioned that cost may be a limiting factor unless the benefit of using SRM outweighed the cost of the material.

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