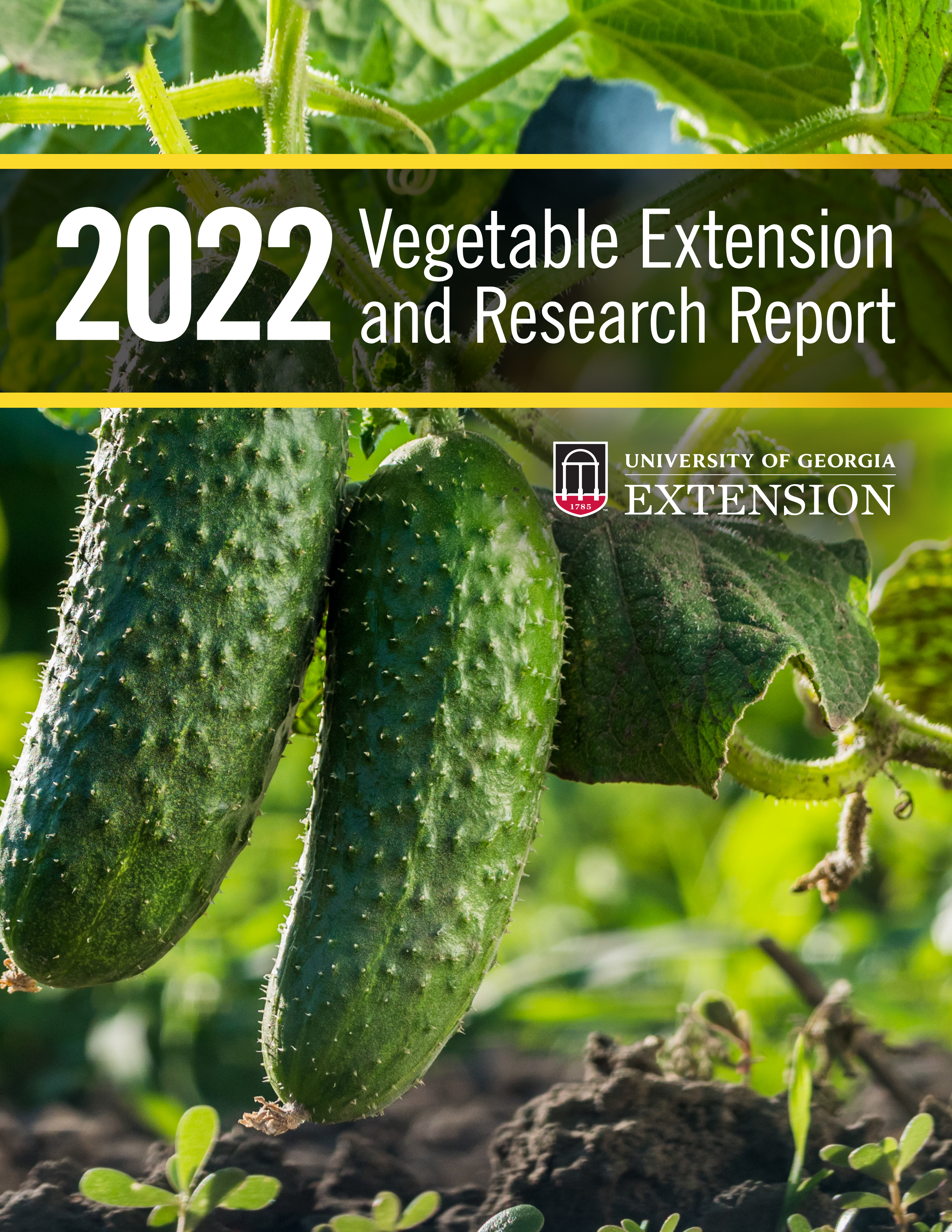

2022 Vegetable Extension and Research Report

UNIVERSITY OF GEORGIA
EXTENSION

Letter from Commodity Commission Chair

The Georgia Commodity Commission for Vegetables (GACCV) is pleased to submit this annual report to the vegetable growers of Georgia, which outlines our 2021 accomplishments.

In the year covered in this report, GACCV supported 15 research projects with more than $180,000 in funding. These projects focused specifically on benefiting and educating producers that grow the following commodities:

- Beans
- Beets
- Bell peppers
- Broccoli
- Cabbage
- Cantaloupes
- Carrots
- Cucumbers
- Eggplant
- Greens
- Specialty peppers
- Squash
- Sweet potatoes
- Tomatoes

With grower assessment funds, these researchers have evaluated weed and pest control, supported the work of the UGA Weather Stations program, evaluated new varieties to improve yields, and investigated ways to improve post-harvest operations.

The research performed for these projects has provided growers with the opportunity to reduce production costs, increase yields, and improve profitability. If you have an interest in serving on any committees or the commission, please let us know.

We look forward to continuing to serve the vegetable growers of Georgia.

Sincerely,

Dick Minor, *Chair*

Commission Members

Dick Minor, Chair
Americus, Georgia

Gary Black
Georgia Department of Agriculture, Commissioner
Atlanta, Georgia

Tom McCall
Georgia Farm Bureau, President
Macon, Georgia

Jamie Brannen
Lake Park, Georgia

Bill Brim
Tifton, Georgia

Brad Calhoun
Ashburn, Georgia

Ken Corbett
Lake Park, Georgia

Glenn Heard
Brinson, Georgia

Jason Tyrone
Lake Park, Georgia

Research Committee

Justin Shealey, Chair
Echols County

Jamie Brannen
Echols County

Justin Corbett
Lowndes County

Tom Daughtrey
Cook County

Kent Hamilton
Colquitt County

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Rabun County

Jamie Patrick
Tift County

Tucker Price
Cook County

Bill Starr
Sumter County

Ty Torrance
Tift County

Jason Tyrone
Echols County

Sam Watson
Colquitt County

Efforts in Education

County Extension Agent Continuing Education

In 2021, the Commission provided funding for Georgia county Extension agents to pursue continuing education opportunities.

Faces of Georgia Grown

To help promote Georgia-grown products, the Commission provided $3,000 in funding to the Georgia Grown Pavilion at the Georgia National Fair.

Georgia Farm Monitor

The Commission gave $4,000 to the Georgia Farm Monitor in 2021. This TV show is produced by Georgia Farm Bureau and works to tell the story of Georgia farmers.

Southeast Fruit and Vegetable Conference Education Supporter

Through our support of the Southeast Regional Fruit and Vegetable Conference, farmers are presented with the latest in vegetable research. The Commission gave $6,000 to the conference in 2021.

Dr. Ji Endowed Professorship

The Commission contributed $10,000 to establish a distinguished professorship in the UGA Department of Plant Pathology in memory of Dr. Pingsheng Ji.

Vegetable Commodity Fund Financials, Fiscal Year 2022 (July 1, 2021, to June 30, 2022)

Item	***Amount***
Assessment received	$247,396
Bank account balance (as of June 30, 2022)	$182,291
Liabilities: University of Georgia research project	$149,635
Uncommitted funds to carry forward to fiscal year 2023	$32,656
Items Paid in Fiscal Year 2022	
Bank charges	$443
Sponsorship for SE Regional Fruit and Vegetable Conference	$6,000
Preparation and printing of annual report	$4,007
Dr. Ji endowed professorship at UGA sponsorship support	$10,000
Georgia Grown — support of Georgia National Fair Building	$3,000
County agent fruit and vegetable conference support	$3,704
UGA College of Ag. dean tour of south Georgia fruit and vegetable farms	$1,336
Administrative cost to Georgia Department of Ag.	$7,932
Vegetable research report — printing and mailing	$4,023
Georgia Farm Bureau — Farm Monitor show sponsor	$4,000
UGA research projects	$298,488
Total Expenses	**$342,933**

2022 University of Georgia Vegetable Extension and Research Report

Timothy Coolong and Theodore McAvoy, *Editors*

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Funds from the Georgia Commodity Commission for Vegetables were used to support all of the research outlined in this report. Without the continued support of the farmers who contribute to the commission, this research would not be possible. In addition to outlined research, commodity grant funds are used to support activities at the Tifton Vegetable Park and the Plant Pathology Diagnostic Lab at the UGA Tifton campus.

GEORGIA
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COMMISSION FOR VEGETABLES

The data analyses for these papers was generated using SAS software unless otherwise noted.

2022 University of Georgia Vegetable Extension and Research Report

Influence of Planting Interval, Tillage, and Irrigation on the Residual Activity of Glyphosate in Bare-Ground Squash

A. S. Culpepper, T. Randell-Singleton, J. Vance

Introduction

As with any vegetable crop, fields must be free of weeds when planting squash. Often, glyphosate (Roundup) is used to prepare fields for planting across Georgia, because of its broad-spectrum activity on many problematic weed species. Recent research, however, indicates its residual activity can result in significant injury to cucurbit, fruiting vegetable, leafy greens, and cole crops, especially when plants are transplanted into sandy soils with low organic matter. Thus, two experiments were conducted to document squash response to the residual activity of glyphosate in a bare-ground production system, and to determine if injury from glyphosate could be mitigated with irrigation, tillage, or irrigation plus tillage.

Material and Methods

Application Interval Experiment. To determine the length of time one should wait between applying glyphosate and transplanting, Roundup PowerMax® II was applied preplant (0, 1, 2, 3 quarts/acre) either 7, 4, or 1 days before planting into a bare-ground, nonmulched system at two locations. Treatments were applied over multiple days while planting all occurred on the same day. During planting, holes were punched into the soil using a traditional hole-punch wheel and 'Grand Prize' (year 1) and 'Enterprise' (year 2) squash were transplanted by hand.

Mitigating Residual Activity of Glyphosate. To determine if the residual activity of glyphosate could be mitigated with cultural practices, Roundup PowerMax II at three rates (0, 2, and 4 quarts/acre) was applied 1 day before planting and was followed by either 1) overhead irrigation of 0.5 cm, 2) light tillage with a rototiller, 3) irrigation plus tillage, or 4) no irrigation and no tillage. The experiment was conducted at two locations; planting involved punching holes into the soil and hand-transplanting 'Enterprise' squash.

Each study was conducted twice at the University of Georgia Ponder Farm located in Ty Ty, GA.

Results

Application Interval Experiment. Combined across locations, Roundup applied 7 or 4 days before planting at the two highest rates injured squash 11–38% and reduced fresh-weight biomass 14–69%. Squash was not impacted when applied at the lowest application rate with 7- or 4-day timing. When applied 1 day before planting, squash was injured 13–53% with biomass being reduced 23–79% regardless of application rate (Figure 1). After 30 harvests, squash fruit numbers were reduced 46–75% with the two highest application rates.

Figure 1. Transplant squash response to Roundup PowerMax II applied preplant. The left side of the image shows untreated plants; the right side of the image shows a treatment rate of 2 quarts/acre applied 1 day before planting.

Cultural Practices Experiment. Combined across locations and without tillage or irrigation, Roundup injured squash 21–57%, reduced biomass 38–56%, and reduced yield 18–43%. Implementing tillage eliminated damages from glyphosate (Figure 2), while irrigation of 0.5 cm alone was not enough to influence visible injury response in squash. Previous research has shown 1 cm of overhead irrigation can reduce the residual activity of glyphosate; further research on irrigation and glyphosate residual activity is warranted.

Figure 2. A light tillage negates the residual activity of glyphosate. The image on the left shows no tillage after treatment; the image on the right shows light tillage following preplant glyphosate treatment.

Conclusion

1. Georgia growers must understand that the residual activity from all glyphosate formulations can pose a significant risk to vegetables, especially when transplanting.
2. New guidelines have been developed to assist in avoiding this issue. These recommendations are shared as a new FIFRA 2(ee) Recommendation Label for Roundup PowerMax 3 herbicide.
3. In general, the following guidelines should be helpful when applying glyphosate prior to planting squash:

   Bare-ground transplants: Apply no more than 1.13 lb acid equivalent (ae) per acre (equal to 30 oz/acre of Roundup PowerMax 3) in a single application. Also, if not tilling after application and prior to planting, irrigate (rain) 0.5 in. and wait at least 7 days between application and transplanting.

   Bare-ground seeding: Wait at least 3 days after application before planting and, if possible, irrigate between application and planting. Suggest ≤ 1.13 lb ae/acre.

   Plasticulture: Apply 1.13 lb ae/acre at least 3 days before transplanting or up to 2.25 lb ae/acre at least 10 days before transplanting. Irrigation or rain of at least 0.5 in. in a single event between application and planting is required, regardless of rate, to remove product from mulch. Do NOT punch holes until after washing the mulch; transplants landing in “old” holes may be damaged.

Transplant Method Influences Herbicide Injury in Broccoli and Collard

A. S. Culpepper, J. Vance, T. Randell-Singleton

Introduction

Leafy greens and cole crops account for an annual farm gate value exceeding $120 million in Georgia. Production is complex, with both seeds and transplants being planted into mulched or nonmulched (bare-ground) systems. Achieving weed control in these systems is extremely challenging, especially with the recent rapid spread of wild radish. Broccoli, collards, and wild radish are all members of the Brassicaceae family; thus effectively controlling wild radish in these crops requires farmers to implement creative management strategies. The objective of this experiment was to determine if different methods of transplanting into bare-ground systems could improve crop safety to Goal® 2XL herbicide (oxyflourofen) applied preplant, thereby increasing wild radish control by safely allowing higher labeled herbicide use rates.

Very important note: Goal herbicide is not labeled for use in collards; this research was conducted in part to generate data in hopes of achieving a label in the future. Goal is labeled for use in broccoli, but many of this study's treatments are not labeled and were conducted only to differentiate between planting methods. Producers should apply Goal only according to label recommendations in broccoli. Also, herbicide injury under cold conditions is expected to be much greater than what was observed in this study.

Material and Methods

An experiment was conducted three times at the University of Georgia Ponder Research Farm in Ty Ty, GA. Tillage was used to remove all weeds prior to planting and to prepare a planting bed. Goal 2XL was applied at rates of 0, 8, 16, 24, 32, or 48 oz/acre and followed by overhead irrigation of 0.35 in. Three days after the herbicide application and irrigation, 'Emerald Crown' broccoli and 'Top Bunch' collards were transplanted. Plants were placed 12 in. apart within the row and 16 in. apart between rows; bed spacing was on 6-ft centers. Soil consisted of 85 to 88% sand with less than 0.7% organic matter. The two methods of transplanting included: 1) the standard hole punching technique accompanied by hand-planting, and 2) using a mechanical carousel transplanter from Mechanical Transplanter Co. (Figure 1).

Figure 1. Comparing transplanting methods.

Results

Control of wild radish was not influenced by transplant method, with Goal 2XL at 8, 16, 24, 32, and 48 oz/acre providing 39, 53, 66, 89, and 95% control, respectively, at 30 days after treatment (DAT; Figure 2).

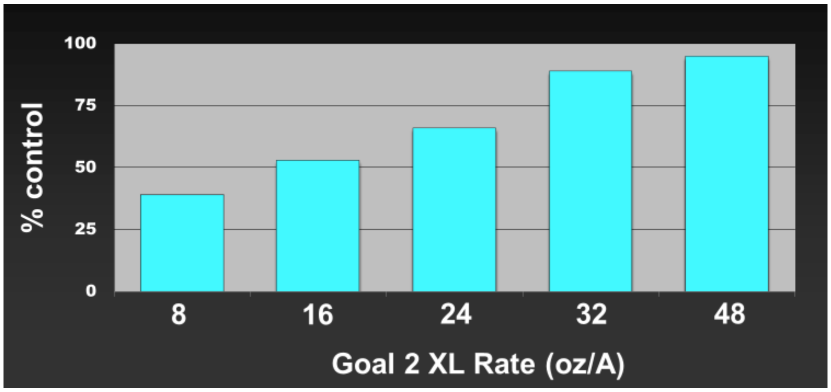
In contrast, planting method influenced the response of both crops to the herbicide. Injury of broccoli and collard transplanted using the traditional hole-punch method was 0–4, 4–8, 7–11, 16–20, and 23–24% by Goal 2XL at the aforementioned rates, respectively (Figures 3 and 4). In contrast to the traditional hole-punch method, which pushes soil from the treated surface into the hole and surrounds the transplant root ball, the mechanical transplanter creates a furrow and more effectively places the transplant below the herbicide-treated soil surface. With the mechanical planting method, Goal 2XL at the aforementioned rates injured the crops only 0–2, 1–3, 2–5, 3–9, and 7–10%, respectively. Transplant method did not influence crop heights at 21 DAT, but as the rate of Goal 2XL increased, crop heights were reduced up to 11%; however, no influence on crop heights was noted by 35 DAT. Although the mechanical transplanter reduced the level of damage to both broccoli and collard from Goal 2XL, neither planting method nor herbicide rate influenced yield of either crop; this likely was a response to very favorable warm growing conditions throughout each study.

Conclusion

1. The mechanical transplanter used in this study significantly reduced the level of Goal 2XL injury visually observed when compared to the traditional hole-punch and hand-transplanting process.

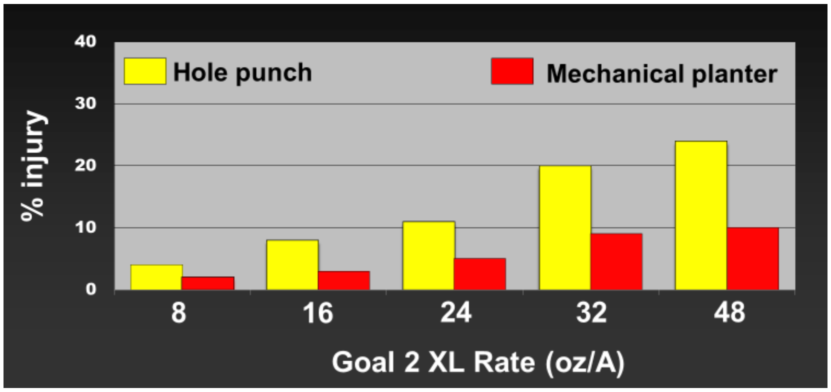
2. Transplanted collards are tolerant to Goal 2XL at rates normally recommended for broccoli—as long as applications are made prior to transplanting, and both irrigation and a 3-day interval occur between application and planting. Again, Goal is not labeled for use in collards, but this research suggests efforts to obtain labeling should be initiated.

Figure 2. Wild radish response to Goal 2 XL as influenced by herbicide rate at 30 days after treatment (DAT).



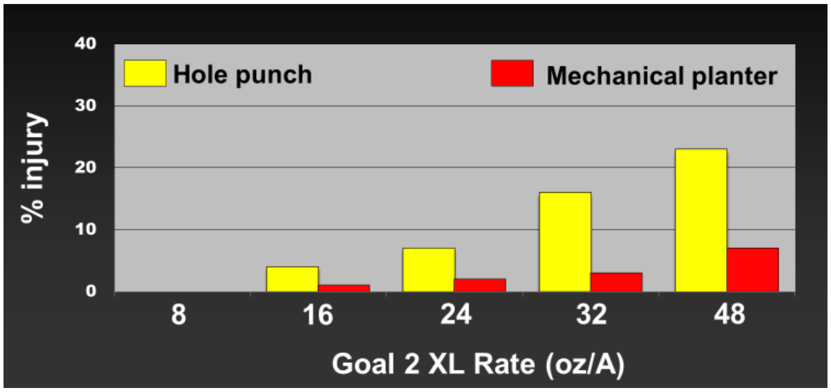
Data pooled over three studies; LSD = 16.

Figure 3. Broccoli response to Goal 2 XL as influenced by herbicide rate and transplant method at 30 DAT.



Data pooled over three studies; LSD = 7.1.

Figure 4. Collard response to Goal 2 XL as influenced by herbicide rate and transplant method at 30 DAT.



Data pooled over three studies; LSD = 4.2.

Evaluating Postharvest Quality of Georgia-Grown Broccoli

A. Deltsidis

Introduction

The broccoli industry of south Georgia has great potential for expansion because soil and climatic conditions are ideal for local production to fill the market window from late fall into early spring. Variety trials recently have been implemented to determine the most suitable varieties for yield, fertilization needs, and overall adaptability to the climate of the region. Most of the studies have focused on different preharvest treatments and their effects on broccoli production. However, little has been done to study the postharvest life of broccoli produced in south Georgia, as well as the postharvest effects of the proposed fertilization schedules.

Material and Methods

Broccoli heads were harvested in the spring of 2021 from a broccoli variety trial that was performed by the University of Georgia Vegetable Production Team. The plants were grown on raised beds following University of Georgia recommendations in order to evaluate yields and study different levels of fertilizer inputs. Heads were harvested at optimum maturity. The trial was a completely randomized block design with three replications. Three varieties were harvested, namely 'BH055', 'BH061', and 'Tahoe' on May 1, May 4, and May 15, respectively. The mid-May harvest date was suggested by the Vegetable Production Team to test whether these varieties would perform well under the climatic conditions of south Georgia.

Visual quality was evaluated upon arrival when broccoli heads were graded, counted, and weighed. Broccoli heads were kept at a temperature of 32 °F in a high relative humidity (95%) storage room to prevent dehydration and loss of firmness. Broccoli heads were stored for a total of 21 days after harvest with evaluations occurring once a week. Changes in respiration rates and chlorophyll levels were measured over time.

Results

The weather pattern for the month of April, as seen in Figure 1, can be summarized as a week (April 1–7) where low temperatures stayed below the average lows for that period of the year, which is early in the growing cycle of the plants. After the first week, there were a number of days (April 15–22) where the temperatures remained close the average range, and toward the end of the growing season there was a prolonged period (April 27–May 4) with high temperatures of 85 °F or higher. This temperature pattern with a heat wave (higher than the 90th percentile—highly unlikely) led to a visible decline in quality with broccoli heads being soft and going through the initial stages of bolting. The visual-quality comparisons rated all three varieties as nonmarketable, as the heads were not firm enough and the individual florets were limp.

Respiration rates are important as they are an indication of shelf life and quality retention since they tend to decline with yellowing and flavor loss. In our case (Figure 2), respiration rates declined over time for all three varieties as expected. 'BH061' showed the largest percent of decline, which could potentially be caused by adverse preharvest conditions that led to aging of the crop. On the other hand, 'Tahoe' showed a less steep decline with its respiration rates.

Conclusion

Producing broccoli in south Georgia later in the spring season may be risky as it is a cool-season crop and weather conditions can be erratic at that time of the year. Temperature fluctuations can negatively impact the crop's quality both at harvest and after harvest. Broccoli grows well with soil temperatures between 65 and 80 °F. As temperatures rise above this range, broccoli quality may decline. Additionally, as the days lengthen and light intensity increases, flowering may be hastened, reducing the harvest window for broccoli.

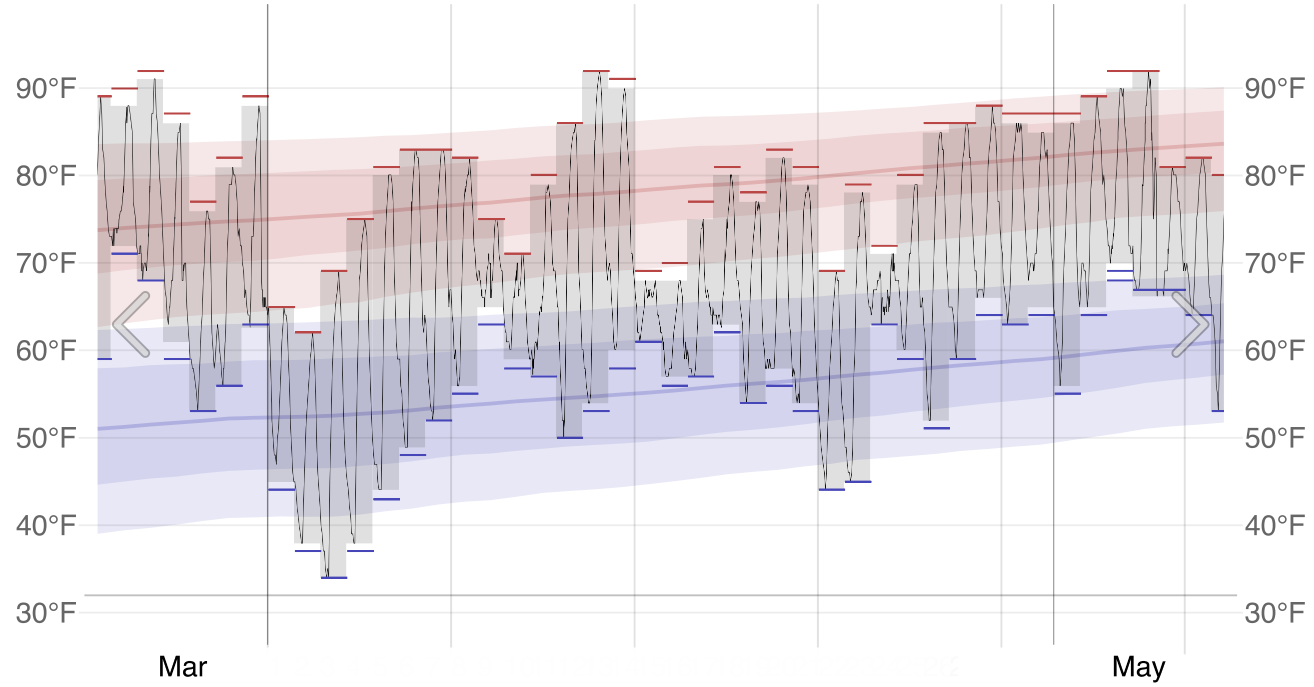


Figure 1. Temperature data from April 2021 in Tifton, GA, in the month preceding the broccoli harvest. The daily range of reported temperatures is represented by gray bars with 24-hr highs (red ticks) and lows (blue ticks), placed over the daily average high (faint red line) and low (faint blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. From "April 2021 Weather History in Tifton" (https://weatherspark.com/h/m/16215/2021/4/Historical-Weather-in-April-2021-in-Tifton-Georgia-United-States#Figures-Temperature). Copyright 2021 by Cedar Lake Ventures, Inc.

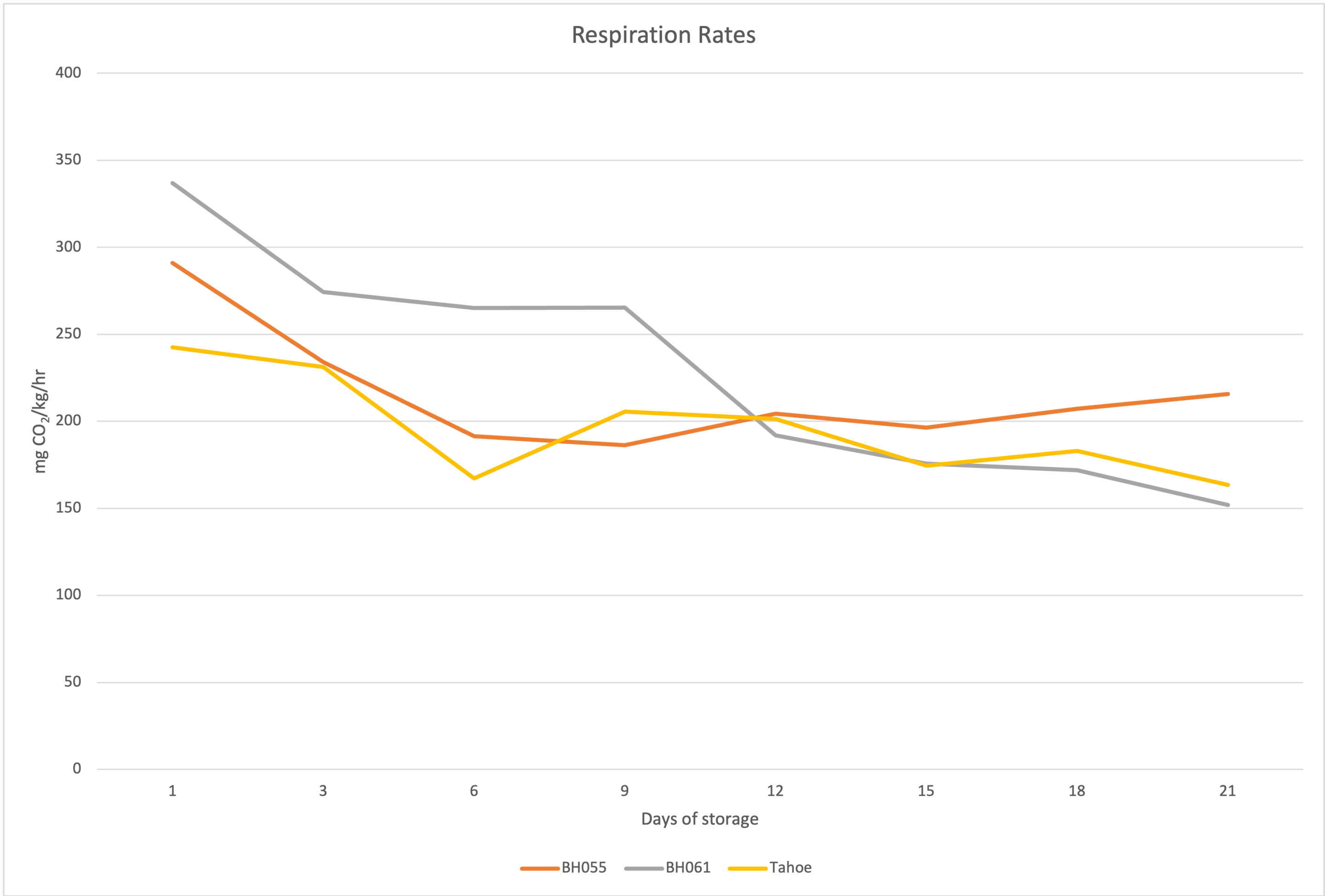


Figure 2. Respiration rates (mg CO_2/kg/hr) of broccoli at harvest and during cold storage.

Plant Growth, Yield, and Incidence of Tomato Yellow Leaf Curl Virus in Tomato Cultivars

J. Díaz-Pérez, S. Bag, J. Bautista, C. Guerra

Introduction

Massive whitefly populations in Georgia vegetable fields cause significant direct (feeding on the crop) and indirect damage (transmitting viruses) to crops such as tomato, squash, and cucumber. Tomato yellow leaf curl virus (TYLCV), a devastating disease transmitted by whiteflies, significantly reduces tomato yield and fruit quality in Georgia, particularly during the fall season. Currently, control of this virus by managing the insect vector has been ineffective. Commercial tomato cultivars from seed companies that claim "intermediate resistance" respond as susceptible under Georgia field conditions. Additionally, fruits from commercial cultivars resistant to TYLCV produce fruit with low-quality attributes. Characterization of the fruit quality of recent tomato cultivars is necessary. The objective of this study was to determine the incidence and severity of TYLCV and fruit yield among tomato cultivars.

Material and Methods

Tomato plugs from seven varieties were grown in a growth chamber to ensure virus-free plants. When plugs were 6 weeks old, they were transplanted at the University of Georgia Tifton Campus in the fall of 2021. Plants were grown using plastic film mulch and drip irrigation, following the recommendations of UGA Cooperative Extension. The experimental design was a randomized complete block, with four replications and seven treatments (cultivars). Plants were evaluated for the presence of TYLCV and disease severity on October 15 and November 11, 2021. Leaf gas exchange was measured with a gas-exchange system (LI-6400, LI-COR). Fruits were harvested and graded as marketable and unmarketable according to USDA standards.

Results

Plant growth. Plant fresh weight showed no statistical differences among cultivars (Table 1).

Tomato yellow leaf curl. All cultivars considered "resistant" showed TYLCV symptoms. TYLCV incidence and severity were statistically similar among cultivars. By the end of the season (November 11), all tomato cultivars had 100% TYLCV incidence.

Nematode severity. Nematode severity index was highest in 'STM-2255' and lowest in 'Marnour' and 'Seventy III'. Root-knot nematode severity ranged from moderate to no visible nematode damage.

Leaf gas exchange. Leaf photosynthesis determines plant growth and yield. Leaf net photosynthesis (mean = 38.3 µmol·m-2·s-1) was similar among cultivars, suggesting that photosynthesis did not explain the differences in fruit yield.

Fruit yield

- Marketable fruit number, weight, percentage, and total fruit weight were highest in 'Charger' and lowest in 'STM2255' (Table 2). Across cultivars, fruit yields likely were low because of the high incidence of TYLCV.
- 'Charger' and 'Grand Marshall' produced the greatest fruit number, while 'STM2255' had the least.
- Individual fruit weight was similar among cultivars.

Conclusion

- 'Charger' had the highest marketable yield, although it was not significantly different from yields in 'Grand Marshall', 'Long Boat', and 'Marnour'.
- Cultivar 'STM-2255' had the lowest marketable yield.
- All cultivars had 100% TYLCV symptoms at the end of the season, resulting in reduced fruit yields.

Table 1. Plant growth, tomato yellow leaf curl virus (TYLCV) incidence and severity, and root-knot nematode rating among tomato cultivars, fall 2021 in Tifton, GA.

Cultivar	**Plant fresh weight (lb/plant)**	**TYLCV incidence (%)**	**TYLCV severity rating**[y]	**Nematode severity rating**[x]
Skyway	2.42	28.6	1.88	1.17 bc[z]
Charger	3.46	1.8	0.25	2.25 ab
Grand Marshall	2.93	16.1	1.0	2.08 abc
Long Boat	3.08	26.8	1.3	1.67 abc
Marnour	3.81	5.4	0.8	1.17 c
STM-2255	3.19	25.1	1.5	2.50 a
Seventy III	2.71	26.8	1.4	1.08 c
p	0.059	0.112	0.132	0.036

[z] Means within columns followed by the same letter are not statistically different, according to Fischer's least significant difference.

[y] TYLCV severity rating: 0 = no damage; 1 = low; 2 = medium; 3 = high; 4 = severe. Measured on October 15, 2021.

[x] Nematode severity rating: 1 = no damage; 5 = severe. Data collected at the end of the season.

Table 2. Tomato fruit yields among tomato cultivars, fall 2021 in Tifton, GA.

Cultivar	**Marketable**			**Total**		**Fruit weight (lb)**
	(1000 A^{-1})	(lb A^{-1})	(%)	(1000 A^{-1})	(lb A^{-1})	
Skyway	13 b[z]	4996 b	44 b	30	8208	0.36
Charger	23 a	9814 a	70 a	33	12044	0.43
Grand Marshall	19 ab	6513 ab	50 b	37	9814	0.35
Long Boat	18 ab	7048 ab	50 b	35	10171	0.39
Marnour	19 ab	8208 ab	54 ab	36	11331	0.41
STM-2255	12 b	4996 b	45 b	27	7405	0.4
Seventy III	13 b	5085 b	35.7 b	34	8743	0.36
p	0.036	0.034	0.028	0.180	0.062	0.121

[z] Means within columns followed by the same letter are not statistically different, according to Fischer's least significant difference.

Managing Whiteflies and Whitefly-Transmitted Viruses in Important Vegetable Crops of Georgia

R. Srinivasan, B. Dutta, C. McGregor, A. Sparks, Jr.

Introduction

The impact of whiteflies and whitefly-transmitted viruses was not as severe in 2021 as in recent years. There are many factors that could be responsible for this reduction in whitefly numbers; nevertheless, it is apparent that whiteflies and viruses have become chronic constraints on fall-season vegetable production in southern Georgia. The roster of viruses found in 2021 was similar to the previous year. These viruses included: tomato yellow leaf curl virus (TYLCV) and tomato chlorosis virus (ToCV) in tomato; cucurbit leaf crumple virus (CuLCrV), cucurbit yellow stunting disorder virus (CYSDV), and cucurbit chlorotic yellows virus (CCYV) in squash; and CuLCrV and sida golden mosaic virus (SiGMV) in snap bean (Figure 1). CCYV in squash was first identified in Georgia in 2020. CuLCrV and CYSDV/CCYV often were found as mixed infection in squash. Similarly, CuLCrV and SiGMV were found as mixed infection in snap bean. The mixed-infection plants typically are more symptomatic than plants infected with one virus and also suffer heavy yield losses.

Our laboratory continues to spend considerable time and resources to understand how these viruses are transmitted by whiteflies, specificity in transmission, whitefly population dynamics, and virus epidemics. This research is continuous because precisely addressing each of these questions requires a multitude of experiments. Our goal is to exploit the knowledge gained to better manage whiteflies and viruses in vegetable crops. Management has centred on host-plant resistance (when available) and on cultural and chemical tactics.

Methods and Results

I. Whitefly cryptic species and virus transmission in vegetable crops

Whiteflies form a cryptic species complex. Cryptic species are morphologically indistinguishable but are biologically different. Based on multiple molecular assays conducted in our laboratory, *Bemisia tabaci* (Gennadius), B, is the predominant cryptic species in Georgia across vegetable and row crops. This scenario has not changed in 2021. However, in a couple of instances Q-cryptic species also have been documented under field conditions, particularly in north Georgia. Our laboratory has been examining what the introduction of Q and its establishment at the field level means for virus transmission and virus epidemics going forward (Gautam et al., 2020).

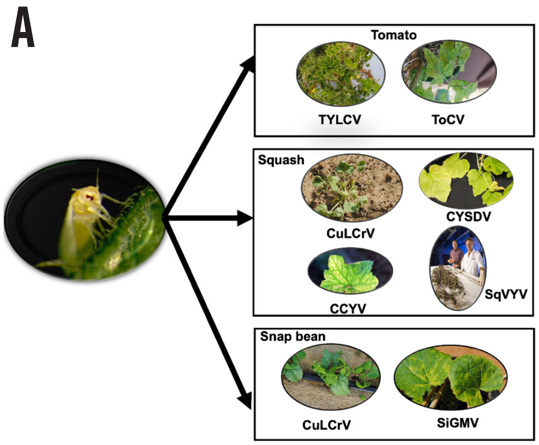


Figure 1A. An illustration of the virus-whitefly web depicting the complexity associated with vegetable hosts and the whitefly-transmitted viruses infecting them. This web structure is getting more elaborate with the addition of new viruses and hosts affected by them.

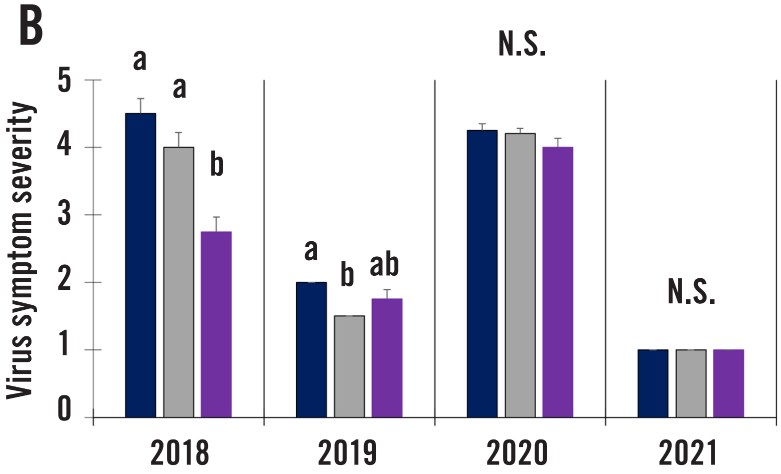
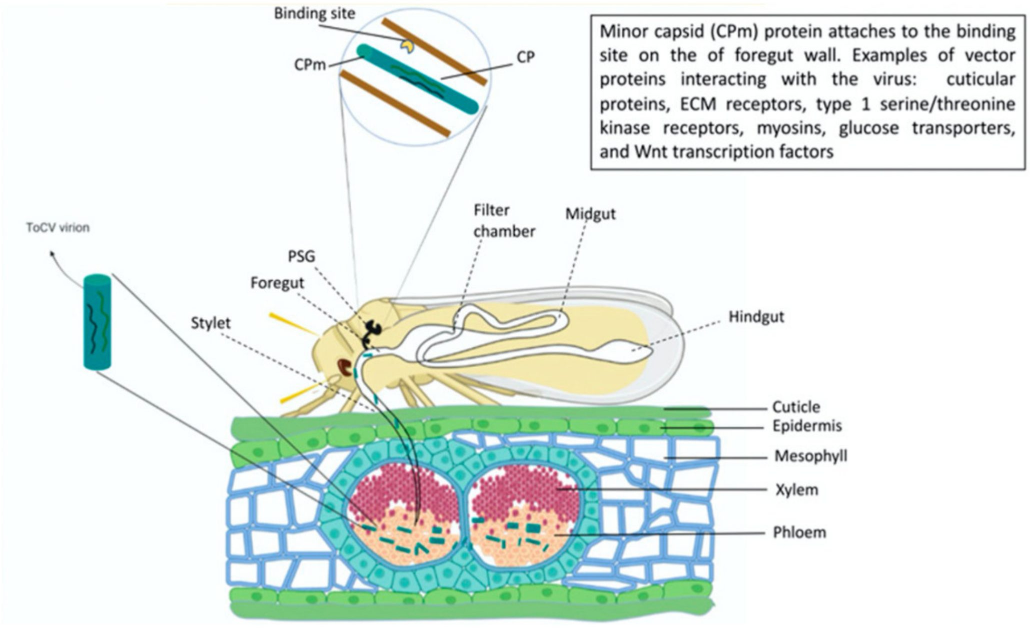
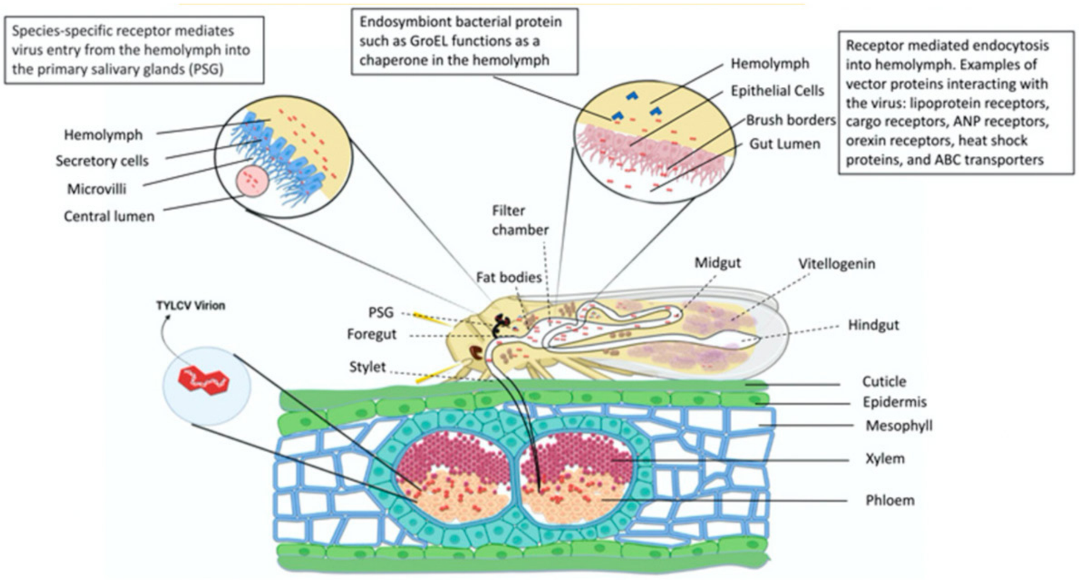


Figure 1B. Virus symptom severity in squash over 4 years (2018–2021) under three mulch types: white plastic (dark blue bars), live mulch with white plastic (grey bars), and UV-reflective silver mulch (purple bars). N.S. indicates nonsignificant differences. Lowercase letters indicate differences between mulch types.



Minor capsid (CPm) protein attaches to the binding site on the of foregut wall. Examples of vector proteins interacting with the virus: cuticular proteins, ECM receptors, type 1 serine/threonine kinase receptors, myosins, glucose transporters, and Wnt transcription factors

ToCV; CYSDV; SqVYV



Species-specific receptor mediates virus entry from the hemolymph into the primary salivary glands (PSG)

Endosymbiont bacterial protein such as GroEL functions as a chaperone in the hemolymph

Receptor mediated endocytosis into hemolymph. Examples of vector proteins interacting with the virus: lipoprotein receptors, cargo receptors, ANP receptors, orexin receptors, heat shock proteins, and ABC transporters

TYLCV; CuLCrV; SiGMV

Figure 2. Virus transmission by the whitefly is a complicated phenomenon and involves a multitude of interactions. The viruses are transmitted via two processes: semipersistent (top) and persistent (bottom).

II. Virus transmission by whiteflies

The presence of Q-cryptic species has been of key interest in our laboratory for two reasons: 1) in some instances, Q is a better transmitter of viruses such as TYLCV; and 2) Q can quickly develop resistance to a wider range of insecticide classes. These two factors could further influence virus epidemics in our already strained vegetable-production system. We have established colonies of both cryptic species in our laboratory and for the last 2 years have been studying the process of virus transmission with two new-world bipartite viruses (CuLCrV and SiGMV) and an old-world monopartite virus (TYLCV). Results thus far indicate that the Q-cryptic species is a very efficient vector of TYLCV but not of the two new-world bipartite viruses such as CuLCrV and SiGMV (Figure 3; Gautam et al., 2022).

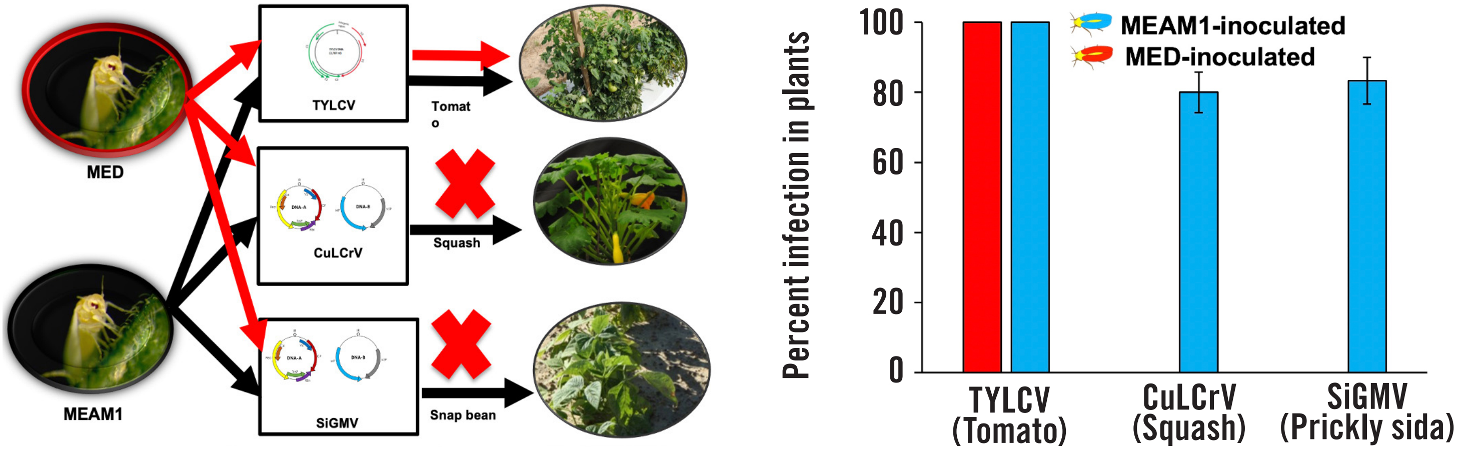


Figure 3. Transmission of TYLCV, CuLCrV, and SiGMV by B (MEAM1) and Q (MED) whitefly cryptic species.

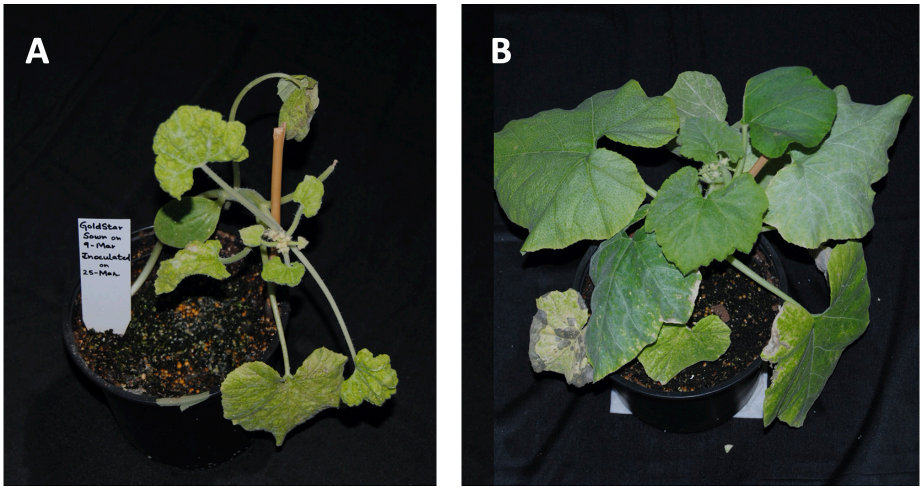


Figure 4. *Cucurbita pepo* (A) and *Cucurbita moschata* (B) genotypes evaluated for susceptibility to whitefly-transmitted viruses in squash.

III. Host resistance

Host resistance is the most important and effective management option when available. Unfortunately, it is only available for tomato. A number of TYLCV resistance-conferring varieties are available and produce fruits of acceptable quality. Currently there is no resistance against whiteflies and/or whitefly-transmitted viruses in squash (*C. pepo*; Figure 4) or in snap bean. Our laboratory is attempting to aid in this process by collaborating with Cecilia McGregor in the case of squash and with Bhabesh Dutta regarding snap bean. These genotypes are being screened for whitefly and virus resistance.

In snap bean, several cultivars and genotypes have been identified that possess field resistance to CuLCrV and SiGMV. Additional lines have become available as well. Screening will continue into 2023 to identify and characterize resistance in snap bean (Agarwal et al., 2021).

IV. Management of whiteflies and/or viruses

Our research is focused on a two-pronged approach to manage whiteflies and whitefly-transmitted viruses. The first, short-term approach is to focus on adopting available management options and maximizing their efficacy. Insecticides, mulches, and row covers have been evaluated in the last 4 years (from 2018–2021). Results have indicated over the years that none of the listed management options have been effective in acting as a "silver-bullet" option. However, even under tremendous pressure, a combination of these tactics seems to be effective. For instance, using the greenhouse seedling protection program could reduce the amount of inoculum going into the field and delay the onset of epidemics (Table 1). The second prong includes long-term management solutions.

Table 1. Effect of insect-exclusion netting (IEN), insecticide, and their interaction on incidence of cucurbit leaf crumple virus (CuLCrV) in squash seedlines grown in the greenhouse.

Treatments by level	Percent CuLCrV incidence[b]
Main plot (IEN)	
IEN	2.89b
No IEN	5.39a
Subplot (insecticide/acibenzolar-S-methyl)	
Nontreated control	2.50b
Acibenzolar-S-methyl (17.51 g/ha)	5.94a
Terpene constituents of *Chenopodium ambrosioides* near *ambrosioides* extract (4.68 L/ha)	5.78a
Cyantraniliprole (0.95 kg/ha)	2.34b
IEN * insecticide/acibenzolar-S-methyl	
No IEN: Nontreated control	3.13ab
No IEN: Acibenzolar-S-methyl	7.81a
No IEN: Terpene constituents of *Chenopodium ambrosioides* near *ambrosioides* extract	7.81a
No IEN: Cyantraniliprole	2.81b
IEN: Nontreated control	1.88b
IEN: Acibenzolar-S-methyl	4.06ab
IEN: Terpene constituents of *Chenopodium ambrosioides* near *ambrosioides* extract	3.75ab
IEN: Cyantraniliprole	1.88b

Note. Means followed by the same letter in each column are not significantly different.

V. Cultural control: Mulch efficacy

Using reflective mulch over the last 4 years has consistently indicated reduction in silver leaf intensity over using white plastic, either alone or in combination with a live mulch (Figure 5).

VI. Chemical control/row cover

In addition to mulch, several insecticides and row covers were evaluated from 2018 to 2021 (Figure 6). Only treatments T1–T8 were included in 2018 and 2019. All treatments (T1–T10) were included in 2020 and 2021. The treatments are as follows: T1 = nontreated control, T2 = imidacloprid (0.73 L/ha), T3 = cyantraniliprole (1.50 L/ha), T4 = flupyradifurone (1.02 L/ha), T5 = terpene constituents of *Chenopodium ambrosioides* near *ambrosioides* extract (7.01 L/ha), T6 = *Chromobacterium subtsugae* (3.36 kg/ha), T7 = paraffinic oil (14.03 L/ha), T8 = row cover followed by cyantraniliprole (1.50 L/ha), T9 = afidopyropen (1.02 L/ha), and T10 = spirotetramat + pyriproxyfen (0.73 L/ha).

Using several insecticides reduced squash silver leaf (SSL) intensity but not virus symptom severity. Some of them boosted yield as well. However, using row covers was better than any insecticide evaluated in terms of reducing SSL intensity and virus symptom severity. Using row covers also boosted yields better than any insecticide evaluated. Additional details are included in LaTora et al. (2022).

VII. Long-term management

Long-term management options include using RNAi approaches and host-plant resistance. Some research is already underway. Also, whitefly transcriptomes—with and without virus infection—recently have been developed to lay the foundation for RNAi-based management (Mugerwa et al., 2022).

Conclusions

Host-plant resistance (resistant cultivars) is the most convincing management option for whitefly-transmitted viruses. In their absence, cultural and chemical options become relevant.

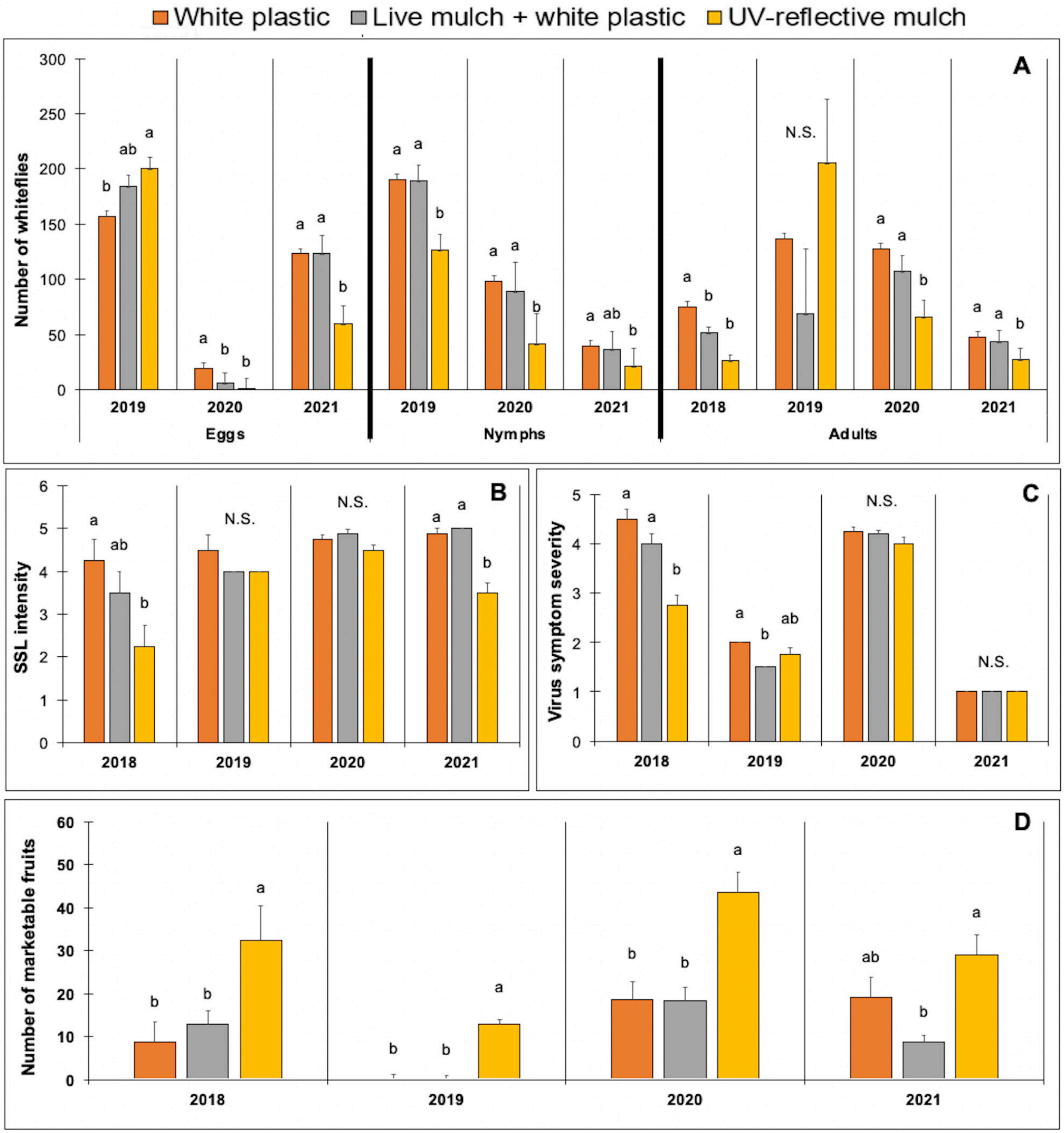


Figure 5. Effect of mulch on whiteflies, squash silver leaf (SSL) intensity, virus symptom severity, and marketable yield.

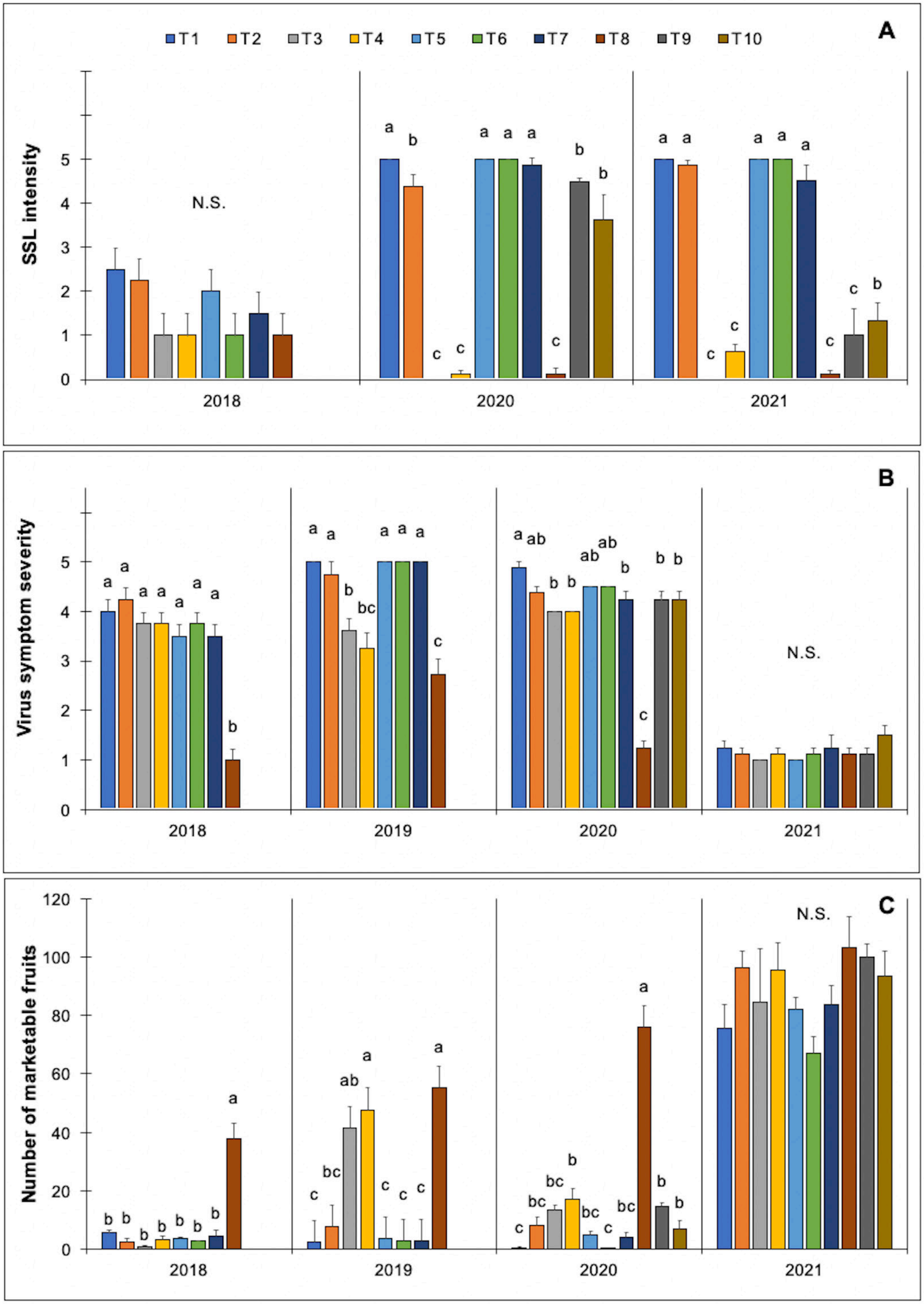


Figure 6. Effect of insecticides and row covers on whiteflies, squash silver leaf (SSL) intensity, virus symptom severity, and marketable yield.

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Control of Whiteflies in Laboratory and Field Tests in Georgia

D. Riley, P. Cremonez

Introduction

Although moderate levels of whiteflies (Figure 1) are adequately controlled by labeled rates of insecticides Exirel (cyantraniliprole), Venom (dinotefuran), and Sivanto Prime (flupyradifurone) at most locations in Georgia, there is an ongoing need to confirm this efficacy in field tests and in laboratory bioassays. With the heavy infestations of whiteflies in summer and fall crops in recent years, there has been an equally heavy use of insecticides, so resistance development is a possibility. In 2021, we monitored insecticide response in whiteflies using standardized toxicological bioassays and compared these results to insecticide spray efficacy in the field. The goal was to confirm that bioassay results could accurately reflect the expected efficacy in a field spray trial.

Figure 1. Whitefly adults on the underside of a squash leaf. Photo: David Riley, University of Georgia, Bugwood.org.

Material and Methods

Adult whitefly maximum-dose bioassays were conducted on two squash and two cucumber field experiments to determine the response of whiteflies to the major insecticides used to control them. Land was prepared in June and July 2021 for all tests with a total of 500 lb of 10-10-10 per acre incorporated into to Tift pebbly clay loam. All tests were direct seeded into 6-ft x 60-ft plots, replicated four times, and maintained with standard cultural practices at the Lang-Rigdon Farm at the Georgia Coastal Plain Experiment Station in Tifton, GA. Adult whitefly bioassays were conducted 24 hr prior to a single insecticide spray in the field to see if these bioassays were predictive of how well products would work in the field. The treatments tested in the bioassay and field spray (results in Figures 2 and 3) were the high labeled rates of imidacloprid (Admire Pro 4.6F [IRAC Group 4A]), dinotefuran (Venom 70SG [4A]), acetamiprid (Assail 30SG [4A]), clothianidin (Belay 50WDG [4A]), sulfoxaflor (Transform WG [4C]), flupyradifurone (Sivanto Prime 1.67SL [4D]), pyriproxyfen (Knack 0.86EC [7C]), flonicamid (Beleaf 50SG [9C]), spiromesifen (Oberon 2SC [23]), and cyantraniliprole (Exirel 0.83SC [28]). Whitefly samples were taken 1 day and 1 week after application on five leaves (one per plant at leaf node 3–6). Whitefly count data were analyzed using GLM and LSD tests for separation of means. Data was averaged over two tests by crop.

Results

The results of our rapid bioassay method were promising in that most of the treatments from the squash and cucumber field spray tests provided similar whitefly control of adults to the cotton leaf bioassay (Figure 2A and B). The exceptions were Beleaf, Transform, and Admire Pro. These products did not provide as good control in the field as in the bioassay, especially Transform in the cucumber test (Figure 2B). Exirel, Sivanto Prime, and Venom continued to be good products for adult whitefly control, both in the bioassay and in the squash and cucumber field treatments. Most of the other treatments provided either intermediate or inconsistent control of adults in the field depending on the crop. For example, Belay worked relatively well in cucumber, but provided poor control of adults in squash. On the other hand, the cotton bioassay was more consistent in ranking efficacy between crops where Belay was ranked intermediate in both tests (Figure 2; compare A and B bar graphs). What was clear from the adult efficacy was that the bioassay was more favorable to showing efficacy than in the field 24 hr post-spray with heavy adult pressure.

Control of nymphs using the bioassay was less consistent between crops (compare Figure 3A [squash] to B [cucumber]). First, the nymph numbers were much higher in squash than in cucumber in both the bioassay and field scouting data. Even though nymphs were higher in the untreated checks compared to all insecticide treatments in both crops, the ranking of treatments for efficacy was not as clear in cucumber as in squash. Venom provided the most consistent

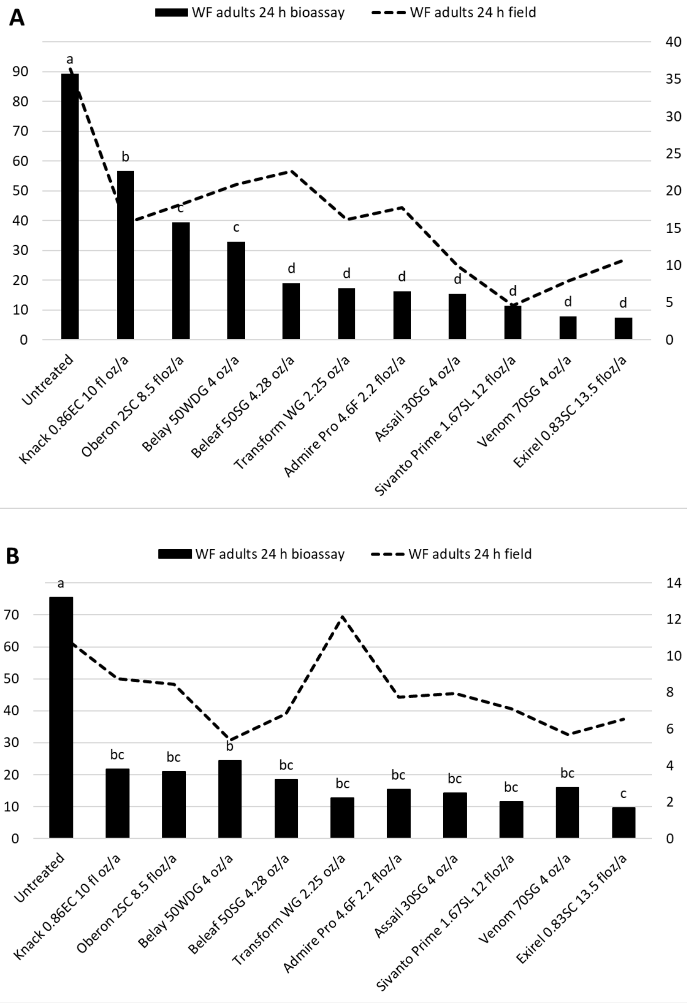


Figure 2. Control of whitefly adults using a lab bioassay (bars) versus what was counted after a field spray (dashed line) 24 hr after application in squash tests (A) and cucumber tests (B). Different letters are significantly different ($p < 0.05$, LSD test).

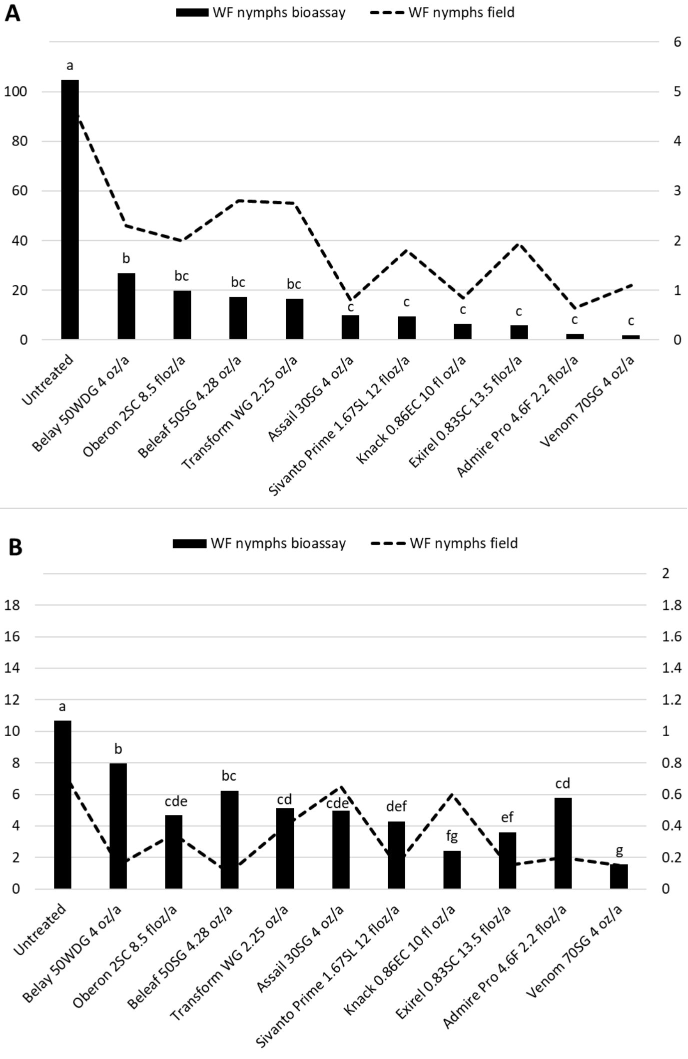


Figure 3. Control of whitefly nymphs using a lab bioassay (bars) versus what was counted after a field spray (dashed line) 24 hr after application in squash tests (A) and cucumber tests (B). Bars with different letters are significantly different ($p < 0.05$, LSD test).

control of nymphs, followed by Exirel, Sivanto Prime, and Knack, but others like Admire Pro and Assail varied significantly in their ranking between crops (Figure 3).

Conclusion

The bioassays seem to work best at identifying the top insecticide treatments for whitefly adult and nymph control. The products with intermediate efficacy in the bioassays usually have variable field results and provide only partial field control. The advantage of the bioassay over the field spray test is that the bioassay doesn't have constant reinvasion of whitefly adults, so it provides a cleaner snapshot of direct whitefly mortality at the time of spray. The advantage of the field spray is that the best treatments under heavy pressure are more clearly demonstrated.

Control of Diamondback Moth in Laboratory and Field Tests

D. Riley, D. Champagne, T. Dunn

Introduction

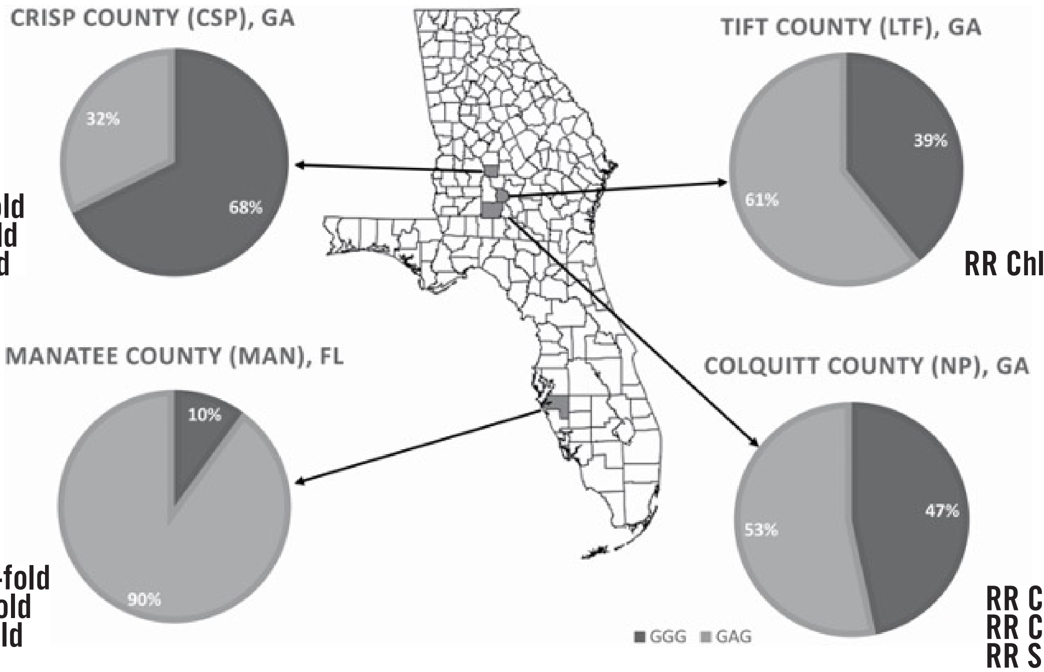
In 2021, the Vegetable Entomology Lab at Tifton conducted insecticide control studies for diamondback moth (DBM; Figure 1). These were conducted in response to control failures with several of the diamide insecticides like Coragen (chlorantraniliprole) and more recently Exirel (cyantraniliprole). We monitored insecticide response with standard toxicological bioassays and tested for the presence of insecticide resistance genes that contribute to these control failures. These data documented the level of insecticide resistance in Georgia DBM populations. In addition, possible alternative control treatments for DBM were tested in the field.

Figure 1. Diamondback moth (top), larva (bottom), and leaf damage (center).

Material and Methods

Diamondback moth insecticide resistance. The bioassay method used was a dose-response, leaf-dip bioassay of DBM colonies from Colquitt, Tift, and Crisp counties in Georgia, as well as Manatee County in Florida. This was done to provide a quantifiable resistance ratio (RR) for chlorantraniliprole, cyantraniliprole, and Radiant (spinetoram) in comparison to the responses of a susceptible control population. Additional larvae that were not used in the bioassays were preserved in RNAlater and stored at -80 °C. Researchers extracted mRNA with a Dynabeads mRNA DIRECT Kit (Invitrogen, Thermo Fisher Scientific) according to the manufacturer's protocol, and first-strand cDNA was generated using SuperScript IV VILO Master Mix (Invitrogen). Additionally, cDNA was used in PCR to screen for known mutations conferring target-site resistance. The resulting PCR products were Sanger-sequenced, and chromatograms were used to identify target-site mutations.

Alternative control field test. In order to reduce the selection for resistance in DBM to synthetic insecticides, we field-tested a Baculovirus product (labeled here as DBMv2; Lepigen produced by AgBiTech: https://www.agbitech.com/global-portfolio) that can kill DBM larvae, even those resistant to synthetic insecticides. The field test was transplanted into two rows per 6-ft bed on July 15, 2021, and maintained with standard cultural practices at the Lang Farm at the Georgia Coastal Plain Experiment Station in Tifton, GA. The transplants came pre-infested with DBM larvae from the commercial vendor, but we also had DBM on old collards at the field site. A total of 500 lb of 10-10-10 was applied initially to field plots of Tift pebbly clay loam, followed by 150 lb of 10-10-10 at first side-dressing. Irrigation was provided overhead as needed. Scouting dates occurred on August 2, August 9, August 11, and August 13, 2021. Dates of foliar applications of insecticide by test were August 5, August 10, August 24, and August 30, 2021. All treatments included a methylated seed oil adjuvant at 0.25% v/v. Damage ratings and harvest sample sizes were taken from 10 plants per plot. Ratings were: 0 = no damage, 1 = slight, 2–3 = medium, and 4–5 = severe damage. Insect counts were analyzed using PROC GLM by date and averaged over all sample dates. Harvest was based on a single harvest of 10 plants on September 9, 2021. Marketable weight was estimated as leaves with less than a medium damage rating, i.e., slight damage to the wrapper leaves was allowed due to the heavy lepidopteran larval pest pressure.



Locations of DBM populations used to establish lab colonies by county

RR Chlo: 109-fold
RR Cyan: 50-fold
RR Spin: 29-fold

RR Chlo: 2,813-fold

RR Chlo: 2,845-fold
RR Cyan: 108-fold
RR Spin: 216-fold

RR Chlo: 4,298-fold
RR Cyan: 67-fold
RR Spin: 59-fold

Figure 2. Allele frequency of the G4946E (GAG) mutant and susceptible (GGG) wild type for diamondback moth colonies from four sites. Resistance ratios (RR) of chlorantraniliprole (Chlo), cyantraniliprole (Cyan), and spinetoram (Spin) for each colony are presented in comparison to a susceptible lab colony. From "A Target Site Mutation Associated With Diamide Insecticide Resistance in the Diamondback Moth *Plutella xylostella* (Lepidoptera: Plutellidae) is Widespread in South Georgia and Florida Populations," by T. P. Dunn, D. E. Champagne, D. G. Riley, H. Smith, and J. E. Bennett, 2022, *Journal of Economic Entomology, 115*(1), pp. 289–296 (https://doi.org/10.1093/jee/toab223). Copyright 2021 by the authors.

Results

Diamondback moth insecticide resistance. Intermediate to high levels of chlorantraniliprole resistance (109 to 4,298-fold) were documented in the DBM colonies, while only intermediate levels of cyantraniliprole (50 to 108-fold) and spinetoram (29 to 216-fold) resistance were documented (Figure 2). The G4946E mutation, which is associated with chlorantraniliprole resistance, seems to be widespread in Georgia and Florida. The estimated frequency of the mutation in each colony seemed to correlate with the chlorantraniliprole RR, while cyantraniliprole and spinetoram RRs did not seem to be influenced as much by the mutation. The absence of the I4790M/K mutation in our samples, which is more closely associated with cyantraniliprole resistance, may explain the lower RR in the colonies, while the lower RR for spinetoram is sensible because that insecticide targets a different receptor. We plan to use this information to develop a PCR diagnostic assay that can better inform growers on which insecticides will be effective in their fields. This work was published in the *Journal of Economic Entomology* (Dunn et al., 2022).

Alternative control field test. In a collard field test in the summer of 2021, both DBMv2 rates significantly reduced all stages of DBM by as much as 64% (Figure 3). The addition of DBMv2 to the synthetic insecticides, Proclaim and Coragen, did not significantly improve efficacy but did tend to reduce larval numbers. This may be important when attempting to control potential resistant individuals, e.g., survivors of spray applications, to reduce the carryover of resistance genes into the next generation of DBM.

The addition of DBMv2 to Proclaim did not significantly reduce the damage rating from the synthetics alone in the field (Figure 4). No damage-reduction benefit was seen from adding the virus product to Proclaim, while the addition of DBMv2 to Coragen tended to reduce damage rating and increase yields. The lowest damage rating was in the Coragen + DBMv2 treatment, which also had one of the highest yielding plots. We also observed that virus-infected DBM larvae tended not to feed and were slower-moving compared to healthy larvae in the test plots. Even though the mortality of DBM larvae was

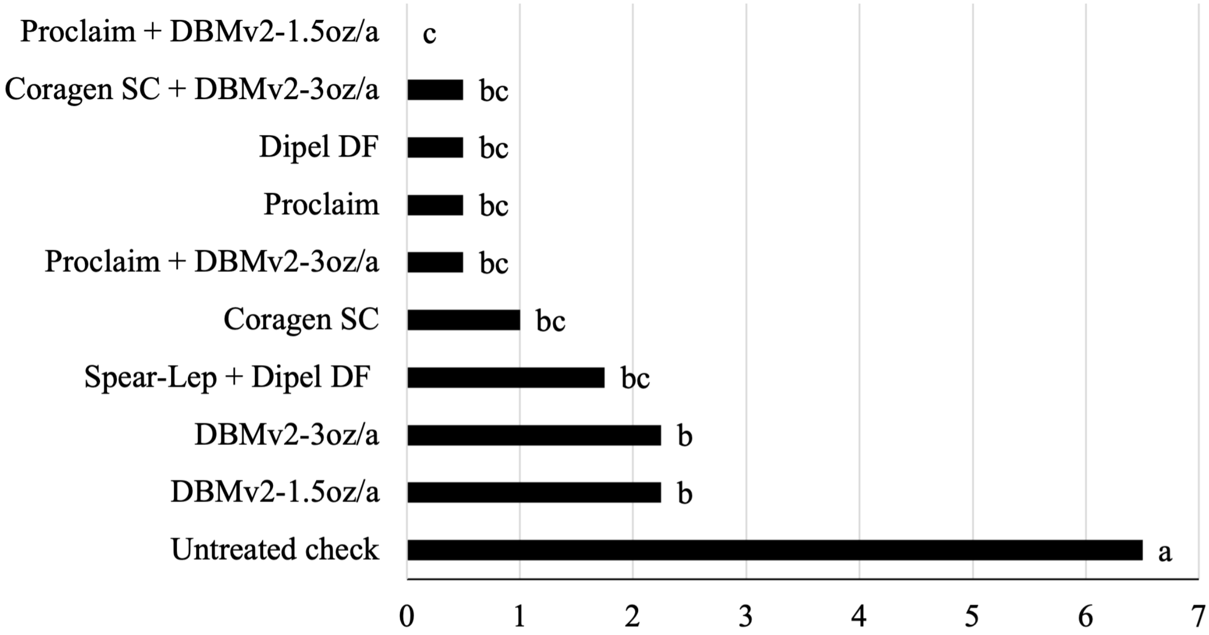


Figure 3. Number of DBM larvae per plot (20 plants). Bars with different letters are significantly different ($p < 0.05$, LSD test).

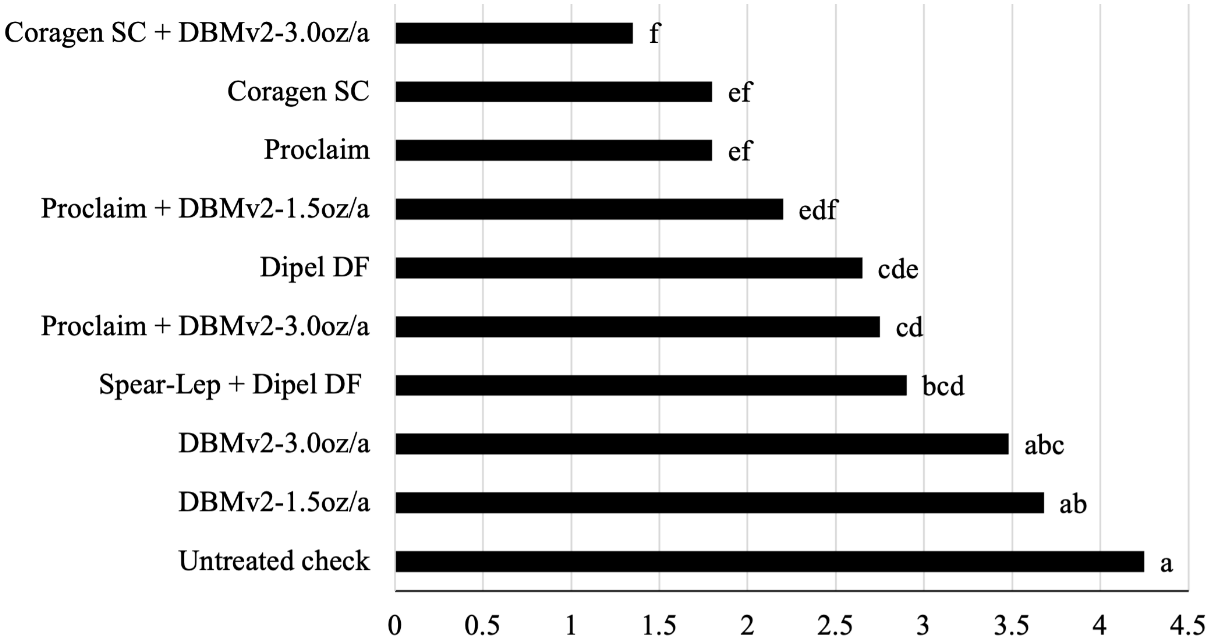


Figure 4. DBM leaf damage ratings, averaged from 10 plants. Ratings ranged from 0 = no damage to 5 = severe damage. Bars with different letters are significantly different ($p < 0.05$, LSD test).

much slower than for the synthetic insecticides, it tended to reduce overall larval survival. This could be useful in reducing diamide resistance carryover to the next generation and improve our long-term management of insecticide resistance in DBM populations in Georgia.

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Control of Weevil Pests in Georgia Vegetable Crops

D. Riley, A. Sparks, Jr.

Introduction

Georgia has three major weevil pests of vegetables, the pepper weevil (*Anthonomus eugenii*), the cowpea curculio (*Chalcodermus aeneus*), and the sweet potato weevil (*Cylas formicarius*), that cause serious damage to peppers, southern peas, and sweet potato, respectively (Figure 1). Most insecticide control efforts for all three weevils target the adult stage because the grubs are inside of the fruit, pod, and tuber, respectively. In 2021, we used standard toxicological bioassays to determine which insecticides, both labeled and unlabeled, provided the best control of adults. These data helped document possible insecticide resistance in Georgia populations, show which insecticides still had efficacy, and identify nonlabeled materials that had potential for labeling in Georgia.

Material and Methods

USDA certified organic pepper fruit were purchased for all pepper weevil bioassays. Pepper weevil was collected from two sites, Tift and Colquitt counties, and brought back to the lab for testing on the same day. We tested an untreated check, Torac 1.29EC 21 fl oz/acre, Brigade 2EC 6.4 fl oz/acre, Exirel 13.5 fl oz + Torac 21 fl oz/acre, Vydate 2 pint/acre (low rate), Vydate 4 pint/acre (high rate), Actara 25WDG 5.5 oz/acre, Broflanilide 3.43 fl oz/acre (low rate), Broflanilide 6.85 fl oz/acre (high rate), ISM-555 76 ml/acre (low rate), and ISM-555 152 ml/acre (high rate). We used the equivalent spray volume of 100 gallons/acre for the drench applications on the cut fruit pieces. We dipped the fruit in 500 ml of mixture plus 0.5 ml of Kinetic nonionic surfactant. The mortality of five adults per petri dish was assessed as either dead, moribund, live at 24, 48, 72 hr, and 1 week. Data was analyzed using GLM and LSD tests for separation of means. We also compared bioassay results to standard field-efficacy studies conducted at the Lang-Rigdon Farm at the Coastal Plain Experiment Station in Tifton, GA. For control of the cowpea curculio, we tested the same insecticides listed above, but dipped organically grown cowpea pods for the adult bioassay. We also field-tested a new GMO curculio-resistant cowpea

Figure 1. Pepper weevil (top), cowpea curculio (middle), sweet potato weevil (bottom).

and other cowpea lines to see what level of resistance to cowpea curculio could be attained under field conditions. Finally, we tested the same insecticide treatments for the control of sweet potato weevil but evaluated 10 weevils per petri dish and performed bioassays on dipped organic sweet potato slices.

Pepper weevil control. The best labeled treatments in 2021 (see Figure 2) were the high rate of Vydate 4 pint/acre, Actara 25WDG 5.5 oz/acre, and Torac 1.29EC 21 fl oz/acre, but note how the lower rate of Vydate was slower acting with one population (Figure 2B). The pyrethroids like Brigade have provided only intermediate control at 48 hr or 1-week posttreatment (Figure 2B) or almost no control (Figure 2A). Therefore, pyrethroids are not recommended for pepper weevil control in Georgia at the current time. We are hoping that the new Syngenta product, ISM-555 with active ingredient Plinazolin®, will be labeled through the IR-4 Project in the near future. In past tests, we have used Rimon 0.83EC 12 fl oz/acre and Exirel 0.83SC 10 fl oz/acre to provide some partial control of pepper weevil, but they are not stand-alone control products.

In a field-spray test for pepper weevil control (Figure 3), we tested some of the same bioassay treatments on a weekly spray schedule. We also evaluated insecticide rotations and simple alternations of insecticides each week. The results indicated that Actara, Vydate alternation treatments, the rotation treatments, and Torac all significantly reduced pepper weevils in the crop; however, as expected, the pyrethroid Hero did not control pepper weevil even when applied weekly.

The cowpea curculio has been the most difficult-to-control pest of Southern peas for over a century, mainly because it has become tolerant to most insecticides used to control it. Currently, only pyrethroid insecticides are registered

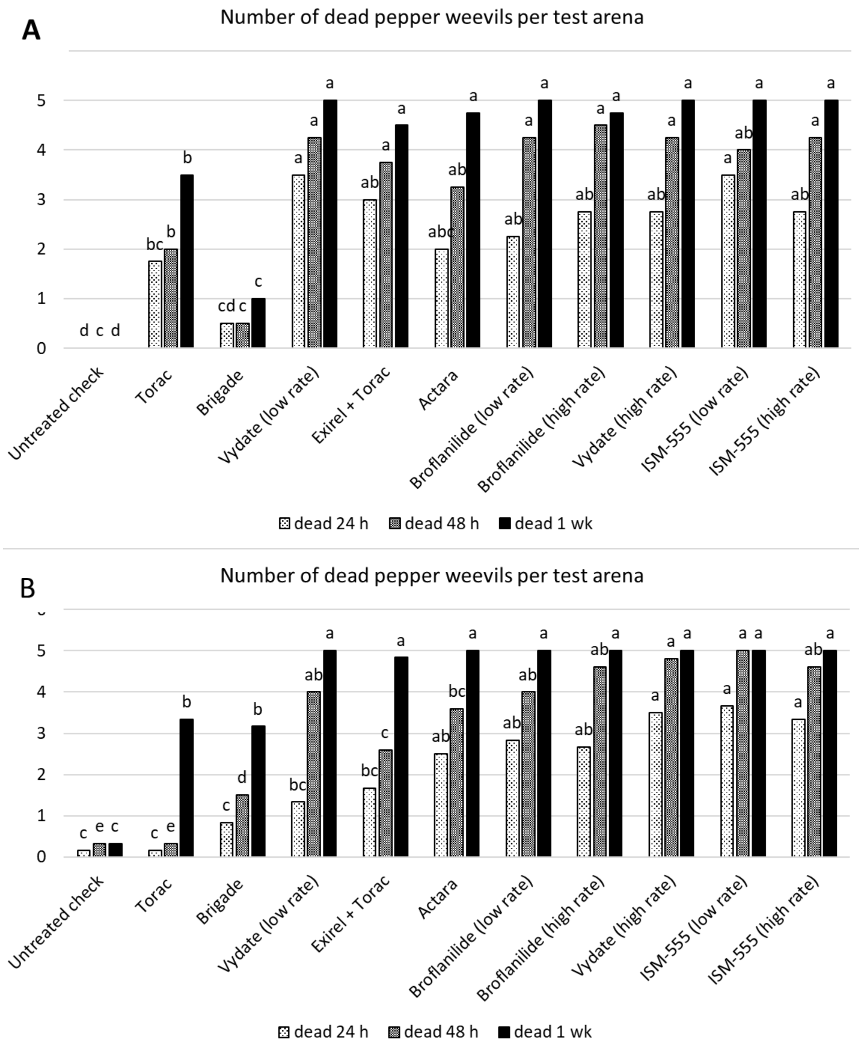

Figure 2. Two distinct Georgia populations of pepper weevil (A and B) tested for control by labeled and experimental insecticides in 2021. Same-colored bars with different letters are significantly different ($p < 0.05$, LSD test).

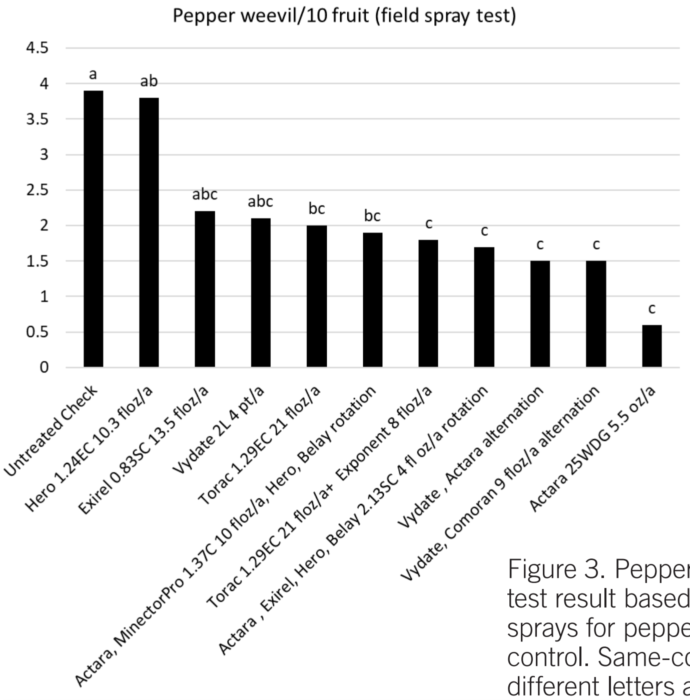

Figure 3. Pepper field spray test result based on weekly sprays for pepper weevil control. Same-colored bars with different letters are significantly different ($p < 0.05$, LSD test).

for its control in Southern peas, and pyrethroids like Brigade provide no significant control (Figure 4). Vydate is still not labeled for use in cowpeas, despite years of requests. As of now there are no good insecticide treatments labeled for use against this devastating pest in Southern peas in Georgia.

We currently are working on host-plant resistance options to manage cowpea curculio. The cowpea breeding lines that provided some resistance to the curculio in field tests—i.e., higher yielding and lower percentage damaged peas with lower curculio grubs surviving—at Tifton in 2021 were PI 582349, PI 663153, PI 214354, and PI 598343. The GMO curculio-resistant cowpea that we have shown in the past to reduce curculio survival in the pods did not yield well at Tifton. The long-term solution to producing a curculio-resistant Southern pea likely will come from this breeding-line selection effort. Another current effort to control cowpea curculio is to target the overwintering soil phase of this insect with soil treatments, like organic insecticide *Beauvaria bassiana*, that reduce the ability of the adult curculio to survive the winter.

In the sweet potato weevil bioassay, we had some background mortality detectable in the check at 1 week posttreatment (Figure 5). However, we were able to rank the insecticides in terms of their efficacy against sweet potato weevil beginning with strongest material, ISM-555 (both rates), followed by Brigade (high rate), Broflanilide (high rate), and lastly Vydate (high rate). Unfortunately, treatment of the weevils is still a big problem as weevils infest tubers that are still developing under the soil surface. Weevil-damaged tubers that are not culled out at harvest can then infest the stored product. This makes this weevil a particularly important pest, because it can reproduce well on stored tubers if not detected and controlled early.

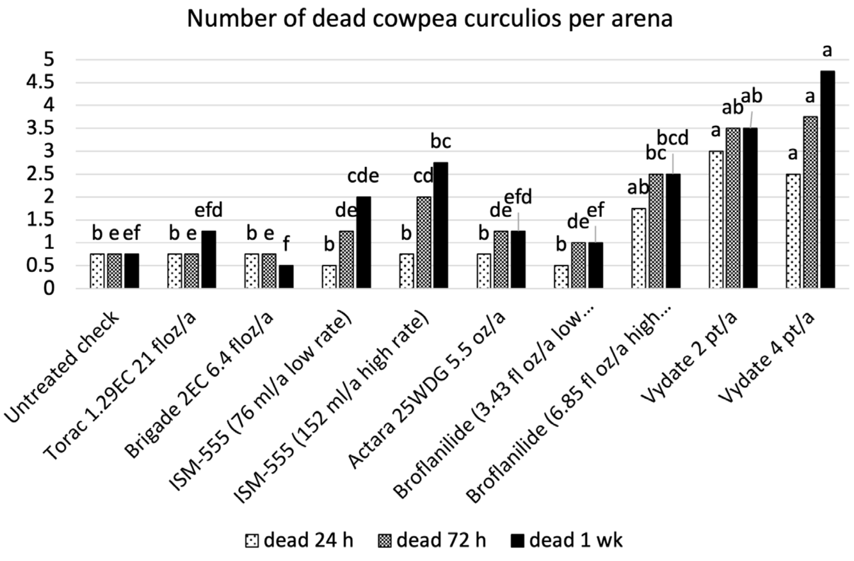

Figure 4. Insecticide control of cowpea curculio in 2021. Same-colored bars with different letters are significantly different ($p < 0.05$, LSD test).

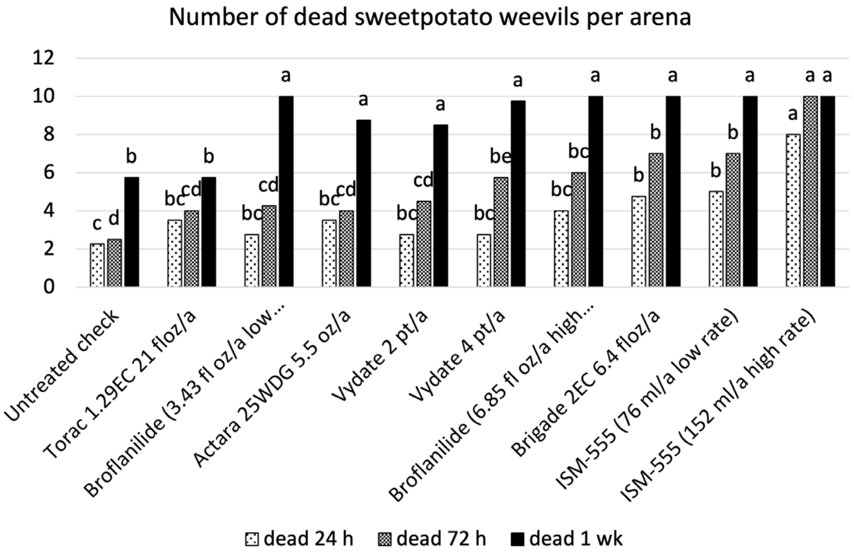

Figure 5. Control of sweet potato weevil in Georgia 2021. Same-colored bars with different letters are significantly different ($p < 0.05$, LSD test).

Monitoring of Overwintering Pepper Weevil in Southern Georgia

A. Sparks, Jr.; Cooperators: T. Torrance, J. Shealey, M. Dowdy, C. Cloud, A. Bruce

Introduction

Pepper weevil, (*Anthonomus eugenii* Cano), is the key pest of peppers wherever both the crop and pest coexist. In Georgia, pepper weevil historically was considered an occasional pest, with infestations generally attributed to man-aided movement. Recent studies demonstrated that pepper weevil now overwinters throughout southern Georgia, including all our primary pepper-production areas. To assess and make growers aware of this issue, pheromone traps were set up in the primary pepper-growing counties in southwest Georgia and monitored throughout the winters of 2020–2021 and 2021–2022. In general, traps were established in early December to determine population levels at the start of the winter and monitored into the following spring planting season to determine if weevils successfully overwintered.

Material and Methods

Fields were monitored in Brooks, Echols, Grady, Worth, and Colquitt counties. Traps primarily were established in fields that had been planted with pepper during the previous fall. In 2021–2022, a few fields were selected that had not been planted with fall peppers but were planned for peppers the following spring. Four pepper weevil traps were established in each field. Traps were baited with the standard two-part pepper weevil pheromone from Trécé® Inc. Traps were monitored weekly and replaced every 2 weeks during 2020–2021. During the 2021–2022 season, traps were posted for 2 weeks each month from December through February, and weekly during March.

Results

Trends are similar for most locations in both years. Large populations enter early winter, and survive well into late winter (Figures 1 and 3). Very high numbers can be captured during the winter, particularly during warmer periods with individual traps occasionally catching more than 1,000 adults in a single week. As the weather warms and planting season approaches, the majority of the weevils appear to die. However, even one weevil per trap is too many at planting time as adults can utilize pepper foliage as a food source and survive until fruit are available for reproduction. Figures 2 and 4 clearly show that few fields had any weeks with zero captures and none remained at zero throughout planting season. Figures 5 through 8 do show some hope for management—but not elimination—of overwintering weevils. Those fields with high weevil numbers in the fall show a definite trend for higher numbers at spring planting, whereas fields with low numbers during the winter show lower weevil numbers at spring planting time. This suggests that while weevils do move throughout the agroecosystem (we do catch weevils everywhere in the spring), movement is restricted and severe problems are localized.

Conclusion

Our research indicates that the majority of weevils entering the winter do not survive to spring planting (suggesting that attempts to control weevils during the winter likely are unwarranted); however, low numbers do survive and can infest the spring crop. The data also suggests that crop rotation away from areas with high weevil populations in the fall will not eliminate the problem but should help make it more manageable.

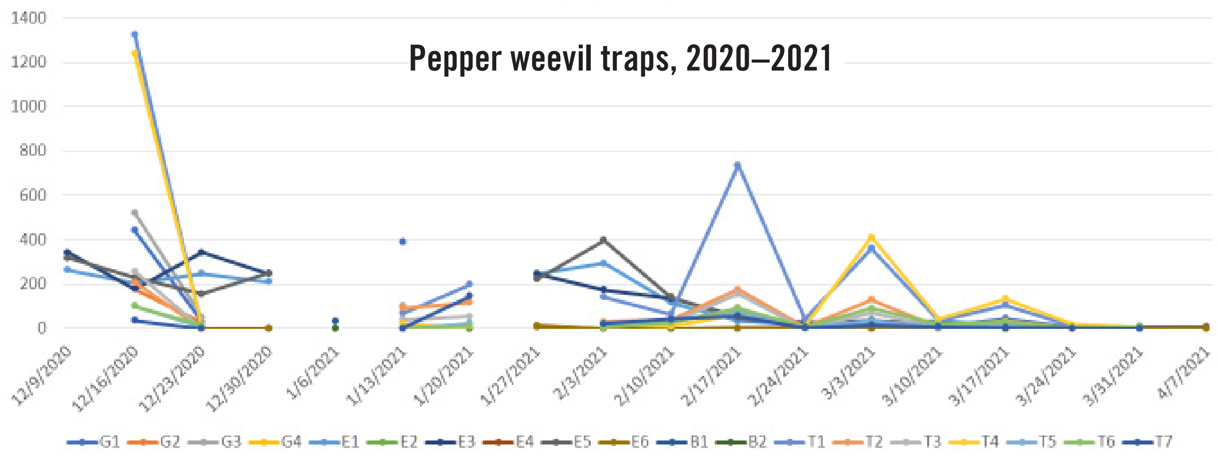

Figure 1. Weevil captures during winter–spring, 2020–2021.

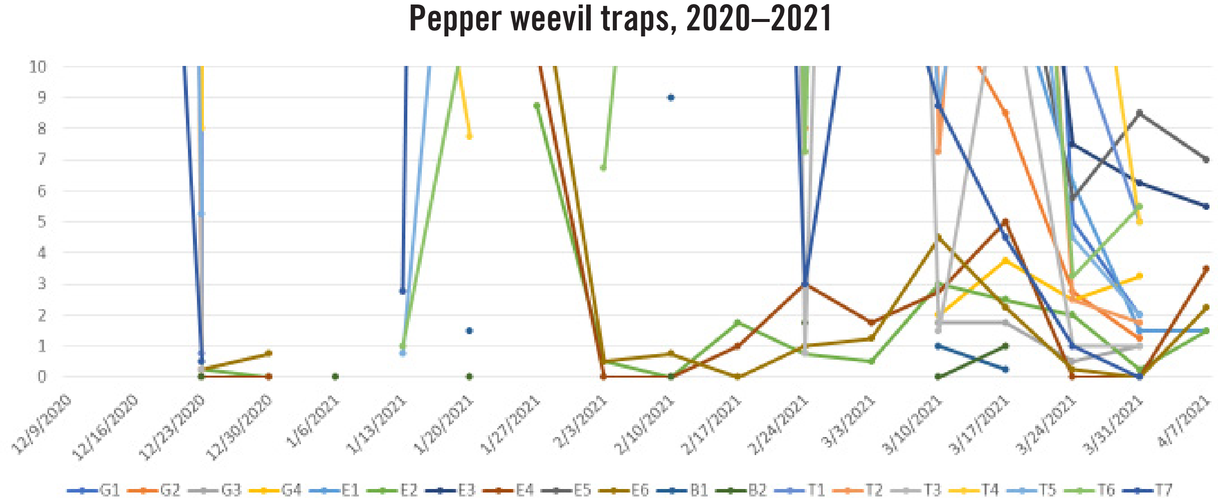

Figure 2. Weevil captures during winter–spring, 2020–2021. Emphasis on lack of zero capture dates.

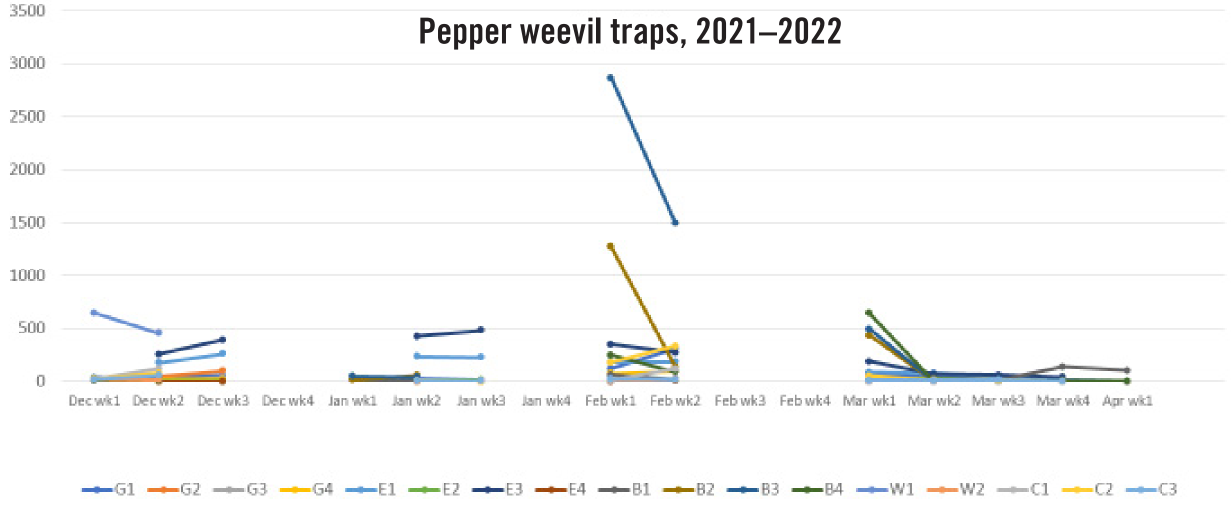

Figure 3. Weevil captures during winter–spring, 2021–2022.

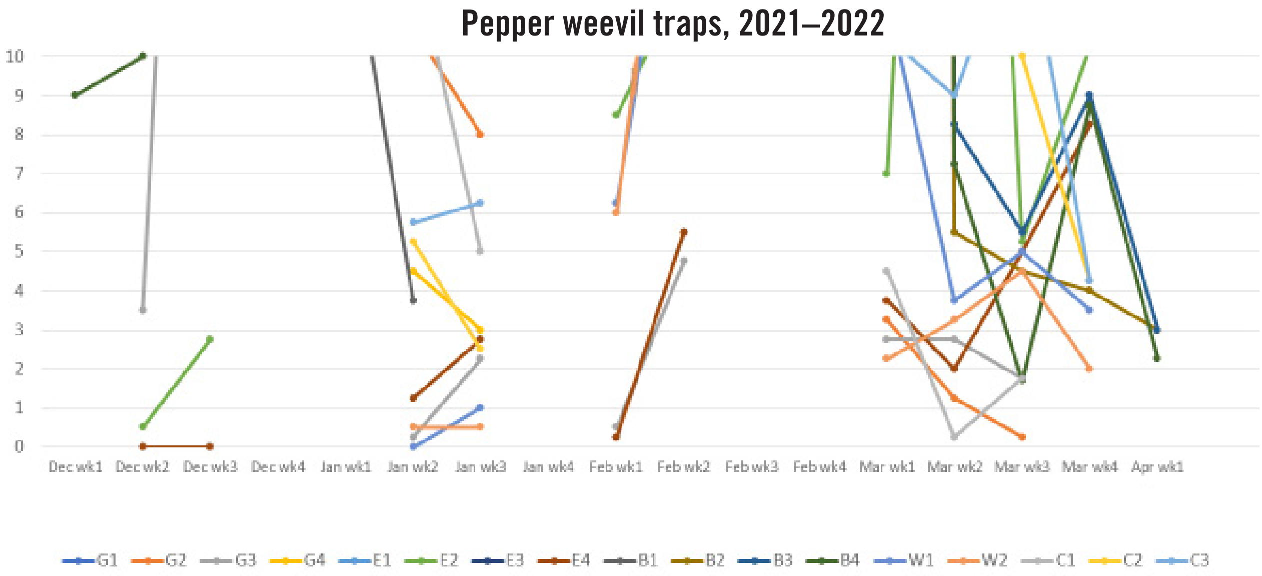

Figure 4. Weevil captures during winter–spring, 2021–2022. Emphasis on lack of zero capture dates.

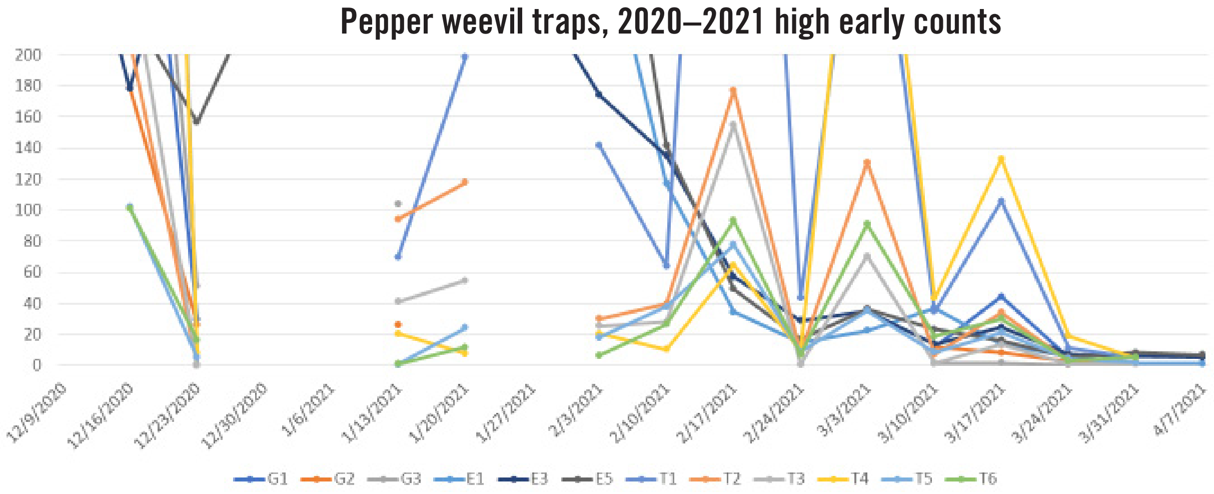

Figure 5. Weevil captures 2020–2021 in fields with high captures early in the season.

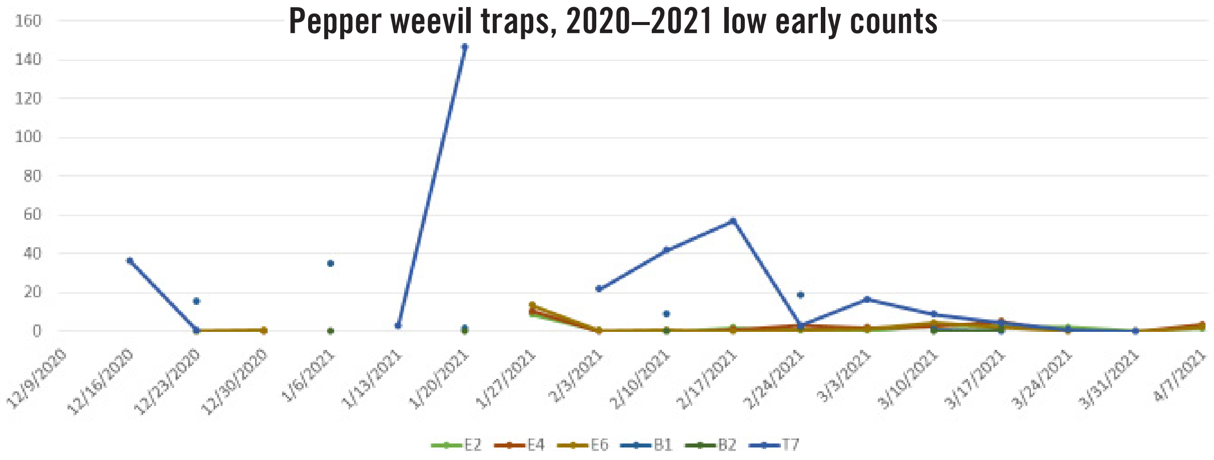

Figure 6. Weevil captures 2020–2021 in fields with low captures early in the season.

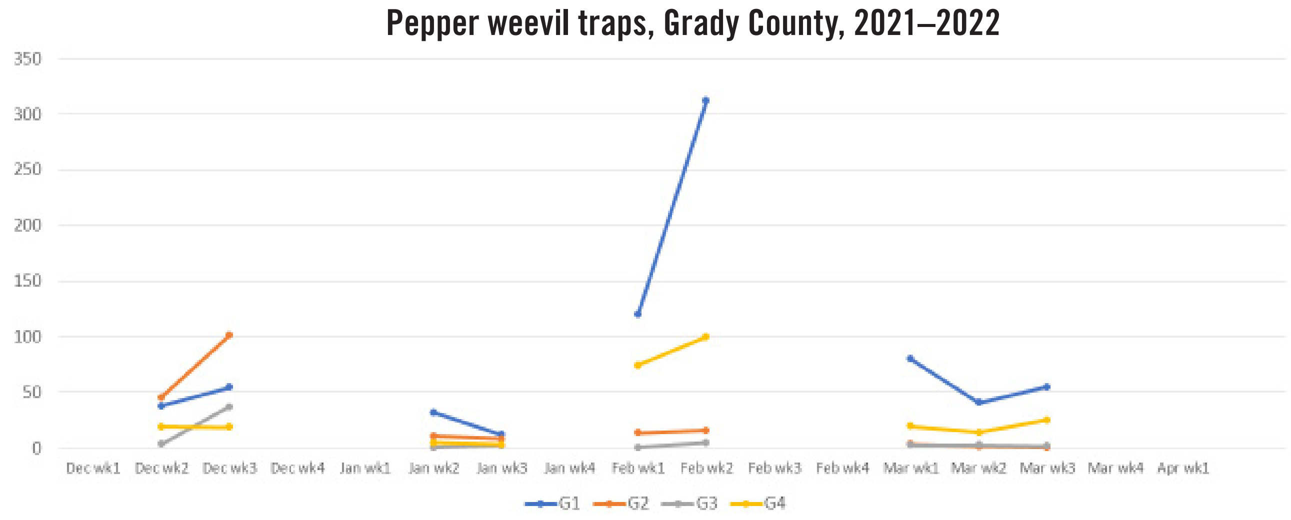

Figure 7. Weevil captures in a Grady County field, 2021–2022.

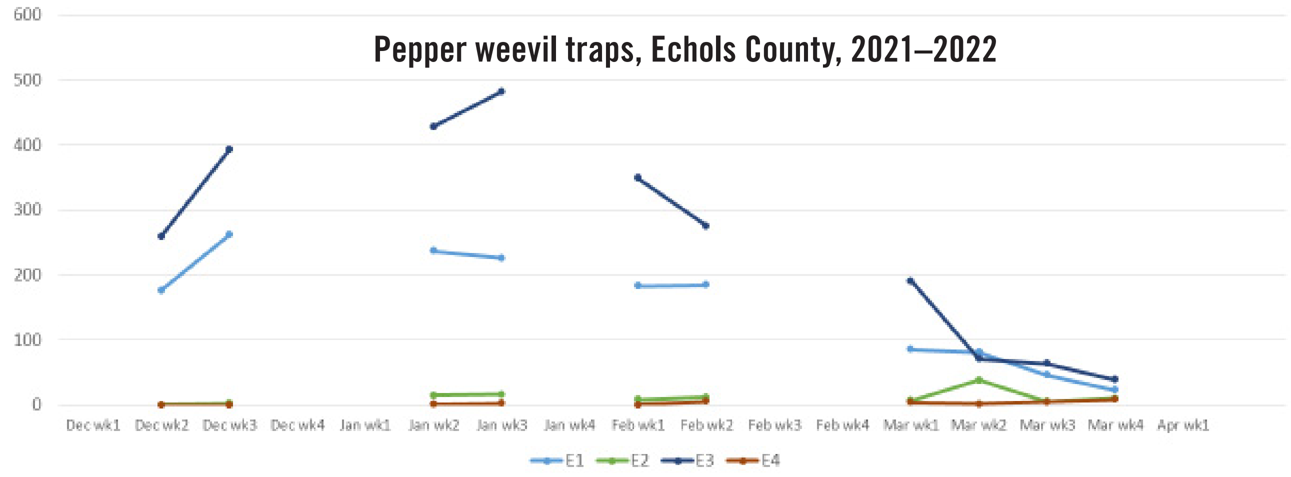

Figure 8. Weevil captures in Echols County fields, 2021–2022.

Assessing the Risk of a New Bacterial Pathogen (*Pseudomonas cichorii*) Causing Bacterial Spot of Pepper in Georgia

M. Zhao, T. Torrance, B. Dutta

Introduction

A new disease outbreak of bacterial leaf spot and blight of pepper occurred recently in greenhouses and transplant houses in Georgia. The pathogen was initially identified as *Pseudomonas cichorii*. The objectives of our project were to characterize whether *P. cichorii* strains can cause disease on other vegetable crops (tomato, eggplant, cabbage, broccoli, lettuce, and watermelon) and if they can be managed by copper applications using greenhouse spray trials. We investigated the phylogenetic relationship of *P. cichorii* recently isolated from pepper with strains isolated from other vegetable crops not only in Georgia but also from other vegetable-growing regions of the United States.

Material and Methods

Pseudomonas strains were collected from bacterial spot outbreaks in Georgia from pepper seedlings in 2019 (strains Pc19-1, Pc19-2, and Pc19-3) and from tomato seedlings in 2020 (strains Pc20-2, Pc20-3, Pc20-4, and Pc20-5). For comparison, three reference strains were obtained from the National Collection of Plant Pathogenic Bacteria (strains NCPPB1511, NCPPB2479, and NCPPB3928), and two *Pseudomonas* strains were obtained from tomato seedlings in Florida (strains GEV417 and GEV1127). The pathogenicity of collected strains was tested on pepper seedlings under greenhouse conditions. The host range was evaluated by artificial inoculation on tomato, eggplant, cabbage, broccoli, lettuce, and watermelon under greenhouse conditions at the UGA Tifton Campus. The copper resistance status of these strains was investigated using in-vitro plate assays. The genetic relationships and population structures of *Pseudomonas* strains, and the genome sequences of Georgia *Pseudomonas* strains from recent pepper and tomato outbreaks, were compared with sequences from other sources. We are in the process of assessing the efficacy of copper-based bactericides on *Pseudomonas* spp.

Results

Three phytopathogenic bacterial strains (Pc19-1^T, Pc19-2, and Pc19-3) were isolated from seedlings displaying water-soaked, dark brown-to-black necrotic lesions on pepper leaves in Georgia. Upon isolation on King's medium B, light cream-colored colonies were observed and a diffusible fluorescent pigment was visible under ultraviolet light. Analysis of their 16S rRNA gene sequences showed that they belonged to the genus *Pseudomonas*, with the highest similarity to *Pseudomonas cichorii* ATCC 10857T (99.7%). Phylogenomic analyses based on whole-genome sequences demonstrated that the pepper strains belonged to the *Pseudomonas syringae* complex with *P. cichorii* as their closest neighbor. These strains formed a separate monophyletic clade (group) from other species. Based on the genome sequence analysis between the pepper strains and *P. cichorii*, the average nucleotide identity values were 91.3%. Furthermore, the digital DNA–DNA hybridization values of the pepper strains when compared to their closest relatives, including *P. cichorii*, were 45.2% or less (Table 1). Therefore, we proposed a new species, *Pseudomonas capsici* sp. nov., with Pc19-1^T as the type strain.

Based on the whole-genome information, the other nine strains in this study belonged to the same *P. capsici* species. A phylogenetic tree from the whole-genome sequence data (Figure 1) showed that the three Georgia *P. capsici* pepper strains formed a subclade, which were closely related to the tomato strain clade (GEV1127, Pc20-3, Pc20-5, and Pc20-4) and a cabbage strain isolated in the United States in 1963 (NCPPB1511). In addition, the 2020 *P. capsici* tomato strain Pc20-2 formed a separate clade with strain GEV417, and was different from other Georgia strains. These results indicated that *P. capsici* strains isolated from pepper and tomato in 2019 and 2020 in Georgia were genetically diverse and closely related to strains isolated from tomato in Florida in 2011 and 2012.

Six out of seven Georgia *P. capsici* strains and one Florida *P. capsici* strain were copper-tolerant in the in-vitro plate assays. These strains were isolated after the year 2012 and could grow on nutrient agar amended with 0.8 mM CuSO4. However, one Georgia *P. capsici* strain (Pc20-2) isolated in 2020 and other reference strains isolated before 2011 were copper-sensitive on agar plates. The copper-tolerant strains encode a cluster of 18 genes related to copper tolerance, which were absent in the genomes of copper-sensitive strains (Figure 1).

Host-range assays of 12 *Pseudomonas capsici* strains showed they all were pathogenic on pepper, tomato, eggplant, cabbage, lettuce, and watermelon, but not pathogenic on broccoli.

Conclusion

The new bacterium in Georgia on pepper and tomato was identified as *Pseudomonas capsici*, a new species based on its taxonomy status but one that previously was isolated as early as 1963 from cabbage in the United States. The pepper and tomato strains from Georgia are genetically diverse, and are closely related to tomato strains from Florida. In lab assays, most Georgia *P. capsici* strains are copper-tolerant. All *P. capsici* strains are pathogenic on a broad range of hosts, including pepper, tomato, eggplant, cabbage, lettuce, and watermelon.

Table 1. Genomic relationship of strains listed under *Pseudomonas cichorii* in NCBI compared to *Pseudomonas capsici* sp. nov. strain Pc19-1^T and *cichorii* ATCC10857^T.

Strain	ANIb (%)		dDDH (%)		
	P. capsici 19-1^T	*P. cichorii* ATCC10857^T	*P. capsici* 19-1^T	*P. cichorii* ATCC10857^T	Species status
MAFF302698	98.5	91.3	88.3	45.2	*P. capsici*
481	98.5	91.3	87.9	45	*P. capsici*
Ku1409-10-1	98.4	91.3	88.1	45.2	*P. capsici*
NB15027	98.4	91.3	87.9	45.2	*P. capsici*
482	98.4	91.3	87.8	45.1	*P. capsici*
136	98.4	91.3	87.8	45.3	*P. capsici*
ICMP1649	98.4	91.3	88.4	45.3	*P. capsici*
474	98.4	91.3	87.8	45.3	*P. capsici*
S-2-2-1	98.4	91.3	87.7	45.2	*P. capsici*
473	97.2	91.2	77.1	45.3	*P. capsici*
Pcic4	92.1	94.0	48.4	57.6	Potential new species
Ku1408-5-5	92.1	94.5	48.2	59.1	Potential new species
REF	91.4	99.9	45.3	99.8	*P. cichorii*
JBC1	91.4	99.9	45.2	99.8	*P. cichorii*
MAFF301184	91.4	99.0	45.1	92.2	*P. cichorii*
ICMP6917	91.4	99.3	45.1	94.4	*P. cichorii*
MAFF302096	89.0	91.4	38.1	45.2	Potential new species
MAFF301764	88.9	91.0	37.8	43.9	Potential new species
ICMP3353	86.8	86.6	32.7	32.6	Potential new species

Note. ANIb and dDDH values were calculated using JSpeciesWS v1.2.1 and Genome-to-Genome Distance Calculator 2.1 (formula 2), respectively. ANIb values larger than 95% are in bold. dDDH values larger than 70% are in bold.

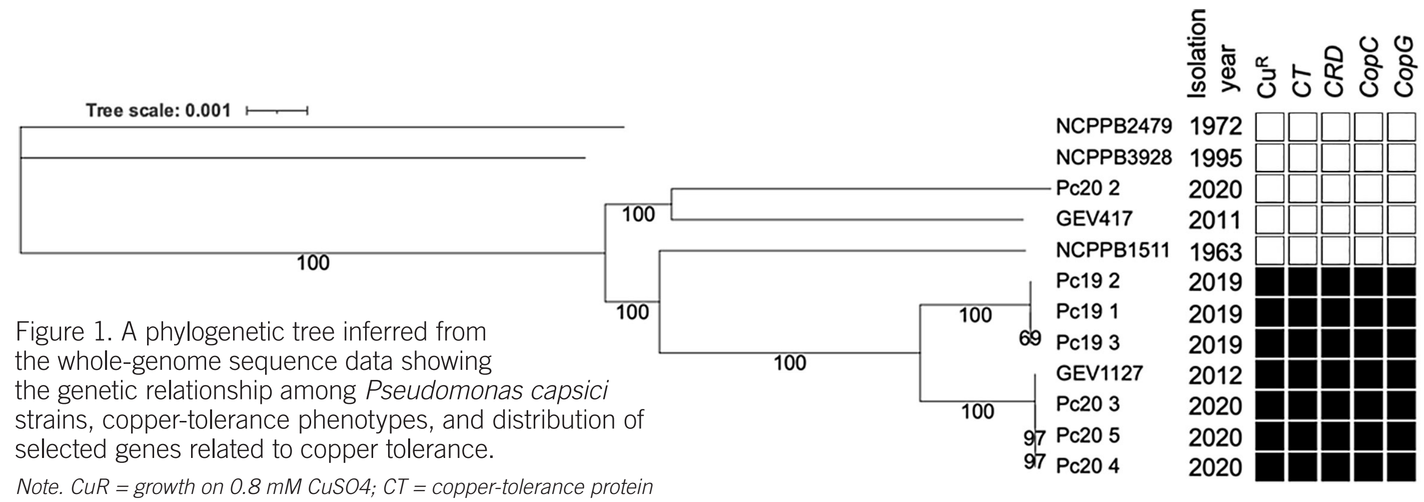

Figure 1. A phylogenetic tree inferred from the whole-genome sequence data showing the genetic relationship among *Pseudomonas capsici* strains, copper-tolerance phenotypes, and distribution of selected genes related to copper tolerance.

Note. CuR = growth on 0.8 mM CuSO4; CT = copper-tolerance protein gene; CRD = copper-resistance protein D; copC = copper-resistance protein C; copG = copper-resistance protein G.

Evaluation of Fungicides Against Alternaria Leaf Blight of Carrot in 2021

B. Dutta, M. J. Foster, M. Donahoo

Introduction

Alternaria leaf blight, caused by *Alternaria dauci*, is an endemic disease of carrot in Georgia. It can cause considerable yield losses, especially if infection occurs early in the season. Symptoms include small lesions commonly found on the margins and tips of carrot leaflets. Under severe conditions, the lesions coalesce and give a blighted appearance. In some cases, larger lesions can develop in the petiole, which may result in girdling and the leaves dying. Severe infection can also kill all the foliage. Severe defoliation and weakened foliage often result in reduced harvest efficiency. Warm to moderate temperatures and prolonged leaf wetness favor the spread of infection. The fungus sporulates readily on necrotic tissues, and moisture on leaf surfaces aids further spore germination. Among other management practices, chemical management through fungicides is important. However, because of a limited number of labeled fungicides and monoculture of carrot in some areas, disease management has been difficult. Our research evaluates using fungicides against Alternaria leaf blight of carrot.

Material and Methods

The experiment was conducted at the University of Georgia Blackshank Farm in Tifton, GA. Carrot (cv. 'Bolero') was direct-seeded into six-row beds on December 17, 2020. Beds were on 6-ft centers with 1-in. plant spacing within rows. Plots were 15 ft long with 10-ft unplanted breaks between plots within the row. The treatments were arranged in a randomized complete block design with four replications. Plots were overhead-irrigated weekly as necessary using a pivot-irrigation system. Fertility and insecticide treatments were applied according to University of Georgia Cooperative Extension recommendations. The field has had a history of Alternaria leaf blight infection since 2015, so natural infection was relied upon for this trial. Fungicide treatments were applied with a backpack sprayer calibrated to deliver 40 gallons per acre at 80 psi through TX-18 hollow-cone nozzles. Fungicide applications were made on 14-day intervals on January 14, January 28, February 11, February 25, March 11, and March 25, 2021. Plots not treated with fungicides served as the nontreated check. Disease severity was assessed on February 22, March 8, March 22, and April 5 as percent leaf area with necrosis per plot. The area under disease progress curve (AUDPC) was calculated for each treatment. Data were analyzed in ARM software using analysis of variance and the Fisher's LSD test to separate means at $p = 0.05$.

Results

Alternaria leaf blight was first observed on February 22, 2021, with 32.5% disease severity in the nontreated check (Table 1). During the same disease-assessment period, disease severity was significantly higher in the nontreated check compared to other treatments. Among the treatments, fungicides alternated with Penncozeb had significantly lower disease severity compared with the same fungicides sprayed without Penncozeb. Disease progressed gradually over the next 7 weeks, and the final disease-severity ratings were recorded on April 5.

Based on disease ratings on April 5, treatments comprised of Merivon and Penncozeb (38.2%), Luna Sensation and Penncozeb (41.5%), Pristine and Penncozeb (42.8%), Switch and Penncozeb (36.4%), or Miravis Prime and Penncozeb (40.5%) each had significantly lower disease severity compared with other treatments and the nontreated check. Alternaria leaf blight severity was not significantly different for treatments with solo application of either Merivon, Pristine, Luna Sensation, Switch, or Miravis Prime; however, both of these treatments had significantly lower disease severity compared to the nontreated check. AUDPC values followed same trend as that of final disease-severity ratings on April 5.

The use of Merivon, Luna Sensation, Pristine, Switch, or Miravis Prime in a program with Penncozeb had significantly lower AUDPC values compared to other treatments and the nontreated control. Phytotoxicity of the fungicides was not observed.

Table 1: Summary of treatments, fungicide application frequency, disease severity, and area under disease progress curve (AUDPC).

Treatment and rate per acre	**Fungicide applications**[z]	**Disease severity (%)**[y]		
		22 Feb	**5 Apr**	**AUDPC**[x]
Merivon 5.5 fl oz	1,3,5	20.5 b[w]	52.2 b	752.2 b
Pristine 10.5 fl oz	1,3,5	17.5 b	58.7 b	735.8 b
Luna Sensation 7.6 fl oz	1,3,5	18.5 b	51.7 b	725.5 b
Switch 11 fl oz	1,3,5	16.2 b	60.2 b	670.2 b
Miravis Prime 9.2 fl oz	1,3,5	18.5 b	58.0 b	768.8 b
Merivon 5.5 fl oz **Penncozeb 2 lb**	1,3,5 2,4,6	11.4 c	38.2 c	325.2 c
Luna Sensation 7.6 fl oz **Penncozeb 2 lb**	1,3,5 2,4,6	8.2 c	41.5 c	275.8 c
Pristine 10.5 fl oz **Penncozeb 2 lb**	1,3,5 2,4,6	9.7 c	42.8 c	342.8 c
Switch 11 fl oz **Penncozeb 2 lb**	1,3,5 2,4,6	8.5 c	36.4 c	288.5 c
Miravis Prime 9.2 fl oz **Penncozeb 2 lb**	1,3,5 2,4,6	7.3 c	40.5 c	249.5 c
Nontreated	n/a	32.5 a	63.5 a	1356.2 a

[z] Spray dates were: 1 = January 14; 2 = January 28; 3 = February 11; 4 = February 25; 5 = March 11; and 6 = March 25, 2021.

[y] Alternaria leaf blight severity was rated on a 0–100 scale where 0 = 0% leaf area affected and 100 = 100% leaf area affected on February 22, March 8, March 22, and April 5, 2021.

[x] AUDPC was calculated from ratings taken on February 22, March 8, March 22, and April 5, 2021.

[w] Means followed by the same letter in each column are not significantly different according to the Fisher's protected LSD test at $p \leq 0.05$.

Support of the UGA Georgia Weather Network

P. Knox

Introduction

The University of Georgia weather network provides weather data and monitors soil conditions at 88 locations at 15-min intervals around the state, mainly in agricultural areas. Support from the Georgia Commodity Commission for Vegetables helps maintain weather stations, store archived data, and calibrate instruments. This support also helps Extension agents monitor crop conditions and environmental data that can be used to predict pest and disease pressures on vegetable crops. Furthermore, this funding has allowed us to explore expansion of the network.

Material and Methods

Our network of 88 Campbell Scientific automated stations is maintained by two technicians (one full-time and one part-time), an electronics engineer who provides IT support and manages the network, and a quality-control specialist who monitors the data for errors and makes appropriate corrections. The technicians visit the stations every 4–6 weeks to clean and repair equipment and ensure that the quality of the site locations is maintained. Instruments are rotated out and calibrated on a regular schedule. The IT specialist maintains the network and is working on moving the historical data files from a Griffin-based service to online cloud storage for improved access. In 2020, we added stations at Glennville and Sparks and temporarily removed the station in Alpharetta because of poor site characteristics; that station was restored to service at a better location nearby on the same golf course. We are now looking for additional sites near Columbus and the Gray/Milledgeville area to fill in gaps in our network.

Results

In 2021, our network maintained nearly continuous availability of current, high-quality weather data, other than some temporary delays because of cellular network outages. We are proud that our data were available nearly 100% of the time because of our comprehensive maintenance program, which the vegetable commission helps fund. Our maintenance schedule is the envy of some weather networks in other states, who visit their stations much less frequently.

In 2021, we continued moving the network's data from server-based text files to a cloud-based database. The migration was delayed temporarily because of the hiring freeze at UGA at the time, which prevented us from hiring a web programmer to assist in the transition. We have created a full database with the help of a graduate student in the statistics department and are working to link it to our website. With the difficulty in hiring a web programmer we are looking at getting internal UGA contract help to get this completed.

Conclusion

Thanks to the support from the vegetable commission as well as other commodity commissions in Georgia, the network performed well and consistently provided continuous and current high-quality data to Extension agents and producers around the state on demand. Upon request, we provided additional archived data to scientists and students for specialized studies of disease and pest management. We hope to continue this service to vegetable producers as well as expand our range of tools in the coming years.

Cucumber Variety Trial, Spring 2021

J. Díaz-Pérez

Objective

To determine fruit yields and physical properties of fruit in cucumber cultivars.

Material and Methods

Treatments (cultivars) were ‘Cobra’, ‘Dasher II’, ‘Dominator’, ‘Mercury’, ‘Mongoose’, and ‘Slice More’, and the experiment design was a randomized complete block with four replications. The transplant date was April 22, 2022.

Plants were grown on raised beds covered with black plastic mulch. There were two rows of plants in each bed, and plants were spaced 1 ft apart within the row. One drip tape (John Deere Ro-Drip) was placed between the two rows of plants, with an 8-in. separation between emitters and a flow rate of 40 gph per 100 ft. Prior to planting, 600 lb/acre of 10-10-10 was applied; beginning May 14, N and K were injected weekly via drip irrigation. Total seasonal N and K applied amounted to 151 lb/acre.

Fruit was harvested from May 21 to June 28, and fruits were graded as marketable or cull, according to USDA grading standards.

Results

Fruit yields (Table 1)
The number and weight of Fancy fruit were similar among cucumber cultivars. US1 fruits were not significantly ($p < 0.05$) affected by treatments, although cv. ‘Dominator’ tended to have the highest yield ($p = 0.092$) of US1 fruit. All cucumber cultivars had similar total fruit numbers and yield of marketable fruit. The number and yield of cull fruit were highest ($p < 0.05$) in cv. ‘Slice More’, although cull yields were low.

Fruit properties (Table 2)
Fruit weight was similar among cultivars. The fruit length-to-width ratio was similar among cultivars, indicating that fruit shape was similar. The presence of hollow heart was low. The rate of fruit water loss (fruit weight loss) was highest in ‘Mercury’, while the rest of the cultivars had similar water-loss rates. The high rate of water loss in ‘Mercury’ indicates that this cultivar may have a reduced shelf-life due to softening and wilting. The percentage of fruit dry matter was similar among cultivars.

Table 1. Fruit yields of cucumber cultivars tested in spring 2021 in Tifton, GA.

Cultivar	Fancy		US1		Total marketable		Cull	
	(#/acre)	(lb/acre)	(#/acre)	(lb/acre)	(#/acre)	(lb/acre)	(#/acre)[z]	(lb/acre)[z]
Cobra	24,503	18,309	13,522	6,261	54,632	30,845	635 b	248 b
Dasher II	24,866	17,687	17,424	7,809	57,445	31,152	0 b	0 b
Dominator	30,855	22,705	18,059	8,792	63,707	36,470	545 b	216 b
Mercury	29,585	20,855	16,335	7,720	54,269	31,725	545 b	256 b
Mongoose	26,136	18,897	17,424	7,416	59,078	31,723	91 b	45 b
Slice More	22,778	17,729	11,707	5,409	47,553	27,877	2,178 a	925 a
Significance[y]	NS	NS	NS	NS	NS	NS	Sig.	Sig.
p	0.510	0.640	0.084	0.092	0.213	0.468	0.034	0.024

[z]Means within columns followed by the same letter are not statistically different according to Duncan's multiple range test ($p < 0.05$).

[y]NS = not significant; Sig. = significant at $p < 0.05$.

Table 2. Cucumber fruit properties measured during a keeping period of 3 days at 68 °F.

Cultivar	Fruit weight	Length-to-width	Water loss rate[z]	Dry matter
	(lb)	ratio	% per day	%
Cobra	0.56	3.7	1.92 b	7.5
Dasher II	0.54	3.6	1.64 b	7.6
Dominator	0.57	3.9	1.76 b	8.1
Mercury	0.58	4.2	2.93 a	7.7
Mongoose	0.53	3.8	1.85 b	7.8
Slice More	0.59	3.8	1.78 b	8.3
Significance[y]	NS	Sig.	Sig.	NS
p	0.275	< 0.0001	< 0.0001	0.484

[z]Means within columns followed by the same letter are not statistically different according to Duncan's multiple range test ($p < 0.05$).

[y]NS = not significant; Sig. = significant at $p < 0.05$.

Conclusion

Marketable fruit number and yield were similar among cultivars ($p < 0.05$). Fruit length-to-width ratio also was similar among cultivars. The cultivar 'Mercury' had the highest rate of fruit water loss after harvest.

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Annual Publication 113-4 **December 2022**