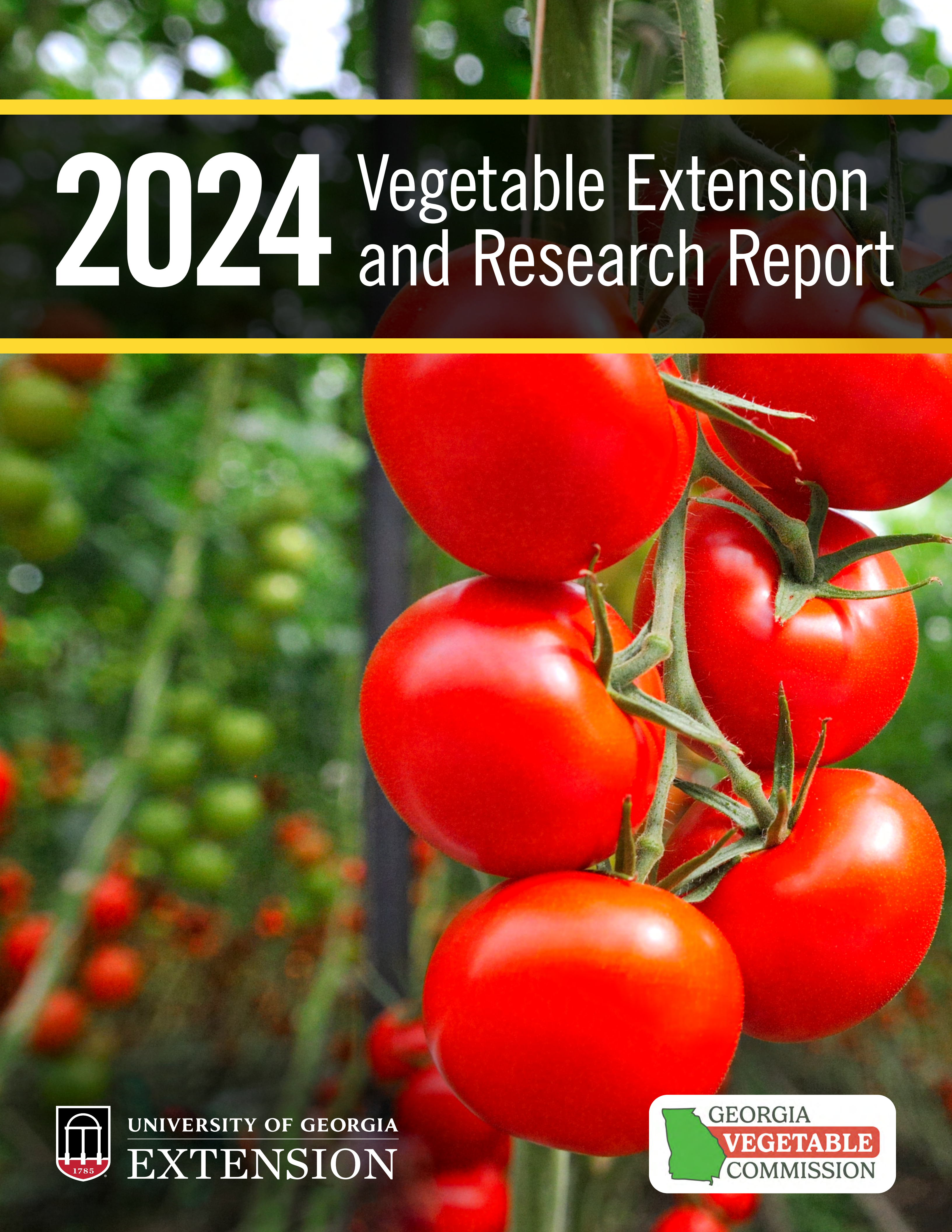
2024 Vegetable Extension and Research Report



UNIVERSITY OF GEORGIA
EXTENSION

GEORGIA VEGETABLE COMMISSION

From the Commodity Commission Chair

The Georgia Commodity Commission for Vegetables (GACCV) is pleased to present our 2024 annual report, highlighting the research findings and educational programs we have initiated to support you, Georgia's most valued vegetable producers.

For the period covered in this report, the Georgia Vegetable Commission supported 18 research projects with almost $200,000 of funding. These projects have provided Georgia vegetable growers significant scientific advancements to help lower production costs, increase yields and enhance profitability. Key commodities included in these findings include:

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

With the help of grower assessment funds, project researchers have addressed and made significant strides, including areas such as pesticide disease resistance, reducing bacterial transmission, variety trials to improve yields, improving refrigeration and cooling efficiencies, and continuing to enhance the UGA Weather Stations program. A project of particular importance in the development of farm bill public policy was a study identifying the economic impact of imports on Georgia's fruit and vegetable industry.

Thank you for your continued dedication to the vegetable industry in Georgia. If you are interested in participating on any Georgia Commodity Commission for Vegetables committees, or serving on the Commission, we would love to hear from you.

We look forward to supporting you in the coming year!

Warm regards,
Dick Minor, *Chair*

Commission Members

July 1, 2023 – June 30, 2024

Dick Minor, Chair
Americus, Georgia

Tyler Harper
Georgia Department of Agriculture, Commissioner
Atlanta, Georgia

Tom McCall
Georgia Farm Bureau, President
Macon, Georgia

Jamie Brannen
Lake Park, Georgia

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Ashburn, Georgia

Glenn Heard
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Lake Park, Georgia

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Jamie Brannen
Echols County

Justin Corbett
Lowndes County

Tom Daughtrey
Cook County

Kent Hamilton
Colquitt County

Melinda James
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Jamie Patrick
Tift County

Tucker Price
Cook County

Bill Starr
Sumter County

Ty Torrence
Tift County

Jason Tyrone
Echols County

Sam Watson
Colquitt County

Efforts in Education

County Extension Agent Continuing Education

In 2024, 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 2024. 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 2024.

Vegetable Commodity Fund Financials, Fiscal Year 2024 (July 1, 2023, to June 30, 2024)	
Item	***Amount***
Assessments received	$269,194
Bank account balance (as of June 30, 2024)	$216,325
Liabilities; University of Georgia research projects	$237,519
Items Paid in Fiscal Year 2024	
Sponsorship for SE Regional Fruit and Vegetable Conference	$6,000
Georgia Grown — support of Georgia National Fair Building	$3,000
County agent support for SE Regional Fruit and Vegetable Conference	$4,179
Market Order referendum expense (printing/postage)	$445
Misc.	$1,961
Administrative cost to Georgia Department of Ag.	$4,211
Preparation, printing, and postage for annual report	$4,209
Georgia Farm Bureau — Farm Monitor show sponsor	$8,000
UGA research projects	$181,281
Total Expenses	**$213,286**

2024 University of Georgia Vegetable Extension and Research Report

Timothy Coolong and Theodore McAvoy, *Editors*

Contributing Authors from the University of Georgia

Department of Crop and Soil Sciences

A. Stanley Culpepper
Pam Knox
Taylor Randell-Singleton
Jenna Vance

Department of Entomology

Donald Champagne
David Riley
Alton N. (Stormy) Sparks, Jr.
Rajagopalbabu (Babu) Srinivasan
Thomas (Sam) Dunn
Gurjit Singh

Department of Horticulture

Timothy Coolong
Juan Carlos Díaz-Pérez
Manisha Kumari
Alex Luckew
Theodore McAvoy
Cecilia McGregor

Department of Plant Pathology

Sudeep Bag
Intiaz Chowdhury
Bhabesh Dutta
Sunil Gangurde
Navjot Kaur
Manish Kumar
Alejandra Jimenez Madrid
Nabin Poudel

Department of Agricultural and Applied Economics

Gopi Munisamy

Cooperative Extension Service County Faculty

Cale Cloud
Joshua Dawson
Justin Shealey
Ty Torrance

Funds from the Georgia Commodity Commission for Vegetables were used to support all of the research outlined in this report. This research would not be possible without the continued support of the farmers who contribute to the Commission. 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.

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 VEGETABLE COMMISSION

2024 University of Georgia Vegetable Extension and Research Report

Evaluation of Preplant Potassium Sources for Pepper Production

T. Coolong, T. McAvoy

Introduction

Traditionally, vegetable growers have used potassium sulfate-based fertilizers with a low salt index (46) to avoid the negative effects associated with muriate of potash (potassium chloride), which has a relatively high salt index (116). However, as fertilizer costs have risen there is significant interest in using more muriate of potash as a preplant potassium source given its lower cost per unit of potassium. There is relatively little research comparing sulfate of potash to muriate of potash in vegetable production systems. The aim of this research was to compare sulfate of potash and muriate of potash in a plasticulture system.

Material and Methods

This trial was conducted during the summer of 2023 and repeated in 2024 in Tifton (loamy sand) and Athens, GA (clay loam) locations. Preplant applications of potassium at six preplant application rates (and a zero control; i.e., 0, 50, 100, 200, 300, 400, and 500 lb/acre potassium) were made by hand prior to laying plastic. Nitrogen was applied at 50 lb/acre preplant using 34-0-0. The widely grown bell pepper variety Antebellum was used in this experiment. Transplants were planted in a double row with 12 in. in row spacing and 6 ft between bed centers for a population of 14,520 plants per acre. Plots were 20 ft long (40 plants). Soil samples were taken at planting and approximately 1 month after transplanting in each plot, and leaf tissue samples were taken at fruit set. Plants were fertigated with 7-0-7 liquid fertilizer to supply approximately 175 and 200 lb/acre nitrogen in the Athens and Tifton locations, respectively. Peppers were harvested four times in Athens and twice in Tifton and graded according to USDA and industry standards for size. Data from the 2023 trial are presented here.

Results

There was no impact of potassium source on soil EC (data not shown). However, as the potassium rate increased, soil EC increased for both the Tifton and Athens locations at planting (Figure 1). The Athens location had a significantly higher EC than Tifton (Figure 1). At planting there were no EC levels at any potassium application rate in Tifton that exceeded thresholds for potential damage to the crop. However, at the highest potassium application rates (400 and 500 lb/acre) EC levels in the Athens planting were potentially great enough (> 1.5 mmhos/cm) to impact plants. It should be noted that no visual salt damage

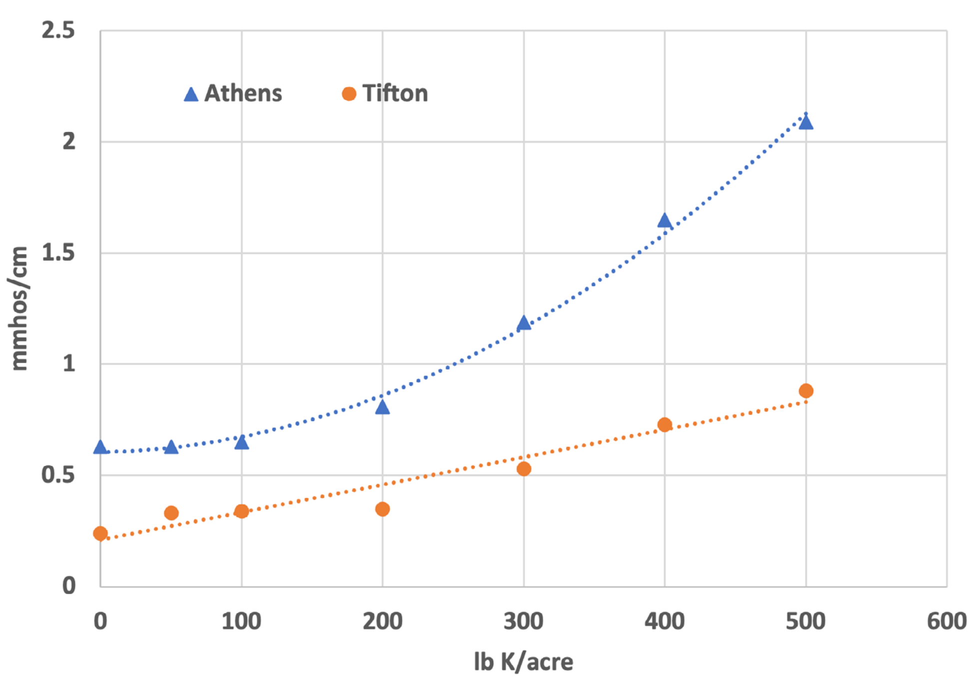

Figure 1. EC Levels at Planting.

was observed on any plants. By the mid-season soil sampling, the EC level had dropped significantly in both locations, though EC levels in the Athens location still approached 1.5 mmhos/cm for the 400 and 500 lb/acre potassium application rates (Figure 2). At the mid-season sampling, potassium source again did not impact EC levels.

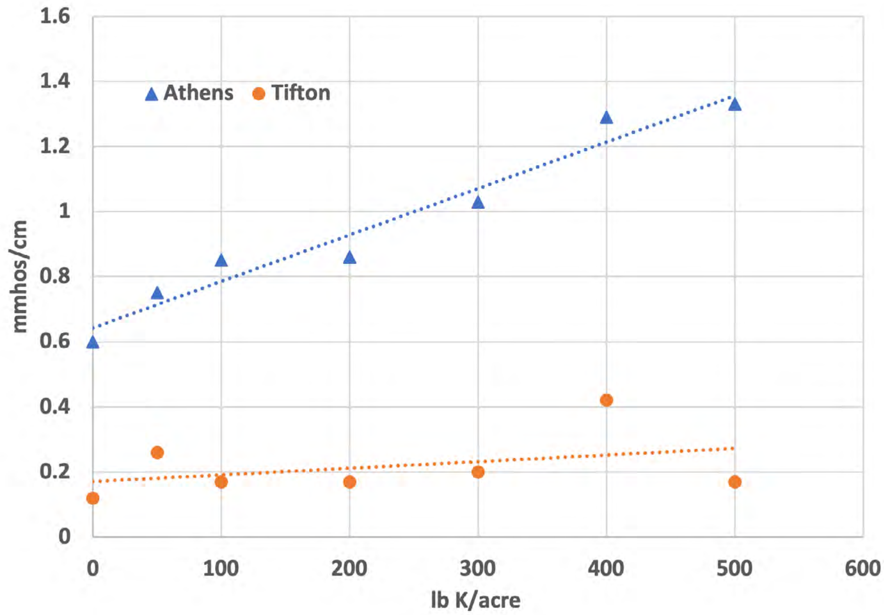

Figure 2. Mid-Season Soil EC.

Total yields were not affected by potassium rate or source for either location, but yields were significantly greater for the Athens location than Tifton (Figure 3). This may have been due to the higher cull rate (43.7%) in Tifton than Athens (6.2%; data not shown). Further, there was not impact of potassium source on yield.

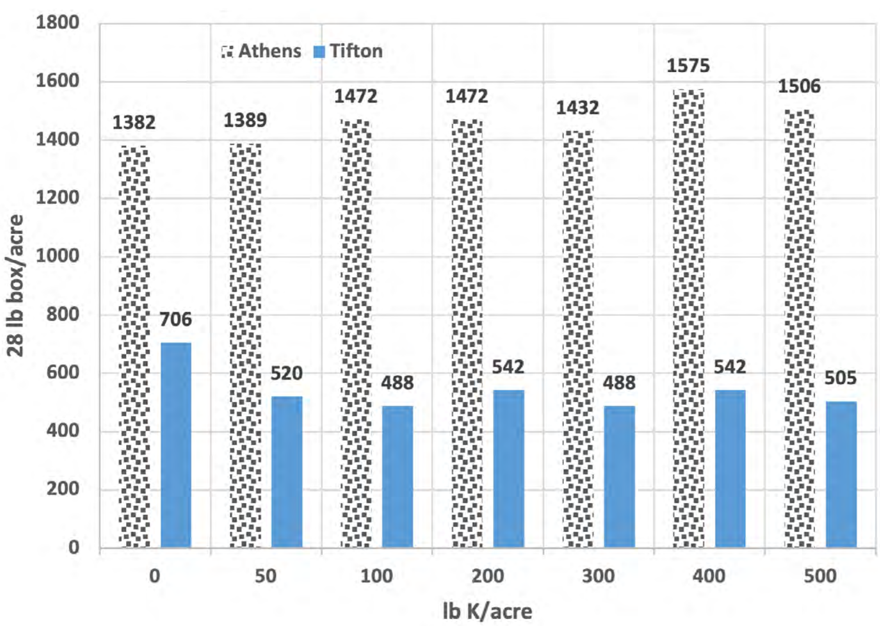

Figure 3. Total Yield Boxes Per Acre.

However, it should be noted that, although total yields were not affected by potassium rate or source, in the Athens location, the yield of 'Jumbo' peppers (the largest fruit graded) decreased at potassium levels above 300 lb/acre, while the yields of extra-large peppers increased (Figure 4). This suggests that the EC values encountered at the highest potassium application rates in Athens may have not affected total yield,but could have negatively affected fruit size.

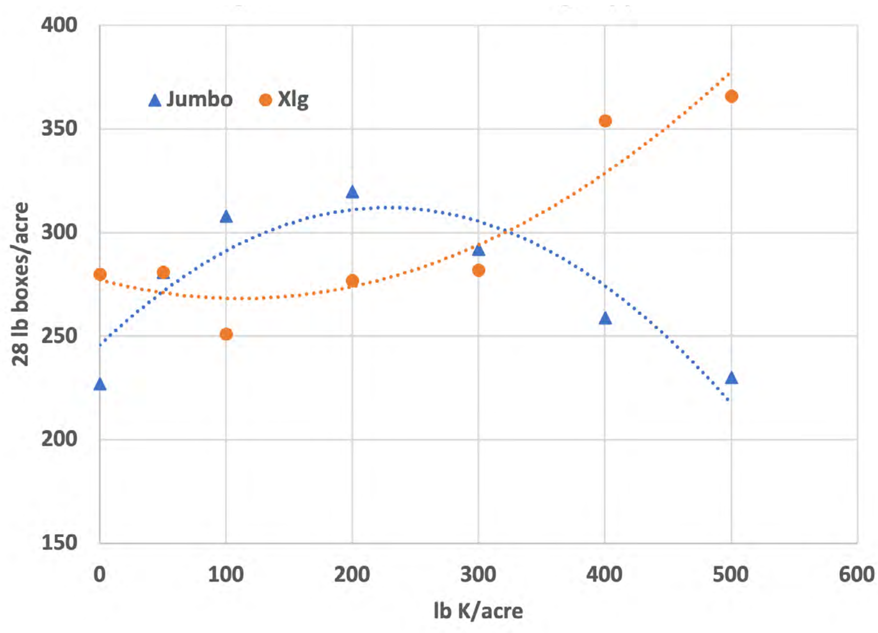

Figure 4. Athens Jumbo vs. Xlg Pepper.

Conclusion

We are repeating this trial in 2024. Our data suggests that potassium source has not had an impact on yield or EC value, but at the highest application rates of potassium (>400 lb/acre potassium) the EC values on clay soils may exceed recommended levels. Keep in mind that 400 lb/acre of actual potassium would correspond to rates of 667 lb/acre for muriate of potash and 800 lb/acre of sulfate of potash, which are higher than typically applied. Our results are similar to those found in Florida in tomato (Santos, 2013).

References

Santos, B. M. (2013). Effects of preplant potassium sources and rates for tomato production. *HortTechnology, 23*(4), 449–452. https://doi.org/10.21273/HORTTECH.23.4.449

Bell Pepper Cultivar Screening for Bacterial Leaf Spot Resistance, Fruit Quality and Performance in Southern Georgia

T. McAvoy, J. Dawson, J. Shealey, M. Kumari

Introduction

Two research trials were performed in spring 2023 to assess resistance to bacterial leaf spot (BLS) in bell pepper cultivar performance in southern Georgia. Studies were conducted in commercial production fields in Echols and Lowndes counties, which are major bell pepper production areas in Georgia. Eleven total cultivars were evaluated. Ten newer bell pepper cultivars with improved disease resistance to BLS races 1–10 [some had additional tomato spotted wilt virus (TSWV), and/or *Phytophthora* (PCap) resistances] were compared to 'Aristotle', which historically was the most widely grown bell pepper hybrid in the southeastern U.S. Our goal was to determine how the new and improved cultivars compared to 'Aristotle' for total yield, fruit size distribution, and unmarketable defects in the absence of disease pressure. To choose commercial bell pepper cultivars with the best yields, ideal fruit size distribution, and most desired fruit qualities, this research screened BLS-resistant cultivars for adaptability within major production regions of southern Georgia.

Material and Methods

The research trials were carried out at different farms in Echols and Lowndes counties in spring 2023. Treatments were arranged in a randomized complete block design with four replications. Plants were managed according to grower standards.

The bed tops were covered with black plastic mulch at all trials, and the field was watered through drip irrigation. Irrigation regimes varied between farms throughout the season with two drip irrigation cycles/day of 30 min to 1 hr per irrigation event as required by the crop. Fertilizer rates varied between 200–300 lb nitrogen per acre. A quarter of total nitrogen was applied preplant as a granular while the remaining liquid nitrogen was applied weekly after transplanting through the irrigation system. Bell pepper seeds were sown in 242-count trays 6 weeks before transplanting. Planting density was 14,934 plants/acre, configured with raised beds spaced 5 ft apart on center. There was a double row of pepper plants on top of the bed and 14 in. within-row spacing. Each plot consisted of 20 plants. Eleven cultivars were evaluated, 10 with resistance to all known races of BLS, compared with 'Aristotle' that only has partial BLS resistance. A total of two harvests were conducted approximately 1 week apart.

The number of fruit/bushel boxes (estimated to be 28 lb) was 30 for jumbo, 40 for extra large, 50 for large, and 60 for medium. A Market Maker Mechanical Grader separated fruit by width using the following cutoffs: 3 in. for medium, 3.5 in. for large, 4 in. for extra large, and greater than 4 in. for jumbo.

Results

There were significant differences in yields between cultivars for jumbo, medium, and total boxes per acre (Table 1). 'SV3255' (1065 boxes/acre) had the highest total yield which was significantly higher than 'Prowler' (661 boxes/acre). All other cultivars had similar total yields (750- 939 boxes/acre).

The highest jumbo yields were seen in 'Standout' (230 boxes/acre), 'Antebellum' (200 boxes/acre), 'Playmaker' (194 boxes/acre), 'Aristotle' (188 boxes/acre), 'Autry' (188 boxes/acre), and 'Green Machine' (188 boxes/acre), while the lowest jumbo yields were seen in 'Nitro' (48 boxes/acre), 'Tarpon' (97 boxes/acre), 'Boca' (97 boxes/acre), and 'Prowler' (103 boxes/acre). 'SV3255' was similar to all other cultivars for jumbo yields (121 boxes/acre). 'Playmaker' (163 boxes/acre), 'Green Machine' (166 boxes/acre), 'Autry' (175 boxes/acre), and 'Aristotle' (188 boxes/acre) had the lowest medium fruit yields, while 'SV 3255' (414 boxes/acre), 'Nitro' (366 boxes/acre), and 'Boca' (363 boxes/acre) had the most.

All other cultivars yielded similar levels of medium-sized fruits (252–290 boxes/acre). There were no differences in yield between cultivars for extra-large (68-268 boxes/acre) or large-sized fruit (200–341 boxes/acre). We did not observe any BLS incidence at either location. Therefore, we could not quantify the yield response under disease pressure.

Conclusion

Despite the lack of BLS disease incidence, this experiment demonstrated an extensive spectrum of variations in fruit size and marketable yields. BLS-resistant cultivars 'SV 3255', 'Standout', 'Autry', 'Green Machine', and 'Antebellum' are our top recommendations for fresh market bell pepper producers in southern Georgia during the spring season based on adaptability, yield, and fruit size distribution. These performed as well as 'Aristotle' in the absence of disease and have the added benefit of having BLS race 1–10 and in most cases TSWV resistance, which are important diseases in pepper during the spring in southern Georgia.

Table 1. Yield and Fruit Size Distribution of Commercially Available BLS-Resistant and Partially-Resistant Pepper Cultivars.

Bushel Boxes[1]/Acre					
Variety	**Jumbo[2]**	**Extra-Large[3]**	**Large[4]**	**Medium[5]**	**Total**
Antebellum	200 ab[6]	150 a	258 a	254 ab	861 ab
Aristotle	188 ab	195 a	247 a	188 b	817 ab
Autry	188 ab	268 a	309 a	175 b	939 ab
Boca	97 bc	150 a	254 a	363 a	864 ab
Green Machine	188 ab	195 a	365 a	166 b	814 ab
Nitro	48 c	182 a	330 a	366 a	926 ab
Playmaker	194 ab	168 a	225 a	269 ab	906 ab
Prowler	103 bc	68 a	200 a	290 ab	661 b
Standout	230 a	182 a	225 a	269 ab	906 ab
SV3255	121 abc	200 a	330 a	414 a	1065 a
Tarpon	97 bc	145 a	341 a	251 ab	834 ab
***P* value**	0.0236	0.1026	0.0975	< 0.0001	0.0465

Note. Study conducted in Echols and Lowndes counties, Georgia, during the spring of 2023.

[1]Bushel box's net weight is 28 lb and the estimated numbers of fruit/bushel boxes are 30 for jumbo, 40 for extra large, 50 for large, and 60 for medium fruit.

[2]Jumbo: bell pepper fruit of width > 4 in.

[3]Extra-large: bell pepper fruit of width 4 in.

[4]Large: bell pepper fruit of width 3.5 in.

[5]Medium: bell pepper fruit of width 3 in.

[6]Means followed by the same letter are not significantly different based on Tukey's honest significant difference test at 95%.

References

Agricultural Marketing Service. (n.d.). *United States standards for grades of sweet peppers.* U.S. Department of Agriculture. https://www.ams.usda.gov/grades-standards/sweet-peppers-grades-and-standards

Kumari, M., Dutta, B., Coolong, T., Torrance, T., Shealey, J., Dawson, J., & McAvoy, T. (2024). Performance of improved bell pepper cultivars in southern Georgia for mature green fresh market production. *HortTechnology, 34*(6), 720–727. https://doi.org/10.21273/HORTTECH05498-24

Bell Pepper Cultivar Screening for *Phytophthora* Resistance, Fruit Quality and Performance in Southern Georgia

T. McAvoy, T. Torrance, J. Shealey, M. Kumari

Introduction

Phytophthora capsici (PCap), which causes Phytophthora root rot, is the most destructive soilborne pathogen for bell pepper production in Georgia. Resistant cultivars offer a practical solution to manage PCap in affected bell pepper fields. However, currently most commercial cultivars resistant to PCap are predominantly grown in the northeastern U.S. This study aimed to screen commercial PCap disease-resistant bell pepper cultivars for adaptability within the main production areas of southern Georgia, and select cultivars with the highest yields, optimum fruit size distribution, and most desirable fruit characteristics.

Material and Methods

Research trials were conducted in commercial bell pepper fields at Doerun and Lake Park, GA, in the spring of 2023. Plants were managed according to grower standards for the region.

Management regimes varied between different farms, with one to three drip irrigation cycles/day of 30 min to 1 hr per cycle/irrigation event, carried out throughout the season as plants grew bigger and temperature increased. Fertilizer rates varied between 250–300 lb nitrogen per acre.

The bed tops were covered with black plastic mulch and the field was watered through drip irrigation. The trials were arranged in a randomized complete block design with four replications. Planting density was 14,520 plants/acre configured with raised beds spaced 6 ft apart on center. There was a double row of pepper plants on top of the bed and with an in-row spacing of 1 ft. Each plot was comprised of 20 plants.

The experiment compared 11 bell pepper cultivars; nine cultivars claimed PCap resistance and two susceptible checks were included: 'Aristotle' and 'Antebellum'. A total of two harvests were conducted approximately 1 week apart. Ten plants from the center of each plot were harvested and fruit were graded and sized according to USDA and industry standards (USDA, 2005). Marketable fruit were sized into four categories: medium (M), large (L), extra large (XL), and jumbo (J). The estimated numbers of fruit/bushel boxes were 30 for jumbo, 40 for extra large, 50 for large, and 60 for medium. A mechanical grader separated fruit by width: 3 in. for medium, 3.5 in. for large, 4 in. for extra large, and greater than 4 in. for jumbo.

Results

There were significant differences between cultivars for total marketable yields and yields of jumbo, extra large, large, and medium-sized fruit categories (Table 1). Total yields ranged from 868 to 1272 boxes/acre. 'Antebellum' (1272) and 'Nitro' (1181) had the highest total bushel boxes/acre, while 'Galileo' (868) and 'Turnpike' (929) had the lowest.

All other cultivars had similar total marketable yields (1038–1149 boxes/acre 'Revolution' had the highest number of jumbo-sized fruit (454 boxes/acre), followed by 'Playmaker' (224 boxes/acre) and 'PS 0994-1819' (200 boxes/acre). The cultivars with the least jumbo boxes per acre were 'Nitro' (36), 'Mercer' (48), and 'Tarpon' (54). All other cultivars had a similar number of jumbo fruit yield ranging from 97 to 163 boxes/acre. 'PS 0994-1819' had the most extra large fruit (354 boxes/acre), while 'Turnpike' and 'Nitro' performed poorly (154–159 boxes/acre respectively), and all other cultivars fared moderately (204–340 boxes/acre).

The highest large fruit yields were observed with 'Antebellum' (479 boxes/acre) and the lowest large yields were seen in 'Revolution' (254 boxes/acre). All other cultivars had a moderate level of large fruit yield (290–443 boxes/acre). Medium fruit yields were highest in the cultivar 'Nitro' (641 boxes/acre), followed by 'Antebellum', 'Mercer', 'Turnpike', and 'Tarpon' (393, 381, 372, and 369 boxes/acre respectively), while 'Revolution' had the lowest medium fruit yields (160 boxes/acre). The other cultivars had moderate medium fruit yields (194–354 boxes/acre).

Conclusion

PCap occurrence was low and sporadic in our experiment. However, based on adaptability, yield, and fruit size distribution in our study, we would recommend the PCap-resistant cultivars ‘PS 0994-1819’, ‘Playmaker’, and ‘Paladin’ for fresh market spring production. ‘Revolution’ would be a good choice for processing bell peppers due to its immense size.

The PCap susceptible cultivars ‘Antebellum’ and ‘Aristotle’ performed well in the absence of PCap pressure. ‘Antebellum’ continues to be a good choice for growers looking for BLS Race 0–10 resistance, and ‘Aristotle’, although old and not particularly disease-resistant, continues to perform well. Newer cultivars ‘Tarpon’ and ‘Nitro’ have a very desirable disease-resistant package and are somewhat promising for Georgia due to their excellent fruit quality. However, both have smaller fruit size compared to other cultivars.

Table 1. Yield and Fruit Size Distribution of PCap-Resistant and Susceptible Bell Pepper Cultivars.

	Bushel Boxes[1] (number/acre)				
Variety	**Jumbo[2]**	**Extra-Large[3]**	**Large[4]**	**Medium[5]**	**Total**
Antebellum	163 bcd[6]	236 ab	479 a	393 b	1272 a
Aristotle	115 bcd	340 ab	319 ab	263 bc	1038 abc
Galileo	115 bcd	254 ab	305 ab	194 bc	368 c
Mercer	48 d	204 ab	443 ab	381 b	1077 abc
Nitro	36 d	159 b	345 ab	641 a	1181 ab
Paladin	97 bcd	218 ab	396 ab	354 bc	1064 abc
Playmaker	224 b	290 ab	290 ab	272 bc	1077 abc
PS 0994-1819	200 bc	354 a	378 ab	218 bc	1149 abc
Revolution	454 a	213 ab	254 b	160 c	1081 abc
Tarpon	54 d	204 ab	410 ab	369 b	1038 abc
Turnpike	73 cd	154 b	330 ab	372 b	929 bc
***P* value**	< 0.0001*	0.0103*	0.0053*	< 0.0001*	0.0032*

Note. Study conducted at Doerun and Lake Park, GA, during the spring of 2023.
[1]Bushel box’s net weight is 28 lb and the estimated numbers of fruit/bushel boxes are 30 for jumbo, 40 for extra large, 50 for large, and 60 for medium fruit.
[2] Jumbo: bell pepper fruit of width > 4 in.
[3]Extra-large: bell pepper fruit of width 4 in.
[4]Large: bell pepper fruit of width 3.5 in.
[5]Medium: bell pepper fruit of width 3 in.
[6]Means followed by the same letter are not significantly different based on Tukey’s honest significant difference test at 95%.

References

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Kumari, M., Dutta, B., Coolong, T. Diaz-Perez, J. C., Torrance, T., Shealey, J. Dawson, J., & McAvoy, T. (2024). Adaptability of *Phytophthora capsica* resistant bell pepper cultivars in southern Georgia. *HortTechnology, 34*(4), 513–520. https://doi.org/10.21273/HORTTECH05425-24

Leaf Epicuticular Wax Mediated Resistance Against *Alternaria brassicicola* in Broccoli

S. Gangurde, N. Kaur, B. Dutta

Introduction

Host resistance, mediated by either plant physical structures or by production of secondary metabolites (phytoalexins), forms the first line of defense against any invading pathogens. Physical structures, such as trichomes, spines, thorns, hairs and cuticular wax that cover plant surfaces and act as a barrier for pathogen penetration, are widely known in different pathosystems. Despite these limited studies that investigated the role of epicuticular wax due to drought stress in broccoli, none of these studies investigated the role epicuticular wax plays in *A. brassicicola* infection in broccoli. We hypothesized that epicuticular cuticular wax in broccoli plays a significant role in the host susceptibility against *A. brassicicola* infection in broccoli.

Another aspect of resistance is related to plant maturity, which is also known as age-related resistance or susceptibility. Previous age-related resistance was reported in broccoli against downy mildew, caused by *Peronospora parasitica*, where older plants (5–6 true leaf stage) showed higher levels of resistance than younger plants (2–3 true leaf stage). Apart from these limited studies, there are no reports on age-related resistance/susceptibility of broccoli foliar growth stages against *A. brassicicola* infection.

Results

Variation in age-related susceptibility across different leaf growth stages of broccoli: The susceptibility of leaves at different growth-stages to *A. brassicicola* infection was assessed in a detached leaf assay (Figure 1A). A significant variation in lesion development across different leaf growth stages of broccoli was observed. The lesion that developed on the leaf after 2 days post-inoculation (DPI) started initially as a small brown spot with a yellow halo that gradually become a dark brown to black circular necrotic lesion by 6 DPI, covering 90% of the leaf area (Figure 1B). Lesion area (mm^2) and associated area under disease progress curve (AUDPC) increased with increasing incubation-period (DPI). There was a positive correlation between the lesion area (mm^2) and incubation-period (DPI) on each true leaf stages investigated ($P < 0.003$; $R^2 = 0.851$). Significant differences in AUDPC were observed for leaf age. Mean AUDPC and lesion area were significantly higher for older leaves [one/first true leaf (1TL)] compared to younger leaves (6TL; Figure 1, B and C).

In a whole-plant in-vivo assessment of leaf growth stage-mediated susceptibility to *A. brassicicola*, similar observations were made as in the detached leaf assay (Figure 2A). The AUDPC values for the youngest-top-most leaf (6TL) was significantly lower than the bottom older leaves (5TL to 1TL; Figure 2B).

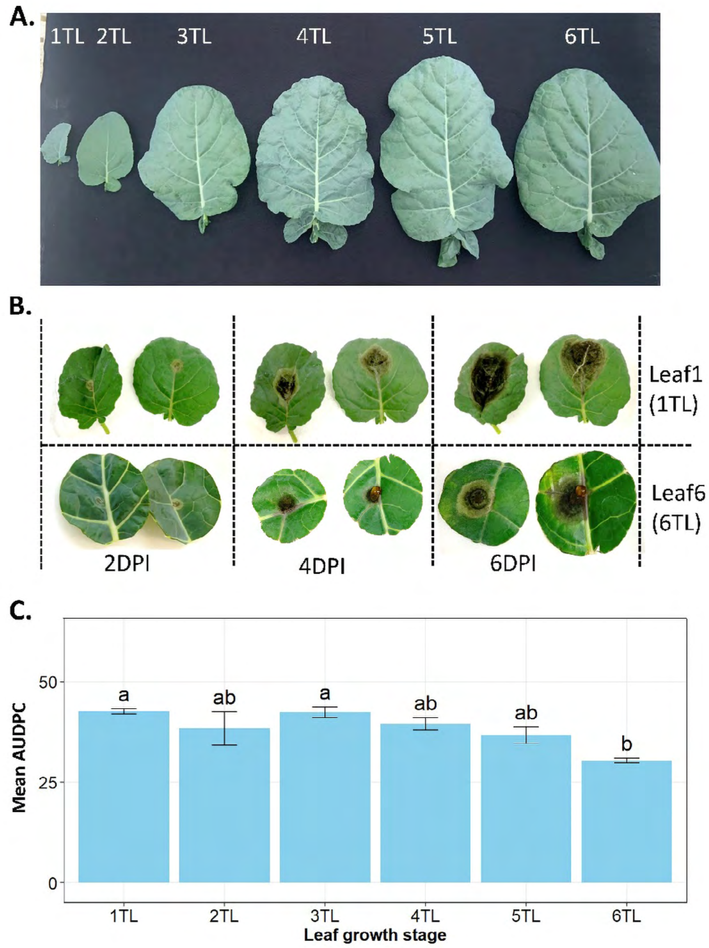

Figure 1. Age-Related Susceptibility of Broccoli Leaves Against *Alternaria brassicicola*.
Pathogenicity assay on detached broccoli leaves at various growth stages, from first true leaf (1TL) stage to sixth true leaf (6TL) stage was performed. Panel A shows each fully expanded true leaf stage annotated as 1TL: first true leaf; 2TL: second true leaf stage; 3TL: third true leaf stage; 4TL: fourth true leaf stage; 5TL: fifth true leaf stage; and 6TL: sixth true leaf stage. Panel B shows phenotypically visible variation in the lesion size at 2, 4, and 6 days post-inoculation (DPI) for two growth stages (1TL, the oldest and 6TL, the youngest). Panel C shows mean area under disease progress curve (AUDPC) at each growth stage, calculated based on lesion area (mm^2) at 0, 2, 4, and 6 DPI. Means on the bars followed by the same letters are not significantly different according to Tukey's honest significant difference ($P < 0.05$).

Furthermore, the AUDPC values for the leaves at the growth stages 2TL to 4TL were significantly higher compared with the younger leaf (5TL; Figure 2B). In addition, the epicuticular wax percentage for leaves at different growth stages were assessed. Since the effect of two experiments on epicuticular wax percentage was significant, each experiment was analyzed and is displayed separately in this manuscript. In Experiment 1, significantly higher epicuticular wax (%) was observed in the youngest-top-most leaf (6TL) compared with the leaves older at the bottom (5TL to 1 TL; Figure 2C). Similar observations were also made in Experiment 2, where significantly higher epicuticular wax (%) was observed with the youngest leaf at the top (6TL) compared to those that were older and at the bottom (5TL to 1TL; Figure 2D).

Correlation between disease susceptibility and percent wax content: Epicuticular wax (%) on the leaf surfaces ranged between 0.339% and 0.791%. The lowest wax deposition was recorded on the oldest, bottom-most leaf (1TL) with 0.339%, whereas the highest wax (%) deposition was observed with the youngest top-most leaf (6TL) with 0.791%. The were not significant differences in epicuticular wax deposition (%) for 2TL (0.351%), 3TL (0.369%), and 4TL (0.367%). When AUDPC values were calculated upon *A. brassicicola* infection, significantly higher AUDPC value was observed with the oldest, bottom-most leaf (1 TL) compared with the youngest top-most leaf (6TL). Interestingly, a negative significant relationship was observed between mean AUDPC and epicuticular wax (%) for the six true leaf stages ($P < 0.001$, $R^2 = 0.681$; Figure 4).

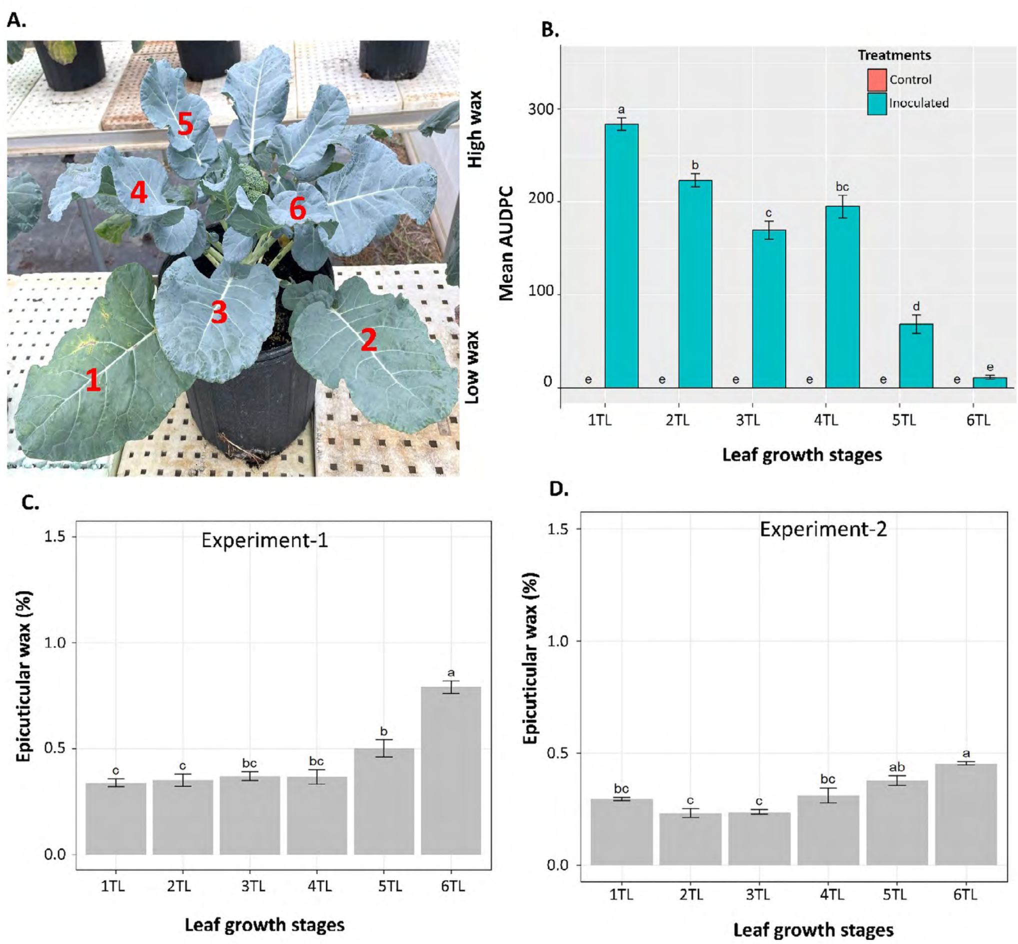

Figure 2. Variation in Age-Related Susceptibility of Various Leaf Tissues in an Intact Broccoli Plant.
A fully matured broccoli plant (cv. 'Eastern Crown') with six to seven true leaves along with head was inoculated with an aggressive isolate of *A. brassicicola* under greenhouse conditions. Inoculation was done by spraying a spore suspension with a highly aggressive isolate of *A. brassicicola* (10 µl of spore suspension of 10^5 conidia/ml) until runoff. Inoculated leaves were screened for percent disease severity in terms of lesion area (mm^2) using a severity rating scale of 0 (no necrotic lesions observed) to 100% (entire leaf area is covered with necrotic lesions) at 0, 5, 10, and 15 days post-inoculation (DPI). Plants inoculated with sterile water served as negative control. Panel B represents bar graphs indicating AUDPC values on leaves at different growth stages [true leaf 1 (oldest) to true leaf 6 (youngest)] of an intact broccoli plant. Panels C and D represent plants at 15 DPI inoculated with either *A. brassicicola* or sterile water (control), respectively.

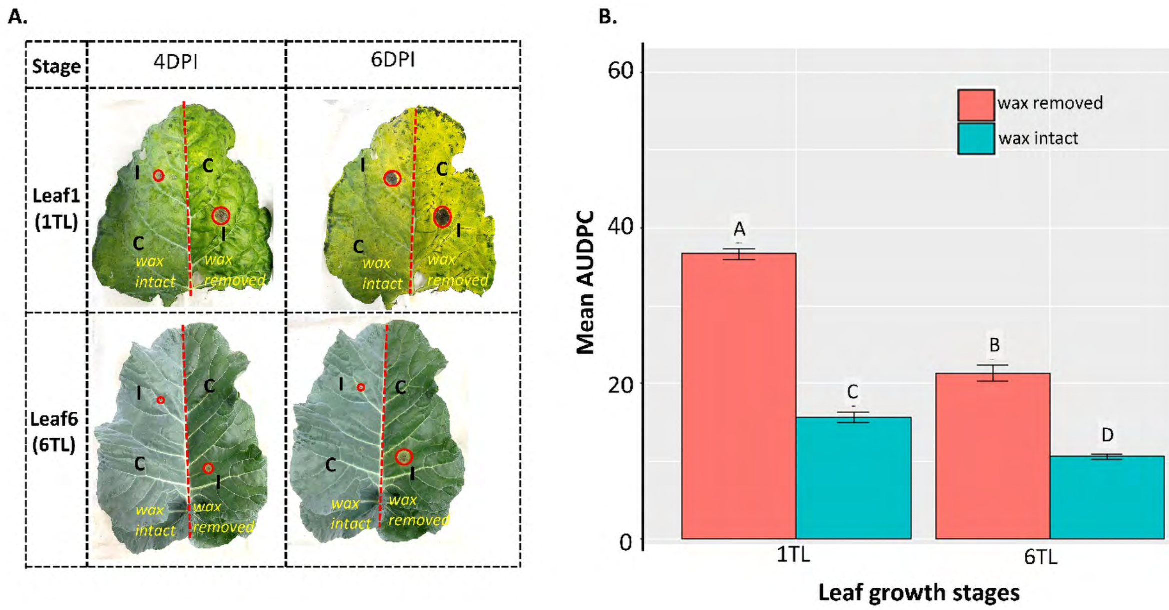

Figure 3. Differential Wax Deposition on Various True Leaves in an Intact Broccoli Plant (cv. 'Eastern Crown').
Wax per unit area on each true leaf of intact broccoli plant was calculated by extracting total wax using a chloroform extraction method and percent wax was calculated [wax (%) = leaf weight (mg) /wax weight (mg) × 100]. Panel A shows leaves from an intact broccoli plant, with wax removed from half of each leaf. Comparison images of the same leaves were taken at 4 and 6 days post-inoculation. In Panel B, the bar graphs labeled B and C show percent wax (%) on each true leaf in Experiment 1 and Experiment 2, respectively. Wax (%) was determined for each true leaf of different age, where the youngest leaf (6TL) is at the top of the plant and the oldest leaf (1TL) is at the bottom in an intact broccoli plant. The experiment was repeated independently, with 10 replicates or plants in each experiment. Means on the bars followed by the same letters are not significantly different according to Tukey's honest significant difference (P < 0.05).

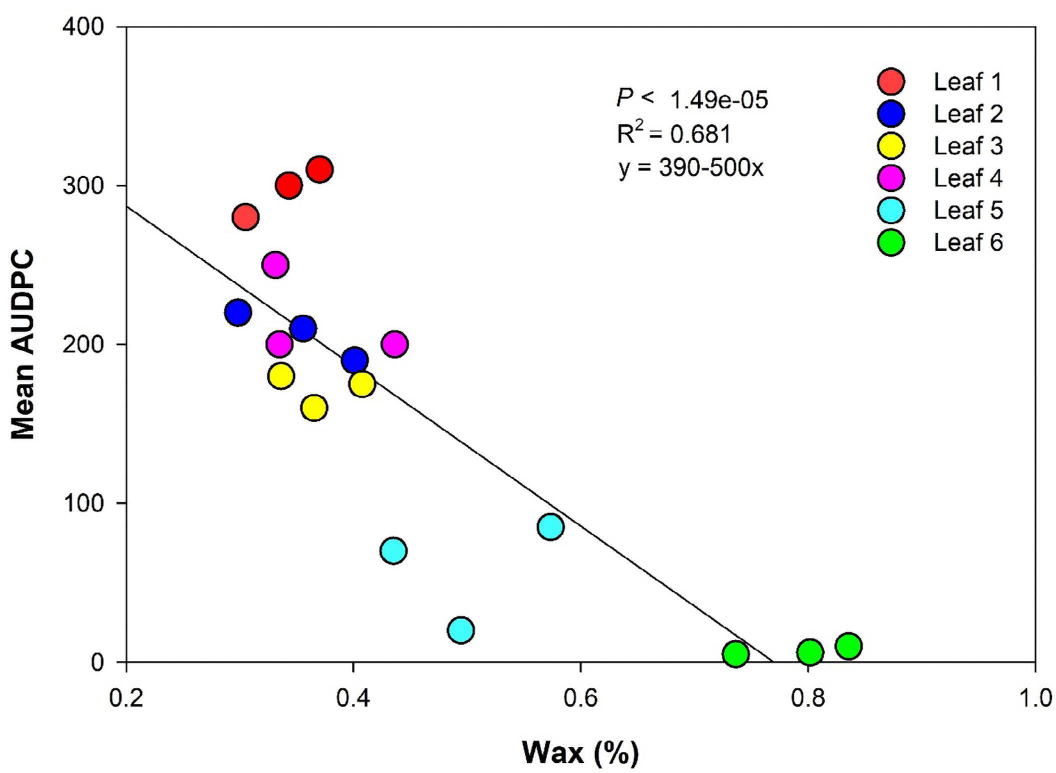

Figure 4. Regression of Percent Wax Deposition on Leaves (%) Versus Mean Area Under Disease Progress Curve (AUDPC).
Mean AUDPC was calculated from percent disease severity in terms of lesion area (mm^2) using a severity rating scale of 0 (no necrotic lesions observed) to 100% (entire leaf area is covered with necrotic lesions) at 0, 5, 10, and 15 DPI. Data points represent the mean lesion area (mm^2) at each sampling period in two independent experiments.

Conclusion

Our study elucidated the potential role of epicuticular wax on age-related susceptibility of broccoli leaves against *A. brassicicola*. We observed a negative correlation between epicuticular wax percentage and AUDPC across leaves from different growth stages. The epicuticular wax percentage increased with decreased leaf age and this was significantly correlated with AUDPC in broccoli leaves.

These observations partly indicate that decreased susceptibility of younger leaves to *A. brassicicola* with increased accumulation/presence of epicuticular wax. Further removal of epicuticular wax resulted in increased susceptibility to *A. brassicicola*, regardless of leaf-growth stage. Leaves with epicuticular wax removed displayed larger lesion area for both youngest, top-most leaf (6TL) and oldest, bottom-most leaf (1TL). However, when lesion area was compared for the epicuticular wax either intact or removed for the same leaf, larger lesion area was observed with the latter compared to the former. These observations were consistent regardless of leaf growth stage, indicating that epicuticular wax may potentially provide physical barrier to pathogen adhesion and subsequent colonization and lesion area development.

Interestingly the differences in epicuticular wax percentages among leaves belonging to closely related growth stages that occurred between youngest top (6TL) and oldest bottom (1TL), i.e., 5TL to 2TL, were not significantly different and displayed no significant differences in their susceptibility to *A. brassicicola*. The only striking difference in epicuticular wax and AUDPC was observed with leaves that were at the oldest bottom (1TL) and youngest top (6TL) growth stages.

These observations suggest that epicuticular wax content does not seem to vary drastically among leaves at closer growth stages with similar levels of susceptibility to *A. brassicicola*. However, these observations may vary with different broccoli genotypes and environmental conditions, which can be assessed in the future.

Protecting the Practical Use of Herbicides for Vegetable Farmers

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

Introduction

As the U.S. Environmental Protection Agency (EPA) rapidly implements pesticide label restrictions to protect endangered and threatened species per court requirements, these restrictions have the potential to challenge the practical use of pesticides for farmers. A robust body of science confirms family farms must have access to economically effective pesticides if they are to continue to provide nutritious food, feed, and fiber for a growing human population. Unfortunately, agricultural stakeholders have historically performed poorly in helping political leaders and nonagricultural individuals understand the importance and value of these tools.

Objective

The objective was to determine the effectiveness and economic value of a diversified herbicide program in summer squash, when compared to various weed management programs that do not utilize herbicides.

Materials and Methods

The experiment was conducted at the University of Georgia Ponder Farm near TyTy, GA. The soil was prepared conventionally, without the use of mulch, followed by the seeding of yellow squash. Weed management programs compared the effectiveness and cost of a conventional herbicide program to the following nonherbicidal programs: 1) tine weeder only (Figure 1); 2) tine weeder plus hand weeding to achieve 80% weed control; 3) tine weeder plus hand weeding to achieve nearly 100% weed control; 4) between-row cultivation only (traditional plow); 5) between-row cultivation plus hand weeding to achieve 80% weed control; 6) between-row cultivation plus hand weeding to achieve 100% weed control; and 7) a no-weed-management control.

The herbicide program consisted of a preemergence application of Reflex 6 oz/acre + Curbit 1 pint/acre, Dual Magnum 10 oz/acre postemergence 14 days after seeding, and a row middle application of Sandea 0.5 oz/acre + Dual Magnum 12 oz/acre + Treflan 1 pint/acre + non-ionic surfactant. Irrigation activated each residual herbicide within 36 hr.

FIgure 1. Tine weeder.

Palmer amaranth (pigweed), wild radish, yellow nutsedge, and large crabgrass were present.

Results

Pigweed, nutsedge, wild radish, and crabgrass were controlled at least 96% by the herbicide program from planting through harvest for a total application and herbicide cost of $38/acre (Table 1; Figure 2). The same level of control was achieved with the tine weeder (15 times, Figure 2) plus hand weeding (286 hr/acre) at a cost of $4041/acre or with the plow (eight times) plus hand weeding (340 hr/acre) to the cost of $4717/acre.

Achieving 80% weed control with tine weeding and plowing programs when accompanied by hand weeding was more economically feasible than achieving 100% control, but compared to the herbicide program, yields were 32%–36% lower; this was a result of less weed control and greater weed competition with the crop (Table 1). Yields with only mechanical tillage were at most 20% of those observed with the herbicide system.

Conclusion

The herbicide program provided nearly complete weed control of several challenging weed pests that often infest squash fields. Additionally, and importantly, the herbicide program was at least 106 times less costly than any other nonherbicidal production systems providing similar weed control and yield.

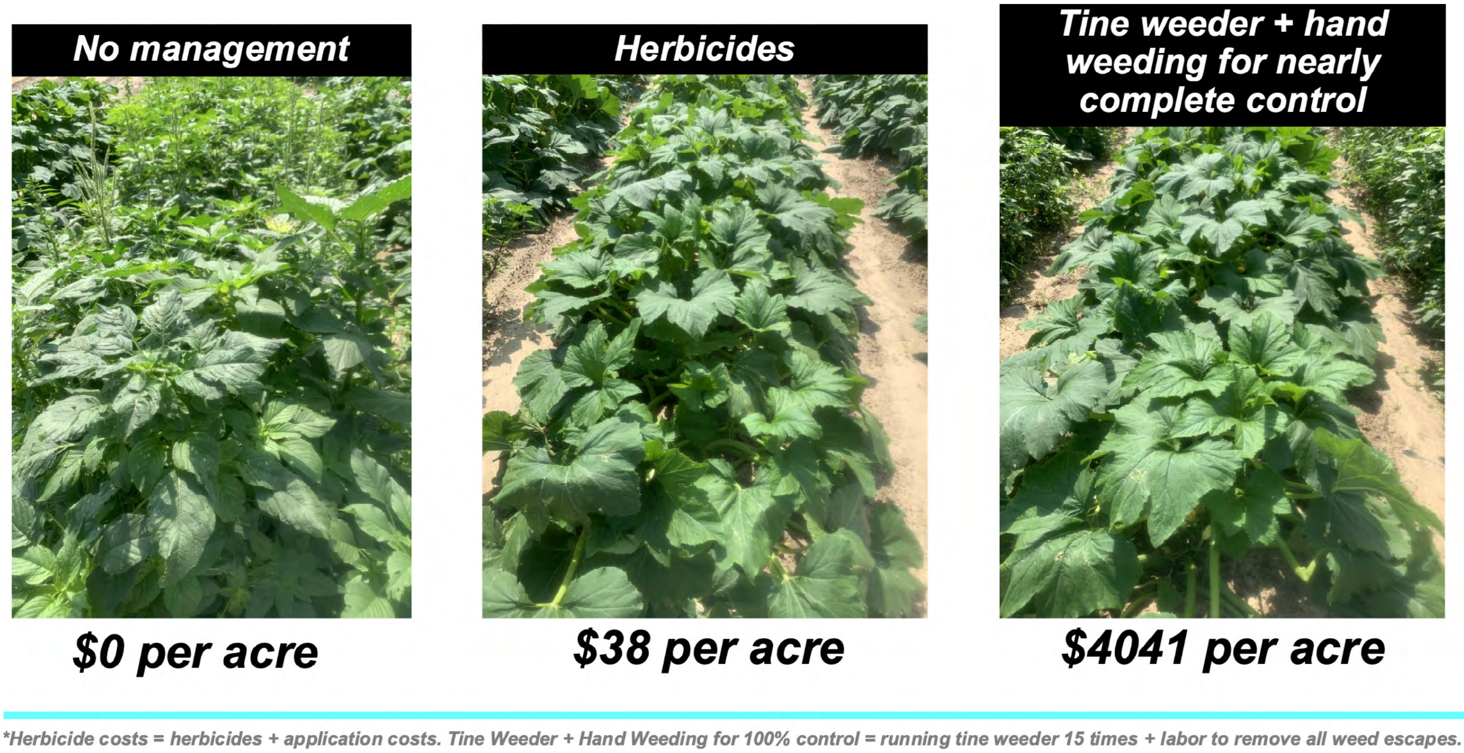

Figure 2. Input Costs to Provide Nearly Complete Weed Control.

Table 1. Weed Management Program Costs, Weed Response, and Yield.*

Management program	Program cost ($/acre)	Pigweed control (%)	Nutsedge control (%)	Wild radish control (%)	Large crabgrass control (%)	Yield (% relative to herbicide system)
Herbicide system	38.00	100 a	96 a	100 a	100 a	100 a
Tine weeder	126.00	38 c	30 c	43 d	60 d	20 c
Time weeder + hand weeding for ~ 100% control	4041.00	100 a	96 a	100 a	100 a	100 a
Tine weeder + hand weeding for ~ 80% control	67.20	78 b	81 b	85 bc	85 b	64 b
Plow	67.20	48 c	80 b	90 b	55 d	14 c
Plow + hand weeding for ~ 100% control	4717.00	100 a	99 a	100 a	100 a	97 a
Plow + hand weeding for ~ 80% control	796.75	80 b	88 ab	84 c	76 c	68 b
Control	0.00	0 d	0 d	0 e	0 e	0 d
*Values followed by the same letter within a column are not statistically different.						

Diamide Resistance in Beet Armyworm Populations from Georgia

T. Dunn, A. Sparks Jr., D. Champagne, D. Riley

Introduction

Diamide insecticides are a crucial component of lepidopteran pest control in the southeastern U.S. The favorable properties of these insecticides, such as low mammalian toxicity and long residual periods, often result in over reliance on these chemistries in agricultural production. This has resulted in resistance outbreaks, most notably in diamondback moth, *Plutella xylostella* (Riley et al., 2020). However, these insecticides may be used for the management of a variety of pests, some of which are developing higher levels of resistance with each year. In 2022, our lab collected a beet armyworm (BAW), *Spodoptera exigua*, population from southern Georgia and recorded resistance to chlorantraniliprole, as well as potential cross-resistance to cyantraniliprole (Dunn et al., 2024). Here, we report a second population of BAW from southern Georgia exhibiting similar levels of resistance to diamides.

Material and Methods

In July of 2024, BAW larvae were collected from edamame, *Glycine max*, in Echols County, GA (ECH population). Larvae were transported to the University of Georgia Athens campus and reared to the first generation prior to toxicological and molecular characterization. The leaf-dip bioassay method was utilized for toxicological assessment of the field-collected colony for diamide and spinosyn insecticides. The insecticide products tested were Coragen (chlorantraniliprole), Exirel (cyantraniliprole), and Radiant (spinetoram). Doses tested were equivalent to the maximum labeled rates as applied at 100 gallons/acre; Coragen 7.5 oz/acre, Exirel 20.5 oz/acre, and Radiant 8 oz/acre. These were completed using untreated collard leaf discs as the bioassay substrate, and 0.2% v/v of Tazer non-ionic adjuvant. Each treatment had a minimum of three replicates, with 10 larvae per replicate. Replicates were checked after 24 and 48 hr, and live, down, dead, and pupated larvae were recorded. The 48-hr results of this experiment were then averaged with unpublished 48-hr results from a previous study on a different diamide-resistant BAW population (SCV population) to produce a composite data set (Dunn et al., 2024).

Results

The averaged percent mortality for the ECH and SCV populations indicated significant differences between Radiant and all other treatment groups. The average percent mortality for Coragen indicated only a marginal difference from the control at 31.51%, while the average percent mortality for Exirel was significantly different from the control at 36.76%. However, the Exirel treatment was only considered to be marginally different from the Coragen treatment (Figure 1). This data suggest that these two populations were resistant to multiple diamide insecticides, while exhibiting susceptibility to the spinosyn insecticide (Radiant) at 81.67% mortality.

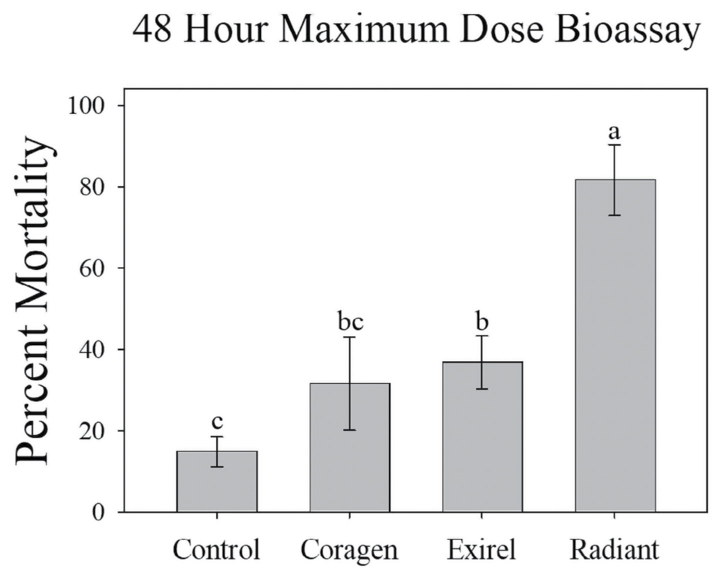

Figure 1. Percent Mortality of Beet Armyworm.
Mortality was averaged for the Scooterville (SCV) and Echols (ECH) populations of beet armyworm for each insecticide treatment at 48 hr. Mean separation analysis was completed via PROC-GLM (Tukey HSD).

Conclusions

This marks the second documented case of diamide resistance in a BAW population from Georgia. In addition, the averaged percent mortality seems to suggest cross-resistance among diamide insecticides in these populations may also occur. Our previous study identified a target site mutation, I4743M, of the BAW ryanodine receptor associated with diamide resistance in a South Georgia population (Figure 2; Zuo et al., 2019; Dunn et al., 2024). Future work utilizing dose response assays should be conducted to confirm the potential cross-resistance between diamide insecticides in BAW populations. Likewise, the identification and study of resistance mechanisms, such as I4743M, in populations exhibiting considerable levels of diamide resistance may also contribute to insecticide resistance management.

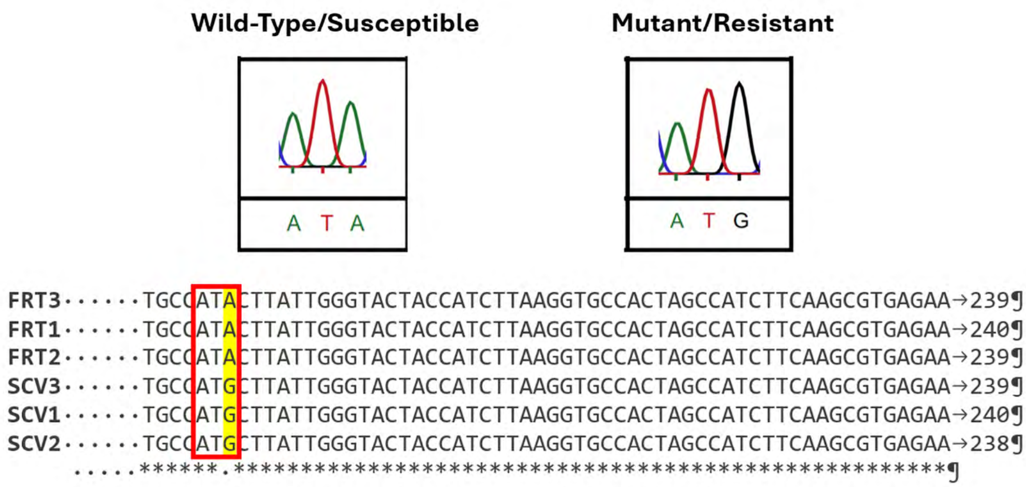

Figure 2. Sequencing Results From Our Recent Study of the Scooterville (SCV) Population (Dunn et al., 2024).
Sequences from the Frontier Susceptible lab colony (FRT) were completely wild type, indicated by the ATA codon in the red outline. Sequences from the SCV population were completely mutant, indicated by the ATG codon in the red outline.

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Current and Futuristic Management Strategies for Whiteflies and Whitefly-Transmitted Viruses in Important Vegetable Crops of Georgia

R. Srinivasan, C. McGregor, B. Dutta, A. Sparks Jr., G. Singh, A. Luckew

Introduction

Our research since 2010 has focused on evaluating host resistance (when available), cultural and chemical management tactics, developing risk-mitigation measures, and making them available to growers to be readily implemented (Srinivasan et. al., n.d.; LaTora et al., 2022).

A major limitation of this work is the lack of reliable host resistance against one or multiple viruses in many crops of interest. Our goal has remained to assist with the development of resistant cultivars and lay a foundation for innovative management strategies aimed at disrupting virus transmission by identifying virus-interacting proteins in whiteflies.

As in the fall of 2023, the fall of 2024 was characterized by whitefly and virus pressure. The consistent epidemics from 2017 to 2024 indicate that whiteflies and viruses are now chronic issues for fall production of cucurbits, tomatoes, and snap beans in Georgia. The list of problematic viruses remained the same in 2024—cucurbit leaf crumple virus (CuLCrV); cucurbit yellow stunting disorder virus (CYSDV); cucurbit chlorotic yellows virus (CCYV); tomato yellow leaf curl virus (TYLCV); tomato chlorosis virus (ToCV); and sida golden mosaic virus (SiGMV). In addition, mixed infection of viruses in squash (zucchini and yellow), snap beans, and tomatoes remained a concern. Virus symptom severity and yield losses often are exacerbated in the presence of mixed infection. Mixed infection of up to three viruses has been documented in squash (CYSDV, CCYV, and CuLCrV) and up to two viruses in snap beans (CuLCrV and SiGMV).

2024 Objectives

1. Evaluate squash germplasm lines for resistance against whiteflies (*Bemisia tabaci*), begomoviruses, and criniviruses.
2. Evaluate snap bean germplasm lines for resistance against whiteflies and begomoviruses.
3. Lay a foundation for the futuristic management of whiteflies and viruses by identifying and evaluating whitefly-interacting proteins to prevent transmission.

Material and Methods

All screening experiments were conducted in the greenhouses at the UGA-Griffin experiment station. For the squash experiments, the viruses CuLCrV, CYSDV, and CCYV were maintained in commercial squash variety 'Goldstar' through repeated whitefly inoculations. Whitefly colonies were maintained on cotton plants as they are not hosts of the viruses evaluated. The squash materials were tested for single and mixed infections using established protocols.

For the snap bean experiments, two viruses were tested individually as well as with mixed infection: SiGMV was maintained in prickly sida plants, and CuLCrV was maintained in summer squash. The snap bean germplasm and other materials were tested for single and mixed infections of these two viruses using established protocols.

To identify virus-interacting proteins in whiteflies, an initial yeast-two-hybrid (Y2H) screen was used. Once proteins were identified, their interactions were characterized using a series of in vivo and in vitro techniques standardized in the laboratory and elaborated in our recent publication, Ghosh et al. (2023).

Results

Squash Screening

Results revealed high infection percentages across most lines for all three viruses. Variation in resistance was observed in *C. moschata*, bridgelines, and *C. okeechobeensis* accessions.

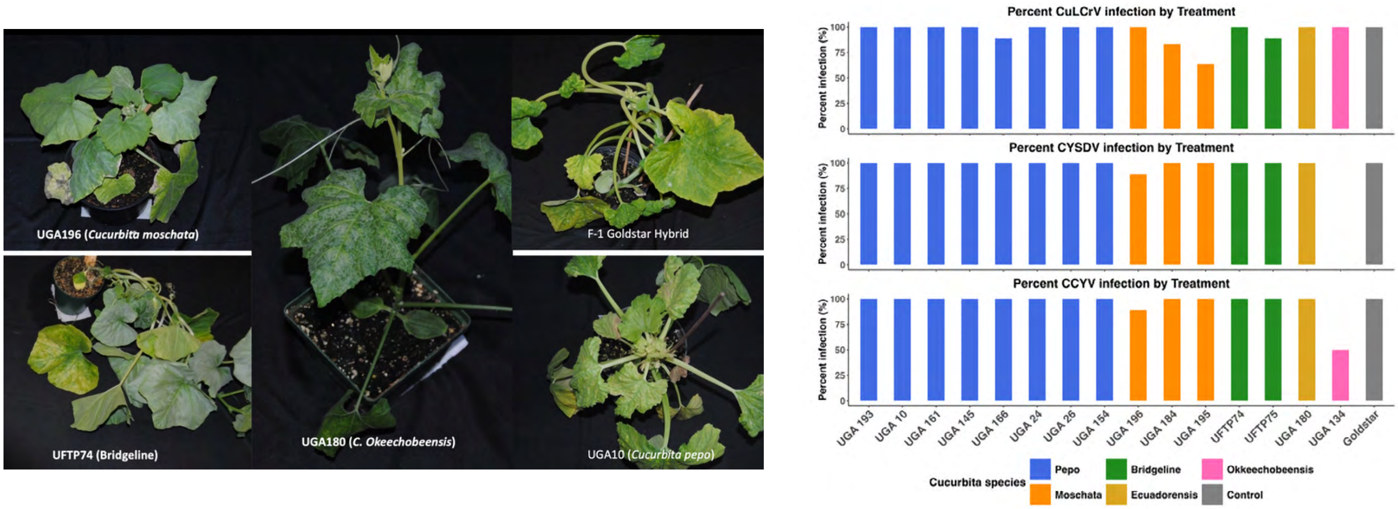


Figure 1. Squash Materials Used for Screening (left) and Percent Infections of CuLCrV, CYSDV, and CCYV (right).

CuLCrV Accumulation: All *C. moschata* and bridgelines exhibited lower virus loads compared with control 'Goldstar' and most other lines. Among *C. pepo*, 'UGA 10' and 'UGA 161' had reduced virus loads.

CYSDV Accumulation: Virus accumulation varied widely. In both wild species, *C. ecuadorensis* and *C. okeechobeensis,* fewer gene copies suggested potential resistance. One *C. pepo* line, 'UGA 154', also had reduced viral loads.

CCYV Accumulation: *C. okeechobeensis* ('UGA 134'), *C. ecuadorensis* ('UGA 180'), and *C. pepo* ('UGA 154') accumulated less virus, whereas most lines had higher levels that were similar to the control.

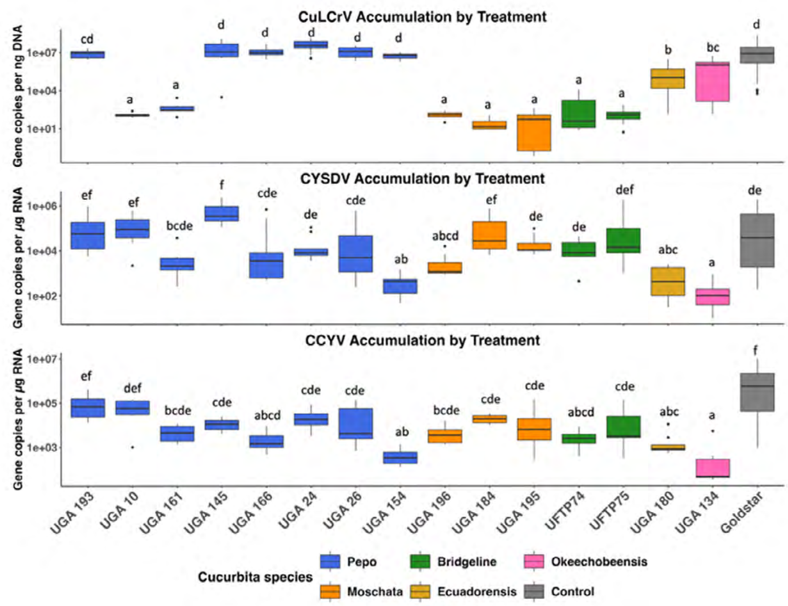


Figure 2. Virus Accumulation (Gene Copies) for CuLCrV, CYSDV, and CCYV in Squash Germplasm.

Snap Bean Screening

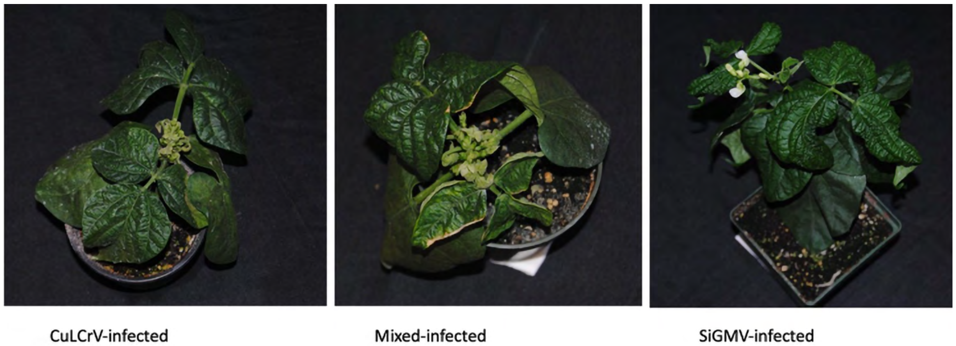
The snap bean germplasm lines were screened for resistance to CuLCrV and SiGMV as both single and mixed infections.

CuLCrV Infection: The percent infection varied significantly between lines. Some lines, such as 'PK7-4' and 'PR0401-259', showed no infection at all. In contrast, the control variety ('Caprice') and 'PI 199047' exhibited nearly 100% infection in singly and mixed-infected plants.

SiGMV Infection: Most germplasm lines, including the control ('Caprice'), displayed high infection under both single and mixed infections. However, certain lines, such as 'PK7-4' and 'ICA Pijao', showed reduced infection percentages, indicating potential resistance, especially in singly infected plants.

Virus Accumulation

Lines such as 'Aifi Wuriti' and 'Cardinal' exhibited the lowest CuLCrV loads, indicating strong resistance to CuLCrV. Other lines, such as 'ICA Pijao', displayed moderate levels of virus accumulation. The control variety 'Caprice' exhibited the highest SiGMV accumulation. In contrast, lines 'PK7-4' and 'Tio Canela' accumulated significantly lower virus loads, indicating strong resistance to SiGMV. Several lines, including 'Aifi Wuriti', 'PI 438917', and 'ICA Pijao', showed moderate virus accumulation.



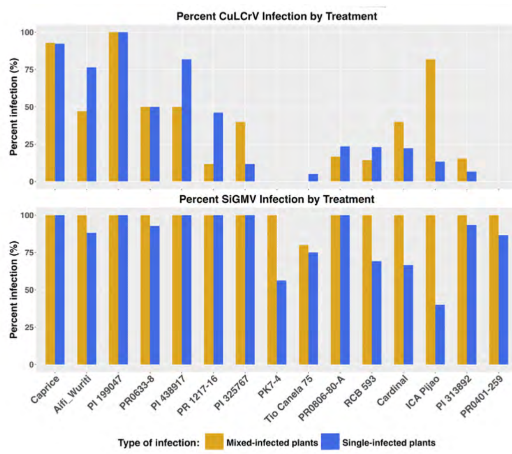


Figure 3. Infection in Span Bean Lines.
On the top, symptoms of CuLCrV and/or SiGMV in susceptible and resistant plant materials. The charts on the bottom indicate the percent infection of CuLCrV and SiGMV in snap bean lines with single and mixed infections.

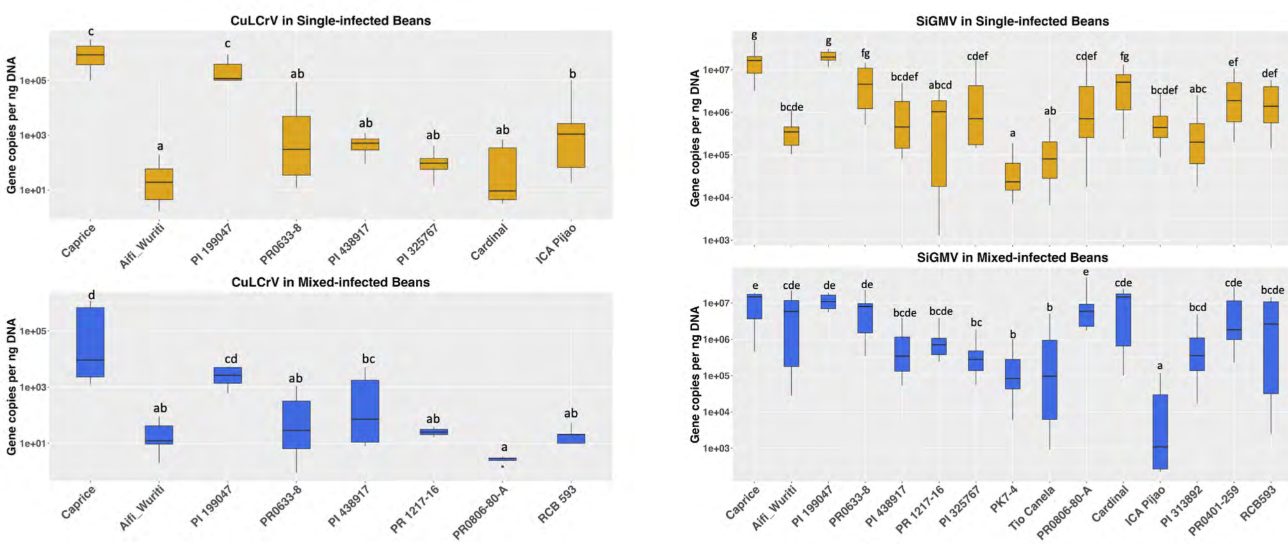


Figure 4. CuLCrV (left) and SiGMV (right) Accumulation (Gene Copies) in Snap Bean Germplasm Lines With Single and Mixed Infections.

Mixed Infection

Overall, these results suggest that certain lines, particularly 'Aifi Wuriti' and 'PR0806-80-A', show resistance to CuLCrV under both single- and mixed-infection conditions. Some lines, particularly 'PK7-4' and 'Tio Canela', consistently accumulated lower viral loads in both single- and mixed-infected conditions, pointing to potential resistance against SiGMV.

Virus-Interacting Proteins in Whiteflies

Several virus-interacting proteins in whiteflies were identified using the Y2H screening. They include zinc finger proteins and secondary messengers, among others. This research indicated that several whitefly proteins interact with the virus capsid proteins, and their silencing under an in vitro system indicated that virus loads within whiteflies can be reduced. Results indicate that these proteins could be used, either alone or in combination, to reduce virus transmission. Research is ongoing.

Conclusion

Host-plant resistance is the best management option for managing whitefly-transmitted viruses. However, there are too few varieties resistant to whitefly-transmitted viruses for squash and snap beans. McGregor and Dutta have identified several resistant materials via field screening, and our laboratory has taken up the collaborative initiative of evaluating them under controlled conditions.

We have begun characterizing resistance in these crops. Also, by identifying and characterizing whitefly proteins that interact with viruses, we intend to exploit them for suppressing virus transmission via RNA interference. This area of research is critical for future research, as whiteflies can rapidly develop insecticide resistance to the limited classes of effective insecticides that are currently available.

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Evaluation of Commercial Tomato Varieties for Resistance against a Complex of Tomato Yellow Leaf Curl and Tomato Chlorosis Viruses under Natural Incidence in Georgia

M. Kumar, T. McAvoy, T. Torrance, C. Cloud, S. Bag

Introduction

Tomato (*Solanum lycopersicum* L.) production in the United States has been severely impacted by the tomato yellow leaf curl virus (TYLCV). Furthermore, a complex association of whitefly-transmitted TYLCV (*begomovirus*) and tomato chlorosis virus (ToCV, *crinivirus*) were recently identified in tomatoes. Several tomato cultivars were developed and commercialized with intermediate resistance (IR) against TYLCV-IL ('Israel'), the predominant strain of TYLCV found in Georgia.

TYLCV-resistant cultivars were tested in open field conditions against multiple whitefly-transmitted viruses in Georgia under natural disease pressure. The area under disease progress curve (AUDPC) over time showed a steady increase in disease severity among all cultivars. Further analysis of infected samples using high throughput sequencing (HTS) and quantitative PCR (qPCR) revealed the presence of TYLCV and ToCV in symptomatic leaves. A mixed infection of both viruses (TYLCV and ToCV) resulted in severe disease development, which may contribute to TYLCV resistance break in commercial tomato plants and lead to decreased fruit quality and marketable yields.

Material and Methods

In the fall of 2022–2023, seven commercially available large round tomato cultivars with different combinations of *Ty* genes (Table 1) were evaluated under natural incidence in Tift County (Horticulture Hill Farm, University of Georgia, Tifton, GA) and commercial fields in Colquitt and Grady counties in Georgia. Symptom severity was visually observed, and disease incidence was monitored every 2 weeks after transplanting. Samples were collected from representative plants and evaluated for the presence of virus using a standard protocol followed in the Plant Virology Lab in Tifton.

Results

Cultivars carrying resistance genes against TYLCV are commercially available in the U.S. Seven such cultivars with different combinations of resistance genes were evaluated under field conditions in different locations in South Georgia during the fall of 2022–2023 when whitefly populations peaked. Virus disease was observed in all of the cultivars evaluated. In Grady County, the symptoms of TYLCV started after 30 days post-transplant (DPT), whereas the symptoms started appearing after 45 DPT in Colquitt County. Symptoms were more severe in Tift County as compared to Colquitt and Grady counties. Due to the lower disease incidence, cultivars evaluated in Grady County expressed less severe symptoms. However, in Tift County after 45 DPT, all seven cultivars evaluated had greater than 50% incidence of TYLCV, and by 60 DPT, there was 100% TYLCV disease incidence.

Detection of ToCV on all samples tested from three different counties indicates that ToCV is now widely prevalent in Georgia. Co-infection of ToCV and TYLCV in tomatoes has been recently reported in China and Spain as well. Mixed infection resulted in increased accumulation of both viruses in tomato plants and induced more severe symptoms. Therefore, mixed infection in tomato cultivars could contribute to a long-term breakdown of resistance to Ty genes. There have been several documented cases worldwide of virus resistance gene breakdown from virus co-infections. It is known that the participation of ToCV during mixed infection with tomato spotted wilt virus can compromise TSWV resistance in tomato. Resistance conferred by Ty-1 is also compromised by co-infection with cucumber mosaic virus infection. Mixed infections with an isolate of ToCV enhanced the breakdown of the TYLCV-tolerance provided by the *Ty*-1 gene either with TYLCV-IL IS76-like or canonical TYLCV-IL isolates.

Conclusion

Significantly high level of disease incidence was observed in all the cultivar evaluated. This study suggests that tomato plants infected with TYLCV-IL along with ToCV advances the breakdown of resistance in plants. Further investigation is needed to determine the role of ToCV in TYLCV-mediated resistance breakdown and a potential chance of the emergence of a new viral strain in resistant tomato varieties.

Table 1. Commercial cultivar evaluated in the field.

Sl. Number	Tomato Cultivar	Source Used	*Ty*-gene
1	Grand Marshall	Sakata Seeds, Morgan Hill, CA, USA	*Ty3* and *Ty6*
2	STM 2255	Sakata Seeds, Morgan Hill, CA, USA	*Ty3* and *Ty6*
3	Red Snapper	Sakata Seeds, Morgan Hill, CA, USA Sakata Seeds, Morgan Hill, CA, USA	*Ty3* and *Ty6*
4	Camaro	Sakata Seeds, Morgan Hill, CA, USA	*Ty3* and *Ty6*
5	Varsity	Syngenta Vegetable Seeds, Greensboro, NC, USA	*Ty1*
6	Jolene	Bejo Seeds, Inc., Oceano, CA, USA	*Ty3* and *Ty6*
7	Myrtle	Bayer Crop Science, Creve Coeur, MO, USA	*none*
8	SkyWay 687	Enza Zaden, Enkhuizen, Netherlands	*Ty3* and *Ty6*
9	HM 8148	HM Clause, Halls, NY	*Ty3* and *Ty6*
10	Saybrook	Bayer Crop Science, USA	*none*

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Host Status of Major Vegetable Crops to Three of the More Aggressive Species of Root-knot Nematodes Recently Detected in Georgia

N. Poudel, I. Chowdhury

Introduction

Root-knot nematodes (RKN) are among the most destructive pathogens, causing widespread damage to a variety of vegetable crops in southern Georgia.

To mitigate these losses, host resistance has been bred into numerous major vegetable varieties, particularly targeting southern RKN (*Meloidogyne incognita*). However, certain aggressive RKN species can overcome this resistance, inflicting severe damage on *M. incognita*-resistant crops.

Recently, several potentially more aggressive RKN species, including guava RKN (*M. enterolobii*) and peach RKN (*M. floridensis*), were detected for the first time in multiple vegetable fields across Georgia. These nematodes can be especially problematic due to their wider host range and greater reproductive potential. Hence, they represent a new challenge for vegetable growers in the Southeast, including Georgia.

To combat these emerging threats, it is crucial to develop practical and sustainable management strategies tailored to Georgia's farming systems. One of the most effective approaches is the use of nonhost or poor-host crops in crop rotation. This study evaluates the susceptibility of seven major vegetable crops commonly grown in Georgia against these newly detected RKN species and southern RKN.

Material and Methods

Greenhouse experiments were conducted in fall 2023 and repeated in spring 2024 to evaluate the host status of seven major vegetable crops grown in Georgia, including bell peppers (cv. 'Regulator'), cabbage (cv. 'Bravo'), broccoli (cv. 'Emerald Crown'), carrots (cv. 'Denver'), beets (cv. 'Detroit Dark Red'), squash (cv. 'Lioness'), and cantaloupe (cv. 'Athena'). Four-week-old seedlings of each crop were inoculated with 8,000 eggs from each nematode species tested in this study. Each crop, inoculated with each species, was replicated eight times in a trial and the trial was repeated once. Sixty days post-inoculation, plants were harvested, and root galling was assessed on a 0–10 scale, where 0 indicated no galling, 1 = 1%–10% galling, 2 = 11%–20%, 3 = 21%–30% and so forth, with 10 representing 91%–100% galling. After galling rating, eggs were extracted from the roots, and the number of eggs per root system was calculated. The reproduction factor (Rf) was determined as the final number of eggs divided by the initial inoculum (8,000). Crops with $Rf < 1$ were classified as poor hosts or nonhosts (if $Rf = 0$), while those with $Rf > 1$ were considered good hosts.

Results

Our study revealed that almost all of the vegetable crops tested are hosts to the newly emerging RKN species except for peppers, which were nonhosts to peach RKN (Table 1).

Among the crops tested, broccoli had the least nematode reproduction for all three species, indicating its potential as a rotational crop. Squash had some of the highest reproduction of all three species. Although peppers were nonhosts for peach RKN, both southern RKN and guava RKN had high reproduction on peppers. Guava RKN consistently demonstrated higher reproduction in crops such as squash, beets, cantaloupe, peppers, cabbage, and carrots, suggesting that guava RKN can outcompete other nematode species in mixed populations. This higher reproduction factor also indicates increased population development, potentially leading to greater damage in these crops. On the other hand, peach RKN exhibited a reproduction rate similar to southern RKN. These results suggest that guava RKN can be a more aggressive species of RKN compared to peach RKN and the commonly detected southern RKN.

Conclusion

Guava RKN and peach RKN, recently detected in Georgia, represent emerging threats to Georgia's vegetable industry. Hence, it is important to stay one step ahead of these threats.

To that end, we evaluated the susceptibility of seven vegetable crops to guava RKN, peach RKN, and the commonly detected southern RKN under greenhouse conditions. According to our results, guava RKN had greater reproduction on all the crops tested compared to the other two species, emphasizing its aggressiveness.

However, our results indicated that some crops are better hosts than others. For example, broccoli represented a relatively poor host for all three species compared to the other crops tested. On the other hand, peppers were nonhosts to peach RKN. Hence, if a field is infested with peach RKN, planting peppers can be an effective nematode management solution. Further evaluation of other vegetable crops, cultivars, and genotypes is necessary to assess their host status against these nematode species. Identifying nonhost or resistant crops, cultivars, or genotypes can be beneficial for crop rotation programs aimed at nematode management.

Table 1. Hosting ability of seven vegetable crops to southern root-knot nematode, peach root-knot nematode, and guava root-knot nematode[1].

Vegetable Crop	Southern Root-Knot Nematode		Peach Root-Knot Nematode		Guava Root-Knot Nematode	
	Galling Severity[2]	Reproduction Factor (Rf)[3]	Galling Severity[2]	Reproduction Factor (Rf)[3]	Galling Severity[2]	Reproduction Factor (Rf)[3]
Squash	4.9	6.9	4.9	5.5	5.6	8.9
Pepper	4.9	5.1	0.0	0.0	5.5	8.4
Cantaloupe	3.4	4.2	3.1	3.8	3.6	6.1
Beet	4.5	2.9	5.2	4.4	5.0	5.4
Cabbage	3.0	2.0	2.9	2.3	3.7	3.3
Broccoli	1.8	1.2	1.8	1.3	1.8	1.4
Carrot	3.4	1.6	3.1	1.2	3.6	2.1

[1]Data from two trials were pooled.
[2]Galling severity was rated on a 0 (no galls) to 10 (100% of roots are galled) scale.
[3]Reproduction factor is a measure of nematode reproduction on each host calculated as the final number of eggs extracted from each plant divided by the initial inoculum (8,000).

The Imported Challenge: Economic Impact of Fresh Fruit and Vegetable Imports on U.S. Producers

G. Munisamy

Introduction

This data highlights the economic impact of imported bell peppers and blueberries on U.S. producers, since these are important crops in Georgia. However, a more detailed report is available (see References) that evaluates the economic impact on U.S. producers for more crops, including asparagus, bell peppers, blueberries, and strawberries.

Summary

American fresh produce growers have been seriously concerned about perpetually increasing imports of fresh fruits and vegetables during their major harvesting windows. In some cases, like cucumbers and squash, the U.S. International Trade Commission (USITC) reported that American growers could fare better if imports were lower than current levels. However, in other cases, like with blueberries and spring table grapes, USITC found that these imports did not harm domestic industry.

This report documents the impact of imports on American growers' revenue in two fresh produce commodities: bell peppers and blueberries. The seasonality, perishability, and distinct harvesting and marketing channels of fresh produce create unique challenges from rising imports. We used an economic framework akin to what's used by USITC to identify additional revenue to American growers of cucumber and squash from lower imports. Unlike USITC, we tracked additional revenues between 2011 and 2021/22. It turns out that growers could have made quite a bit more revenue if above-average or excessive import growth of fresh produce had been removed from American markets. The additional revenues, up to 7.5% of what growers earned on average between 2011 and 2021/22, varied by state and season and depended on their contribution to domestic consumption. The upward trending pattern of additional revenues identified here did not change when using prices at different marketing stages (farm gate, terminal markets, and shipping points) or when accounting for some produce that is transshipped (re-exported).

Previous policy efforts by growers to limit imports did not find remedies in U.S. trade laws. We find, as some groups have claimed, that consumer prices will be higher if imports are limited. To protect revenues, American growers will need improved risk management strategies—similar to those offered to program commodities in the Farm Bill—and new technologies to stay competitive while keeping prices reasonable for consumers.

1. The Imported Challenge

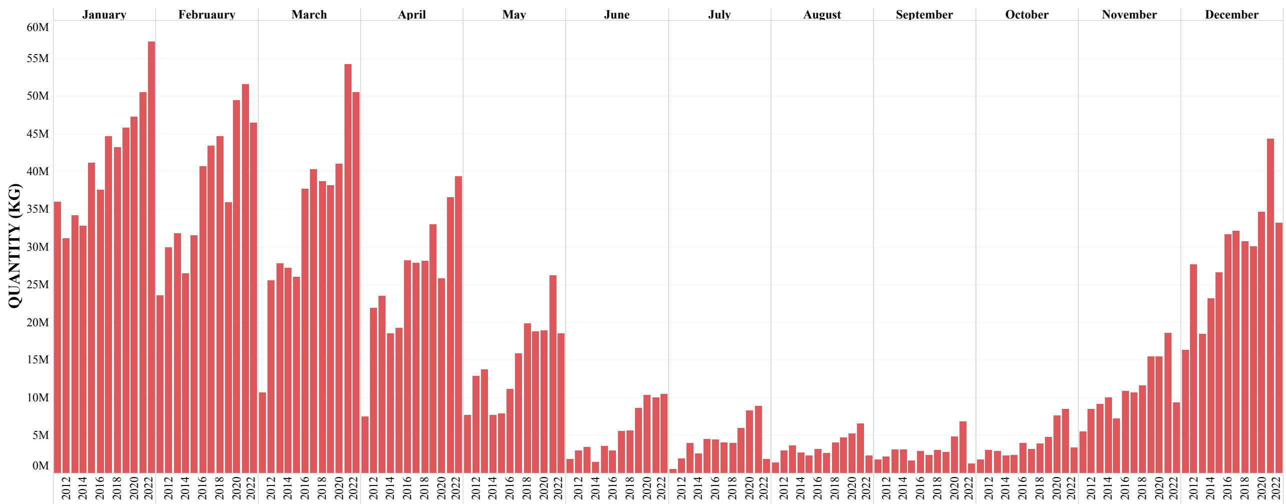
According to the U.S. Department of Agriculture (USDA), the United States imported around 60% of its fresh fruit and 40% of its vegetable consumption in 2021, which was a significant increase compared to 2007 when these numbers were 50% and 20%, respectively. Mexico has been a major source of these imports, supplying a large portion of American fruit and vegetable consumption. The USDA also indicates the fresh produce sector is important to national, state, and local economies since it supports millions of jobs and raises a significant amount of revenue through crops produced and sold.

Before 2010, the United States mainly imported fresh fruits and vegetables in the winter. However, in the past decade, there has been a lot more competition from imports during American harvesting windows (March/April through September/October). American growers have higher costs, especially for labor, compared to countries like Mexico, which makes it harder for them to make a profit. They also have been facing labor shortages, which adds to the challenges faced by American growers. Moreover, several Mexican policies over the past decade have promoted fruit and vegetable production with subsidies for infrastructure such as greenhouses, shade houses, and high tunnels. Thus, American growers believe that the increase in imports during their harvesting seasons, aided by other countries' low wages and policies, is lowering their revenue.

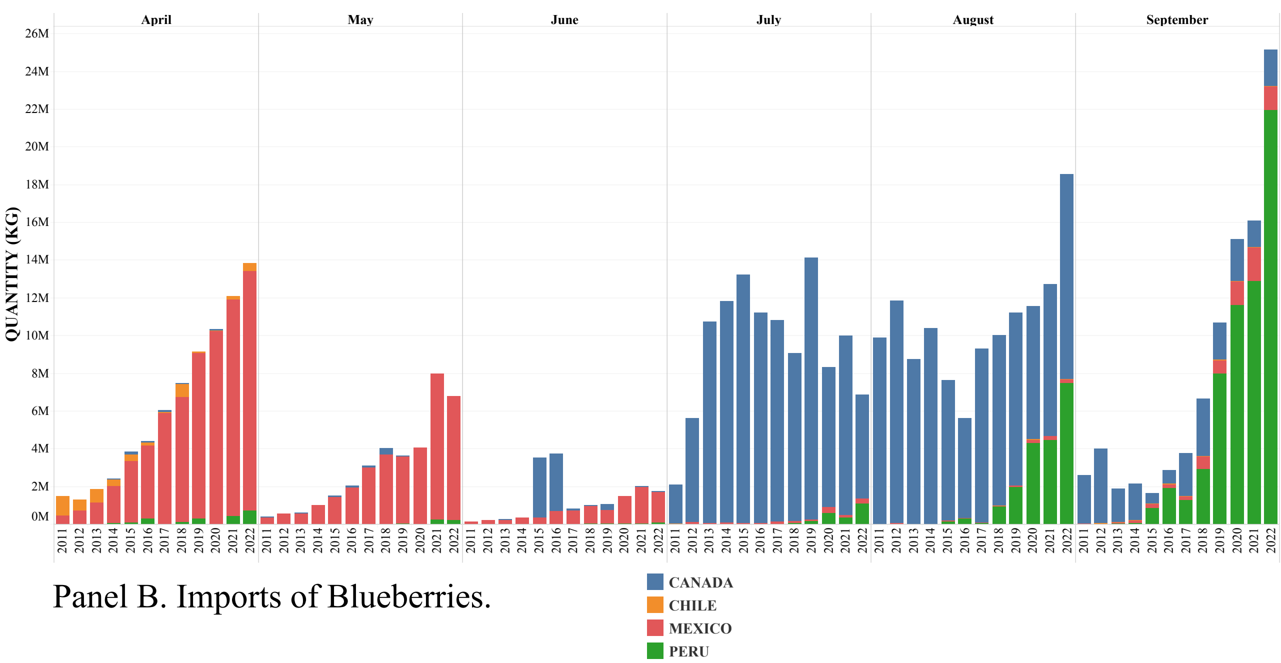
The rise in imports from Mexico led American growers to look for new government policies to help them deal with the impact on their prices and income. When the North American Free Trade Agreement (NAFTA) was renegotiated, U.S. representatives proposed a provision for antidumping/countervailing proceedings of seasonal and perishable products to protect against unfair and cheap imports. However, the final U.S.-Mexico-Canada Agreement (USMCA) did not include any such provision. Still, American growers continued to seek investigations into whether imports were damaging their businesses, particularly for crops like grapes, cucumbers, squash, and blueberries. In 2021, a study by the USITC found that if there were fewer imports of cucumbers and squash, American growers would earn more—in some cases, up to 37% of actual revenues. But for blueberries and grapes, the USITC found that the increase in imports was not hurting U.S. growers. In 2022, the U.S. Trade Representative began working with the USDA to help American growers gain a competitive advantage against imports.

Using the USITC's economic framework from their studies in cucumbers and squash, government data [U.S. Census Bureau and USDA National Agricultural Statistics Service (USDA NASS)], and interviews with growers' associations and members of commodity commissions, we estimated the additional revenue American growers would have made if imports were held below a threshold defined by USITC. We paid special attention to major growing states: California, Washington, Michigan, Florida, Georgia, North Carolina, and New Jersey.

The import quantities of fresh blueberries and fresh bell peppers grew by approximately 194% and 110%, respectively, from 2011 to 2022, according to the U.S. Census Bureau.



Panel A. Imports of Bell Peppers.



Panel B. Imports of Blueberries.

Figure 1. Major Imports of Fresh Vegetables (Bell Peppers) and Fruits (Blueberries) to the United States, 2012–2022. The color of the bars indicates the country of origin. Data Source: U.S. Census Bureau.

2. Recent Trends in Fresh Produce Imports

Between 2007–2009 and 2019–2021, the American appetite for fresh produce year-round was served with a significant increase in imports. Figure 1 presents the monthly imports by overseas origin during 2012–2022 for blueberries and bell peppers.

Mexico is the main supplier of fresh bell peppers to American markets, accounting for most of the imports. The import periods of bell peppers (Figure 1, Panel A) match the harvest seasons in Florida, Georgia, and California—in other words, the increased imports coincide with the peak harvesting times in these states, suggesting competition between local production and imports, unlike before 2010.

Peru is the largest exporter of fresh blueberries to the American market, followed by Mexico. While imports from Mexico and Peru have grown, those from Canada and Chile have declined during 2011–2022. The increase in imports from Mexico and Peru coincides with American harvesting windows (Figure 1, Panel B), particularly affecting major blueberry-producing states like Georgia, California, North Carolina, New Jersey, Washington, and Oregon.

Many authors have broadly attributed the increase in fresh fruit and vegetable imports to four culprits: favorable climate and weather conditions in exporting countries, labor availability and lower labor costs, trade and other economic partnership agreements, and government support of production. Mexico and Peru have climates that allow year-round production of blueberries. Labor costs are a significant concern for American growers, with rising minimum wages and a decline in the availability of both domestic and imported farm labor. The coastal regions of Peru offer benefits for blueberry production, such as skilled labor and shipment logistics. Government support in Mexico, including subsidies for infrastructure development, has boosted their production of fresh fruits and vegetables. Trade agreements with Mexico and Peru have also facilitated the increase in imports, providing them with streamlined market access. There is little doubt that rising imports, especially during the U.S. harvest seasons, have put pressure on domestic prices, revenue, and the income of American growers.

3. Methodology and Data Sources

As we noted earlier, the economic framework used here mimics that of the USITC which examined the effect of imports of cucumbers and squash on American growers' price and revenue. In this framework, American consumers buy either local or imported produce depending on their preferences and respective prices. Domestic supply depends on prices received by growers. Initially, the American market is expected to balance total domestic demand with domestic and imported supplies. Then, we follow USITC in identifying a rate to lower imports, referred to as "above-average import growth."

The counterfactual import growth, computed for each season (or month), lowers foreign supplies during that period, allowing domestic growers to fill the resulting demand gap. The next step is to extract prices and domestic volumes—both supplied and consumed—in this hypothetical scenario. We employ data from government sources (USDA, Census Bureau) as well as prior peer-reviewed scholarly publications to calculate prices and revenues when imports are set to their counterfactual levels. The difference between revenues in the original or actual setting and the counterfactual scenario is referred to as the "additional revenue" American growers could have made if imports had been lowered by the formula detailed above. We refer interested readers to review additional details in the technical report cited in the References.

Data on imports, production, and prices are taken as follows:

- Monthly import data is obtained from the U.S. Census Bureau, including the amount (in kilograms) and value (in U.S. dollars) of imported produce from 2011 to 2022.
- For blueberries, HTS code 0810400029 was used, covering imports from Canada, Mexico, Peru, and Chile.
- Likewise, bell peppers, mostly imported from Mexico, were identified using HTS code 0709604085 before July 2022. After that, six different HTS Codes were aggregated to compute imports, including codes for green, red, yellow, orange, and other sweet bell peppers, as well as fresh/chilled bell peppers.
- For production and prices, yearly state-level data from 2011–2022 was compiled from the USDA NASS, focusing only on produce intended for fresh consumption. Missing values were imputed using historical data and cross-validation with growers' commission data. Monthly production estimates were derived from annual data using information

from interviews with growers and produce commission representatives.

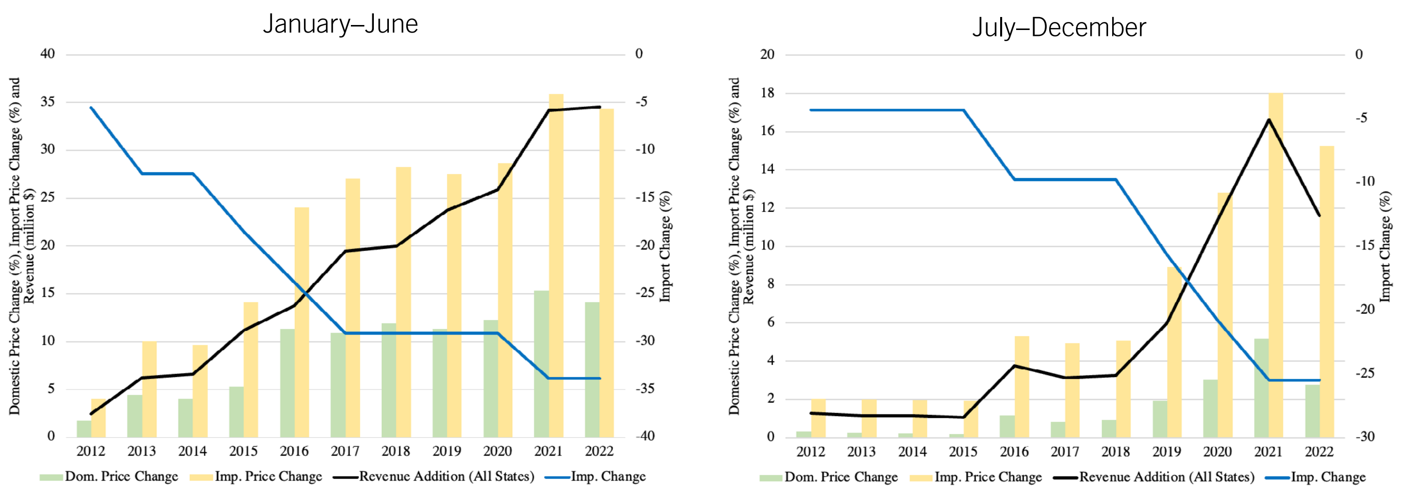
4. Findings

The main finding of this study is that American growers could earn additional revenues in the absence of above-average growth of fresh produce imports, especially in the last few years. For both commodities—bell peppers and blueberries—and in all seasons since 2011, additional revenues would have accrued to the domestic industry without the steep increase observed in import volumes. These additional revenues arise from both higher domestic production and higher prices; the latter would be of concern to consumers. Nonetheless, options to balance producer and consumer interests are needed as discussed in the final section. Findings for each commodity by state and season are shown below, and readers interested in additional details, e.g., monthly estimates, are directed to the technical report in the References.

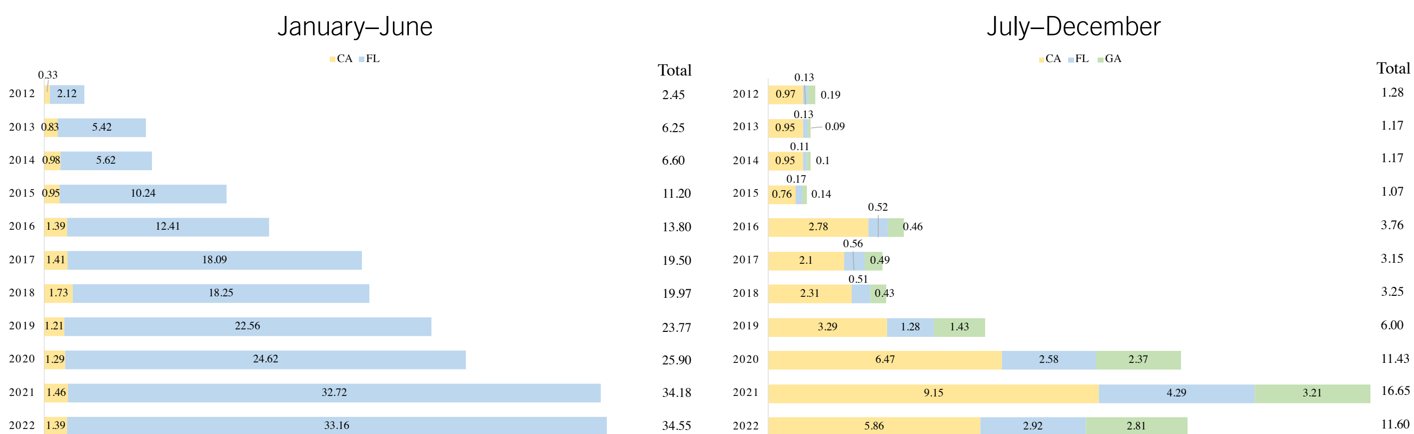
4.1 State-Level Seasonal Economic Effects (2011–22)

4.1.1. Bell Peppers

California, Georgia, and Florida, which together produced 77% of the United States' fresh market bell peppers in 2021, are the primary states considered in our study. The two harvesting seasons are delineated as January–June and July–December. We find that the elimination of above-average imports in 2022 would increase both domestic and import prices of bell peppers, particularly in the January–June season (Figure 2, Panel A). Our calculations also showed that domestic production could have slightly increased while imports would have significantly decreased in both seasons.



Panel A. Domestic and Import Price Change, Import Change, and Revenue Change from Simulation-All States.



Panel B. Additional Revenue from Simulation-State Level.

Figure 2. Seasonal Economic Effects: Bell Peppers (2012–2022).

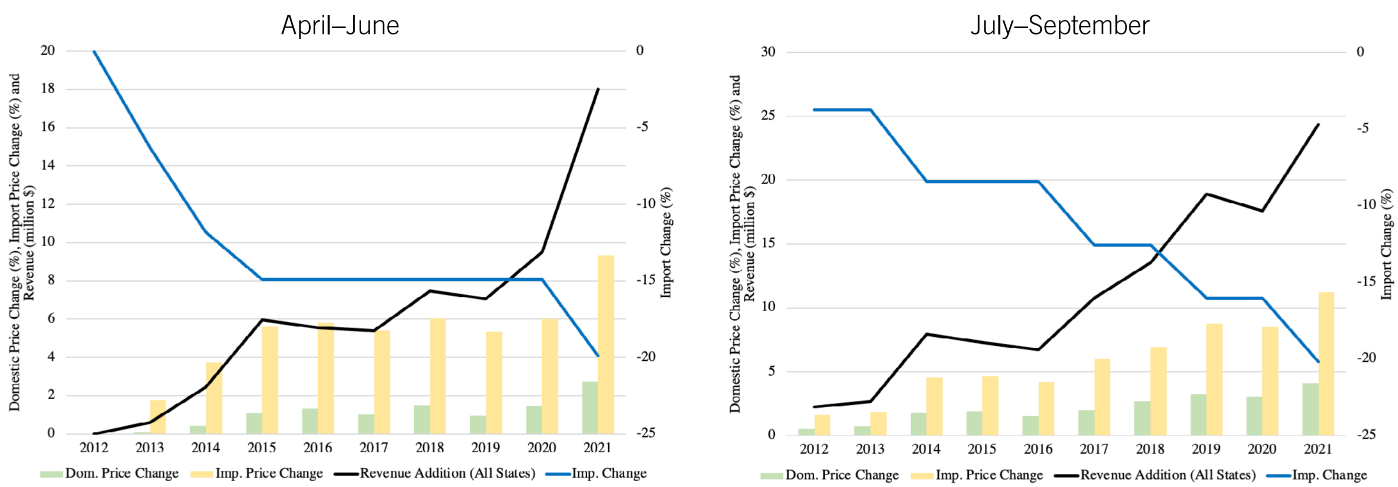
Each year from 2011 to 2022, the additional revenue for bell pepper growers was higher in the January–June season compared to the July–December season, mainly because there was a larger reduction in imports during the early season. The early season also saw a higher import share in the market, which increased over time, leading to higher additional revenue during this period. In 2022 only, the additional revenue without above-average import growth was estimated at $34.55 million for the January–June season and $11.60 million for the July–December season. The total additional revenue for 2022 was about $46.15 million.

Note that Florida, the largest producer, gained the most additional revenue in the January–June season (Figure 2, Panel B). California, which supplies more in the July–December season, received the largest share of additional revenue during that period.

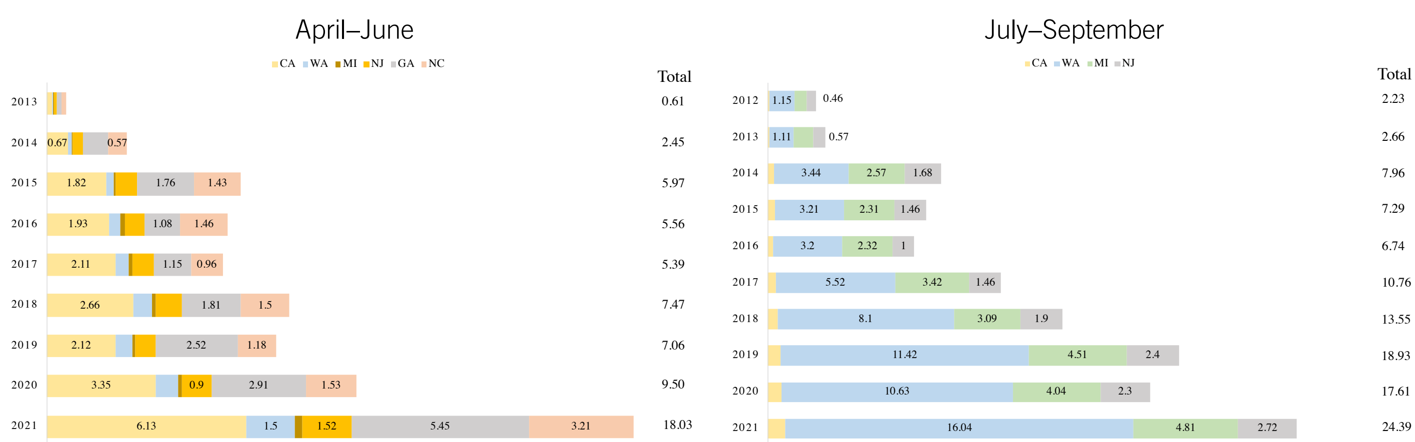
4.1.2. Blueberries

The main U.S. blueberry producers—California, Georgia, Michigan, New Jersey, North Carolina, and Washington (including Oregon)—account for 94% of American fresh market blueberry production in 2021. The two blueberry seasons are April–June and July–September. Again, we find that reducing excessive imports in 2021 would have increased both domestic and import prices of blueberries, especially in the July–September season (Figure 3, Panel A). Furthermore, American production could have modestly increased, while imports would have significantly decreased in both seasons.

We estimate the additional revenue to U.S. blueberry growers in 2021 to be around $18.03 million in the April–June season and $24.39 million in the July–



Panel A. Domestic and Import Price Change, Import Change, and Revenue Change from Simulation—All States.



Panel B. Additional Revenue from Simulation—State-Level.

Figure 3. Seasonal Economic Effects: Blueberries (2012–2021).

September season. The total additional revenue from April through September was about $42.42 million. The higher revenue in the July–September season is attributed to a higher share of actual imports during that season as well as significant import reductions in the counterfactual scenario.

As the largest producer, Washington (including Oregon) would have gained the most additional revenue, especially in the July–September season, followed by Michigan and New Jersey (Figure 3, Panel B). California, Georgia, and North Carolina were the major suppliers in the April–June season, with California being the largest producer for most years. Other blueberry studies also highlight similar losses to American growers because of increased blueberry imports, particularly affecting California and southeastern states like Florida, Georgia, and North Carolina. We confirm the challenges faced by the American blueberry industry caused by rising imports.

Table 1 presents revenue results based on the most recent import data (2021 for blueberries and 2022 for bell peppers). Additional revenues to growers range from 4.48% (blueberries) to 7.53% (bell peppers). They represent the peak, in most cases, of the upward trend in additional revenues shown in Figures 2 and 3.

5. What Next?

Imports of fresh fruits and vegetables into the United States have increased dramatically in recent years. American growers facing declining market shares have argued that higher imports—increasingly during the seasonal harvesting window of domestic producers—are challenging domestic production, prices, and revenue. Previous efforts to quantify the economic impact of imports on domestic growers have yielded mixed results. In this study, we use an economic framework employed by the USITC to analyze the economic effect of bell pepper and blueberry imports. The distinguishing features of these commodities include their significant import growth in recent years and their perishability and seasonal nature (unlike their frozen counterparts).

Utilizing data from USDA and the Census Bureau on production and trade, respectively, and farm gate prices and customs unit value data from 2011–2021/22, this study simulates state-level monthly and seasonal additional revenue that growers would have earned in the absence of above-average import growth as defined by USITC. We find that American growers would have gained higher seasonal additional revenue of $46.15 million (bell peppers in 2022) and $42.42 million (blueberries in 2021), if the counterfactual scenario (no above-average import growth) had played out. These revenues are achievable by reducing import levels, on average, by less than a fourth of the actual levels.

The findings of this research provide valuable insights to growers of fresh produce and to policymakers concerned with the competitiveness of the domestic industry. Liberalized trade offers economic benefits and promotes welfare. In this context, U.S. consumers appear to be the primary beneficiaries of lower prices

Table 1. Actual and Counterfactual Revenues from 2021/22.

Commodity	Actual Revenue (mil $)	Counterfactual Revenue (mil $)	Share of Additional Revenue in Actual Revenue (%)
Bell Peppers (2022)	612.57	658.72	7.53
Blueberries (2021)	604.47	631.58	4.48

and year-round availability of fresh produce. Moreover, there has been opposition to limiting imports in any form during recent testimonies to the U.S. Trade Representative from consumer groups as well as U.S. producers with Mexican operations. While some regions, e.g., the Southeast, demonstrated significant domestic producer losses from imports, regional injuries do not have recourse in U.S. trade laws. The recent revision to NAFTA, i.e., USMCA, also did not address safeguards on significant import growth in fresh produce.

This study identified additional revenue to domestic producers of fresh produce from limiting imports, although it came with price increases to consumers. What options can help domestic growers without distorting markets? The balancing of gains and losses from trade is a decades-old problem, and most solutions point to improved risk management and technological investments—in this case, labor-saving machinery—to enhance U.S. competitiveness. Many such examples can be found in the Farm Bill, and addressing inequities arising from agricultural trade may be useful elsewhere in the economy to build consensus towards future economic partnerships with the rest of the world.

References

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Support of the UGA Georgia Weather Network

P. Knox

Introduction

The University of Georgia weather network provides 15-min-interval weather data and monitors soil conditions at 90 locations 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, as well as work with Extension agents to 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 90 Campbell Scientific automated stations is maintained by one full-time and one part-time technician, 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 an online cloud storage for improved access. In 2023, we moved the Brunswick station to Jekyll Island to provide weather data to the airport there. In 2024, we installed a new station in Echols County near Lake City to take the place of the Valdosta station, which was no longer suitable because of site issues. We are still looking for an additional site near Columbus to fill a gap in our network.

Results

In 2023, our network maintained nearly continuous availability of current high-quality weather data other than some temporary delays that were due to cell network outages. We are proud that our data were available nearly 100% of the time due to 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 2023, the work of moving the network data storage from server-based text files to a cloud-based database was continued. The migration has been delayed because of the lack of a suitable applicant to take over that task. As a result, in 2023, we contracted with a web development team at UGA-Tifton to assist us in finishing this project. A programmer was hired in summer 2024 to help with this project. 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.

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. We provided additional archived data to scientists and students for specialized studies of disease and pest management on request. We hope to continue this service to vegetable producers, as well as expanding our range of tools, in the coming years.

Funding for Advanced Diagnostic Support to Benefit Georgia Vegetable Growers

A. J. Madrid, B. Dutta

Introduction

Plant pathogens and pests cause significant yield losses annually on many important crops grown in Georgia. A reliable and timely disease diagnosis is critical for implementing management strategies that will prevent or reduce the impact of such yield losses. The Plant Disease Clinic operating through the University of Georgia's Department of Plant Pathology provides routine diagnostic support to commercial vegetable growers and other clientele by performing traditional diagnostics on plant samples submitted to the Tifton clinic. Currently, novel molecular tools are available and essential to accurately identify plant health problems. Therefore, the Tifton Plant Disease Clinic, in coordination with the Plant Molecular Diagnostic Lab (MDL), offers advanced testing at an affordable cost to stakeholders. The continued funding provided by the Georgia Commodity Commission for Vegetables was instrumental in providing advanced, accurate, and timely diagnoses of vegetable samples at no cost in a first come, first serve basis to Georgia vegetable growers.

Material and Methods

Diseased vegetable samples are closely inspected for symptoms and signs of pathogens. Visual observation and microscopy are regularly employed to determine if a pathogen may be involved. Moist chamber and pathogen isolation, when possible, is conducted on artificial media and incubated at ideal conditions to promote pathogen growth (if present). Conidia and colony morphology is used to confirm any suspected pathogen. Serological detection assays, such as ImmunoStrips (Agdia) and ELISA, are frequently used to test plant pathogenic viruses, bacteria, oomycetes, and fungi affecting vegetables. Molecular assays, including PCR, real-time PCR, and sequencing are coordinated with the MDL for confirmation of species or other features, such as fungicide/antimicrobial resistance, and a more detailed diagnosis is generated.

Results

Diagnostic support was provided with no cost to the grower or submitter of the sample. Between January and September of 2024, the Tifton clinic received about 162 vegetable samples, including watermelon, cucumbers, tomatoes, potatoes, onions, peppers, pumpkins, cabbage, collards, beans, squash, cantaloupe, melons, okra, eggplant, turmeric, beets, carrots, broccoli, turnips, and lettuce. Watermelon, pepper and tomato samples were the most received. Approximately 12% of samples required advanced diagnostics using current DNA/RNA based lab assays. Samples with bacterial and viral symptoms often require advanced diagnosis for efficient management recommendations and regulatory concerns. Samples that required fungicide resistance testing were also processed to help determine any resistance development.

A fast, accurate diagnosis of a problem not only helps reduce yield loss but also allows for selective treatments that can reduce or eliminate unwarranted extra chemical applications. In many cases, this depends on isolation and identification of a plant pathogen. In 2024, diagnostic services included isolating fungal and oomycetes (100 samples) and bacterial (23 samples) pathogens on growth media. No pathogen was found in 34 samples, three samples tested positive for virus, and two samples were diagnosed with insect damage. Among the tests used, microscopy and isolation were primarily conducted. However, PCR and DNA sequencing for identification were needed in 19 samples (Table 1).

Table 1. Number of vegetable samples tested in 2024 using different methods.

Testing Method	Number of Samples[1]
Microscopy	43
ImmunoStrip	27
Isolation on media	84
Moist chamber	8
Sequencing	19
Bacterial streaming	3
Visual observation	5

[1]Some samples (n = 27) required more than one testing method for final confirmation.

Conclusion

The funds provided by the Georgia Commodity Commission for Vegetables were significant in providing 162 advanced, accurate and timely diagnoses of vegetable samples in support of our vegetable growers. By collaborating with the MDL, the Tifton Plant Disease Clinic was able to expand molecular diagnostic capabilities for critical and emerging bacterial, fungal, and viral plant pathogens, such as *Phytophthora* spp., *Fusarium oxysporum*, *Ralstonia* spp., and tomato spotted wilt virus (TSWV). Correct diagnosis of plant diseases ultimately impact management recommendations and reduce losses that are due to plant pathogens.

Funding for UGA Tifton Vegetable Park Research Farm

T. McAvoy, J. C. Diaz-Perez, B. Dutta, A. Sparks Jr., A. S. Culpepper

Introduction

The University of Georgia (UGA) Tifton campus is ideally located in the heart of southern Georgia vegetable production regions. In addition, the Tifton Vegetable Park (TVP) is the primary research farm at UGA-Tifton that the vegetable team faculty conducts vegetable trials in various disciplines including horticulture, plant pathology, entomology, and weed science. This research site is important for conducting high quality research that cannot be performed in commercial vegetable production fields. The TVP allows researchers to apply experimental chemistries, control fertilizer and irrigation rates, inoculate with diseases, and leave control plots weedy, insect-infested, or full of pathogens. Infrastructure and equipment at TVP allow plasticulture (raised beds covered with plastic mulch using drip irrigation/fertigation), bare ground, or small greenhouse experiments to be conducted at the highest levels. Funding for TVP is critical to continue valuable research that positively impacts the vegetable industry.

Material and Methods

Funding in 2023 was used to procure various supplies, including crop maintenance chemicals (fertilizer, fungicides, insecticides, and herbicides), plastic mulch, irrigation supplies (poly hose, timers, drip tape, connectors, and flush valves), vegetable seeds, cover crop seeds, sprayer tips, picking bins, seedling trays, wooden stakes, twine, labels, flags, marking tape, and spray paint.

Results

Impactful vegetable research was conducted at TVP under controlled parameters in similar climatic conditions to the surrounding vegetable production regions of southern Georgia to provide high-quality data for making meaningful recommendations.

Conclusion

Monies for recurring supplies and equipment maintenance benefit all research at TVP, every department, and ultimately the entire vegetable industry in Georgia.

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