NEWSLETTER

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ADVANCING THE FUTURE OF CITRUS INNOVATION

Welcome to the first edition of Citrisphere, your trusted source for research, updates, and innovations shaping the future of citrus production. At the Texas A&M University-Kingsville Citrus Center, we are committed to supporting growers and stakeholders through science-driven solutions that enhance productivity, sustainability, and resilience in an evolving agricultural landscape.

HIGHLIGHTS

TEXAS A&M UNIVERSITY-KINGSVILLE CITRUS CENTER

FEATURES

DIRECTOR'S FOREWORD

It is with great pleasure and renewed commitment that I present the relaunch of our Citrus Center Newsletter. In an era marked by evolving production challenges notably shifting environmental pressures and increasingly complex citrus production and business landscapes, the value of clear, timely, and science-driven communication to stakeholders cannot be overstated. This newsletter is intended to serve as a trusted conduit that brings you the latest findings from our research programs, ongoing field trials, and emerging technologies that support the continued strength and resilience of our citrus industry.

Our mission remains steadfast: ***to generate knowledge that empowers you, the growers and stewards of this industry, to make informed decisions that enhance productivity, sustainability, and resilience of our citrus industry.*** The research we share is shaped not only by academic rigor, but also by your daily realities, your challenges, and your vision for the future of citrus production in Texas and beyond.

Our team remains deeply committed to addressing the issues that matter most to you whether it is pest and disease management, water issues and irrigation stewardship, soil health, nutrient optimization, or grove management innovations to ensure optimal tree health and productivity. Through this newsletter that will be brought to you twice a year (in spring and fall), we aim to share practical insights, highlight new developments, and provide science-based recommendations that can be readily applied in your operations. While this newsletter will mainly focus on scientific communication, we will also update you on other ongoing activities at the Center.

I invite you to view this communication platform not merely as a newsletter, but as a shared space for progress. I encourage you to engage with us, ask questions, and let us know the types of information that would be most useful. Your feedback strengthens our work, and your collaboration continues to drive the progress of the Texas citrus industry.

Thank you for your continued partnership, trust, and support. We look forward to keeping you informed and working together toward a resilient and thriving citrus industry in Texas.

DR. MAMOUDOU SÉTAMOU

Citrus Rust Mite: The Citrus Rust Mite, Tiny but Mighty for The Texas Citrus Industry

TOLULOPE AGUNBIADE AND MAMOUDOU SÉTAMOU

The citrus rust mite (CRM), *Phyllocoptruta oleivora Ashmead* (Arachnida: Acari: Eriophyidae), is a microscopic arthropod measuring about 0.13 - 0.17 mm in length (Figure 1). Adults have an elongated, wedge-shaped body with their color varying from light yellow to straw color. They have two pairs of short anterior legs and a pair of lobes on the posterior end that help them cling to plant surfaces. CRM is a serious pest of citrus in most tropical and sub-tropical regions of the world and currently has been the most economically important arthropod pest of Texas citrus since the inception of the industry. CRM may be tiny, but its impact on citrus production is substantial enough to earn it the nickname "the mighty mite" among Texas citrus researchers and growers. These mites infest the leaves, branches, and fruits of almost all citrus varieties, though they show preferences in this order: lemons > grapefruit > oranges > tangerines.

CRM has a short life cycle of about 7 to 10 days during warm conditions, extending to about 14 days in winter. During their 4- to 6-week lifespan, female mites can lay up to 30 eggs each especially during the summer months. Eggs hatch in 2 to 3 days into nymphs that pass through two developmental stages before becoming adults. These mites tend to aggregate within trees and on individual fruit based on environmental factors. They do not like full shade. They move towards light but particularly avoid direct sunlight. The north-bottom quadrants of citrus trees typically support the highest populations. In Texas, CRM is problematic throughout the growing season with populations increasing in early spring and often reaching peak levels from late spring through early fall. While feeding on fruits, CRM damages epidermal cells by puncturing oil glands with their piercing mouthparts.

This feeding causes fruit rind russeting (called "sharkskin" when it occurs early in fruit development, Figure 2), bronzing effect on mature fruit (Figure 3), and leaf damage, causing brownish spots or mesophyll collapse. Heavy CRM damage can contribute to increased fruit and leaf drop and reduced fruit size. CRM-damaged fruit may be smaller in size than unaffected fruit and generally contain higher concentrations of soluble solids, but the loss in fruit quality and marketability due to surface blemish can be significant. Texas citrus is primarily grown for the fresh fruit market, thus highlighting the importance of CRM as a pest of economic importance. CRM has continually been a pest problem in South Texas citrus, and as the growing season progresses, understanding this pest and implementing timely management strategies therefore becomes increasingly important.

Management Approaches

Monitoring

Effective management begins with regular monitoring, about once every two weeks during the active growing season. Check 4 leaves and/or 4 fruit from each randomly selected tree. Sample at least 20 trees in a 10-acre block. A threshold of 10% of fruit or 20% of leaves infested, or an average of 4 CRM/leaf or 2 CRM/fruit should trigger the implementation of control measures.

Cultural Control

Maintain proper irrigation practices that will minimize canopy humidity while maintaining optimal soil moisture.
Skirt trees to improve grove aeration.

Chemical Control

The most effective management approach in Texas often involves proactive application of miticides. A suggested timing of chemical control based on citrus phenology includes:

a. **Pre-Bloom (January - February):** In January to early February, mite populations are generally low and an early proactive treatment is recommended that can drive populations even lower, thus reducing the risks of infestation on the first flush of the year.

b. **Post-Bloom (April):** A post-bloom spray may be warranted if mite threshold is reached.

c. **Late-Spring (May - June):** This period coincides with the beginning of rapid CRM populations build-up, and control measures should be implemented to prevent early fruit infestation and damage.

d. **Summer (July - August):** Due to higher temperature, a rapid increase of CRM populations is observed. Thus, timely application of miticides must be made when infestation thresholds are reached to prevent fruit damage.

e. **Late Summer (August - September):** Climatic conditions continue to be favorable for CRM development and population increases, thus making citrus fruit vulnerable to infestation and damage. A timely action is necessary.

f. **Fall:** To avoid late season fruit damage, monitoring should inform whether control action is necessary to avoid late season fruit damage.
To ensure effective and residual control in case of heavy infestations, combine a miticide and an insect growth regulator. As an important precaution, ensure an interval of four weeks between sulfur and oil sprays.

Resistance Management

Because citrus rust mites can develop resistance to miticides, it is important to rotate between different mode of actions throughout the growing season. This practice, along with careful monitoring and well-timed applications, forms the foundation of an effective integrated pest management program for this tiny but mighty citrus pest.

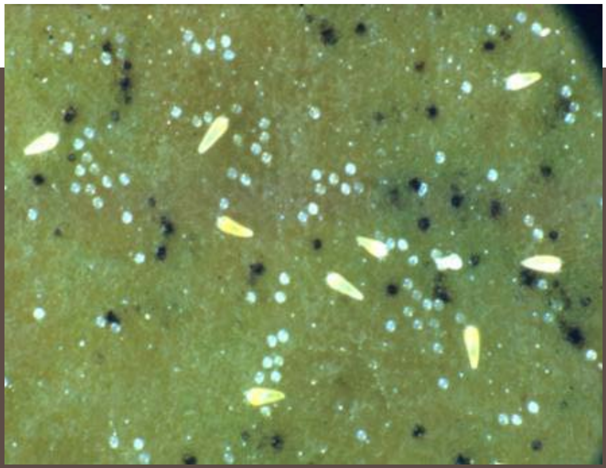


Figure 1: Adult citrus rust mite

Figure 2: Sharkskin damage

Figure 3: Bronzing damage

New Approach for Managing California Red Scale

ANDREW CHOW AND MAMOUDOU SÉTAMOU

Currently, the best approach for controlling California red scale (CRS) is mating disruption. Why? No need to target CRS with insecticides. Mating disruption for CRS delay/prevent mating of males with females. Unmated CRS females do not produce crawlers and late mated females produce fewer crawlers, thus reducing overall scale densities and fruit infestations. Suterra CheckMate® CRS (Figure 1) or Alpha Scents X-Mate CRS (Figure 2) are mating disruption products registered for Texas and based on dispensers that release a synthetic mimic of CRS sex pheromone into air. These dispensers, when deployed inside tree canopies, saturate groves with CRS sex pheromone to confuse males and prevent them mating with females. Deployment of one dispenser per citrus tree, once every year preferably before June, can reduce scale infestation of fruit by up to 95%. Suterra or Alpha Scents provide recommendations for deployment rate of their dispensers based on tree spacing/density, but we tested one dispenser per tree in groves in Texas with excellent results.

Use of mating disruption for CRS control will greatly benefit Texas citrus growers that produce fruit mainly for fresh fruit markets. Effective control of CRS adults and immature stages is critical and mating disruption is a sustainable alternative to traditional insecticides. Enhancing sustainable suppression of CRS in citrus groves will substantially reduce cosmetic damage to fruit, raise fresh fruit utilization, and increase the share of premium fruits for domestic or export markets. Mating disruption using CheckMate® CRS or X-Mate CRS also has no re-entry interval and no pre-harvest interval. Additionally, the dispensers can be deployed in conventional or organic groves. The synthetic sex pheromone released by these dispensers has no known adverse effects on natural enemies, pollinators, or humans. Unlike resistance development to chemical insecticides, it is unlikely for CRS to become resistant to synthetic sex pheromone. Integration of this mating disruption strategy into citrus pest management programs will reduce frequency of insecticide treatments, decrease development of insecticide resistance by citrus pests, and lessen negative impacts on humans and our environment.

Figure 1: Suterra CheckMate® CRS

Figure 2: Alpha Scents X-Mate CRS

Managing Soil Health: A Practical Solution for Mitigating Drought Stress in Citrus Production

ADITI SATPUTE AND MAMOUDOU SÉTAMOU

Huanglongbing (HLB) has already taken a heavy toll on U.S. citrus production, but growers in the Lower Rio Grande Valley (LRGV) of Texas—the nation's third-largest citrus-producing region—are facing an additional and compounding challenge: *a persistent drought*.

In recent years, prolonged drought and the dwindling irrigation water supply have become one of the biggest threats to citrus production in South Texas. Current irrigation practices relying on the Rio Grande river as the sole source of water, are no longer sufficient to meet the year-round water needs of citrus trees, especially during peak fruit growth from April through September. For Texas growers, who depend heavily on the sale of fresh fruit for their returns, water availability during this period can mean the difference between premium-quality fruit and significant economic losses.

Drought also worsens the damage caused by HLB. When trees are water-stressed, HLB damage intensifies leading to smaller fruit sizes, increased pre-harvest fruit drop, thus reducing the marketable yield.

"As a result, reducing drought stress has become a top priority for Texas citrus growers."

Research conducted at the TAMUK Citrus Center in Weslaco points to a promising solution: *improved grove floor management*. Our findings show that strengthening soil health doesn't just support tree growth—it significantly improves how citrus groves cope with water stress. By enhancing soil ecology and increasing water retention in the root zone, growers can make every irrigation event more effective. For Texas citrus operations that are increasingly facing shortage of irrigation water supply from the Rio Grande river, soil-based strategies could be a game-changer in the fight against both drought and HLB.

Soil Health and Drought Resilience

Citrus production is a long-term investment, often spanning over 30 years, and soil health is the foundation of that longevity. Although LRGV soils are moderately alkaline and calcareous, their sandy clay loam texture can support citrus trees for decades when irrigation and nutrition are properly managed. Historically, good soil structure, adequate aeration, and supplemental rainfall have supported successful citrus production in the region.

However, increasing water scarcity has exposed key soil health challenges in the LRGV, including low organic matter, higher salt levels, and limited soil health management. Organic matter is critical because it acts like a sponge, holding moisture in the soil. Without it, the soil dries out faster between irrigations leading to crop stress.

Improving soil moisture retention is therefore essential for managing drought stress. Practices such as applying organic soil amendments can increase organic matter and improve the soil's ability to retain water. Mulching is another simple and effective strategy, as it protects the soil surface, reduces degradation, and helps preserve moisture by significantly reducing evaporation. In particular, plastic-based mulching can address multiple issues at once by improving moisture retention, supporting root growth, and protecting overall soil health. Black-colored woven mesh has the advantage of preventing weed growth while regulating soil temperature.

At the TAMUK Citrus Center, we showed that soil health-focused grove floor management can significantly improve how citrus trees handle drought. Healthier soils hold water longer and make irrigation more effective. Application of soil amendments such as biochar or compost, as well as the deployment of woven black plastic mesh as groundcover (Graphic. 1) significantly improved soil moisture retention at the end of each irrigation cycle (Fig. 1). Soil amendment with biochar or compost keeps water in the root zone longer than bared untreated soils, suggesting their potential in reducing tree water stress and irrigation frequency, and contributing to water conservation. In addition to improving soil water holding capacity, biochar or compost application increased soil total carbon content essential to support the proliferation and activity of beneficial microbes, while substantially reducing the salt content of soils (Fig. 2). Together, these practices have additive effects and collectively offer practical tools to help Texas citrus growers build more resilient groves in the face of ongoing drought and HLB pressure.

Tools Growers Can Use Now to Address the Dual Threat of HLB and Water Stress in Citrus:

Soil Amendments

- Compost and biochar increase organic matter and reduce salt stress
- Improve soil moisture-holding capacity
- Help keep water available in the root zone longer

Deployment of Groundcover

- Reduces evaporation and conserves water
- Protects soil surface from heat and degradation
- Supports better root growth and tree productivity
- Improves water-use efficiency
- Prevents weed growth and reduces herbicide use
- Protects against root weevil infestation and damage

Due to the ongoing drought and dwindling availability of irrigation water, growers can't always supply more water to groves—but they can help soil hold onto it. By improving soil health through amendments and groundcover, growers can:

- Reduce drought stress
- Improve irrigation efficiency
- Lessen the impact of HLB
- Protect fruit size and yield

These soil-based strategies offer a practical, cost-effective way to improve grove resilience under ongoing drought conditions.

Soil amendments application

Groundcover

Graphic 1: Demonstration sites at TAMUK-Citrus Center research station, Weslaco, TX

Biochar is pyrolyzed organic biomass generated under low oxygen conditions. For the purpose of this study, we used Wakefield™ screened biochar at the rate of 10 kg/tree. The compost was procured from local organic grower and applied at the rate of 19 kg/tree on the tree floor as shown in the graphic. Groundcover (GC alone) 8-ft wide was deployed on each side of the tree covering soil underneath tree. Treatments were applied in September 2021.

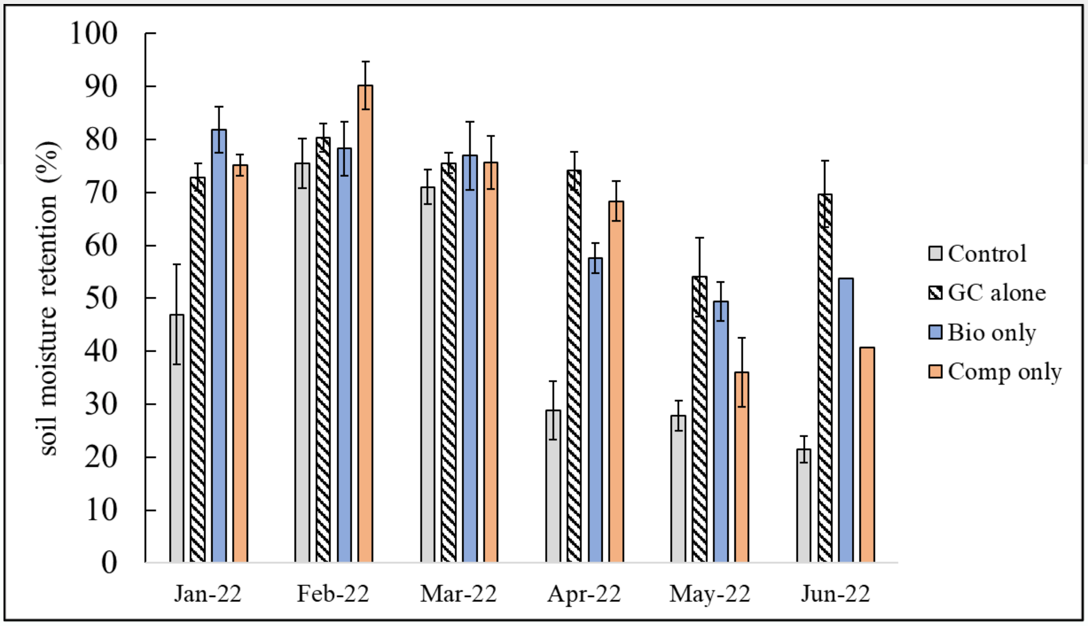


Figure 1. Soil moisture retention calculate at the end of monthly irrigation cycle. Bio only, biochar at 10 kg/tree, Comp only, compost at 19 kg/tree, GC alone, woven plastic mesh groundcover. Treatments were applied in September 2021. Soil moisture data were collected using TEROS 12 (METERS group), volumetric soil moisture sensors installed at 6 inches deep in the soil at canopy drip-line

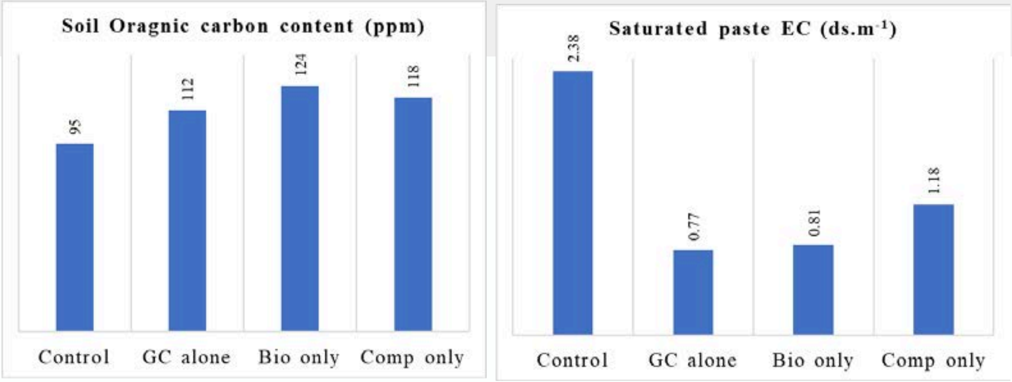


Figure 2. Effect of soil amendments and ground-covering on A: soil organic carbon and B: Saturated paste analysis. Soil samples in the treatments and control group were collected (n=3) 12-months post application of treatments in august-2022. Soil health evaluations includes various physical and biochemical analyses. Saturated paste analysis indicates the soil salinity status. The EC (electrical conductivity) of above 2 ds.m-1 is an indication of moderate soil salinity.

The 4Rs of Nitrogen Management for Citrus Production in Southern Texas.

JOEL CABRERA, VERONICA ANCONA, AND MADHURABABU KUNTA

Nitrogen (N) is an essential nutrient for long-term, profitable citrus production. Nitrogen supports tree vegetative growth, and its adequate supply is important to ensure high yield and fruit quality. In this article, we present current management practices evaluated in mature citrus orchards at the TAMUK Citrus Center. These nutrition management practices are centered around the concept of "4Rs": **R**ight time, **R**ight amount, **R**ight source, and **R**ight location. Extreme weather events common in southern Texas such as winter storm 'Uri' (14 February 2021), heat dome (22 June 2023), and flash floods (28 March 2025) reminds us that we must approach fertilization carefully to maximize tree uptake of nutrients and reduce escape off-farm.

- Right-time: Fertilization should be performed at the highest peak of crop demand, which for our citrus crops in southern Texas occur early in the Spring (Feb-Mar). However, it could be beneficial to split applications when environmental conditions are suitable, primarily around expected rainfall, and highly recommended after certainty of adequate soil moisture to avoid leaching or runoff of nutrients. Irrigation water availability must also be included in the equation if rainfall is absent in the forecast.
- Right amount: This aspect remains controversial, and subject to producer approach to risk. The amount of fertilizer applied is adjusted on farm, block, and row basis. However, for clayed, high-pH, calcareous soils of southern Texas, a baseline of 112 kg N ha-1 annually (i.e.,100 lbs N/acre) is recommended to replenish N exported in fruits, and supply tree needs.
- Right source: Synthetic sources of nutrients such as urea (46% N), UAN-32, a urea ammonium nitrate solution (32% N) continue to offer advantages as source of N to the trees. However, organic sources of N such as compost, mulch, and biochar are alternatives that improve soil health indicators, and offer additional advantages to the system, especially soil moisture conservation.
- Right location: The row arrangement of trees in commercial fields makes broadcasting of granular fertilizers a cost-efficient choice (Figure 1). However, care should be taken to reduce weed pressure that could compete for valuable nutrients (not only N, but also other essential nutrients).

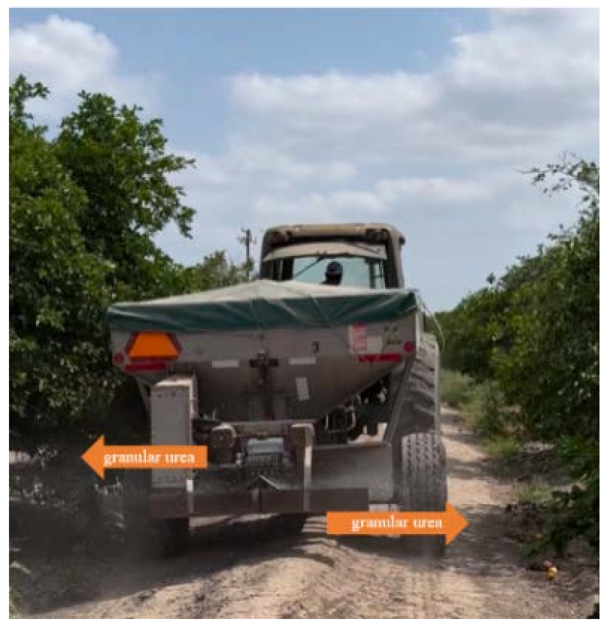


Figure 1. Spreader attached to the tractor broadcasting urea to mature citrus rows in Spring 2024.

Future steps: We continue to improve our orchard management practices to refine the 4Rs of nutrient application, and share our findings with producers, and relevant stakeholders. Field studies using variable nitrogen rate application technology based on fertility zones are explored to offer future guidelines to citrus producers in southern Texas. Moreover, we expect to share results of future trials delivering nutrients through fertigation, which can increase N and others nutrients delivery efficiency.

Keeping Citrus Strong by Promoting Healthy Root Systems

VERONICA ANCONA, JOEL CABRERA, AND MADHURABABU KUNTA

As we breathe a sigh of relief after the much-awaited rain in March, one can only wonder about the risks associated with it. Receiving from 12 to 24 inches of rain across the region sounds great, except that it was in a short period of time, leaving areas flooded, including citrus orchards for several days. Under these circumstances, poor drainage can stress citrus trees in different ways. Roots that are underwater for several days can start to decay, decreasing root mass that is needed for tree support, nutrient and water uptake. Excessive humidity can also exacerbate *Phytophthora* pressure. *Phytophthora* thrives under flooding conditions, infecting roots and tree trunks, leading to root rots, gummosis, and tree decline. Moreover, weakened root systems have a harder time to maintain tree growth and productivity during drought and heat stress. Conditions that we face nearly every summer in South Texas. Thus, protecting and promoting a strong root system in citrus trees is of utterly importance.

There are several ways to promote healthy roots systems. For new plantings, the use of raised beds has shown to enhance root growth compared to flat beds. Moreover, raised beds protect the base of the young trees from being submerged in water during flooding events or irrigation. Application of fungicides (mefenoxam, fosetyl-A) can be effective at reducing *Phytophtora* populations and avoid root infections. It is important to scout the area to look for symptoms of gummosis, as these can cause rapid tree decline in young trees, especially if the trees are challenged by multiple stresses.

Figure. 1. Flooded citrus orchard after the heavy rains on 28 March 2025. Standing water is drained out to increase root respiration

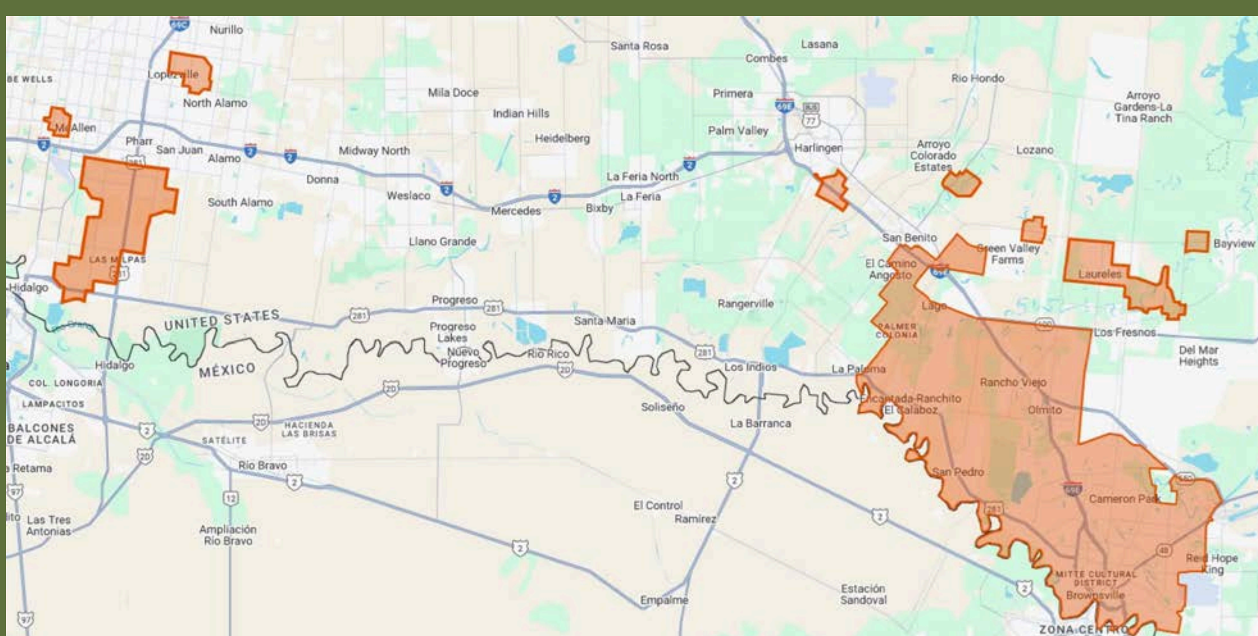
In flooded areas, a way to stop excessive root damage due to the lack of oxygen can be achieved by channeling water out of the orchard into ditches or other low areas (Figure 1). It is important to develop a fertilization program that promotes root growth and development by incorporating phosphorous and potassium to adequate levels in accordance with annual soil test. Proper planning is key to minimize the risks associated with unforeseen extreme weather events, either excessive rain or drought. Transitioning from flood to pressurized irrigation systems (drip/micro-sprinklers) can be an orchard-saver in events of limited water availability. Improving drainage in orchards with low permeability with drainage tiles. Promoting tree and root health also makes tree hardier to withstand the extreme conditions of South Texas, and it is conducive to high fruit production, which supports producers bottom-line and long-term sustainable production.

In-Field Determination of Bacterial Strain causing Citrus Canker

JONG-WON PARK AND MADHURABABU KUNTA

In the early 20^{th} century, a bacterial disease, called citrus canker caused by a bacterium *Xanthomonas citri*, had caused severe economic losses in the US citrus industry. Although it was successfully eradicated by mid-1900s, the disease re-emerged in the 1980s and 1990s in Florida where the disease became endemic. Not only in the US, the disease also re-appeared in other countries such as in Brail and Australia.

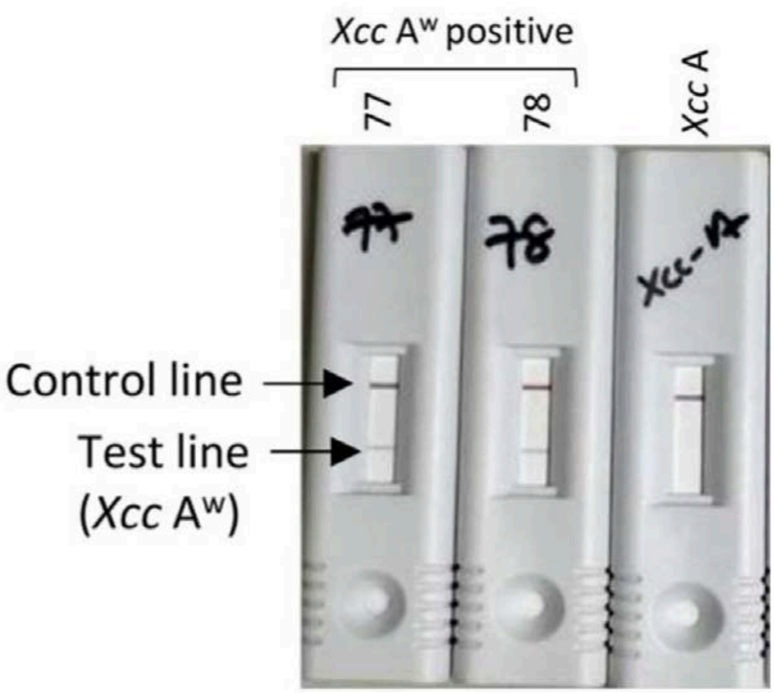
There are three major types of citrus canker, each of which is caused by a different X. *citri* pathotype, among which Asiatic canker (Canker A), caused by X. *citri* pv. *citri* (Xcc A), is the most widespread and severe type of citrus canker affecting most citrus varieties. Thus far, two bacterial variants, A^* and A^w, of Xcc A have been identified, respectively, in Southwest Asia and Florida. Both Xcc A^* and A^w have a narrow host range known to be limited to Mexican limes for A^* and Mexican limes and alemow A^w. In 2015, citrus canker caused by Xcc A^w was reported in residential Mexican lime trees in Lower Rio Grande Valley. Later in 2016, the more severe citrus canker caused by Xcc A was confirmed in the Houston area. Although the incidence of Xcc A has been thus far limited to the Greater Houston area, the occurrence of Canker A in this region has posed a potential threat to the Texas commercial citrus industry located in the Rio Grande Valley of South Texas.



Citrus canker quarantine area in Rio Grande Valley as of Mar. 2025(Source: Texas Department of Agriculture (https://texasagriculture.gov/Regulatory-Programs/Plant Quality/Pest-and-Disease-Alerts/Citrus-Canker))

In the Rio Grande Valley, Xcc A^w incidence has been sporadically, but continuously, reported, resulting in the expansion of the quarantine areas in the valley. Due to the geographical proximity between Greater Houston area and the Rio Grande Valley of South Texas, when new outbreak of citrus canker is reported in the valley, it is necessary to quickly determine whether the new canker case is caused by Xcc A or A^w to deploy proper disease management practices as early as possible to prevent the severe canker type A from spreading. Since the current canker diagnostic methods based on qPCR or immunoassay cannot detect Xcc A^w, we recently developed a quick assay that can be conducted at 68°C for the detection of Xcc A^w in the field without the need of a sophisticated thermocycler. The new method used an isothermal DNA amplification method, called loop-mediated isothermal amplification (LAMP), coupled with an immunoassay cassette to visualize the test result on site.

The result showed that the new method detects specifically Xcc Aw, but not Xcc A. In addition, we confirmed that the new method can be run with crude DNA extracts prepared with 0.8% sodium hydroxide, facilitating the field applicability of the new method.



Detection of Xcc A^w on an immuno-detection cassette after the loop-mediated isothermal assay (**Source:** Sidireddi et al. (2024) Int. J. Mol. Sci. 25(21):11590)

Screening of 'Redblush' Grapefruit varieties and their pigmented bud-sport variants maintained at TAMUK-Citrus Center germplasm

ADITI SATPUTE, MADHURABABU KUNTA, AND MAMOUDOU SÉTAMOU

Texas State Fruit: Red Grapefruit

The world's best vibrant red-fleshed grapefruit varieties, the 'Rio Red' and 'Star Ruby', and the more recently developed redder 'Texas Red' are cultivated in the Lower Rio Grande Valley (LRGV) of South Texas. For nearly a century, the red grapefruit has been a specialty fruit crop globally appreciated by consumers for its ideal balance of sweetness and tartness. Grapefruit, a natural hybrid of pummelo and sweet orange, is believed to have originated in Barbados. The odyssey of grapefruit through generations of travelers and settlers made its way to Florida's shores and eventually found the true home in South Texas (Louzada and Ramadugu, 2021). Grapefruit has established and flourished in the subtropical-semi-arid climate of south Texas as a prime agricultural commodity.

Texas Redblush Evolution

The remarkable journey of grapefruit in LRGV began in the late 1800s, with the first grove planted around 1893. By 1937, Texas growers were producing a quarter of America's grapefruit production that established the dominance of South Texas in national grapefruit production. But the game changer moment was in 1929 with the discovery of the 'Ruby Red' grapefruit – a natural mutation found on 'Thompson Pink' tree that forever changed the industry and sparked the chain of discoveries for redblush variants (da Graça et al., 2004).

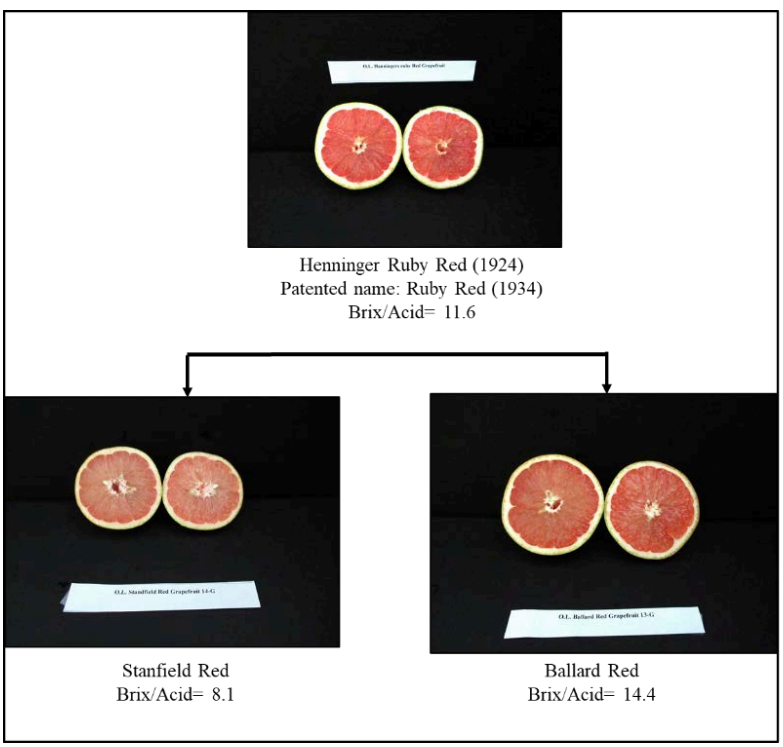


Figure 1a: 'Ruby Red' and its pigmented bud-sport variants. Photographs by Dr. Satpute January 2025

The first red-blushed 'Webb' variety was observed by Dr. J. B Webb of Donna in 1931, helping to further establish the dominance of Texas in the national grapefruit industry (Baker & Sons. 1936). Subsequently, Charles Hudson found his namesake variety in 1930.

By the 1970s, Robert Ray, a scientist at Texas A&I University Citrus Center, Weslaco, developed varieties like 'Star Ruby' using radiation. Samuel Henderson pushed the boundaries even further by developing the 'Henderson' grapefruit in Texas and the Florida's famous 'Flame' grapefruit. All these inventions opened the market for Texas 'Redblush' grapefruit varieties nationwide and worldwide. The crown jewel came in 1984 with the development of a mush redder flesh grapefruit variety, the 'Rio Red' that quickly became the industry's flagship variety (Rouse et al., 2001). Most recently, in 2020, Texas A&M University-Kingsville Citrus Center introduced the deeper red flesh variety known as 'Texas Red', continuing the legacy of innovation in grapefruit breeding.

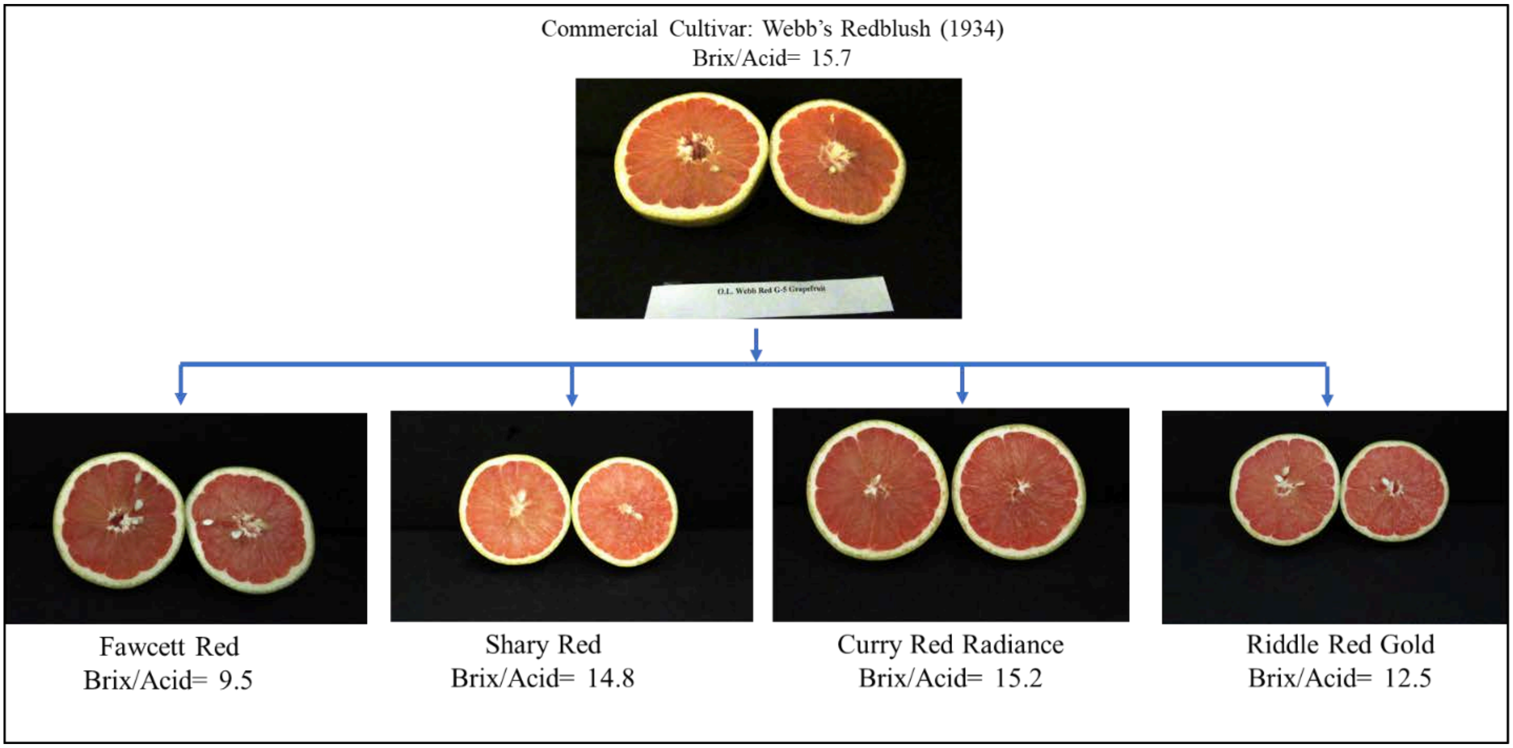


Figure 1b: 'Webb' Redblush cultivar and its pigmented bud-sport variants.
Photographs by Dr. Satpute January 2025

Screening of Redblush Grapefruit

Texas has a huge collection of redblush grapefruit varieties that merit evaluation for their marketability for the fresh fruit and juice industries. Our team-initiated screening of germplasm collection of Redblush grapefruit and its pigmented bud sport variants (Fig. 1a and 1b). We tested 18 different varieties, measuring their juice quality through brix and acid content, while also putting them through rigorous taste panel evaluations. Fruits from different Redblush grapefruits and their pigmented bud-sport variants at TAMUK-Citrus Center germplasm were collected in late January 2025. In each cultivar, 2-3 individual fruits were selected to measure fruit size, weight, rind-thickness and juice quality. Juice-brix and acid parameters were measured from 2-3 individually extracted fruits using digital refractometer (ATAGO® PAL-BX/ACID1, Tokyo, Japan). The cultivars were further shortlisted for sensory analysis at taste panel based on criteria of juice Brix/Acid Ratio above 11. the unique flavor profiles and juice characteristics of Redblush varieties represents the initial stage in the broader effort to reintroduce several lesser-known grapefruit varieties.

Taste Panel Approach: Taste panel consisted of voluntary participation of 11 individuals. These individuals are regular consumers of grapefruits for at least 10 years. The taste panel was trained to conduct two sensory evaluations as follows: Our taste panel completed two rounds of evaluations: first, a blindfolded tasting to assess flavor and potential purchase interest, followed by visual assessment of fruit color and appeal.

Blindfolded Flavor Assessment: In this evaluation, all panelists were blindfolded before tasting to remove nay bias from color. A slice from each test fruit was served in a Styrofoam cup marked only with a letter code. Panelist took a taste and immediately rated their first flavor impression using nine-point Hedonic scale (1: Dislike Extremely, 2: Dislike Very Much, 3: Dislike Moderately, 4: Dislike Slightly, 5: Neither Like or Dislike, 6: Like Slightly, 7: Like Moderately, 8: Like Very Much, 9: Like Extremely). Subsequently, panelists also rated fruit sweetness and bitterness. For sweetness; 0 indicated no flavor (like water), 1-50: watery to slightly sweet, 51-100: mild to moderate pleasant sweetness, 101-150: enjoyable sweetness that enhance grapefruit flavor. Bitterness rating; 0 for no bitterness, 1-50: mild bitterness that complemented the flavors fruit, 51-100: moderate, but manageable bitterness, and 101-150:

after taste harsh bitterness negatively affecting the fruit flavor. At the end, panel members answered whether they would purchase this grapefruit based solely on blindfolded flavor and taste assessment, with four options as follows: "Definitely would purchase", "probably would purchase", "might or might not purchase" and, "definitely would not purchase".

Visual Internal Fruit Color Rating: In a different session, the test fruits were cut open and displayed for visual-only assessment. Panelists rated the flesh color and overall appearance using nine-point hedonic scale (1 for dislike extremely and 9 for like extremely). All samples were number coded for anonymous and unbiased assessment.

Study Highlights:

Blindfolded Flavor Assessment: (Fig. 2): 'Nuc. Rio Red' is the most recognized grapefruit variety, showed a more balanced distribution of responses. Despite its popularity, 'Rio Red' shows the diverse taste preference among the panelists. The 'Curry Red Radiance' emerged as standout, with 36.4% of panelist showed nclination to the choice of 'Definitely would purchase', and none of the panelist voted 'Curry Red Radiance' in the category of 'Definitely would not purchase'. 'Webb's Red' and 'Shary Red' scored 54.6% votes of panel members in "Definitely would purchase" and "probably would purchase" showed interest towards purchasing, while the least votes (9.1%) were scored in 'Definitely would not purchase'.

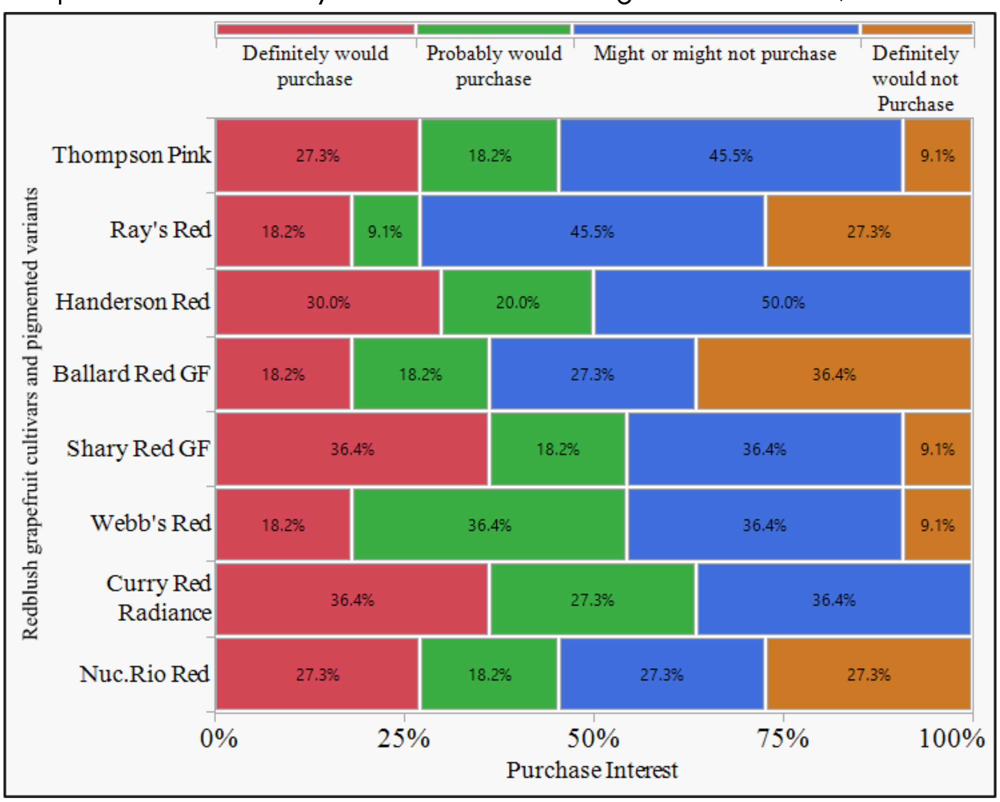
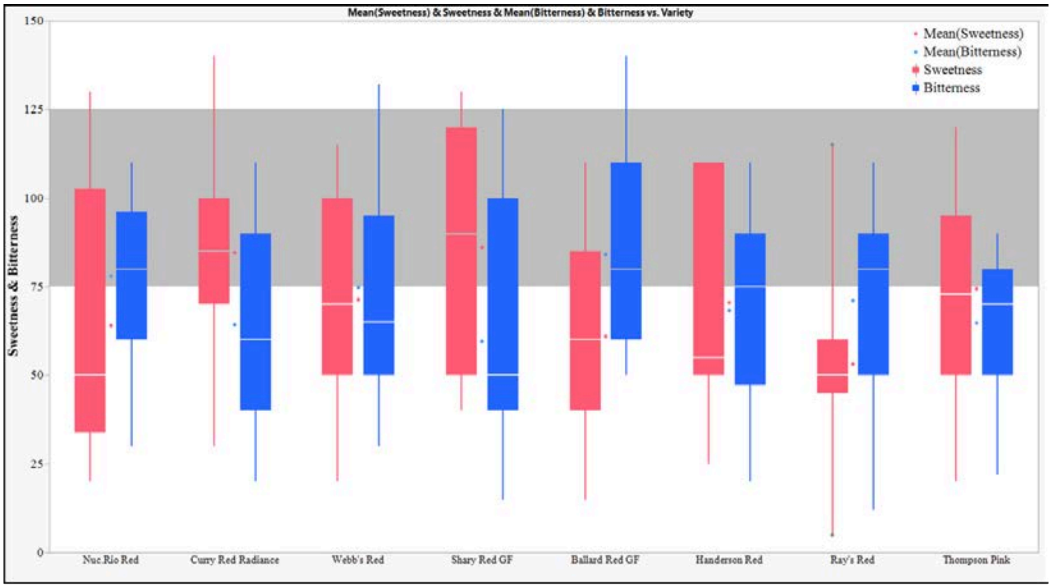


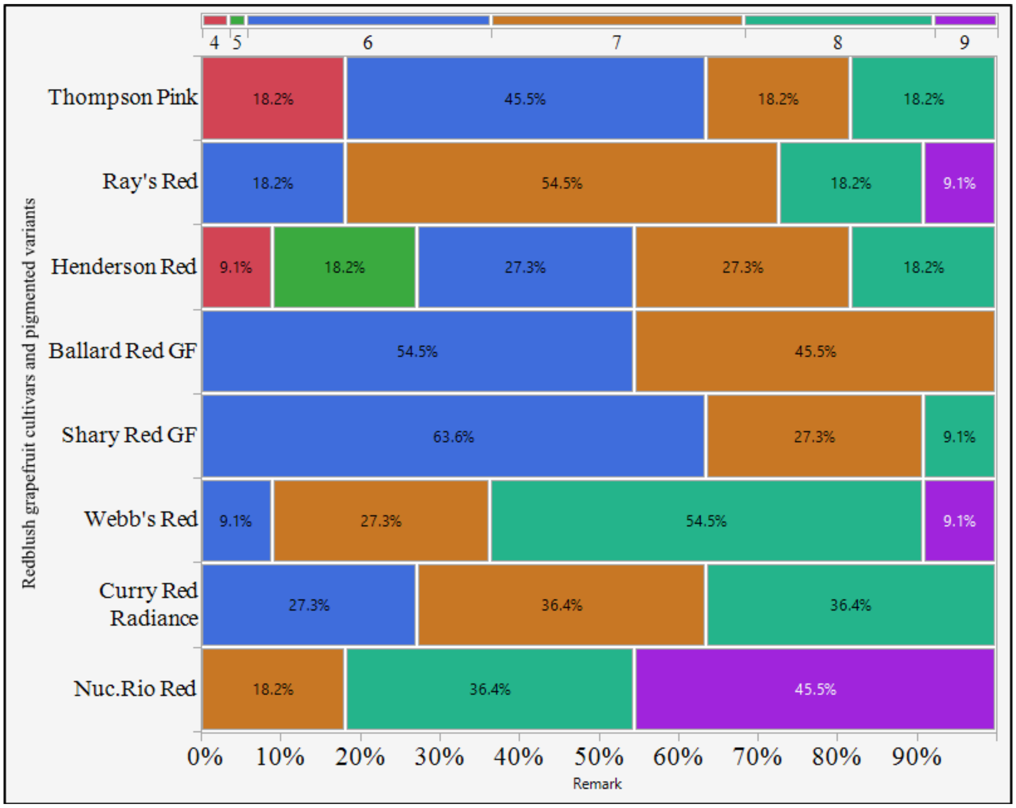
Figure 2. Taste panel response (%) to concluding Purchase interest in blindfolded sensory evaluation.



Taste Evaluation (Fig 3): Analysis of taste parameters revealed notable differences among the grapefruit cultivars. Both 'Curry Red Radiance' and 'Shary Red' exhibited the highest perceived sweetness, with median panelist scores exceeding 75 on the sensory scale.

Figure 3: Box graph depicting means and distribution of points scored for sweetness (red) and bitterness (Blue).

Bitterness levels for these cultivars were moderate, ranging from 50 to 60. These findings suggest that Red blush variants such as 'Curry Red Radiance' and 'Shary Red' may offer a more options for consumers those prefer sweeter grapefruit due to their desirable balance of sweetness and bitterness.



Visual Rating (Fig. 4): Panelists strongly favored the internal flesh color of 'Nuc. Rio Red', with all ratings at 7 or higher on the hedonic scale, shows broad appeal from "Like Moderately" to "Like Extremely". 'Curry Red Radiance', 'Webb's Red', 'Shary Red', 'Ballard Red' and 'Ray's Red' were also scored rating in 6 and above suggesting consistent likability for their red hues.

Figure 4. Taste panel votes (%) to visual rating for fruit flesh color based on hedonic scale.

'Curry Red Radiance' standout with 72.8% of panelists scored it as 'Like Moderately' or "Like Very Much", though it did not receive any top "Like Extremely'" rating. 'Webb's Red' ranked in the 2nd in the highest ("Like Extremely") category, and 81.8% of panel members rated it at 'Very Much Liking' (7) or 'Like Moderately' (8), suggesting the strong visual appeal.

This screening efforts indicate that deep red flesh color is a major factor shaping consumer preference in grapefruit. Several newer cultivars including bud sport variants like 'Curry Red Radiance' and cultivars such as 'Webb's Red' demonstrate visual qualities with real commercial potential (Fig 4). These selections should be further explored as fringe varieties, as they can broaden the range of grapefruit pallet to consumers. In addition to their striking appearance, unique flavor profiles in these cultivars can further boost the appeal of grapefruit (Fig 3), paving the way for a more diverse and expanding market for red-fleshed varieties.

Developing Sustainable Solutions for Citrus Huanglongbing Disease

MADHURABABU KUNTA[1] AND CHANDRIKA RAMADUGU[2]
[1] TEXAS A&M UNIVERSITY, CITRUS CENTER, WESLACO, TX
[2] UNIVERSITY OF CALIFORNIA RIVERSIDE, RIVERSIDE, CA

Citrus trees are affected by many diseases that can negatively impact their production. Huanglongbing (HLB), or citrus greening, has wreaked havoc in many citrus-growing regions. HLB is caused by an unculturable bacterium and transmitted by a psyllid vector. It is considered the greatest challenge to citrus cultivation in many areas. The Florida citrus industry is severely affected by HLB, reducing citrus production during 2024-2025 to about 5% of the pre-HLB levels. The disease mechanism is poorly understood despite extensive research for about 20 years. The pathogen associated with HLB cannot be cultured, and the disease symptoms may be expressed many years after the plants are infected.

Controlling psyllid populations is an effective disease management strategy. The psyllid can multiply profusely, and effective control of the insect vector requires pesticides that may be harmful to the environment; in addition, constant use of the same pesticide will result in insecticide resistance. Several management strategies are being developed for HLB mitigation; the industry is in dire need of sustainable, long-term solutions for this disease.

The severity of HLB is known to vary in different geographical regions. It is possible that in Texas, due to environmental factors, the disease may not cause as much damage as it did in Florida. HLB was first detected in Texas in 2012. After about 13 years, the disease has established and has spread to other areas (expanding the quarantine zones), but the reported yield loss due to HLB is not substantial in Texas. However, it is prudent to develop HLB-resistant citrus varieties for use in Texas, California, Florida, and other citrus-growing regions.

Our approach to developing HLB resistance in citrus cultivars is through breeding. We have identified Australian limes with HLB resistance/tolerance traits. Since they are sexually compatible with some citrus varieties, breeding resistance into cultivated citrus types is possible. Citrus breeding has many challenges: long generation times (four to nine years), juvenility resulting in late flowering, male and female sterility in many cultivated citrus varieties, and nucellar embryony (seeds germinate and produce clones of the female parent) are some of the challenges for breeding. However, the advantages of the breeding approach outweigh the limitations. If new hybrids inherit the HLB resistance trait from the Australian lime parent, they can be used to develop disease-resistant cultivars. Breeding with close relatives like the Australian limes will result in genetic enhancement of the cultivars, which is advantageous when new pathogens get established in citrus-growing regions.

Since breeding is a long-term project, we can utilize genomic information to expedite selection. Genome-assisted (marker-based) breeding can hasten the overall breeding scheme. To state it simply, if we know which part of the genomic DNA is needed for the newly generated hybrids to have disease-resistance traits, we can pre-select the hybrid population for further evaluation. We have sequenced the HLB-resistant Australian lime species used as breeding parents to facilitate this process. In addition, we are sequencing some citrus parents that were utilized to generate novel hybrids. During meiosis (cell division resulting in sexual gametes with half the number of chromosomes as the parent), there is a recombination process. Segments of the homologous chromosomes (similar chromosomes derived from the maternal and paternal sources) may recombine in various ways, leading to recombination and introducing genetic diversity. The addition of new genomic fragments or rearrangement of the existing material will contribute to variation. Based on how many fragments from the Australian lime are needed to incorporate disease resistance, a certain percentage of hybrids will show the resistance trait.

Another essential objective of the breeding process is to select hybrids that have citrus-like fruit traits. If the genomic regions involved in conferring resistance are proximal to the regions determining fruit traits, the resistant hybrids will also inherit the undesirable trait of bad fruit quality. In the hybrids of the first generation (F1- derived by crossing a mandarin with citrus), the fruits generally have flavor components of the Microcitrus parent, leading to undesirable fruit quality. A second round of crosses is performed using disease-resistant F1 hybrids with selected citrus cultivars. The advanced hybrids (of the second generation) will have more citrus-like fruit traits. We have fruits from about 150 advanced hybrids in Riverside, CA. Figure 1 shows images of some fruits from this population. Some hybrid fruits taste like mandarins, lemons, grapefruit, etc. We conduct molecular analysis to determine the chemical composition of the fruit juice and compare it with known oranges, mandarins, grapefruit, or lemon. While it is impossible to generate a hybrid identical to one of the existing commercial cultivars (but with HLB resistance trait), we can attempt to create sweet orange-like, mandarin-like, grapefruit-like, or lemon-like hybrid plants. We expect to get orange-like fruits from advanced hybrids in a short time.

The program's critical component is generating hybrids with HLB resistance or tolerance. If a plant does not support the establishment of the HLB pathogen, it is considered resistant. In tolerant plants, the pathogen can establish but does not affect yield significantly. We plan to conduct field trials in Texas for 250 advanced hybrids generated in the program to evaluate HLB resistance. Resistant hybrids with acceptable fruit quality traits will be developed as cultivars suitable for different citrus-growing regions in the United States.

Figure 1. Advanced hybrids of the second generation. Hybrid numbers are 103(1); 109 (2); 175 (3); 240 (4); 275 (5); 279 (6); 298 (7); 301 (8); 311 (9); 354 (10); 378 (11); 381 (12); 409 (13); 636 (14); 930 (15); 997 (16); Finger lime parent (17); Microcitrus australis parent (18).

Citrus Center Updates

Achievements and Awards

Graduate students

Priyanka Kesoju
Diagnostic and Molecular Biology
Recipient of departmental outstanding student award
Defended Master's thesis on 'Efficacy of Oxytetracycline (OTC) for Huanglongbing (HLB) Management in South Texas 'Rio Red' Grapefruit'

Seth Kuby
Plant Pathology
Secured first place in oral presentation at Subtropical Agriculture and Environmental Society Annual Meeting, 2025, Mission, TX
Defended Master's thesis on 'Assessing Dragon Fruit's (Selenicereus spp.) Potential as a Water-Use Efficient Crop in South Texas'

Faculty & Staff

Staff Council Member

Marissa Gonzalez

Service Awards

Dr. Madhurababu Kunta and Adam Villarreal- 20 years
Jose Hernandez – 10 years
Maria Olguin – 5 years
Joel Sanchez – 5 years

Presidential Award Outstanding Faculty Member

Dr. Veronica Ancona

Citrus Center Showcase

Livestock Show Parade

Texas A&M University Chancellor, Dr. John Sharp, was the Grand Marshall for the 2025 Rio Grande Valley Livestock Show Parade on Saturday, March 8. Citrus Center faculty Drs. Setamou, Kunta, Park and Agunbiade participated.

CITRUS GROWERS WORKSHOP

Dr. Agunbiade organized a well-attended citrus grower workshop in April 2025 that brought together citrus growers, researchers/scientists, and extension specialists to share updates, discuss current citrus production challenges, and gather grower input to help shape future research priorities.

TEXAS A&M UNIVERSITY-KINGSVILLE CITRUS CENTER

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(956) 447-3370

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Address comments or inquiries to Newsletter Managing Editor, Dr. Madhurababu Kunta, Texas A&M University-Kingsville Citrus Center, 312 N. International Blvd, Weslaco, Texas 78599 or in the case of signed articles, directly to the faculty member named. Articles appearing in the Newsletter may be reproduced, in part or in whole, without special permission. Newspapers, periodicals and other publications are encouraged to reprint articles which would be of interest to their readers. Credit is requested if information is reprinted. Mention of a trademark, proprietary product or vendor does not constitute a guarantee or warranty of the product by the Texas A&M University-Kingsville Citrus Center and does not imply its recommendation or the exclusion of the other products that may also be suitable.

Thank you!
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