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Plant Disease Review of South Texas Crops and their Management

Juan R. Anciso and Olufemi J. Alabi

Texas A&M AgriLife Extension Service
2401 East Business Highway 83, Weslaco, Texas 78596

*Corresponding author email: : j-anciso@tamu.edu

ABSTRACT

The Lower Rio Grande Valley (LRGV) of south Texas is one of the most intensive agricultural areas in the southern United States and distinguishes itself by the diversity of vegetables, row crops and tree/vine crops that are grown in the area. The southern location combines sub-tropical and semi-arid weather conditions and 347 frost free days to create a diverse agricultural crop sector that constantly faces new and old threats from plant pathogens. Even though many of these plant pathogens are reported, a review of the current plant diseases especially for the 2000's has not been done recently. This review of the plant diseases is intended to be of new and emerging diseases as well as long known diseases that created economic damages to some of the most recognized or economic crops of the area. This review is also not intended to be an all-inclusive list of plant diseases for the area but rather a short list of the most notable plant diseases from 2000 to 2020.

Additional index words: Lower Rio Grande Valley (LRGV), plant pathogens, bacterial, fungal, viral, phytoplasma

A plant disease is an unfortunate outcome of interactions between a disease-causing agent (pathogen), a susceptible plant (host), under the influence of a conducive environment. Whereas some plant pathogens are capable of directly invading their host plants, other require entry points facilitated by insects and other arthropods or mechanical damage to the plant tissue. Regardless of the pathogen involved and the mode of the plant host invasion, the disease outcome of the plant-pathogen interaction directly or indirectly limits the crop's production and economic potential via yield or quality losses, added cost of disease and/or vector management, limitations to what/when certain crops can be grown in an area, etc.

The subtropical weather conditions of the Lower Rio Grande Valley (LRGV) of south Texas, while enabling the cultivation of diverse crops, is also conducive to an equally diverse groups of plant pathogenic agents. The most common of these diseases include those of fungal, bacterial, and viral etiologies and plants could be affected at different stages of their growth. Due to the evergreen nature of the LRGV landscape, these pathogens can perpetuate themselves between seasons alternating between their primary and alternative or alternate host plant species. In addition, the geographical location of the LRGV along international boundaries makes it vulnerable to exotic and invasive pathogens and infective vector species. Little wonder then that the region is infamous for many first pathogen detections in the United States. The goal of this review is to highlight a few notable diseases of vegetables, row crops and tree/vine crops that are either endemic or have the potential to develop into significant epidemics in Texas and across the USA. In addition to providing a short historical background on each disease, this review will cover the causative organism of each disease, the mode of spread, economic impact and integrated pest management tactics for their management.

REVIEW

Zebra chip disease
Pest (bacterial)
Crop: Chipping potatoes

Internal browning of tuber due to severe infection.

The zebra chip disease is a major disease of chipping potatoes in the Lower Rio Grande Valley and throughout Texas. The actual causal bacterial agent, *Candidatus* Liberibacter solanacearum, was first reported in 2008 (Abad et al. 2008). However, the disease symptoms and defects in chipping potatoes had been noticed in Texas since 2000 (Secor et al. 2006). When these symptoms were first observed in the early 2000's, many investigators were not sure but suspected the causal agent to be a phytoplasma, virus or even an abiotic disease. Many investigations clearly indicated that this pathogen was transmitted by the potato psyllid, *Bactericera cockerelli*, before the actual causal agent was identified (Munyaneza et al. 2007). In 2006 an IPM program was developed to control the potato psyllid pest to prevent disease transmission (Goolsby et al. 2008). The impact of an IPM program was very apparent in the comparison of the untreated controls to commercial fields with a pest management program for the potato psyllid (Goolsby et al. 2012). The two key predictors of Zebra chip disease at harvest for chipping potatoes are the number of *Ca*. L. solanacearum–infected adult psyllids and the number of large nymphs (Goolsby et al. 2012). Approximately 2,000 acres of chipping potatoes can be at risk in South Texas. *Ca*. Liberbacter solanacearum is also a minor disease agent on other solanaceous crops such as tomato and eggplant.

Citrus greening disease
Pest (bacterial)
Crop: Citrus

Yellow mottle and raised vein symptoms on leaves of infected sweet orange citrus tree.

The Asian citrus psyllid, *Diaphorina citri*, was first identified on Texas citrus in September 2001 (French et al. 2001). It was found on nursery citrus seedlings and on a citrus relative ornamental called orange jessamine, *Murraya paniculata* (French et al. 2001). The arrival of the Asian citrus psyllid was feared by the Texas industry because it was known to efficiently transmit the bacterial pathogen, *Candidatus* Liberibacter asiaticus, the causal agent of citrus greening disease. At that time the citrus greening disease had not been reported in the United States. This citrus greening disease has since been reported in several southeastern US states to include Florida since 2005, California 2012 and was confirmed in Texas on January 2012 (Kunta et al. 2012). The citrus greening disease gets its name because the fruit remains green around the navel area even when mature and leaves it bitter tasting and misshapen. Therefore, the fruit is un-marketable, but the disease can cause the trees to decline in vigor, production and eventually lead to tree death. In 2008 before the detection of citrus greening, an area-wide management program that includes dormant spray applications (November and early February) targeting the Asian citrus psyllid was initiated in a small scale to eventually encompassing the entire citrus acreage and continues to this day to keep these psyllid populations as low as possible to help reduce the spread of the disease in commercial orchards (Setamou et al. 2012). The National Research Council of the National Academy of Sciences recommended a three-pronged approach to manage citrus greening disease to include effective psyllid control, removal of known infected trees and clean or uninfected nursery trees (Alabi et al. 2014). With new regulations requiring commercial and retail citrus nurseries in Texas to transition from open-field facilities to enclosed insect-resistant screened facilities, the commercial citrus industry has faced minimal levels of citrus greening disease in the orchards (Alabi et al 2014). Door-yard citrus continues to harbor and increase in the number of positive trees with the citrus greening and has been difficult to get rid of these infected trees. Approximately 24,000 acres of citrus can be at risk in the Lower Rio Grande Valley.

Black rot of crucifers
Pest (bacterial)
Crop: Crucifers

Typical leaf edge necrosis and yellowing symptoms of black rot on cabbage.

Black rot, *Xanthomonas campestris* pv campestris, is one of the most damaging diseases of crucifers and most damaging in tropical, subtropical, and other areas with warm humid conditions (Williams 1980). From the fall of 2014 to spring 2017, severe black rot of crucifers was experienced primarily in the springs on various crucifers to include cabbage, broccoli, kale, kohlrabi, and Napa cabbage. While black rot is occasionally found after periods of excessive moisture in the Lower Rio Grande Valley it had never been this devastating on crucifers especially to the entire crop of cabbage. These years had experienced unusually long rainfall conditions than normal primarily due to an El Nino event, but commonly grown cabbage varieties for years had not faced such problems. About half of the 3,000 acres of cabbage was lost in 2016-2017 season and this magnitude of losses due to black rot had not been experienced since the 1980's (KRGV news report 2017). The most commonly grown cabbage varieties such as Pennant, Cheers, Blue Vantage, Primo Vantage, Savoy Blue and Savoy King showed the worst black rot symptoms and demonstrated to be poor choices as far as varieties that easily succumb to black rot bacteria. Variety trials indicated that some newer cabbage varieties such as Xtreme Vantage (FCB-3344), Celebrate and Corton show improved to significant resistance to black rot. As far as chemical treatments when disease pressure is low, peroxides were slightly better than copper sprays but when disease pressure is high then neither treatment is effective when compared to the untreated control. Approximately 5,000 acres of crucifers can be at risk in the Lower Rio Grande Valley and selection of black rot resistant varieties of crucifers and weather play a role in the severity and management of black rot in crucifers.

Black rot blight of Apiaceae
Pest (fungal)
Crop: Dill

Yellowing and death of leaves in lower canopy.

Approximately 200 acres of dill are grown in the Lower Rio Grande Valley for fresh uses and is part of the diversity of leafy green vegetables that are grown and marketed for the mixed loads that are destined to US and Canadian markets. While dill has been a rather inexpensive and easy to cultivate crop over the years, recent disease problems have made it difficult to grow. Any slight necrosis or browning is immediately rejected by retail buyers and its shelf life is greatly reduced. Since 2016 to 2019, this necrotic foliage has consistently been observed in association with *Alternaria radicina* as reported by Plant Disease Diagnostic Report 2019-175. High humidity and reduced air movement in the dill crop favors the development of this black rot blight. There are a few specific fungicides that are cleared for use on dill to control this Alternaria species. Management of black rot blight can include actions that reduce plant stress to include proper fertility and water management, allowing air movement by spacing plants and using pathogen-free seed. Approximately 200 acres of dill can be at risk in the Lower Rio Grande Valley with fungicides as the last resort to manage this disease.

Pink root disease
Pest (fungal)
Crop: Onion

Pink colored roots with less root mass.

Pink root, caused by the fungus *Phoma terrestris*, is a major disease of onions in south Texas since the 1940's (Walker 1947). The disease derived its name from the characteristic pinkish discoloration of the roots of affected onion plants. A major consequence of the infection is the loss of the limited root systems of affected onion plants, which in turns impairs the uptake of water and mineral nutrients from the soil. The causative fungus can survive and persist in the soil for years, inducing disease under favorable soil temperature (80^{o}F) conditions. The leaf tips of affected onion plants may die (so-called tip blight), thus predisposing the plant to infection by other onion pathogens such as *Botrytis* blight and *Fusarium* basal rot. A major detrimental impact of pink root is the reduction in the size of bulbs produced by affected plants. The management of pink root relies mainly on the use of resistant/ tolerant onion varieties and the avoidance of (or rotation from) fields with history of the disease, and. Soil fumigation is also effective, though cost prohibitive. As new onion varieties are introduced into the market for various quality components, many of these new varieties do not have the pink root tolerance or resistance that many of the better known onion varieties. Approximately 6000 acres can be at risk in South Texas.

Cotton root rot
Pest (fungal)
Crops: Wine grapes, many crops including cotton and alfalfa

Sudden death of leaves often left frozen on plant next to unaffected grape vine.

The Texas wine grape industry rapidly expanded during the 2000's with acreage more than doubling during this time to 4,500 production acres and another 1,000 acres as non-bearing in Texas in 2017. While most of the 500 plus wineries in Texas use out of state production, the rapidly growing acreage has been a response to the demand for local Texas wines (>75% by volume of wine must come from Texas). The Gulf Coast region that includes the Lower Rio Grande Valley also increased its attempts in growing wine grapes that were resistant to Pierce's Disease (bacteria transmitted by an insect), the region's historically most devasting disease to susceptible wine grape varieties. These Pierce's Disease resistant varieties are not 100% *Vitis vinifera* (classic wine varieties) but hybrids such as Blanc du Bois and other species such as Black Spanish. It was estimated that acreage in the Lower Rio Grande Valley reached 30 acres of Blanc du Bois and Black Spanish but many of these vineyards encountered serious problems with cotton root rot. Cotton root rot, *Phymatotrichopsis omnivore*, is a soil-borne fungus (formerly known as *Phymatotrichum omnivorium*) that has been documented to attack over 2,000 species of plants (Streets and Bloss 1973). Some of the best-known crops that can be attacked by cotton root rot include cotton, alfalfa, peaches, olives and grapes (Streets and Bloss 1973). The most common symptom in grapes and other plants is the sudden wilt and death of the infected plant. Since cotton root rot is a soil-borne disease it has proven to be difficult to control with fungicides but a registered fungicide flutriafol has shown promising results in certain situations. Certain grafted grape varieties with the rootstocks of Dog Ridge or 1103P rootstocks have also shown promising results in certain situations. Remaining wine grape acreage in the Lower Rio Grande Valley remains in a decline due to cotton rot root, viruses and little opportunity to market or sell these Pierce's disease hybrid grapes.

Lethal bronzing disease
Pest (Phytoplasma)
Crops: Specific Palm species

Drooping dead leaves from homeowner's Phoenix sp. palm.

The disease now known as lethal bronzing disease of palms (Bahder and Helmick 2018) was previously known as date palm lethal decline or Texas Phoenix palm decline. The causative phytoplasmas of lethal bronzing is a member of 16S rDNA RFLP group 16SrIV, subgroup D (16SrIV-D) (Bahder and Helmick 2018), which is detectable only using molecular tests. The disease is believed to have first appeared in the Lower Rio Grande Valley, Texas area in the late 1970s, and sporadic outbreaks have occurred in other parts of the state as well (Giesbrecht et al. 2014). Symptoms due to lethal bronzing occurs progressively and consists of yellow, rotted and loose leaves and fruit, with the fruits dropping prior to their maturation. Extensive root decay also occurs making the palm susceptible to environmental stresses. Lethal bronzing affects several palms species, including *Phoenix* spp., *Syagrus romanzoffiana*, and *Sabal palmetto* and its occurrence have been reported from multiple counties in Texas, including Bexar, Cameron, Harris, Hidalgo, Kleberg, Nueces, and Willacy counties. The disease is mainly transmitted via movement of infected palms. Phytoplasmas in general are also transmissible by planthoppers and leafhoppers but the specific vector for lethal bronzing disease is yet to be determined. Once infected, there is no cure for the disease hence the primary control measure is to avoid introducing the disease into the landscape. To this end, it is important to comply with quarantine regulations enacted by the Texas Department of Agriculture to prevent its spread. The preventative injection of antibiotics such as oxytetracycline-hydrochloride may help reduce the risk of infection but has no curative effect.

Cucurbit yellowing diseases
Pest (viral)
Crops: Specific to honeydew and cantaloupe

Yellowing of older leaves vs. younger leaves.

In the fall of 1999, general yellowing symptoms of the older leaves were observed in whitefly infested cantaloupe (muskmelon) and honeydew melon fields in the Lower Rio Grande Valley that were part of a new geminivirus complex (Brown et al. 2000). Extremely large populations of the sweet potato whitefly, *Bemisia tabaci* B-biotype, have been observed in the Rio Grande Valley since the fall of 1990 severely impacting the cucurbit industry throughout the entire 1990's (Anciso and Kern 1992). In addition to devasting numbers of whiteflies causing plant stunting and death, unusual symptoms on vegetables were observed such phytotoxemias or virus-like symptoms on numerous whitefly-infested vegetables (Anciso 1992). Prior to 1999, the only New World whitefly transmitted begomovirus (geminivirus) was *Squash leaf curl virus* but this caused a yellowing and mottling of the newer younger leaves and had been found in watermelon and squash in the desert southwest of the US and Texas in the early 1990's with the arrival of the sweet potato B-biotype whitefly. The *Cucurbit leaf curl virus* was a new previously undescribed bipartite begomovirus of cucurbits that was found to be causing new problems in pumpkin, cantaloupes and honeydew fields in Arizona, Mexico and Texas. There are no known cantaloupe and honeydew cultivars that are resistant to the virus so careful management of the sweet potato whitefly is recommended. Other viruses recently documented from diseased cucurbit fields include watermelon crinkle leaf-associated virus 1 (WCLaV-1) and WCLaV-2 infecting watermelon (*Citrullus lanatus*) (Hernandez et al. 2021a), *Squash vein yellowing virus* infecting butternut squash (*Cucurbita moschata*) (Hernandez et al. 2021b), and cucurbit chlorotic yellows virus (CCYV) infecting cantaloupe (*Cucumis melo*) (Hernandez et al. 2021b). Most of these viruses occur in mixed infections. Approximately 200 acres of cantaloupes and honeydew melons can be at risk in the Lower Rio Grande Valley and is more troublesome in fall plantings rather than spring plantings because of higher whitefly populations.

Okra yellow mosaic Begomoviruses complex
Pest (viral)
Crop: Okra

Yellow mosaic symptoms on okra.

Okra is an important fresh and processing market vegetable crop in southern Texas, United States. A few fungal diseases such as Fusarium wilt, cotton root rot, charcoal rot, etc. were documented for okra in the Texas Plant Disease Handbook but none of them appear to a major production constraint in south Texas. During fall 2018, an investigation was conducted to identify the associated agent(s) of a virus-like disease outbreak on a 4.9-ha okra (cv. Clemson Spineless) farm in Hidalgo Co., Texas. The symptoms consisted of yellow mosaic, bleaching, and vein-clearing of the leaves and total crop loss was recorded due to a 100% disease incidence which occurred by the middle of the growing season. The disease was also observed on the same field during spring 2019. An analysis of symptomatic plants collected during both seasons implicated a mixed infection of two exotic whitefly vectored begomoviruses, the monopartite cotton leaf curl Gezira virus (CLCuGeV) and the bipartite okra yellow mosaic Mexico virus (OkYMMV), in the disease

(Villegas et al. 2019). CLCuGV was also found along with its associated DNA satellite molecules, i.e., cotton leaf curl Gezira alphasatellite (CLCuGeA) and cotton leaf curl Gezira betasatellite (CLCuGeB). Whereas OkYMMV had been reported previously reported from okra plants in Texas (Hernandez-Zepeda et al. 2010), CLCuGV and its satellite DNA molecules, which are endemic to some countries in Africa and the Middle East appear to have been recently introduced into the state. Since there is no known resistance to this begomovirus complex in okra and other malvaceous host plants, their management will have to rely on the use of chemical and cultural control tactics to reduce whitefly populations and avoid their infestation periods. Approximately 100 acres are grown in the LRGV several thousand acres grown across the Rio Grande River for processors in the LRGV.

Papaya ringspot disease
Pest (viral)

Symptoms of PRSV-W on zucchini squash fruits (left photo) and PRSV-P on papaya fruit (right photo).

Crops: Papaya, Cucurbits, Peppers

Papaya ringspot disease, caused by papaya ringspot virus (PRSV), is the most serious disease of papaya globally (Fermin et al. 2015). PRSV has a worldwide distribution and two major host-specific strains of the virus have been described. These are PRSV-P (type P) and PRSV-W (type W), which mainly infects members of the *Caricaceae* and cucurbits, respectively. Other hosts of PRSV include peppers, amaranths, etc. PRSV induces diagnostic chlorotic rings on leaves and fruits of infected plants in addition to other symptoms such as chlorosis, mosaic patterns, vein clearing, leaf distortion, etc. Both PRSV types are non-persistently transmitted by several aphid species and their management relies primarily on the use of cross protection and transgenic resistance since effective natural genetic resistance against the virus is lacking (Gonsalves 1998). During a recent investigation into the etiology of a severe disease outbreak on a 50-ha commercial papaya orchard planted with variety Red Maradol in Hidalgo Co., Texas, implicated the mixed infection of PRSV and two other viruses with the outbreak (Alabi et al. 2016). Further analysis revealed that the PRSV isolates involved in the disease outbreak was a resistance breaking strain of PRSV-P (Alabi et al. (2017). This outbreak caused the affected plants to be stunted, have reduced or no fruit set, poor fruit quality, and eventually led to the abandonment of the crop. The same virus combination was responsible for a separate disease outbreak in another papaya field in Hidalgo Co. in 2018, also devastating the crop.

Tomato yellow leaf curl disease
Pest (viral)

Severe curling of young tomato leaves due to TYLCD.

Crops: Papaya, Tomato, Peppers

Tomato yellow leaf curl disease (TYLCD), caused by several tomato yellow leaf curl viruses (TYLCVs), is a yield-limiting disease of tomatoes and other solanaceous crops. It is believed that TYLCD is responsible for the decline in the tomato acreage in Texas, particularly in the Rio Grande Valley production area. Symptoms due to the whitefly transmitted TYLCVs include reduced leaf size, upward leaf curl, flower abscission, stunted growth, small unmarketable fruit, or no fruit production. The first record of TYLCV occurrence in Texas was made in 2007 in two transplant production areas, with materials from these facilities already shipped to other counties across the state prior to the virus diagnosis (Isakeit et al. 2007). More recently, the natural occurrence of TYLCV was detected in papaya for the first-time during investigations conducted to unravel the etiology of a severe disease outbreak in a Texas papaya orchard (Alabi et al. 2016, 2017). The results of this latter study showed that the genome of the papaya-infecting TYLCV-IL is relatively more diverged from the tomato-infecting isolate of the virus described earlier in 2007 (Isakeit et al. 2007). The TYLCV-IL isolate, introduced into Texas, has been linked to recent devastating outbreaks globally and is reported to be efficiently transmitted by whiteflies. TYLCD management relies on successful control of the whitefly vector using a combination of chemical control, use of tolerant/resistance varieties, and cultural practices such as adjustment of planting dates to avoid periods of heavy whitefly infestations, use of reflective mulches, rouging of alternative weed host of the virus, and the practice of host-free period.

Grapevine nepoviruses complex
Pest (viral)

Foliar discoloration and uneven ripening of grape cv. Merlot vine due to TRSV.

Crop: Wine grapes

The soilborne nepoviruses are a group of nematode transmitted pathogens that are serious economic pests of grapevine. Whereas some such as the grapevine fanleaf virus (GFLV) are specific pathogens of grapes, others such as tobacco ringspot virus (TRSV) have very broad host range that includes both annual and perennial plants. The primary symptoms on grapes due to nepoviruses include stunted vines, mosaic and chlorosis of leaves, shortened vine internodes, uneven and irregularly sized berries, and overall decline of the vine with time. Both red-fruited and white-fruited grape varieties are susceptible to infection by nepoviruses. During statewide surveys conducted to document the occurrence and distribution of viruses in Texas vineyards, sampled vines of the interspecific hybrid bunch grape cultivar Blanc du Bois (*Vitis* spp.: 'Florida D 6-148' × 'Cardinal') with symptoms of leaf deformation, chlorotic specks, stunted shoots, and general decline in a vineyard block located in Hidalgo Co., Texas (McBride et al. 2017). Molecular tests performed on these vines revealed that they were positive for TRSV, representing the first report of the virus in Texas wine grapes and the first documentation of its occurrence in Blanc du Bois cultivar (McBride et al. 2017). The most effective strategy for the management of nepoviruses is the propagation of clean virus-tested materials. It is also important to use virus resistant scion or rootstock cultivars where available. Although soil fumigation against the nematode vectors of nepoviruses are feasible, they are not very effective due to the ability of dagger nematodes to migrate deep into the soil beyond the reach of the fumigants.

DISCUSSION

Of the twelve diseases in the review, five were viral, three bacterial, three fungal and one phytoplasma in origin. The early 2000's indicated the increased problems being caused by new and old bacterial pathogens as well as newly evolved or newly detected viral pathogens. The identification of the new *Candidatus* Liberibacter species problems being transmitted by insect vectors brought its challenges in identification and management. Long known bacterial pathogens such as *Xanthomonas* species became also quite difficult to manage. Long known viral pathogens were found on previously unknown hosts and more diverged than previously detected sister viruses. Soilborne fungal diseases continue to be as difficult to manage as they have been in the 20th century. New methodologies and techniques have certainly helped in the rapid detection of these particular viral and bacterial pathogens, but this is most evident with phytoplasmas as only molecular techniques are the only way to help identify and understand these plant pathogens.

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