

SATSUMA CULTIVAR SUSCEPTIBILITY TO CITRUS CANCKER CAUSED BY

Xanthomonas axonopodis pv. *citri*



CITRUS IS THE MOST POPULAR FRUIT TREE GROWN COMMERCIALY AND IN HOME BACKYARDS IN LOUISIANA.

Satsumas dominated citrus production, with 63% of total citrus acreage. In 2018, 183,408 bushels of satsumas were produced in the state with a total gross farm value of \$6.2 million (Louisiana Summary Agriculture and Natural Resources 2018).

During the past decade, satsuma production drastically reduced by 54,526 bushels, which is attributed to diseases and natural disasters. After Hurricane Katrina in 2005, Louisiana lost the majority of its citrus industry, and the total acreage was greatly reduced. In 2008 and 2010, citrus greening and sweet orange scab were confirmed in the state for the first time (Hummel and Ferrin, 2010; Singh and Ferrin, 2011). In June of 2013, citrus canker (Figure 1) was reconfirmed in the state for a second time in Orleans Parish (Singh, 2013). The disease was first reported in Louisiana in 1914 (Loucks, 1934) and considered eradicated in 1940 (Dopson, 1964). Since 2013, citrus canker has been spreading rapidly to all commercial and backyard citrus production areas in the state. Currently, citrus canker is reported from 10 Louisiana parishes, including Plaquemines, where the majority of commercial citrus is grown (Louisiana Department of Agriculture and Forestry Cooperative Agriculture Pest Survey Report 2019).

All citrus varieties are susceptible to citrus canker, although some varieties are less susceptible than others. Copper-based fungicides may suppress the disease but not control it. No bactericides have been labeled to use on citrus to manage citrus canker in Louisiana. Without effective management options, citrus canker has the potential to adversely affect the survival of Louisiana's valuable citrus industry. Therefore, it is critical to develop alternate methods to mitigate the spread of citrus canker in the state. One of the alternate methods is to discover satsuma cultivars that are highly tolerant and can withstand high disease pressure in our canker-conducive environment.

The results from an annual citrus cooperative agricultural pest survey (CAPS) conducted by the LSU AgCenter and LDAF from 2014-2016 revealed that satsumas are highly tolerant to citrus canker, with only 2.5% disease incidence. In some situations, the satsuma samples were collected from trees planted in the same backyard with heavily infested grapefruit, Meyer lemons, navel oranges and other citrus varieties. The survey lacked data on types of satsuma cultivars that were sampled. The cultivar susceptibility data plays a critical role when promoting different types of satsumas to commercial and backyard growers in canker-infested areas. The objective of this study was to screen the susceptibility of satsuma cultivars against citrus canker under natural disease inoculum conditions.



Figure 1: Citrus canker lesions present on the upper leaf surface of a grapefruit tree (source of natural citrus canker bacterium).

Five cultivars of satsuma, including Brown's Select, LA Early, Miho, Owari, and St. Ann, were screened along with three citrus varieties with known varying degrees of susceptibility to citrus canker disease. These ranged from a highly susceptible (HS) Ruby Red grapefruit, a moderately susceptible (MS) Hamlin sweet orange and a least susceptible (LS) sweet kumquat. Trees that were 18 months old and grown in 3-gallon pots were placed under diseased mature grapefruit trees at a public garden in New Orleans and a commercial citrus orchard in Paulina. The study was conducted during 2018 and 2019 growing periods at both experimental sites.

The disease onset among the five satsumas varied at both New Orleans and Paulina sites during 2018 and 2019, but Brown's Select, Miho and Owari satsumas had consistently delayed onsets of citrus canker, with only 20% of incidence within weeks two and three after experimental trees were placed (Figure 2). Miho had an additional delayed disease onset that extended into week four, with only 20% disease incidence in 2019 in Paulina. Similarly, Owari satsumas developed canker lesions during week five at the New Orleans site, with 20% disease incidence. LA Early and St. Ann satsumas were highly inconsistent in getting infected with citrus canker. The highly susceptible Ruby Red grapefruit and moderately susceptible Hamlin sweet orange had a large number of trees getting infected early during the screening periods (Figure 2).

In a New Orleans public garden (grapefruit trees planted in a courtyard surrounded by brick wall), the satsuma cultivars Miho and Brown's Select showed the lowest average number of lesions

in both years (Table 1) and a delayed disease onset compared with the other satsuma cultivars (Figure 3). Miho, for instance, never developed citrus canker symptoms after the three-week period in which the experimental trees were placed. In an open orchard in Paulina, Miho and St. Ann had the lowest average number of lesions per leaf in the two years of evaluation (Table 1), and Miho exhibited delayed onset of disease (Figure 3). The cultivars Brown's Select and Miho in New Orleans had the smallest numbers of 3.07 and 0.21 lesions per leaf, respectively. In Paulina the satsuma cultivars with the lowest number of lesions per leaf were observed on St. Ann (0.49 lesions per leaf) and Miho (1.69 lesions per leaf) (Table 1).

The disease pressure on mature grapefruit trees at New Orleans and Paulina was 100% during both years, and the weather conditions were conducive for canker at both sites. Despite the high disease pressure and weather conditions, satsumas Brown's select, Miho and Owari performed best and had less disease with delayed onset of symptoms.

The size of the canker lesion is also an important predictive parameter on canker impact and spread. Lesions on leaves and twigs are probably the most epidemiologically significant inoculum for secondary infections, as canker lesions remain active for many months and the bacteria produced on lesions are dispersed by water splashes, resulting in infection and further production of more canker lesions. In this study, the difference in canker lesion size among the five satsumas cultivars was observed in New Orleans but not in Paulina (Figure 4).

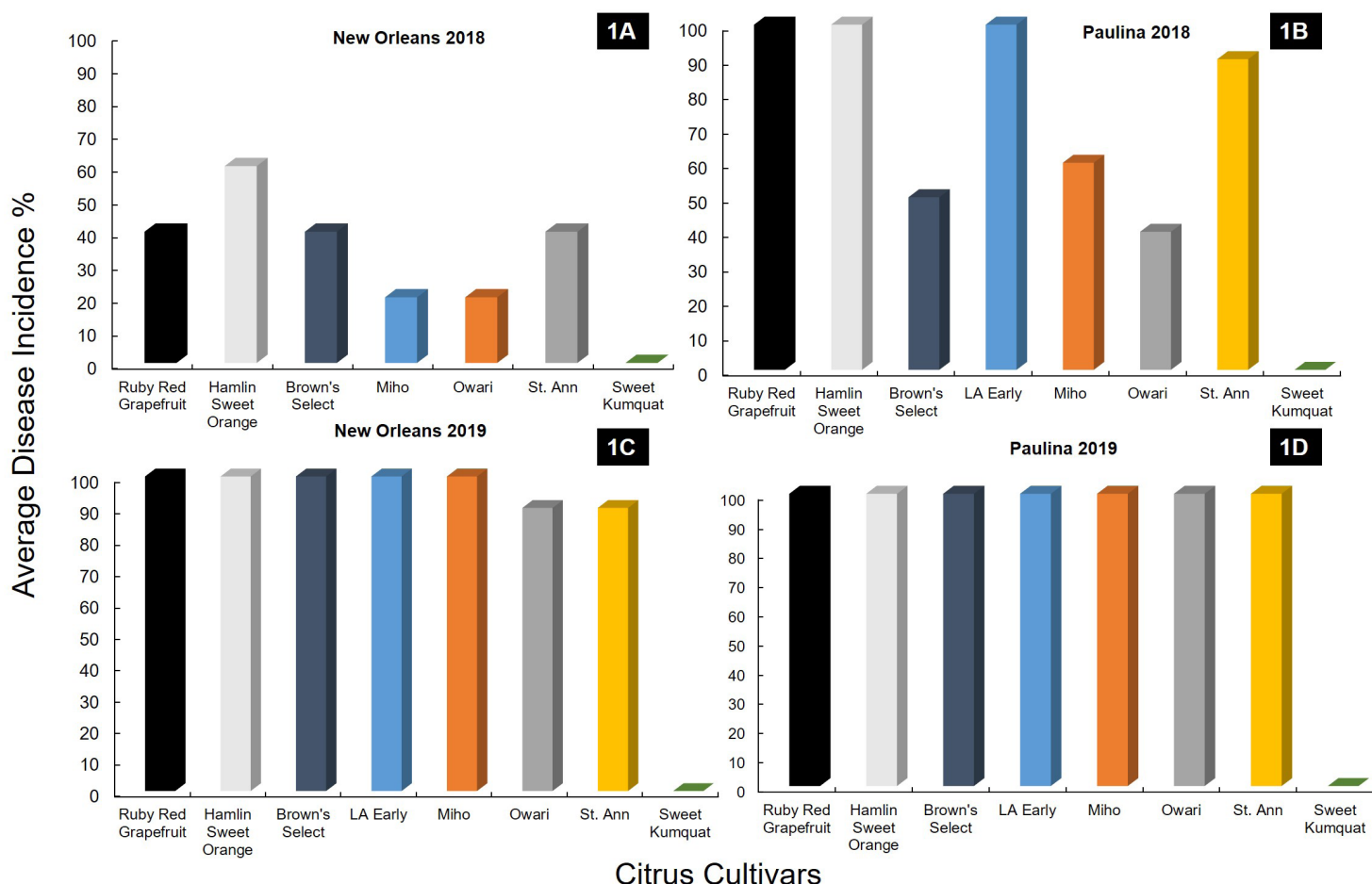


Figure 2: Disease incidence showed as mean percentage of experimental screened citrus cultivars trees infected with citrus canker at the end of the experiment in New Orleans (1A and 1C) and Paulina (1B and 1D) during 2018 and 2019, respectively.

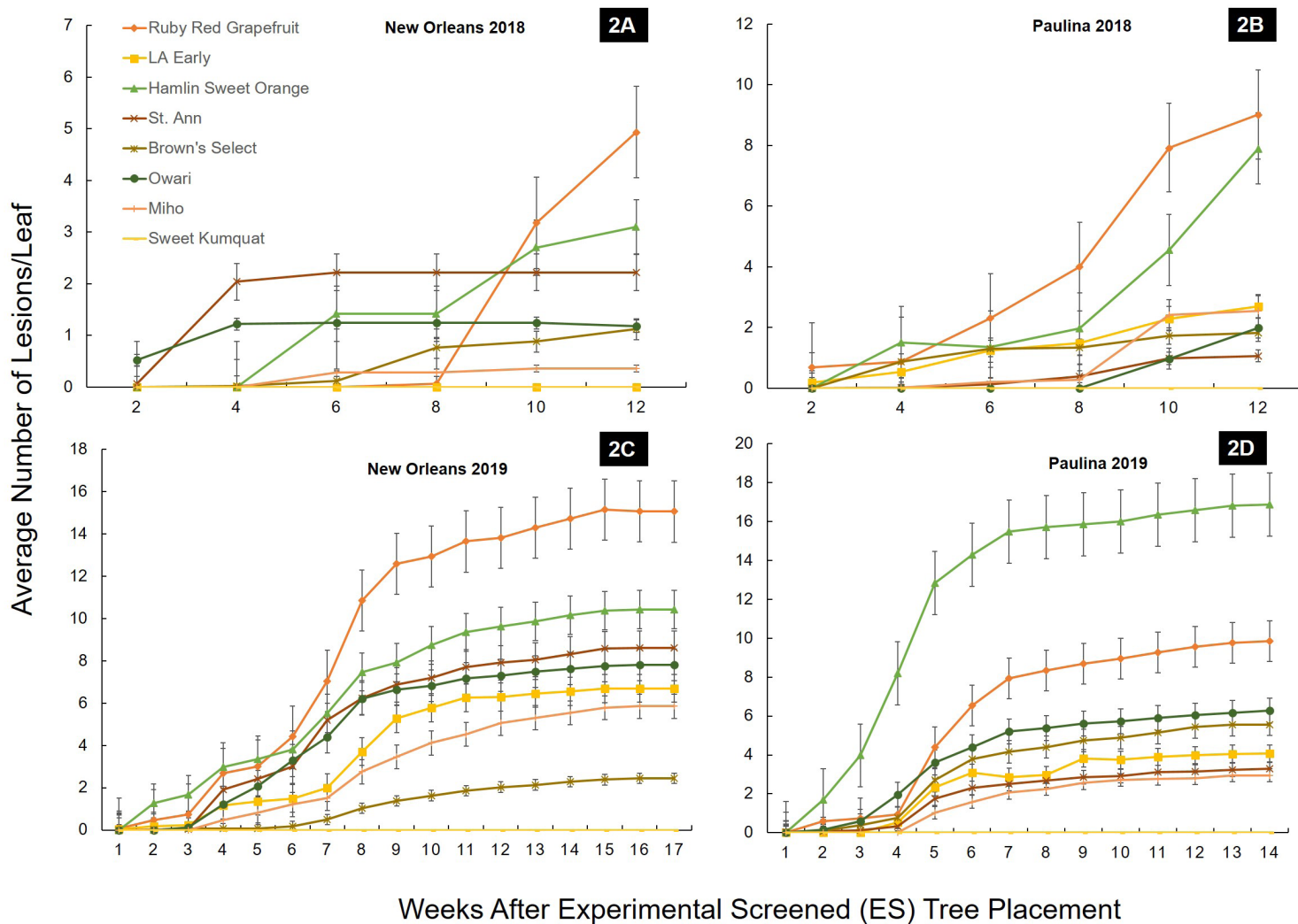


Figure 3: Disease severity expressed as the average number of citrus canker lesions per leaf on experimental screened citrus cultivars trees in New Orleans (2A and 2C) and Paulina (2B and 2D) during 2018 and 2019 screening period, respectively.

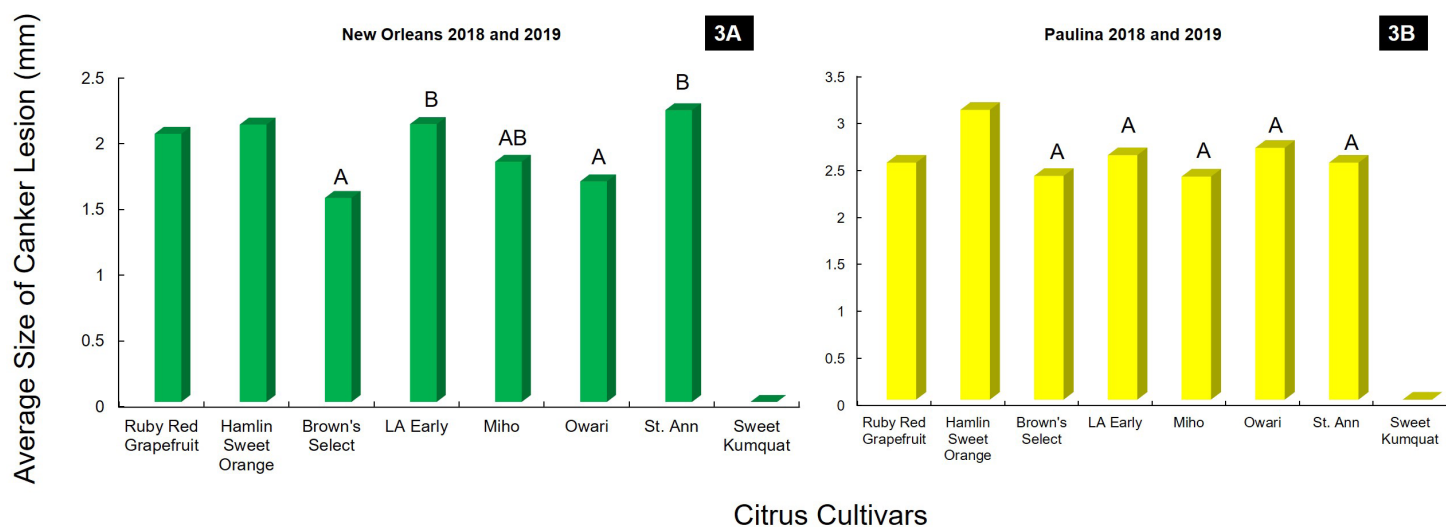


Figure 4: Average diameter in millimeters of citrus canker lesions on experimental screened citrus cultivars trees in New Orleans (3A) and Paulina (3B) during 2018 and 2019 screening period, respectively.

Table 1. Mean number of citrus canker lesions per leaf in experimental citrus cultivars trees in New Orleans and Paulina during 2018 and 2019.

	2018		2019	
	New Orleans	Paulina	New Orleans	Paulina
Ruby Red grapefruit (HS)	1.36	4.14	9.2	6.11
Hamlin sweet orange (MS)	1.44	2.88	6.64	11.64
Brown's Select	0.48 AB	1.17 C	1.20 A	3.41 AB
LA Early	-	1.40 C	3.93 B	2.52 AB
Miho	0.21 A	0.90 B	3.07 AB	1.69 A
Owari	1.10 BC	0.49 A	4.92 B	4.07 B
St. Ann	1.75 D	0.43 A	5.34 B	2.02 A
Sweet kumquat (LS)	0.0	0.0	0.0	0.0

Means followed by different letters in the column are different by Tukey's HSD test at 5%. Comparisons were made among the five satsuma cultivars only.

In Louisiana, environmental conditions are optimal for citrus canker development, and a lack of effective chemicals to manage the disease pose a continuous challenge for citrus growers. The popularity of growing satsumas in Louisiana orchards and backyard gardens may help reduce the disease spread and development. This study provides field-based scientific evidence that Brown's Select, Miho and Owari consistently had less disease severity with delayed incidence and, therefore, categorized as less susceptible to citrus canker compared to LA Early, St. Ann, Hamlin sweet orange and Ruby Red grapefruit. Additionally, the smaller lesion size on both Brown's Select and Miho may result in lesser canker inoculum production for secondary infections. Louisiana growers must incorporate these satsumas in their future plantings as an alternate citrus canker management strategy.

Furthermore, in addition to the satsuma cultivar susceptibility data, this study provides the field-based data on sweet kumquat resistance to citrus canker. This information can be readily incorporated into citrus hybrids by conventional breeding.

In conclusion, this study provides valuable and reliable field-based scientific information on satsuma susceptibility to citrus canker in Louisiana, which can help the growers select lesser susceptible cultivar to mitigate this high impact disease.

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Authors:

Raj Singh, LSU AgCenter Associate Professor and Director, Horticulture Pathology Extension Specialist
Monique De Souza, Research Associate, Plant Diagnostic Center, Plant Pathology and Crop Physiology.

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William B. Richardson, LSU Vice President for Agriculture

Louisiana State University Agricultural Center, Louisiana Agricultural Experiment Station, Louisiana Cooperative Extension Service, LSU College of Agriculture