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Addressing the Threat Posed by Fusarium Wilt of Lettuce to Florida in an Attempt to Limit Its Spread

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Fusarium wilt of lettuce is caused by the fungal pathogen *Fusarium oxysporum* f. sp. *lactucae*. The disease was first reported in the U.S. in 1990, and is now widespread in California and Arizona. In 2016, symptomatic plants displaying vascular discoloration and wilting were observed in Florida for the first time and the disease was confirmed. Capable of being seed-borne, it is suspected that the pathogen arrived on infected seed. The climatic conditions and histosols of the Everglades Agricultural Area (EAA), Florida's major lettuce growing region, have supported the survival of numerous Fusarium pathogens over the years and there is fear that the lettuce wilt pathogen will likewise thrive. In response, University of Florida research and extension personnel are working with scouts and the lettuce industry to examine prospects for host-plant resistance in Florida adapted varieties, fungicidal control, sanitation procedures, and cultural controls to slow the spread of Fusarium wilt. Pathogen isolates are being collected for pathotyping and records are being kept regarding geographical distribution throughout the EAA. To better understand the scope of this threat, a grower workshop was held to educate all aspects of the industry. Steve Koike, former Farm Advisor with the University of California at Salinas, was an invited expert speaking on the current status of *Fusarium* wilt on lettuce in the western U.S. Following such extension outreach efforts, growers are now trained to be part of the solution in the collective effort to prevent *Fusarium* wilt from devastating Florida's Lettuce Industry.

Florida's Lettuce Industry

Lettuce (*Lactuca sativa*), a member of the sunflower family Asteraceae, was originally cultivated from its wild parent thousands of years ago in ancient Egypt (Harlan, 1986). This cool season crop is valued as a source of vitamins A and K with a good amount of C, some B vitamins, and other phytonutrients (Bunning and Kendall 2012). According to USDA estimates, Americans consumed an average of 24.5 lb annually per capita from 2012–15 (USDA–ERS Dietary Assessment, 2016). This steady demand benefits Florida's lettuce industry, valued at $70 million (Rockey, 2018). With a typical commercial production season beginning with late September plantings and a final harvest in May, Florida's 15,000 acres ranks third behind only California and Arizona as the largest producers of lettuce in the country (USDA Vegetables Summary, 2017). Florida's commercial lettuce producers are concentrated in the western part of Palm Beach County known as the Everglades Agricultural Area (EAA). This region, just south of Lake Okeechobee, possesses fertile soil, rich in organic matter.

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Environmental Influences on the Primary Diseases of Florida Lettuce

South Florida's sub-tropical environment makes it a relatively good location for lettuce production during the fall, winter, and spring months. Progressing toward summer, rain showers become more frequent and high temperatures ranging from the upper 80s to the mid-90s °F trigger the crop to bolt, putting an end to the lettuce growing season. Growers time the late-September planting season to coincide with the end of summer and the coming of cooler fall temperatures and fewer rain events. Though becoming less persistent than during the summer, thunderstorms and heat remain influencing factors for disease development for months to come. The Atlantic hurricane season remains active until 1 Dec.; more intense tropical weather events are typically more frequent during September and October. Consequently, disease activity can be quite severe during these initial weeks and months of the lettuce-growing season because of high humidity, temperatures, and rainfall.

Wet soil conditions, high humidity, and warm temperatures are serious threats to newly emerging seedlings as they may succumb to damping-off, whose characteristic symptom is a constriction of the succulent stem often associated with necrosis at or just below the soil line. This girdling of the stem results in wilting

and is most commonly the result of infections by *Pythium* spp. or *Rhizoctonia solani*. Once the lettuce plant has outgrown the tender seedling stage, *Pythium* is no longer a threat to the crop but *Rhizoctonia* may remain active on leaves touching the soil's surface resulting in the development of bottom rot. Symptoms of this disease include sunken reddish-brown lesions on the leaves and midribs of the most mature foliage. As bottom rot progresses, necrosis of infected plant parts occurs, becoming somewhat slimy and eventually collapsing the developing plant. Corky root rot, caused by *Rhizomonas suberifaciens* is another disease favored by warm temperatures which results in stunted chlorotic plants. This bacterium causes a somewhat dry necrosis of the feeder roots and cortical area resulting in cracking of the root system.

Cercospora leaf spot is another lettuce disease favored by the warm temperatures and high humidity that characterize the start of Florida's lettuce growing season. Symptoms of this disease, caused by the fungus *Cersospora longissimi*, manifest as tan-colored, circular lesions on the foliage. *Xanthomonas campestris* pv. *vitians* also causes leaf spots, but is most commonly encountered during periods of cool wet weather. The resulting lesions are also distinctly different from that of fungal pathogens. Bacterial leaf spot of lettuce results in very dark, water-soaked leaf spots delineated by veins and often surrounded by a yellow margin. A third commonly encountered leaf spot disease is lettuce downy mildew caused by the fungus *Bremia lactuacae*. Cool moist weather also favors this pathogen, which causes chlorotic angular lesions, often exhibiting white sporulation on the lower leaf surface. As the disease progresses, the leaf spots coalesce and become necrotic. Lettuce drop caused by *Sclerotinia sclerotiorum* is also favored by cool, wet conditions, but symptoms result in a crown rot followed by wilting and death of the plant. The mycelia often associated with lettuce drop symptoms are thick and cottony white, whereas those of bottom rot are thin, sparse, and light to brown colored.

Local growers, scouts, and crop consultants are well schooled in recognizing symptoms of the most common lettuce diseases in the EAA thanks, in part, to the biannual Lettuce Advisory Committee meetings, which feature faculty updates and recommendations for pest management. In 2016 however, local lettuce scouts became suspicious of young stunted plants wilting, becoming chlorotic, and frequently dying (Fig. 1). Upon closer inspection, they observed no necrosis of the tap or feeder roots and detected no crown rot. Examination of the root system did however reveal vascular discoloration and necrosis (Fig. 2). Plant samples were brought to the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) Everglades Research and Education Center (EREC), where they were examined by Richard Raid, Professor of Plant Pathology. He was the first to dissect the root systems of the suspect plants and recognize the red-brown coloration as similar to that caused by *Fusarium spp*. on other crops (Fig. 3). In his 30 years of local experience, this was the first time he had encountered these symptoms in lettuce from the EAA. Confirmation came with microscopic observations of media-plated plant samples yielding characteristic microconidia, macroconidia, and chlamydospores (Matheron and Koike, 2003).

Fig. 1. *Fusarium* wilt symptoms on Florida lettuce (photo by Richard Raid, 2016).

Fig. 2. Vascular discoloration of early *Fusarium* wilt symptoms on Florida lettuce (photo by Richard Raid, 2016).

Fig. 3. Vascular discoloration and necrosis from *Fusarium* wilt on lettuce in Florida (photo by Richard Raid, 2016).

UF/IFAS Research and Extension Response to Fusarium Wilt of Lettuce

Though *Fusarium* wilt of lettuce was initially reported in the United States in 1990 and is currently widespread throughout the lettuce growing regions of California and Arizona, the 2016 finding in the EAA was a Florida first. As a result, UF/IFAS research and extension personnel notified area growers of the new threat to the local lettuce industry and gave recommendations to mitigate spread of the inoculum. Arrangements were also made

for an experienced expert from California to come to Florida and be the keynote speaker at an educational grower meeting. The following season, Steve Koike, former Farm Advisor with University of California Cooperative Extension addressed a group of 74 representatives of Florida's lettuce industry and explained the current state of *Fusarium* wilt of lettuce in the western United States.

Florida lettuce growers learned the *Fusarium* wilt inoculum likely initially arrived on contaminated seed and can be easily spread with infested soil and plant material. Successful long-term management of this disease will eventually come from breeding locally adapted lettuce cultivars with resistance to the pathogen since there are no known effective pesticides. UF/IFAS EREC researchers are currently exploring lettuce genes for resistance but a viable cultivar for adoption in south Florida is likely years in the making.

Recommendations for Fusarium Wilt of Lettuce

The main goal at this time is to minimize the movement of the pathogen from locations where the *Fusarium* wilt pathogen was initially detected in the EAA. Abiding by good cultural practices that focus on sanitation is currently the best recommendation. Growers are advised to clean tools and equipment after use in a contaminated field. They can also benefit from starting with pathogen-free seed. If they have a choice of planting time and location, they should consider waiting until the cooler winter months to plant in contaminated fields since the pathogen is less active then. Though *Fusarium* spp. can enter plants through natural openings, growers should also advise their workers to minimize damage to root systems since the fungus can penetrate plants via wounds as well. Timely incorporation of plant residues into the soil and crop rotation are additional cultural practices to implement. Literature shows however that *Fusarium oxysporum* f. sp. *lactucae* can asymptomatically survive on other hosts including melons, tomato, broccoli, spinach, cauliflower, and cotton (McAvoy, 2018). Total removal of contaminated soil is impossible, it is hoped that these recommendations slow the spread of inoculum and new locally adapted varieties with resistance or tolerance to the disease can be developed.

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