DEPUTY CHIEF CONSULTANT
VICTOR FRANCOVICH
COMMITTEE SECRETARY
NICOLE WILLIS

Assembly
California Legislature

STATE CAPITOL
P.O. BOX 942849
SACRAMENTO, CA 94249-0089
(916) 319-2084
FAX: (916) 319-2184

ASSEMBLY COMMITTEE ON AGRICULTURE
ROBERT RIVAS, CHAIR
ASSEMBLYMEMBER, THIRTIETH DISTRICT

Impatiens Necrotic Spot Orthotospovirus, Pythium Wilt and other Leafy Green Plant Diseases

Wednesday, December 1, 2021
2:30– 4:30 p.m.
State Capitol, Room 4202

Overview

California's Monterey County is known as "the Salad Bowl of the World." In 2020, leafy greens, including leaf and head lettuce, cabbages, spinach, and kale, were the number one crop in Monterey County, valued at over $1.1 billion. Leafy greens add to California's economy and supply the state and the U.S. with nutrient-rich food.

Last year, California's agriculture industry faced many problems, including wildfires, drought, and the ongoing COVID-19 pandemic. Another challenge this season has been the multi-million dollar decline in leafy greens production caused by infected plants. Currently, diseases like Pythium wilt, which infects the roots of different lettuce plants, and Impatiens Necrotic Spot Virus (INSV), which causes damage to plants, have destroyed many crops is the Salinas Valley. Researchers say that the diseases are not dangerous to humans.

Leafy Green Diseases

Pythium wilt is caused by Pythium uncinulatum. The pathogen produces swimming zoospores that allow it to move in the soil and spread via surface or sub-surface water flow. The pathogen also produces a sexual spore (oospore) encased within a spiny outer covering. Pythium uncinulatum is host specific to lettuce and apparently does not infect other vegetable crops such as broccoli, cabbage, carrot, onion, pepper, radish, spinach, or tomato. Pythium wilt disease has become the main root rot problem on coastal California lettuce. First found in the Salinas Valley in 2011 on only two ranches, this disease is now present in numerous fields throughout this coastal region.

The genus name Tospovirus was derived from tomato spotted wilt virus (TSWV), which was first described in Australia in 1915. In the late 1980s, a significant new virus disease problem began to develop in the greenhouse floriculture industry. Symptoms were very typical for TSWV: stunting, necrotic and chlorotic spotting, stem cankers, line patterns, and ring spots. Initially, it was designated TSWV-I (Impatiens strain) but later characterized as a separate virus and named INSV. Both TWSV and INSV are vectored primarily by western flower thrips (thrips) in California and have a wide host range.

In 2006, and continuing through today, severe outbreaks of disease caused by INSV have affected the coastal lettuce crop in Monterey, San Benito, Santa Cruz, San Luis Obispo, and Santa Barbara counties. Lettuce growers suffered substantial economic losses and populations of western flower thrips are large and difficult to control. All types of lettuce are susceptible including iceberg, butterhead, romaine, and leaf lettuces. Spinach grown in Salinas is also affected. Lettuce production in coastal California is regularly affected by outbreaks of INSV. Transmission of INSV among lettuce crops in this growing region, attributed predominantly to the thrips. The virus replicates within the insect vector and is transmitted to new plants by adult thrips as they feed on susceptible host plants. All currently grown cultivars of lettuce are susceptible to the disease. Screening lettuce for resistance to INSV under field conditions is problematic because natural infections appear sporadically, and the virus is not evenly distributed across infected fields.

Current management of INSV is to get rid of any vectors that may carry the disease. However, only insecticide can destroy vectors. Another acceptable method would be resistance plants, which would kill off any infected cells and prevent the virus' spread. Furthermore, greater distance between plants could help mitigate the spread of the disease. This can be done by controlling weeds and thrips, the most common vector transmission. Chemical controls of herbicides and insecticides can be implemented and are the best form of control.

Earlier this year the California Department of Food and Agriculture proposed increasing the pest rating for INSV due to its high economic and environmental impact on the leafy greens agriculture products. More research on prevention and eradication is needed to confront the increased economic and ecological threat due to INSV and other leafy green pests and diseases. This year's budget allotted a $1 million investment to the California Leafy Greens Research Program within the Department of Food and Agriculture to provide grants to study the INSV/PW epidemic in Monterey County.

Funding for Pest Disease and Prevention

In California, research and funding have increased to combat the threat of other pests and diseases affecting major crops. Winegrape producers and citrus growers have tackled

the issue with a combination of funding from growers and state and federal sources, as described below:

> Pierce's disease (PD) is a lethal disease of grapevines, spread by the glassy-winged sharpshooter (GWSS). GWSS spread in California in the 1980s and 1990s created a new and serious threat of significant statewide damage. In response, new legislation was passed to allow winegrape growers the ability to assess themselves and fund research to prevent the spread of PD. Winegrape grower basement is three dollars for each one thousand dollars' worth of wine grapes produced. The 2018-19 Pierce's Disease Control Program (PDCP) budget was $20.1 million. The funds came from the federal USDA ($15 million, CDFA general funds ($1.7 million) and winegrape growers ($3 million). Over 20 years, PDCP has funded 225 research grants, containment efforts, testing, statewide surveys and detection, and educational outreach programs.
>
> In 2008 Huanglongbing (HLB) and its vector, the Asian citrus psyllid (ACP), were discovered in California. After a 2005 discovery in Florida, it took only two years for HLB to transmit to all 32 Florida citrus-producing counties and infect over half of the citrus trees in that state. The threat of HLB prompted citrus growers to create, through legislation, California Citrus Pest and Disease Prevention Program (CCPDP). In 2016, CCPDP increased the self-assessment to $0.12 per 40-lb. carton of citrus. For the 2020-2021 budget year, the CCPDP had a budget of nearly $40 million. The funds came from USDA ($14 million), CDFA ($5 million) and citrus growers ($20 million). In the past 10 years, CCPDP funded numerous research grants, containment efforts, testing, statewide surveys and detection, and educational outreach programs.

The California Department of Food and Agriculture (CDFA) conducts an annual competitive solicitation process to award Specialty Crop Block Grant Program (SCBGP) funds to projects that enhance the competitiveness of California specialty crops. Specialty crops are fruits, vegetables, tree nuts, dried fruits, and horticulture and nursery crops (including floriculture). For 2021, SCBGP awarded 14 grant that worked on various agriculture pest and diseases. The average grant in this category was $366,000.

SALINAS VALLEY AGRICULTURE
Highlighting agricultural developments, problems, research, & issues for central coast CA

Observations of Pythium and INSV Infections in Lettuce Fields

Published on: September 23, 20

Authors: Richard Smith, JP Dundore Arias, Daniel Hasegawa and Steve Koike

Farm Advisor, UCCE Monterey; Plant Pathology Professor, Cal State Monterey Bay; Research Entomologist, USDA ARS; Director, TriCal Diagnostics, respectively

In 2020 the incidence of Pythium wilt (caused by *Pythium uncinulatum*) of lettuce has increased in severity and in the number of affected fields. Pythium infections in lettuce fields have been observed frequently, but not always, occurring with INSV infection. As a result, there has been confusion distinguishing between these two diseases and the role of each of them in causing the problems in fields. In this blog we will discuss these two diseases and explain from our current state of knowledge about the disease dynamics occurring in affected fields.

INSV has been a production problem on lettuce in the Salinas and surrounding valleys for a number of years and in 2020 it continues to be a serious production issue. Pythium wilt of lettuce is a relatively new problem and was first discussed in a blog entry in October 2015 by Steve Koike (https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=19327). However, in 2019 and 2020 we have seen an increase in the number of acres affected by Pythium wilt as well as the severity within fields. Given that Pythium is a relatively new problem and the extent of the problem suddenly increased, some growers and PCAs are confronting this problem for the first time. To add to the confusion, at times INSV and Pythium infections are occurring together on the same plants which has caused confusion and has led to much speculation about the role of each disease in the observed damage.

Symptoms of INSV

Issues with INSV infections on head and leaf lettuce types are not a new occurrence in the Salinas Valley and many growers and PCAs are familiar with the symptoms and the patterns of infection in the field, especially on romaine. In general, INSV on lettuce causes characteristic patterns of chlorosis and necrosis on the inner leaves of the plant, as well as significant stunting (Photo 1). However, INSV can cause significant necrosis and lesions on and at the base of the ribs of lettuce plants (Photo 2). It should be mentioned that Tomato Bushy stunt virus (TBSV) can cause symptoms that can be confused with INSV and Pythium wilt; however, lettuce dieback symptoms are always seen on the outer, older leaves and the TBSV pathogen is commonly restricted to low-lying areas along the river. In addition, head lettuce varieties and some romaine varieties are resistant to this virus. When in doubt, it is important to have a sample tested. That said, INSV is the overwhelming virus issue facing growers and PCAs in 2020.

Photo 1. Common symptoms of INSV on romaine lettuce.

Photos 2a and 2b. Moderate to severe symptoms of INSV on ribs of romaine.

Viral vs. Fungal Symptoms

One important detail about lettuce plants infected with only INSV is that they do not exhibit wilting of the outer leaves of the plant or show root rot or root discoloration. This is important to note because in 2019 and 2020 we have visited many fields where the plants exhibit symptoms of INSV and have wilting older leaves. In these situations, the roots and crowns of the plants should be examined for symptoms caused by soilborne pathogens such as the wilt pathogens (Fusarium and Verticillium), Sclerotinia, and Pythium. Fusarium and Verticillium do not cause rot on the fine roots or crown. However, they always cause characteristic vascular discoloration in the taproot and crown of the plant. Distinguishing these two pathogens without a laboratory evaluation is not advised, but in general, Fusarium occurs earlier in the crop cycle and often causes a red-to-brown discoloration internally along the taproot and at the base of the crown. Symptoms of Verticillium on the above ground parts of head lettuce become obvious close to harvest; the taproot and crown tissue of infected plants have dark brown-to-black discolorations. Plants with INSV can also be infected with Sclerotinia (*S. minor*) which is recognized by the characteristic rotting of the crown tissue of the plant and the presence of white,

cottony growth and small blacksclerotia (Photo 3). Plants infected with Sclerotinia easily break off at the soil line when you gently tug on them. However, if the plants do not break off at the soil line and do not show any rot on the crown tissue but do exhibit rot on the fine feeder roots or lower down on the taproot, then Pythium wilt is suspected and can be verified by laboratory evaluation.

Photo 3. Sclerotinia infection on lettuce. Note that it infects and rots crown tissue of the plant.

Biology and Symptoms of Pythium

Pythium wilt is caused by the water mold, *Pythium uncinulatum*. It infects lettuce roots with swimming spores (zoospores) that move to the roots within the water film in the soil. Additionally, it produces a second type of spore (oospore) that allows the pathogen to survive in the soil in the absence of a host plant. Previous studies have reported *P. uncinulatum* is almost exclusively a pathogen of lettuce and does not cause disease on other vegetable crops. However, it remains unknown whether other crops may contribute to a build-up of the pathogen in the soil. Affected plants will exhibit rotting of the fine and tap roots (Photo 4) and frequently dark discoloration of the inner core of the main root (Photo 5). Symptoms of the above ground parts of the plant include stunting, yellowing, and wilting of the outer leaves and eventual death (Photo 6). Sometimes the plants have a characteristic look where the younger leaves remain upright, but the older leaves are totally wilted down to the soil (Photo 7). This year, we frequently observed fields where plants are infected with Pythium wilt but are also infected with INSV. These mixed infections are confusing and make it more difficult to distinguish what is the cause of the damage. In our experience to date, plants that show foliar symptoms of INSV and that have wilting older leaves are typically infected with both INSV and, in many cases, Pythium wilt. It should be mentioned that we have also observed plants infected with INSV as well as Fusarium.

The distribution of Pythium wilt in a lettuce field can be variable. Earlier in the summer, fields with this disease typically were infected along the upper or lower ends of the field indicating that the disease may be responding to irrigation or drainage issues. It is possible that there may be a difference in the level of infection between sprinkler and drip irrigated fields, but we cannot say anything definitive at this time. The disease has been found from King City to Castroville. There is a significant difference in the susceptibility of varieties. In fields with multiple leaf type lettuce, we have observed significant differences in susceptibility among varieties with red types being less susceptible (Photo 8). Recently, there have been severe losses in some fields. It is not clear as of this writing, but it is possible that the incidences occurred in response to the heat spells. It is likely that diseased plants were not able to withstand the weather stress due to damaged roots or that extra water applied to address the heat may have stimulated the development of Pythium wilt. Another observation we have made is that at times Pythium mostly infects the fine roots higher up on the root system and in other situations it is more severe at the bottom of the taproot (Photo 9) which may indicate disease initiated farther down on the root system. Given that the disease needs a period of soil saturation for the swimming spores to travel to the roots, issues with soil preparation, drainage and irrigation management may affect the severity of the disease.

Research Efforts

Daniel Hasegawa is conducting research on the epidemiology and spread of thrips and INSV. JP Dundore Arias is working on a project with the California Leafy Greens Research Board monitoring the occurrence of Pythium wilt in the Salinas Valley. He is also characterizing isolates of this disease to better understand the organism and will be conducting preliminary evaluations of the sensitivity of the organism to fungicides. Given the rapid onset of severe damage of Pythium and the continued severity of INSV, we are trying to better understand these diseases and how they may interact. We are interested in receiving samples of Pythium wilt. Please contact Richard (rifsmith@ucdavis.edu) or JP (jdundorearias@csumb.edu) to submit samples.

Photo 4. Pythium wilt infection of fine lettuce roots.

Photo 5. Pythium wilt infection on lettuce taproot.

Photo 6. Mini romaine infected with Pythium wilt.

Photo 7. Romaine infected with INSV and Pythium wilt. Note that the older leaves are wilted and lay on the ground.