Bacterial Diseases of Onions in Georgia

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EXTENSION

The Vidalia area in southeastern Georgia is known for producing the world's sweetest onions. The region has the perfect climate for onion production, but unfortunately, the climate is also conducive for many different plant diseases that make growing onions a challenge.

While there have been sporadic years when fungal diseases such as downy mildew, Stemphylium leaf blight, and Botrytis leaf blight have caused the greatest losses, most growers, onion researchers, and University of Georgia Cooperative Extension agents and specialists would agree that bacterial diseases have been the most important and most difficult to manage over the past several decades. There are several different bacterial pathogens that fill different environmental niches based on their temperature requirements and survival habitats. Different bacterial species survive locally on weeds, in soil, in insects, or in seeds.

Most years, one can set their calendar by when the different diseases are likely to occur. During the time of seeding and transplant growth, warm conditions favor diseases such as Xanthomonas blight and center rot (only foliar blight). As temperatures decline over the growing season, these diseases are replaced by those that prefer cooler temperatures. From late December to mid-March, bacterial streak and bulb rot as well as yellow bud are prevalent. By mid-March, the incidence of these diseases decline and center rot re-appears. At that time of year, higher temperatures not only favor center rot development, but flushes of thrips migrate into onion fields and can serve as vectors for bacterial transmission to healthy onions. Finally, at the end of the season when temperatures are once again higher, diseases such as Xanthomonas blight and sour skin can be problematic. *Burkholderia cepacia*, the causal agent of sour skin, is the most devastating late-season disease. This bacterium is favored by temperatures above 80 °F and can even be a problem in drying bins, which can act as a bacterial incubator. Specific information on individual bacterial diseases follows.

Center rot

Symptoms

Foliar symptoms initially consist of water-soaked lesions that expand and span the length of the leaf blade, causing the leaf to become bleached and blighted. As the disease progresses, severe wilting and blighting of foliage can occur, leading to complete foliage collapse and the death of aboveground plant tissues. Bacteria move from foliar tissue into the bulb, causing bulb decay, which has been demonstrated experimentally with *Pantoea ananatis,* one of four *Pantoea* species that have been associated with center rot. Additionally, Carr *et al.* (2013) observed that the specific bulb scale showing symptoms could be traced back to the corresponding infected blade (Figure 1). Therefore, the authors concluded that protecting onion leaves can reduce bulb rot incidence.

Figure 1. Symptoms of center rot on an onion's foliage and bulb. A: The leftward arrow points to a white, bleached, water-soaked, necrotic lesion on foliage. B: The downward arrow refers to an interior necrotic lesion and bulb rot associated with onion scales.

P. ananatis can survive on the surface of leaves without causing symptoms (asymptomatic epiphyte) or inside plant tissues causing symptoms (symptomatic endophyte) on both dicots and monocots. *P. ananatis* is widely distributed throughout Georgia on numerous weed species commonly found near onion production sites. *P. ananatis*, a known pathogen of pineapple, was first reported on onion in the U.S. in Georgia in 1997, and it has also been isolated from many economically important crops around the world including honeydew melon in Ecuador, sudangrass in the U.S., eucalyptus in South Africa, rice in Italy and Russia, netted melon in Japan, maize in Argentina and Poland, and sorghum in Brazil. However, it has been observed that *P. ananatis* strains isolated from onion (foliage or bulb) are pathogenic on onion in most cases. In the U.S., *P. ananatis* has been rarely associated with diseases on the other hosts stated above.

Pantoea agglomerans, another species capable of causing the disease, was first described as a causal agent for center rot of onion in South Africa (1981). Later, the bacterium was identified as a causal agent of center rot in Georgia in 2006. This was the first report of the bacterium causing this disease in the United States. *P. allii* was identified as the third member in the *Pantoea* species complex causing center rot of onion in Georgia and most recently, *P. stewartii* subsp. *indologenes* was included as the fourth member in the center rot complex of onion along with *P. ananatis*, *P. agglomerans* and *P. allii*. In the field, all four species cause nearly identical symptoms making it impractical to differentiate them based solely on visual symptoms.

Disease cycle and epidemiology

The life cycle of *P. ananatis* is complex, as bacteria can overseason to infect onions in a number of different ways. Like many bacterial pathogens, *P. ananatis* can be seedborne, with infested seed serving as a survival mechanism as well as a means of dissemination. Based on seeds collected from the umbels of onion plants with no obvious symptoms present, Walcott *et al.* (2002) demonstrated that *P. ananatis* can be both naturally seedborne and asymptomatically seed-transmitted in onion. Although *P. ananatis* can be seedborne, the proposed primary mode of transmission is by two insect vectors. Two species of thrips, tobacco thrips (*Frankliniella fusca*) and onion thrips (*Thrips tabaci*), have the ability to transiently acquire and transmit *P. ananatis* and *P. agglomerans*. Tobacco thrips are quite prevalent in Georgia, whereas onion thrips are commonly found in other onion growing regions of the U.S.

P. ananatis can survive epiphytically (on the surface of leaves without causing symptoms) and endophytically (inside the plants without inciting any symptoms) on a wide range of hosts. These alternative hosts can serve as a source of inoculum in fields where susceptible crops are grown. In Georgia alone, 25 weed species, including carpetweed (*Mollugo verticillata*), common ragweed (*Ambrosia artemisiifolia*), crabgrass (*Digitaria sanguinalis*), common cocklebur (*Xanthium pensylvanicum*), curly dock (*Rumex crispus*), Florida pusley (*Richardia scabra*), sicklepod (*Cassia obtusifolia*), stinkweed (*Thlaspi arvense*), Texas panicum (*Panicum texanum*), vaseygrass (*Paspalum urvillei*), wild radish (*Brassica* spp.), yellow nutsedge (*Cyperus esculentus*), as well as some crop plants were found to harbor *P. ananatis* populations asymptomatically. Many of these weeds were found in or nearby onion production fields providing a local inoculum source.

Disease management

Center rot requires an integrated approach that targets reducing potential sources of inoculum to counter bacterial spread. Onion cultivars resistant to *Pantoea* spp. are not commercially available. Use certified onion seed to avoid introducing inoculum into the production field. Planting early-maturing or mid-maturing onion cultivars is often recommended for growers. Epidemics are favored by high thrips pressure as well as hot and humid conditions, which are more commonly encountered with late-maturing cultivars, as they require a longer growing season. These conditions are more prevalent in the Southeast U.S. compared with other onion-growing regions of country. Early-maturating cultivars are able to avoid conditions that are suitable for bacterial disease development and *P. ananatis* infection. Controlling the thrips population can be an effective management strategy to reduce center rot incidence, as these vectors play an important role in the movement of bacteria among plants and fields. Effective in-season disease management options are limited. Center rot management typically relies on weekly protectant copper applications mixed with an ethylenebisdithiocarbamate fungicide (EBDC), such as mancozeb. However, researchers identified *P. ananatis* strains that are copper-tolerant, indicating overuse and potential risk of insensitivity to this active ingredient *P. ananatis* inoculum in the field. By reducing weeds, growers can potentially reduce initial inoculum. For example, effective weed management has been observed to reduce the spread of *Pseudomonas viridiflava* in onion farmscapes in Georgia.

Bacterial streak and bulb rot

Bacterial streak and bulb rot of onion, caused by *Pseudomonas viridiflava*, was first reported in Georgia in the early 1990s, but has since been reported elsewhere including in Colorado, Florida, Pennsylvania, Texas, Uruguay, and Venezuela. In Georgia, the disease is favored by excessive fertilization and prolonged periods of rain during the cooler winter months of onion production. Onions are at the greatest risk for infection from the first of January until mid-March, but they are vulnerable anytime during the growing season when conditions are favorable. The primary source of inoculum in Georgia is from weeds. Many different weed species may serve as either a resident or susceptible host for *P. viridiflava* and include cutleaf evening primrose (*Oenothera laciniata*), dandelion (*Taraxacum* sp.), common fumitory (*Fumaria officinalis*, purple cudweed (*Gamochaeta purpurea*), spiny sowthistle (*Sonchus asper*), Virginia pepperweed (*Lepidium virginicum*), and wild radish (*Raphanus raphanistrum*).

Symptoms

In onions, leaf symptoms initially appear as oval-shaped lesions or streaks that later result in the total collapse of the entire leaf (Figure 2A). Initially, streaks are water-soaked but later turn brown or dark green and eventually into almost-black lesions near the base of infected leaves (Figure 2A). At later stages of disease development, if not rotted, collapsed leaf areas may also have a distinctly ribbed or corrugated appearance due to protruding veins (Figure 2A). Infected leaves will generally fall off the bulb when any tension is applied to pull them, and these frequently detach from the bulb when lifting at harvest. Initial symptoms in inner scales are lemon yellow in color but quickly turn reddish-brown to dark brown in harvested bulbs. On rare occasions, infected tissues can be blue-green in color (Figure 2B). Infections will proceed downward to the base of the leaf and in to the bulb. If infected bulbs are harvested and not discarded during grading, they will develop postharvest rot that can spread to healthy bulbs in storage.

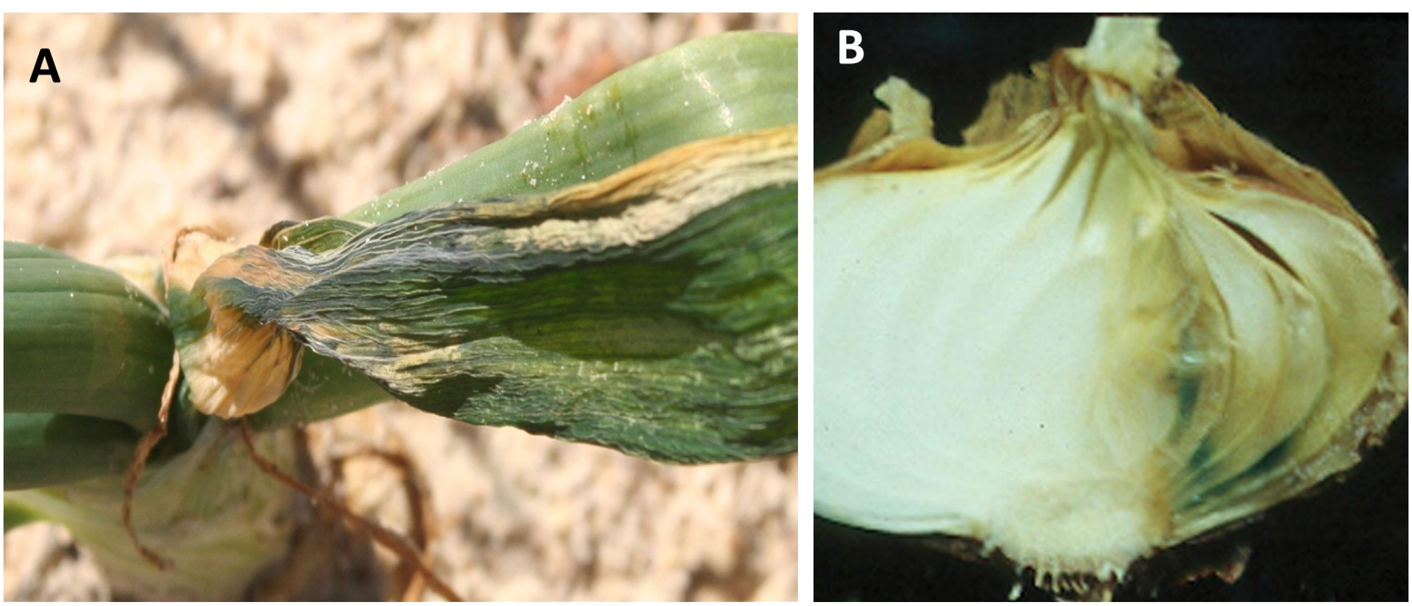

Figure 2. Bacterial streak and bulb rot caused by *Pseudomonas viridiflava*; A: Foliar symptoms with a water-soaked lesion and collapsed leaf tissues; corrugated appearance due to protruding veins in leaves; B: Blue-green appearance occasionally observed in postharvest rots caused by this pathogen.

Disease management

Field trials in Georgia demonstrated a three-fold reduction in disease incidence when weeds were effectively managed in the field. It may be advisable to manage weeds along field borders and in irrigation strips if using fixed irrigation. It is advisable not to enter fields when leaf wetness is present to reduce potential plant-to-plant spread on equipment, tools and people. Preventive applications of fixed copper materials tank-mixed with EBDC fungicides (Maneb, Mancozeb, Manzate, Dithane, Penncozeb and others) significantly reduces the incidence and spread of this disease. Avoiding over-fertilization with nitrogen during winter months may reduce losses to bacterial streak. Also, practices that reduce postharvest rot such as harvesting onions at the proper stage of maturity, field-curing onions for a minimum of 48 hours under dry conditions prior to clipping, and avoiding bruising or wounding at all times will help to reduce disease problems. Postharvest rot due to this disease was significantly reduced (7% vs 55% rot) in onions that were stored in controlled atmospheric conditions vs. typical cold storage (34 °F). No data are available on the effects of ozone on the reduction of storage rot due to *P. viridiflava*.

Sour skin

Burkholderia cepacia is the causal agent of sour skin of onion.

Symptoms

In Georgia, sour skin usually manifests itself during harvest in the latter portion of the Vidalia onion-growing season when temperatures are warmer, but being temperature-dependent, symptoms can occur earlier if warmer conditions prevail. The disease may progress from the upper foliage to the lower leaves and then to the outer scales of the bulb. Infected bulbs develop a cheesy or slimy yellow growth between scales and then a dark brown soft rot (Figure 3). Infected scales may separate from adjacent scales, allowing firmer inner scales to slide out when the bulb is squeezed. Bulbs infected with sour skin usually have an acrid, sour, vinegar-like odor and other foul odors that may be associated with secondary organisms. Initially, bulb tissues may appear translucent, but over time, they will turn reddish-brown to brown in color as tissues rot and copious amounts of fluids are produced. Sour skin primarily affects onion bulbs, but *B. cepacia* has been reported in some onion-growing areas as infecting foliage through leaf axils. In those cases, this phase of the disease has been referred to as bacterial canker of onion or "soreshin." Typically, soreshin is not observed in Georgia, but nonetheless, it is likely that bacteria may colonize the plant in this area as an epiphyte where it may wash down to the bulb and bulb neck.

Figure 3. Bulb rot symptoms of sour skin caused by *Burkholderia cepacia*. *Photo: David B. Langston, University of Georgia, Bugwood.org*

Disease management

Long-term crop rotation may help to reduce sour skin in the field, but *B. cepacia* is typically found in most agricultural soils to some degree. It is, however, less frequently found in soil not cropped to onion. *B. cepacia* has been isolated from rhizospheres of corn, cotton, cucumber, rye, soybean, and tobacco. Furthermore, greater genetic variation and different forms have been observed in the bacterial populations recovered from corn roots. Under controlled conditions in the laboratory, populations of *B. cepacia* declined in the soil because of direct contact with root exudates of pearl millet (*Pennisetum glaucum*).

Initially, double-cropping onion with pearl millet reduced sour skin incidence and severity in field trials. However, by the fourth year of continuous double-cropping of onion with pearl millet, the beneficial effects of reducing sour skin were significantly reduced, indicating a possible rapid adaptation to the biological effects of the pearl millet. Avoidance of overhead irrigation near harvest time will reduce losses to this disease. Also, practices that reduce the chances of irrigation water becoming contaminated with the sour skin bacteria will be beneficial. Thus, irrigating from wells or clean irrigation ponds, with weed-free borders and lack of water weeds, can reduce levels of initial inoculum. Incorporating gypsum into the soil has shown some level of sour skin reduction, but growers need to monitor the pH and sulfur levels in their soil to maintain a proper balance in order not to adversely affect plant growth or pungency.

Wounds exacerbate infections, so using wind breaks and orienting rows to minimize damage from wind-blown sand can be beneficial. Despite the lack of symptoms on foliage, using copper mixed with zinc and manganese EBDC has reduced sour skin levels in field trials. In addition, avoiding entry into the field while leaves are wet should reduce spread of the bacterium. Careful use of equipment to avoid wounding in the field prior to or during harvest is highly recommended. Onions should be harvested at an optimum level of maturity and then allowed to field-cure (air dry) for a minimum of 48 hours, which will reduce infections from clipping wounds when topping. Harvested immature onions are more prone to infection because the leaves do not dry enough to retard movement of the bacterium into the bulb from clipping wounds. Infected bulbs should be discarded before storing, as disease can spread from infected bulbs to healthy bulbs. Infected onions should not be heat-cured after harvest as this will rapidly spread this pathogen to uninfected bulbs, but rapid drying with forced air of less than 70% relative humidity can be beneficial. Storing onions in cool (34 °F) dry areas will prevent bulb-to-bulb spread of sour skin. Improvements in grading onions and removing sour skin infected bulbs prior to storage may be available in the future. This is potentially possible with the use of shortwave infrared hyperspectral imaging systems. In studies at the University of Georgia, hyperspectral imaging could discriminate between healthy onions and onions that appeared to be healthy but were sour skin infected in 87.5% of the times.

Yellowbud

Symptoms

Yellowbud results in intense chlorosis (yellowing) in emerging leaves and severe blight in the older leaves. As disease progresses, it may lead to stand loss, reduced bulb size, and may create possible avenues of ingress for secondary soft rot organisms (Figure 4).

Figure 4. Foliar symptoms of yellowbud disease on onion caused by *Pseudomonas coronafaciens*. Note the intense chlorosis on emerging leaves and severe blight on the older leaves.

Photo: Ronald D. Gitaitis, University of Georgia, Bugwood.org

Disease cycle and epidemiology

Yellowbud was officially reported in Georgia in 2014 but was first observed in the state in 2007. The disease is caused by the bacterium *Pseudomonas coronafaciens*. It is not clear if the Georgia strain is a variant of *P. coronafaciens* pv. *porri*, a known pathogen of onion, or if it is a different subspecies altogether because yellowbud symptoms have not been observed in other onion-growing regions where *P. coronafaciens* pv. *porri* occurs. However, environmental conditions may play a role, as *P. coronafaciens* pv. *porri* has mainly been isolated from blighted, long-day onions, which are typically produced under warmer conditions than what is experienced during a typical Georgia onion-growing season. Nonetheless, the yellowbud bacterium is a strong ice-nucleating bacterium that will cause ice-formation in leaves when temperatures are slightly higher than when ice forms on plants not harboring bacteria. Thus, on occasion, plant death from freezing damage can occur. Beyond the effects of freezing, yellowbud has two distinct phases.

The first is associated with the epiphytic colonization of leaves. Leaves will turn a bright yellow due to the production of coronatine, a toxin that not only affects chloroplasts but is also known to open stomates (pores), allowing bacteria to more easily enter plant tissues for phase two. The structure of coronatine is similar to certain plant hormones and can interfere with salicylic acid signaling, thus disrupting the plant's disease resistance metabolism. Bacterial production of the toxin is regulated by temperature, with its highest production at 64 °F decreasing until 82 °F. Later in the growing-season, as temperatures increase, reduced symptoms are often observed. Field studies have documented yield reduction in previously affected plants.

The second phase of yellowbud is blight and extensive death of plant tissues. This phase is not always observed but can occur if plants are exposed to the toxin for extended periods of time and tissues remain heavily colonized by bacteria. As of this time, it is not fully understood how environmental conditions interact with disease development. If blighting occurs, there will be no remission of symptoms.

The bacterium survives on numerous types of weeds. Two of the most important that may play a role in onion outbreaks are Italian ryegrass (*Lolium multiflorum*) and curly dock (*Rumex crispus*), although the bacterium was also found on Carolina geranium (*Geranium carolinianum*), cutleaf evening primrose (*Oenothera laciniata*), Virginia pepperweed (*Lepidium virginicum*), and wild mustard (*Sinapis arvensis*). The disease has also been observed in onion seed beds, so infected transplants could be widely dispersed to areas throughout the Vidalia onion zone in Georgia or elsewhere. Studies also demonstrated that the pathogen can be seedborne and seed-transmitted, and the occurrence of yellowbud in seedbeds may be an indication that the pathogen is seedborne in onion. Nonetheless, to date, it has not been found in any commercial seedlots of onion seeds. Under some conditions, the bacterium can survive on organic matter, such as pollen, that collects in irrigation nozzles, setting up conditions where it may be spread by irrigation water.

Disease management

The recommended management strategies for yellowbud include sanitation, avoiding entry into fields with free water on the leaves, maintaining an effective weed management program, and spraying with fixed copper bactericides tank-mixed with an EBDC fungicide.

Other bacterial diseases

Several other bacterial pathogens may also infrequently infect onions in Georgia. These bacteria include: *Burkholderia gladioli* pv. *allicola*, *Dickeya chrysanthemi*, *Enterobacter cloacae*, *Pectobacterium carotovora* pv. *carotovora*, *Pseudomonas aeriginosa*, *P. fluorescens* (formerly classified as biovar 2 strains that were pectinolytic = *P. marginalis sensu stricto*), and *Xanthomonas axnopodis* pv. *allii*. While X. *axonopodis* pv. *allii* causes foliar blight, most of these cause soft rots of either the foliage or bulbs (Figure 5).

In Georgia, Xanthomonas leaf blight caused by X. *axonopodis* pv. *allii* is usually observed in seed beds when temperatures are warm in the late summer or early fall. It is rarely observed during the winter. Interestingly, it is rarely a problem in the spring, even when the temperatures become more favorable.

Figure 5. Foliar symptoms of bacterial leaf blight of onion caused by *Xanthomonas axonopodis* pv. *allii*.

Photo: Howard F. Schwartz, Colorado State University, Bugwood.org

Management recommendations for this disease include buying clean seed from a reputable source and spraying with fixed-copper compounds tank-mixed with an EBDC fungicide.

Figure 6. Onion bulbs sliced open to reveal damage by infection with *Enterobacter cloacae*.
Photo: Howard F. Schwartz, Colorado State University, Bugwood.org

Soft rots are caused by *D. chrysanthemi*, *P. carotovora*, *P. aeruginosa*, and *P. fluorescens*. Of these, *D. chrysanthemi* and *P. fluorescens* are the two most commonly associated with onions in Georgia. *D. chrysanthemi* and *P. carotovora* are known to survive in water, so irrigating from clean ponds, with few weeds in or surrounding the pond, will avoid these pathogens. These two organisms can also survive and grow in anaerobic conditions. The risk of soft rot caused by these two pathogens is higher in times of drought. This is largely due to water levels dropping in ponds and irrigation pump intakes stirring up bacteria-containing sediment that is then pumped through the irrigation lines.

Enterobacter cloacae is a facultative anaerobic bacterium that can survive in the presence or absence of oxygen. In Georgia, only bulb symptoms were observed with this pathogen (Figure 6). This is the newest bacterial pathogen reported from onions and little is known about it at this time. Although it has been detected in Georgia, it is a much larger problem in the Pacific Northwestern states.

Finally, slippery skin, caused by *B. gladioli* pv. *allicola*, has a disease cycle similar to sour skin (Figure 7). Both organisms are soilborne, so crop rotation may be of some benefit, but unlike sour skin bacterium, less is known about the interaction of this bacterium with other crops. It is also less prevalent than sour skin. It is unknown whether it survives on foliage and is affected by copper sprays in the same manner as *B. cepacia*, but until more knowledge is gained, recommendations for controlling slippery skin are the same as those for sour skin. A common practice with all of these diseases is to use good sanitation practices in seed beds, production fields, and packing houses. It is especially advisable to carefully handle and sort onions to avoid placing infected onions in storage where they will promote secondary rots. Figure 8 features a generalized timeline depicting the risk of different bacterial diseases during onion-growing season.

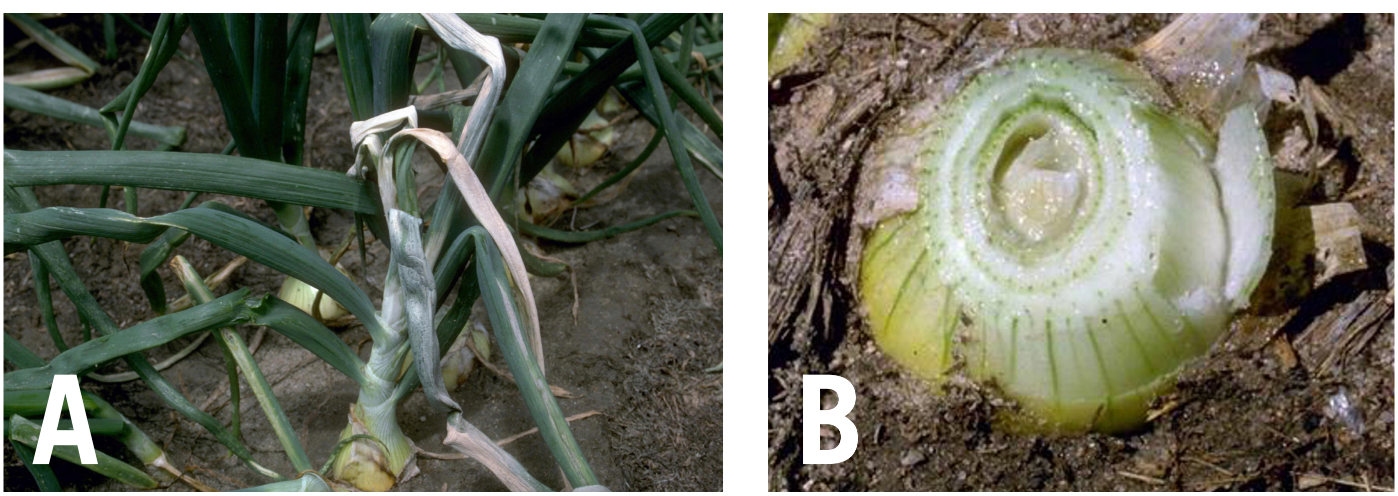

Figure 7. An onion plant displaying symptoms of slippery skin in the foliage and bulb caused by *Burkholderia gladioli* pv. *alliicola*; A: white and bleached leaves with soft-rot symptoms (both central and lateral leaves can show these symptoms); B: soft-rot symptoms in bulbs—in severe cases liquefaction of tissue can occur with foul odor.
Photo: Howard F. Schwartz, Colorado State University, Bugwood.org

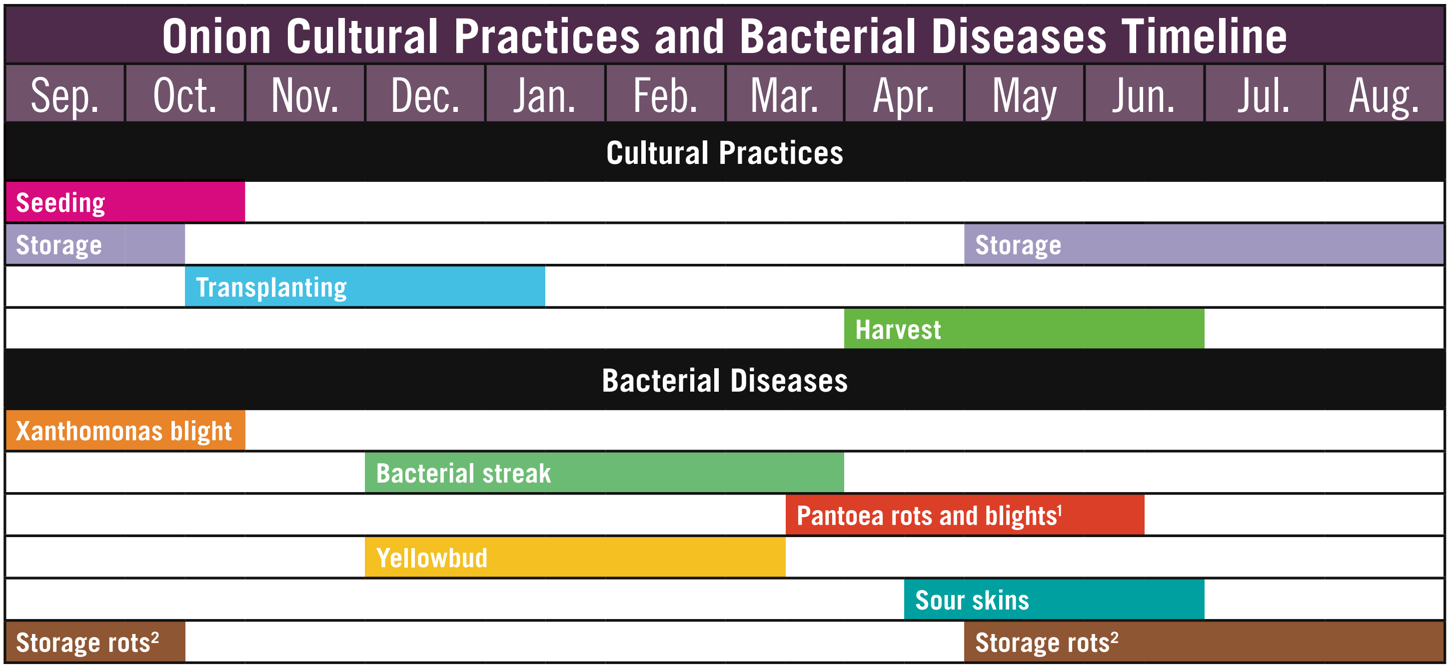

Figure 8. A generalized timeline of onion cultural practices and the risk of bacterial diseases in onions.

[1]*P. ananatis* is more prevalent than *P. allii*, *P. agglomerans*, and *P. stewartii* subsp. *indologenes*.

[2]*Pantoea* sp., *Pseudomonas viridiflava*, *Burkholderia cepacia,* and *Burkholderia allilicola* are the prominent storage rotters. Other pathogens including *Enterobacter cloacae*, *Pseudomonas fluorescens*, and *Pseudomonas aeruginosa* do not occur in a routine manner in the field but could be encountered as postharvest rots.

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Bulletin 1534 **August 2020**

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