# Celery

## Wednesday afternoon 2:00 pm

**Where:** Grand Gallery (main level) Room D

**MI Recertification credits:** 2 (1B, COMM CORE, PRIV CORE)
**OH Recertification credits:** 1.5 (presentations as marked)
**CCA Credits:** CM(2.0)

**Moderator:** Mark Cnossen, Cnossen Farms, Wayland, MI

2:00 pm Celery Anthracnose: It's Epidemiology and Prospects for Management (OH: 2B, 0.5 hr)

- Richard Raid, Everglades Research and Education Center, The Univ. of Florida

2:45 pm Food Safety on Celery Packing and Processing Lines

- Elliot Ryser, Food Science Dept., MSU

3:10 pm Managing *Pythium* Root Rot on Celery Seedlings (OH: 2B, 0.5 hr)

- Mary Hausbeck, Plant, Soil and Microbial Sciences Dept., MSU

3:35 pm Celery Insect Management Update (OH: 2B, 0.5 hr)

- Zsofia Szendrei, Entomology Dept., MSU

4:00 pm Session Ends

Annual meeting of Michigan Celery Research Inc. will be held at the conclusion of the Celery session.

# Food Safety on Celery Packing and Processing Lines

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An increasing number of foodborne outbreaks traced to fresh fruits and vegetables are being partially attributed to current production and processing methods. In the United States, the progression from locally grown produce to centralized production has led to numerous multi-state and nationwide outbreaks of foodborne illness. In many cases, fruits and vegetables are grown on centralized large-scale farms in locations that specialize in a specific product. Under these conditions, one contamination event at a large centralized grower or packer could lead to a potential recall and/or outbreak of foodborne illness as has been seen for leafy greens, tomatoes and cantaloupe.

*Listeria monocytogenes* is one serious foodborne pathogen (a cause of meningitis, abortions and perinatal septicemia) that has been identified in ready-to-eat salads containing raw celery (Cordano 2009), as well as in other types of ready-to-eat salads (Jalali 2008, Sizmur 1988, Lin 1996). In 1979, an outbreak of listeriosis involving 23 individuals was epidemiologically linked to consumption of raw celery, tomatoes, and lettuce (Ho 1986). Nine years later, an outbreak of gastroenteritis at the United States Air Force Academy originally attributed to *Salmonella* was later traced to diced celery that was washed and stored in non-potable water contaminated with norovirus (Warner 1991). More recently, in 2010 ten listeriosis cases, including 5 deaths, were traced to diced celery from a produce processing facility in San Antonio, Texas (FDA 2010) with this contaminated celery subsequently used as an ingredient in chicken salad that was served to hospital patients (Gaul 2013).

Outbreaks such as these can result from microbial contamination of fresh produce at any point in the farm-to-fork continuum. During harvesting, foodborne pathogens may contaminate celery via decaying vegetation, feces, soil, irrigation water, or sewage effluent (Beuchat 1996), or through dissemination by animals such as wild birds (Fenlon 1985). Worker handling during harvest and post-harvest processing may also lead to contamination if inadequate hygiene and sanitation practices are followed (Beuchat 1997). During post-harvest processing, fresh produce including celery is prone to contamination from other products, wash water, or processing equipment (e.g., conveyors, knives), allowing the spread of microbial pathogens (Tauxe 1997). Post-processing such as slicing and dicing can further spread these microbial contaminants (Kaminski et al. 2014) with storage at improper temperatures then permitting growth of foodborne pathogens to levels potentially hazardous to consumers (Wenting Zheng 2013).

Nearly all Michigan celery is grown in muck soil which is high in nutrients and moisture but extremely susceptible to flooding. Hence, this flood water is a potential source for foodborne pathogens including *Escherichia coli* O157:H7, *Salmonella* and *Listeria* due to run-off from nearby fields and livestock operations. Celery can be readily contaminated with a wide range of microorganisms – including potential foodborne pathogens, during mechanical harvesting. Hence, both the harvester (e.g., wheels, frame) and the harvest wagon may need to be periodically cleaned during extended harvesting periods to prevent the unwanted build-up of soil and other organic debris (Figure 1).

Upon delivering the celery to the packing shed, the field worker driving the tractor should remain on the tractor with those in the packing shed unloading the incoming celery. Worker hygiene is critically important during the unloading and trimming of celery. Special attention needs to be given to the cleanliness of the worker's gloves, aprons and trimming knives. Periodically sanitizing the trimming knives will help decrease the transfer and subsequent spread of microorganisms during long periods of use. Mechanical conveyors of various types are universally used in celery packing lines (Figure 2). It is critically important that the belts be properly designed for effective cleaning and sanitizing with continuous belts much preferred over pleated varieties since the latter types are highly prone to organic build-up and biofilm formation. Spraying the belt an appropriate sanitizer (e.g., chlorine, peroxyacetic acid) should be considered to minimize the spread of microbial contaminants. All celery trim should be segregated from the trimmed celery and conveyed away from the processing area. After trimming, the celery is mechanically cut and conveyed to the washing station where it is washed in water containing a chlorine- or peroxyacetic acid-based sanitizer (Figure 3). Regardless of the type of wash system used (e.g., open flume, spray cabinet), the effectiveness of this washing step is dictated by the sanitizer concentration and contact time with the celery. Thereafter, the washed celery is conveyed to the packaging area with smooth belting materials in combination with a sanitizer spray again recommended to minimize contamination. Lastly, it is important that packing sheds be properly designed in terms of product flow. Incoming product from the field should move linearly through the facility from receiving to packaging with all of the heavily contaminated trim and waste exiting the facility in opposite direction from the packaging area (Figure 4). Every attempt should also be made to minimize haphazard movement of the workers in the packing shed during production.

**References**

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Figure 1. Celery harvester from the field

Figure 2. Conveying celery and removing trim

Figure 3. Celery cutting and spray washing/sanitizing

Figure 4. Discarding celery trim

# Managing Pythium Root Rot on Celery Seedlings

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Commercial celery production begins with transplants produced in plug trays using peat-based growing media in the greenhouse. Root rot disease caused by *Pythium* spp. is considered a sporadic problem in greenhouses and can cause loss of plant vigor and an uneven plant stand. The affected roots often show brown lesions and the feeder roots may become rotted and slough off (Figure 1). Although the root rot disease may be identified at the seedling stage, field plants may also be affected when the weather is cool and wet during the spring and summer.


***Figure 1.*** ***A,*** *Brown lesions on the root of a celery seedling.* ***B,*** *Red-brown root discoloration and advanced root rot.* ***C,*** *Complete rotting and destruction of the root system.*

A previous study in California showed that *P. mastophorum* was associated with seedling stunting, discoloration and root rot in greenhouse-grown celery. Field surveys conducted in Australia and France identified the *Pythium* spp. associated with root diseases in crops of the *Apiaceae* family (i.e. parsley, parsnip and carrot) and indicated that there were more than one species present in diseased plants. Both studies reported finding both *P. sulcatum* and *P. intermedium*.

**Michigan scouting results.** Celery seedlings were scouted during February through July of 2014 at five commercial greenhouses and fields located in Allegan, Van Buren and Kent Counties. A total of 645 celery samples, including healthy-appearing and symptomatic diseased plants with an emphasis on root rot, were collected during this time for diagnosis. Samples included seedlings and mature plants from celery cultivars Duchess, CR-1 and WA-7. Disease symptoms included stunting and discoloration of the roots (Figure 2).


**Figure 2.** Symptoms on celery seedlings observed during scouting of commercial greenhouses and fields. **A,** Uneven growth of seedlings in the greenhouse. **B,** Seedlings with completely rotted and brown, discolored roots. **C,** Celery plants from the field: healthy (left) compared with a more mature, severely stunted plant (right), showing poor root development and root browning.

The celery samples were taken to the laboratory and the roots were rinsed with tap water without further surface-disinfestation. Four root portions were randomly selected from each plant, excised, and placed onto water agar (1.6%). The recovered mycelia obtained after 4 to 5 days of incubation at room temperature under artificial lights were transferred to potato dextrose agar. Isolates with morphological structures distinctive of the Oomycetes group were selected using single hyphal tip transfer. The internal transcribed spacer (ITS) was sequenced and compared to GeneBank and a curated *Pythium* database to confirm their identity.

Seven different species were molecularly identified from a total of 46 *Pythium* isolates collected from apparently healthy and symptomatic seedlings and mature plants of celery from Michigan greenhouses and fields, respectively. The species identified include: *P. intermedium*, *P. sulcatum*, *P. mastophorum*, *P. sylvaticum*, *P. oopapillum*, *P. coloratum* and *P. aff. diclinum*. The most frequently isolated species from the 46 species obtained were *P. intermedium* (37%), *P. mastophorum* (22%) and *P. sulcatum* (13%) (Figure 3). Additionally, *P. intermedium* was also the species most commonly found among the five locations surveyed from Van Buren County. *P. mastophorum* and *P. sylvaticum* were exclusively found in one grower's facility in seedling samples from the greenhouse and field, respectively. In some locations, there were differences in species of the *Pythium* isolated from plants collected from the field compared to those collected from the greenhouse.

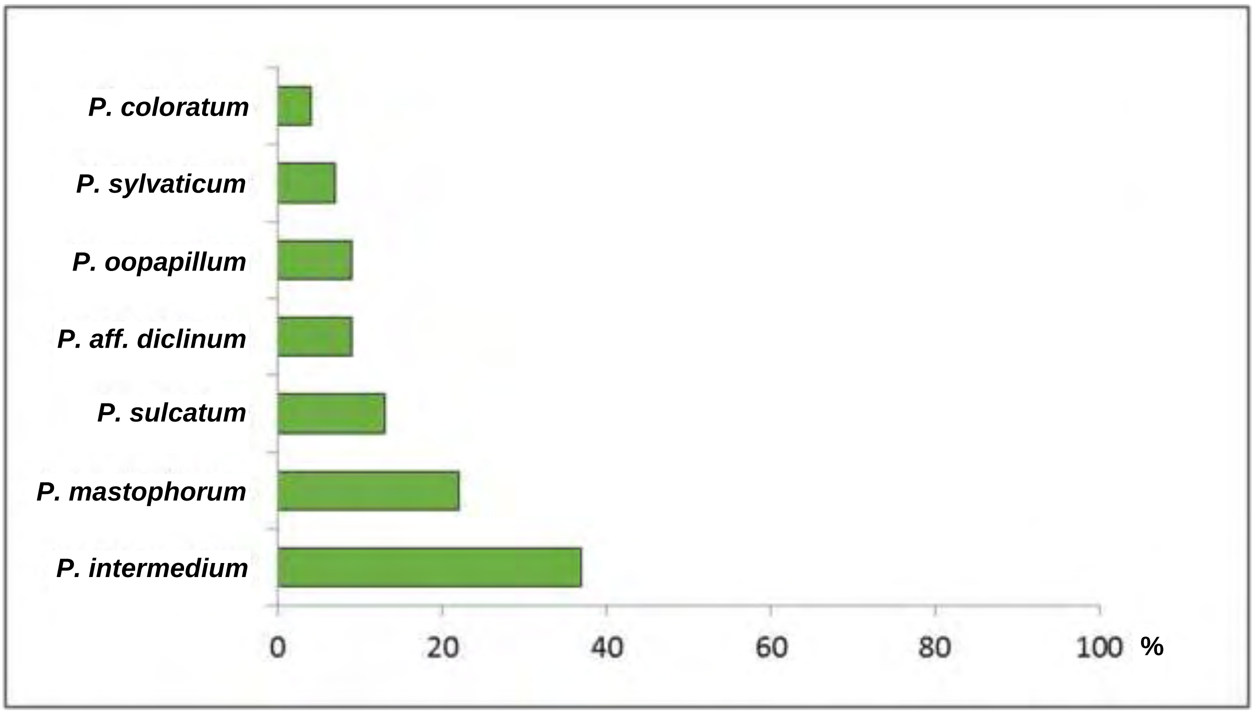


**Figure 3.** Incidence of *Pythium* spp. identified from a total of 46 *Pythium* isolates collected from Michigan greenhouses and fields in 2014.

*P. mastophorum* was typically isolated in association with symptoms including stunting, root discoloration, and damage to the root system. Although *P. intermedium* has been found to be a typical soil inhabitant, it has been reported to cause severe root rot to parsnip seedlings in greenhouse experiments. *P. sulcatum* is a major pathogenic species causing 75 to 90% of the lesions in cavity spot of carrot and identified as highly pathogenic for parsley and parsnip seedlings. *P. coloratum* was found to be one of the pathogens associated with cavity spot on mature carrots and has also been reported in New York as pathogenic to onion seedlings. *P. sylvaticum* was isolated from soybeans with typical symptoms of damping off and has been associated with root rot of parsley, parsnip and carrot. *P. oopapillum* and *P. diclinum* have also been found as the cause of soybean damping off.

Since the *Pythium* spp. found in our survey have been linked to seedling and root diseases in different hosts, future studies evaluating the pathogenicity could improve management strategies.

**Root rot control.** Limiting *Pythium* root rot in the greenhouse focuses on cultural practices including sanitation and a clean growing environment. If reused, transplant trays and flats must be washed and treated with a commercial disinfestant. Avoid overwatering and maintain a dry greenhouse environment to limit root rot. Remove and destroy diseased seedlings to reduce the spread of the pathogen to adjacent seedlings. Healthy-appearing plants close to infected seedlings may need to be discarded to avoid pathogen spread. Proper chemical treatment (Table 1) may help to reduce the level of pathogens on the seedlings.

**Table 1.** List of products registered for greenhouse use on celery in Michigan.

| Fungicide/Biological Product | Active Ingredient |
|---|---|
| Alude, Fosphite, Rampart | phosphorous acid salts |
| Badge SC, Badge X2 | copper oxychloride/copper hydroxide |
| Camelot | copper salts of fatty and rosin acids |
| Cease, Serenade ASO, Serenade Max | *Bacillus subtilis* strain QST 713 |
| Cuprofix Ultra 40 Disperss | basic copper sulfate |
| Kentan DF, Kocide 3000 | copper hydroxide |
| Micora | mandipropamid |
| Microthiol Disperss | sulfur |
| Oxidate | hydrogen dioxide |
| PlantShield Granules | *Trichoderma harzianum* strain T-22 |
| RootShield WP | *Trichoderma harzianum* strain KRL-AG2 |
| Sonata | *Bacillus pumilus* strain QST 2808 |

**Acknowledgements.** This research was supported by funding from Celery Research Inc., and by Project GREEEN GR14-023.