Identification of the most important factors driving bacterial bulb rot of onion in New York and Pennsylvania and implications for management

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Background and introduction

Bacterial diseases of onion are considered the most significant production constraint of this crop in the Northeastern U.S., surpassing losses due to other diseases, insect pests, or weed competition. Due to bacterial disease, reductions in marketable onion yields in recent years have exceeded 60% for some Pennsylvania farms, and up to 40% loss in New York. Losses vary significantly between fields and farms in the same year, even with conscientious disease management, and factors contributing to bacterial diseases in these states were largely unknown.

Though onion fields in these states experience similar climatic conditions, onion production in PA and NY differs considerably due to market considerations. In PA, most growers prepare silt-loam fields with broadcast N fertility, plastic mulch, and drip irrigation in late March, and bare-root plants, frequently cv. 'Candy,' are transplanted in April. These onions are typically fertigated through the season, with weeds managed through hand-labor or herbicide spot-treatments. Onion thrips are the primary insect pest, but only about half of growers apply insecticides for management, and some farms seem to naturally have low populations. Bacterial disease management is focused on applications of copper mixed with ethylene-bis-dithiocarbamate fungicides (EBDC; a common example is mancozeb), which some growers apply as frequently as weekly. Center and soft rots, caused by *Pantoea* spp. and *Pectobacterium carotovorum* and *Pseudomonas marginalis*, respectively, are the most common diseases affecting PA onions, with bleached leaf symptoms first becoming noticeable near the onset of bulbing, then progressing to the bulb through the growing season (Fig. 1). Onions are pulled in early- to mid-July, with initial field curing for several days, followed by foliage removal and additional fan-mediated bin curing for two weeks. Most onions grown in PA are marketed under the Simply Sweet® program, the state's only trademarked crop, which requires that bulbs are one of three approved low-pungency cultivars, at least 3-in. diameter, and with 6% soluble sugars.

Fig. 1: Mature onion plant with several bleached, limp inner leaves, which are consistent with center rot.

Onion production in NY initiates in late March to early May by direct-seeding into high organic matter muck or silt fields, some of which have produced onions for multiple seasons. At least 20 different varieties are produced by NY growers and include white, yellow, and red cultivars. Most N soil fertility is applied prior to the start of

the season, and planting configurations, which are related to bulb size, may vary from farm to farm. Onion thrips, the most problematic insect pest in NY, may be managed through carefully timed insecticide programs utilizing multiple products with different modes of action, such as carbamates, spinosyns, and products with section labels. In-season N fertility is typically side-dressed, and disease management focuses on copper-EBDC applications. Sour and slippery skin, caused by the bacterial species *Burkholderia cepacia* and *B. gladioli*, are common bacterial diseases, in addition to Enterobacter bulb decay and more recent incidence of center rot, caused by *Pantoea* spp. Mature bulbs are harvested August-September after up to two weeks drying in the field, followed by foliage removal and continued bin-curing. Onions are usually marketed in bags and may be effectively stored until the following spring or later.

Study design and data collection

With widely variable losses occurring from field to field within a given year, a hypothesis-driven, multistate, replicated-plot study was undertaken to determine environmental and management factors associated with bacterial disease incidence. In 2011 and 2012 respectively, 28 and 26 PA onion fields, and 22 and 32 NY onion fields were visited three or four times throughout the growing season. Three replicate plots were established in each of these fields in each year. Soil N fertility, soil type, hourly soil temperatures, plant tissue N, and midseason ratings of disease, weed, and insect pressure were recorded. Disease incidence and yield were recorded at harvest and from storage, and values averaged by field were analyzed using multiple regression analyses. The project goal is to further refine bacterial disease management practices, in addition to developing more targeted replicated research trials focusing on the factors associated with higher bacterial disease losses.

Environmental and production factors associated with bacterial rots of onion

Higher soil temperatures are associated with higher bacterial disease incidence

In PA in 2011 and in the combined-year NY dataset, higher soil temperatures at bulbing (approx. 3 and 5 weeks prior to harvest, respectively) were associated with higher levels of bacterial rot at harvest. When all PA fields were combined, those with 30% or more yield loss due to bacterial disease had consistently higher soil temperatures throughout the growing season than fields with less than 30% loss (Fig. 2). From previous work completed by Howard Schwartz and colleagues, higher air temperatures near bulbing were associated with the onset of Xanthomonas leaf blight (another bacterial disease of onion) in Colorado. Based on understanding the biology of bacteria, these associations between temperature and pathogen levels are not surprising: bacteria reproduce more quickly under warmer conditions, which would allow populations to increase quickly. Larger pathogenic bacterial populations in fields result in more inoculum, and potentially higher disease incidence in onions and faster disease spread. After hearing of these results, a few PA growers independently chose to slash their plastic mulch at or slightly after bulbing to increase air flow and reduce soil temperatures, which they considered effective in reducing harvest losses.

Higher soil nitrate-N is associated with higher bacterial disease incidence

Higher levels of soil nitrate-N were related to higher levels of bacterial rot in multiple datasets, based on the at-transplanting soil measurement in the combined-year PA dataset and the midseason soil measurement in the combined-year NY dataset. There were no relationships observed between either of the soil N measurements taken at the other two seasonal time points, nor was there a direct association between soil ammonium-N and bacterial disease in these datasets. Combining these

results with those from other trials, we are now beginning to explore how different types of nitrogen fertilizer may differentially affect bacterial rots of onion, in addition to the timing of these N-fertilizer applications during the growing season, in efforts to refine fertility recommendations.

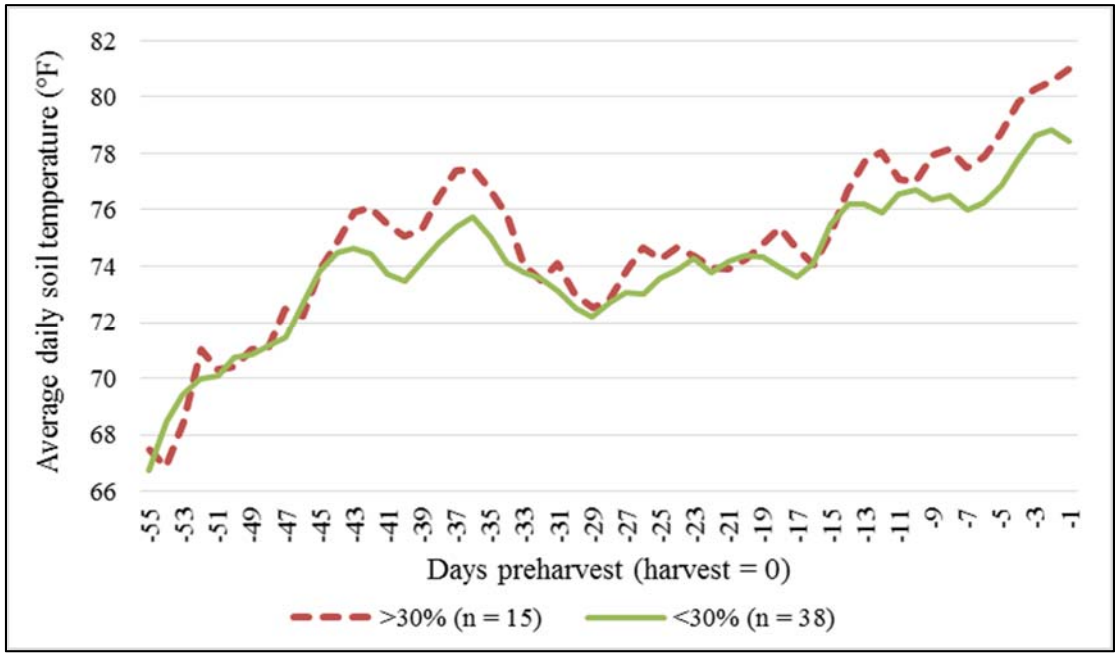

Fig. 2: Average daily soil temperatures prior to harvest in PA fields, grouped by losses due to bacterial disease. Soil temperatures were recorded hourly in PA field plots over the 2011 and 2012 growing seasons, then plots were harvested at the end of the season. Farms were grouped based on the total percentage of bacterial rot from harvest and storage combined (> 30% loss, n = 15 fields; < 30% loss, n = 38 fields).

Higher foliar N at midseason is associated with lower bacterial disease incidence

Foliar N was very influential in the PA datasets, where analyses from both years indicated a negative association between midseason foliar N and bacterial rots. This was surprising because high foliar N was thought to result in delayed onion maturity and an abundance of young, susceptible plant tissue that may be easily infected, which has been shown to be the case with other plant diseases. The opposite was true for both years in PA, which indicated bacterial disease incidence was lower in fields that had higher foliar N content at midseason. Further analysis of the combined-year dataset suggested that plants from fields with higher levels of soil ammonium-N early in the season had higher levels of foliar N at midseason, but soil ammonium-N did not directly affect disease in these datasets. It is important to note that our PA field plots only included the cultivar 'Candy,' since it is by far the predominant cultivar grown in state. Combined with the NY analysis with eight included cultivars, where there was not association between foliar N and bacterial rot, this suggests the foliar N – bacterial disease association may be cultivar-specific.

Red cultivar has higher bacterial disease incidence than bold yellow cultivars in NY

In the combined-year NY dataset, the only red onion cultivar sampled, Red Wing, had higher disease incidence than the other eight bold cooking cultivars sampled. Red Wing averaged 15% total losses due to bacterial disease, while the other cultivars ranged from 2 – 7% total losses (Fig.

3). Further research with other red cultivars is necessary to determine if disease incidence is generally higher in red onions than in bold cooking onions, or if relationships between onion pungency and harvest disease incidence exist.

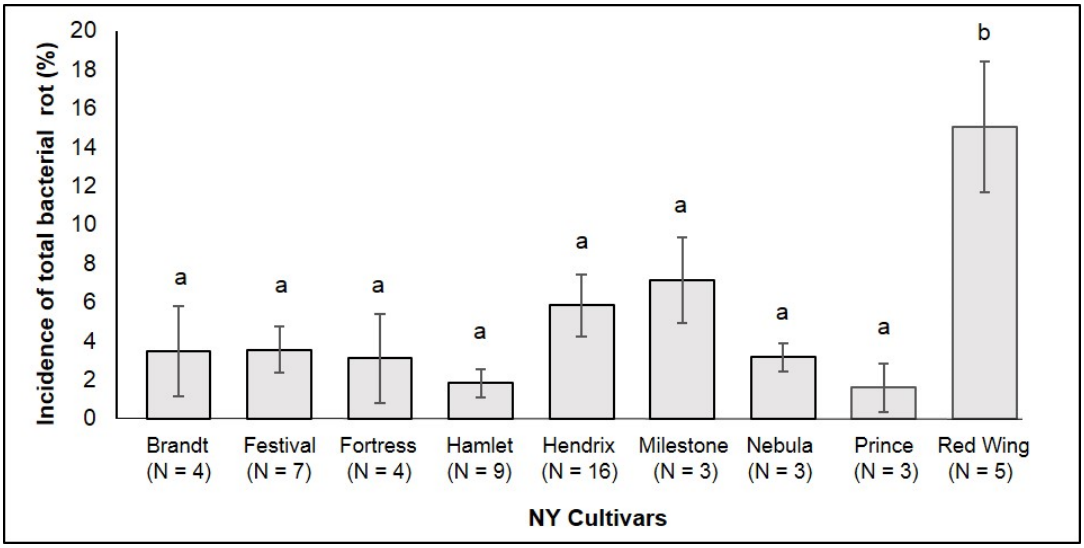

Fig. 3: Total bacterial disease incidence in eight onion cultivars sampled from NY in 2011 and 2012. Bars represent the average disease incidence for each cultivars, with error bars representing the standard error of the mean. Different letters above each bar indicate statistically significant results by Fisher's LSD.

Future work

Based on results from these datasets, several more replicated research trials on bacterial rots of onion are planned for the 2015 and 2016 growing seasons. Nitrogen fertilizer type and application timing will be compared using multiple fertigation programs to begin to develop updated fertility recommendations. A cultivar susceptibility trial will be completed using low pungency onions suitable for the PA Simply Sweet® program. Timed mulch removal will be conducted in replicated plots to determine if this is effective in reducing bacterial rots and when during the season removal should occur. Results from these trials will generate updated recommendations for integrated management of bacterial rots of onion.

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