Exploring the Relationship Between Nitrogen, Plant Spacing and Bacterial Diseases of Onion in New York:
Reduced Nitrogen and Closer Spacing Could Result in Less Rot

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It is important to emphasize that "exploring" is in the present tense. In New York, we are just beginning to delve into the fascinating relationship between nitrogen, plant spacing and bacterial diseases of onions. Our preliminary results suggest that reduced soil nitrogen and tighter plant spacing results in less bacterial decay. In this article, we report preliminary findings from exploratory studies and the observations that lead to these trials. We stress that we are not making recommendations at this time. However, we are hopeful that further studies will lead to specific recommendations.

Bacterial diseases are a serious threat to sustainable onion production: Bacterial diseases of onions have become a serious threat to the sustainability of the New York onion industry. The bacterial pathogens, *Burkholderia cepacia*, *Pantoea ananatis* and *Enterobacter cloaceae* are the most common that plague onions in New York. Because bacterial bulb decay often affects only a single internal bulb scale while the outer scales remain firm (Fig. 1), such infected bulbs are virtually impossible to detect on the grading line. When such onions are shipped and consequently rejected, this often results in entire loads being dumped, despite only a small percentage of bulbs being infected, resulting in significant economic losses for growers.

The solution lies in an integrated approach: Ultimately, an Integrated Pest Management (IPM) approach will be required to manage bacterial diseases of onions, which might involve many different tactics including field sanitation, less susceptible varieties, materials that induce plant resistance, bactericides, crop rotation, anti-bacterial cover crops, soil amendments, strategic curing conditions, imaging technology to detect internal rots prior to shipping, and also, regulating plant spacing and reducing nitrogen fertility. Researchers and Extension professionals at Cornell and Nationwide have been working on several of these components. Here, we report on our exploratory work of reduced nitrogen and closer plant spacing.

High levels of soil nitrogen increase bacterial bulb decay: In 2010, an important observation was made in a small-plot on-farm field trial in onions grown on plastic in Pennsylvania. The plots located at the bottom of the slope had 83% bacterial bulb decay at harvest. The amount of decay decreased progressively in each replicate moving up the slope to 58% to 17% to zero in the replicate at the top of the slope. The trial was located on a diversified farm that had been heavily manured. Perhaps, heavy rainfall had caused nitrogen to leach from the top to the bottom of the slope, and thus, increased nitrogen at the bottom of the slope may have contributed to the higher levels of bacterial bulb decay.

Also in 2010, incidence of bacterial bulb decay at harvest was assessed in a study that was designed to evaluate the effect of nitrogen on onion thrips. In that study, onions grown with only

2.0 lb/A of applied nitrogen had 0.7% bacterial rot at harvest (Fig. 2). Onions grown with the Cornell recommended rate of 125 lb/A of nitrogen had 10.8% bulb decay, which was 15 times more than the rot that occurred at the 2.0 lb/A rate. Compared to the recommended rate, onions grown with reduced rates of applied nitrogen, 62 and 94 lb/A, had significantly less than half (4.9%) and one third (7.3%), respectively, of bacterial decay without any significant differences in yield.

In-depth studies initiated: In 2011, two major studies were undertaken to further investigate the relationship between nitrogen, plant spacing and resulting bacterial diseases of onions. The objective of the first study was to identify the most important factors associated with bacterial diseases of onion in commercial onion fields in both New York and Pennsylvania. In New York, 22 muck land direct seeded onion fields were surveyed from seven growers in seven counties, and included six varieties. A similar survey was conducted in Pennsylvania, which focused on onions grown from transplants on plastic.

The second on-farm study investigated the effect of reduced applied nitrogen and reduced plant spacing on bacterial bulb rot. This trial was a follow-up to studies conducted by Hoepting *et al.* (2009, 2010) which showed that reduced plant spacing in small-scale production of onions on plastic provided 53 to 64% control of bacterial bulb decay at harvest. Whether reduced plant spacing also impacts bacterial bulb decay in direct seeded onions grown on muck lands with higher planting densities was unknown.

In this study, three rates of nitrogen, 0, 45 and 90 lb per acre, and three seeding rates, 5.3, 7.5 and 10 seeds per foot, were evaluated in each of two varieties, Nebula and Prince. Onions were direct seeded into 32" wide raised beds with two single rows of onions spaced 12 inches apart on the bed. The trial was established in muck soil by a grower cooperator in Oswego County, New York. Unfortunately, soil test results showed no difference between the 0 and 45 lb per acre rates of nitrogen, so they were pooled together as "low nitrogen 0-45 lb/A".

Results:
In NY, in 2011 there were low levels of bacterial bulb decay with incidence in the observational survey ranging from 0 to 17.4% at harvest. The variety, Hendrix had the widest range of bacterial rot. In this variety, we found that the strongest correlation occurred among percent bacterial bulb decay at harvest and available nitrate-nitrogen (NO_3-N) in the mid-season at the 7-9 leaf stage. The fields with the highest available nitrogen also had the highest incidence of bacterial rot at harvest. Across the 66 survey sites available NO_3-N in mid-season ranged from 70 to 936 ppm with an average of 296 ppm. **These results suggest that there is opportunity to manage nitrogen fertility more efficiently and effectively with the potential benefit of reducing losses from bacterial diseases.**

Fortunately for our grower cooperator, but unfortunately for us, in the Oswego County trial, there was an average of 0.44% and 1.5% bulb rot at harvest and out of storage, respectively. Therefore, we need to carry out similar studies in which the incidence of bacterial decay is much higher. Nevertheless, this trial suggested some interesting relationships and revealed several horticultural effects.

Variety had an effect on bacterial decay: Variety was the only variable where there were significant differences in bacterial decay. Nebula had almost double bulb decay as Prince (Fig. 3). Assuming this difference was to transfer to situations where bacterial disease pressure is higher, then selecting less susceptible varieties may be a very important factor in managing bacterial diseases of onion. This warrants further investigation and a preliminary study is underway in New York to evaluate the relative susceptibility of onion varieties commonly grown in New York to bacterial diseases.

Low nitrogen and high seeding rate had less bacterial decay: As expected, when the results were pooled across variety and seeding rate, the incidence of bacterial disease was 1.5 times higher with the high rate of nitrogen (90 lb/acre) than the low rate (0 to 45 lb/acre) (Fig. 3). Similarly, the highest seeding rate (10 seeds/ft) had only about half the bacterial bulb decay as the standard seeding rate (7.5 seeds/ft) (Fig. 3). However, not as expected, the lowest seeding density (5.3 seeds/ft) did not have higher incidence of bacterial decay than the standard. A breakdown of the data indicated that Prince had higher incidence of bacterial rot as seeding rate decreased in both rates of nitrogen, especially at the high rate of nitrogen, but Nebula did not exhibit any consistent trends. Thus, it seems that different varieties respond differently to reduced nitrogen and increased spacing, which may be related to plant vigor, and future studies should aim to understand these interactions.

An integrated approach should not compromise yield: Our preliminary results indicate that applying less nitrogen and decreasing plant spacing may be useful for managing bacterial diseases of onions. For either of these strategies to be feasible, they must not reduce yield. When the results were broken down, the highest seeding rate consistently had the highest yield in both varieties only with the high nitrogen rate. At the low nitrogen rate, seeding rate did not have an effect on marketable yield in the larger variety, Prince. In Nebula, the lowest seeding rate had 49 (= 6.5%) and 57 (=7.6%) cwt/A less total marketable yield than the high and standard seeding rates, respectively. These results remind us that increasing seeding rate and reducing nitrogen to the extent that each component works best independently may compromise yield due to nitrogen deficiency. Different varieties with different vigor and days to maturity may also respond differently to these factors. Small and medium sized onions tend to fetch lower prices and may be in limited demand. Of course, if high nitrogen rates and low seeding rates result in high levels of bacterial bulb decay, increased yields from smaller sized onions may very well be more feasible economically than larger rotten bulbs.

We also observed that the high rate of nitrogen and seeding rate delayed maturity. In some cases, delayed maturity is not a desirable trait. All of these factors must be considered as we develop an IPM approach to managing bacterial diseases of onions.

Opportunity to reduce nitrogen inputs in New York: Regardless of whether reduced nitrogen rates can significantly reduce bacterial diseases of onion, the results from all of these studies strongly suggest that there is opportunity to reduce the use of nitrogen fertilizer in onion production. In the nitrogen and seeding rate study, the “high” rate of nitrogen of 90 lb/A is actually only 72% of the Cornell recommended rate of 125 lb/A and yet this field still yielded 893 cwt per acre of marketable onions. Even more impressive, the low rate (0-45 lbs/A) yielded 832 cw per acre! Soil samples collected for these studies consistently showed that the majority

of onion fields have excessive levels of available nitrogen in mid-season. Preliminary findings warrant further study. In the meantime, **we strongly encourage onion growers to "experiment" on their own farms with reduced nitrogen inputs for onion production.**

This information was presented at the 2012 Empire State Fruit and Vegetable Expo on January 26, 2012 by Christy Hoepting, Vegetable Specialist with the Cornell Cooperative Extension Vegetable Program, cah59@cornell.edu; 585-798-4265 x38. A copy of the presentation is available online at http://www.hort.cornell.edu/expo/2012proceedings.php. Funding for studies mentioned in this project was provided by the Northeast IPM Partnership and Competitive grants in collaboration with Steve Beer, Cornell and Beth Gugino, Penn State.

Figure 1. Inner scale(s) of onion bulb is infected with bacterial decay, while outer scales remain firm making detection on grading line challenging. Photo courtesy of Steve Beer.

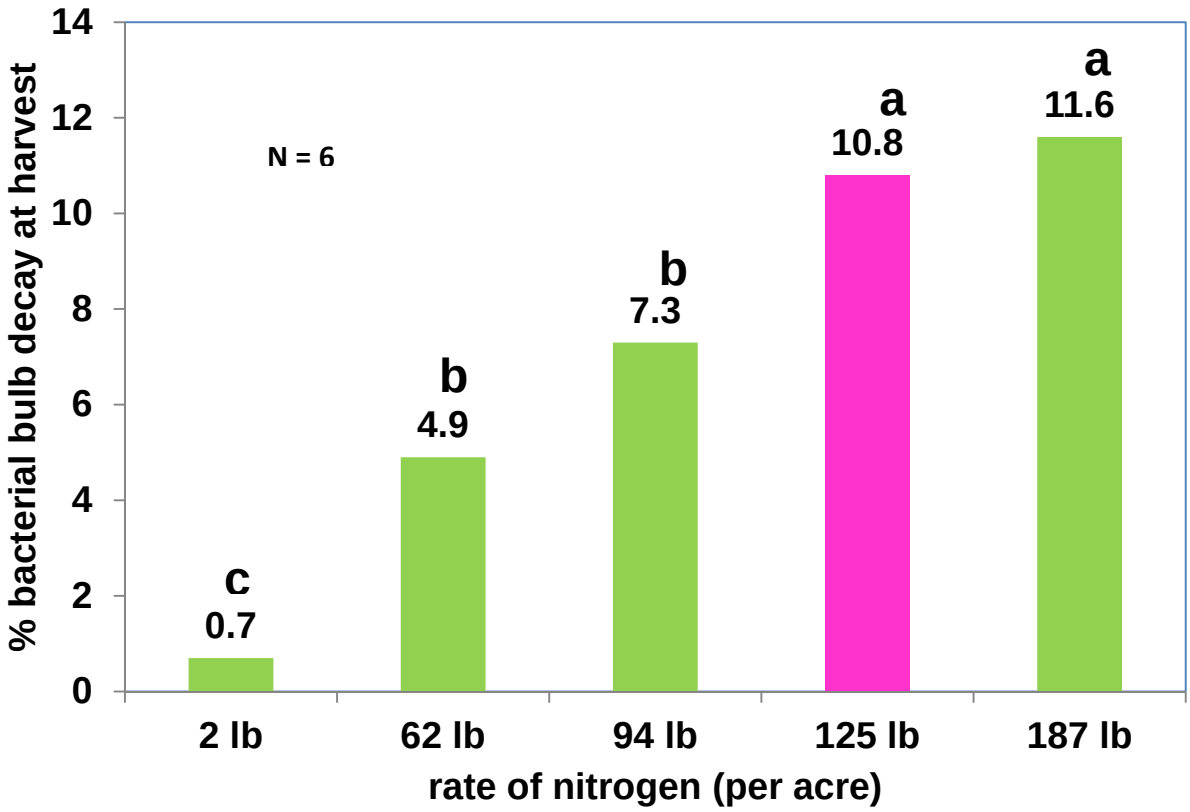

Figure 2. Effect of amount of applied nitrogen on bacterial bulb decay at harvest. The trial was an on-farm, small-plot replicated field study in muck land in Elba, NY, 2010 (Hoepting, Hsu and Nault, 2010). Data bars with the same letter are not significantly different, Fisher's Protected LSD test ($p<0.05$). The pink bar indicates the recommended rate of nitrogen.

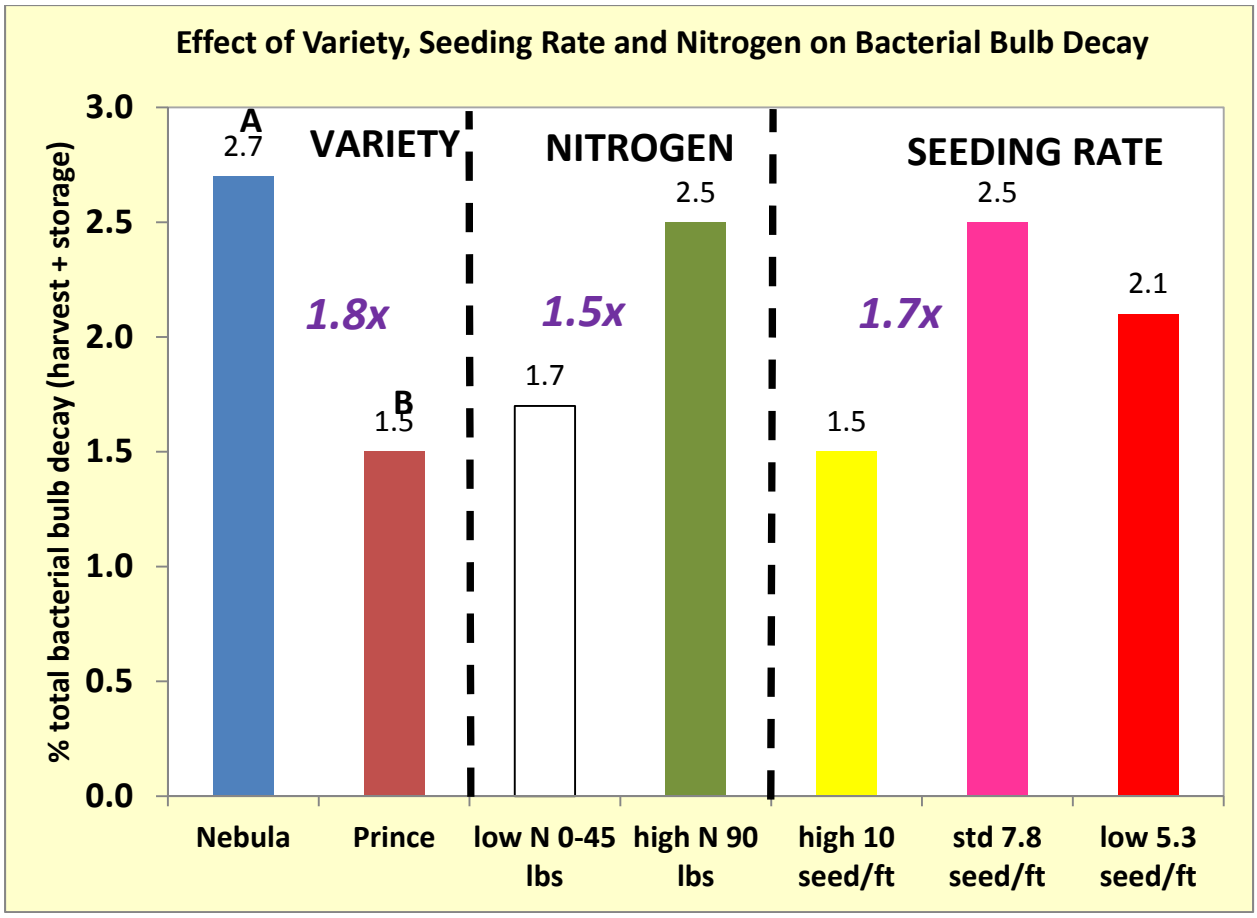

Figure 3. Effect of variety, reduced nitrogen and seeding rate on bacterial bulb decay following storage, Oswego Co., 2011 (Hoepting & Beer). With a category such as variety or nitrogen, bars followed by the same letter are not significantly different according to Fisher's Protected LSD test ($p<0.05$). Purple numbers indicate the "fold" difference (e.g. Nebula had 1.8x more rot than Prince) between adjacent bars.