Battling Onion Bacterial Diseases with Bactericides

By Lindsey du Toit, Tim Waters, Michael Derie and Jennifer Darner, Washington State University

Onions are a hardy species. However, like most living things, onions can become infected by a diversity of pathogens, including fungi, bacteria, viruses, nematodes, phytoplasmas, parasitic plants and others. About 20 species of bacteria alone can cause diseases of onion plants and bulbs. Some of these bacteria cause distinct lesions on onion leaves that reduce photosynthesis. Others cause the foliage to die back into the necks, leading to soft rot of bulbs in the field. (Fig. 1)

Some bacteria infect onion plants and bulbs in the field without causing visible symptoms. These latent infections can, insidiously, start to rot the bulbs after harvest, in storage or when the bulbs are shipped to markets, after all production and packing costs have been incurred. These bacterial diseases have been estimated to cause $60 million in losses annually in the United States alone. Losses can vary widely among regions, seasons and fields, depending on environmental conditions and production practices.

Favorable Conditions for Bacterial Diseases

Bacterial diseases of onion are favored by moisture, whether from irrigation, rain or dew. The bacteria are spread by splashing water. Storms are particularly conducive to bacterial diseases because of the combination of moisture and physical damage to the crop from wind, hail and even sandblasting. Frost, feeding injury from pests such as thrips and mechanical practices that cause wounding when the plants are still green can all predispose onion plants to infection by bacteria. Overhead irrigation, rains, irrigating excessively late in the season when bulbs should be field curing, excessive nitrogen fertility (particularly after bulb initiation) and dense plant stands that increase relative humidity in the canopy by limiting air movement all create favorable conditions for bacterial diseases of onion.

Many of these bacteria are common in soil and surface water, a few can be seedborne, some colonize certain weed species that act as reservoirs of inoculum, and some can be carried by pests such as thrips.

Figure 2. *Michael Derie applied inoculum of two bacterial pathogens of onion,* Burkholderia gladioli *pv.* allicola *and* Pantoea agglomerans, *to relevant plots after sunset on the evenings of Aug. 1 (~5 percent tops down) and Aug. 15, using a CO_2-pressurized backpack sprayer.*

Management Tools

Managing bacterial diseases of onion effectively requires a comprehensive box of management tools, even in semi-arid regions of production where the amount of water used to grow an onion crop typically can be managed more readily than in regions with high rainfall and humidity.

Management tools include purchasing high quality seed or transplants, using good sanitation practices such as removing culled onions and onion volunteers that can harbor inoculum, taking precautions to minimize wounding of plants and bulbs, avoiding excessive irrigation and fertility (particularly in the latter part of the season), applying pesticides that have efficacy against bacteria, using cultural practices that speed up field curing (e.g. undercutting and timely tapering of irrigation) and careful postharvest curing to speed up drying of the necks for storage of bulbs.

Pesticide Limitations

Numerous pesticides are registered for use in onion crops for control of bacterial diseases. However, there is very little independent information available to growers on the relative efficacy of these products for control of onion bacterial diseases. Furthermore, these bactericides largely function as protectants; in other words, they cannot cure existing infections. This means pesticides need to be applied preventatively.

Also, almost none of these bactericides are systemic, meaning they are not absorbed and moved internally within the plant. Therefore, it is extremely important to get good coverage of the crop canopy with any applications, particularly to get the products on the necks of plants late in the season during the period of greatest risk of bulb infections.

Figure 1. *Bacterial pathogens of onion can cause a wide range in symptoms, including leaf yellowing or chlorosis (A), water-soaked lesions on leaves (B), severe leaf dieback (C) and soft rot in the field (D), and bulb rot at harvest or in storage (E).*

Further complicating the choices growers face in selecting relevant pesticides are the numerous formulations of the same or similar active ingredients, such as the many copper products available to growers.

Onion Bactericide Trial

In 2019, the Interregional 4 (IR-4) Minor Crops Pest Program provided funding for Lindsey du Toit, professor and vegetable seed pathologist at Washington State University (WSU), and Beth Gugino, professor and extension plant pathologist at Pennsylvania State University, to evaluate a diversity of pesticides for control of bacterial diseases of onion. This report summarizes results of the IR-4 field trial completed in the semi-arid Columbia Basin of central Washington in 2019-20. For details of the Pennsylvania trial, email Gugino at bmk120@psu.edu.

Seed of the onion cultivar Calibra was planted on April 1, 2019, at a population of 164,000 seeds per acre at the WSU Pasco Extension Farm in Pasco, Washington. Fifteen bactericide treatments were evaluated (Table 1) using a split-plot, randomized complete block design with four replicate plots of each treatment combination. The bactericide products were each applied to four main plots, with each main plot consisting of two beds of onions that functioned as split-plots. One bed (split-plot) was inoculated with bacterial pathogens of onion, and one was not inoculated. Plots were each 15 feet long, with a 5-foot alley between the ends of adjacent plots. The trial included a total of 120 split-plots (15 bactericides x 2 inoculations x 4 replications). Each product was applied three to five times at a five- to seven-day interval (Table 1), based on label instructions, with the first applications made on July 24.

Inoculum consisting of a mixture of two bacterial pathogens of onion, *Burkholderia gladioli* pv. *allicola* and

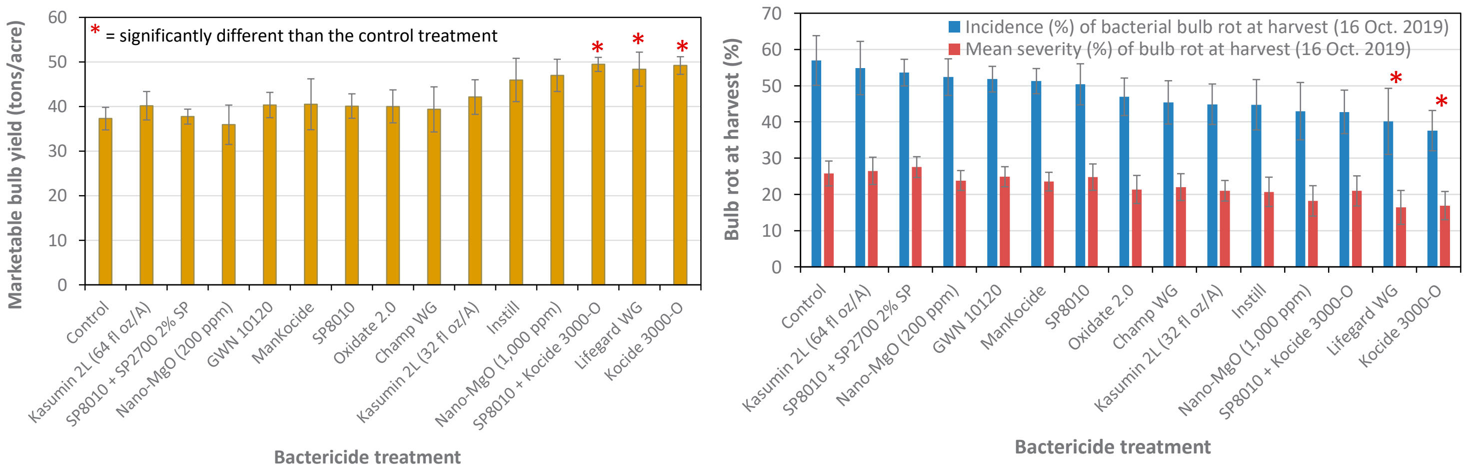

Figure 3. *Effects of various bactericide treatments on marketable bulb yield (left figure) and incidence and severity of bacterial bulb rot (right figure) at harvest in an onion trial in the Columbia Basin of Washington state in 2019-20*

Pantoea agglomerans, was applied to the relevant split-plots during the evenings of Aug. 1 (at approximately 5 percent tops down) and Aug. 15, using a CO2-pressurized backpack sprayer. Inoculum was applied at 108 CFU/ml inoculum at 20 psi in 44.5 gpa (Fig. 2). The trial was drip-irrigated but, to create conducive conditions for bacterial infection, overhead sprinklers were turned on for 15 minutes in the late afternoon every other day in July and August.

Each plot was rated six times on a weekly basis for the percentage of plants with symptoms of bacterial leaf blight (incidence of disease) and severity of bacterial leaf blight on a 0 to 7 scale, from July 23 to Aug. 27. The plots also were rated on Aug. 6 and Aug. 27 for phytotoxicity from the products applied.

Bulbs were harvested from a 5-foot section of each split-plot on Oct. 7, sized and weighed to calculate marketable yield. Fifty bulbs were cut lengthwise and rated for the presence and severity of bacterial rot to determine the incidence (percentage) of bulbs with bacterial rot and the mean severity of bacterial rot per plot. An additional 50 bulbs from each plot were placed in a commercial storage facility and rated on Feb. 11, 2020, for the incidence and severity of bacterial rot. The data were subjected to analyses of variance and means comparisons.

Results

The inoculation protocol used in the Washington trial was highly successful at causing bacterial leaf blight and bulb rot (Table 2). Symptoms of bacterial leaf blight were first observed 19 days after inoculation. On average, 38 percent of the plants in inoculated plots had symptoms of bacterial leaf blight by Aug. 20, with a mean severity of 4.3 (on a 0 to 7 scale), compared to 8 percent of plants in the non-inoculated plots with a mean severity of 1.7. A week later, on Aug. 27, 63 percent of plants in inoculated plots had symptoms vs. 23 percent of plants in non-inoculated plots, and the severity of symptoms had increased to 5.7 vs. 4.3, respectively. Inoculum spread between adjacent inoculated and non-inoculated split-plots because of the proximity of split-plots and dispersal of the bacteria by overhead sprinklers.

Inoculating the plots with *B. gladioli* and *P. agglomerans* significantly affected all the variables measured (Table 2). The tops fell over more quickly in inoculated plots (55 vs. 48 percent tops down by Aug. 6). Marketable bulb yield was 15 percent less in inoculated plots (39 tons/acre) compared to non-inoculated plots (46 tons/acre). In addition, 51 percent of the bulbs in inoculated plots had bacterial rot symptoms at harvest vs. 35 percent in non-inoculated plots. The severity of bulb rot in inoculated plots was 17 percent compared to 9 percent in non-inoculated plots. After four months in storage, 55 percent of the bulbs from inoculated plots had bacterial rot (mean severity of 27 percent) compared to 40 percent of bulbs from non-inoculated plots (mean severity of 17 percent).

Disappointingly, most of the bactericide treatments provided no significant control of bacterial leaf blight or bulb rot. There also was no significant interaction between bactericide treatments and inoculation treatments for any of the variables measured. Kocide 3000-O and Lifegard WG were the only treatments that caused a significant increase in marketable bulb yield compared to the control plots (Fig. 3). Marketable bulb yield averaged 49 and 48 tons/acre for plots treated with Kocide 3000-O and Lifegard WG, respectively, compared to 37 tons/acre for control plots. Similarly, Kocide 3000-O and Lifegard WG were the only two products that reduced the percentage of bulbs with bacterial rot at harvest (38 and 40 percent bulb rot, respectively, vs. 57 percent for control plots) (Fig. 3) and reduced severity of bulb rot after four months in storage (28 percent rot for bulbs from plots with these two treatments vs. 55 percent from control plots). Adding SP8010 to Kocide 3000-O did not add a benefit compared to Kocide 3000-O alone. None of the bactericide treatments caused symptoms of phytotoxicity.

Next Steps

The very high bacterial disease pressure in this field trial illustrated the extent to which frequent wetting of the canopy from overhead sprinkler irrigation was so conducive to bacterial infection. The bactericide treatments evaluated were largely ineffective, except for Kocide 3000-O and Lifegard WG, despite all the plots having been treated at least twice with the products before the plots were first inoculated. This highlights the limited capacity for growers to manage bacterial diseases in onion crops using pesticides alone. Effective management of these pathogens should be based primarily on the use of pre-harvest cultural practices, particularly judicious irrigation and fertility practices, rather than a focus on pesticide applications.

In fall 2019, the USDA National Institute of Food and Agriculture awarded grant number 2019-51181-30013 for four years of funding to 24 onion researchers and extension specialists from 12 states as well as South Africa to help producers manage bacterial diseases more effectively in onion production. The project, titled "Stop the Rot - Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies," focuses on onion bacterial disease characterization and development of effective management recommendations. A team of 12 onion stakeholders from across the U.S. serves on the Stakeholder Advisory Panel to provide guidance over the duration of the project. Surveys and numerous field trials focused on practical aspects of onion are being carried out across seven regions of production in the U.S. over three field seasons. This includes additional bactericide trials to build on results of this IR-4 project. For updates on this project, visit www.alliumnet.com/projects/stop-the-rot or contact du Toit, Stop the Rot project director at dutoit@wsu.edu; or Heather MacKay, project manager, at heather.mackaybrown@wsu.edu. We welcome your input.

Table 1. *Products evaluated for control of bacterial leaf blight and bulb rot in an onion trial in the Columbia Basin of Washington state in 2019-20*

No.	Product	Active ingredient	Rate of application	No. of applications	Application interval
1	Control	-	-	-	-
2	ManKocide	Mancozeb + copper hydroxide	2.25 lb/A	5	7 days
3	Kocide 3000-O	Copper hydroxide	1.5 lb/A	5	7 days
4	Champ WG	Copper hydroxide	1.5 lb/A	5	7 days
5	Oxidate 2.0	Hydrogen peroxide + peroxyacetic acid	1.25 fl oz/2 gal	7	5 days
6	Kasumin 2L	Kasugamycin	32 fl oz/A	4	7 days
7	Kasumin 2L	Kasugamycin	64 fl oz/A	4	7 days
8	Nano-MgO	Nano-magnesium oxide	200 ug/ml	5	7 days
9	Nano-MgO	Nano-magnesium oxide	1,000 ug/ml	5	7 days
10	GWN 10120	Ammonia copper hydroxide	2.0 pt/A	5	7 days
11	SP8010	Unknown	19 fl oz/A	5	7 days
12	SP8010 + Kocide 3000-O	Unknown + copper hydroxide	19 fl oz + 1.5 lb/A	5	7 days
13	SP8010 + SP2700 2% SP	Unknown	19 fl oz + 4.2 oz/A	5	7 days
14	Lifegard WG	*Bacillus mycoides J*	4.5 oz/100 gal	5	7 days
15	Instill	Copper sulfate + metallic copper	0.86 lb active ingredient/100 gal	3	7 days

Pesticide Disclaimer

Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action. It is the user's responsibility to check the label before using any product to ensure lawful use and obtain all necessary permits in advance.

Table 2. *Effects of inoculating onion plants with* Burkholderia gladioli *pv.* alliicola *and* Pantoea agglomerans *at the start of the tops falling and again two weeks later in an onion trial in the Columbia Basin of central Washington*

Variable	Inoculated	Non-inoculated	ANOVA *P* value*
Percentage of plants with bacterial leaf blight on Aug. 20	37.7 ± 2.5%	7.5 ± 1.2%	<0.0001
Percentage of plants with bacterial leaf blight on Aug. 27	63.1 ± 3.3%	23.4 ± 2.2%	<0.0001
Severity of bacterial leaf blight on Aug. 20 (0 to 7 scale)	4.3 ± 0.2	1.7 ± 0.2	<0.0001
Severity of bacterial leaf blight on Aug. 27 (0 to 7 scale)	5.7 ± 0.2	4.3 ± 0.2	<0.0001
Percentage of tops down on Aug. 6	55.1 ± 3.8%	47.8 ± 4.0%	0.0620
Percentage of bulbs with bacterial rot at harvest	50.9 ± 2.2%	35.0 ± 2.3%	<0.0001
Mean severity of bacterial rot per bulb at harvest (% of cut surface area with symptoms of rot)	16.7 ± 1.1%	8.5 ± 0.8%	<0.0001
Number of marketable bulbs/5 ft of bed	34.0 ± 1.2	37.2 ± 1.3	0.0205
Marketable bulb yield (tons/acre)	38.7 ± 1.3	45.8 ± 1.3	<0.0001
Percentage of bulbs with bacterial rot in storage (Feb. 11)	55.2 ± 1.8%	40.4 ± 2.2	<0.0001
Mean severity of bacterial rot on bulbs in storage (Feb. 11)	27.4 ± 1.2%	17.1 ± 1.1%	<0.0001

ANOVA P value = Analysis of variance probability of no significant effect of inoculation on the variable measured. A probability <0.05 was considered evidence of a significant effect of the inoculations.