ONION (*Allium cepa*'Calibra')
Center rot; *Pantoea agglomerans*
Slippery skin; *Burkholderia gladioli* pv. *alliicola*

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Efficacy of bactericides for management of bacterial leaf blight and bacterial bulb rot in an onion crop in Pasco, WA, 2020.

A field trial was planted on 2 Apr 20 at the Washington State University Pasco Vegetable Extension Farm using pelleted seed of the cv. Calibra to evaluate the efficacy of seven bactericide treatments for management of bacterial leaf blight and bulb rot caused by *Pantoea agglomerans* and *Burkholderia gladioli* pv. *alliicola* in storage onion bulb crops in the Columbia Basin of central Washington and northcentral Oregon. The trial was a split plot, randomized complete block design with five replications of a factorial treatment design: two inoculation treatments (inoculated or not inoculated) applied to main plots, and eight bactericide treatments (seven products and a control treatment) applied to split plots. Each plot was one 34-in. bed wide (with 2 double-rows of onion) x 15 ft long, including 5 ft of bed as a buffer between the ends of adjacent plots. Each product was applied five times at a 7-day interval, on 15, 22, and 29 Jul, and 4 and 12 Aug, with a tractor-mounted 3-nozzle spray boom at 30 gpa and 25 psi with 110º air induction O2 nozzles. The surfactant R-11 was used with each product at 32 oz/100 gal water (0.25% v/v). Control plots were not treated with water or surfactant. Inoculum consisting of an equal ratio of the two pathogens was applied to relevant main plots on 30 Jul, at 5% tops down (the day after the second application of each bactericide treatment), and on 13 Aug, at 50% tops down (a day after the fifth application of each bactericide). Inoculum was applied in the evening at 10^8 CFU/ml with a CO_2-pressurized backpack sprayer and 3-nozzle boom (XR8003 tips) at 32.8 gpa and 20 psi. The trial was irrigated by center-pivot and managed with typical practices for the Columbia Basin. All plots were irrigated with 0.12 in. of water in the late afternoon every other day from mid-Jul through Aug to favor bacterial infection. Each plot was rated six times for incidence (percentage of plants with bacterial leaf blight) and severity of foliar symptoms (percentage of canopy with symptoms): on 14 Jul, prior to the first bactericide application, on 21 and 28 Jul, and on 4, 11, and 18 Aug. Severity of phytotoxicity from the applications was rated at all but the first of these dates. Plots also were rated for percentage tops down on 11 and 18 Aug, and were undercut on 25 Aug. Bulbs were harvested from two 5-ft sections/split plot on 14 Sep. Bulbs harvested from one 5-ft section were cut vertically and the plot rated for incidence (%) of bulbs with internal bacterial rot and severity (% of cut surface area of each bulb) of symptoms. Bulbs harvested from the second section were sorted into bulbs culled because of external symptoms of bacterial rot, bulbs culled for other reasons (split bulbs, green shoulders, double-bulbs, or bolted), and marketable bulbs. Marketable bulbs were sized (pre-pack, medium, jumbo, and colossal), and counted and weighed by size to calculate marketable yield (t/A). The marketable bulbs were placed in a commercial onion storage facility (40ºF, 70% relative humidity) for 5 months, and then cut vertically on 26 Feb 21) and rated for the incidence and severity of internal bulb rot. Data were subjected to analyses of variance (ANOVAs) and means comparisons using Fisher's protected least significant difference (LSD).

Within a week of the first application of bactericides, symptoms of phytotoxicity from each of the copper products were observed as white to silver spots or irregular lesions on the south-facing side of leaves and on leaves in a horizontal orientation, i.e., the surface exposed to the afternoon sun. Symptoms of phytotoxicity were observed through August in all plots treated with copper products, regardless of whether plots were inoculated or not (no significant inoculation effect or inoculation-by-bactericide interaction in the ANOVAs for all six weeks). By 4 Aug, plots treated with Badge SC had the most severe phytotoxicity (33.0%), followed by plots treated with the other three copper products (7.0 to 16.9% severity). There was no evidence of phytotoxicity from Oxidate 2.0, Lifegard WG, or nano-magnesium oxide, or in control plots. Maximum air temperature reached >100ºF almost daily from mid- to late July, peaking at 112ºF. Phytotoxicity from copper treatments likely was associated with hot, dry conditions at the time of applications. Symptoms of bacterial leaf blight were first observed on 11 Aug, two weeks after the first inoculation, at which time the incidence of plants with symptoms averaged 3.9% in inoculated plots vs. 1.1% in non-inoculated plots, and severity averaged 0.5% in inoculated plots vs. 0.3% in non-inoculated plots. By 18 Aug, the incidence of symptomatic plants had increased to 17.4% in inoculated plots vs. 4.5% in non-inoculated plots, with an average severity of 3.7% in inoculated plots vs. 0.5% in non-inoculated plots. The timing and method of inoculation, combined with brief overhead irrigation every other evening the month prior to harvest, effectively established bacterial infections. None of the bactericide treatments reduced the incidence or severity of bacterial leaf blight at any of the ratings ($P \geq 0.6033$), and there was no significant interaction between inoculation and bactericide treatments (P = 0.1095 to 0.6904). The percentage tops down was not affected by inoculation treatments, bactericide treatments, or the interaction of these main effects (*data not shown*), with an average 40.4 and 75.6% tops down on 11 and 18 Aug, respectively. Bactericide treatments had no significant effect on any of the measurements of bulb yield (number and weight of pre-pack, medium, jumbo, and colossal bulbs; total marketable bulbs, culled bulbs, and culled bulbs with external symptoms of bacterial rot), regardless of inoculation treatment. However, inoculation reduced the yield (t/A) of jumbo, colossal, and total marketable bulbs, and increased the yield of culled bulbs with external symptoms of bacterial rot. Inoculated vs. non-inoculated plots averaged 35.7 vs. 39.6 t/A of marketable bulbs and 2.8 vs. 0.3 t/A of bulbs culled at harvest because of external symptoms of bacterial rot. At harvest, 21.9% of bulbs from inoculated plots had internal bacterial rot, with an average severity of 9.0% per bulb, whereas 1.6% of bulbs from non-inoculated plots had internal bacterial rot with 0.5% average severity per bulb. Bactericide treatments had no effect on incidence or severity of internal bacterial bulb rot at harvest or after 5 months of storage. Similar differences in incidence and severity of internal bacterial bulb rot between inoculated and non-inoculated plots were observed after 5 months of storage. Isolations from symptomatic bulbs primarily yielded *B. gladioli* pv. *alliicola*. In summary, despite preventative and weekly applications, none of the seven bactericides evaluated provided effective control of bacterial leaf blight and bulb rot of onion under the conditions of this trial.

Main plot and split plot treatments	Foliar phyto-toxicity (4 Aug)[z]	Foliar bacterial symptoms (18 Aug): Incidence (% of plants)	Foliar bacterial symptoms (18 Aug): Severity (% of canopy)	Bulb yield (t/A): Marketable bulbs	Bulb yield (t/A): Bacterial culls	Internal bacterial bulb rot, At harvest: Incidence of bulbs (%)	Internal bacterial bulb rot, At harvest: Severity per bulb (%)	Internal bacterial bulb rot, After storage: Incidence of bulbs (%)	Internal bacterial bulb rot, After storage: Severity per bulb (%)
Main plots									
Inoculated	8.2	17.4 a	3.7 a	35.7 b	2.8 a	21.9 a	9.0 a	14.9 a	7.9 a
Non-inoculated	8.3	4.5 b	0.5 b	39.6 a	0.3 b	1.6 b	0.5 b	1.4 b	0.6 b
LSD	2.9	Rank[x]	Rank	3.2	Rank	Rank	2.1	Rank	Rank
P value	0.9335	0.0001	0.0001	0.0110	0.0001	0.0001	0.0428	0.0001	0.0001
Split-plots and rate/A									
Kocide 3000 1.5 lb	7.0 b[y]	22.4	3.8	37.9	3.6	20.4	8.0	15.7	8.3
ManKocide 2.25 lb	16.9 b	12.0	3.5	35.1	2.8	25.9	10.9	12.3	5.9
Badge SC 2.75 pt	33.0 a	14.4	3.0	36.9	0.9	25.4	9.7	11.0	4.9
Cuprofix Ultra 40 Disperss Dry Flowable 2.5 lb	9.0 b	11.2	2.2	36.8	2.1	16.9	5.7	10.8	6.1
Oxidate 2.0 1.25 fl oz/2 gal water	0.0 c	16.8	3.4	38.6	3.1	21.7	9.0	12.3	5.7
Lifegard WG4.5 oz/100 gal	0.0 c	22.4	3.5	30.7	4.5	19.3	8.5	23.2	13.4
Nano-MgO 1,000 ppm	0.0 c	22.4	5.0	33.1	1.4	20.4	8.5	16.0	8.1
Control	0.0 c	17.6	4.8	36.7	3.8	25.0	11.8	18.1	10.5
LSD	Rank	Rank	Rank	9.8	2.6	11.4	5.9	8.8	Rank
P value	0.0001	0.5242	0.7184	0.7499	0.1142	0.6856	0.5800	0.1008	0.1341

[z] Mean foliar phytotoxicity ratings resulting from bactericide treatments are averaged across inoculated and non-inoculated plots because there was no significant effect of inoculation ($P = 0.7306$) and no significant interaction of inoculation treatments with bactericide treatments ($P = 0.9967$). Mean ratings for bactericide treatments for all other variables are shown only for inoculated plots because of a significant inoculation effect for these variables ($P < 0.05$), very little infection observed in non-inoculated plots, and no significant interaction of inoculation treatments with bactericide treatments in the ANOVAs ($P > 0.05$).

[y] Within each inoculation treatment comparison, and within each bactericide treatment comparison, means within a column followed by the same letter are not significantly different based on Fisher's protected least significant difference (LSD). If the F-test in the ANOVA was not significant, means separation letters are not shown.

[x] 'Rank' = data subjected to Friedman's non-parametric rank test to meet assumptions for parametric analyses. Original means are shown but means separation is based on the transformed analysis.