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

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**Effects of application method and bactericides on control of bacterial leaf blight and bulb rot of onion, Pasco, WA, 2022-23.**

A field trial was planted on 31 Mar 22 at the Washington State University Pasco Vegetable Extension Farm, using pelleted seed of the onion cv. Calibra (210,000 plants/A), to evaluate the efficacy of spray boom vs. chemigation applications of three bactericide products on management of bacterial leaf blight and bacterial 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-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, two methods of application (spray boom vs. chemigation) applied to split pots, and four bactericide treatments (Badge SC, ManKocide, Lifegard WG, and a control treatment) applied to split-split plots. Each split-split plot was one 34-in. bed wide (2 double-rows of onion) x 15 ft long, including 5 ft of bed as a buffer between adjacent plots. Each bactericide product was applied five times at 7-day intervals (13, 20, and 27 Jul, and 3 and 10 Aug), either with a tractor-mounted 3-nozzle spray boom at 40 gpa and 25 psi using AIXR11002 air-induction nozzles, or with a tractor-mounted spray boom modified to mimic center pivot chemigation by applying 2,700 gpa through three S.S.CO. Fulljet ¾ HH 7 nozzles (9 mm diameter orifice). R-11 surfactant was used with each product at 32 oz/100 gal water (0.25% v/v). Bactericide control plots were not treated with water or surfactant. Inoculum consisting of an equal ratio of the two pathogens, produced as overnight shake cultures in nutrient broth yeast extract medium and diluted to $10^8$ CFU/ml in 0.0125M phosphate buffer plus 0.01% Tween 20, was applied to relevant main plots on 28 Jul (5% tops down), one day after the second application of each bactericide treatment, and on 11 Aug (50% tops down). Inoculum was applied in the evening with a $CO_2$-pressurized backpack sprayer and 3-nozzle boom (XR8003 tips, 34.65 gpa, 20 psi). The trial was irrigated by center-pivot and managed with typical practices for the region. Plots also were irrigated with 0.12 in. water in the late afternoon every other day from mid-Jul through Aug to favor bacterial infection. Plots were rated seven times for incidence (percentage of plants with symptoms) and severity of bacterial leaf blight (percentage of canopy with symptoms): 12 Jul, prior to the first bactericide application; and 19 and 25 Jul, and 2, 9, 16, and 23 Aug. Severity of phytotoxicity symptoms from bactericide applications was rated at the first five dates, and plots were rated for percentage tops down on all seven dates. Plants were undercut on 24 Aug. Bulbs in a 5-ft section/split-split plot were topped and harvested manually on 12 Sep, and then 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). Marketable bulbs were placed in a commercial onion storage facility (40°F, 70% relative humidity) for 5 months. On 2 Feb 23, bulbs were cut vertically and rated for incidence (%) of bulbs with bacterial rot and severity of bacterial rot (% of cut surface area of each bulb with symptoms). Data were subjected to analyses of variance (ANOVAs) and means comparisons using Fisher's protected least significant difference (LSD). The project was funded by Specialty Crops Research Initiative Award 2019-51181-30013 of the USDA National Institute of Food and Agriculture.

Mild foliar symptoms of phytotoxicity (<3% injury) were observed primarily in plots with spray boom applications of Badge SC, not chemigated plots, i.e., there were significant main effects of bactericide treatment and application method, and a significant interaction of the two factors. Inoculation treatments did not affect phytotoxicity ratings. Bacterial leaf blight was first observed on 2 Aug, 5 days after the first inoculation, with an average 5.7% of plants symptomatic across the trial, and no difference in inoculated vs. non-inoculated plots. Foliar disease incidence increased rapidly in inoculated plots, reaching an average of 65.8% by 23 Aug vs. 8.0% in non-inoculated plots, by which date severity of symptoms averaged 30.9 vs. 3.3%, respectively. Foliar disease development was affected by bactericide treatments. On 23 Aug, plots treated with Badge SC had the least bacterial leaf blight (28.5% average incidence for inoculated and non-inoculated plots), followed by ManKocide (34.0%), Lifegard (43.5%), and control plots (41.5%). In inoculated plots, Badge SC and ManKocide reduced foliar disease incidence by 15 and 9%, respectively, compared to control plots. Lifegard treatments did not reduce foliar symptoms. In non-inoculated plots, only Badge SC reduced foliar disease incidence (to 2.0%) compared to control plots (17.0%). The method of bactericide application did not affect foliar disease ratings. Onion tops fell more rapidly in inoculated vs. non-inoculated plots (79.9 vs. 95.6% on 16 Aug, respectively), and Badge SC caused a slight delay in tops falling compared to the other two bactericide treatments and control plots. There was no effect of application method on tops down (*data not shown*). Marketable bulb yield was affected by inoculation, method of application, and bactericide treatments. Inoculations reduced yield by 14.2 t/A and increased the weight of bulbs culled at harvest because of bacterial rot by 11.1 t/A. Inoculations also increased the incidence and severity of bacterial bulb rot at harvest and after 5 months in storage, with a total 51.3% of bulbs rotten (harvest + storage) vs. 14.7% for non-inoculated plots. Chemigated plots had 2.6 t/A less yield, 1.7 t/A more bacterial culls, and 5.4% more bulb rot than plots with spray boom bactericide applications. The increase in bacterial disease in chemigated vs. spray boom-treated plots was primarily evident in non-inoculated plots. Applications of Badge SC or ManKocide increased marketable bulb yield by 2% compared to control plots or plots treated with Lifegard WG. However, none of the bactericide treatments reduced the incidence or severity of bulb rot at harvest and in storage. In summary, weekly preventative applications of Badge SC and ManKocide provided some control of bacterial leaf blight and a slight increase in marketable bulb yield but had no effect on bacterial bulb rot at harvest or in storage. The adverse effect of chemigation vs. spray boom applications of bactericides on yield and bacterial bulb rot reflected the impact of the large amount of water applied by chemigation during a critical window of susceptibility to bacterial infection, as moisture in the senescing necks facilitates bacterial infections progressing into the bulbs.

| Main plot, split plot, and split-split plot treatments | Foliar phyto-toxicity (2 Aug) | Foliar bacterial leaf blight (23 Aug) | | Bulb yield at harvest (t/A) | | Bulbs culled at harvest because of bacterial rot | | Bacterial bulb rot after 5 months in storage | | Total incidence of bacterial bulb rot at harvest + in storage (%)[z] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Incidence (% of plants) | Severity (% of canopy) | Marketable bulbs[z] | Bacterial culls | Incidence (% of bulbs) | Severity per bulb (%) | Incidence of bulbs (%) | Severity per bulb (%) | |
| Main plot treatments | | | | | | | | | | |
| Inoculated | 0.9 | 65.8 a[x] | 30.9 a | 24.1 b | 14.4 a | 37.3 a | 45.9 a | 14.0 a | 12.5 a | 51.3 a |
| Non-inoculated | 0.9 | 8.0 b | 3.3 b | 38.3 a | 3.3 b | 8.3 b | 25.4 b | 6.4 b | 3.3 b | 14.7 b |
| LSD | Rank[y] | Rank | Rank | Rank | Rank | Rank | Rank | 2.5 | Rank | Rank |
| *P* value | 1.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Split plot treatments | | | | | | | | | | |
| Chemigation | 0.3 b | 36.5 | 17.5 | 29.9 b | 9.7 | 25.3 a | 36.7 | 10.4 | 8.2 | 35.7 a |
| Boom sprayer | 1.5 a | 37.3 | 16.6 | 32.5 a | 8.0 | 20.3 b | 34.6 | 9.9 | 7.5 | 30.3 b |
| LSD | Rank | Rank | Rank | Rank | Rank | Rank | Rank | 2.5 | Rank | Rank |
| *P* value | 0.0014 | 0.6722 | 0.5558 | 0.0157 | 0.0551 | 0.0493 | 0.8078 | 0.7088 | 0.3487 | 0.0050 |
| Split-split plot treatments and amount/A | | | | | | | | | | |
| Badge SC 2.75 pt | 2.8 a | 28.5 c | 16.6 | 32.1 ab | 8.7 | 21.6 | 41.9 | 9.6 | 7.0 | 31.2 |
| ManKocide 2.25 lb | 0.5 b | 34.0 b | 13.8 | 32.5 a | 7.9 | 20.6 | 32.1 | 11.9 | 9.6 | 32.5 |
| Lifegard WG 4.5 oz /100 gal | 0.1 c | 41.5 ab | 17.7 | 30.1 b | 9.5 | 25.4 | 32.9 | 8.6 | 6.8 | 34.0 |
| Control | 0.1 c | 43.5 a | 20.1 | 30.2 b | 9.2 | 23.7 | 35.7 | 10.6 | 8.2 | 34.3 |
| LSD | Rank | Rank | Rank | Rank | Rank | Rank | Rank | 3.6 | Rank | Rank |
| *P* value | 0.0001 | 0.0007 | 0.0749 | 0.0449 | 0.1308 | 0.1175 | 0.1366 | 0.3107 | 0.1722 | 0.6102 |
| Analysis for inoculated plots only | | | | | | | | | | |
| Split plot treatments | | | | | | | | | | |
| Chemigation | 0.3 b | 61.5 | 30.7 | 23.1 | 15.1 | 39.8 | 46.8 | 13.9 | 12.5 | 53.6 |
| Boom sprayer | 1.5 a | 70.0 | 31.0 | 25.0 | 13.8 | 34.8 | 44.9 | 14.1 | 12.4 | 48.9 |
| LSD | 0.2 | 9.9 | Rank | 3.2 | 2.3 | 6.1 | 5.8 | 4.2 | 3.4 | 5.2 |
| *P* value | 0.0004 | 0.1979 | 0.9406 | 0.3849 | 0.4035 | 0.2496 | 0.5098 | 0.9154 | 0.9674 | 0.0693 |
| Split-split plot treatments and amount/A | | | | | | | | | | |
| Badge SC 2.75 pt | 2.8 a | 55.0 c | 31.5 | 25.0 | 14.4 | 35.8 | 52.1 | 11.9 | 10.4 | 47.7 |
| ManKocide 2.25 lb | 0.5 b | 61.0 bc | 23.6 | 23.7 | 13.4 | 34.9 | 46.4 | 15.7 | 14.0 | 50.6 |
| Lifegard WG 4.5 oz /100 gal | 0.1 c | 77.0 a | 34.3 | 22.3 | 16.6 | 43.7 | 41.0 | 12.1 | 11.1 | 55.8 |
| Control | 0.1 c | 70.0 ab | 34.1 | 25.3 | 13.4 | 34.9 | 44.0 | 16.2 | 14.3 | 51.1 |
| LSD | 0.3 | 14.0 | Rank | 4.6 | 3.2 | 8.6 | 8.1 | 6.0 | 4.9 | 7.4 |
| *P* value | 0.0001 | 0.0148 | 0.0548 | 0.4784 | 0.1396 | 0.1040 | 0.0594 | 0.3299 | 0.2722 | 0.1740 |
| Analysis for non-inoculated plots only | | | | | | | | | | |
| Split plot treatments | | | | | | | | | | |
| Chemigation | 0.3 b | 11.5 | 4.3 | 36.7 b | 4.3 a | 10.9 a | 26.6 | 7.0 | 3.9 | 17.9 a |
| Boom sprayer | 1.5 a | 4.5 | 2.2 | 40.0 a | 2.2 b | 5.8 b | 24.2 | 5.8 | 2.7 | 11.6 b |
| LSD | 0.2 | Rank | Rank | Rank | Rank | Rank | 11.0 | Rank | 1.7 | Rank |
| *P* value | 0.0004 | 0.2663 | 0.4154 | 0.0019 | 0.0227 | 0.0403 | 0.6835 | 0.4756 | 0.1280 | 0.0111 |
| Split-split plot treatments and amount/A | | | | | | | | | | |
| Badge SC 2.75 pt | 2.8 a | 2.0 b | 1.8 | 39.2 ab | 3.0 | 7.4 | 31.8 | 7.4 | 3.5 | 14.8 |
| ManKocide 2.25 lb | 0.5 b | 7.0 ab | 4.0 | 41.3 a | 2.5 | 6.3 | 17.7 | 8.1 | 5.2 | 14.4 |
| Lifegard WG 4.5 oz /100 gal | 0.1 c | 6.0 ab | 1.1 | 37.9 bc | 2.4 | 7.1 | 24.8 | 5.1 | 2.4 | 12.2 |
| Control | 0.1 c | 17.0 a | 6.2 | 35.1 c | 5.1 | 12.5 | 27.4 | 5.0 | 2.1 | 17.5 |
| LSD | 0.3 | Rank | Rank | Rank | Rank | Rank | 15.5 | Rank | 2.4 | Rank |
| *P* value | 0.0001 | 0.0494 | 0.1322 | 0.0007 | 0.1556 | 0.2059 | 0.2874 | 0.4366 | 0.0513 | 0.2915 |

[z] There was a significant interaction of inoculation treatments with bactericide treatments for marketable bulb yield at harvest ($P$ = 0.0416) and incidence of bacterial bulb rot at harvest + in storage ($P$ = 0.0381).

[y] Rank = Friedman's non-parametric rank test, with original means shown but means separation based on transformed analysis.

[x] Means in a column followed by the same letter are not significantly different based on Fisher's protected least significant difference (LSD, $P$ <0.05). If the F-test in the ANOVA was not significant, means separation letters are not shown.