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

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Efficacy of late-season cultural practices on bacterial leaf blight and bulb rots in an onion bulb crop in Pasco, WA, 2020.

Three field trials were planted on 2 Apr 20 at the Washington State University Pasco Vegetable Extension Farm using pelleted seed of the cv. Calibra to evaluate the effects of three late-season cultural practices on management of foliar and bulb infections caused by *Pantoea agglomerans* and *Burkholderia gladioli* pv. *alliicola* in onion crops in the Columbia Basin of central Washington and northcentral Oregon: 1) a trial evaluating the effects on bacterial diseases of undercutting vs. not undercutting onion bulbs with a rod-weeder; 2) a trial evaluating the effect of rolling vs. not rolling the tops of onion plants to assess if wounding associated with rolling affects bacterial disease development; and 3) a trial evaluating the effect of early, standard, or late topping (cutting) of onion plants on bacterial disease development. Each trial was a split plot, randomized complete block design with five replications of a factorial treatment design: the two inoculation treatments (inoculated or not inoculated with the bacterial pathogens) were applied to main plots, and two (undercutting trial and rolling tops trial) or three (timing of topping trial) cultural practice treatments were applied to split plots. Each split plot was one 34-in.-wide bed (with 2 double-rows of onion plants) x 15 ft long, including 5 ft of bed as a buffer between the ends of adjacent plots. Inoculum consisted of an equal ratio of the two pathogens, and was applied at 10^8 CFU/ml in the evening on 30 Jul (5% tops down) and 13 Aug (50% tops down) with a CO_2-presurized backpack sprayer and 3-nozzle boom (XR8003 tips, 32.8 gpa, and 20 psi). The trial was irrigated by center-pivot and managed using typical practices for the Columbia Basin. In addition, the trial was irrigated with 0.12 in. of water in the late afternoon every other day from mid-Jul through Aug to favor bacterial infection. Plants were undercut on 25 Aug (100% tops-down) with a tractor-mounted rod-weeder. Rolling was done manually by pulling a metal roller (36-in. wide, 18-in. diameter, 35 lb) over relevant split plots on 12 Aug. Topping was done manually on 25 Aug, 11 Sep, and 22 Sep for the early, standard, and late topping treatments, respectively, using topping shears. Each plot was rated for incidence (%) of plants with bacterial leaf blight and severity (%) of foliar symptoms on 29 Jul (prior to the first inoculation), and again on 5, 12, and 20 Aug. Plots were rated for percentage tops down on 12 and 20 Aug. Plots in the rolling tops and timing of topping trials were undercut on 26 Aug. Bulbs were harvested from two 5-ft sections/split plot on 15 Sep for the undercutting and rolling tops trials, and on 24 Sep for the topping trial. Bulbs harvested from one 5-ft section were cut vertically and 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 culled bulbs with 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 stored in a commercial onion storage facility (40°F, 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, $P < 0.05$), with relevant transformations to meet assumptions for parametric analyses.

In all three trials, symptoms of bacterial leaf blight were observed two weeks after the first inoculation with *P. agglomerans* and *B. gladioli* pv. *alliicola*. Incidence and severity of foliar symptoms increased thereafter. In the undercutting trial, the incidence and severity of bacterial leaf blight on 12 Aug was greater in inoculated plots (9.2 and 0.02%, respectively) than in non-inoculated plots (1.6 and 0.004%, respectively). Similar differences in inoculated vs. non-inoculated plots were observed on 20 Aug. In inoculated plots, undercutting bulbs affected bacterial leaf blight only at the third rating (12 Aug), when inoculated plots that were undercut had 12.8% incidence and 0.03% severity of bacterial leaf blight, vs. 5.6% incidence and 0.008% severity in inoculated plots that were not undercut. The incidence of tops down was not affected by inoculation or undercutting on 12 and 20 Aug. Inoculation reduced marketable bulb yield (39.1 t/A vs. 44.6 t/A for non-inoculated plots), increased the weight of culled bulbs with external bacterial rot (3.5 vs. 0.3 t/A), and increased the incidence and severity of internal bacterial bulb rot at harvest (19.4 vs. 1.2% incidence and 8.8 vs. 0.2% severity for inoculated vs. non-inoculated plots, respectively) and after 5 months in storage (17.7 vs. 0.8% incidence and 5.2 vs. 0.1% severity, respectively). Undercutting bulbs did not affect any measure of yield or bulb rot at harvest or in storage. In the rolling tops trial, inoculation very significantly increased the incidence and severity of bacterial leaf blight on 12 and 20 Aug, and the incidence and severity of internal bacterial bulb rot at harvest and after 5 months in storage. Inoculation reduced marketable bulb yield (36.6t/A vs. 40.6 t/A in non-inoculated plots) by reducing yield of jumbo bulbs. Inoculation did not affect percentage tops down on 12 and 20 Aug, and yield of bulbs culled because of external bacterial rot. Rolling tops did not affect tops down, bacterial leaf blight ratings, yield measurements, and internal bacterial bulb rot at harvest and after 5 months of storage. In the timing of topping trial, inoculation very significantly increased incidence and severity of bacterial leaf blight on 12 and 20 Aug, and incidence and severity of internal bacterial bulb rot at harvest and in storage. Inoculation reduced marketable bulb yield (32.4 t/A vs. 38.4 t/A in non-inoculated plots) by reducing yield of jumbo bulbs, and increased yield of culled bulbs with external bacterial rot. Inoculation did not affect percentage tops down or yield of bulbs culled because of external bacterial rot. Rolling the tops also did not affect tops down, bacterial leaf blight ratings, bulb yield measurements (t/A of marketable bulbs or bacterial culls), or internal bacterial bulb rot at harvest or after 5 months of storage. In all three trials, there were no interactions between inoculation treatments and split plot treatments for the variables measured. In summary, undercutting bulbs, rolling tops, and the early vs. standard vs. late topping of plants did not affect marketable bulb yield or bacterial bulb rot at harvest and in storage in these trials, but inoculation significantly increased bacterial leaf blight and bulb rot, and reduced yield.

Trial, and main plot and split plot treatments	Tops down (12 Aug)	Foliar bacterial symptoms (12 Aug)		Bulb yield (t/A)		Internal bacterial bulb rot			
						At harvest		After storage	
		Incidence (% of plants)	Severity (% of canopy)	Marketable bulbs	Bacterial culls	Incidence of bulbs (%)	Severity per bulb (%)	Incidence of bulbs (%)	Severity per bulb (%)
1) Undercutting trial									
Main plots									
Inoculated	83.5	9.2 a	0.020 a	39.1 b	3.5 a	19.4 a	8.8 a	17.7 a	5.2 a
Non-inoculated	86.4	1.6 b	0.004 b	44.6 a	0.3 b	1.2 b	0.2 b	0.8 b	0.1 b
LSD	11.1	3.8	Rank[x]	4.0	0.9	Rank	Rank	Rank	Rank
P value	0.5787	0.0001	0.0003	0.0164	0.0041	0.0001	0.0001	0.0001	0.0001
Split-plots									
Bulbs undercut	84.0	12.8 a[z]	0.030 a[z]	38.9[z]	5.2[z]	16.7[z]	8.2[z]	18.0[z]	3.5[z]
Bulb not undercut	85.9	5.6 b	0.008 b	39.4	1.9	22.1	9.3	17.4	7.0
LSD	11.1	8.2	0.025	7.0	5.4	18.1	13.5	8.6	Rank
P value	0.7150	0.0111	0.0150	0.8599	0.1079	0.3253	0.7916	0.8702	0.0529
2) Rolling tops trial									
Main plots									
Inoculated	59.0	8.8 a	0.004 b	36.6 b	2.3	32.7 a	13.7 a	22.2 a	6.4 a
Non-inoculated	67.0	1.6 b	0.020 a	40.6 a	0.9	2.4 b	0.5 b	2.2 b	0.6 b
LSD	24.3	3.2	Rank	3.0	2.4	5.1	3.0	5.0	1.7
P value	0.4625	0.0001	0.0001	0.0155	0.1914	0.0001	0.0001	0.0001	0.0001
Split-plots									
Tops rolled	73.5	7.2[z]	0.020[z]	38.3[z]	0.7	35.7[z]	15.1[z]	18.1[z]	5.9[z]
Tops not rolled	52.5	10.4	0.020	35.0	2.5	29.7	12.3	26.4	6.9
LSD	24.8	9.6	0.022	4.2	2.6	6.3	5.6	11.8	4.4
P value	0.1687	0.4051	0.9226	0.0932	0.1772	0.0564	0.2421	0.1228	0.5462
3) Topping trial									
Main plots									
Inoculated	51.7	4.8 a	0.000	32.4 b	4.0 a	31.3 a	14.3 a	29.3 a	10.6 a
Non-inoculated	48.7	0.3 b	0.007	38.4 a	0.2 b	2.4 b	0.9 b	1.5 b	0.4 b
LSD	25.6	Rank	Rank	3.7	Rank	10.2	Rank	5.5	Rank
P value	0.8096	0.0002	0.0001	0.0035	0.0001	0.0001	0.0001	0.0001	0.0001
Split-plots									
Early topping	63.0	4.8[z]	0.005[z]	30.5[z]	4.2[z]	27.1[z]	11.9[z]	30.4[z]	10.8[z]
Standard topping	49.5	4.0	0.002	34.2	3.0	32.7	14.7	26.2	9.8
Late topping	38.0	5.6	0.004	32.5	4.9	34.1	16.4	31.2	11.3
LSD	25.6	8.1	0.017	6.3	3.8	21.9	11.7	Rank	9.0
P value	0.2738	0.9037	0.6704	0.4339	0.5166	0.7458	0.6757	0.3513	0.9055

[z] Mean ratings for the split plot treatments for all variables, except tops down in all three trials and bacterial culls in the rolling tops trial, are shown only for inoculated plots because of a significant inoculation effect for these variables ($P < 0.05$), very little infection observed in the non-inoculated plots, and no significant interaction of inoculation treatments with split plot treatments ($P > 0.05$) in the ANOVAs.

[y] For the inoculation treatments, and for the second main factor, 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.