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

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Effects of time of topping on bacterial leaf blight and bulb rot in an onion crop in 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 effects of the timing of topping of onion plants at the end of the season on management of 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 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 three timings of topping (early, normal, and late) applied to split plots. Each split plot consisted of a 34-in.-wide bed (with 2 double-rows of onion plants) x 15 ft long, including 5 ft of bed as a buffer between adjacent plots. 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) and 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. Topping was done manually on 10 Aug, 7 Sep, and 13 Sep for the early, 'standard', and late topping treatments, respectively. The three treatments originally were intended to be at 2-week intervals, but standard topping accidentally was delayed to 4 weeks after early topping, so the late topping was done 5 weeks after early topping. Plants were undercut on 24 Aug with a tractor-mounted rod-weeder. Plots were rated for incidence (%) of plants with bacterial leaf blight and severity (%) of foliar symptoms on 1, 8, 15, and 22 Aug. Plots were rated for percentage tops down on 15 Aug. Bulbs were harvested from a 5-ft section/split plot 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.

Symptoms of bacterial leaf blight were observed by 1 Aug, 4 days after the first inoculation, at a low level in all plots. By 8 Aug, foliar disease incidence and severity were greater in inoculated plots (2.2% incidence, 10.7% severity) than non-inoculated plots (1.0% incidence, 4.7% severity). By 22 Aug, inoculated plots averaged 84.0% incidence of bacterial leaf blight vs. 20.0% in non-inoculated plots. Inoculation with *P. agglomerans* and *B. gladioli* pv. *alliicola* increased the percentage tops down, with 96.3% of tops down in inoculated plots on 15 Aug vs. 50.5% in non-inoculated plots. The timing of topping did not have a significant effect on bacterial leaf blight or tops down, in part because tops were cut on 10 Aug for plots with early topping, and the 'standard' and late toppings were done 4 and 5 weeks later, respectively. Inoculations reduced marketable bulb yield by 54%, from 25.8 t/A in non-inoculated plots to 11.8 t/A in inoculated plots, largely by increasing the weight of bulbs culled because of bacterial rot (from 11.3 t/A in non-inoculated plots to 21.5 t/A). Inoculations increased the incidence of bacterial bulb rot at harvest, from 30.7 to 65.5%, and the incidence of bacterial bulb rot after 5 months in storage, from 17.0 to 19.4%. The total loss of bulbs to bacterial rot (harvest + storage) was 72.8% greater in inoculated vs. non-inoculated plots (77.6 vs. 44.9%, respectively). The timing of topping significantly affected marketable bulb yield and bacterial bulb rots. Plots topped early had less than half the marketable bulb yield at harvest than plots topped 4-5 weeks later, both in inoculated and non-inoculated plots, but there were no significant differences between plots with the two later topping treatments. This largely reflected the increase in bacterial culls at harvest in non-inoculated plots topped early vs. those topped later. Plots topped early had much more bacterial bulb rot at harvest and after five months of storage, with a total loss of 83.7% of the bulbs to bacterial rot (harvest + storage) compared to 51.6 and 48.6% for plots with the two later topping treatments. In summary, topping onion plants at ~50% tops down increased bacterial bulb rot and reduced marketable bulb yield compared to topping 4 to 5 weeks later. This was true for both inoculated and non-inoculated plots under the high disease pressure in this trial. The results reflect the increased risk of bacterial infection of necks and bulbs when onions are topped (wounded) before the necks have cured (dried).

Main plot and split plot treatments	Tops down (15 Aug)	Bacterial leaf blight (22 Aug)		Bulb yield at harvest (t/A)		Bacterial culls at harvest		Bacterial bulb rot after 5 months in storage		Total bulb rot incidence (%, harvest + storage)
		Incidence (% of plants)	Severity (% of canopy)	Marketable bulbs	Bacterial culls	Incidence (% of bulbs)	Severity (% per bulb)	Incidence (% of bulbs)[z]	Severity (% per bulb)	
Main plots										
Inoculated	96.3 a[y]	84.0 a	37.7 a	11.8 b	21.5 a	65.5 a	54.6 a	12.1	19.4 a	77.6 a
Non-inoculated	50.5 b	20.0 b	6.6 b	25.8 a	11.3 b	30.7 b	38.1 b	14.2	17.0 b	44.9 b
LSD	Rank[x]	17.9	Rank	4.7	4.0	10.1	7.9	6.1	Rank	9.8
P value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.4499	0.0487	0.0001
Split-plots										
Early topping	-----[w]	-----[w]	-----[w]	9.0 b	23.0 a	71.9 a	64.1 a	11.8	30.0 a	83.7 a
Standard topping	71.0	54.0	22.6	23.1 a	13.8 b	37.2 b	39.1 b	14.4	11.8 b	51.6 b
Late topping	75.8	50.0	21.7	24.3 a	12.4 b	35.2 b	35.9 b	13.4	12.7 b	48.6 b
LSD	Rank	17.9	Rank	5.8	4.9	12.3	9.7	7.5	Rank	12.0
P value	0.3171	0.6842	0.2011	0.0001	0.0004	0.0001	0.0001	0.7548	0.0196	0.0001
Inoculated plots										
Early topping	-----[w]	-----[w]	-----[w]	3.6 b	26.2 a	86.5 a	70.7 a	5.9 b	21.6	92.4 a
Standard topping	99.0	80.0	35.2	16.2 a	20.4 ab	56.8 b	44.2 b	14.2 a	15.8	71.0 b
Late topping	93.6	88.0	40.2	15.7 a	17.9 b	53.3 b	49.0 b	16.4 a	20.7	69.7 b
LSD	7.5	30.9	29.7	Rank	6.8	16.4	12.0	8.0	16.9	14.0
P value	0.1174	0.5122	0.5989	0.0053	0.0268	0.0029	0.0002	0.0271	0.6928	0.0098
Non-inoculated plots										
Early topping	-----[w]	-----[w]	-----[w]	14.4 b	19.7 a	57.2 a	57.6 a	17.9	38.4 a	75.1 a
Standard topping	43.0	28.0	10.0	29.9 a	7.3 b	17.6 b	34.0 b	14.5	7.8 b	32.2 b
Late topping	58.0	12.0	3.2	32.9 a	6.9 b	17.1 b	22.8 b	10.3	4.7 b	27.4 b
LSD	Rank	39.8	13.2	Rank	6.1	15.2	18.4	14.9	23.8	14.2
P value	0.5796	0.2521	0.1381	0.0078	0.0019	0.0004	0.0068	0.4350	0.0207	0.0001

[z] There was a significant interaction of inoculation treatments with topping treatments for incidence of bacterial bulb rot in storage ($P = 0.0376$).

[y] For the main plot treatments and split plot treatments for each variable, means within a column followed by the same letter are not significantly different based on Fisher's protected 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. Original means are shown but means separation is based on the transformed analysis.

[w] Bulbs were topped on 10 Aug for the early topping treatment, before the 15 Aug tops down rating and 22 Aug foliar rating.