MANAGEMENT OF BACTERIAL BULB ROTS IN ONION–2021

Stuart Reitz, Ian Trenkel, Kyle D. Wieland, Erik B. G. Feibert, and Alicia Rivera, Malheur Experiment Station, Oregon State University, Ontario, OR

James Woodhall and Mack Murdock, Parma Research and Extension Center, University of Idaho, Parma, ID

Objective

Evaluate bactericides for management of bacterial bulb rots in dry bulb onions.

Introduction

Dry bulb onions are subject to various bacteria that may cause bulb rots. Because onions in the Treasure Valley are almost exclusively grown under drip or furrow irrigation, they are typically less vulnerable to bacterial diseases than onions grown under overhead irrigation. However, bacterial infections can be triggered by rain or hail storms, or when onion leaves are damaged by windstorms. Copper-based bactericides are often applied after such events when conditions favor bacterial infection. This study was undertaken to determine the effects of various copper-based bactericides on bacterial bulb rot incidence and onion yield in dry bulb onions.

Materials and Methods

Onions were grown in 2021 on a Greenleaf silt loam previously planted to wheat. After the wheat was harvested in 2020, the stubble was shredded and the field was irrigated to sprout unharvested wheat kernels and then the field was disked and plowed. A soil analysis taken in the fall of 2020 showed a pH of 7.2, 3.2% organic matter, 6 ppm nitrogen (N) as nitrate, 4 ppm N as ammonium, 29 ppm phosphorus (P), 419 ppm potassium (K), 41 ppm sulfur (S) as sulfates, 2480 ppm calcium, 516 ppm magnesium, 201 ppm sodium, 2.9 ppm zinc, 5 ppm manganese (Mn), 1 ppm copper (Cu), 8 ppm iron, and 0.8 ppm boron (B). Based on the soil analysis, 50 lb N/acre, 44 lb P/acre, 83 lb K/acre, 200 lb S/acre, 11 lb Mn/acre, 2 lb Cu/acre, and 2 lb B/acre were broadcast after plowing. After the fertilizer was broadcast, the field was groundhogged and fumigated with Kapam® at 15 gal/acre and bedded at 22 inches.

Onion seed of cultivar ‘Granero’ (Nunhems, Parma, ID) was planted at 150,000 seeds/acre (3.8 inches between seeds) on March 24, 2021. Seed was planted in double rows spaced 3 inches apart on beds spaced 22 inches apart. Onion emergence started on April 12. On May 13, alleys 4 ft wide were cut between plots, leaving plots 23 ft long.

The field had drip tape laid at 4-inch depth between pairs of beds during planting. The drip tape had emitters spaced 8 inches apart and an emitter flow rate of 0.09 gallons per hour (0.22 gal/min/100 ft, Toro Aqua-Traxx, Toro Co., El Cajon, CA). The distance between the tape and the center of each double row of onions was 10 inches.

The following herbicides were applied: Poast® (sethoxydim) at 24 oz/acre on April 15; Prowl® H_2O (pendimethalin) at 2 pints/acre, GoalTender® (oxyfluorfen) at 4 oz/acre, and Brox® 2EC (bromoxynil) at 16 oz/acre on May 13; Poast at 24 oz/acre on May 27.

For thrips control, the following insecticides were applied by ground: Aza-Direct® (azadirachtin) at 12 oz/acre and M-Pede® (potassium salts of fatty acids) at 123 oz/acre on May 27; Movento® (spirotetramat) at 5 oz/acre and Aza-Direct at 12 oz/acre on June 3; Movento at 5 oz/acre and M-Pede at 123 oz/acre on June 11; Exirel® (cyantraniliprole) at 20 oz/acre on June 18 and June 28, and Agri-Mek® SC (abamectin) at 3.5 oz/acre on July 13; Radiant® (spinetoram) at 8 oz/acre on July 21.

The experimental design was a randomized complete block with ten bactericide treatments (Table 1) and non-inoculated and inoculated treatments as split plots within main plots. The inoculated split plots had a solution of *Pantoea agglomerans* broadcast on July 29 and August 12. The ten bactericide treatments were replicated four times. Each main plot was eight double onion rows wide by 23 feet long. Each split plot within main plots was 4 double rows wide.

The bactericide treatments and the bacterial inoculations were applied with a CO_2 backpack sprayer with a 4-nozzle boom with 11004 nozzles at 30 PSI and 35 gallons per acre. The first bactericide application was made preventatively before the first bacterial inoculation. The second and third applications were made shortly after each of the bacterial inoculations. The fourth application was made when the majority of plants had fallen down (>50% tops down). In treatment 10, applications were only made two times, once after each bacterial inoculation.

To simulate rainfall, the field was sprinkler irrigated, applying 0.25 inches weekly from July 23 to August 23, totaling 2 inches. The sprinkler system had laterals along each side of the trial (30 ft apart) and risers spaced 30 ft apart along the laterals. The sprinkler system used Nelson Rotator R2000LP sprinklers and applied 0.10 inch per hour.

Table 1. Bactericide treatment specifications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021. Bactericides were applied A July 28, B August 03, C August 10, and D August 17. Bacterial inoculations were made on July 29 and August 12. Simulated rainfall was applied by sprinklers weekly beginning on July 23 and ending on August 23.

Treatment	Product	Rate	Unit	Application	Active ingredient
1	Untreated control			--	
2	Badge	2.75	pt/acre	ABCD	Copper hydroxide and copper oxychloride
3	Previsto	2.75	pt/acre	ABCD	Copper hydroxide
4	Kocide 2000	1.5	lb/acre	ABCD	Copper hydroxide
5	MEM	6	lb/acre	ABCD	---
6	MEM HAF-01	6 17	lb/acre lb/acre	ABCD	-- --
7	Badge	1.375	pt/acre	ABCD	Copper hydroxide and copper oxychloride
8	Previsto	2.75	pt/acre	ABCD	Copper hydroxide
9	Kocide 2000	0.75	lb/acre	ABCD	Copper hydroxide
10	Badge	2.75	pt/acre	BD	Copper hydroxide and copper oxychloride

Onions were irrigated automatically by drip line to maintain the soil water tension (SWT) at 8-inch depth in the onion root zone below 20 cb. Soil water tension was measured with eight granular matrix sensors (GMS, Watermark soil moisture sensor model 200SS, Irrometer Co. Inc., Riverside, CA) installed at 8-inch depth in the center of the double row of onions in plots in the adjacent trial. Sensor readings were not influenced by the sprinkler irrigations. The GMS were connected to the datalogger via multiplexers (AM16/32, Campbell Scientific, Logan, UT). The datalogger (CR1000, Campbell Scientific) read the sensors and recorded the SWT every hour. The field was irrigated if the average of the eight sensors was 20 cb or higher. The datalogger automatically made irrigation decisions every 12 hours. The irrigations were controlled by the datalogger using a controller (SDM-CD16AC, Campbell Scientific) connected to a solenoid valve. Irrigation durations were 8 hours, 19 minutes, to apply 0.48 inch of water. The water was supplied from a well and pump that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by a pressure-regulating valve. The automated irrigation system was started on May 6, and irrigations stopped on August 27.

Starting on May 27, root tissue and soil samples were taken every week from plot border rows representing the whole field and analyzed for nutrients by Western Laboratories, Inc., Parma, ID. Root tissue was analyzed for nutrient concentrations, and soil samples were analyzed for concentrations of nutrients in the soil solution. Nutrients were applied only if both the root tissue and soil solution concentrations were simultaneously below the critical levels. Since both root tissue and soil solution levels were above the critical level all season (Figures 1 and 2), N applications ended in early July. A total of 80 lb N/acre was applied as urea ammonium nitrate solution (URAN) injected through the drip tape.

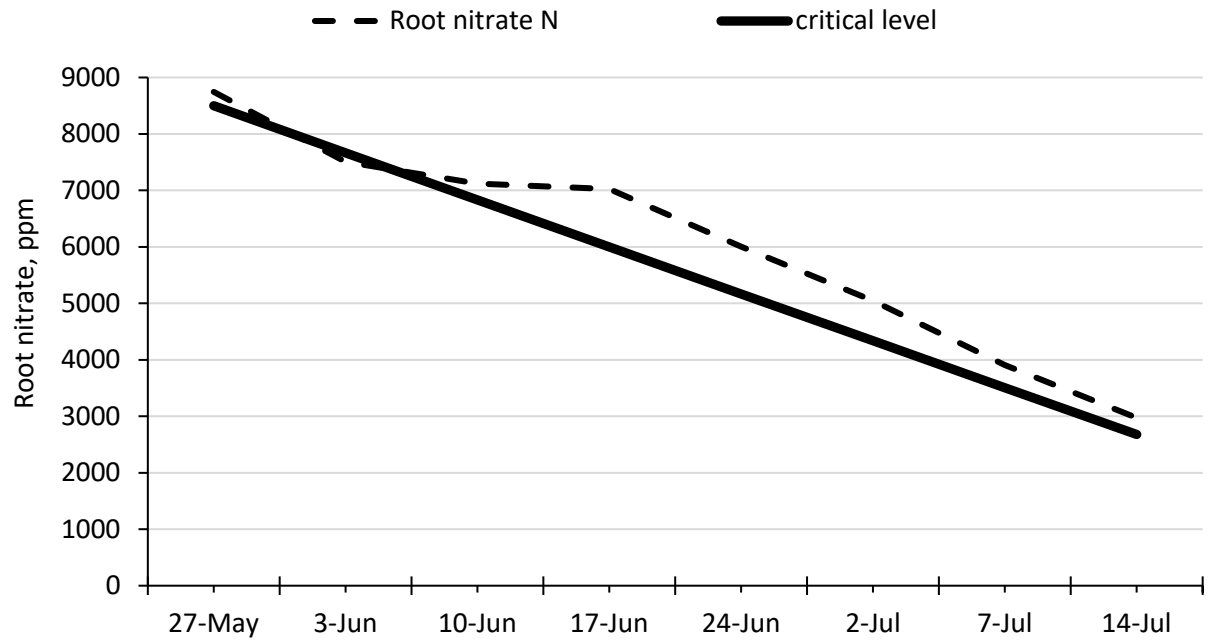

Figure 1. Root nitrate over time, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

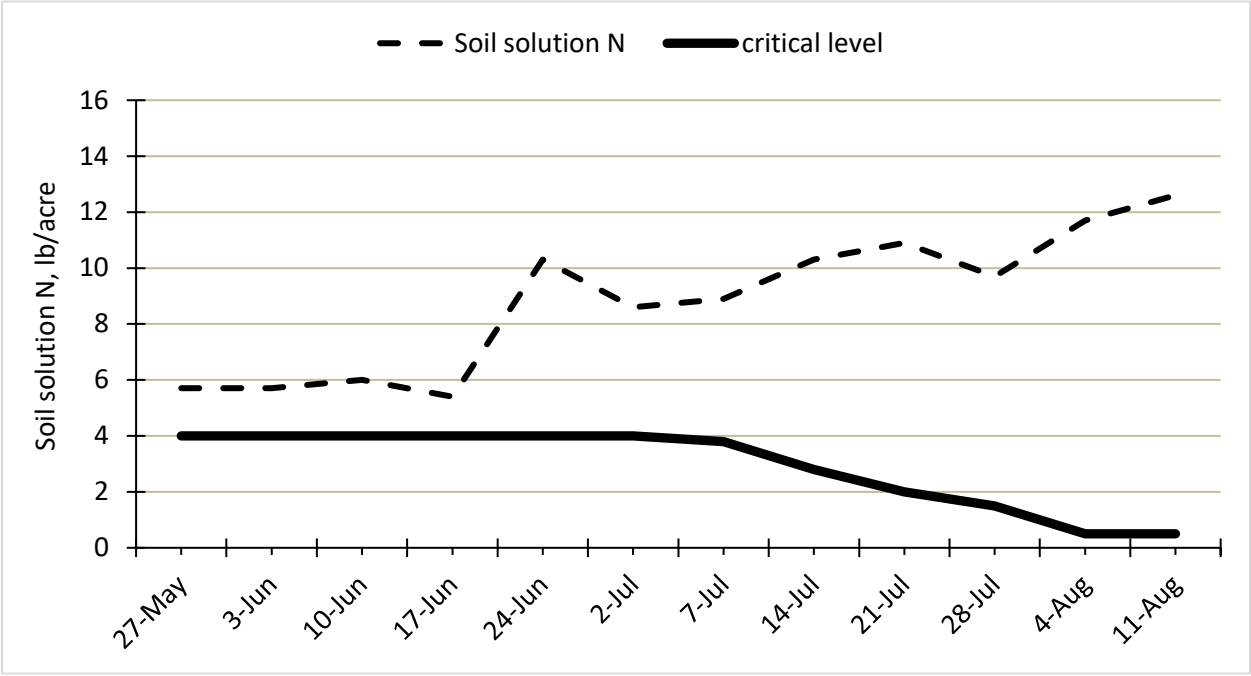

Figure 2. Soil solution nitrogen over time, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

The onions were lifted on September 7 to field cure. Onions from the middle two rows in each plot were topped by hand and bagged on September 16. The bags were moved into storage on September 20. The storage shed was ventilated, and the temperature was slowly decreased to maintain air temperature as close to 34°F as possible. Onions were graded out of storage in January 2021.

During grading, bulbs were separated according to external quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), bulbs infected with the fungus *Botrytis allii* or *Botrytis aclada* in the neck or side, bulbs infected with the fungus *Fusarium oxysporum* (plate rot), bulbs infected with the fungus *Aspergillus niger* (black mold), and bulbs infected with unidentified bacteria in the external scales. The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼–3 inches), jumbo (3–4 inches), colossal (4–4¼ inches), and super colossal (>4¼ inches). Marketable yield consisted of No.1 bulbs larger than 2¼ inches.

After grading, No. 1 bulbs from each plot were cut longitudinally and evaluated for the presence of incomplete scales, dry scales, internal bacterial rot, and internal rot caused by *Fusarium proliferatum* or other fungi. Incomplete scales were defined as scales that had more than 0.25 inch from the center of the neck missing or any part missing lower down on the scale. Dry scales were defined as scales that had either more than 0.25 inch from the center of the neck dry or any part dry lower down on the scale. Yield data were adjusted to account for rots detected during the internal evaluations.

Results and Conclusions

In 2021, the months of June and July were unusually hot. Above average air temperature occurred for prolonged periods in June and July. The average maximum air temperature for July was the highest since records began at the Malheur Experiment Station in 1943. The average low temperatures for June and July were the highest since 1943.

Total precipitation from the start to the end of automated irrigations totaled 1.9 inches. Water applications over time tracked onion evapotranspiration (ET_c), but water applications were lower than ET_c (Figure 4). A total of 20.7 inches of irrigation water plus precipitation was applied from the start of automated irrigations to the last irrigation. Another 2 inches was applied with the sprinkler system. The automated drip irrigation system maintained the soil water tension at 8-inch depth close to the target of 20 cb (Figure 3).

Bacterial and fungal infections were present in all treatments. Thrips-transmitted Iris yellow spot virus was present at lows levels (<5%) in all plots.

There was a significant interaction between bactericide treatment and bacterial inoculation on the incidence of bulbs infected with bacteria ($F= 4.42$; $P = 0.01$). However, there was no consistent trend in incidence of bacterial infected bulbs (Table 2, 3). The incidence of bacterial infections ranged from approximately 11% to 21% over the twenty total treatments (bactericide x inoculation). No bactericide treatments significantly lowered the incidence of bacterial infections compared with the untreated control (Tables 2 and 3).

The incidence of bulbs infected with Botrytis neck rot, caused by the fungi *Botrytis aclada* and *Botrytis allii* ranged from 2 to 6%. There were no significant differences among the treatments in the incidence of Botrytis neck rot.

The incidence of bulbs infected with *Fusarium proliferatum* ranged from 10 to 14%, which may reflect the stress the extremely hot growing conditions placed on the plants. There were no significant differences among the treatments in the incidence of *Fusarium proliferatum* infections. The incidence of all rots (bacterial and fungal) ranged from 28 to 32%. Again, there were no differences among the bactericide treatments.

Total yields ranged from 1150 cwt/acre to 1215 cwt/acre. Even with the extraordinary environmental conditions and bacterial inoculations, over 95% of the total yield (by weight) was marketable. Marketable yields (the weight of medium- and larger-sized bulbs) did not differ among the treatments and ranged from 1093 to 1171 cwt/acre (Table 2). Jumbo yields were significantly greater by approximately 6% without the additional bacterial inoculations. The jumbo size class composed 73 to 86% of the total yield. Usually, there is a greater proportion of colossal and supercolossal sized bulbs. However, the hot growing conditions limited plant growth.

Acknowledgments

We appreciate the technical assistance of Hannah Rose, Eileen Froshiersar, Aidan Dwyer, Tessa Hart. Funding for this research was provided by a grant from USDA NIFA SCRI "Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies," (2019-51181-30013). Additional support was provided by Gowan, SunCor, and Nunhem's (BASF Vegetable Seeds).

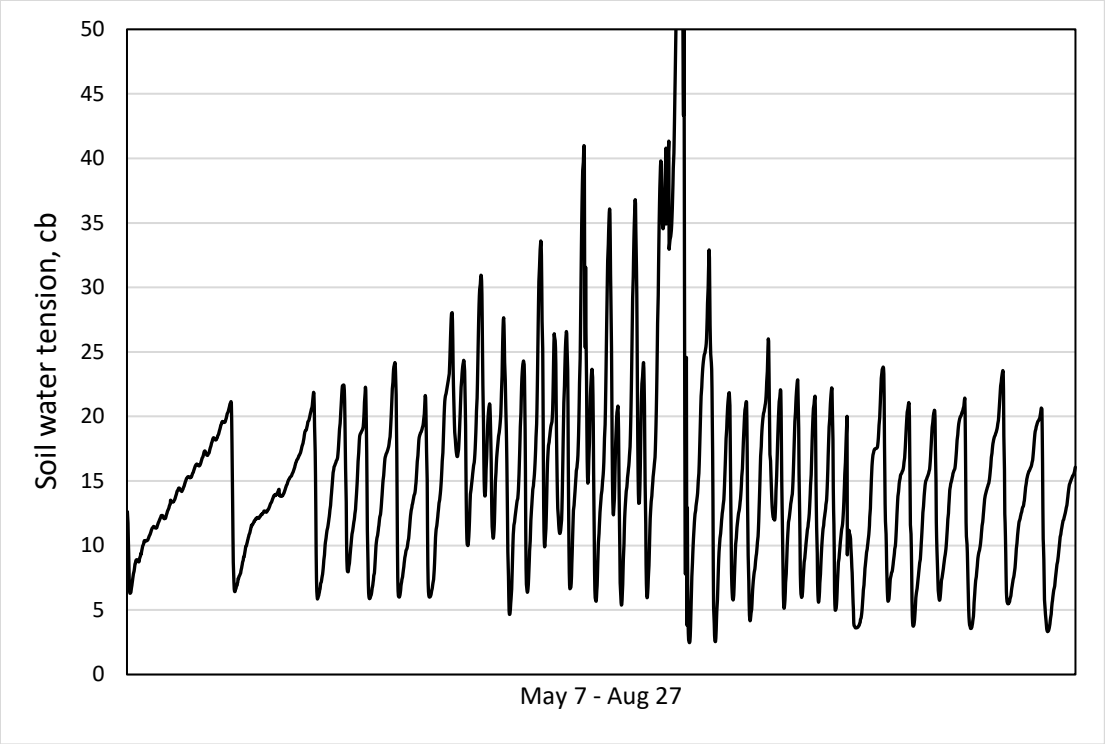

Figure 3. Soil water tension over time, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

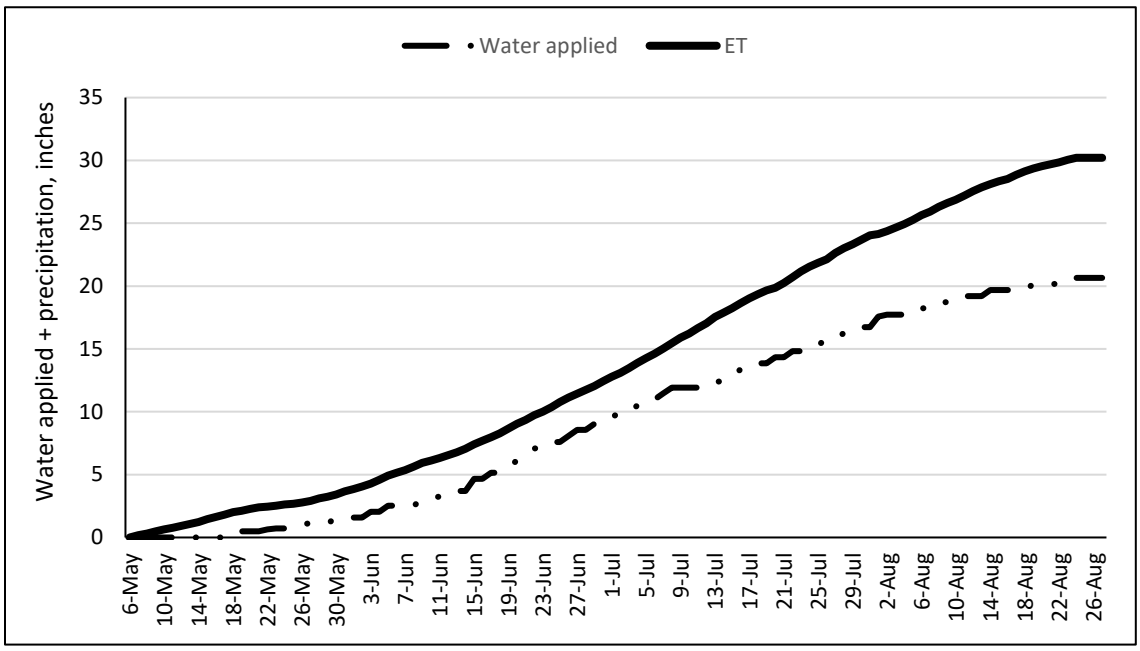

Figure 4. Water applied plus precipitation and onion evapotranspiration over time, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

Table 2. Effects of bactericide treatments and bacterial inoculation on yield, grade, and disease incidence in full-season 'Granero' yellow onions graded out of storage in January 2022, Malheur Experiment Station, Oregon State University, Ontario, OR. Data are means ± standard errors.

Treatment	Rate	Bacterial treatment	Bacterial rot	Neck rot	Medium	Jumbo	Colossal	Super colossal	Marketable	Marketable (%)
			cwt/acre							
Untreated control		Uninoculated	18.53 ± 7.82	4.58 ± 7.45	13.48 ± 2.98	929.72 ± 12.39	181.65 ± 20.15	3.62 ± 2.15	1128.46 ± 29.08	97.48% ± 0.90%
		Inoculated	36.35 ± 15.81	9.36 ± 6.10	17.96 ± 0.98	808.84 ± 60.95	213.67 ± 24.09	33.32 ± 13.74	1073.79 ± 35.81	94.79% ± 1.90%
Badge	2.75 pt/acre	Uninoculated	22.66 ± 5.80	4.00 ± 9.52	9.53 ± 1.76	931.42 ± 41.59	166.69 ± 17.16	14.26 ± 9.64	1121.90 ± 41.29	97.26% ± 0.44%
		Inoculated	26.03 ± 4.29	15.69 ± 15.92	18.56 ± 2.40	881.75 ± 44.33	195.71 ± 41.49	23.44 ± 12.27	1119.45 ± 24.80	95.84% ± 0.45%
Previsto	2.75 pt/acre	Uninoculated	24.41 ± 6.58	11.82 ± 7.59	17.90 ± 3.58	909.61 ± 20.74	168.81 ± 22.71	11.31 ± 4.73	1107.63 ± 41.28	96.31% ± 1.08%
		Inoculated	28.60 ± 10.70	6.52 ± 12.16	27.74 ± 4.73	898.31 ± 40.13	190.43 ± 30.76	22.47 ± 8.81	1138.95 ± 27.09	96.55% ± 0.67%
Kocide 2000	1.5 lb/acre	Uninoculated	18.47 ± 8.75	5.62 ± 11.75	16.14 ± 2.23	968.13 ± 24.28	138.79 ± 27.83	7.10 ± 2.87	1130.17 ± 46.23	97.31% ± 0.66%
		Inoculated	15.56 ± 8.08	10.91 ± 10.72	12.37 ± 3.28	867.87 ± 29.39	248.29 ± 36.82	21.05 ± 4.50	1149.57 ± 10.73	96.82% ± 0.51%
MEM	6 lb/acre	Uninoculated	34.48 ± 9.11	5.62 ± 5.89	13.79 ± 1.68	928.44 ± 34.22	172.52 ± 42.75	27.94 ± 13.59	1142.69 ± 33.41	96.05% ± 0.83%
		Inoculated	40.55 ± 6.59	10.07 ± 7.83	17.43 ± 3.18	870.77 ± 29.01	226.96 ± 33.34	33.81 ± 10.55	1148.97 ± 23.66	95.41% ± 0.78%
MEM HAF-01	6 lb/acre 17 lb/acre	Uninoculated	27.96 ± 9.30	7.23 ± 9.14	15.59 ± 1.25	937.94 ± 25.03	134.36 ± 14.34	8.45 ± 5.97	1096.33 ± 29.70	96.61% ± 1.14%

Treatment	Rate	Bacterial treatment	Bacterial rot	Neck rot	Medium	Jumbo	Colossal	Super colossal	Marketable	Marketable (%)
			cwt/acre							
		Inoculated	24.50 ± 5.74	7.36 ± 8.61	14.73 ± 6.14	879.55 ± 75.70	176.56 ± 12.72	16.79 ± 6.48	1087.63 ± 64.25	96.40% ± 0.60%
Badge	1.375 pt/acre	Uninoculated	21.69 ± 7.19	5.94 ± 7.72	16.57 ± 1.80	947.29 ± 17.90	128.88 ± 29.94	7.85 ± 3.09	1100.59 ± 14.08	96.91% ± 0.65%
		Inoculated	18.40 ± 9.04	11.23 ± 5.72	11.49 ± 2.17	917.81 ± 30.71	183.57 ± 31.51	27.59 ± 2.80	1140.47 ± 22.40	96.95% ± 0.94%
Previsto	2.75 pt/acre	Uninoculated	19.56 ± 5.90	10.27 ± 15.42	16.61 ± 2.63	964.52 ± 17.87	128.20 ± 33.86	14.59 ± 5.27	1123.92 ± 21.71	96.94% ± 0.80%
		Inoculated	28.47 ± 5.98	1.68 ± 3.83	28.64 ± 6.08	817.93 ± 75.61	248.70 ± 39.59	21.23 ± 8.33	1116.50 ± 39.02	96.50% ± 0.57%
Kocide 2000	0.75 lb/acre	Uninoculated	21.82 ± 11.32	3.62 ± 4.33	14.82 ± 1.98	939.67 ± 7.29	139.67 ± 29.83	21.51 ± 12.15	1115.68 ± 33.98	97.15% ± 0.92%
		Inoculated	32.62 ± 4.55	7.10 ± 9.58	22.57 ± 2.89	908.93 ± 47.87	224.80 ± 29.90	14.90 ± 9.36	1171.20 ± 18.80	96.39% ± 0.80%
Badge	2.75 pt/acre (2 applications)	Uninoculated	47.16 ± 15.41	0.90 ± 4.13	21.84 ± 5.41	902.34 ± 9.28	162.12 ± 18.94	7.23 ± 5.11	1093.53 ± 31.62	95.38% ± 1.63%
		Inoculated	26.41 ± 5.02	2.78 ± 5.87	10.91 ± 1.79	972.03 ± 29.92	186.84 ± 24.71	11.35 ± 4.30	1181.13 ± 32.47	97.18% ± 0.78%

Table 3. Effects of bactericide treatments and bacterial inoculation on bulb counts in full-season 'Granero' yellow onions graded out of storage in January 2022, Malheur Experiment Station, Oregon State University, Ontario, OR. Data are means + standard errors. Bulb counts are based on a per acre basis. The % Difference in Marketable bulbs (far right column) shows the percent difference in marketable bulbs between the uninoculated and inoculated treatment for each bactericide treatment. A positive value indicates there were more bulbs in the uninoculated treatment compared with the inoculated treatment.

Treatment	Rate	Bacterial Treatment	Bacterial rot	Neck rot	Medium	Jumbo	Colossal	Super colossal	Marketable	Difference in marketable bulbs (%)
			bulbs per acre							
Untreated control		Uninoculated	21,511.90 ± 5,153.75	3,848.52 ± 2,083.61	4,261.27 ± 1,538.85	114,021.13 ± 679.22	15,882.90 ± 1,062.21	258.26 ± 149.11	134,423.55 ± 2,533.72	-14.97%
		Inoculated	18,292.45 ± 2,927.98	3,148.17 ± 1,148.72	5,036.04 ± 504.60	92,585.67 ± 6,572.06	18,207.22 ± 2,070.10	2,195.20 ± 928.18	118,024.13 ± 4,529.96	
Badge	2.75 pt/acre	Uninoculated	16,201.85 ± 2,720.70	4,918.53 ± 2,323.85	2,840.84 ± 909.01	110,663.77 ± 6,524.54	13,687.70 ± 1,238.57	903.90 ± 610.24	128,096.22 ± 6,458.17	9.04%
		Inoculated	17,666.17 ± 2,432.59	8,221.66 ± 1,650.64	5,423.43 ± 1,240.28	101,108.20 ± 7,814.54	16,012.03 ± 3,334.10	1,549.55 ± 816.69	124,093.21 ± 4,450.10	
Previsto	2.75 pt/acre	Uninoculated	17,627.43 ± 3,732.04	3,921.66 ± 1,722.67	4,906.91 ± 1,848.04	110,405.51 ± 2,059.35	14,333.35 ± 1,842.83	774.78 ± 333.41	130,420.54 ± 3,377.14	34.77%
		Inoculated	23,755.91 ± 2,559.45	6,280.85 ± 462.37	7,747.76 ± 2,444.25	105,498.60 ± 4,573.29	15,753.77 ± 2,295.45	1,420.42 ± 572.65	130,420.54 ± 1,556.73	
Kocide 2000	1.5 lb/acre	Uninoculated	17,796.59 ± 1,948.97	6,067.78 ± 1,394.04	4,648.65 ± 1,149.65	114,925.03 ± 2,817.29	11,879.89 ± 2,300.29	516.52 ± 210.87	131,970.09 ± 4,510.28	5.80%
		Inoculated	18,828.34 ± 1,766.38	5,535.77 ± 1,102.55	3,873.88 ± 1,696.63	100,204.30 ± 4,748.03	20,273.29 ± 2,839.87	1,420.42 ± 247.26	125,771.89 ± 2,006.00	
MEM	6 lb/acre	Uninoculated	18,719.87 ± 1,179.36	3,043.58 ± 1,386.02	4,906.91 ± 869.29	112,600.71 ± 5,445.95	14,204.22 ± 3,310.68	1,936.94 ± 997.45	133,648.77 ± 2,924.73	6.39%

		Inoculated	19,916.90 ± 4,431.30	4,044.33 ± 671.73	4,777.78 ± 1,643.93	101,753.85 ± 4,840.75	18,723.74 ± 2,832.03	2,324.33 ± 683.29	127,579.70 ± 2,431.81	
MEM HAF-01	6 lb/acre 17 lb/acre	Uninoculated	18,965.52 ± 2,459.24	4,718.54 ± 2,039.32	4,906.91 ± 644.02	114,279.39 ± 3,021.93	11,750.76 ± 974.91	516.52 ± 365.23	131,453.58 ± 3,073.90	12.04%
		Inoculated	21,249.51 ± 4,284.15	4,444.63 ± 1,486.95	4,261.27 ± 3,171.80	103,432.53 ± 9,746.47	15,108.12 ± 1,082.94	1,162.16 ± 488.87	123,964.08 ± 7,979.57	
Badge	1.375 pt/acre	Uninoculated	22,682.84 ± 2,999.83	3,987.51 ± 1,546.98	5,036.04 ± 929.65	113,117.22 ± 1,563.86	11,105.12 ± 2,352.85	516.52 ± 210.87	129,774.90 ± 1,236.34	-9.30%
		Inoculated	20,572.87 ± 3,551.93	2,952.98 ± 1,404.44	3,357.36 ± 1,118.69	108,468.57 ± 4,222.63	16,012.03 ± 2,616.79	1,807.81 ± 149.11	129,645.77 ± 2,692.19	
Previsto	2.75 pt/acre	Uninoculated	22,476.24 ± 6,756.35	7,964.69 ± 2,208.88	5,165.17 ± 1,356.41	115,699.81 ± 3,509.53	10,975.99 ± 2,816.28	903.90 ± 324.97	132,744.87 ± 1,505.91	-4.55%
		Inoculated	21,453.74 ± 3,193.57	1,976.19 ± 1,145.57	7,876.88 ± 3,141.79	95,168.26 ± 8,814.57	19,498.52 ± 3,269.29	1,420.42 ± 572.65	123,964.08 ± 4,169.64	
Kocide 2000	0.75 lb/acre	Uninoculated	28,944.32 ± 1,892.00	2,233.94 ± 1,152.96	4,519.52 ± 1,025.15	112,471.58 ± 1,651.98	12,396.41 ± 2,608.28	1,291.29 ± 683.29	130,678.80 ± 2,011.52	-31.93%
		Inoculated	19,702.54 ± 2,663.47	4,948.23 ± 1,655.19	6,456.46 ± 1,494.10	108,597.70 ± 6,921.38	19,369.39 ± 2,864.23	1,033.03 ± 632.60	135,456.58 ± 4,008.53	
Badge	2.75 pt/acre	Uninoculated	15,399.90 ± 3,124.41	2,131.77 ± 864.31	5,939.95 ± 2,793.14	109,372.47 ± 645.65	13,687.70 ± 1,542.36	516.52 ± 365.23	129,516.64 ± 3,072.97	37.25%
	2 applications	Inoculated	21,135.88 ± 3,948.31	3,031.95 ± 1,908.86	2,969.97 ± 924.66	115,441.55 ± 2,895.13	15,753.77 ± 1,868.29	774.78 ± 258.26	134,940.07 ± 3,165.63	