Evaluation of SporeKill® for *Xanthomonas* management in carrot seed crops

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Introduction

Bacterial blight, caused by *Xanthomonas hortorum* pv. *carotae* is an important seedborne disease of carrot. Reducing *Xanthomonas* in harvested carrot seed would benefit the carrot seed industry by minimizing the need for hot water treatment and lessening the impact of bacterial blight on carrot root crops in California, Washington, and other carrot-producing states and countries. Copper-based bactericides such as ManKocide® (mancozeb + copper hydroxide) are a primary control measure for bacterial blight in carrot seed crops and are often applied several times during carrot seed production to manage bacterial blight. However, copper-based bactericides are most effective when used as preventative treatments and have limited ability to reduce *Xanthomonas* populations once the pathogen becomes established in a seed crop (du Toit and Derie 2008). Previous research revealed that SporeKill® (12% didecyldimethyl ammonium chloride; ICA International Chemicals) was effective at reducing *Xanthomonas* in harvested carrot seed, but its ability to manage the pathogen on carrot foliage is not known. The objective of this study was to evaluate the efficacy of SporeKill® to reduce *Xanthomonas* populations on carrot plants in the greenhouse.

Materials and Methods

Commercial carrot stecklings of a proprietary female line were planted on April 7, 2017 in 1-gallon pots and grown in the greenhouse. A total of five bactericide treatments were tested: SporeKill® (1% vol/vol) applied post-inoculation; SporeKill® (0.5% vol/vol) applied post-inoculation; SporeKill® (1% vol/vol) applied before inoculation; SporeKill® (0.5% vol/vol) applied before inoculation; and ManKocide® (2.5 lbs/A) applied after inoculation. A CO_2 backpack sprayer was used to inoculate foliage of post-inoculation treatments with a suspension of *X. hortorum pv. carotae* (2×10^6 CFU) on June 5 and June 21. Treatments were applied on July 5 using a CO_2 backpack sprayer, after which all plants were inoculated as described above. Bactericide treatments were compared to a non-inoculated/non-treated control and an inoculated/non-treated control. The experiment was arranged as a randomized complete block design with five replications per treatment.

Bacterial blight symptoms were evaluated on a weekly basis following inoculations. Foliage was sampled 7- and 14-days after treatment and subjected to a leaf wash assay to determine foliar *Xanthomonas* populations. Phytotoxicity was evaluated using a 0-5 scale (0 = no phytotoxicity, 5 = dead plant). The impact of each treatment on bolting frequency and timing was also evaluated.

Results and Discussion

Although bacterial blight symptoms were not observed, large populations of *Xanthomonas* (5.1×10^4 to 3.8×10^8 CFU/g leaf tissue) were recovered from inoculated plants. Pre-inoculation treatments of SporeKill® at both the 0.5X and 1X rates significantly reduced *Xanthomonas* populations compared to the non-treated/non-inoculated control at 1- and 2-weeks post-treatment

(Table 1); however, pre-inoculation treatments were only exposed to one inoculation event compared to the post-inoculation treatments, which were exposed to three inoculation events. An additional study is needed to determine if the reduced *Xanthomonas* populations observed 1- and 2-weeks after pre-inoculation treatments were due to SporeKill or lower initial inoculum levels. Regardless, post-inoculation treatments of SporeKill® (both rates) and ManKocide® did not reduce *Xanthomonas* populations. These results are consistent with previous studies showing bactericides such as ManKocide® work best when used preventatively and suggest that SporeKill® may also be most effective as a preventative treatment for bacterial blight, though this needs to be confirmed. No effect of any treatments on phytotoxicity or bolting were observed.

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Tables

Table 1. Effect of SporeKill® treatments on colony forming units (CFU) of *Xanthomonas hortorum* pv. *carotae* on carrot foliage[1]

		CFU/g tissue			
Treatment	**Bactericide timing**	**1 week**		**2 weeks**	
Non-inoculated/non-treated control	**NA**	1.6×10^3	a	3.0×10^2	a
SporeKill® (0.5X rate)	**Pre-inoculation**	1.0×10^6	ab	5.1×10^4	b
SporeKill® (1X rate)	**Pre-inoculation**	6.8×10^4	a	7.2×10^5	b
ManKocide®	**Post-inoculation**	7.3×10^7	c	1.8×10^8	c
SporeKill® (0.5X rate)	**Post-inoculation**	1.8×10^8	c	1.6×10^8	c
SporeKill® (1X rate)	**Post-inoculation**	1.5×10^8	bc	3.0×10^8	c
Inoculated/non-treated control	**NA**	7.5×10^7	c	3.8×10^8	c

[1] Treatments followed by the same letter are not significantly different using Tukey's test at $P = 0.05$.