Evaluation of Late-Season Bactericide Applications to Reduce *Xanthomonas hortorum* pv. *carotae* on Harvested Carrot Seed

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Abstract

Field plots were established to evaluate the efficacy of late-season applications of ManKocide and Phyton 27 AG for the suppression of *Xanthomonas hortorum* pv. *carotae* (*Xhc*) on harvested carrot seed. Bactericide applications were made in late August one to two weeks before harvest in each of two fields, and harvested seed from the plots was assayed by plating dilutions of seed washes onto a semi-selective agar medium. Seed assays were conducted in parallel by two labs. A significant ($P = 0.0008$) reduction in *Xhc* populations on harvested seed was observed in one of the two fields, but only for seed tested in one of the two labs. In general, both treatments reduced *Xhc* levels on harvested seed compared to the control plots but not to the extent that would reduce the need for hot water seed treatment.

Introduction

Bacterial blight of carrot, caused by the plant pathogenic bacterium *Xanthomonas hortorum* pv. *carotae* (*Xhc*), is a common disease in most areas where carrot is grown. The disease can affect carrot foliage, stems, umbels, and roots and can be seed-borne. Symptoms of bacterial blight include small, irregular, chlorotic areas on leaves that can manifest into water-soaked, necrotic lesions. Lesions can also occur on stems and petioles. Floral infections can result in blighted umbels, reduced seed yield, and reduced germination rates of harvested seed. Bacterial blight is of particular concern to carrot seed producers because *Xhc* is seedborne and seed treatments with hot water or disinfectants may not entirely eradicate the pathogen.

Carrot seed producers would like to reduce *Xhc* populations on harvested seed in order to minimize the need for hot water treatment and lessen the impact of bacterial blight on root crop producers that purchase the seed. Copper-based bactericides such as ManKocide (mancozeb + copper hydroxide) routinely are applied multiple times each season to manage bacterial blight and increase seed quality. However, the effect of ManKocide on bacterial populations on leaves is generally short-term and ManKocide does not consistently reduce bacterial populations on seeds. Alternative strategies aimed at reducing *Xhc* infestations on harvested seed need to be explored. The objective of this study was to evaluate the impact of late-season, pre-harvest applications of ManKocide and Phyton 27 AG (copper sulfate pentahydrate) in carrot seed crops on *Xhc* populations on harvested seed.

Materials and Methods

Plots, each comprised of two four-row sets of female carrot plants, were established in each of two grower-cooperators' seed fields. Treatments included ManKocide (2.5 lb/acre), Phyton 27 AG (21.6 oz/acre, or 4 oz/10 gal of solution), and non-treated plots that were replicated 5 times in a randomized complete block design. Each treatment was applied twice to the same plots. The first application was made after bees and male plants were removed while the second application was timed to occur 7 to 14 days before harvest. Field A was treated on August 12 and 28, and

field B was treated on August 17 and 30. Each application consisted of two passes of a tractor-mounted spray boom of the plot for a total treatment volume of approximately 54 gal/acre.

Seed from each plot was harvested mechanically and cleaned separately according to standard practices. Seed from the first few feet of each plot was discharged from the combine to avoid contamination between plots. Field A plots were harvested on September 20 and 21, and field B plots were harvested on September 10 and 11. Cleaned and sized seed from each plot was assayed for *Xhc* using a seed wash dilution plating assay on the semi-selective XCS agar medium. Three 10 g subsamples of seed from each plot were soaked for 2 hours at room temperature in a 250 ml Erlenmeyer flask containing 100 ml of sterilized PO_4 buffer (0.0125 M) and one drop of Tween 20. After the soak the flasks were placed on a horizontal shaker set at 250 rpm for 5 minutes. A 10-fold dilution series was prepared for each suspension, ranging from 10^{-1} to 10^{-5} concentration using sterilized PO_4 buffer. A 0.1 ml aliquot of each dilution series was spread onto each of three plates of XCS agar medium for each dilution. The plates were incubated at 28°C in the dark and monitored for the development of colonies typical of *Xhc*. The number of colonies typical of *Xhc* were counted after 6 days of incubation and suspect colonies were subcultured onto YDC agar medium to observe the development of growth typical of the pathogen. Parallel assays with different subsamples of seed from each plot were conducted at Oregon State University (OSU) and Washington State University (WSU) in order to compare and confirm results.

Results and Discussion

Xhc was detected in seed at levels ranging from 3.59×10^5 to 2.60×10^7 CFU/g carrot seed. The OSU assays detected a significant reduction in amount of *Xhc* recovered from seed harvested from plots treated with Phyton 27 AG and ManKocide compared to the control plots in Field A, but neither of the treatments reduced the amount of pathogen detected on seed harvested in Field B ($P > 0.6775$) (Table 1). There were no significant differences in the amount of *Xhc* recovered on seed from plots with the different treatments in the WSU seed assays for either field ($P = 0.0610$ in Field A and $P = 0.9965$ in Field B). Numerically, seed harvested from non-treated control plots had the greatest levels of *Xhc* recovered in 3 out of the 4 assays (Table 1). *Xhc* levels were lowest in ManKocide-treated plots in Field A, although this was not significantly different than the amount of *Xhc* detected in seed harvested from Phyton 27 AG-treated plots in that field. Field B was damaged by a severe hail storm on August 25 which potentially affected interpretation of results from these plots. The results support previous research concluding that copper-based bactericides are most effective when used as preventative treatments, and have very limited ability to reduce *Xhc* populations once the pathogen becomes established in a seed crop.

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Tables

Table 1. Populations of *Xanthomonas hortorum* pv. *carotae* recovered from harvested seed following late-season applications of Phyton 27 AG or ManKocide in carrot seed crops in each of two fields in central Oregon[1]

	Field A		Field B	
Treatment	**OSU**	**WSU**	**OSU**	**WSU**
Non-treated	1.26E+07 a	2.60E+07	4.65E+05	1.41E+07
Phyton 27 AG	9.17E+06 b	2.11E+07	3.59E+05	1.25E+07
ManKocide	7.10E+06 b	1.66E+07	4.93E+05	1.26E+07
***P*- value**	0.0008	0.0610	0.6775	0.9965

[1] Seed samples from each plot of each field were assayed in parallel at Oregon State University (OSU) and Washington State University (WSU). Means followed by different letters are significantly ($P < 0.05$) different based on Tukey's test.