Evaluation for Improved Control of Bacterial Blight of Carrot with Early Season Copper Bactericides, 2006-2007

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Abstract

A field trial was carried out to evaluate a number of antibacterial pesticides sprayed singly or in combination onto carrot foliage in a replicated field trial in the fall of 2006 (twice) and early spring of 2007 (once), following artificial point-source infestations of *Xanthomonas campestris* pv *carotae* (Xcc). The number of colony forming units (CFUs) per gram of dry foliage was used to calculate the mean number of bacteria present on plants. In late fall 2006, Xanthomonas was not recovered from infested-but-unsprayed plots, and initial post-winter recovery was very low. In infested-but-unsprayed plots, frequency of recovery and net plot Xanthomonas populations on plants increased regularly through 2007, resulting in recovery from all replications of each variety. By mid-summer, all plots were highly infested with Xcc and many plots showed actual bacteria blight symptoms. Results did not show significant population control of bacteria by a specific single or combination chemical treatment and the trial was removed and seed was not harvested. All three varieties suffered widely different winter injury and frost heaving damage, which may have contributed to disease proliferation.

Introduction

Bacterial blight of carrots is incited by *Xanthomonas campestris* pv *carotae***.** In carrot seed fields in central Oregon and central Washington, bacterial blight disease generally is mild and occasional, even frequently absent, although high disease incidence does flare up in some fields in some years. More problematic is that Xanthomonas is abundant on seed harvested from these regions, even in the absence of bacterial blight disease. Such infested seed, without treatment, may be a source of infection for more damaging disease in commercial plantings.

The following summarizes the results of carrot seed field monitoring over several years in the Pacific Northwest (Du Toit et al. 2005): contamination levels of 10^6-10^8 colony forming units (CFUs)/10,000 harvested seed are common for commercial seed lots from central Oregon and central Washington. In seed-to-seed production, Xanthomonas incidence on foliage becomes established on a very low proportion of plants soon after planting of seed in fall, increasing progressively in most fields until a high proportion of plants harbor a population before harvest the following year. On individual plants, the population increases very rapidly, frequently reaching levels of 10^6-10^8 CFU/g dry weight. Seed lots used to plant seed fields almost never test positive for Xanthomonas, indicating that seed lots are either carefully chosen and/or that all or most are hot water treated. Sources for infestation of seed fields typically are local, probably originating in older seed fields. A few fields seem to escape all Xanthomonas infestation each year. Other crops and weeds appear not to harbor this strain of Xanthomonas.

Investigations presented below probed the concept that antibacterial pesticide sprays may improve control of Xanthomonas infestation. Our working hypothesis has been that Xanthomonas management might be achieved if initial infestation could be eliminated soon after Xanthomonas arrives in newly seeded fields during the first month after emergence. It is this period when wind-

blown inoculum is most prevalent (DuToit et al. 2005). Once Xanthomonas infestations become established, especially on larger plants where Xanthomonas populations may be very high and where spray coverage is difficult, chemical control would become much more difficult and probably unlikely. Even if fields become infested in spring or early summer, fall control might delay Xanthomonas population increases enough that lower seed infestation might result.

Materials and Methods

Three varieties of seed-to-seed carrots were established in a trial area and planted into strips with 2 replications of 11 treatments. Seeding was on 10 August 2006, on 30-inch rows in long strips through the field. Strips were separated by a 20-ft unplanted alley. Emergence was roughly September 1, after which carrots were removed by tillage from 30-ft cross-alleys between plots along the strips. Thus, plots were 20 ft wide (8 rows) by 20 ft long, separated by alleys either 20 or 30 ft wide. Plants were not thinned, and averaged 1 plant per 2 inches. Although frequent plant sampling did thin the plots slightly, plant stands remained at least as thick as commercial fields throughout the season.

In central Oregon, seed-to-seed carrots initially are sprinkler irrigated prior to and after emergence through the fall. Irrigation from spring through fall may be by sprinkler, furrow, or drip. In this trial, sprinkler irrigation was continued through the growing season. All fertilization, herbicide application, and other practices were as per commercial production for the region. Only a female carrot line was planted to prevent this field from cross-pollinating with other fields in the area. No bees were installed at pollination, but bees, flies, and other insects were active on flowers. The field was removed before seed set.

We attempted to initiate a mini-epidemic of Xanthomonas in each plot by establishing small, point-source infestations simulating Xanthomonas-infested dust falling onto newly seeded carrot fields on September 27. Trial area was irrigated 30 minutes prior to infestation to wet foliage for adhesion of inoculum. The alley structure discussed above was intended to contain each mini-epidemic within each plot, and prevent plot-to-plot cross-contamination.

Treatments were various antibacterial pesticide products sprayed onto foliage. Sprays were made on October 9 at the three- to four-leaf stage of growth. A repeat application was on October 23 when carrots had approximately five leaves. A third application was made on April 9 at which time only three to six small green leaves were present following winter die back of the fall foliage. Winter freeze and heaving damage occurred, which limited adequate sampling in several plots until later in the season.

Previous trial data determined that coverage of carrot foliage was critical to product efficacy. A commercially designed tractor-mounted spray tank and boom were used in this trial, with nozzle orientation in a triangular fashion over each carrot row. Two nozzles sprayed towards the sides of seedling carrots, and one nozzle sprayed from above. This seemed to be the most optimal commercially used orientation available. All products were applied at 40 gal/acre broad acre, but only the carrot rows were sprayed so that in reality it was 20 gal/acre. For each plot, the tractor-sprayer was started up in the middle of the alley so that it was at application speed by the time any spray was applied. Similarly, the spray was continued at pace until reaching well past each plot. Wide alleys allowed the spray rig to be easily maneuvered among plots. All applications included 9 oz/100 g water of Silken, a silicone-based spreader sticker, plus an antifoaming agent. Enough product was mixed in the spray tank to allow for spraying all six replications per treatment with a single tank. The tank and spray rig were purged between each treatment. Spray treatments included the following, with all rates as the amount of commercial product:

1. Non infested (negative check, to assess plot-to-plot spread of Xcc)
2. Infested, no chemical treatment (positive check, to assess unmanaged infestation)
3. ManKocide® 2.5 lb/acre
4. ManKocide 2.5 lb/acre + Tanos® 8 oz/acre
5. ManKocide 2.5 lb/acre + Tanos 12 oz/acre
6. Kocide 3000 + Tanos 8 oz/acre
7. Kocide 3000 + Tanos 12 oz/acre
8. Serenade® Max 3 lb/acre (*Bacillus subtilis* strain QST713)
9. Micro 108® 9 oz/acre (*Streptomyces lydicus*)
10. Chlorine (12.5 percent) 1 qt/acre

Beginning a week after infestation, untreated check plots were sampled weekly until Xcc was detected, after which all plots were sampled on an approximately monthly basis except for mid-winter. Sampling involved collecting foliage from 30 plants per plot, placing foliage into a new plastic bag, storing it in a refrigerator, chopping it finely within 24 hours of harvest, and soaking it in phosphate buffer for 1 hour on a gyratory shaker. A dilution series of the rinsate was prepared up to 10^{-7} onto XCS agar, a semi-selective medium for Xcc, using sterile technique. Dilution plates were incubated at 28ºC in the dark for one week, after which the numbers of CFUs were calculated. The chopped and rinsed leaves were dried at 55ºC and then weighed to calculate the mean number of CFUs per gram of dry weight. When small, all the foliage from each composited carrot was sampled. As plants became larger and bolted, plants were subsampled to include a representative amount of foliage, petioles, stems, and umbels.

Results and Discussion

Beginning in the spring of 2007, detection frequency increased regularly in the untreated check and most treated plots through the end of the season. Freezing temperatures and a wet spring caused many of the plots to heave and thus caused winter die back. In early May, only one variety produced enough new growth to adequately sample. Xanthomonas was detected in all five replications of the check plots by 7 May 2007. Plots sampled showed an equal level of bacteria.

All the products used in this trial are nonresistant and none would be expected to sustain control for more than a short period of time or to protect new foliage. Presumably, their effects must have been from eliminating or reducing early infestations, thus greatly delaying epidemic buildup of Xcc. Two weeks later in May, all plots were sampled, and all plots contained levels of bacteria (Table 1). By June and July, symptoms were visible in the field in most plots, across all varieties. Levels of bacteria were extremely high and so monitoring this trial ended.

A similar trial was initiated in the fall of 2007 that will be carried through 2008. The trial will be furrow irrigated beginning April 2008. It will include seven replications, with nine treatments of seed to seed plots as well as four treatments with steckling carrots. Treatments will focus on timing of copper bactericides in conjunction with multiple disease inoculations.

Table 1. Log colony forming units (CFUs) recovered from seed carrots, Madras, Oregon.

Treatment	Log (CFUs/g dry foliage)			
	27-Oct	7-May*	22-May	5-Jul
Non iInfested	0	3.4	2.6	5.6
Infested, no chemical treatment	0	3.3	3.0	6.9
ManKocide 2.5 lb/acre	0	6.4	1.5	6.1
ManKocide 2.5 lb/acre + Tanos 8 oz/acre	0	0.0	3.9	6.9
ManKocide 2.5 lb/acre + Tanos 12 oz/acre	0	3.6	2.1	6.3
Kocide 3000 1.5 lb/acre	0	3.4	2.0	6.0
Kocide 3000 + Tanos 8 oz/acre	0	3.5	2.0	5.9
Kocide 3000 + Tanos 12 oz/acre	0	3.4	2.3	7.0
Serenade Max 3 lb/acre	0	3.4	2.2	6.2
Micro 108 9 oz/acre	0	3.9	2.7	6.1
Chlorine (12.5%) 1 qt/acre	0	7.7	3.4	7.3

*Only one variety (2 replications) were sampled due to winter die back.

References

Du Toit, L.J., F.J. Crowe, M.L. Derie, R.B. Simmons, and G.Q. Pelter. 2005. Bacterial blight in carrot seed crops in the Pacific Northwest. Plant Disease 89:896-907.