Managing Bacterial Spot in Ontario Field Tomato Production: Time to Hit the Refresh Button

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Bacterial spot, caused by a group of *Xanthomonas* bacteria, is an ongoing challenge for field tomato growers in Ontario. For many years, a program of fixed copper sprays was used to manage bacterial spot in plug transplants and field tomatoes. Transplant growers were advised to apply a fixed copper bactericide beginning 2 ½ weeks after seeding at 5-day intervals for a total of 5 applications. For field growers, the recommendation was to start to apply the copper within 7 days after transplanting -- applying at least 3 applications at 7-day intervals. Knowing that copper and other products are relatively weak on bacterial disease, the strategy was to suppress populations early in the season while they are still low. Once symptoms are present, the bacterial populations are so high that we would not expect to have a significant impact on disease development with a spray program.

Efficacy Trials

In the decade or so since these protocols were developed there have been several new products registered that include bacterial spot on their label, and many more efficacy trials to evaluate the field performance of these treatments (Table 1). In trials completed from 2010-2014 at Ridgetown Campus, University of Guelph, with a copper sensitive *Xanthomonas gardneri* isolate, the only consistent spray program year after year was 8 applications of Kocide 2000 + Actigard beginning within 7 days of transplanting, applied at 7-day intervals. This treatment resulted in measurable disease reductions in all years, although it did not always increase yield or reduce spotting on fruit.

Other copper-based programs, as well as other tested products, were inconsistent or ineffective. The efficacy data suggests that growers will not see an economic benefit from copper applications for bacterial spot management in field tomatoes. The efficacy of copper and other treatments on tomato transplants continues to be evaluated at Ridgetown Campus.

These results are consistent with those from a survey of the Ontario processing tomato industry we completed in 2014. Over 80% of the growers that responded had used a copper-based spray program in 2014, but only 18% of them thought it had helped to reduce losses to bacterial disease. Furthermore, Dr. Pervaiz Abbasi (AAFC) reports that more than 70% of bacterial spot causing *Xanthomonas* spp. isolated from tomato in southern Ontario in 2012 were resistant to copper.

Table 1. Efficacy of products for suppression of bacterial spot in Ontario processing tomatoes at Ridgetown Campus, Univ. of Guelph. Tomatoes were inoculated with copper sensitive *Xanthomonas gardneri* (2013-14) or *Pseudomonas syringae* pv. *tomato* and *X. gardneri* (2010-12) two to three weeks after transplanting. All programs, except the Cal-Mag-B/KP programs, were applied 8 times on a 7-day interval, with the first application no more than 7 days after transplanting each year. The Cal-Mag-B/KP programs consisted of a total of 11 applications. Trials from 2010 to 2013 were completed using tomato cv. H9909 and the trial in 2014 was completed using cv. H5108. Not all products are registered for use in Canada on tomatoes.

TABLE LEGEND: E = reduction in early season disease incidence, D = reduction in defoliation, Y = increase in yield, F = reduction in incidence or severity on fruit, '– ' = no significant effects, Dark boxes = not tested. Expand Table

Treatment (Active Ingredient)	Reduction vs. Untreated Control [a]					
	2010	2011	2012	2011 + 2012 [b]	2013	2014
Kocide 2000 (Copper hydroxide)	**E**	**E**	-	-	- / - [c]	**D**
Kocide 2000 + Dithane (Copper hydroxide + mancozeb)	**E**	**E**	-	-	**D / D** [c]	**D, F**
Serenade Max (*Bacillus subtilis* QST 713)	**E**	-	-		-	-
Kocide 2000 + Serenade Max (Copper hydroxide + *Bacillus subtilis* QST 713)	**E**	**E**	-			-
Kocide 2000 alt. Serenade Max (Copper hydroxide alt. *Bacillus subtilis* QST 713)	**E**	**E**	-			
Regalia Maxx (Extract of *Reynoutria sachalinensis*)	-	-	-		-	-
Kocide 2000 + Regalia Maxx (Copper hydroxide + extract of *Reynoutria sachalinensis*)	**E**	**E**	-			-
Kocide 2000 alt. Regalia Maxx (Copper hydroxide alt. extract of *Reynoutria sachalinensis*)	**E**	**-**	-			
Actigard (Acibenzolar-S-methyl)		-	-	-	-	**E**
Kocide 2000 + Actigard (Copper hydroxide + acibenzolar-S-methyl)		**E**	**E**	**E, D, Y**	**E**	**D, F**
Kocide 2000 alt. Actigard (Copper hydroxide alt. acibenzolar-S-methyl)		**E**	**-**	**-**		
Kasumin (Kasugamycin)	**E**					
Kocide 2000 + Kasumin (Copper hydroxide + kasugamycin)	**E**					
Kocide 2000 alt. Kasumin (Copper hydroxide alt. kasugamycin)	**E**					
Bravo (Chlorothalonil)					-	-
Kocide 2000 + Bravo (Copper hydroxide + chlorothalonil)					-	**F**
Quintec (Quinoxyfen)					-	
Kocide 2000 + Quintec (Copper hydroxide)					-	
Kocide 2000 + Dithane + Quintec (Copper hydroxide + mancozeb + quinoxyfen)					-	
496/A + 497/B (Unknown)					-	
496/A + 497/B + Actigard (Unknown + acibenzolar-S-methyl)					-	
Taegro (*Bacillus subtilis* var. *amyloliquefaciens* FZB24)					-	
Agral 90 (Non-ionic surfactant)					-	
Surround (Kaolin clay)						-
Double Strength Trace Elements (Water soluble copper)		-				
THIS Copper & Sulfur (Elemental copper + sulphur)		-				
Cal-Mag-B alt. KP350DP (Ca, Mg, B alt. extract from *Saccharomyces cerevisiae*, chelated micronutrients, alpha-keto acids, and humic acid)			-			
Cal-Mag-B alt. KP350OR (Ca, Mg, B alt. extract from *Saccharomyces cerevisiae*, chelated micronutrients, alpha-keto acids, and humic acid)			-			
Cal-Mag-B alt. KP1000DP (Ca, Mg, B alt. chelated micronutrients, alpha-keto acids, and humic acid)			-			

[a] Letters indicate the following significant differences from the untreated control in each year ($P \leq 0.05$, Duncan's new MRT or Tukey's HSD). [b] Results from a trial that was repeated in 2011 and 2012. Data from both years was pooled together because analysis indicated no significant trt*trial interaction. [c] Included in two trials in 2013.

New Strategy

What is clear is that if we hope to improve management of bacterial spot, we have to move beyond a spray program that has little or no effect on reducing losses in yield and quality. We suggest a new focus on tactics to exclude the pathogen from tomato cropping systems and reduce its spread. **The overarching strategy is to adopt multiple practices to limit spread and delay an epidemic of bacterial spot as much as possible.** We have developed a list of best management practices for field tomato growers in Ontario.

Tier 1 - likely to have the biggest impact	
Shipping/ Picking Up Transplants	**One crop per load.** ➢ Do not arrive to pick up transplants with a trailer already ½ loaded with host plants (tomatoes, pepper) from another greenhouse.
	Clean and sanitize plant trailer between loads. ➢ Use appropriate sanitation chemicals & concentrations (see Additional Resources).
Transplanting	**Clean and sanitize the transplanter (surfaces that contact plants and trays) between fields and varieties.** ➢ Use appropriate sanitation chemicals & concentrations (see Additional Resources).
	Transplanting crew cleans and sanitizes their hands at every break or changes to new disposable gloves. ➢ Bacteria can be spread from plant to plant on workers' hands. ➢ Consider this: at a transplanting rate of 1.5 ac/hour with 6 workers (1/row) and 13,000 plugs per acre, 3,250 plugs are touched per person per hour.
Tier 2 - some impact expected	
In-season	**Avoid planting tomatoes immediately adjacent to other host crops (peppers, other tomatoes).**
	Clean and sanitize sprayer / cultivator equipment between fields. ➢ Bacteria can be spread from field to field on equipment that comes into contact with the crop.
	In processing and unstaked fresh market tomatoes, eliminate hoeing beyond 3 or 4 weeks after transplanting. ➢ This will reduce leaf tearing once the rows start to fill in.
	Eliminate inter-row cultivating beyond 3 or 4 weeks after transplanting. ➢ This will reduce leaf tearing once the rows start to fill in.
	When working with staked plants (pruning, tying), clean and sanitize tools between each plant. Change gloves or clean and sanitize hands every row. ➢ Bacteria can be spread from plant to plant on tools and workers' hands.
	Crop scouts and other visitors instructed to clean and sanitize hands or wear gloves prior to entering each field. Wearing plastic booties which are changed after each field will also limit the spread of soilborne pathogens from field to field.
	Use 8 applications of copper + Actigard, applied on a 7-day interval, starting within 7 days of transplanting. ➢ Five years of research trials at Ridgetown Campus have shown that this is the most consistent program for reducing early season disease and in some cases, reducing defoliation. It is the only program that has shown a yield benefit (in 1 year out of 5) in the research trials. See Table 1.

Tier 3 - little impact expected compared to tiers 1 or 2	
In-season	**Controlling weeds in the field.** ➢ Weeds are potential hosts for bacterial spot and interfere with air movement and drying of the crop canopy.
	Fallowing weak areas within the field (historic poor drainage, low areas). ➢ This may be where the severe symptoms show up first, but is probably not the initial source of the inoculum.
Tier 4 – no impact expected on bacterial spot	
Pre-season	**Crop rotation.** ➢ This is beneficial for management of a number of pests, but is not as useful for managing bacterial spot.
In-season	**Applying other protective spray programs, except the program listed in Tier 2.** ➢ Five years of bacterial spot efficacy research at Ridgetown Campus has shown minimal to no beneficial impact to any of the spray programs tested, except copper + Actigard as described in Tier 2. See Table 1.
	DSV-based spraying of bactericides. ➢ TomCAST is designed based on the biology of the fungal pathogens that cause early blight, septoria leaf spot, and anthracnose. DSV-based spray timing is not appropriate for bacterial spot management.
	Using disinfectant on tools, equipment, hands, and other surfaces without pre-cleaning to remove films and organic matter. ➢ Disinfectants must be applied to clean surfaces to be effective.
	Beginning a program of cleaning and disinfecting tools, equipment, hands, and other surfaces after disease is already established. ➢ Bacteria are present (and can be spread) long before the first symptoms are visible.

Do More Than Think About It

When adopting a new bacterial disease management program on-farm, it is critical to have it written down, to train the people who will be doing the work, and to keep records. Written protocols and/or checklists don't have to be elaborate, but are needed to ensure activities are not forgotten. Review them often as a team; update them and make changes based on experience and new information.

In conclusion, the research shows that it is time to move beyond the spraying strategy and put the focus on other management practices. The emphasis must be on **tactics to exclude the pathogen from tomato cropping systems** and **reduce its spread** within the crop. This will require adoption of multiple practices to limit spread and delay an epidemic of bacterial spot as much as possible. This is not a simple strategy, and there are costs involved, but keep in mind the cost of spray programs that have marginal if any benefit and the cost in potential losses to bacterial spot.

Additional resources

On-Farm and Greenhouse Sanitation and Disinfection Practices to Minimize the Impact of Plant Pests (BC Ministry of Agriculture)