Shift in Performance of Fungicides for the Control of Tomato Early Blight

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ABSTRACT
Most tomato cultivars (*Solanum esculentum*) are very susceptible to foliar infection with early blight (EB) caused by *Alternaria tomatophila*. Fungicide sprays consisting of protectants (mancozeb and chlorothalonil), strobilurins (i.e. azoxystrobin and pyraclostrobin), and more recently boscalid, are commonly used for control. Concern for fungicide resistance has required that more attention be paid to the selection and scheduling of all products. Use of *A. tomatophila* in our spray trials has resulted in high infection levels and a clearer separation for efficacy among protectant and newer fungicides. Mancozeb was shown to be equal or better than chlorothalonil in providing control, and can be an effective tool in managing resistance concerns among fungicides of differing chemistry.

INTRODUCTION
Early blight (EB) is an extremely common disease of potato (*Solanum tuberosum*) and tomato (*Solanum esculentum*) and has been traditionally thought to be caused by a single fungal species, *Alternaria solani* Sorauer. Simmons (5) reported that two morphologically and culturally distinct species are responsible for the disease, and assigned *A. tomatophila* Simmons as the cause of tomato EB. The key differences described are in length, widths, and branching patterns of the beaks as well as cultural differences. Frazer (2) confirmed these morphological differences and showed that *A. tomatophila* is more virulent than *A. solani* on tomato leaves, petioles, and stems, and that isolates of *A. tomatophila* can exist as either light or dark phenotypes. Since this report, the light phenotype of *A. tomatophila* has been used in our subsequent field trials to provide better distinction and separation for efficacy among the products tested (6, 7).

Early blight infections in upstate New York typically begin the middle of July and can increase dramatically during the August. Weather conditions are generally favorable for disease development during this time, resulting in plant defoliation in excess of 60% in the unsprayed control plots (6, 7).

Fungicides are commonly used to control early blight and consist of protectant products like mancozeb (Dithane) and chlorothalonil (Bravo), or systemic fungicides belonging to the strobilurin class (1). Strobilurin compounds are site specific fungicides, and although very effective initially, resistance has been identified for a number of fungi including EB (1, 4).

MATERIALS AND METHODS
Fungal isolate and inoculations. The light phenotype of *A. tomatophila* was grown on V-8 with a 12-hour photoperiod and at a temperature of 27° C. This isolate was used to inoculate the disease spreader rows in the field plots (approx. 20,000 spores/ml applied in mid-July).

Field establishment and spray treatments for fungicide spray plots. Supersonic tomato seedlings were transplanted in early June in field plots located at Freeville, NY. Treatments were arranged in a randomized complete block design with three (2004) or four (2005) replications. Each spray plot consisted of eight plants spaced 22 in. apart within a 15 ft row with 10 ft between each block and 14 ft between each row. Inoculated spreader rows provided a constant disease source, which ran the length of the plot, and were equidistant from each treatment row. Fungicides were applied with a CO_2 pressurized boom sprayer at 60 psi, delivering 23 gal/A, through four TeeJet XR11003 flat fan nozzles spaced 20 in. apart.

Data collection. Defoliation was assessed using the Horsfall-Barratt rating scale on a weekly basis where 0 = no defoliation and 11 = dead plants (3). Foliar data were converted using the area under the disease progress curve (AUDPC) model to account for foliar disease, which progressed over time. The data were analyzed using one-way ANOVA at P=0.05 and significant differences between means were separated using Tukey's Studentized Range Test at □=0.05.

RESULTS AND DISCUSSION

In both 2004 and 2005, fungicide treatments provided significantly better control of early blight defoliation when compared with the unsprayed control (Table 1). Chlorothalonil (Bravo) has long been considered the standard fungicide for comparison sake, and in our trials it has performed well, and did so in the 2004-2005 trials. However when compared with mancozeb (trialed as Dithane) in a head-to-head comparison, mancozeb was equivalent or even slightly better than chlorothalonil. This enhanced performance was apparent in a reduction in the percent defoliation and in the reduced number of EB-infected fruit. Mancozeb also proved to be a good mixing partner when it was included with sprays like Phostrol (phosphorous acid) and Forum (dimethomorph) that were intended for late blight control. This is important since many fungicides need to be tank-mix with a protectant like mancozeb to control the full range of diseases affecting tomato. Boscalid (Endura) provided the best control of EB both seasons, although in both trials the product was used on a weekly basis and not on an alternating basis as prescribed on the label. The added value of using mancozeb with boscalid was observed in the 2004 trial, when with the addition of mancozeb to the Endura and Forum sprays, significantly better disease control was achieved.

Despite the occurrence of reduced sensitivity of *A. solani* (and probably *A. tomatophila*) to strobilurins (4), this resistance is found exclusively in states that relied heavily and without rotation of these materials for potato production. In our trials, Quadris Opti (azoxystrobin + chlorothalonil) and Amistar (azoxystrobin) performed well when alternated with chlorothalonil and mancozeb in 2004 and 2005, respectively, and continue to have a place for tomato disease control. Boscalid is an additional fungicide with a different mode of action that will fit nicely into rotational programs.

Previous work in potato has shown that repeated use of the same protectant fungicides like chlorothalonil and triphenyltin hydroxide can result in a shift of pathogens (*A. solani* and *A. alternata*) and an overall reduction in efficacy. We have also demonstrated that rotation of multi-site protectant fungicides can be as important as the rotation of fungicides with more specific modes of action.

Table 1. Performance of fungicides for the control of early blight (*A. tomatophila* - light phenotype) during trials in 2004 and 2005 at Freeville, NY.

2004 Season cool, wet - Treatments (spray schedule)[a]	**% defol.**	**EB inf. fruit**	**2005 Season hot, dry – Treatments (spray schedule)[a]**	**% defol.**	**EB inf. fruit**
Control (A-H)	199 f	31 f	Control (A-H)	150 c	60
Bravo (AB/CDEF/GH)	160 e	23 ef	Bravo (AB/CDEF/GH)	111 b	54
Dithane alone (not tested)	--	--	Dithane (AB/CDEF/GH)	89 ab	54
Dithane (AB/CDEF/GH) with Phostrol[b] (--/-DEF/GH)	128 abcd	11 abcde	Dithane (AB/CDEF/GH) with Phostrol (--/--EF/GH)	92 b	48
Bravo (AB/C-E-/G-) with Ouadris Opti --/-D-F/-H	133 bcde	16 bcde	Dithane (AB/CD-F/-H) with Actigard (AB/----/--) and Amistar (--/--E-/G-)	86 ab	59
Endura (AB/CDEF/GH) with Dithane + Forum[b] (--/-DEF/GH)	98 a	2 ab	Endura (AB/CDEF/GH) Dithane + Forum (--/--/EF/GH)	56 a	38
Endura (AB/CDEF/GH) with Forum (--/-DEF/GH)	139 cde	5 abcd	Endura alone (not tested)	--	--

[a] Weekly spray schedule with sprays A and B applied in Jul, CDEF applied in Aug, and GH applied in Sep.

[b] Phostrol and Forum sprays were included for anticipated occurrence of late blight in the plots.

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