Are Biological Controls and Resistance Activators Viable Alternatives to Streptomycin?

Daniel R. Cooley
Department of Plant, Soil, & Insect Sciences, University of Massachusetts

The compounds that may be applied to manage fire blight are limited. For many years there have been two, copper and streptomycin. Streptomycin is very effective at bloom, but does nothing against shoot blight. Copper reduces bacterial populations on the buds and bark of apples, but is far from a guarantee that bloom and shoot infections will not develop.

Since 2000, several new compounds have been developed that have been labeled for use against fire blight. These materials are not antibiotics or chemical toxins, but rather biological controls and compounds that stimulate a plant's resistance mechanisms. Biological controls are microbes that attack pathogenic microbes, while resistance stimulating chemicals are called resistance activators or elicitors. Because there are so few options for fire blight management, these new biopesticides have generated interest on the part of applied plant pathologists.

They have also generated interest because they are not broadly toxic, but present relatively less risk to the environment and applicators. This also allowed them to be registered using EPA's faster procedures for biological pesticides. With non-biological pesticides, there is generally a period of several years while the company is pursuing toxicological studies that they also test efficacy of materials with universities, Extension and private companies. The biological pesticides have often been put on the market with little or no third-party testing. Over the last 10 years, these compounds have been tested in several university programs, and the results published by the American Phytopathological Society in their on-line journal, *Plant Disease Management Reports.*This has made it possible to form a picture of how effective these new biopesticides in absolute terms and relative to the standard, streptomycin.

I examined the results of *PDMR* tests for a set of five biopesticides or their active agent done beginning in 1997. These include Actigard, BlightBan A506, Bloomtime, Messenger and Serenade Max.

-- Actigard 50WG - acinbenzolar-S-methyl. A chemical resistance activator. Syngenta.
-- BlightBan A506 - *Pseudomonas fluorescens* strain A506, bacterial biocontrol. NuFarm Americas, Inc. OMRI approved.
-- BlightBan C9-1 –*Pantoea agglomerans* strain C9-1, bacterial biocontrol. NuFarm Americas, Inc.
-- Bloomtime FD – *Pantoea agglomerans* strain E325, bacterial biocontrol. Northwest Ag Products. OMRI approved.
-- Messenger – harpin, a bacterial protein, resistance activator. Eden Bioscience Corp.
-- Serenade – *Bacillus subtilis* strain QST 713, bacterial biocontrol. AgraQuest, Inc.

The tests that are included in this analysis used either the formulated product as listed, or its active ingredient. Control was evaluated based on blossom blight. Conditions of each test varied by cultivar, pathogen inoculation timing and methods, weather, site and method of disease evaluation. However, it was possible within each test to determine the percent of fire blight control relative to an untreated check. For example, if the untreated check trees averaged 20 fire blight strikes per tree, and a treatment averaged 10 strikes per tree, that treatment gave 50% disease control. If another treatment averaged five strikes per tree, that treatment would have given 75% control. The higher the percentage, the better the control. If the reduction in disease was significant, then the percent reduction is shown. If it was not significant, the percent reduction is listed as 0. Where both inoculated and non-inoculated tests were reported, the inoculated test is

Table 1. Percent control of different biological and SAR controls for blossom blight stage of fire bight of apple relative to streptomycin in reports to Plant Disease Management Reports and related publications, 2000 to 2007.

Trial	Actigard	BlightBan A506	Blighban C9-1	Bloomtime	Messenger	Serenade	Streptomycin	Strep. Sign.[1]
(Aldwinckle & Penev 2004)				58%		57%	78%	y
(Aldwinckle et al. 2002)					0	0	56%	y
(Bhaskara-Reddy et al. 2000)	0		40%		46%		65%	y/n
(Bhaskara-Reddy et al. 2001)	0				58%	64%	64%	n
(Maxson et al. 2001)	56%						95%	n
(Penev & Aldwinckle 2003)					16%	50%	86%	y
(Sholberg et al. 2000)		0		33%			86%	y
(Sundin & Ehret 2004a)[4]						60%	98%	y
(Sundin & Ehret 2004b)[4]						32%	96%	y
(Sundin & Ehret 2005a)[3]		0				57%	91%	y/n
(Sundin et al. 2005b)		0				61%	92%	n/y
(Sundin et al. 2006a)		74%	0			67%	70%	n
(Sundin et al. 2006b)						83%	86%	n
(Sundin et al. 2007)[2]		88%	83%	78%			97%	n/y
(Travis et al. 2003)						0	19%	n
(Travis et al. 2004)						0	87%	y
(Werner et al. 2005)		0		0		21%	44%	y
(Werner et al. 2006a)		0		0		0	80%	y
(Werner et al. 2007a)	0						72%	y
(Werner et al. 2007b)		0		0			45%	y
(Yoder et al. 2001)	0					0	49%	y
(Yoder et al. 2003)		20%				24%	60%	y
(Yoder et al. 2004)						42%	70%	n
(Yoder et al. 2006)		0	0			0	47%	y
(Yoder et al. 2007)		0	44%	52%		61%	55%	n
Total tests	5	10	5	7	4	18	24	-
Number of significant tests	1 (20%)	3 (30%)	3 (60%)	4 (57%)	3 (75%)	12 (67%)	24 (100%)	-
Tests where streptomycin is significantly better than alternatives (%)	80%	80%	60%	86%	50%	67%	-	-

[1]Streptomycin is significantly better than the biorationals in the test

[2]The Blightban in this test is a combination of A506 and C9

[3]The "streptomycin" treatment in this case is a combination of Agrimycin and Mycoshield (tetracycline) because the *Erwinia amylovora* in the block are resistant to streptomycin. While both 'Jonathan' and 'Golden Delicious' were evaluated, the more significant results for 'Jonathan' are reported.

[4]Data taken on terminal strikes/tree.

reported here. Where multiple cultivars were evaluated separately, the most sensitive cultivar is reported here. If more than one formulation of streptomycin were tested, Agrimycin 17W was used as the streptomycin standard.

It is clear that streptomycin gives more consistent blossom blight control than the biological controls or SRC activators tested. In every test the streptomycin treatment reduced blossom blight from levels in untreated check trees. Biocontrol/activator results were much less consistent. Generally, slightly more than half the tests of biocontrol/activator treatments had control levels significantly better than untreated checks. Actigard produced the fewest significant tests, 20%, while Messenger produced the most, 75%. The most widely tested product, Serenade, had significant control in 67% of its tests.

In most tests, streptomycin performed significantly better than the biocontrol/activators. Compared with Messenger, streptomycin had significantly better control in 50% of tests, while against Bloomtime performance was significantly better in 86% of the tests. Streptomycin was better than Serenade in 67% of the tests.

Over all tests, streptomycin averaged 71% control. In other words, if untreated check trees averaged 100 blighted blossoms, there would be only 29 blighted blossoms on streptomycin treated trees. By comparison, depending on which alternative is used, control ranged from 11 to 35%, the equivalent of 89 to 65 blighted blossoms per tree. Discounting those tests where the biocontrol/activators treatments were not significantly

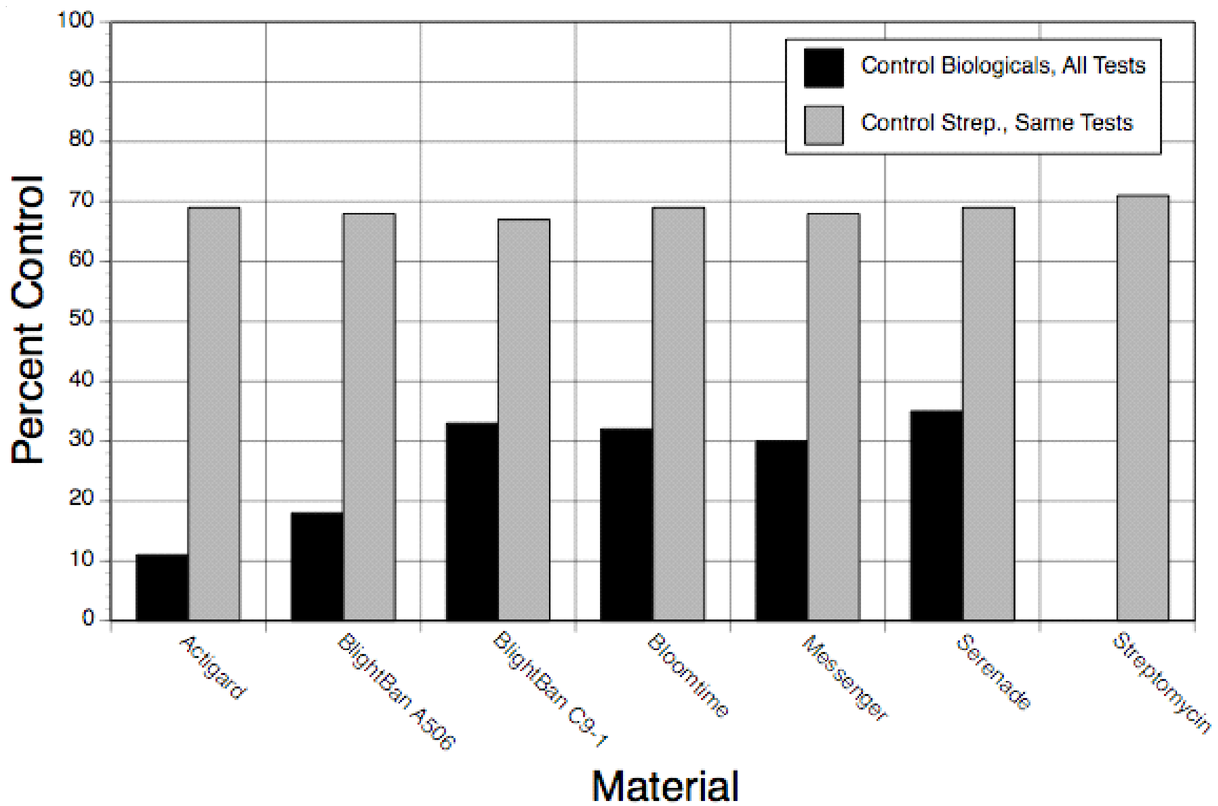

Figure 1. Average percent blossom blight control for biocontrols and SRC activators compared with streptomycin in 24 field tests, 2000 to 2007, including all tests regardless of significance relative to untreated trees.

different from untreated checks improved performance, with a range of control from 40 to 61%. Still, in equivalent tests, streptomycin control was better than that in all tests, ranging from 72 to 95%.

This last comparison probably is the result of disease pressure. That is, in tests where disease incidence in checks is low, indicating relatively lower risk of infection, biocontrol/activators can reduce blossom blight, while streptomycin reduces blossom blight even more.

The conditions of these controlled field tests were generally designed to produce significant levels of bloom blight. Blossoms were inoculated with pathogenic *Erwinia amylovora* to insure infection. The timing of such inoculations relative to treatment applications varied across tests. The biological controls, and particularly the activators, generally must be applied well before significant infection periods in order to be effective. For the biological controls it's important to have the competing bacteria established in and on blossoms before significant numbers of *E. amylovora* arrive. Activators must have time to stimulate SAR to be effective. In many tests, this requirement was taken into account and inoculations were made appropriately. However, in some tests, inappropriate application timing may account for poor performance of a biological/ activator.

Given that these alternative fire blight treatments are still relatively new, this data may still reflect this relative unfamiliarity with the materials and how to best use them. However, the consistently superior performance of streptomycin strongly suggests that it should be the preferred treatment against blossom blight.

References

Aldwinckle, H. S., H. L. Gustafson, G. Heidenreich, R. Penev and N. LoGiudice (2002). Field evaluation of materials for control of fire blight infection of apple blossoms, 2001. Fungic. Nematic. Tests 57: PF01.

Aldwinckle, H. S. and R. Penev (2004). Field evaluation

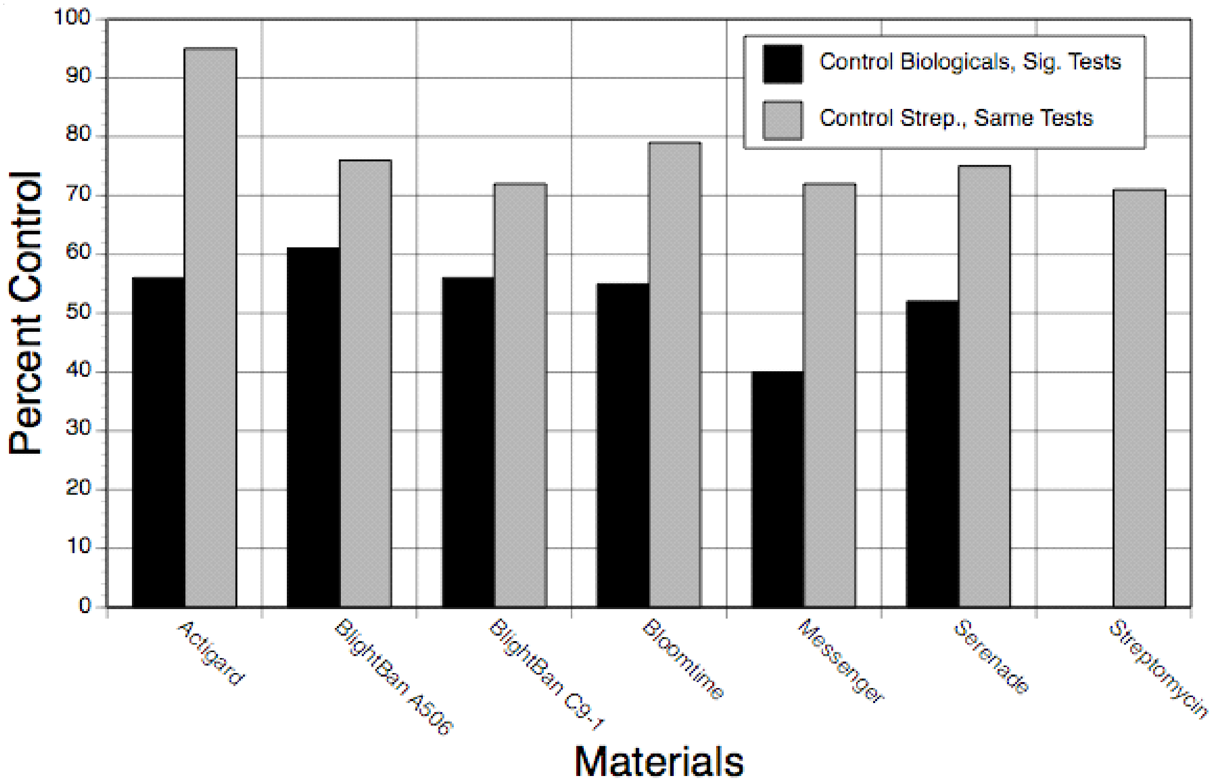

Figure 2. Average percent blossom blight control for biocontrols and SRC activators compared with streptomycin in 24 field tests, 2000 to 2007, including only those tests in which biocontrols and activators had levels of control significantly greater than untreated trees.

of materials for control of fire blight infection of apple blossoms, 2003. Fungic. Nematic. Tests 59: PF016.

Bhaskara-Reddy, M. V., J. L. Norelli and H. S. Aldwinckle (2000). Control of fire blight infection of apple blossoms, 1999. Fungic. Nematic. Tests 55: PF22.

Bhaskara-Reddy, M. V., J. L. Norelli and H. S. Aldwinckle (2001). Biologicals, SAR inducers, copper compounds and other chemicals for blossom blight control on apple, 2000. Fungic. Nematic. Tests 56: PF34.

Maxson, K. L., G. R. Ehret and A. L. Jones (2001). Field evaluation of Actigard for control of fire blight in apple, 2000. Fungic. Nematic. Tests 56: PF11.

Penev, R. and H. S. Aldwinckle (2003). Field evaluation of materials for control of fire blight infection of apple blossoms, 2002. Fungic. Nematic. Tests 58: PF004.

Sholberg, P. L., P. Haag, J. Boulé and K. E. Bedford (2000). Efficacy of two biological control agents for control of fire blight of apple, 1999. Biol. Cult. Tests 16: N57.

Sundin, G. W. and G. R. Ehret (2004a). Biological control of fire blight with Serenade in 2003. Fungic. Nematic. Tests 59: PF008.

Sundin, G. W. and G. R. Ehret (2004b). Fire blight control on Jonathan apple in 2003. Fungic. Nematic. Tests 59: PF007.

Sundin, G. W. and G. R. Ehret (2005a). Control of fire blight on Jonathan and Golden Delicious apple in 2004. Fungic. Nematic. Tests 60: PF033.

Sundin, G. W., G. R. Ehret and G. C. McGhee (2006a). Biological control of fire blight on Jonathan and Golden Delicioius apple in 2005. Fungic. Nematic. Tests 61: PF009.

Sundin, G. W., G. R. Ehret and G. C. McGhee (2006b). Fire blight control on Gala apple in 2005. Fungic. Nematic. Tests 61: PF008.

Sundin, G. W., G. R. Ehret and G. C. McGhee (2007). Efficacy of bacterial antagonists in controlling fire blight on 'Jonathan' apple, 2006. Plant Disease

Management Reports (online) 1: PF038.
Sundin, G. W., G. R. Ehret and W. W. Shane (2005b). Evaluation of bactericides for fire blight control in a commercial orchard near Benton Harbor, Michigan, 2004. Fungic. Nematic. Tests 60: PF038.
Travis, J. W., N. O. Halbrendt, E. Anderson, C. Wilson, J. L. Norelli and E. Burchard (2004). Evaluation of biological agents for control of fire blight on apple, 2003. Biol. Cult. Tests 19: N001.
Travis, J. W., K. D. Hickey, N. O. Halbrendt, E. Anderson and B. Jarjour (2003). Fire blight blossom blight incidence on Rome Beauty apple treated with bactericides, 2002. Fungic. Nematic. Tests 58: PF018.
Werner, N. A., G. Heidenreich and H. S. Aldwinckle (2005). Field evaluation of materials for control of fire blight infection of apple, 2004. Fungic. Nematic. Tests 60: PF030.
Werner, N. A., G. Heidenreich and H. S. Aldwinckle (2006a). Field evaluation of biological and chemical control of fire blight of apple, 2005. Fungic. Nematic. Tests 61: PF020.
Werner, N. A., G. Heidenreich and H. S. Aldwinckle (2007a). Field evaluation of SAR-inducers for management of fire blight of apple, 2006. Plant Disease Management Reports (online). St. Paul, MN, American Phytopathological Society. 1: PF003.
Werner, N. A., G. Heidenreich and H. S. Aldwinckle (2007b). Field evaluation of biological controls against fire blight of apple, 2006. Plant Disease Management Reports (online). St. Paul, MN, American Phytopathological Socieity. 1: PF004.
Yoder, K., A. E. Cochran, W. S. Royston and S. W. Kilmer (2003). Fire blight blossom treatments on Golden Delicious and Rome Beauty apples, 2002. Fungic. Nematic. Tests 58: PF025.
Yoder, K., A. E. Cochran, W. S. Royston and S. W. Kilmer (2004). Evaluation of fire blight blossom treatments on Golden Delicious and Rome Beauty apples, 2003. Fungic. Nematic. Tests 59: PF030.
Yoder, K., A. E. Cochran, W. S. Royston and S. W. Kilmer (2007). Integrated biological and streptomycin treatments for fire blight control on Idared apples, 2006. PDMR (online) 1: PF028.
Yoder, K., A. E. Cochran, W. S. Royston, S. W. Kilmer and L. Brumback (2006). Fire blight control by integrated biological and streptomycin treatments on Idared apple, 2005. Biol. Cult. Tests 21: N004.
Yoder, K., A. E. Cochran, W. S. Royston, S. W. Kilmer and A. DeMarsay (2001). Evalution of bloom treatments for fire blight suppression on Golden Delicious and Rom Beauty apples, 2000. Fungic. Nematic. Tests 56: PF36.

* * * * *