Use of Streptomycin and Oxytetracycline for Fire Blight Management
In Organic Pear Production in California

October 15, 2011

Fire blight (*Erwinia amylovora*) is one of the principal limiting factors in the production of organic pears in California. As a pear producer and independent pest control adviser I have served on the research committee of the California Pear Advisory Board the last 14 years. Using this experience and that gained in serving as an independent pest and disease management advisor to conventional pear growers for 40 years and to organic growers in the last four crop cycles, I am writing to outline our current utilization of streptomycin, oxytetracycline and biological fire blight treatments in California pear production.

Fire blight (*Erwinia amylovora)* can be a devastating bacterial disease that kills tree shoots, branches, and whole trees. Costs to apply protective treatments and to remove old infections, an important practice in disease management prior to each season, can be substantial. Resistance of the pathogen to the antibiotic streptomycin has been known to be a problem in California pears since the 1970s (1,2,3,4,5). Currently this resistance essentially excludes streptomycin use in Central Valley pear districts and oxytetracycline has primarily been relied upon, together with limited use of biologicals and coppers. Oxytetracycline has been permitted on pears since the 1970s and more recently on apples.

Because weather is usually less favorable for disease development in the Coastal Mountain pear districts, treatment frequency is usually half that needed in the Central Valley districts, and antibiotic amounts used per treatment are also lower. In the Coastal Mountain districts, where streptomycin use and resistance had been least, antibiotic use continues as a tank mix of streptomycin (40-60 ppm) and oxytetracycline (200 ppm) at much lower overall antibiotic rates than in the Central Valley districts. The reason this tank mix is used is to slow the development of resistance to oxytetracycline. It had been postulated in the early 1970s that perhaps the development of resistance to streptomycin could be attributed, at least in part, to the cancellation in1960 of a 15% streptomycin/1.5% oxytetracycline premixture (Agrimycin 100, Pfizer) that was used in the 1950s. This premixture was replaced with a product containing only streptomycin. It had been shown earlier that streptomycin resistant strains developed *in vitro* on exposure to the antibiotic. This combined use is an attempt to extend this reasoning to prolong oxytetracycline use in areas with little streptomycin resistance (6,7). Currently, resistance to streptomycin has persisted in the Central Valley pear districts (8,9,10). Resistance (or reduced sensitivity) to oxytetracycline was shown to be present in two Central Valley locations (in isolates that at one location were also highly resistant to streptomycin) in 2007, 2008 and 2009 surveys (8,10,11), but not in a 2010 survey (9). In 2010 one of the sites was not included in the survey because the orchard was removed. Recently, other labs have confirmed the reduced sensitivity of these strains but the mechanism remains unknown (J. E. Adaskaveg, personal communication).

In organic situations, coppers and biologicals are utilized if the pears are destined for marketing in Europe, where use of the antibiotics is not accepted on organic products. *Pseudomonas fluorescens*, the bacterium present in the biological control product Blight Ban A506, has been extensively tested by University of California scientists in tests funded by the pear industry in fire blight management since the 1970s. These bacteria will not attain competitive populations in blossoms using tank mixes with oxytetracycline, coppers or sulfur (13) as well as with some conventional pear scab (*Venturia pirina*) fungicides (14). This greatly restricts the utility of this product in fire blight management. The tests also indicate that this product is best integrated with antibiotic treatments to attain sufficient fire blight control. This has been true of other biologicals, as well. Other products such as Bloomtime Biological, *Pantoea agglomerans*, have been shown to be efficacious in some trials and less effective in other trials, especially in locations with high disease pressure (14,15,16,17,18,19,20,21). A new yeast product is currently being tested in Oregon and Washington and shows promise in one year of California trials, but needs more extensive testing (9,22). The result has been most reliance in organic production on antibiotics and coppers, where possible. Where antibiotic use is not possible because of market destination, sub-standard blight control and sub-standard scab control in the worst seasons has resulted. Increased russet and some loss of fresh market quality in most seasons, has also resulted. These are chief reasons that more organic production of pears in California has been slow in developing.

Apple and pear growers use integrated management plans to control fire blight. They remove overwintering inoculum cankers and may utilize copper applications at early green-tip stage to reduce fire blight inoculum levels. Applications before infection are known to be more effective than those applied after infection (9,23). Prescribed, preventive treatment use is based on predicted weather conditions and is essential to properly time treatments and to minimize the use of them. In apples, the Maryblyt Model (24), the Thomson-Schroth Average Temperature Model (25), or Cougar Blight (26) may be used to predict the initial presence of the fire blight bacteria in the relatively short primary bloom period (27,28,29). However, Maryblyt and Cougar Blight failed to predict warm dew infection periods during rainless weather (29). Pears have lengthy primary and secondary bloom periods that may last 2 months. The average temperature models are also utilized in pears (25,30,31). The Maryblyt Model was tested in pears and found to predict early season infections, but did not predict later season infections in the year of trial (32). The Zoller Degree Hour Model (33,34,35) predicts the presence of the causal bacteria in blossoms. It also suggests risk-based changes in treatment frequency needed during the lengthy season, including rainless infection periods, and is widely used in pears (36,37). Another degree hour model Cougar Blight (which has recently been revised) is widely used in the Northwest but has yet to be extensively tested in California pears (22,26). The Billings system developed in Europe also has not been applied in California (38). Refinement of these models is on-going. Some authors have commented on the difficulty in utilizing fire blight warning systems that have been developed in regions with dissimilar environmental conditions (39). However, use of all these disease models serves to minimize treatment and reduces the threat of resistance development to treatment materials. Post-infection treatment use is discouraged as being less or not effective, except in emergencies such as hailstorms.

Fire blight is a somewhat sporadic disease in severity, one dependent on annual temperature and wetting conditions during the bloom period. Because growers typically apply preventative treatments only on an “as needed” basis as predicted by disease models, the amount used by California growers may vary considerably from year to year and district to district. As in other geographic production areas, fire blight has become a more frequent problem in apples as this industry has transitioned to smaller trees, whose dwarfing rootstocks are very susceptible and because some newer, more preferred, apple cultivars are very susceptible and can be killed more easily by outbreaks.

The antibiotics are preferred over less effective, allowable products. Coppers are used at green-tip stage in apples, and this use is currently being tested in pears. Coppers cannot be used at bloom and shortly thereafter on clear-skinned fruit intended for the fresh market, because they cause unacceptable fruit russet. The bacterial antagonists *Pseudomonas fluorescens* A506, *Pantoea agglomerans* strains C9-1 and E325, and preparations of *Bacillus subtilis* QST 713 have been tested in fire blight management as described above. The latter three, however, have not been tested in California over as long a period of time as the first one. Furthermore, when examined individually, these biological control materials were not consistently effective in reducing blossom infection. More consistent control of blossom infection was observed when the biological control materials were integrated as separate treatments into programs with antibiotics, resulting in a reduction of the number of antibiotic applications needed for similar levels of control. However, in achieving necessary separation of the biologicals from other treatments, this integration can sometimes interfere with timing of fire blight treatments and with scab treatments; although this integration is manageable (40,41), it presents year to year difficulties which will be magnified if the option of antibiotic use is lost. Taken together, these results reduce the prospects for relying solely on biological control for fire blight in California.

Thank you for the opportunity to comment on this important issue. Please contact me if you have questions or need additional information.

Sincerely,

Broc Zoller

Dr. Broc G. Zoller
The Pear Doctor Inc.; PO Box 942, Kelseyville, CA 95451
peardoc@pacific.net

References:

1. Moller, W. J., Beutel, J. A., Reil, W. D., and Zoller, B. G. 1972. Fire blight resistance to streptomycin in California. Phytopathology 62: 799 (Abstract).
2. Zoller, B.G. 1973. Seasonal fire blight bacteria population in Sacramento valley in California in 1972. Proc. WOPDMC 47:84. http://entomology.tfrec.wsu.edu/wopdmc/1973PDF/Stone-7.pdf
3. Zoller,B.G. 1977. Resistance of *Erwinia amylovora* to streptomycin in 29 commercial pear orchards from 1972-1976 in California. Proc. WOPDMC 51:67. http://entomology.tfrec.wsu.edu/wopdmc/1977PDF/Disease-6.pdf
4. Schroth, M.N., Thomson, S.V. and Moller, W.J. 1979. Streptomycin resistance in California. Phytopathology 69:565-568.
5. Moller, W.J., Schroth, M.N., and Thomson, S.V. 1981. The scenario of fire blight and streptomycin resistance. Plant Disease 65:563-568.
6. English, A.R. and Gelwicks, P.C. 1951. The in vitro microbial resistance pattern to terramycin. Antibiotics and Chemotherapy 1:118-124.
7. English, A.R. and VanHalsema, G. 1954. A note on the delay in the emergence of resistant *Xanthomonas* and *Erwinia* strains by the use of streptomycin plus terramycin combinations. Pl. Dis. Reptr. 38:429-431.
8. Adaskaveg, J.E. and Gubler, W.D. 2007. Evaluation of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports.aspx
9. Adaskaveg, J.E. and Gubler, W.D. 2010. Evaluation of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://www.calpear.com/_pdf/research-reports/JEA%20Fireblight.pdf.
10. Adaskaveg, J.E. and Gubler, W.D. 2008. Evaluation of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports.aspx
11. Adaskaveg, J.E. and Gubler, W.D. 2009. Evaluation of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports.aspx
12. Adaskaveg, J.E., Driever, G.F., Forster, H., Gubler, W.D., Wade, L.M., Holtz, B.A. 2008. Detection of *Erwinia amylovora* strains with reduced sensitivity to currently registered antibiotics and management of fire blight of pome fruits using kasugamycin in integrated strategies. Acta. Hort. 793:375-382.
13. Lindow, S.E. 1993. Control of frost injury, fire blight and fruit russet of pear caused by leaf surface bacteria. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports-archive.aspx.
14. Lindow, S.E. 1998. Integrated control of frost injury, fire blight and fruit russeting of pear using biological and cultural control methods. Annual report for California Pear Advisory Board. http://calpear.com/industry/research-reports-archive.aspx
15. Lindow, S.E., McGourty, G. and Elkins, R.B. 1996. Interactions of antibiotics with *Pseudomonas fluorescens* strain A506 in the control of fire blight and frost injury to pear. Phytopathology 86:841-848.
16. Elkins, R.B., Ingels, C.A., and Lindow, S.E. 2005.Control of fire blight by *Pseudomonas fluorescens* A506 introduced into unopened pear flowers. Acta Hort. 671:585-594.
17. Adaskaveg, J.E. and Gubler, W.D. 2005. Evaluations of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports-archive.aspx
18. Adaskaveg, J.E. and Gubler, W.D. 2006. Evaluations of new bactericides for control of fire blight of pears caused by *Erwinia amylovora*. Annual Report for California Pear Advisory Board. http://calpear.com/industry/research-reports-archive.aspx
19. Holtz. B.A., Martin-Duvall, T., Adaskaveg, J.E. and Lindow, S.E. 2008. Efficacy of bactericides and biological antagonists for the control of fire blight of apple in the San Joaquin valley of California. Acta. Hort. 793:445-449.
20. Stockwell, V.O. , Temple, T.N., Johnson, K.B., and Loper, J.E. 2008.Integrated control of fire blight with antagonists and oxytetracycline. Acta. Hort.793:383-390.
21. Stockwell,V.O., Johnson, K.B., and Loper, J.E. 1996. Compatibility of bacterial antagonists of *Erwinia amylovora* with antibiotics used to control fire blight. Phytopathology 86:834-840.

22. Smith, T.J. 2011. Improving the management of two critical pome fruit diseases. Final Project Report, WTFRC Project Number cp-09-904.
23. Keil, H.L. and Wilson, R.A. 1962. Six years of testing streptomycin-oxytetracycline for control of fire blight on Bartlett pear. Pl. Dis. Reptr. 46:397-400.
24. Steiner, P.W. 1990. Predicting apple blossom infection by *Erwinia amylovora* using the Maryblyt model. Acta Hort. 173:158-194.
25. Thomson, S.V., Schroth, M.N., Moller, W.J., Reil, W.O. 1982. A forecasting model for fire blight of pear. Plant Disease 66:576-579.
26. Smith, T.J. 1996. A risk assessment model for fire blight of apple and pear. Acta. Hort. 411:97-104.
27. UCIPM On-Line. 2010. Summary of the Schroth "UC" or "mean- temperature" model. http://www.ipm.ucdavis.edu/MODELS/FBEA/aboutfireblight.html
28. Holtz, B.A., Teviotdale,B., and Turini, T. 1999. Comparison of models to predict the occurrence of fire blight in the San Joaquin valley of California, Acta, Hort. 489:437-444.
29. Holtz, B.A., Hoffman, E.W. and Teviotdale, B.L. 2002. Predicting the occurrence of fire blight in the San Joaquin valley of California. Acta Hort. 590:167-174.
30. Zoller, B.G., and Sisevich, J. 1975. A prediction system for timing fire blight control applications. Proc. WOPDMC 49:86. http://entomology.tfrec.wsu.edu/wopdmc/1975PDF/PomeDisease-5.pdf.
31. Zoller, B.G., and Hanke, L. 1975. A prediction system for timing fire blight control applications. Proc. WOPDMC 49:85. http://entomology.tfrec.wsu.edu/wopdmc/1975PDF/PomeDisease-4.pdf.
32. Vogel, G. Gubler, W.D., and Ogawa, J.M. 1990. Comparison of the standard UCIPM fire blight model with the Maryland blight model. Annual Report for the California Pear Advisory Board. http://calpear.com/industry/research-reports-archive.aspx
33. Zoller, B. G., and Sisevich, J. 1979. Blossom populations of *Erwinia amylovora* in pear orchards vs accumulated degree hours over 18.3C (65F), 1972-1976 Phytopathology 69:1050. (Abstract).
34. Van der Zwet, T. B., Zoller, B. G., and Thomson, S. V. 1988. Controlling fire blight of pear and apple by accurate predication of the blossom blight phase. Plant Disease 72:464-472.
35. Zoller, B. G. 2000. Fire blight control experiences in the Sacramento Valley of California 1973 – 1999. Proc. WOPDMC 74:103-104. http://entomology.tfrec.wsu.edu/wopdmc/2000PDF/8-TREE%20FRUIT/Tree%20Fruit%2000-1.pdf
36. Gubler, W.D., Zoller, B.G., Duncan, R.A., and Lindow, S.E. 2007. Chapter 21 Diseases, in Mitcham, E.J. and Elkins, R.B. (eds), Pear production and handling manual. UCANR Publication 3483.
37. UCIPM On-Line. 2010. Summary of the degree hour model. http://www.ipm.ucdavis.edu/MODELS/FBEA/aboutfireblight.html
38. Billing, E. 2000. Chapter 15 Fire blight risk assessment systems and models, in Vanneste, J.L. (ed), Fire blight: the disease and its causative agent. CAB International.
39. Shtienberg, D., Schwartz, H. Oppenheim, D., Zilberstaine, M., Herzog, Z., Manulis, S., and Kritzman, G. 2003. Evaluation of local and imported fire blight warning systems in Israel. Phytopathology 93:356-363.
40. Lindow, S.E., Holtz, B.A., and Elkins, R.B. 2008. Improved biological control of fire blight of pear and apple by introduction of antagonistic bacteria into un-opened flowers. Acta. Hort. 793:451-452.
41. Johnson, K.B. and Stockwell, V.O. 2000. Chapter 16 Biological control of fire blight, in Vanneste, J.L. (ed), Fire blight: the disease and its causative agent. CAB International.