A Philosophy for Effective Fire Blight Management

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Introduction

Success in plant disease management requires a change in philosophy about man's role in agriculture. Rachel Carson, in her revolutionary book, Silent Spring (1962), cited a most appropriate quote from E. B White: I am pessimistic about the human race because it is too ingenious for its own good. Our approach to nature is to beat it into submission. We would stand a better chance of survival if we accommodated ourselves to this planet and viewed it appreciatively instead of skeptically and dictatorially. Agroecosystems are not natural entities and exist only with the continued input of energy by man in his deliberate attempt to keep 'nature' in abeyance while he produces the food and fiber crops of his choice. Should that input be withdrawn, such systems are unstable and quickly begin to revert to the prevailing natural ecosystem.

The purpose of this discussion is to address the changes required in our thinking about disease management in the agroecosystem so that the strategies and tactics we choose to apply can be implemented with maximum effectiveness, a challenge that goes well beyond following standard 'control' recommendations.

Problems posed by modern orchard agroecosystems

There are at least five major characteristics of modern agroecosystems aimed at economically efficient production that actually encourage the development of plant disease epidemics. All of these come into play when we look at the incidence and severity of fire blight under most conventional programs. If you doubt this, examine the changes in your own orchard operation over the last two decades and see how many of these factors seem to apply.

1. Limited number of plant species planted at high densities. Most modern apple orchards are limited to two species: apples and grass ground cover. Fifty years ago apple orchards were routinely planted at densities of 100 trees per acre or less; now, we aim for tree populations of between 250 to 1,500 per acre.

2. Wide use of susceptible plants. While some apple cultivars demonstrate a moderate to high degree of resistance to fire blight, even that can be breeched by hail, wind or frost damage. Market demands over the last two decades have encouraged the production of new cultivars like Gala, Fuji, Braeburn, Empire, Ginger Gold and Granny Smith along with many traditional

favorites like Rome, Jonathan, York and others that are moderately to highly susceptible to fire blight.

3. Wide use of genetically similar or identical cultivars and rootstocks. Apple and pear cultivars must be propagated vegetatively to maintain the characteristics of those varieties. In addition, to support the high tree densities that are now standard, clonal apple rootstocks such as M.26 and M.9 are widely used. Indeed, it is likely that 60% of U.S. apple production over the next decade will be on these two rootstocks which are both highly susceptible to fire blight.

4. Monoculture in time and space. Fruit crops are perennials and are planted with the full expectation that they will remain in place and productive for at least 15 to 20 years. This is monoculture in time. Monoculture in space occurs when a fruit industry develops in certain areas having climate and soil conditions most favorable for fruit production so that concentrations of several thousand acres or more provide an ideal base for maintaining important pathogen populations.

5. Uniform management practices throughout an orchard and across entire regions are required for both efficient production as well as for meeting specific market demands. As a result, large portions of the crop may be uniformly susceptible should conditions favorable for disease develop.

All of these factors are necessary for the efficient production of high quality apple and pear production. Eliminating even one of these factors reduces the viability of the business of commercial fruit production. Understanding the risks these elements pose for disease development, however, is an important step in the design and implementation of effective disease management programs that do not decrease the overall efficiency of production.

Control vs. management philosophy

The terms 'control' and 'management' are often used interchangeably when, in fact, they imply quite different approaches. In the early 1970s, J. Lawrence Apple summarized this issue nicely. Control, he suggests, implies a degree of dominance by man over nature that is simply not possible. Control also conveys a notion of finality, of having controlled and, thereby, dispatched a problem. Furthermore, should that problem develop again, the control action need only be repeated. Management, by contrast, implies an ongoing process that continues throughout a season and from season to season for the life of the crop. Management also implies that pathogens and pests are regular components of the agroecosystem and that our primary aim is to reduce the harm they cause rather than to annihilate them. Plant disease management, then, is the knowledgeable selection and use of all appropriate strategies and tactics to suppress the harm caused by disease to an acceptable level. When an explosive epidemic of fire blight occurs, it is hard to think of an "acceptable" threshold. At the same time, we have all experienced fire blight epidemics that are relatively minor affairs. One of the problems here is that when there is little fire blight in the orchard, little effort is expended in its management because the impact on total pack-out at the end of the season does not seem to justify the costs. In reality, the pay off with a continuing good management program for fire blight the overall effect is cumulative because the risks for damaging losses are not only reduced in the current season but in the seasons that follow.

Epidemiological basis for disease management

One of the unique characteristics of plant diseases is that they always develop as epidemics. The severity of these epidemics vary as a function of the amount of primary inoculum at the start of the each season and the apparent rate at which new infections occur. Every management tactic we might wish to use, whether cultural, biological or chemical accomplishes one or both of two primary objectives with respect to the development of epidemics: (1) reducing the amount of primary inoculum contributes to a delay in the development of an epidemic; and (2) reducing the apparent rates of infection slows the progress of the epidemic. The best plant disease management programs integrate the use of multiple tactics in a planned program to accomplish both of the above objectives. Tactics executed closest to the sources of inoculum are always more efficient in terms of overall input and those executed before infection are almost always more effective than those taken after infection. In our experience, even those methods taken after infection with the express purpose of reducing secondary sources of inoculum can have a major impact on reducing the overall losses commonly encountered with fire blight epidemics.

Deploying multiple strategies and tactics is the key to stabilizing a good disease management program because there is a multiplier effect, not an additive one. Using three different methods, each with the potential to reduce the amount and distribution of primary inoculum by 90% means a total reduction in the amount of inoculum to 0.1% [0.10 x 0.10 x 0.10 = 0.001 or 0.1%]. The addition of a similar combination of tactics aimed at reducing infection rates can have the end result of operating with inoculum levels of only 1/1000th the starting level with infections proceeding at 1/1000th the rate.

Plant disease management and fire blight

Our experience in using the Maryblyt© fire blight forecasting program and multiple approaches to eliminate sources of inoculum and reduce infection rates has proven that effective management can be accomplished using simple, conventional approaches that include one copper treatment, 3 or fewer streptomycin sprays and a pair of pruning shears. The key to this success lies in knowing when and how to use these simple tools for maximum effect. The best guide to the decision-making required for such this approach can be expressed in two sets of paired questions that need to be asked frequently throughout the life of the orchard: (1) Where is the pathogen now and what is it doing? and, (2) What am I doing and, specifically, why am I doing it? Let's examine each of the tactics routinely employed for fire blight management in the light of these two questions.

Dormant removal of all infected limbs is the first critical step. The purpose is to reduce the number and distribution of sources of primary inoculum that will fuel the following season's blight epidemic. During the winter, the pathogen is harbored in living bark tissues within an inch or less from the margins of overwintering cankers. This directed sanitation effort must be done every year in every orchard, regardless of how much blight developed the previous season.

Copper applications in the spring or fall have no effect on bacteria harbored internally in the bark tissues. These bacteria become active at approximately the tight cluster to early pink stage of apple bud development in response to the mobilization of reserve carbohydrates needed to support early bud and shoot development. A thorough application of copper (almost any formulation) not earlier than the green tip or later than half-inch green stage of bud development ensures the persistence of the greatest amount of active copper residue when it is needed to reduce the colonization of bark and bud surfaces that continues throughout the pre-bloom period. Such applications can be combined with spray oil for mite control and to enhance thorough coverage of copper and, indeed, will perform quite nicely as the first apple scab fungicide. Making this application earlier than green tip can subject copper residues to several weeks of weathering before they need to be in place. Furthermore, since the colonization of trees in the orchard is accomplished largely at random through wind, splashing rain and casual insect visits (mostly flies), maximum effectiveness can be achieved only when entire orchard blocks are treated, no just the trees most susceptible to fire blight. Applications after the half-inch stage carry a high risk for phytotoxic damage to foliage and fruit.

Streptomycin sprays during bloom are often, but not always, required to prevent blossom infections. Once the stigmas of the first open flower are colonized, further dispersal is no longer random but is directed specifically at other open flowers through the activities of honey bees and other pollinators. Even when thousands of flower stigmas are selectively colonized in this manner, infection does not occur until there is a continuous film of water is established between the stigmas and the nectarthodes in the base of the flowers, where 99% of blossom infections occur. There are four minimum requirements for the initiation of an epidemic of blossom blight: (1) the flowers must be open (to expose stigmas for colonization) with petals intact (flowers in petal fall are resistant); (2) the accumulation of 198 degree days >650F; (3) a wetting event occurring as either rain or dew; and (4) an average daily temperature of 600F or more.

When streptomycin is applied on the day of or the day before an anticipated blossom infection event, the level of control is nearly absolute. Applications made before or after this window are not totally ineffective, but can allow significant amounts of blossom blight to occur. Including an activator type spray adjuvant (e.g., Regulaid™) improves the coverage and penetration of streptomycin enough to allow reduced rates of this antibiotic to be used safely. Streptomycin does not kill bacteria but, instead, inhibits their multiplication and, thus, reduces the rate at which flower stigmas are colonized and, most importantly, the subsequent multiplication of the bacteria within the nectarthodes. Where coverage is good, any blossom open at the time of application is protected until its petals begin to fall and natural resistance comes into play. For this reason, streptomycin sprays should never be applied on an alternate row middle basis. Since 1988, when we first started making spray timing decisions using the Maryblyt© program, we've usually had cause to recommend only one or two sprays during bloom, sometimes none, occasionally three, and never four or more sprays. The conventional practice of using streptomycin at regular 4- to 5-day intervals during bloom, often provides adequate control but is usually excessive (more cost) and, sometimes, fails to prevent a serious outbreak.

Cutting out active infections is often viewed quite skeptically as being an impossible job that requires much labor and often seems to be ineffective. In truth, this practice can be extremely effective in limiting the number and distribution of secondary canker and shoot infections as well as reducing the risks for serious damage following summer hail and wind storms. To be really effective, cutting operations need to begin as soon as early symptoms appear. In addition, it is absolutely imperative that all cuts be made using the "ugly stub" approach in which cuts are always made into wood that is at least 2 years old to take advantage of natural physiological resistance expressed even in susceptible varieties. It has also been shown that there is no advantage to be gained by following the old recommendation of surface sterilizing cutting tools between each cut. The "ugly stub" method acknowledges the fact that the bacteria are systemic and can be several feet to yards ahead of any visible symptoms so that any cutting wounds provide an excellent opportunity for the resident bacteria to colonized and quickly establish a small canker around the cut. When cuts are made in the traditional fashion, flush with the next healthy branch union, many of these cankers will remain in the orchard to fuel next year's epidemic. Cutting back to a 4- to 6-inch naked stub does not prevent the formation of small cankers, but their position is now such that the stubs and the canker can be safely and completely removed during the regular dormant pruning operation. Simply spray painting these stubs makes them easier to find when the trees are dormant. The primary purpose of this cutting effort is to reduce the number and distribution of secondary sources of inoculum that can fuel a continuing epidemic of shoot blight through the season. Two factors are important in obtaining maximum effect: the cutting must begin promptly when early symptoms first appear; the cut material must be removed from the orchard; the cuts must be made following the ugly stub procedure; such cutting must be done every year, even when the overall amount of blight is very low.

A single streptomycin spray after hail or high wind damage is recommended as a prudent measure to limit the ability of the bacteria to colonize the many open wounds in the orchards. Such treatments, however, must be made within 12 to 18 hours after the damage.

An optimistic prognosis

The repeated use of all these multiple measures every year, regardless of the amount of blight that might develop greatly reduces the risks for catastrophic losses due to fire blight even in seasons when conditions favoring disease development occur. Single method or "silver bullet" approaches will never be effective in managing a disease like fire blight. Silver bullets are known to be effective in only one instance - in dispatching werewolves. We have much more to learn about fire blight management, but I'm confident that this approach program will allow us to not only continue the use of the highly susceptible M.26 and M.9 clonal apple rootstocks, but to begin looking at redeveloping a viable commercial pear industry in the Eastern U.S. The potential for new products like Actigard™ [Novartis, Inc.] to induce systemic acquired resistance and Apogee™ [BASF, Inc.] to curtail limit the development of secondary shoot infections can only enhance the effectiveness of this management approach in dealing with destructive fire blight.

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Blossom blight control was statistically equivalent to the industry standard streptomycin in all experiments. E. amylovora populations remained constant on apple flower stigmas pretreated with Kasumin and were â‰ˆ100-fold lower than on stigmas treated with water. Kasumin applied to apple trees in the field also resulted in a 100-fold reduced total culturable bacterial population compared with trees treated with water.Â Our data confirm the importance of kasugamycin as an alternate antibiotic for fire blight management and lay the groundwork for the development and incorporation of resistance management strategies. Substance Nomenclature: 0 (Aminoglycosides) 0 (Anti-Bacterial Agents) EC 2.1.1. Integrated fire blight control with lime sulfur thinning followed by Blossom Protect. We define 6 â€˜integrated controlâ€™ of fire blight as programs of different 5 materials that when sprayed in sequence result in an improved (high) level of disease suppression. The 4 improvement in control is achieved by suppression of the two distinct phases of the floral infection process: 3 suppression the pathogenâ€™s prerequisite epiphytic phase 2 on floral stigmas -- accomplished by a competing UTC LSFO LS LS LS ATS 2% 3% 6% 9% 1.6% microorganism or by lime sulfur -- and suppression of infection by the patho...Â After several years of orchard trials, non-antibiotic programs that utilize Blossom Protect continue to be the most effective and consistent for fire blight control. Obj. 2b. An Annual Fire Blight Management. Program for Apples: An Update, Fruit Notes, Volume 80, p.18-26. 6. Hartman J., Hershman D., 2002.Â 19. Steiner P.W., 2000. A philosophy for effective fire blight management, University of Maryland, College. of Agriculture and Natural Resources Sciences MD, Keraneyswille Tree Fruit Research and. Education Center WV, p.1-5.