Managing Apple Scab in High Inoculum Orchards

Dave Rosenberger and Kerik Cox
New York State Agricultural Experiment Station, Cornell University

In apple orchards where scab was poorly controlled last fall, growers will need to compensate this spring for what we might call the five curses of high-inoculum, as outlined below:

1. Expect more ascospores: Using data from a study by Gadoury and MacHardy (1986), New Hampshire orchards that had less than 1% leaf scab in autumn produced an estimated 888,000 ascospores/A as compared to 6.1 billion spores/A for an orchard with 20% leaf scab (Table 1). These data suggest that orchards with 20% leaf scab may produce nearly 7,000 times more ascospores than orchards that had less than 1% leaf scab. Thus, orchards with a lot of scabby leaves in fall are indeed "high-inoculum" orchards.

2. Expect more ascospores at green-tip: This is a logical corollary to the previous item. However, it is noted separately because the spores that are discharged early in the season pose the greatest risk for generating economic losses in commercial orchards. If ascospores initiate infections at green tip, then the first generation of conidia will become available about the time that trees are in bloom, and that is a period when fruit and leaves are at maximum susceptibility. Also, fungicide protection sometimes lapses toward the end of bloom if a fungicide spray is delayed with the objective of combining the fungicide with petal fall insecticides. Thus, having more ascospores at green tip escalates the risk of getting green-tip infections that will produce conidia before petal fall, which in turn ratchets up the risk of fruit scab.

3. Conidia may overwinter in buds: Work by Holb et al. (2005) in the Netherlands showed that when scab incidence in autumn exceeded 40% of terminal leaves, then small numbers of viable conidia would often survive through winter inside bud scales. Although the numbers of conidia surviving in buds under the worst-case scenarios reported by Holb are dwarfed by the numbers of ascospores that would be produced in those orchards, the conidia in buds are perfectly positioned to cause infections as buds begin to grow in spring. Thus, conidia in buds can be expected to have much greater infection efficiency than ascospores since the majority of ascospores released at green tip will never find tissue where they can cause infections. Incidentally, viable spores have been found inside buds on at least several occasions in New York, so it seems probable that the results reported by Holb from studies in the Netherlands are also applicable to high-inoculum orchards in northeastern United States.

4. Expect more infections from marginal infection periods: In low-inoculum orchards, relatively small numbers of ascospores are released during any given wetting period, and only a few of those released will be deposited on host tissue and complete the infection process in the minimum time listed for infections in the revised Mill's table. As the duration of wetting increases, more and more spores can be deposited on host tissues, so the severity of infection periods increases with time at any given temperature. In high-inoculum orchards, the total spore contingent is much higher (perhaps 7000 times higher as pointed out in #1 above), so many more spores will succeed in completing the infection process during short or "marginal" infections periods.

5. Fungicides will seem less effective: If one assumes that 2% of the total season's ascospores could be released at green tip, that only 1% of those released will succeed in causing infections in unsprayed orchards, and that a green-tip fungicide spray will be 99.9% effective (which may be optimistic), then one might expect only 0.18 scab infections/A for orchards that had less than 1% leaf scab last year whereas orchards with 20% leaf scab last year might see 1,218 infections per acre (Table 1). The only options for changing the odds are to either improve fungicide efficacy via higher rates, shorter intervals, and better spray coverage, or to implement inoculum reduction practices in the high-inoculum orchards.

Considering all of the above, the three early-season strategies outlined below are logical options for managing scab in high-inoculum orchards:

First, apply one or more inoculum-reduction strategies to reduce the potential ascospore load. Four

Targit Sales

"Specializing in Farm Market Packaging"

1-800-526-9224

Biodegradable

PLASTIC BAGS

Targit Sales is proud to introduce our line of Biodegradable plastic bags. Our bags use a proprietary additive that renders the plastic ultimately biodegradable.

We are offering the Biodegradable bag program with all of our "Custom Imprinted" plastic bags. Our Biodegradable bags have the "EPI" (the additive company) logo on the bag as proof of its biodegradable properties.

Advertise your business along with a "tag line" to express your company's efforts to keep your community and planet green.

Targit Sales can fully customize your bags to your specifications. We can make any size, strength, and style of bag to fit your needs. We can assist you with your design, setup, and artwork.

COMMON SIZES OF BAGS:

13 x 10 x 24 (Great for pies, cakes and corn)
12 x 8 x 24 (Great for your store front)
8 x 5 x 21 (Perfect size for tailgate markets)

BIODEGRADABLE PLASTIC BAG BENEFITS!

* Superior Strength!
* Less expensive to make and ship versus paper bags!
* Superior imprinting capability and quality...(looks better)!
* Easier and more affordable to store (inventory)!
* Flexibility! (customize the size, thickness, color and style to your specifications)
* Reusability!
* Biodegradable..breaks down quickly!

MOST COMMON QUESTIONS asked about biodegradable bags.

Will the bags begin to break down while being stored? No, the bags will retain its strength and integrity while properly stored. The breakdown only begins after it is directly exposed to certain environmental conditions such as: soil/landfill, heat/moisture, and sunlight.

Is this process more expensive? Not really, the cost increase is only a few percentage points higher. You will more than make this up with the goodwill you will be conveying to your community and customers.

Does the bag lose its strength or feel...does it look different? No, it is almost impossible to tell the difference between the Biodegradable bags and the traditional plastic bags. This is why we recommend putting a tag line on your printed biodegradable bags.

Can these bags be recycled and/or reused? Yes, these bags can be recycled and reused.

For more information or to order contact
Targit Sales
1-800-526-9224 • www.targitsales.com

Targit sales associates
"Specialty Food Packaging"

proven options for reducing ascosporic inoculum include (A) treating orchards in either late fall or early spring by applying 40 lb/A of urea dissolved in water and sprayed over the orchard floor (Sutton et al., 2000); (B) flail chopping leaf litter to speed leaf degradation (Sutton et al., 2000); (C) applying dolomitic lime to the orchard floor at the rate of 2.25 tons/A (Spotts et al., 1997); or (D) raking or vacuuming the leaf litter and removing it from the orchard. More details on methods for urea treatment or flail mowing can be found in a Scaffolds article published in 2009 (Rosenberger, 2009).

The use of dolomitic lime has only been tested for lime applied in late fall or winter, so its effectiveness following springtime applications is uncertain. Removing leaf litter from the orchard is practical only for small homeowner orchards unless one invests in specialized raking/vacuuming equipment that that can cover large acreages efficiently.

We have received several questions recently about the efficacy of lime-sulfur for suppressing ascospore production. Lime sulfur sprays were evaluated early in the 20th century, and three applications in spring partially suppressed ascospore production. However, later researchers abandoned lime-sulfur in favor of urea, which generally proved more effective.

Second, begin fungicide applications at silver tip or green tip. Having a fungicide in place before the first infection period after bud break is absolutely essential, especially in orchards where the DMI fungicides are no longer effective. As noted above, failure to control early infections vastly increases the risks of economic losses.

Third, use higher rates of fungicides or fungicide combinations: In low-inoculum orchards, the scab risk at green tip can be adequately addressed with a copper spray (as applied to suppress fire blight) or by using mancozeb at 3 lb/A. Either of these options will provide about seven days of protection against apple scab. Even in low inoculum orchards, however, we know that higher rates of fungicide are needed as we approach tight cluster because 3 lb/A of mancozeb used alone is not adequate to control scab during the period of peak ascospore discharge between tight cluster and petal fall. In high-inoculum orchards, high numbers of ascospores may be released at green tip. Therefore, we suggest that high inoculum orchards should be treated with a combination of either mancozeb at 3 lb/A plus copper, or mancozeb at 3 lb/A plus Syllit at 1.5 pt/A. (Note that Syllit and copper are NOT compatible!) Syllit is the liquid formulation of dodine. The new label no longer contains the restriction against using apple pomace from Syllit-treated trees for cattle feed.

For many years, dodine provided excellent scab control when applied in early-season sprays because of its excellent retention and redistribution characteristics, and also because it provides 48 hr of post-infection activity. Thus, it is an ideal mixing partner for mancozeb in green tip and half-inch green sprays except where dodine-resistant populations of apple scab are known to predominate. Recent testing in the Cox lab at Geneva suggests that dodine-resistant scab is less prevalent in NY than was previously suspected, so Syllit may again prove useful for one or two early-season sprays in many orchards. However, because no one can be absolutely certain that an orchard is entirely free of dodine-resistant scab, Syllit should never be used alone. By using it in combination with mancozeb, we anticipate

Table 1: Effect of inoculum levels on ascospore production based on predicted ascospore doses calculated for New Hampshire orchards by Gadoury and MacHardy (1986).

Scab incidence on leaves in autumn	0.03-0.52%	1.1-3.5%	4-10%	20%
Number of orchards used for the estimate	10	5	3	1
Total ascospores produced/A (X 1000)	888	9,262	242,559	6,090,000
Ascospores/A released at green tip (X 1000)[1]	18	185	4,851	121,812
Potential scab lesions/A from a green-tip infection period[2]	0.18	1.85	48.5	1,218

[1] Assuming that 2% of ascospores are released at green tip. The actual percentage of total ascospore load released at green tip may be much less than 2%, especially under cold conditions.
[2] Assuming 1% of released spores could cause infections but 99.9% of those would be prevented by fungicides applied before the infection period. The actual infection efficiency and fungicide effectiveness are unknown and will vary widely depending on infection conditions and spraying conditions.

better scab control than where mancozeb is used alone (again, with the exception of orchards with very high levels of dodine resistance). Where mancozeb-copper combinations are used in the first spray of the season, the mancozeb-Syllit combination could be used in the second spray to enhance early-season disease control. Where dodine-resistance is known to be present, mancozeb-captan mixtures should be used instead of mancozeb-Syllit mixtures.

Combinations of mancozeb plus Scala or mancozeb plus Vangard might also be considered at green-tip and half-inch green. However, so far as we can tell, Scala and Vangard do not redistribute very well and we therefore believe that mancozeb-copper, mancozeb-Syllit, or mancozeb-captan combinations are preferable to combinations with Scala or Vangard. The exception would be dodine-resistant orchards where an infection period occurred before any fungicide was applied. In that scenario, combinations of mancozeb with either Scala or Vangard could provide 48-72 hr of post-infection activity (counting from the start of the wetting period) whereas mancozeb-copper and mancozeb-captan combinations will only reach back 12-18 hr from the start of a wetting period.

In summary, high-inoculum orchards pose special challenges and must be treated with extra caution from the very beginning of the growing season. This is especially true for orchards where the DMI fungicides are no longer effective. Until the emergence of full-blown DMI resistance, DMIs provided an effective backstop for scab control programs because, when applied at bloom or petal fall, the DMIs could arrest any scab that had escaped early-season sprays. Where DMI fungicides are no longer effective, failure to control scab at green tip in high-inoculum orchards can potentially lead to significant economic losses and a summer full of headaches because once established in trees, scab will likely remain active throughout the entire growing season.

In a future article, we will discuss additional fungicides, including new products that are becoming available, that may help to control scab during the period from tight cluster to first cover.

Literature Cited

Gadoury D.M., and MacHardy, W.E. 1986. Forecasting ascospore dose of *Venturia inaequalis* in commercial apple orchards. Phytopathology 76:112-118.

Holb, I.J., Heinje, B., Jeger, M.J. 2005.The widespread occurrence of overwintered conidial inoculum of *Venturia inaequalis* on shoots and buds in organic and integrated apple orchards across the Netherlands. *European J. of Plant Pathology 111:157-168.*

Spotts, R.A., Cervantes, L.A., and Niederholzer, F.J.A. 1997. Effect of dolomitic lime on production of asci and pseudothecia of Venturia inaequalis and V. pirina. Plant Dis. 81:96-98.

Sutton, D.K., Mac Hardy, W.E., and Lord, W.G. 2000. Effects of shredding or treating apple leaf litter with urea on ascospore dose of *Venturia inaequalis* and disease buildup. Plant Dis. 84 1319-1326.

Rosenberger, D. 2009. Act now to reduce scab inoculum in problem orchards. Scaffolds Fruit Journal 18(1):6-8. Online at http://www.nysaes.cornell.edu/ent/scaffolds/2009/